

Spirit Mission Manager Reports:

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Spirit Remains Silent at Troy - sols 2621-2627, May 18-May 24, 2011:

More than 1,300 commands were radiated to Spirit as part of the recovery effort in an attempt to elicit a response from the rover. No communication has been received from Spirit since Sol 2210 (March 22, 2010). The project concluded the Spirit recovery efforts on May 25, 2011. The remaining, pre-sequenced ultra-high frequency (UHF) relay passes scheduled for Spirit on board the Odyssey orbiter will complete on June 8, 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2615-2620, May 12-May 17, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project is continuing the recovery effort with both Deep Space Network X-band and ultra-high frequency (UHF) relay communication attempts.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2608-2614, May 5-May 11, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project is continuing the recovery effort of both Deep Space Network X-band and ultra-high frequency (UHF) relay communication attempts.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2602-2607, April 29-May 4, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project is continuing the recovery effort of both Deep Space Network X-band and ultra-high frequency (UHF) relay communication attempts.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2594-2601, April 21-April 28, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and commanding covering a range of frequencies and local solar times on Mars is continuing. Selected over flights by the relay orbiters are exercised to elicit a response from the rover through the separate ultra-high frequency (UHF) system.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2580-2586, April 6-April 12, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and commanding covering a range of frequencies and local solar times on Mars is continuing. Selected over flights by the relay orbiters are exercised to elicit a response from the rover through the separate ultra-high frequency (UHF) system.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2574-2579, March 31-April 5, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and recovery commanding continue. The project has been systematically conducting commanding over a range of frequencies and over a range of local solar times on Mars. This covers possibility that the rover's receiver has degraded and/or the clock has drifted significantly since March of 2010.

The project is continuing the commanding of extra-long ultra-high frequency (UHF) relay passes to account for possible rover clock drift or clock error and to make the rover responsive to UHF relay (if it is has experienced a mission-clock fault). The team is also commanding the backup solid-state power amplifier, in case the primary X-band transmitter has failed.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2567-2573, March 24-March 30, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and recovery commanding continue. The project has been systematically conducting commanding over a range of frequencies and over a range of local solar times on Mars. This covers the possibility that the rover's receiver has degraded and/or the clock has drifted significantly since March of 2010.

The project is continuing the commanding of extra-long ultra-high frequency (UHF) relay passes to account for possible rover clock drift or clock error and to make the rover responsive to UHF relay (if it is has experienced a mission-clock fault). The team is also commanding the backup solid-state power amplifier, in case the primary X-band transmitter has failed.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2560-2566, March 17-March 23, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010), over a year ago.

Deep Space Network X-band listening and recovery commanding continue. The project has been systematically conducting commanding over a range of frequencies and over a range of local solar times on Mars. This covers the possibility that the rover's receiver has degraded and/or the clock has drifted significantly since March of 2010.

The project is continuing the commanding of extra-long ultra-high frequency (UHF) relay passes to account for possible rover clock drift or clock error and to make the rover responsive to UHF relay (if it is has experienced a mission-clock fault). The project is also commanding the backup solid-state power amplifier, in case the primary X-band transmitter has failed. Peak solar energy production for Spirit at the Gusev site is estimated to have already occurred back around March 10, 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2553-2559, March 9-March 16, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and recovery commanding continue. The project has been systematically conducting commanding over a range of frequencies and over a range of local solar times on Mars. This covers possibility that the rover's receiver has degraded and/or the clock has drifted significantly since March of 2010.

The project began this week commanding extra-long ultra-high frequency (UHF) relay passes to account for possible rover clock drift or clock error and to make the rover responsive to UHF relay (if it is has experienced a mission-clock fault). The project is also commanding the backup solid-state power amplifier, in case the primary X-band transmitter has failed. Peak solar energy production for Spirit was estimated to occur around March 10, 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2546-2552, March 2-March 8, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010). Deep Space Network X-band listening and "Sweep & Beep" commanding continue. The project has been systematically conducting the Sweep & Beep commanding over a range of frequency reference offsets and over a range of local solar times on Mars. This covers the possibility that the rover's receiver has degraded and/or the clock has drifted significantly since March of 2010.

Shortly, the project will command the use of the backup transmitter (in case the primary transmitter has failed), and will command extra-long ultra-high frequency (UHF) passes to account for possible timing drift of the relay passes, and to make the rover responsive to UHF relay (if it is has experienced a mission-clock fault). Normally, only X-band communication is possible under mission-clock fault.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2540-2545, Feb. 24-March 1, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and "Sweep & Beep" commanding continue. The Sweep & Beep command duration has been shortened to 10 minutes, increasing the likelihood of commands being received within the 20-minute awake (fault) window for the case of a mission clock fault response on Spirit.

Further, the Deep Space Network X-band frequency reference offset (FRO) is stepped over a much larger range to account for the possibility of a degraded receiver on the rover. Scheduled DSN passes now occur over a broader range of local times of day on Mars covering the possibility that the rover's clock has drifted significantly since March of 2010. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2533-2539, Feb. 17-Feb. 23, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

Deep Space Network X-band listening and "Sweep & Beep" commanding continues. The Sweep & Beep command duration has been shortened to 10 minutes, increasing the number of command attempts and the possibility of commands being received within the 20-minute awake (fault) window for the case of a mission clock fault response on Spirit.

Further, the DSN X-band frequency reference offset (FRO) is stepped over a much larger range to account for the possibility of a degraded receiver on the rover. Scheduled DSN passes now occur over a broader range of local times of day on Mars covering the possibility that the rover's clock has drifted significantly since March of 2010. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2527-2532, Feb. 11-Feb. 16, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The solar conjunction communication moratorium has concluded. Solar conjunction is the period when communications between Earth and Mars are disrupted because the Sun is directly in between the two planets.

The Deep Space Network (DSN) X-band listening and "Sweep & Beep" commanding have resumed. The Sweep & Beep paging strategy has been changed and augmented. The Sweep & Beep command duration has been shortened to 10 minutes, increasing the number of command attempts and the possibility of commands being received within the 20-minute awake (fault) window for the case of a mission clock fault response on Spirit.

Further, the DSN X-band frequency reference offset will be stepped over a much larger range to account for the possibility of a degraded receiver on the rover. DSN passes have also been modified to occur over different local times of day on Mars covering the possibility that the rover's clock has drifted significantly since March of 2010. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2520-2526, Feb. 3-Feb. 10, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

However, the solar conjunction communication moratorium has now begun and will extend until approximately Feb. 12, 2011. Solar conjunction is the period when communications between Earth and Mars are disrupted because the Sun is directly in between the two planets. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2512-2519, Jan. 26-Feb. 2, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

However, the solar conjunction communication moratorium has now begun and will extend until approximately Feb. 7, 2011. Solar conjunction is the period when communications between Earth and Mars are disrupted because the Sun is directly in between the two planets. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2505-2511, Jan. 19-Jan. 25, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network (DSN) and the Mars orbiters for autonomous recovery communication from a low-power fault case. Different frequency reference offsets will be used by the DSN in case Spirit's receiver's frequency response has drifted.

The project also continues the "Sweep & Beep" paging strategy to stimulate the rover in the case of a mission-clock fault. The time window for the Sweep & Beep commanding is being expanded to cover more possible timing cases. The JPL Radio Science team is also expanding the time window over which it listens to cover the possibility that Spirit's clock may have drifted more than estimated, and the rover locks up at a different time on the signal to the Mar Reconnaissance Orbiter (which shares the same X-band frequency channel). The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2498-2504, Jan. 12-Jan. 18, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network (DSN) and the Mars orbiters for autonomous recovery communication from a low-power fault case. Different frequency reference offsets will be used by the DSN in case Spirit's receiver's frequency response has drifted.

The project also continues the "Sweep & Beep" paging strategy to stimulate the rover in the case of a mission-clock fault. The time window for the Sweep & Beep commanding is being expanded to cover more possible timing cases. The JPL Radio Science team is also expanding the time window over which it listens to cover the possibility that Spirit's clock may have drifted more than estimated, and the rover locks up at a different time on the signal to the Mar Reconnaissance Orbiter (which shares the same X-band frequency channel). The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2492-2497, Jan. 6-Jan. 11, 2011:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network (DSN) and the Mars orbiters for autonomous recovery communication from a low-power fault case. Different frequency reference offsets will be used by the DSN in case Spirit's receiver's frequency response has drifted.

The project also continues the "Sweep & Beep" paging strategy to stimulate the rover in the case of a mission-clock fault. The time window for the Sweep & Beep commanding is being expanded to cover more possible timing cases. The JPL Radio Science team is also expanding the time window over which it listens to cover the possibility that Spirit's clock may have drifted more than estimated and the rover locks up at a different time on the signal to the Mars Reconnaissance Orbiter (which shares the same X-band frequency channel). The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2486-2491, Dec. 31-Jan. 5, 2011:

No communication has been received from the Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network (DSN) and the Mars orbiters for autonomous recovery communication from a low-power fault case. Different frequency reference offsets will be used by the DSN in case Spirit's receiver's frequency response has drifted.

The project also continues the "Sweep & Beep" paging strategy to stimulate the rover in the case of a mission-clock fault. The time

window for the Sweep & Beep commanding is being expanded to cover more possible timing cases. The JPL Radio Science team is also expanding the time window over which it listens to cover the possibility that Spirit's clock may have drifted more than estimated and the rover locks up at a different time on the signal to Mars Reconnaissance Orbiter (which shares the same X-band frequency channel). The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2478-2485, Dec. 22-Dec. 29, 2010:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from a low-power fault case. The project also conducts a "Sweep & Beep" paging strategy to stimulate the rover in the case of a mission-clock fault. The time window for the Sweep & Beep commanding is being expanded to cover more possible timing cases. The period of maximum solar insolation (energy production) for Spirit occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2471-2477, Dec. 15-Dec. 21, 2010:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from a low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault. The period of maximum solar insolation (energy production) occurs around mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2465-2470, Dec. 9-Dec. 14, 2010:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from a low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault. The period of maximum solar insolation (energy production) occurs mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2458-2464, Dec. 2-Dec. 8, 2010:

No communication has been received from Spirit since Sol 2210 (March 22, 2010).

The project continues to listen with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from a low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault. The period of peak solar insolation (energy production) is not until mid-March 2011.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2450-2457, Nov. 24-Dec. 1, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project continues to listen for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault. The period of peak solar insolation (energy production) is not until mid-March 2011. So Spirit has plenty of occasion to respond.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2445-2449, Nov. 18-Nov. 22, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project continues to listen for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault. The period of peak solar insolation (energy production) is not until mid-March 2011. So Spirit has plenty of occasions to respond.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2438-2444, Nov. 11-Nov. 17, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project continues to listen for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" to stimulate the rover in the case of a mission-clock fault.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2431-2437, Nov. 4-Nov. 10, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project continues to listen for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case. The project is also conducting a paging technique called "Sweep & Beep" strategy to stimulate the rover in the case of a mission-clock fault.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2424-2430, Oct. 28-Nov. 3, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project continues to listen for Spirit with the Deep Space Network and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case. The project is also conducting a paging technique called "sweep & beep" to stimulate the rover in the case of a mission-clock fault. Improving solar insolation levels should provide an environment for the rover batteries to recharge with increasing likelihood of hearing from Spirit in the period ahead.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2417-2423, Oct. 21-Oct. 27, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project is listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault. Improving solar insolation levels should provide an environment for the rover batteries to recharge with increasing likelihood of hearing from Spirit in the period ahead.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2410-2416, Oct. 13-Oct. 20, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project is listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault. Improving solar insolation levels should provide an environment for the rover batteries to recharge, with increasing likelihood of hearing from Spirit in the period ahead.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2402-2409, Oct. 5-Oct. 12, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

The project is listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault. Improving solar insolation levels should provide an environment for the rover batteries to recharge, with increasing likelihood of hearing from Spirit in the period ahead.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2397-2402, Sept. 30-Oct. 5, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

Spirit likely experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. If energy levels during the winter were lower than predicted, the rover may have also tripped a mission clock fault.

The project is listening for Spirit with the Deep Space Network and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault. With the onset of Martian spring, improving solar insolation levels should provide an environment for the rover batteries to recharge with the likelihood of hearing from Spirit increasing in the period ahead.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2390-2396, Sept. 23-Sept. 29, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. The rover internal electronics will experience colder temperatures than previous winters, because heaters will be shut off. There is the additional risk that the rover may trip a mission clock fault.

The project is listening for Spirit with the Deep Space Network and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault. With the onset of Martian spring, improving solar insolation levels should provide an environment for the rover batteries to recharge.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2383-2389, Sept. 16-Sept. 22, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. The rover internal electronics will experience colder temperatures than previous winters, because heaters will be shut off. There is the additional risk that the rover may trip a mission clock fault.

The project is listening for Spirit with the Deep Space Network and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2376-2382, Sept. 9-Sept. 15, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. The rover internal electronics will experience colder temperatures than previous winters,

because heaters will be shut off. There is the additional risk that the rover may trip a mission clock fault.

The project is listening for Spirit with the Deep Space Network and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Although power levels are estimated to be improving with the advancing springtime in the southern hemisphere of Mars, atmospheric conditions historically deteriorate (higher atmospheric opacity) at this time. Thus, a response from Spirit is still not expected for some time.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2369-2375, Sept. 1-Sept. 8, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. The rover internal electronics will experience colder temperatures than previous winters, because heaters will be shut off. There is the additional risk that the rover may trip a mission clock fault. The project is listening for Spirit with the Deep Space Network (DSN) and the Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Although power levels are estimated to be improving with the advancing springtime in the southern hemisphere of Mars, atmospheric conditions historically deteriorate (higher atmospheric opacity) at this time. Thus, a response from Spirit is still not expected for some time.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2362-2368, Aug. 25-Aug. 31, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. The rover internal electronics will experience colder temperatures than previous winters, because heaters will be shut off. There is the additional risk that the rover may trip a mission clock fault. The project is listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Although power levels are estimated to be improving with the advancing springtime in the southern hemisphere of Mars, atmospheric conditions historically deteriorate (higher atmospheric opacity) at this time. Thus, a response from Spirit is still not expected for some time.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at 'Troy' - sols 2356-2361, Aug. 19-Aug. 24, 2010:

Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. There is the additional risk that the rover may trip a mission clock fault. To respond to either case, the project is both listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Although power levels are estimated to be improving with the advancing springtime in the southern hemisphere of Mars, atmospheric conditions historically deteriorate (higher atmospheric opacity) at this time. So, a response from Spirit is still not expected for some time.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Still Not Talking Back - sols 2350-2355, Aug. 13-Aug. 18, 2010: Spirit remains silent at her location on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a

deep sleep, trying to recharge her batteries. There is the additional risk that the rover may trip a mission clock fault. To respond to either case, the project is both listening for Spirit with the Deep Space Network and Mars Odyssey orbiter for autonomous recovery communication from the low-power fault case, and conducting a "Sweep & Beep" strategy to stimulate the rover in the case of a mission clock fault.

Although power levels are estimated to be improving with the advancing springtime in the southern hemisphere of Mars, atmospheric conditions historically deteriorate (higher atmospheric opacity) at this time. So a response from Spirit is still not expected for some time.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

'Sweep & Beep' Campaign Continues - sols 2342-2349, Aug. 5-Aug. 12, 2010: Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would lose track of time and remain asleep until there is enough sunlight on the solar arrays to wake the rover, a state called "Solar Groovy."

When the rover wakes from a mission clock fault, she would only listen. So starting on Sol 2333 (July 26, 2010), the project implemented a new procedure to address the possible mission clock fault. Each sol, the Deep Space Network (DSN) mission controllers send a set of X-band beep commands, called "Sweep & Beep." If the rover has experienced a mission clock fault and is awake during the day, the rover will be listening during brief, 20-minute intervals each awake hour. Because of the possible clock fault, the timing of these 20-minute listening intervals can't be known. So the project will fill the likely awake period with multiple "Sweep & Beep" commands. If the rover hears one of these commands, it will respond back with an X-band beep signal, telling us she is there and allowing the project to investigate the state of the rover further. A response from Spirit is not expected for some time, as the season is still very early spring on Mars.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit in 'Sweep & Beep' Mode - sols 2335-2341, July 28-Aug. 4, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would lose track of time and remain asleep until there is enough sunlight on the solar arrays to wake the rover, a state called "Solar Groovy." When the rover wakes from a mission clock fault, she would only listen. So starting on Sol 2333 (July 26, 2010), the project implemented a new procedure to address the possible mission clock fault.

Each sol, the Deep Space Network mission controllers send a set of X-band beep commands, called "Sweep & Beep." If the rover has experienced a mission clock fault and is awake during the day, the rover will be listening during brief, 20-minute intervals each awake hour. Because of the possible clock fault, the timing of these 20-minute listening intervals can't be known. So the project will fill the likely awake period with multiple "Sweep & Beep" commands. If the rover hears one of these commands, it will respond back with an X-band beep signal, telling them she is there and allowing them to investigate the state of the rover further. Although the project is using this new strategy now, a response from Spirit is not expected for some time, as the season is still very early spring on Mars.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Awaits "Solar Groovy" - sols 2330-2334, July 23-July 27, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep, trying to recharge her batteries. There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would lose track of time and remain asleep until there is enough sunlight on the solar arrays to wake the rover, a state called "Solar Groovy." When the rover wakes from a mission clock fault, she would only listen.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2321-2329, July 14-July 22, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake-up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently, and there is enough sunlight on the solar arrays to wake the rover. With the southern winter solstice back on May 13, 2010, solar energy levels and temperatures are expected to be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Status Not Changed - sols 2315-2320, July 8-July 13, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake-up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently, and there is enough sunlight on the solar arrays to wake the rover. With the southern winter solstice back on May 13, 2010, solar energy levels and temperatures are expected to be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Still Silent - sols 2308-2314, July 1-July 7, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

As stated previously, it is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. With the southern winter solstice back on May 13, 2010, solar energy levels and temperatures are expected to be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Still Listening for Spirit - sols 2301-2307, June 23-June 30, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

As stated previously, it is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. With the southern winter solstice back on May 13, 2010, solar energy levels and temperatures are expected to be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Standing by At Troy - sols 2295-2300, June 17-June 22, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

As stated previously, it is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. With the southern winter solstice back on May 13, 2010, solar energy levels and temperatures are expected to be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Catching More Rays - sols 2286-2294, June 8-June 16, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate.

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. The southern winter solstice was on May 13, 2010, so solar energy levels and temperatures should be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent at Troy - sols 2281-2285, June 3-June 7, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. The rover electronics module (REM) is expected to get colder than ever before. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate over X-band and Ultra-High Frequency (UHF).

There is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. With the passing of the southern winter solstice (on May 13, 2010), solar energy levels and temperatures should be improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Team Listens for Spirit - sols 2274-2280, May 27-June 2, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. The rover electronics module (REM) is expected to get colder than ever before. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate over X-band and Ultra-High Frequency (UHF).

Although the rover may not wake for some time, the project has been listening every day for any X-band signal from Spirit through the Deep Space Network (DSN) using the radio science receiver (RSR). The Mars Odyssey orbiter is also listening for any scheduled UHF relay passes. If energy levels for the rover are even lower than estimated, there is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the batteries have recharged sufficiently and there is enough sunlight on the solar arrays to wake the rover. With the passing of the southern winter solstice (on May 13, 2010), solar energy levels and temperatures should begin to improve.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Still in Deep Sleep - sols 2267-2273, May 20-May 26, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. The rover electronics module (REM) is expected to get colder than ever before. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin

to communicate over X-band and Ultra-High Frequency (UHF).

Although the rover may not wake for some time, the project has been listening every day for any X-band signal from Spirit through the Deep Space Network (DSN) using the Radio Science Receiver (RSR). The Mars Odyssey orbiter is also listening for any scheduled UHF relay passes. If energy levels for the rover are even lower than estimated, there is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the Martian spring or summer when bright sunlight is needed to wake the rover. With the passing of the southern winter solstice two weeks ago, solar energy levels and temperatures should begin improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit is Past Winter Solstice - sols 2260-2266, May 12-May 19, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication and gone into a deep sleep. While sleeping, the rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate over X-band and Ultra-High Frequency (UHF).

Although the rover may not wake for some time, the project has been listening every day for any X-band signal from Spirit through the Deep Space Network (DSN) using the Radio Science Receiver (RSR). The Mars Odyssey orbiter is also listening for any scheduled UHF relay passes. If energy levels for the rover are even lower than estimated, there is the additional risk that the rover may trip a mission clock fault. If that happens, the rover would remain asleep until the Martian spring or summer when bright sunlight is needed to wake the rover. The winter solstice has past. Energy and temperatures should begin improving.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Winter Solstice Is Tomorrow - sols 2254-2259, May 6-May 11, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication. The rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate over X-band. When that does happen, Spirit will also trip an up-loss timer fault. This fault response will allow the rover to communicate over Ultra-High Frequency (UHF) as well.

It is not known when the rover will wake up, so the project has been listening every day for any X-band signal from Spirit through the Deep Space Network (DSN) using the Radio Science Receiver (RSR). Mars Odyssey is also listening for any scheduled UHF relay passes. The winter solstice is tomorrow.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Winter Solstice One Week Away - sols 2248-2253, April 30-May 5, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication. The rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate over X-band. When that does happen, Spirit will also trip an up-loss timer fault. This fault response will allow the rover to communicate over Ultra-High Frequency (UHF) as well.

It is not known when the rover will wake up, so the project has been listening for any X-band signal from Spirit through the Deep Space Network every day. The Mars Odyssey orbiter is also listening over any scheduled UHF relay passes. The winter solstice is only one week away.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Winter Solstice Two Weeks Away - sols 2240-2247, April 22-April 29, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication. The rover will use

the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate. When that does happen, Spirit will also trip an up-loss timer fault. This fault response will allow the rover to communicate over Ultra-High Frequency (UHF), as well as X-band.

It is not known when the rover will wake up, so the project has been listening for any X-band signal from Spirit through the Deep Space Network every day. The Mars Odyssey orbiter is also listening over any scheduled UHF relay passes. The winter solstice is about two weeks away.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Winter Solstice Just Three Weeks Away - sols 2233-2239, April 15-April 21, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has powered off all sub-systems, except her master clock. The rover will use the available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate. When that does happen, Spirit will also trip an up-loss timer fault. This fault response will allow the rover to communicate over Ultra-High Frequency (UHF) as well as X-band.

It is not known when the rover will wake up, so the project has been listening for any X-band signal from Spirit through the Deep Space Network every day. The relay orbiters are also listening over any scheduled UHF relay passes. The winter solstice is just three weeks away (Sol 2261, or May 13, 2010).

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Awaits Winter at Troy - sols 2227-2232, April 8-April 14, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication. The rover will use the available solar-array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate. When that does happen, Spirit will also trip an up-loss timer fault. This fault response will allow the rover to communicate over Ultra-High Frequency (UHF), as well as X-band.

It is not known when the rover will wake up, so the project has been listening for any X-band signal from Spirit through the Deep Space Network every day. The Mars Odyssey orbiter is also listening over any scheduled UHF relay passes. The winter solstice is still about a month away.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Remains Silent - sols 2219-2226, March 31-April 7, 2010:

Spirit remains silent at her location called "Troy" on the west side of Home Plate. No communication has been received from the rover since Sol 2210 (March 22, 2010).

It is likely that Spirit has experienced a low-power fault and has turned off all sub-systems, including communication. The rover will use all available solar array energy to recharge her batteries. When the batteries recover to a sufficient state of charge, Spirit will wake up and begin to communicate. It is not known when that will happen, so the project has been listening for any X-band signal from Spirit through the Deep Space Network (DSN) every day. The Mars Odyssey orbiter is also listening over selected Ultra-High Frequency (UHF) relay passes for any signal from Spirit. It may be weeks to months before Spirit communicates.

Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit in Hibernation - sols 2211-2218, March 23-March 30, 2010:

The scheduled downlink from Spirit on Sol 2218 (March 30, 2010), via Ultra-High Frequency (UHF) relay through the Odyssey orbiter was not received.

Odyssey reported nominal operations for their orbiter, but there was no received Spirit telemetry and no evidence of a UHF signal from the surface of Mars at Gusev crater. The team was anticipating Spirit to experience a low-power fault about this time. So, the most likely explanation for the missing downlink is that Spirit did go into that low-power fault taking her batteries off-line, sometime between the last downlink on Sol 2210 (March 22, 2010), and Sol 2218 (March 30, 2010).

With a low-power fault, Spirit is in a deep sleep with all loads turned off (no communication) and only the master clock being powered. The clock will stir Spirit on regular intervals to see if the batteries have recharged enough to wake up. If not, Spirit will remain deeply sleeping with the solar arrays trying to charge the rover batteries. The project had already begun listening for the possible X-band fault [communication] windows associated with the low-power fault. No X-band fault window has been detected, yet. The Deep Space Network radio science receiver (RSR) is being used to search for any X-band signal from Spirit. The rover will also experience an Uploss timer fault, since the rover would not be awake for us to reset that timer with a ground command. When the Uploss timer does expire, Spirit will also be responsive to UHF relay passes. However, Spirit will only respond with an X-band fault window or a UHF relay pass, if her batteries have recharged sufficiently. The team does not expect a response from Spirit for some time, but will listen every day. Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Solar Energy Levels Dropping - sols 2204-2210, March 16-March 22, 2010:

In position for the fourth winter, embedded at "Troy" on the west side of Home Plate, Spirit continues to execute a single seven-sol plan each week, as long as power permits.

The seven-sol plan contains a single X-band uplink and a single Ultra-High Frequency (UHF) downlink. The activity on each sol consists simply of a brief wakeup, an atmospheric opacity (τ) measurement, and then a shutdown for the rest of the day and night. The last downlink from the rover was on Sol 2210 (March 22, 2010). From that downlink, Spirit was still under master sequence control and all systems were green. Energy production was down to 134 watt-hours per sol. Solar array energy production levels will continue to drop, leading to widening energy deficits and decreases in battery state of charge. The solid-state power amplifier (SSPA), as a proxy for the rover electronics module (REM), reached a new record low temperature of minus 41.5 degrees Celsius (minus 42.7 degrees Fahrenheit). Spirit continues to get colder. A change was noticed on Sol 2203 (March 15, 2010), in the behavior of the battery survival heaters. The implications are not known, but it is being investigated. The plan for this week is to sequence another seven-sol plan to be uplinked this Friday with a single UHF downlink by early next week.

Spirit could enter low-power fault at anytime and become quiet for an extended period of time to charge her batteries. As of Sol 2210 (March 22, 2010), the rover solar array energy production was to 134 watt-hours with an atmospheric opacity (τ) of 0.353, as measured on Sol 2209 (March 21, 2010). Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Electronics Getting Colder - sols 2200-2203, March 12-March 15, 2010:

In her winter position, still embedded in the area called "Troy" on the west side of Home Plate, Spirit has transitioned to executing a single, seven-sol plan each week, as long as power permits.

The seven-sol plan contains a single X-band uplink and a single Ultra-High Frequency (UHF) downlink. The activity on each sol consists simply of a brief wakeup, an atmospheric opacity (τ) measurement, and then a shutdown for the rest of the day and night.

The last downlink from the rover was on Sol 2203 (March 15, 2010). From that downlink, Spirit was still under master sequence control and all systems were green. Energy production was down to 139 watt-hours per sol. Battery state of charge did not decrease significantly, suggesting that Spirit was able to stay roughly power neutral over the last few sols. Solar array energy production levels will continue to drop and rover heating requirements will continue to increase, leading to widening energy deficits.

The solid-state power amplifier (SSPA), as a proxy for the rover electronics module (REM), reached a record low temperature of minus 41 degrees Celsius (minus 41.8 degrees Fahrenheit). Spirit is getting colder than ever before. The plan for this week is to sequence another seven-sol plan to be uplinked this Friday with a single UHF downlink over the weekend. Spirit could enter low-power fault at anytime and become quiet for an extended period of time to charge her batteries.

As of Sol 2203 (March 15, 2010), the rover solar array energy production was to 139 watt-hours with an atmospheric opacity (τ) of 0.379 measured on Sol 2202 (March 14, 2010), and a dust factor of 0.507. Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit Has A Light Winter Schedule - sols 2192-2199, March 3-March 11, 2010:

Spirit is in her winter position, still embedded in the area called "Troy" on the west side of Home Plate.

Winter operations have begun with the rover, which consists of a single 7-sol plan each week. The 7-sol plan contains a single X-band uplink and a single Ultra-High Frequency (UHF) downlink. The activity on each sol consists simply of a brief wakeup, an atmospheric opacity (τ) measurement, and then a shutdown for the rest of the day and night. The last downlink from the rover was on Sol 2195 (March 7, 2010). The next downlink from the rover is not scheduled yet, but expected to be sequenced for this coming weekend. Energy production by the solar arrays has just been matching energy consumption by the rover. However, this will diverge as solar array energy decreases as the sun descends lower in the sky and as rover energy needs increase from heaters as environmental temperatures drop. The risk of a low-power fault (where batteries are drawn down below a specific cell voltage threshold) increases each sol going forward.

As of Sol 2195 (March 7, 2010), the rover solar array energy production was to 151 watt-hours with an atmospheric opacity (τ) of 0.339 (measured on Sol 2193, March 5, 2010) and a dust factor of 0.506 (from Sol 2193 data). Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Winter Preparations Nearly Complete - sols 2185-2191, Feb. 24-March 2, 2010:

Spirit is in her winter position, still embedded in the area called "Troy" on the west side of Home Plate.

Efforts are nearing completion to prepare the rover for winter. Because of the low power levels, multi-sol plans are being developed with reduced communication activity to save energy. Only one or two planning cycles occur each week. These plans have a single uplink to the rover and few Ultra-High Frequency (UHF) downlinks to return the data. The new long-range UHF communication table is onboard and various settings for winter are being finalized.

As of Sol 2191 (March 2, 2010), the rover solar array energy production was to 153 watt-hours with an atmospheric opacity (τ) of 0.331 and a dust factor of 0.510. Total odometry is unchanged at 7,730.50 meters (4.80 miles).

Spirit in Energy Saving Mode - sols 2177-2184, Feb. 16-Feb. 23, 2010:

Spirit is in her winter position, still embedded in the area called "Troy" on the west side of Home Plate. Efforts continue to prepare the rover for winter.

Because of the low power levels, multi-sol plans are being developed with reduced communication activity to save energy. These plans have a single uplink to the rover and few Ultra-High Frequency (UHF) downlinks to return the data. The new long-range UHF communication table is on board and various settings for winter are being prepared.

A special Deep Space Network (DSN) test was performed with Spirit to confirm that even during the time of weakest signal, the DSN should be able to detect the rover's signal with the DSN's Radio Science Receiver (RSR) even if the Mars Reconnaissance Orbiter is transmitting.

As of Sol 2184 (Feb. 23, 2010), the rover solar array energy production was to 163 watt-hours with an atmospheric opacity (τ) of 0.367 and a dust factor of 0.518. Total is 7,730.50 meters (4.80 miles).

Spirit Hunkers Down for Winter - sols 2171-2176, Feb. 10-Feb. 15, 2010:

Spirit is parked for the winter in the embedded area called "Troy" on the west side of Home Plate. Efforts continue to prepare the rover for winter.

On Sol 2174 (Feb. 13, 2010), the robotic arm (IDA) was positioned to the most favorable orientation for winter. Documentary imaging is being collected of the terrain and rover. On board flash memory is being emptied, getting down all essential data products. A special table of long-range UHF communication passes is being developed to cover the entire winter period and beyond. As energy levels decrease rover wake times are shortened and many communication passes are being deleted.

As of Sol 2176 (Feb. 15, 2010), the rover solar array energy production was to 173 watt-hours with an atmospheric opacity (τ) of 0.361 and a dust factor of 0.526. Total odometry is 7,730.50 meters (4.80 miles).

Spirit Parks for the Winter - sols 2166-2170, Feb. 5-Feb. 9, 2010

Spirit is now parked for the winter in the embedded area called "Troy" on the west side of Home Plate.

The last winter-preparatory movement of the rover was commanded on Sol 2169 (Feb. 8, 2010). The rover was commanded to flatten the suspension system on the right side and accentuate the suspension wheelie on the left side, all to enhance northerly tilt. Very little change in tilt was achieved.

At this point, the project is now adjusting various rover parameters and positioning the robotic arm for the winter period. The communication window for various fault conditions has been adjusted to the optimal time of day during the coldest part of the winter. A special table of long-range UHF communication passes is being developed to cover the entire winter period and beyond.

As of Sol 2170 (Feb. 9, 2010), the rover solar array energy production was to 185 watt-hours with an atmospheric opacity (τ) of 0.292 and a dust factor of 0.527. Total odometry is 7,730.50 meters (4.80 miles)

Improving Northerly Tilt - sols 2159-2165, Jan. 29-Feb. 4, 2010

Spirit is still embedded in the area called "Troy" on the west side of Home Plate.

Energy levels for Spirit have been decreasing rapidly as winter approaches. To increase energy production and to prepare for winter, the rover mobility system is being driven to improve northerly tilt.

On Sol 2161 (Jan. 31, 2010), Spirit drove her wheels backwards, employing several autonomous recovery techniques to prevent early termination of the drive from mobility faults. These autonomous recovery techniques have been effective in permitting the driving to

continue much further than otherwise. Several centimeters of backward progress were made by the rover without further sinkage. Northerly tilt improved by about a degree. Every degree in improvement in northerly tilt enhances daily energy production by about 5 watt-hours.

On Sol 2165 (Feb. 4, 2010), another drive was sequenced. This drive achieved less progress and had only a modest improvement in tilt. The next drive plan is to cause the rover suspension to lift one side of the rover, improving northerly tilt. This is likely to be the last rover motion before winter, as energy levels are dropping below levels able to sustain driving. The project is configuring the rover's communication settings and fault parameters in preparation for the winter.

As of Sol 2165 (Feb. 1, 2010), the rover solar array energy production was to 188 watt-hours with an atmospheric opacity (τ) of 0.359 and a dust factor of 0.523. Total odometry is 7,730.48 meters (4.80) miles.

Spirit Prepares for Winter - sols 2151-2158, Jan. 20-28, 2010

Spirit is still embedded in the area called "Troy" on the west side of Home Plate. Energy levels for Spirit have been decreasing rapidly as winter approaches. To prepare for winter, the project is taking actions to improve northerly tilt of the rover to maximize solar illumination.

The best approach has been to drive Spirit backwards. The drives employ a wheel steering action "frog kick" with each drive step. To mitigate against wheel stalls associated with driving in this embedded terrain, an autonomous wheel diagnostics has been added. If a wheel stall occurs, the diagnostic test is run on the stalled wheel. If the wheel passes the diagnostic, then driving resumes. This has been effective in permitting the driving to continue much further than otherwise.

Spirit continues to make several centimeters of backward progress with each drive without further sinkage. In some cases, the rover has gained in elevation. However, northerly tilt has not improved due mainly to the counterclockwise yaw of the rover. Backward driving will continue with the aim to position the rover for the winter with the most favorable orientation achievable.

As of Sol 2158 (Jan. 28, 2010), the rover solar array energy production was down to 182 watt-hours with an atmospheric opacity (τ) of 0.379 and a dust factor of 0.522. Total odometry is 7,730.46 meters (4.80 miles).

Little Progress in Backward Driving - sols 2144-2150, Jan. 13-19, 2010

Spirit is still embedded in the area called "Troy" on the west side of Home Plate.

The project has begun backward driving with Spirit as the next technique to try for extrication. On Sol 2145 (Jan. 14, 2010), the first backward drive was performed. Up until this point, all extrication attempts had been with forward driving. Backward driving includes the additional technique of steering the wheels side-to-side before performing each drive step. The hypothesis on the wheel steering is two-fold. It clears out material in front of the wheel and allows material to slough off the face of the wheel trench providing traction under the wheel, and the flat surface of the wheel side (hub) "kicks" against the loose material like a swimmer's frog kick or breast stroke to provide motive force.

This backward driving technique has shown promise on sols 2145 (Jan. 14, 2010), 2147 (Jan. 16, 2010) and 2050 (Jan. 19, 2010) with the rover moving 3 to 4 centimeters (1.2 to 1.6 inches) per drive and the rover climbing in elevation, even with only four functioning drive wheels.

During the last drive, the left-middle wheel experienced a motor stall. The nature of the stall is not known: whether it is an external obstruction (e.g., a rock) or an internal actuator problem. A set of diagnostics have been sequenced on the rover before the next drive is attempted. As of Sol 2150 (Jan. 19, 2010), the rover solar array energy production was to 211 watt-hours with an atmospheric opacity (τ) of 0.400 and a dust factor of 0.542. Total odometry is 7,730.24 meters (4.80 miles).

Little Forward Progress -- sols 2137-2143, Jan. 6 - 12, 2010

Spirit remains embedded at the location called "Troy" on the West side of Home Plate. Extrication drives were tried on sols 2138, 2140 and 2142 (Jan. 7, 9 and 11, 2010). Each of these drives employed a new technique of steering the wheels back and forth before driving. This has shown some efficacy at sweeping material out of the wheel tracks and allowing fresh material to slough off the leading trench face providing traction under the wheel. Slower wheel speeds were also tried on two of the drives. However, even with these new techniques, little forward progress has been achieved. And excessive sinkage continues to occur with each attempt.

Both the right-front and right-rear wheel continue to be non-functional.

Next, Spirit will switch directions and attempt to drive backward to see if that provides better progress.

As of Sol 2143 (Jan. 12, 2010), Spirit's solar-array energy production is 225 watt-hours, with an atmospheric opacity (τ) of 0.490 and a dust factor of 0.539. Total odometry is 7,730.12 meters (4.80 miles).

Toe-In Maneuver Before Drive -- sols 2131-2136, Dec. 31, 2009 - Jan. 5, 2010

Spirit remains embedded at the location called "Troy" on the west side of Home Plate. Attempts to extricate Spirit have been complicated by the lack of functionality in both the right-rear and right-front wheels.

On Sol 2132 (Jan. 1, 2010), the left-front, left-rear, and right-rear wheels were steered 60 degrees toe-in to try and cause material in front of the wheels to collapse into the trenches in which the wheels are embedded. The wheels were then steered back to straight forward in an attempt to use the flat outer surface of the wheel to push the previously collapsed material to the side of the wheel. The intent of this is to provide a free space in front of each wheel into which it may move. Four 2.5-meter (8.2-foot) forward drive steps were then commanded. The right-front wheel was then steered inward 60 degrees to allow driving with the wheel threads more aligned with the direction of motion. The Sol 2132 drive was terminated during the initial steering of the wheels due to the flight software believing the left-rear steering motor had stalled. The left-rear wheel was continuing to steer but resistance from the surrounding soil had slowed it to a rate that the flight software did not detect as motion.

For Sol 2136 (Jan. 5, 2010), the team sequenced a drive to continue where the Sol 2132 drive terminated. The left-front, left-rear, and right-rear wheels were commanded back to straight. Four 2.5-meter (8.2-foot) drive steps were then commanded. The right-front wheel was then commanded to steer inward 60 degrees. An additional four 2.5-meter (8.2-foot) drive steps were commanded. The drive was terminated due to the onboard sinkage measurement in excess of 1 centimeter (0.4 inch). This drive achieved only 2.28 centimeters (0.9 inch) of forward progress.

As of Sol 2136 (Jan. 5, 2010), Spirit's solar-array energy production is 243 watt-hours, with an atmospheric opacity (τ) of 0.482 and a dust factor of 0.545. Total odometry is 7,730.08 meters (4.80 miles).

Intermittent Functionality in Right-Front Wheel -- sols 2118-2124, Dec. 17-24, 2009

Spirit remains embedded in the location called "Troy" on the west side of Home Plate.

The right-side wheels were tested on Sol 2118 (Dec. 17, 2009) before that sol's drive. The tests show the right-front wheel has intermittent and limited functionality. The right-rear wheel remains non-functional. The drive completed only the first of four steps and produced barely perceptible movement forward.

A drive on Sol 2120 (Dec. 19, 2009), intended to gather wheel performance data, produced no apparent progress but showed the left bogie angle increasing. This suggested the left-middle wheel was being lifted into the air. Efforts to "flatten" the suspension system on Sol 2122 (Dec. 22, 2009) proved counterproductive, with wheels digging into the soil instead of pulling laterally.

A further drive for Sol 2126 (Dec. 26, 2009) was planned using different speeds on different wheels to try to "flatten" the suspension system and improve traction on the left middle wheel.

The anomalous voltages first seen on the single-point ground on Sol 2104 (Dec. 3, 2009) have persisted and are likely permanent.

As of Sol 2124 (Dec. 24, 2009), Spirit's solar-array energy production was 270 watt-hours, with an atmospheric opacity (τ) of 0.450 and a dust factor of 0.544. Total odometry is 7,730.01 meters (4.80 miles).

Surprise from Right-Front Wheel -- sols 2111-2117, Dec. 10-16, 2009

Spirit remains embedded in the location called "Troy" on the west side of Home Plate. Because of continuing problems with the right-rear wheel, a test of the right-front wheel was done on Sol 2113 (Dec. 12, 2009) to gain insight into the signature for a failed wheel. The right-front wheel had become inoperable back on Sol 779 (March 13, 2006). Surprisingly, the right-front wheel indicated normal motor continuity.

The project also discovered a change in what is known as the single-point ground. A negative voltage is present where no voltage should be. This suggests some sort of electrical short to the rover chassis. The behavior of this single-point ground correlates with the onset of problems with the right-rear wheel and with usage of any of the mobility actuators. This suggests that the rover's motor controller board is suspect.

The right wheels were tested again and driven as part of an extrication maneuver on Sol 2117 (Dec. 16, 2009). The right-front wheel functioned normally for the first three steps of the drive and stopped working during the last step, completing about 10 wheel revolutions. The right-rear wheel did not move at all. The rover only moved slightly during this drive. The project is continuing the investigation of these electric and wheel problems and continuing to explore the functionality of the right-front wheel.

As of Sol 2117 (Dec. 16, 2009), Spirit's solar-array energy production is down to 277 watt-hours, with an atmospheric opacity (τ) of 0.503 and a dust factor of 0.557. Total odometry is 7,730.01 meters (4.80 miles).

Trouble with Right-Rear Wheel -- sols 2100-2110, Nov. 29 - Dec. 9, 2009

Spirit remains embedded in the location called "Troy" on the west side of Home Plate.

Diagnostic tests from Sol 2109 (Dec. 8, 2009) on Spirit's right-rear wheel indicate a troubled wheel. The right-rear wheel rotor resistance tests continue to show very elevated resistance. No motion of the right-rear wheel occurred during a backward commanded motion test. The rotor resistances on all the other operating wheels are nominal.

The plan ahead includes more rotor resistance tests, application of higher voltage to the right-rear wheel to see if any movement will occur, and a check of the right-front wheel to confirm its status and to see if it may offer insight into the right-rear wheel's condition.

As of Sol 2110 (Dec. 9, 2009), Spirit's solar-array energy production is 298 watt-hours, with an atmospheric opacity (τ) of 0.517 and a dust factor of 0.563. Total odometry is 7,730.00 meters (4.80 miles).

Diagnostic Wheel Tests Continue -- sols 2096-2099, Nov. 25-28, 2009

Spirit's extrication from her embedded location at Troy on the west side of Home Plate has been complicated by a recurring stall condition with the right rear wheel.

After diagnostic tests on Sol 2095 (Nov. 24, 2009), indicated a freely moving wheel, another two-step drive with 5 meters (16 feet) of wheel spin was commanded on Sol 2099 (Nov. 28, 2009). That drive resulted in another right rear wheel stall after only 1.4 meters (5 feet) of wheel motion. Analysis of a right rear wheel stall back on Sol 1837 (March 25, 2009), well before embedding, suggests that the stall may not be terrain related, but could be internal to the wheel motor and gearbox. To investigate this, three sets of rotor resistance tests at cold, ambient and warm temperatures were commanded over Sols 2104 (Dec. 3, 2009), and 2105 (Dec. 4, 2009), to check the health of the motor windings and motor brushes. A small right rear wheel motion in the direction of the stall was also commanded on Sol 2104 to see if the stall persists.

The results of these diagnostic tests should be known later tonight (Thursday) and Friday with analyses performed on Friday and over the weekend. The next drive for Spirit would be no sooner than Monday (Dec. 7, 2009).

As of Sol 2099 (Nov. 28, 2009), the rover solar array energy production was 316 watt-hours with an atmospheric opacity (τ) of 0.572 and a dust factor of 0.567. Total odometry is 7,730.00 meters (4.80 miles).

Extrication Attempt Continues -- sols 2091-2095, Nov. 20-24, 2009

The Spirit team is continuing with the process of attempting to extract her from her embedded location at Troy on the west side of Home Plate.

On Sol 2092 (Nov. 21, 2009), a two-step 5-meter (16 feet) forward motion was commanded. After the rover completed about 4 meters (13 feet) of wheel spin, a stall occurred in the right-rear wheel. Telemetry suggested that the wheel was bogging down.

On Sol 2095 (Nov. 24, 2009), a series of diagnostic tests on the right-rear wheel was commanded. The test results indicated a fully functioning right-rear wheel free of obstruction. As part of the diagnostics, a short (1.5 meter) forward drive of the rover was commanded. The rover moved forward about 2 millimeters (0.08 inch). The plan ahead is to continue with extrication. Another 5-meter (16 feet) two-step drive is planned for the Thanksgiving holiday weekend. As of Sol 2095 (Nov. 24, 2009), the rover solar array energy production was 325 watt-hours, with an atmospheric opacity (τ) of 0.590 and a dust factor of 0.575. Total odometry is 7,730.00 meters (4.80 miles).

Flash Memory in Use Again -- sols 2077-2083, Nov. 5-11, 2009

Spirit is preparing to attempt extrication from her embedded location at "Troy" on the west side of "Home Plate."

The project was successful in reformatting Spirit's on-board flash memory file system on Sol 2083 (Nov. 11, 2009). The rover is now again using the non-volatile flash file system for telemetry storage.

On Sol 2078 (Nov. 6, 2009), Spirit straightened her wheels in preparation for the first straight-ahead extrication drive, currently planned for Sol 2088 (Nov. 17, 2009). Spirit also collected another microscopic imager (MI) mosaic of the rover underbelly on Sol 2081 (Nov. 9, 2009).

As of Sol 2082 (Nov. 10, 2009), Spirit's solar-array energy production was 368 watt-hours, with an atmospheric opacity (τ) of 0.569 and a dust factor of 0.5995. Total odometry remains at 7,729.97 meters (4.80 miles).

Dealing with Flash Access -- sols 2070-2076, Oct. 29-Nov. 4, 2009

Spirit is still suffering from the inability to access the on-board, non-volatile (flash) memory file system. However, the operations team has developed a strategy to allow science activities to continue.

To ensure that science data collected by Spirit is returned to Earth, the team has been keeping Spirit awake each sol from the morning communication session through the data relay via the Odyssey orbiter. (Data stored in volatile, random-access memory is not retained when the rover powers down for energy-conserving sleep.)

The engineering team has determined that reformatting the file system portion of flash memory will restore the use of the flash memory for data storage. The Flash file system has been formatted once before on Spirit on Sol 32. This was part of the recovery from the anomaly experienced on Sol 18. The project intends to re-format the Flash file system shortly.

As of Sol 2076 (Nov. 4, 2009), Spirit's solar-array energy production is 359 watt-hours, with an atmospheric opacity (τ) of 0.599 and a dust factor of 0.633. Total odometry remains at 7,729.97 meters (4.80 miles).

Amnesia-like Symptoms Return -- sols 2063-2069, Oct. 22-28, 2009

Spirit has experienced another complication. On Sol 2065 (Oct. 24, 2009), Spirit experienced a reset event and a problem with mounting its non-volatile flash memory. The rover resumed activities without using its flash memory, instead using its volatile random-access memory (RAM) to store telemetry. When the rover goes to sleep, telemetry stored only in RAM is lost. The project has instructed the rover to stay awake until its afternoon relay pass with Mars Odyssey to return the day's data before napping.

The project is planning to reformat the rover's flash memory file system to restore it to normal operation. Spirit is otherwise in good health.

As of Sol 2069 (Oct. 28, 2009), Spirit's solar-array energy production was 411 watt-hours. On Sol 2064 (Oct. 23, 2009), atmospheric opacity (τ) was 0.599. Total odometry remains at 7,729.97 meters (4.80 miles).

Antenna Back to Normal Use -- sols 2056-2062, Oct. 15-21, 2009

Spirit has recovered from X-band fault and is using her steerable high-gain antenna (HGA) normally.

The clearing of the X-band fault was to occur on Sol 2056 (Oct. 15, 2009), but a Deep Space Network (DSN) station outage at the last minute prevented the commands from reaching the rover.

On Sol 2058 (Oct. 17, 2009), the commands were successfully sent to the rover that cleared the X-band and HGA errors and resumed normal HGA X-band operation. Spirit went on to conduct several days of Moessbauer (MB) spectrometer integration on the surface target "Thoosa" and to search for dust devils with the navigation camera (Navcam).

On Sol 2059 (Oct. 18, 2009), more panoramic camera (Pancam) images of "Scamander Plains" were collected along with miniature thermal emission spectrometer (Mini-TES) observations of the target "Pioneer." Early in the morning of Sol 2061 (Oct. 20, 2009), the rover woke up to characterize the Tstat box. On that sol, Spirit also collected another 11-frame microscopic imager (MI) mosaic of the underbelly of the rover and set up for more MB integration on Thoosa.

As of Sol 2062 (Oct. 21, 2009), Spirit's solar-array energy production is 410 watt-hours, with an atmospheric opacity (τ) of 0.570 and a dust factor of 0.594. Total odometry remains at 7,729.97 meters (4.80 miles).

In X-Band Fault Mode -- sols 2050-2055, Oct. 9-14, 2009

Spirit is still in X-band fault mode due to a high-gain antenna (HGA) dynamic brake anomaly that first occurred back on Sol 2027 (Sept. 15, 2009) and has re-occurred most recently on Sol 2052 (Oct. 11, 2009). With the HGA fault, all X-band uplinks use the low-gain antenna (LGA) and uplink bandwidth is limited.

Spirit was to be back under normal HGA operation on Sol 2054 (Oct. 13, 2009). However, a Deep Space Network (DSN) station outage at the last minute, with no alternative station available, prevented the HGA-recovery uplink from getting to Spirit. Spirit will be under runout sols, and the next planned uplink will be on Sol 2057 (Oct. 16, 2009). So the Sol 2057 plan is to clear the X-band and HGA faults and change the communication behavior manager (CBM) back to X-band nominal. The HGA dynamic brake status has been masked already in flight software.

Spirit is otherwise in good health (power positive, thermally stable and communicative over LGA and UHF) conducting limited remote sensing science in the runout sols. The Mössbauer (MB) spectrometer is positioned on a surface target and will resume an extended integration on Sol 2057 (Oct. 16, 2009).

As of Sol 2054 (Oct. 13, 2009), Spirit's solar array energy production was 427 watt-hours with an atmospheric opacity (τ) of 0.605. The dust factor is 0.6075, meaning that about 61 percent of the sunlight hitting the solar array is penetrating through the dust on the array.

Total odometry as of Sol 2055 (Oct. 14, 2009): 7,729.97 meters (4.80 miles).

Busy with Antenna Brake Testing and Underbelly Imaging -- sols 2042-2049, Sept. 30-Oct. 8, 2009

Spirit is still currently in X-band fault mode due to a high-gain antenna (HGA) dynamic brake anomaly that first occurred on Sol 2027 and recurred again on Sol 2037. With this HGA fault, all X-band uplinks use the low-gain antenna (LGA), and uplink bandwidth is very limited. Forward-link commanding through Mars Odyssey is being used for all large commanding sequences like data management bundles and science sequencing. On Sol 2044, Spirit completed another Microscopic Imager (MI) mosaic of the underneath of Spirit for extraction analysis, along with another test of the HGA dynamic brake. Results of that brake test were largely nominal. The current plan is to bring Spirit out of the X-band fault mode on Sol 2050 and perform a long-duration HGA motion test before resuming normal HGA operation. Spirit's systems are otherwise in good health. As of Sol 2049, the rover solar array energy production was 423 watt-hours with an atmospheric opacity (τ) of 0.657 and a dust factor of 0.603.

Total odometry as of Sol 2049: 7,729.93 meters

Intermittent Problem with Antenna Brake -- sols 2035-2041, Sept. 23-29, 2009

Spirit had a reoccurrence of the dynamic brake fault with the high-gain antenna (HGA) on Sol 2037 (Sept. 25, 2009) during the attempt to restore normal usage of the HGA. The dynamic brake problem is more frequently intermittent, requiring an alternate approach to resolving the problem. Until the HGA can be restored, the low-gain antenna (LGA) and forward-link commanding through the Mars Odyssey relay will be used.

The low bandwidth over the LGA and the latency with forward-link commanding limits the pace of recovery. The project is implementing a more exhaustive set of diagnostics on the HGA dynamic brake. Those diagnostics should illuminate the nature of the dynamic brake problem and guide the recovery strategy. Despite the HGA problem, Spirit will collect an extended panorama of her underbelly using the microscopic imager (MI) on the end of the robotic arm (IDA) and then place the Moessbauer (MB) spectrometer on a surface target for a long integration. Spirit is otherwise in good health.

As of Sol 2041 (Sept. 29, 2009), Spirit's solar-array energy production is 437 watt-hours. Atmospheric opacity (τ) is 0.727. The dust factor is 0.614, meaning that about 61.4 percent of the sunlight hitting the solar array is penetrating through the dust on the array. Total odometry remains at 7,729.93 meters (4.80 miles).

Progress on Antenna Actuator -- sols 2029-2034, Sept. 17-22, 2009

Spirit is recovering from the high-gain antenna (HGA) anomaly that occurred on Sol 2027 (Sept. 15, 2009). The HGA problem is suspected to be an apparent intermittent behavior in the dynamic brake relay for the HGA actuators, a problem that has been seen and mitigated before in other rover actuators. Diagnostics were run on the HGA and each actuator moved freely in both directions without problems with the dynamic brake behaving normally.

The challenge for the rover team has been trying to uplink HGA recovery sequences over the low-gain antenna (LGA). Data rates over the LGA are so low that there is often insufficient time in the uplink window to get up all the necessary commands. Because of that, the project is using forward link UHF relay commanding through Mars Odyssey. The forward link has the additional complication that there is additional latency in getting the commands to the rover, so the pace of recovery is impacted. Return to normal HGA usage for Spirit is anticipated by next week. Spirit is otherwise in good health.

As of Sol 2033 (Sept. 21, 2009), Spirit's solar-array energy production was 418 watt-hours with an atmospheric opacity (τ) of 0.972 and a dust factor of 0.626. Total odometry remains at 7,729.93 meters (4.80 miles).

Diagnostics on Antenna Actuator -- sols 2022-2028, Sept. 10-16, 2009

Spirit is continuing science investigations with remote-sensing and robotic-arm instruments while positioned at her embedded location on the west side of Home Plate.

Spirit began the week with the alpha particle X-ray spectrometer (APXS) examining dust on the capture magnet located up on the rover deck. On Sol 2024 (Sept. 12, 2009), the robotic arm (instrument deployment device, or IDA) collected another microscopic imager (MI) mosaic of the rover underbelly, then took a stack of MI images of the surface target "Penina4" followed by the APXS placement on the same target. On the next sol the Moessbauer (MB) spectrometer was placed on Penina4.

On Sol 2027 (Sept. 15, 2009), a high-gain antenna (HGA) fault occurred. Telemetry indicates anomalous behavior with the dynamic brake on the HGA actuators. Diagnostics are underway and a likely workaround is in development. Spirit is otherwise in good health.

As of Sol 2028 (Sept. 16, 2009), Spirit's solar-array energy production is 403 watt-hours with an atmospheric opacity (τ) of 1.21 and a dust factor of 0.631. Total odometry remains at 7,729.93 meters (4.80 miles).

Examining Target 'Olive Leaf' -- sols 2015-2021, Sept. 3-9, 2009

Spirit is continuing remote sensing and in situ science while positioned at her embedded location on the west side of Home Plate.

On Sol 2015 (Sept. 3, 2009), a Moessbauer (MB) integration was completed on target "Olive Leaf." On the next sol, a rock abrasion tool (RAT) calibration and a RAT diagnostics were performed, then the APXS was placed on Olive Leaf for an overnight integration. On the sol after that, the robotic arm (instrument deployment device, or IDD) positioned the microscopic imager (MI) to take an image of the capture magnet on the rover deck. Then the alpha particle X-ray spectrometer (APXS) was placed on that magnet for a multi-sol integration.

The panoramic camera (Pancam) was busy taking 13-filter images of "Scamander Plains" and documentary images of the rover deck.

Ground testing continued at JPL with tests using the Mars-weight surface system testbed (SSTB Lite) rover with its center-of-gravity over a rock.

As of Sol 2021 (Sept. 3, 2009), Spirit's solar-array energy production is 418 watt-hours, with an increased atmospheric opacity (τ) of 1.65 and a dust factor of 0.669. Rover power plans have been conservative because of the elevated atmospheric opacity. Total odometry remains at 7,729.93 meters (4.80 miles).

Sky Clearer at 'Troy,' Smoky at JPL -- sols 2009-2014, Aug. 27 to Sept. 2, 2009

Spirit is positioned at her embedded location, called "Troy," on the west side of Home Plate. The regional dust storm that had dusted up the skies over Gusev has abated and the skies are clearing. Atmospheric opacity (τ) has decreased and rover solar-array performance has improved.

The week's activities for both rovers have been impacted by problems with other spacecraft that resulted in lost Deep Space Network (DSN) coverage for the rovers. Because there was no DSN uplink available for Spirit on Sol 2009 (Aug. 27, 2009), the rover executed an onboard run-out sequence. Later in the week, planning for Spirit was impacted again when wildfires near the Jet Propulsion Laboratory (JPL) forced closure of the laboratory for air-quality reasons on Aug. 31, 2009. So Spirit executed another run-out sol on Sol 2013 (Sept. 1, 2009).

On Sol 2014 (Sept. 2, 2009), Spirit resumed normal (master sequence) operation and continued with a Moessbauer (MB) integration on the target "Ulysses Spear." Before the wildfires, ground testing was completed with the two different weight engineering test rovers in two different soil stimulants at JPL. A Mars Program-level review was held on Sept. 2, 2009, of the Spirit recovery effort.

As of Sol 2014 (Sept. 2, 2009), Spirit's solar-array energy production has increased to 564 watt-hours. By Sol 2013 (Sept. 1, 2009), the atmospheric opacity (τ) had improved to 0.890 (Sol 2013) and the dust factor had recovered to 0.720, meaning that about 72 percent of the sunlight hitting the solar array was penetrating through the dust on the array. Spirit's total odometry remains at 7,729.93 meters (4.80 miles).

Regional Dust Storm -- sols 2002-2008, Aug. 20-26, 2009

Spirit continues to profile the geology at her embedded location, called "Troy," on the west side of Home Plate. However, the rover is currently affected by a large regional dust storm.

Although orbital observations indicate the storm is abating, the skies over Gusev crater are expected to remaining dusty for several sols. As a result, the rover team has been conservative with Spirit's planning, keeping energy consumption low and maintaining high states of charge in the batteries until the skies clear.

Spirit began the week continuing a long Moessbauer (MB) integration of the surface target "Polyphemus Eye." On Sol 2006 (Aug. 24, 2009), Spirit initiated a set of penetrometer experiments to directly measure physical properties of the embedding soil. The rock abrasion tool (RAT) was pressed into the soil at three different pre-load levels of force. The resulting indentation (soil penetration) after each pre-load was then documented with a set of images. Also on the same sol an atmospheric argon measurement was collected with the alpha particle X-ray spectrometer (APXS), and the MB was placed for another multi-sol integration.

On Earth, testing is being done with two different-weight rovers, the full-weight surface system testbed (SSTB) rover and the near Mars-weight SSTB Lite rover, in two different soil simulants. Testing with both rovers will help determine the effects of different gravity on Earth-based test results, all in preparation for the first extraction moves on Mars.

Atmospheric conditions have deteriorated owing to the large regional dust storm. As of Sol 2007 (Aug. 25, 2009), Spirit's solar-array energy production was precipitously down to 322 watt-hours, with a large increase in the atmospheric opacity (τ) to 2.61. The dust factor declined to 0.658, meaning that about 65.8 percent of the sunlight hitting the solar array penetrates through the dust on the array. Spirit's total odometry remains at 7,729.93 meters (4.80 miles).

More than 2,000 sols -- sols 1995-2001, Aug. 13-19, 2009

Spirit has passed 2,000 sols on the surface of Mars, yet another milestone. Starting its third sol millennia, Spirit continues to profile the geology at the location where the rover is embedded, a site called "Troy" on the west side of "Home Plate."

On Sol 1995 (Aug. 13, 2009), Spirit continued the campaign of grinding deeper into surface targets, then collecting in situ (contact)

measurements at each grind depth. The rock abrasion tool (RAT) executed a grind on the target "Polyphemus_Eye_2." Then the panoramic camera (Pancam) and the microscopic imager (MI) took images of where the grind had been performed, and the robotic arm placed the alpha particle X-ray spectrometer (APXS) on the freshly-ground target. On the next sol, the rover changed tools to the Moessbauer (MB) spectrometer and placed it on the target for an overnight integration. The rover continued on the next sol with an MI mosaic of a different target, "Olive_Leaf," followed by an APXS placement on that target. On the following sol, the MB was placed on target Polyphemus for a multi-sol integration.

On Earth, the surface system testbed (SSTB) rover extraction testing continues in preparation for the first extraction moves on Mars.

Atmospheric conditions over Spirit have deteriorated owing to a regional dust storm. As of Sol 2001 (Aug. 19, 2009), the rover solar-array energy production was down to 744 watt-hours with atmospheric opacity (τ) increasing to 0.718 and the dust factor remaining around 0.8315. Spirit's total odometry remained at 7,729.93 meters (4.80 miles).

Deeper Look into Soil Targets -- sols 1989-1994, Aug. 7-12, 2009

Spirit continues to profile the geology at the rover's embedded location, called "Troy," on the west side of the low plateau called Home Plate.

On Sol 1990 (Aug. 8, 2009), Spirit continued the campaign of grinding deeper into surface targets, then collecting contact measurements at each grind depth. The rock abrasion tool (RAT) performed a grind on the target Cyclops_Eye_6, followed by imaging of the resulting surface by the panoramic camera (Pancam) and the microscopic imager (MI). The MI also took a new look at the underbelly of the rover to further assess possible obstruction by a rock underneath.

Before an attempt to have the robotic arm (instrument deployment device, or IDD) place the Moessbauer (MB) spectrometer on the surface, a command sequence fault occurred with the arm. This fault was explained as a benign error that occurs from time to time due to very small positioning errors in the IDD. With this error investigated, understood and cleared, the IDD went on to have the RAT perform a grind scan on Sol 1993 (Aug. 11, 2009) in preparation for another profile grind.

On Earth, the surface system testbed (SSTB) rover extraction testing continues in preparation for Spirit's first extraction moves on Mars.

As of Sol 1994 (Aug. 12, 2009), Spirit's solar-array energy production is 895 watt-hours with atmospheric opacity (τ) of 0.352 and a dust factor of 0.844 on the solar array. Total odometry remains at 7,729.93 meters (4.80 miles).

Illumination Experiment and Other Studies -- sols 1981-1988, July 30 - Aug. 6, 2009

Spirit's examination of the soil around the rover using tools on the robotic arm (instrument deployment device, or IDD) continued this week with Moessbauer (MB) spectrometer on target "Cyclops Eye" and microscopic imaging of target "Penina." On Sol 1986 (Aug. 4, 2009), the rock abrasion tool (RAT) was prepared for grinding into the target Cyclops Eye on a later sol.

With the surplus of power, Spirit continues to perform science observations at a variety of times. This includes an illumination experiment, which consists of a set of navigation camera observations acquired at different times of day to help examine texture in the terrain. The resulting information could aid future driving.

On Earth, the surface system testbed (SSTB) rover extraction testing continues with end-to-end testing in differentiated soil in preparation to the first extraction moves on Mars.

As of Sol 1988 (Aug. 6, 2009), Spirit's solar array energy production is 907 watt-hours with atmospheric opacity (τ) of 0.330 and dust factor of 0.821 on the solar array. Total odometry remains at 7,729.93 meters (4.80 miles).

Robotic Arm Diagnostics -- Sols 1975-1980, July 24-29, 2009

Spirit is continuing its ambitious remote sensing and in-situ (contact) science campaign using all her payload elements while embedded at the location called Troy on the west side of Home Plate.

During in situ (contact) work with the robotic arm on Sol 1975 (July 24, 2009), the Instrument Deployment Device (IDD) Joint 2 (shoulder elevation) stalled. The stall occurred between two Microscopic Imager (MI) mosaics. A series of diagnostics were sequenced on Sol 1979 (July 28, 2009).

The diagnostics included an elbow and turret motion (Joints 3, 4 and 5) to reduce torque on Joint 2, a rotor resistance test of the Joint 2 motor, and then a series of small Joint 2 diagnostic motions, a MI mosaic and a placement of the alpha particle X-ray spectrometer (APXS) on a surface target. The IDD Joint 2 motor resistances are normal and the IDD Joint 2 moved successfully to all commanded diagnostic motions. All MI images were taken and the APXS is positioned on the surface target. There are no mobility/IDD errors or preclusions. The IDD Joint 2 appears to be okay.

On Earth, the surface system testbed (SSTB) rover extraction testing continues with end-to-end testing in differentiated soil in

preparation for the first extraction moves on Mars.

As of Sol 1980 (July 29, 2009), the rover solar array energy production was 914 watt-hours, with atmospheric opacity (τ) of 0.380 and a dust factor of 0.831.

Total odometry as of Sol 1980 (July 29, 2009): 7,729.93 meters (4.80 miles)

Poking 'Cyclops Eye' -- sols 1968-1974, July 16-23, 2009

Spirit, positioned on the west side of Home Plate, continues to be engaged in ambitious remote sensing and in-situ (contact) science using all her payload elements. The embedding of the rover back on Sol 1899 (May 6, 2009) has exposed a subsurface emplacement of likely remobilized minerals with a strong water association.

On Sol 1968 (July 16, 2009), the microscopic imager (MI) collected images for a mosaic of the surface target "Olive." Then, the Moessbauer (MB) spectrometer was placed on target "Cyclops_Eye_4" for a multi-sol integration over the weekend. On Sol 1972 (July 20, 2009), the rock abrasion tool (RAT) performed a seek-scan procedure in preparation for a RAT grind of a surface target. On the next sol, the RAT ground the target "Cyclops_Eye_5" and then the APXS was placed for an integration.

The rover's panoramic camera (Pancam) and miniature thermal emission spectrometer (Mini-TES) continue to collect observations of selected remote targets, including detailed images of the vertical section of the west side of Home Plate.

The surface system testbed (SSTB) rover continues to be used in extraction testing in a simulated-Mars sandbox at JPL. Testing in undifferentiated soil is complete. The test sandbox will be reconfigured to allow testing in differentiated soil. Differentiated soil is what is seen by the rover on Mars.

As of Sol 1974 (July 23, 2009), Spirit's solar array energy production is 935 watt-hours with atmospheric opacity (τ) of 0.376. On Sol 1973 (July 22, 2009), the dust factor was 0.819, indicating that 84.4 percent of sunlight hitting the array was penetrating the layer of dust on it. Total odometry remains at 7,729.93 meters (4.80 miles).

More Soil Studies and Extraction Tests -- sols 1961-1967, July 9-15, 2009

Spirit, positioned on the west side of Home Plate, has been continuing her ambitious science campaign of remote sensing and in-situ (contact) science using all her payload elements.

On Sol 1963 (July 11, 2009), the robotic arm (instrument deployment device, or IDD) retracted the rock abrasion tool (RAT) from the surface where it had been positioned by an earlier placement. The rover then performed a RAT calibration, collected a stack of images from the microscopic imager (MI), and replaced the RAT on the target to do a seek-scan procedure for locating the surface.

On Sol 1965 (July 13, 2009), a RAT brushing was performed on the target. At the completion of the RAT brushing, the IDD was swung out of the way. On the next sol, an MI mosaic was collected of the brushed target and the alpha particle X-ray spectrometer (APXS) was placed for an overnight integration. On Sol 1967 (July 15, 2009), the IDD positioned the instruments over another target and collected an MI mosaic before placing the APXS.

The rover is continuing nighttime activities to increase the depth of discharge in the batteries for battery health and maintenance.

The surface system testbed (SSTB) rover extraction testing in a simulated-Mars sandbox at JPL continues. Several extraction tests have been performed with more to be conducted in coming days.

As of Sol 1967 (July 9, 2009), Spirit's solar array energy production is 944 watt-hours. Atmospheric opacity (τ) is 0.398. The dust factor on the solar array is 0.844, indicating that 84.4 percent of sunlight hitting the array penetrates the much-reduced layer of dust on it. Total odometry remains at 7,729.93 meters (4.80 miles).

Active Days and Nights -- sols 1953-1960, July 1-8, 2009

Spirit remains positioned just west of Home Plate, in the location called "Troy," where the rover has been continuing an ambitious science campaign.

The campaign includes extensive observations with the panoramic camera (Pancam) and miniature thermal emission spectrometer (Mini-TES) plus contact science using all the tools on the robotic arm (instrument deployment device, or IDD). On Sol 1954 (July 2, 2009), the rock abrasion tool (RAT) repeated a seek-scan procedure on a surface soil target in preparation for brushing that target, but the seek-scan was unable to make sufficient contact with the target for brushing.

With abundant daily energy after repeated array-cleaning events, the rover is conducting nighttime activities to increase the depth of discharge in the batteries for battery health and maintenance.

Activities continue on Earth for extraction testing of the surface system testbed (SSTB) rover in a simulated Mars environment. On July 6, 2009, testing began with the SSTB on the series of proposed extraction maneuvers in the new test fixture ("dust bin") at JPL.

As of Sol 1960 (July 8, 2009), Spirit's solar array energy production is 938 watt-hours. Atmospheric opacity (τ) is 0.349. The dust factor on the solar array is 0.82, indicating that 82 percent of sunlight hitting the array penetrates the much-reduced layer of dust on it. Total odometry remains at 7,729.93 meters (4.80 miles).

Soil Investigation Continues -- sols 1948-1952, June 26-30, 2009

Spirit remains positioned on the west side of Home Plate. The rover has been continuing an ambitious science campaign of extensive observations with the panoramic camera (Pancam) and miniature thermal emission spectrometer (Mini-TES) plus contact science using all the tools on the robotic arm (instrument deployment device, or IDD).

On Sol 1948 (June 26, 2009), the IDD placed the Moessbauer (MB) spectrometer on the target called "Cyclops_Eye_3" for a multi-sol integration. On Sol 1952 (June 30, 2009), the rock abrasion tool (RAT) was calibrated. Then, a RAT grind-scan was performed on a surface target in preparation for brushing that target.

With abundant daily energy, the rover continues to conduct nighttime activities to increase the depth of discharge in the batteries for battery health and maintenance.

Activities continue on the ground for extraction testing of the surface system testbed (SSTB) rover in a simulated Mars environment. Several tons of soil simulant were mixed and prepared in the new test fixture (sandbox) at JPL. On June 30, 2009, the SSTB was driven into this new test sandbox in preparation for the extraction tests.

As of Sol 1951 (June 29, 2009), Spirit's solar array energy production is at 927 watt-hours, with atmospheric opacity (τ) of 0.356 and dust factor of 0.798. Total odometry remains at 7,729.93 meters (4.80 miles).

Studying Troy -- Sols 1941 to 1947, June 18-24, 2009

Spirit is continuing her ambitious remote sensing and in-situ (contact) science observations at the location called "Troy" on the west side of Home Plate.

Using the rover robotic arm (instrument deployment device, IDD), the rover has been exploring a set of surface targets that hold clues to the past geologic history at this location.

On Sol 1941 (June 18, 2009), a Microscopic Imager (MI) stack of images was collected on target Penina3, then the Alpha Particle X-ray Spectrometer (APXS) was placed for an overnight integration. On the next sol, the Moessbauer Spectrometer (MB) was placed on a different target for a multi-sol integration. The next few sols included some late-day activities where the rover imaged the Earth and Venus in the night sky.

On Sols 1945 and 1946 (June 22 and 23, 2009), Spirit investigated another set of surface targets, again with MI stacks and APXS overnight integrations. On Sol 1946 (June 23, 2009), another solar array dust cleaning event occurred, increasing the available energy each sol even more.

At JPL, a special test form has been installed for ground testing with the surface system testbed (SSTB) rover to guide the eventual extraction activities on Mars for Spirit. The materials for the soil simulant to be used in the test form have been delivered and are in the process of being formulated and mixed. As of Sol 1947 (June 24, 2009), solar array energy production increased to 945 watt-hours with atmospheric opacity (τ) of 0.480 and an improved dust factor of 0.834. Total odometry remains at 7,729.93 meters (4.80 miles).

Soil Investigation -- sols 1934-1940, June 11-18, 2009

Spirit remains stationary on the west side of Home Plate in the location called "Troy". The rover continues to be busy with an ambitious observation campaign employing both remote sensing and in-situ (contact) science with the robotic arm (instrument deployment device, IDD).

The soil disturbed by the rover's embedding has been the subject of extensive science investigation. Five out of the past seven sols have involved using the instruments on the end of the robotic arm to collect images and composition spectra of five distinct targets. Images from the panoramic camera (Pancam) and spectra from the miniature thermal emission spectrometer (Mini-TES) have also been collected. Extensive nighttime observations have been planned to make use of the abundant energy the rover has right now.

At JPL, preparations are continuing for ground testing with the surface system testbed (SSTB) rover. A special test form has been constructed to hold the new soil simulant that will recreate Spirit's martian terrain. The new simulant has been validated with single-wheel "shoebox" testing by the SSTB rover. Large quantities of simulant ingredients have been ordered and are expected within days.

As of Sol 1939 (June 17, 2009), Spirit's solar array energy production is at 853 watt-hours, with atmospheric opacity (τ) of 0.486 and a dust factor of 0.760. Total odometry remains at 7,729.93 meters (4.80 miles).

Observation Campaign at 'Troy' -- sols 1927-1933, June 4-10, 2009

Spirit remains stationary on the west side of Home Plate. Work continues on developing the ground testing to assist the rover in extracting itself from the embedding in this location, called "Troy".

The rover has been busy with an ambitious observation campaign employing both remote sensing and in-situ (contact) science with the robotic arm (instrument deployment device, IDD). The soil, disturbed by the rover embedding, reveals unconsolidated, light-toned material. Analysis indicates this material consists of differing amounts of ferric sulfate, calcium sulfate, silica and other constituents.

On Sol 1927 (June 4, 2009), the IDD used the microscopic imager (MI) to collect a stack of stereo images, then placed the alpha particle X-ray spectrometer (APXS) for an overnight integration. On the next sol, the APXS was moved to a different surface target for a second integration. On Sol 1929 (June 6, 2009), another set of MI images was collected and the Moessbauer (MB) spectrometer was placed for a multi-sol integration.

On Sol 1933 (June 10, 2009), a full-rotation test was performed on the left-middle wheel to explore a stall event from Sol 1899 (May 6, 2009). The test successfully rotated the wheel one full rotation backwards and more than one full rotation forward past the point of the original stall. The wheel moved freely with no re-occurrence of a stall.

Preparation for ground testing of embedding extraction techniques continues. A soil simulant has been established by way of a series of "shoebox" (single wheel) tests of candidate materials with the surface system testbed (SSTB) rover in the sandbox at JPL. A test form to contain rover-scale quantities of soil simulant is under construction.

Underbelly Photography -- sols 1920-1926, May 28 to April 30 to June 3, 2009

Although Spirit has yet to begin to extricate herself from the loose, soft terrain on the west side of Home Plate, the rover has been active using her instruments to assess her embedded state.

This week the robotic arm (Instrument Deployment Device, IDD) with the Microscopic Imager (MI) were used to take a mosaic of images of the rover's underbelly. The MI, a short focus camera, was never designed to take these types of long-focus images. This technique was first tested by Opportunity and the test demonstrated that although the images will not be sharply focused, sufficient detail can be seen.

Spirit's first MI mosaic of the underbelly was collected on Sol 1922 (May 30, 2009). The IDD then positioned the MI to collect a stack of images of a science soil target and placed the Moessbauer (MB) spectrometer on the science target for a multi-sol integration. Spirit collected a second underbelly image mosaic on Sol 1925 (June 2, 2009). This time the IDD extended further under the rover to capture more detail. The IDD then collected another MI stack of images of a science target followed by the placement of the Alpha-Particle X-ray Spectrometer (APXS) on the same target. Frames of a 360-degree color panorama, called the Calypso panorama, were collected. Targeted observations were made with the miniature thermal emission spectrometer.

The project was successful in restoring files to a computer server so that the surface system testbed (SSTB) rover at JPL could be operated. Soil simulant tests with the SSTB were performed on "Bag House" dust simulant. Unfortunately, the test results show that the Bag House dust is not suitable as a simulant for Spirit's situation. A new simulant is being formulated and will be tested shortly.

As of Sol 1926, solar array energy production was generous at 884 watt-hours with atmospheric opacity (τ) of 0.458 and a dust factor of 0.772. Spirit's total odometry remains at 7,729.93 meters (4.80 miles).

Recovery Efforts Continue -- sols 1913-1919, May 21-27, 2009

Spirit remains stationary, pending development of a recovery strategy to free her from the loose, soft terrain on the west side of Home Plate.

The rover continues to conduct extensive remote sensing observations of its local terrain. A 360-degree color panorama, called the Calypso panorama, is being collected, and includes the rover's deck. Additional mini-thermal emission spectrometer (TES) observations have been sequenced. Thanks to the extra energy made possible by recent solar array dust cleaning events, Spirit has been collecting measurements of atmospheric argon almost every day using its alpha-particle X-ray spectrometer (APXS).

The project continues to investigate the left middle wheel stall that occurred back on Sol 1899 (May 6, 2009). A small (4-degree) backward wheel motion test was sequenced on Sol 1913 (May 21, 2009). The wheel and motor performed satisfactorily. A second, larger test (16 degrees) was performed on Sol 1916 (May 24, 2009), and again, the wheel performed satisfactorily, showing no signs of a jam in the backward direction.

Pending the recertification of the robotic arm (the instrument deployment device, or IDD), a microscopic imager (MI) mosaic of Spirit's underbelly is planned for this coming weekend to assess the rover's embedded condition.

On the ground, testing with the surface system testbed (SSTB) rover at JPL is held up due to a computer server disk crash. That server

is being restored from a huge backup tape, which is taking considerable time. In parallel, the SSTB-Lite rover (an alternate, lower-fidelity testbed rover) is being set up to conduct early tests of candidate soil simulants.

Spirit is very active, with abundant energy. Once again, Spirit has received a beneficial solar array dust cleaning. Dust factor (a measure of array cleanliness) improved about 10 percent on Sol 1918 (May 26, 2009). As of Sol 1919 (May 27, 2009), solar array energy production was 843 watt-hours, enough to run a 100-watt bulb for more than eight hours, with atmospheric opacity (τ) around 0.606. The dust factor increased to 0.774, meaning that about 77.4 percent of the sunlight hitting the solar array penetrates through the dust on the array.

Spirit's total odometry as of Sol 1919 (May 27, 2009) is 7,729.93 meters (4.8 miles).

Spirit Works on Exit Strategy -- Sols 1907 to 1912, May 15-20, 2009

Rover team members continue their recovery strategy to extricate Spirit from the loose, soft terrain on the west side of "Home Plate." The rover continues to conduct extensive remote sensing observations of the local terrain.

With the extra energy Spirit has gained from recent solar array dust cleaning events, morning UHF relay passes have been added. A low-voltage continuity test of the motor on the left middle wheel was performed on Sol 1908 (May 16, 2009). The results showed normal resistance for a healthy motor. Even though very small voltages were used in that test, a tiny amount of motion (less than a degree) was observed. This is not unexpected, as the motion was opposite of the apparent jam from Sol 1899 (May 6, 2009) and is likely due to the unwinding (relaxation) of the strain in the 1500:1 gearbox. The small motion means it is now less likely there is a jam in the gearbox. A small 4-degree backward wheel motion test is planned for Sol 1913 (May 21, 2009) to investigate the wheel further.

On the ground, work continues on the preparation of the sandbox at JPL to recreate the terrain and conditions of the rover on Mars. A "shoebox" test of a soil simulant, called Bag House dust (a ground basaltic cinder), will be performed under one wheel of the surface system testbed (SSTB) rover to see if the simulant exhibits the characteristics of the soil on Mars. However, testing with the SSTB rover at JPL is held up due to a computer server disk crash. That server loss is being remedied, but will take some time.

As of Sol 1912 (May 20, 2009), solar-array energy production was 716 watt-hours, with atmospheric opacity (τ) around 0.628 and the dust factor improved to 0.680. Spirit has been responsive and communicative, with no reoccurrence of the anomalies from 30 sols ago.

As of Sol 1912 (May 20, 2009), Spirit's total odometry remains 7,729.93 meters (4.8 miles).

Embedded and Cleaner -- sols 1900-1906, May 7-14, 2009

Spirit is embedded in loose, soft terrain on the west side of Home Plate. There is a real risk the rover may be high-centered (underside touching) on a small mound of rocks right under the belly of the rover. Additionally, a left wheel motor stall occurred during the last rover motion on Sol 1899 (May 6, 2009). No motion has been commanded since.

The project is engaged in a recovery activity. This involves extensive remote sensing observations by the rover of the local soil characteristics, and ground testing using the surface system testbed rover in the sandbox at JPL.

There has been no recurrence of the anomalous behavior that happened between Sol 1872 (April 9, 2009) and Sol 1881 (April 18, 2009). There is still no explanation for the previous anomalies, and the investigation is continuing.

The week provided more good news about solar array energy. Spirit experienced yet another substantial solar array dust cleaning event. On Sol 1900 (May 7, 2009), energy production improved by about 30 percent. With the significant improvement in energy, the rover can now support morning UHF relay passes, which will help with the backlog of collected data onboard. The Mars Odyssey project has made special efforts to support this additional relay.

As of Sol 1905 (May 13, 2009), solar array energy production is estimated around 652 watt-hours, with atmospheric opacity (τ) at 0.774. The dust factor has improved substantially to 0.678, meaning that 67.8 percent of sunlight hitting the solar array penetrates the layer of dust on the array. As of Sol 1906 (May 14, 2009), Spirit's total odometry remains 7,729.93 meters (4.80 miles).

Another Power Boost, But Difficult Driving -- sols 1893-1899, April 30 to May 6, 2009

Spirit has now completed 19 sols of operation without any recurrence of the anomalous behavior that happened between Sol 1872 (April 9, 2009) and Sol 1881 (April 18, 2009). In addition to changes made to the rover's wake-sleep cycle and internal data logging, a new ability to detect "amnesia" events has been implemented. There is still no explanation for the previous anomalies, and the investigation is continuing.

Spirit is currently challenged by some very difficult terrain on the west side of Home Plate. The rover encountered very loose, soft material while driving south on its current path. So Spirit is now in the process of backing out. However, with only five driving wheels, its progress has been very difficult. Only centimeters have been achieved over the last four drive sols. It is expected that extracting Spirit from this location will require many more drive sols.

The good news is that Spirit experienced another solar array dust cleaning event. On Sol 1899 (May 6, 2009), energy production improved by more than 25 percent.

As of Sol 1899 (May 6, 2009), Spirit's solar array energy production is about 500 watt-hours, equivalent to what is needed to light a 100-watt bulb for five hours. Atmospheric opacity (τ) is at 0.821. The dust factor has improved substantially to 0.515, meaning that about 51.5 percent of sunlight hitting the solar array penetrates the layer of dust on the array. Spirit has more solar array energy than Opportunity for the first time in a very long time. Spirit's total odometry is 7,729.93 meters (4.80 miles).

Well Behaved, Less Dusty, in Difficult Terrain -- sols 1886-1892, April 23-29, 2009

Spirit has completed 11 consecutive sols of operation without any faults or resets. Anomalous behavior from the period after Sol 1872 (April 9, 2009) has not recurred. There is still no explanation for those anomalies, and the investigation is continuing.

Changes were made to rover wake-sleep cycle to be more resilient against any future "amnesia" occurrences. Also, changes were made to record internal data for a longer period of time if the rover again misses any wakeups. Four drive sols were successfully executed this week. However, the terrain, once again, is very difficult, and the rover achieved very limited progress. The rover drove on sols 1886, 1889, 1891 and 1892 (April 23, 26, 28 and 29, 2009), covering a total of about 3 meters (10 feet).

Spirit experienced another small solar array dust cleaning event. On Sol 1891, energy production improved by more than 10 percent, supplementing a similar improvement the previous week.

As of Sol 1892 (April 29, 2009), Spirit's solar array energy production is about 372 watt-hours, compared with 223 watt-hours at the end of March (Sol 1864). Atmospheric opacity (τ) is around 0.855. The dust factor has improved to around 0.418, meaning that about 41.8 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover's behavior has been good and responsive, and solar energy production is well improved. Spirit's total odometry is 7,729.73 meters (4.80 miles).

Another Reset and a Cleaning Event -- sols 1879-1885, April 16-22, 2009

Spirit experienced another reset event over the weekend, but otherwise has been well-behaved.

The investigation into Spirit's recent anomalous behavior continues, but there is still no explanation. A team of experts involved in the original design and construction of the rover has been consulted. Although the anomalous behavior is frustrating, the rover continues to be healthy in terms of power, temperature and communication.

The plan going forward is to implement some enhanced data-collecting techniques in order to gather more information from any future anomalous events, and to resume near-normal operations. A short drive for Spirit has been sequenced on Sol 1886 (April 23, 2009).

Spirit also had a small dust cleaning event on her solar arrays on Sol 1881 (April 18, 2009). Solar array energy improved by more than 10 percent

As of Sol 1885 (April 22, 2009), Spirit's solar array energy production is 306 watt-hours, about as much as is used in lighting a 100-watt bulb for three hours. Atmospheric opacity (τ) is estimated around 0.964. The dust factor has improved to about 0.377, meaning that about 37.7 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. Spirit's total odometry remains at 7,726.78 meters (4.80 miles).

Memory Gaps and Unexplained Resets -- sols 1872-1878, April 9-15, 2009

Spirit experienced a series of anomalous events beginning on Sol 1872 (April 9, 2009).

Spirit failed to wake up for three planned events. The rover eventually woke up from an expiring alarm clock timer 27 hours later. Then, an unexpected reset of the rover occurred on Sol 1874 (April 11, 2009). A second reset occurred on Sol 1875 (April 12, 2009). It was also discovered that the rover did not record any data in flash memory on sols 1874 and 1876 (April 11 and April 13, 2009).

Sols 1877 and 1878 (April 14 and April 15, 2009) have been normal without any errors or anomalies. At this time, there is no explanation for these anomalies. The rover is power positive with the batteries fully charging each day. All temperatures are well within allowable limits. The project is systematically resetting sub-systems to bring the rover back to normal operations while continuing to investigate this anomalous behavior. Normal, but cautious, operations are expected by the middle of next week.

As of Sol 1878 (April 15, 2009), Spirit's solar array energy production is 241 watt-hours, with atmospheric opacity (τ) around 0.964. The dust factor is around 0.316, meaning that about 31.6 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. Spirit's total odometry is 7,726.78 meters (4.80 miles).

Four Drives Add to Progress -- sols 1865-1871, April 1-8, 2009

Spirit has been busy making good progress around the western edge of "Home Plate." The rover drove four out of the past seven sols, making more than 40 meters (131 feet) of total distance.

First, Spirit completed a science campaign on light-toned material unearthed the preceding week, then the rover resumed driving on Sol 1866 (April 3, 2009; no sol number for Spirit corresponded to April 2, 2009, using the criterion of the date in Los Angeles at local solar noon on Mars). The Sol 1866 drive achieved only about 3 meters (10 feet) of progress due to excessive slip. On the next drive sol, Sol 1868 (April 5, 2009), Spirit avoided the troubled terrain and completed about 17.5 meters (57 feet). A pair of drives on Sols 1870 and 1871 (April 7 and 8, 2009) added another 20 meters (66 feet) of progress.

As of Sol 1871 (April 8, 2009), Spirit's solar array energy production is 240 watt-hours, equivalent to what it takes to light a 100-watt bulb for 2.4 hours. Atmospheric opacity (τ) has improved slightly to 0.99. The dust factor is 0.304, meaning that 30.4 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover is in good health as it makes progress around Home Plate. Spirit's total odometry is 7,726.78 meters (4.80 miles).

More Bright Soil Exposed by Driving -- sols 1859-1864, March 26-31, 2009

Spirit is running under new flight software, version R9.3, and all is working well. The rover continued driving around the west of "Home Plate."

A drive on Sol 1861 (March 28, 2009) achieved almost 23 meters (75 feet) and something extra. Light-toned soil was unearthed by the right-front wheel as the rover drove along this western portion of Home Plate. The science team, suspecting that this may be more silica, developed a contact science campaign for this revealed material. On Sol 1863 (March 30, 2009), the robotic arm (IDA) was deployed and extended to the light-toned soil. A microscopic imager (MI) stack of images was collected and then the alpha particle X-ray spectrometer (APXS) was placed right on the target soil. Integration with the APXS continued through Sol 1864 (March 31, 2009). Observations of this light-toned material were also made with the miniature thermal emission spectrometer (Mini-TES).

As of Sol 1864 (March 31, 2009), Spirit's solar array energy production is 223 watt-hours. Atmospheric opacity (τ) remains elevated at 1.19. The dust factor on the solar array has worsened slightly to 0.297, meaning that 29.7 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover is in good health despite dusty skies. Spirit's total odometry is 7,686.61 meters (4.78 miles).

Distance Record for Five-Wheel Driving -- sols 1852-1858, March 19-25, 2009

Spirit is making good progress around Home Plate to the west. After getting clear of troublesome rocks, Spirit drove 13.8 meters (45.3 feet) on Sol 1854 (March 21, 2009). The next drive, on Sol 1856 (March 23, 2009), achieved a new distance record for five-wheel driving. Spirit drove 25.82 meters (84.7 feet), beating the old record by about a meter. Spirit completed another drive of 12.9 meters (42.3 feet) on Sol 1858 (March 25, 2009).

The sol ahead will see the building of the new R9.3 flight software on board the rover. The rover will boot the new software on the subsequent sol.

As of Sol 1858 (March 25, 2009), Spirit's solar array energy production is 233 watt-hours. Atmospheric opacity (τ) remains elevated at 1.15. The dust factor on the solar array, 0.309, means that 30.9 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover is in good health in spite of dusty skies. Spirit's total odometry is 7,665.02 meters (4.76 miles).

Getting Away from a Trouble Spot -- sols 1845-1851, March 12-18, 2009

Although Spirit will now attempt the western route around the low plateau "Home Plate," it must first safely move away from difficult terrain around the northeast corner of Home Plate. One tactical concern was a potato-size rock near the inside of the right rear wheel that posed a risk of getting stuck inside the wheel. Short maneuvers on Sol 1845 (March 12, 2009) and Sol 1847 (March 14, 2009) carefully moved the rover away from this hazard. On Sol 1850 (March 17, 2009), Spirit moved about 5 meters (16 feet), getting completely away from this trouble spot.

Spirit also conducted some panoramic camera (Pancam) imaging and miniature thermal emission spectrometer (Mini-TES) spectral measurements of various science targets in the vicinity and performed an atmospheric argon measurement with the alpha particle X-ray spectrometer (APXS).

Atmospheric conditions have worsened lately over the Gusev site, although no storm conditions have been reported.

As of Sol 1851 (March 18, 2009), Spirit's solar array energy production has decreased to 230 watt-hours, down 18 percent from a week earlier. Atmospheric opacity (τ) has increased sharply, to 1.19. The dust factor on the solar array is 0.313, meaning that 31.7 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover is in good health in spite of dustier skies.

As of Sol 1850 (March 17, 2009), Spirit's total odometry is 7,612.49 meters (4.73 miles).

Change to Western Route -- sols 1838-1844, March 5-11, 2009

Spirit continued to struggle in local terrain on the northeast corner of "Home Plate." Several drive attempts failed to make significant progress to the east up the modest slopes consisting of loose material.

On Sol 1839 (March 6, 2009) a wheel diagnostic test was performed to make sure a wheel stall seen on an earlier sol was not an actuator problem. The actuator is fine.

Drives on sols 1839, 1841 and 1843 (March 6, 8 and 10, 2009) all reinforced the futility of attempting further drives in this direction. Therefore, the project decided to head Spirit in the other direction, west around Home Plate. Spirit will begin to head that way in the sols ahead.

As of Sol 1844 (March 11, 2009), Spirit's solar array energy production is 281 watt-hours. Atmospheric opacity (τ) is 0.755. The dust factor on the solar array is 0.317, meaning that 31.7 percent of sunlight hitting the solar array penetrates the layer of accumulated dust on the array. The rover is in good health as it begins to head west around Home Plate.

As of Sol 1843 (March 10, 2009), Spirit's total odometry is 7,607.68 meters (4.73 miles).

Slight Progress on New Route -- sols 1831-1837, February 26 to March 4, 2009

After initially making good progress on a new route around "Home Plate" to the east, Spirit has been struggling in local terrain on the northeast corner of Home Plate. The route is difficult because the direction is up-slope with a lot of loose, fine material denying the five-driving-wheel rover good traction.

After getting about 15 meters (49 feet) away from Home Plate last week in just two drives, Spirit made only 1.4 meters of progress on Sol 1831 (Feb. 26, 2009). The next two drive sols accomplished only about 2 meters each. On Sol 1837 (March 4, 2009), Spirit had difficulty turning to face a new direction, again because of the soft terrain.

The plan is to back downslope a little, turn and attack the uphill grade a little more cross-slope.

As of Sol 1837 (March 4, 2009), Spirit's solar array energy production is 282 watt-hours, atmospheric opacity (τ) is 0.742, and the dust factor on the solar array is 0.320. The rover is in good health as it attempts to make its way around the northeast corner of Home Plate. Spirit's total odometry is 7,602.42 meters (4.72 miles).

sol 1716-1722, October 30 - November 06, 2008: *Still Trying to Drive Uphill*

Spirit has been trying to drive back up the slope toward the top of "Home Plate" to achieve a more favorable tilt of the solar panels toward the Sun as it moves higher in the sky. Spirit at first made promising progress on sols 1709 (Oct. 23, 2008) and 1713 (Oct. 27, 2008). Subsequent drives have not been as successful. Spirit began veering to the rover's right, which resulted in the right front wheel getting close to slipping off the top of Home Plate and onto the slope. The right front wheel is the one that no longer drives, so if it moves onto the slope it could be difficult to get it back on top of Home Plate.

Fortunately, rover planners have a seemingly bottomless bag of tricks and they continue to try different strategies to make progress up the slope. If necessary, they can direct the rover to drive downslope and take an alternate route back up Home Plate. They can save time if Spirit can make it up the slope from the rover's present location.

Spirit is also preparing for solar conjunction. This is a period of approximately two weeks, beginning November 29, when the Sun will be between Earth and Mars, preventing communication. Preparations include making sure that Spirit's battery is charged and that Spirit has sufficient computer memory available to store data collected during conjunction until it can be sent to Earth.

Spirit is healthy, with all subsystems performing as expected as of the latest transmission from NASA's Odyssey orbiter on sol 1722 (Nov. 6, 2008). Energy from Spirit's solar arrays has been averaging 230 watt-hours (equivalent to the amount of energy needed to light a 100-watt bulb for about 2 hours and 20 minutes).

Sol-by-sol summary

In addition to measuring dust-related changes in atmospheric clarity each day with the panoramic camera, Spirit completed the following activities:

Sol 1716 (Oct. 30, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit resumed inching uphill. After the drive, Spirit took a single-frame image with the navigation camera as well as images with the hazard-avoidance cameras.

Sol 1717: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover recharged the batteries.

Sol 1718: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit continued inching uphill and, after the drive, acquired images with the navigation and hazard-avoidance cameras.

Sol 1719: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover made observations of the spectrometer's calibration target and recharged the batteries.

Sol 1720: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover acquired four, time-lapse movie frames in search of clouds with the navigation camera and took spot images of the sky for calibration purposes with the panoramic cameras. Spirit completed a "quick fine attitude" adjustment to determine the rover's precise position relative to the Sun. Spirit acquired images with the rear and front hazard-avoidance cameras and used visual odometry to track the rover's actual position based on the surface imprints made by its wheels.

Sol 1721: Spirit continued trying to inch upslope. After stopping, Spirit acquired a single-frame image with the navigation camera as well as images with the hazard-avoidance cameras.

Sol 1722 (Nov. 6, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer, completed a mini-survey of the sky and ground with the instrument, and recharged the batteries.

Odometry:

As of sol 1721 (Nov. 4, 2008), Spirit's total odometry was 7,528.56 meters (4.68 miles).

sol 1709-1715, October 23-29, 2008: *Spirit Begins Driving Uphill*

With the Sun moving higher in the sky, Spirit's solar panels must move in the same direction to maximize their exposure to sunlight. To achieve optimal solar input, the panels still must tilt to the north, but not as steeply as before. To change the tilt, rover drivers have begun moving Spirit back upslope toward the top of "Home Plate." Their goal is to reduce the rover's northerly tilt from 30 degrees to 20 degrees.

The change in tilt is vital, as Spirit is seeing the lowest energy levels of the mission. On Martian day, or sol, 1713 (Oct. 27, 2008), solar-array energy dropped to 207 watt-hours (that's enough energy to light a 100-watt bulb for slightly longer than two hours). The drop in energy was partly due to an increase in atmospheric dust believed to be related to distant dust storm activity. The same day, dust-related loss of visibility, known as Tau, reached a high of 0.69 before dropping to 0.60 on sol 1715 (Oct. 29, 2008).

Because of the limited solar energy, the energy used for driving comes, in part, from the rover's batteries. As solar energy improves, Spirit will have to dip less into the batteries for driving. Fortunately, temperatures are warmer now than in the depths of winter. As a result, the dip in battery reserves is not nearly as great as it would have been if Spirit also required more battery power for heating.

So far, rover drivers are pleased with Spirit's progress. The rover completed three upslope drives to achieve a northerly tilt of 21.8 degrees. Rover operators hope that a couple more budes will give Spirit a northward tilt of 20 degrees.

Eventually, if Spirit can drive all the way back on top of Home Plate, the rover will save a significant amount of time while heading out on the next science campaign. If necessary, Spirit still has the option of driving downslope.

Spirit is healthy, with all subsystems performing as expected as of sol 1715 (Oct. 29, 2008).

Sol-by-sol summary

In addition to measuring dust-related changes in atmospheric clarity each day with the panoramic camera and relaying data to Earth each evening via NASA's Odyssey orbiter, Spirit completed the following activities:

Sol 1709 (Oct. 23, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. Spirit then began inching uphill, and after the drive, took a single-frame image to document progress with the navigation camera.

Sol 1710: Spirit surveyed the horizon with the panoramic camera, drove, and acquired images with the hazard-avoidance cameras as well as a quarter-frame image of the spacecraft deck with the panoramic camera.

Sol 1711: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument.

Sol 1712: Spirit monitored dust on the panoramic-camera mast assembly and recharged the batteries..

Sol 1713: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit drove a bit farther upslope.

Sol 1714: Spirit acquired a single-frame, post-drive image with the navigation camera as well as images with the hazard-avoidance cameras.

Sol 1715 (Oct. 29, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover then calibrated the spectrometer and began inching upslope again. After the drive, Spirit took a single-frame image with the navigation camera as well as images with the hazard avoidance cameras.

Odometry

As of sol 1715 (Oct. 29, 2008), Spirit's total odometry remained at 7,528.42 meters (4.68 miles).

sol 1702-1708, October 16-22, 2008: *Mars Rover Gets Ready to Move*

At Spirit's winter outpost on Mars, the atmosphere has been like the sky on many a clear day in Los Angeles. Smog is not noticeable and details are visible in the surrounding hills, though not with sparkling clarity.

For Spirit, the degree of clarity is especially important because it affects the rover's solar power levels. Lately, the rover has been on a "data diet" of limited atmospheric observations, each one typically generating less than a megabit of data.

One exception during the past week was a 5-by-1 mosaic of images that Spirit acquired to provide a wide-angle view of the rover's winter surroundings. This big-picture view will serve as a guide for putting together the many individual frames of the full-color, "Bonestell panorama" so they fit like the pieces of a jigsaw puzzle.

Spirit's top priority has been the transfer of data from the rover's flash memory files to Earth. Even with reduced activity, the downlink has been slow. When Spirit resumes driving as planned on sol 1709 (Oct. 23, 2008), these downlinks will become even more challenging.

A week ago, dust-related atmospheric murkiness, known as Tau, increased to 0.45. Since then, atmospheric clarity, solar power levels, and dust accumulation have remained steady. Energy from the solar arrays is about 236 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). The dust factor is about 0.33, meaning that only about one-third of sunlight reaching the solar arrays actually penetrates the coating of dust to generate electricity.

On Martian day, or sol, 1700 (Oct. 14, 2008), Spirit checked and adjusted the rover's measurements of Tau. Changes in Tau and the dust factor account for changes in solar energy production. In this instance, the recalibration raised Tau by 0.1 (meaning atmospheric dust levels worsened) and lowered the dust factor by 1 percent (meaning solar penetration was better than engineers thought). At the same time, an actual increase in atmospheric dust caused Tau to go up 0.05, for a total increase of 0.15. The higher dust levels drove down energy production by 18 to 20 watt-hours, compared to dust levels a couple of weeks ago.

The recalibration of Tau measurements is essential because it helps scientists measure changing amounts of dust on the camera lenses. Like drivers watching the road ahead, they need to know if the view is murky because the window is dirty or the atmosphere is hazy. To figure this out on Mars, they tell Spirit to measure Tau near noon when the Sun is overhead and again near sunset when the Sun is low in the sky. They also duplicate the measurements using both the panoramic and navigation cameras.

In preparation for the first roll of the wheels since hunkering down for the winter, Spirit stowed the robotic arm beneath the spacecraft deck. Plans call for the rover to try to climb back up onto "Home Plate" next week. Spirit will drive just far enough to change the northward tilt of the solar panels from 30 degrees to about 20 degrees. The change in position will keep the solar panels pointed toward the Sun. Should the rover be unable to climb the slope, Spirit will drive downhill onto flatter ground.

Spirit remains healthy, with all subsystems performing as expected as of sol 1708 (Oct. 22, 2008).

Sol-by-sol summary

In addition to measuring dust-related changes in atmospheric clarity each day with the panoramic camera and relaying data to Earth each evening via NASA's Odyssey orbiter, Spirit completed the following activities:

Sol 1702 (Oct. 16, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument.

Sol 1703: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument.

Sol 1704: Spirit recharged the batteries.

Sol 1705: Spirit acquired a 5-by-1 mosaic of images to provide a wide-angle, big-picture view of the Bonestell panorama.

Sol 1706: Spirit recharged the batteries.

Sol 1707: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover calibrated the miniature thermal emission spectrometer. Spirit stowed the robotic arm and its science instruments in preparation for the rover's first post-winter drive.

Sol 1708 (Oct. 22, 2008): Spirit took spot images of the sky for calibration purposes.

Odometry

As of sol 1708 (Oct. 22, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1695-1701, October 09-15, 2008: *Getting Ready to Make the Next Move*

In recent weeks, increasing solar power has enabled Spirit to complete more science activities. Spirit has finished the 360-degree, full-color view of its winter surroundings, known as the "Bonestell panorama," and acquired extra frames at super resolution to enhance details in the imagery. The rover also has documented seasonal changes in the atmosphere by measuring argon gas with the alpha-particle X-ray spectrometer.

The tradeoff has been that by funneling most available power into science activities, Spirit has not had much power for sending data to Earth. That is about to change, because Spirit's on-board memory is nearly full. Instead of sending data only every fourth day, Spirit will begin relaying data every day to NASA's Odyssey orbiter for transmission to Earth.

Rover operators will use the data to plan Spirit's first, post-winter drive to adjust the rover's position to keep the solar panels facing the Sun. The move will put the rover in optimum position before solar conjunction, when Earth and Mars will be on opposite sides of the Sun and communication will not be possible. Solar conjunction will take place on Martian days, or sols, 1745-1760 (Nov. 29-Dec. 15, 2008).

Meanwhile, Spirit is healthy, with all subsystems performing as expected as of sol 1700 (Oct. 14, 2008). Solar-array energy has been 242 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). After weeks of remarkably clear skies, atmospheric opacity or tau, a measure of the decrease in sunlight caused by atmospheric dust, has risen slightly to 0.294. Atmospheric dust levels remain low, but are beginning to trend upward and affect solar power levels. This increase is expected, as it has occurred at this time of year in each of the previous three Martian years.

The dust factor -- the percentage of light penetrating dust on Spirit's solar arrays -- has remained steady. Only 32 percent of the sunlight reaching the arrays penetrates the dust to generate electricity.

Sol-by-sol summary

In addition to making daily measurements of the amount of atmospheric dust preventing sunlight from reaching the rover's solar arrays, Spirit completed the following activities:

Sol 1695 (Oct. 9, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer, surveyed the sky and ground with the instrument, did survey work with the panoramic camera, and surveyed a surface target dubbed "Jules Verne" with the miniature thermal emission spectrometer.

Sol 1696: Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and made some finishing touches to the lower edge of the full-color, 360-degree view of the rover's winter surroundings by acquiring 3 panels of images known as "Bonestell lower tiers" 1, 2, and 3.

Sol 1697: Spirit used the miniature thermal emission spectrometer to survey the sky, the ground, and a target known as "Stapledon." Spirit parked the panoramic camera mast assembly with the panoramic camera pointed below the horizon to minimize dust accumulation.

Sol 1698: Spirit took spot images of the sky for calibration purposes with the panoramic camera and spent much of the day recharging the battery.

Sol 1699: Spirit surveyed the sky at different elevations as well as the ground with the miniature thermal emission spectrometer and used the panoramic camera to survey the horizon and take thumbnail images of the sky on the rover's right (starboard).

Sol 1700: Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and took spot images of the sky with the panoramic camera. Spirit relayed information from Mars to NASA's Odyssey orbiter for transmission to Earth.

Sol 1701 (Oct. 15, 2008): Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and monitored dust accumulation on the panoramic-camera mast assembly.

Odometry:

As of sol 1700 (Oct. 14, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1690-1694, October 03-08, 2008: *Spirit's Memory Is Getting Full*

Taking advantage of recent improvements in battery power, Spirit has been rushing to complete top science activities before making a "sun-chasing" adjustment in position in late October. As a result, Spirit's on-board memory has been filling up dramatically as the rover relays data to Earth only once every four Martian days, or sols. In addition, transmissions are challenging because of the rover's position relative to NASA's Odyssey orbiter.

Rover operators plan to increase the flow of information to Earth via Odyssey to about three sessions per week starting on sol 1700 (Oct. 14). Even so, Spirit may need to go on a bit of a science diet over the next few weeks to free up sufficient memory for solar conjunction. That's the period when the Sun is between the Earth and Mars and blocks communications.

Spirit completed work on the 360-degree view of its winter surroundings, known as the "Bonestell panorama." The finished product includes a few select frames taken at super resolution for more detailed study. Spirit also completed another measurement of argon gas in the Martian atmosphere using the alpha-particle X-ray spectrometer. The measurements help scientists characterize seasonal airflows between the Martian poles.

In the past, rover operators have relied on "beeps" from Spirit to know if the rover received and activated command sequences from Earth. The beeps were X-band transmissions sent to Earth over Spirit's low-gain antenna. As power levels sank in the depth of winter, engineers discontinued the beeps to save energy. Recently, they attempted to start sending beeps again, only to find that the signal strength from the low-gain antenna was not great enough for Earth to hear. They decided to send a few beeps from Spirit's dish-shaped, high-gain antenna. Those transmissions were excellent. Rover planners have used them to get a rough estimate of the time drift in the rover's clock during the past nine months or so. The "timing beeps" show that the spacecraft clock has drifted 40 to 50 seconds from "Earth" time.

Spirit is healthy, with all subsystems performing as expected as of sol 1694 (Oct. 8, 2008). Solar-array energy dropped slightly during the past week to 255 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau, a measure of

the amount of sunlight blocked by atmospheric dust, increased from 0.134 to 0.209. Historically, dust levels have been elevated at this time of year. Rover operators are keeping close tabs on atmospheric dust because of its potential impact on the rover's low power state.

Sol-by-sol summary

In addition to standard daily activities, which include using the panoramic camera (sometimes more than once) to measure the amount of atmospheric dust preventing sunlight from reaching the solar arrays, checking for drift (changes with time) in the miniature thermal emission spectrometer, and surveying the sky and ground with the instrument, Spirit completed the following activities:

Sol 1690 (Oct. 4, 2008): Spirit acquired column 23, part 3, and column 25, part 3 of the Bonestell panorama, a full-color, 360-degree view of the rover's winter surroundings made with all 13 color filters of the panoramic camera. Before relaying data to Odyssey to be transmitted to Earth, Spirit acquired four movie frames in search of clouds with the navigation camera.

Sol 1691: Spirit acquired column 27, part 3; column 26, part 3; column 24, part 3; and column 22, part 3 of the Bonestell panorama. The rover supplemented the usual, panoramic-camera measurements of atmospheric dust with measurements from the navigation camera. Spirit used the navigation camera to acquire a four-frame movie in search of Martian clouds.

Sol 1692: Spirit acquired column 20, part 3 of the Bonestell panorama as well as half of a super-resolution frame nicknamed "A" and later nicknamed "Hercules Joyner," in honor of a member of the all-black Tuskegee Airmen who served in World War II. The rover acquired a four-frame movie in search of clouds with the navigation camera.

Sol 1693: Spirit surveyed the sky at high Sun with the panoramic camera and acquired half of a super-resolution frame dubbed "General BO Davis," in honor of another Tuskegee Airman. The rover surveyed a target known as "Gernsback" with the miniature thermal emission spectrometer.

Sol 1694 (Oct. 8, 2008): After sending data to Odyssey, Spirit measured atmospheric argon with the alpha-particle X-ray spectrometer.

Odometry:

As of sol 1694 (Oct. 8, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1685-1689, September 28 - October 03, 2008: *Spirit and Earth Stick Together*

Spirit is poised to begin making more "phone calls" to Earth and engineers are preparing to contact Spirit more frequently as a result of improving solar power input on Mars. Though Spirit's energy levels are still low, they are improving significantly as Martian winter gradually fades into spring. The rover will use some of the energy to let engineers and scientists know how things are going on Mars.

Spirit stays in touch by transmitting data at UHF frequencies to NASA's Odyssey orbiter. Odyssey sends it to Earth. On the other end of the line, engineers send new activity plans to Spirit using X-band transmissions from Earth that go directly to the rover's dish antenna. More frequent communication allows greater operational flexibility as the rover gradually returns to a normal planning schedule and prepares to drive again in mid- to late October.

Spirit's first post-winter drive will be short, just far enough to adjust the rover's position so its solar panels remain tilted toward the Sun as it moves higher in the sky. The goal is to have Spirit in the best possible position before solar conjunction -- the time of year when the Sun passes between Mars and Earth and temporarily prohibits communication.

Meanwhile, Spirit has been working hard to complete the full-color "Bonestell panorama" of the rover's winter surroundings. After a long hiatus caused by power limitations, Spirit resumed making measurements of argon gas in the Martian atmosphere.

Spirit is healthy, with all subsystems performing as expected as of sol 1686 (Sept. 30, 2008). Solar-array energy increased to 262 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Skies remained clear, with tau, a measure of the amount of sunlight blocked by atmospheric dust, at 0.134. Historically, dust levels at this time of year have been higher. Rover operators are keeping close tabs on atmospheric dust because of its potential impact on the rover's power state.

Sol-by-sol summary

Spirit completed the following activities:

Sol 1685 (Sept. 28, 2008): Spirit listened for communications from Earth with the rover's low-gain antenna, checked for drift -- changes with time -- in the miniature thermal emission spectrometer, surveyed the sky and ground with the instrument, and measured atmospheric opacity caused by dust (tau) with the panoramic camera. Spirit monitored dust accumulation on the panoramic-camera mast assembly and acquired column 22, part 2, and column 24, part 2 of the so-called "Bonestell panorama," a full-color, 360-degree view of the rover's winter surroundings, created with all 13 color filters of the panoramic camera.

Sol 1686: Spirit received new instructions from Earth at X-band frequencies sent to the rover's high-gain antenna and spent three hours measuring argon gas in the Martian atmosphere with the alpha-particle X-ray spectrometer. Spirit relayed data to NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1687: Spirit measured dust-related changes in atmospheric darkness with the panoramic camera and acquired column 23, part 2 and column 25, part 2 of the Bonestell panorama.

Sol 1688: Spirit checked for drift in the miniature thermal emission spectrometer, surveyed the sky and ground with the instrument, and measured atmospheric opacity caused by dust with the panoramic camera. Spirit acquired column 27, part 2 and column 26, part 2 of

the Bonestell panorama. The rover supplemented panoramic-camera measurements of atmospheric dust with measurements from the navigation camera and acquired a four-frame movie in search of clouds with the navigation camera.

Sol 1689 (Oct. 3, 2008): Plans called for Spirit to measure dust-related changes in atmospheric darkness with the panoramic camera and acquire column 19, part 3 and column 21, part 3 of the Bonestell panorama. The rover was to assess atmospheric dust levels with the navigation camera and produce a four-frame, time-lapse movie of potential clouds passing overhead.

Odometry:

As of sol 1686 (Sept. 30, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1678-1684, September 21-27, 2008: *Spirit Upgrades Calling Plan*

Thanks to clear skies and longer Martian days, Spirit can accept three "collect phone calls" a week from Earth instead of two. The rover "pays" for each phone call, which is filled with new activities, with solar energy. As winter fades and sunlight increases with the coming Martian spring, Spirit can stay awake a little longer and accomplish more each day. For example, Spirit is making significant progress toward completing the 360-degree view of the north-facing slope where the rover has spent the past winter.

Spirit continues to phone home less frequently, however, sending news only every fourth Martian day, or sol. That's because the link to NASA's Odyssey orbiter occurs late in the Martian afternoon, when the rover's solar arrays are not generating much energy. The transmission relies almost completely on battery power. Spirit can "bounce back" from the current schedule by replenishing the battery after the Sun rises the next day, but more frequent downlinks remain problematic.

On sol 1680 (Sept. 23, 2008), Spirit completed the interplanetary equivalent of synchronizing watches. The rover sent a five-minute "timing beep" to Earth at X-band frequencies from its high-gain antenna. Antennas on Earth listened for the beep, which couldn't be detected by humans (if humans could hear microwaves, the beep would sound like a five-minute tone). By comparing the expected end time of the beep with the measured end time, rover operators estimated "drift" in Spirit's on-board clock. Currently, Spirit's clock lags by about 45 seconds, well within operational tolerance.

Spirit is healthy, with all subsystems performing as expected as of the report from NASA's Odyssey orbiter on sol 1678 (Sept. 21, 2008). Solar-array energy has increased ever so slightly from 255 watt-hours to 256 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Skies remain clear, with tau, a measure of the amount of sunlight blocked by atmospheric dust, at 0.14. The dust factor remains steady, with 32.3 percent of incoming sunlight actually penetrating dust on the solar arrays to generate electricity.

Sol-by-sol summary

In addition to taking daily measurements of dust-related changes in atmospheric opacity (tau), Spirit completed the following activities:

Sol 1678 (Sept. 21, 2008): Spirit acquired column 24, part 1 and column 25, part 1 of the so-called "Bonestell panorama," a full-color, 360-degree view of the rover's winter surroundings, using all 13 color filters of the panoramic camera. The rover checked for drift -- changes with time -- in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. Spirit relayed data to NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1679: Spirit completed the runout portion of the master sequence of commands and recharged the batteries.

Sol 1680: Spirit sent a five-minute timing beep to Earth to synchronize its clock with Earth's clocks. The rover completed the runout portion of the master sequence of commands and recharged the batteries.

Sol 1681 (Sept. 24, 2008): Spirit switched from planning 2 days a week to planning 3 days a week. The new schedule calls for more "up time" to accommodate more frequent uplinks from Earth and more science activities. Spirit checked for drift in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. The rover acquired column 26, part 1; column 27, part 1; and column 18, part 2 of the Bonestell panorama, using all 13 filters of the panoramic camera.

Sol 1682: Spirit checked for drift in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. Spirit took spot images of the sky for calibration purposes with the panoramic camera and recharged the batteries.

Sol 1683: Plans called for Spirit to listen for signals from Earth with the rover's low-gain antenna, check for drift in the miniature thermal emission spectrometer, survey the sky and ground with the spectrometer, and calibrate the spectrometer. Spirit was also to acquire column 18, part 3; column 18, part 4; and column 20, part 2 of the Bonestell panorama. The rover was to take color images of the external calibration target with the panoramic camera.

Sol 1684 (Sept. 27, 2008): Plans called for Spirit to check for drift in the miniature thermal emission spectrometer, survey the sky and ground with the instrument, and acquire column 19, part 2, and column 21, part 2 of the Bonestell panorama.

Odometry:

As of sol 1682 (Sept. 25, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

Twitter:

New calling plan: Spirit hears from Earth 3 times a week instead of 2. With longer days, Spirit stays awake longer and takes more pictures!

Spirit doesn't call home as often as her parents would like, but communications are improving. Spirit now takes 3 calls a week from Earth to Mars!

sol 1669-1677, September 12-20, 2008: *Warming Up on Mars*

With Martian winter on the wane, Spirit is using significantly less energy to stay warm. During the winter solstice, Spirit needed 90 watt-hours to run the heater. Now, the rover uses between 30 and 40 watt-hours. The reduced demand for power, more than the slow increase in solar-array input, has freed up energy for other things. In particular, Spirit has added more images to the 360-degree view of its winter surroundings, known as the "Bonestell panorama." The top tier, one of three tiers needed for the final image mosaic, is almost complete.

Plans called for Spirit to use the miniature thermal emission spectrometer for the first time in several months. The last time the rover used the instrument was on Martian day, or sol, 1558 (May 21, 2008). On sol 1675 (Sept. 18, 2008), Spirit's schedule of activities included calibrating the spectrometer and using it to observe the sky and ground. Normally, scientists use the observations to measure temperatures at different heights and create a temperature profile of the ground and atmosphere. In this case, the purpose of the measurements is to verify that the spectrometer is still working after a long, cold period of disuse. The measurements will also enable scientists to estimate the amount of dust on the optics. They may or may not provide a useful temperature profile.

Spirit is healthy and all subsystems are performing as expected as of the most recent report from NASA's Odyssey orbiter on sol 1674 (Sept. 17, 2008). Solar-array energy has inched upward to 255 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Skies are clearer than last week, with tau, a measure of the amount of sunlight blocked by atmospheric dust, dropping to 0.141.

Sol-by-sol summary

In addition to taking daily measurements of dust-related changes in atmospheric opacity (tau), Spirit completed the following activities:

Sol 1669 (Sept. 12, 2008): Spirit recharged the batteries.

Sol 1670: Spirit received new instructions directly from Earth sent at X-band frequencies to the rover's high-gain antenna. The rover relayed data to NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1671: Spirit acquired column 20, part 1 and column 21, part 1 of the full-color Bonestell panorama, using all 13 color filters of the panoramic camera. The rover took spot images of the sky for calibration purposes with the panoramic camera.

Sol 1672: Spirit recharged the batteries.

Sol 1673: Spirit recharged the batteries.

Sol 1674: Spirit received new instructions from Earth via the rover's high-gain antenna. The rover relayed data to Odyssey to be sent to Earth.

Sol 1675: Plans called for Spirit to acquire column 22, part 1 and column 23, part 1 of the Bonestell panorama and then verify that the miniature thermal emission spectrometer was still functional. This involved warming up the actuator, calibrating the instrument, measuring ground temperature, and measuring atmospheric temperatures at different heights. Plans also called for Spirit to calibrate the panoramic camera by taking images in darkness while the instrument was warm.

Sol 1676: Plans called for Spirit to recharge the batteries.

Sol 1677 (Sept. 20, 2008): Plans called for Spirit to recharge the batteries.

Odometry:

As of sol 1674 (Sept. 17, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1663-1668, September 06-11, 2008: *Light Duty for Now*

Spirit continues to conserve solar power while performing light science activities during the Martian winter. During the past week, Spirit studied the atmosphere and acquired two frames of the full-color image mosaic known as the "Bonestell panorama."

Spirit is healthy and all subsystems are performing as expected as of the relay of information from NASA's Odyssey orbiter on sol 1666 (Sept. 9, 2008). Solar-array energy and tau -- a measure of atmospheric opacity caused by suspended dust -- are holding steady at 245 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour) and 0.20, respectively.

Sol-by-sol summary

In addition to taking daily measurements of dust-related changes in atmospheric opacity (tau), Spirit completed the following activities:

Sol 1663 (Sept. 6, 2008): Spirit recharged the batteries.

Sol 1664: Spirit acquired column 18 of the Bonestell panorama, using all 13 color filters of the panoramic camera.

Sol 1665: Spirit recharged the batteries.

Sol 1666: Spirit recharged the batteries.

Sol 1667: Spirit received new instructions from Earth via the rover's high-gain antenna and relayed data to the UHF antenna on NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1668 (Sept. 11, 2008): Spirit monitored dust accumulation on the panoramic-camera mast assembly and acquired column 19 of the Bonestell panorama.

Odometry:

As of sol 1666 (Sept. 9, 2008), Spirit's total odometry was 7,528.0 meters (4.7 miles).

sol 1657-1662, August 31-September 05, 2008: *Spirit Continues Work on Winter Panorama*

Spirit continues to conserve power during the waning Martian winter while performing light science activities. As power permits, Spirit continues to acquire the individual frames of an image mosaic known as the "Bonestell panorama," which will portray a full-color view of the rover's winter outpost.

Spirit is healthy, with all subsystems performing as expected as of the most recent report from Mars sent by NASA's Odyssey orbiter on sol 1658 (Sept. 1, 2008). Solar-array energy had increased slightly from 235 to 245 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau -- a measure of atmospheric opacity caused by suspended dust -- dropped from 0.274 to 0.218, meaning the skies were slightly clearer.

Sol-by-sol summary

In addition to taking daily measurements of dust-related changes in atmospheric opacity (tau), Spirit completed the following activities:

Sol 1657 (Aug. 31, 2008): Spirit acquired column 13, part 1 of the so-called "Bonestell panorama" of the rover's winter surroundings, using all 13 color filters of the panoramic camera.

Sol 1658: Spirit relayed data from Mars to NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1659: Spirit received new instructions from Earth via the rover's high-gain, X-band antenna.

Sol 1660: Spirit recharged the batteries.

Sol 1661: Spirit recharged the batteries.

Sol 1662 (Sept. 5, 2008): Spirit recharged the batteries.

Odometry:

As of sol 1658 (Sept. 1, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1651-1656, August 25-30, 2008: *Spirit Still Biding Time -- and Checking the Clock*

To adjust for changes, known as "drift," in synchronicity between Spirit's clock and Earth-based clocks, engineers instructed Spirit to send a "timing beep" to Earth on Martian day, or sol, 1652 (Aug. 26, 2008). For a specifically scheduled duration of time, Spirit radiated a signal to Earth over its low-gain antenna. Rover operators listened for the signal, in order to make sure Spirit's clock and Earth clocks were in agreement.

Spirit continues to ride out the Martian winter by doing minimal activities in an attempt to save power. Spirit conducts science observations every three to four Martian days, known as sols. Every four sols, the rover sends data to NASA's Odyssey orbiter for transmission to Earth. Otherwise, Spirit mostly rests and recharges the batteries. This pattern of activity is not likely to change until sunlight on the rover's solar panels consistently generates 250 watt-hours (enough energy to light a 100-watt bulb for 2.5 hours) or more. Engineers do not expect that to happen until approximately mid-October, barring wind-related, dust-cleaning events between now and then.

Spirit remains healthy, with all subsystems performing as expected as of the downlink of information from NASA's Odyssey orbiter on sol 1650 (Aug. 24, 2008). Solar-array energy as of the same sol was 232 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau -- a measure of atmospheric opacity caused by suspended dust -- was 0.274. Spirit is approaching a time of year when the rover has historically seen increased atmospheric dust levels. Given the rover's already low power state, engineers will be on the lookout for dust-related changes in solar power.

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1651 (Aug. 25, 2008): Spirit measured dust-related changes in atmospheric clarity (tau) with the panoramic camera. Spirit acquired column 17, part 1 of the so-called "Bonestell panorama" of the rover's winter surroundings, using all 13 color filters of the panoramic camera.

Sol 1652: Spirit received new instructions from Earth via the rover's high-gain, X-band antenna and transmitted the requested "timing beep" to Earth.

Sol 1653: Spirit recharged the batteries.

Sol 1654: Spirit measured dust-related changes in atmospheric clarity with the panoramic camera and acquired column 15, part 1 of the full-color Bonestell panorama. Spirit relayed data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1655: Spirit recharged the batteries.

Sol 1656 (Aug. 30, 2008): Plans called for Spirit to receive a new set of instructions from Earth via the rover's high-gain antenna.

Odometry:

As of sol 1654 (Aug. 28, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1643-1650, August 16-24, 2008: *Spirit Still Biding Time*

Spirit continues to ride out the Martian winter by doing minimal activities to conserve power. The rover completes very light science observations every three to four Martian days, known as sols, and relays data to NASA's Odyssey orbiter to be transmitted to Earth every four sols. Otherwise, Spirit mostly sleeps. This pattern is not likely to change until sunlight on the rover's solar array consistently generates 250 watt-hours or more (enough energy to light a 100-watt bulb for 2.5 hours). Barring dust-cleaning winds, that is not expected to happen before about mid-October.

Spirit remains healthy, with all subsystems performing as expected as of the Odyssey downlink to Earth on sol 1646 (Aug. 19, 2008). Solar-array energy has dropped back to 229 watt-hours after recently reaching the high 230's. This drop is the result of an increase in tau -- a measure of atmospheric opacity caused by suspended dust -- from 0.19 to 0.29. Spirit is approaching a time of year when the rover has historically seen increased atmospheric dust levels. Given the rover's low power state, engineers will be watching this trend very closely.

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1643 (Aug. 16, 2008): Spirit monitored atmospheric darkness caused by dust with the panoramic camera. Spirit acquired column 15, part 2 of the so-called "Bonestell panorama," using all 13 filters of the panoramic camera.

Sol 1644: Spirit recharged the batteries.

Sol 1645: Spirit recharged the batteries.

Sol 1646: Engineers on Earth transmitted a new plan of activities at X-band frequencies directly to Spirit's high-gain antenna. Spirit relayed data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1647: Spirit monitored atmospheric opacity with the navigation camera and acquired column 17, part 2 of the "Bonestell camera," using all 13 color filters of the panoramic camera.

Sol 1648: Spirit recharged the batteries.

Sol 1649: Plans called for Spirit to continue to rest and recharge the batteries.

Sol 1650 (Aug. 24, 2008): Spirit was to receive a new plan of activities transmitted at X-band frequencies directly to Spirit's high-gain antenna. The rover was scheduled to relay data to NASA's Odyssey orbiter for transmission to Earth.

Odometry:

As of sol 1642 (Aug. 15, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1635-1642, August 08-15, 2008: *Spirit Standing By*

Though Spirit is using less energy to run heaters as Martian winter slowly gives way to spring, dust on the rover's solar arrays continues to block sunlight. Presently about one-third -- 34 percent -- of sunlight reaching the arrays is penetrating the layer of dust to generate electricity. This is a primary reason why Spirit's third winter on the red planet has been more difficult than the first two.

Energy has been steady, averaging 235 watt-hours daily (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau, a measure of atmospheric dust, and the dust factor, a measure of the amount of dust on the solar arrays, have also been steady at 0.197 and 0.340, respectively. The Tau measurement indicates that 80 to 82 percent of direct sunlight makes it through the atmosphere and reaches the array (the rest is scattered or absorbed, though scattered light also contributes to Spirit's energy).

Currently, Spirit spends one of every four Martian days, or sols, taking science images. The slight energy increase isn't yet sufficient to allow more activity.

Spirit remains healthy and all subsystems are normal as of the latest downlink of information from the Odyssey orbiter on sol 1638 (Aug. 11, 2008).

Sol-by-sol summary

In addition to measuring atmospheric dust with the panoramic camera, Spirit completed the following activities:

Sol 1635 (Aug. 8, 2008): Spirit implemented the runout portion of the master sequence of commands already on board the rover, then received new instructions from Earth via the rover's high-gain antenna. The rover recharged the batteries.

Sol 1636: Spirit implemented the runout portion of the master sequence of commands already on board the rover and recharged the batteries.

Sol 1637: Spirit woke up and listened for potential transmissions from Earth at X-band frequencies using the rover's broad-beam, low-gain antenna. Spirit acquired column 13, part 2 of the so-called "Bonestell panorama," using all 13 filters of the panoramic camera.

Sol 1638: Spirit woke up and listened for signals from Earth at X-band frequencies using the low-gain antenna. Spirit completed the runout portion of the master sequence of commands on board the rover and relayed data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1639: Spirit woke up and listened for signals from Earth using the rover's low-gain antenna. Engineers on Earth transmitted a new plan of activities at X-band frequencies to the rover's high-gain antenna. Those plans called for Spirit to spend the day surveying the horizon and monitoring the dune field known as "El Dorado" with the panoramic camera.

Sol 1640: Plans called for Spirit to complete the runout portion of the master sequence of commands on board the rover. Spirit was to wake up and listen for signals from Earth using the low-gain antenna and recharge the batteries. To save energy, Spirit was not directed to measure atmospheric opacity, known as Tau.

Sol 1641: Plans called for Spirit to complete the runout portion of the master sequence of commands on board the rover. Spirit was to wake up and listen for signals from Earth using the low-gain antenna and recharge the batteries. Spirit was not scheduled to measure atmospheric opacity.

Sol 1642 (Aug. 15, 2008): Plans called for Spirit to wake up and listen for signals from Earth using the low-gain antenna. Later, the rover was to relay information to Odyssey about the past four sols of activity.

Odometry:

As of sol 1638 (Aug. 11, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1628-1634, August 01-07, 2008: *Waiting Out the Winter*

Spirit's battery levels are slowly edging upward, thanks to a slight decrease in atmospheric dust (Tau) and a gradual increase in sunlight as winter gives way to spring.

Early in the week, Spirit spent two Martian days carrying out contingency plans following a temporary delay in data transmission from Earth. Spirit implemented the so-called "runout" portion of an earlier master sequence on sols 1628 and 1629 (Aug. 1-2, 2008). Subsequent relays of new instructions from Earth on sols 1629 and 1632 (Aug. 2 and Aug. 5, 2008) went off without a hitch.

Spirit remains healthy, with all subsystems performing as expected as of sol 1630 (Aug. 3, 2008).

Sol-by-sol summary

In addition to using the panoramic camera to make daily measurements of dust-related changes in atmospheric clarity, Spirit completed the following activities:

Sol 1628 (Aug. 1, 2008): Spirit implemented the runout portion of the master sequence of commands already on board the rover.

Sol 1629: Upon awakening, Spirit continued to implement the runout portion of the master sequence sent earlier. Spirit then received new instructions directly from Earth via the rover's high-gain antenna.

Sol 1630: Spirit acquired column 13 of the "Bonestell panorama" using all 13 color filters of the panoramic camera. The rover relayed fresh data from Mars at UHF radio frequencies to NASA's Odyssey orbiter to be transmitted to Earth.

Sol 1631: Spirit recharged the batteries.

Sol 1632: Spirit received new instructions from Earth via the rover's high-gain antenna.

Sol 1633: Spirit acquired six freeze frames for a time-lapse movie in search of Martian clouds using the navigation camera. The rover took spot images of the sky for calibration purposes with the panoramic camera and monitored dust on the panoramic-camera mast assembly.

Sol 1634 (Aug. 7, 2008): Spirit transmitted fresh data to Odyssey to be relayed to Earth.

Odometry:

As of sol 1634 (Aug. 7, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1621-1627, July 25-31, 2008: *With Batteries Charged, Spirit is Ready for More Science*

Spirit has fully recovered from a recent rundown in battery power. Energy has improved to levels not seen since sol (Martian day) 1604 (July 7, 2008). The hit in battery energy was primarily the result of data transmissions taking place later in the day, when less solar energy was available.

During the past week, rover planners eliminated the late communications sessions. Spirit is not scheduled to have another one until sol 1636 (Aug. 9, 2008). To mitigate the impact that one will have on power, rover planners plan to shorten the duration of data transmission

from 20 minutes to only 10 minutes. This will allow sufficient time to get new instructions on board the rover while minimizing battery drain.

A transmitter problem thwarted data transmission on sol 1625 (July 29, 2008). The uplink from Earth was to have loaded activity plans and maintenance instructions for sols 1626, 1627, 1628 and 1629 (July 30-Aug. 2, 2008). The sequences already on board Spirit were designed with built-in contingency plans to handle just such an event. As a result, while Spirit continues the "runout" portion of the earlier master sequence, rover operators will send a new set of commands for sols 1630, 1631 and 1632 (Aug. 3-5, 2008) on sol 1629 (Aug. 2, 2008).

Spirit remains healthy, with all subsystems performing as expected as of sol 1626.

Sol-by-sol summary

In addition to using the panoramic camera to make daily measurements of dust-related changes in visibility, Spirit completed the following activities:

Sol 1621 (July 25, 2008): Spirit recharged the batteries.

Sol 1622: Spirit received instructions from Earth via the rover's high-gain antenna and relayed data to NASA's Odyssey orbiter via the rover's UHF antenna.

Sol 1623: Spirit acquired images of sand formations with the rear hazard-avoidance and navigation cameras. The rover took six, time-lapse, movie frames in search of clouds with the navigation camera, as well as images of the sky (called "sky flats") for calibration purposes.

Sol 1624: Spirit recharged the batteries.

Sol 1625: Spirit took spot images of the sky for calibration purposes with the panoramic camera and acquired movie frames in search of clouds with the navigation camera.

Sol 1626: Spirit completed a horizon survey with the panoramic camera and relayed data to Odyssey for transmission to Earth.

Sol 1627 (July 31, 2008): Spirit recharged the batteries.

Odometry:

As of sol 1626 (July 30, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1615-1620, July 19-24, 2008: *Time to Recharge the Batteries*

Spirit is recovering from a recent rundown in battery power. Over the last two weeks, Spirit's battery levels have steadily dropped by about 18 percent. The decrease appears to be a result of transmitting data to Earth later in the day and staying awake longer to accommodate extra science activities.

When Spirit sends transmissions late in the day, there's not enough sunlight left to recharge the batteries. As a consequence, each late uplink has contributed to an energy deficit.

Barring sudden changes in Martian temperature or atmospheric dust levels, engineers expect it may take as long as two weeks to recharge the batteries enough to resume work on the Bonestell panorama and other science activities.

Spirit remains healthy and all subsystems are operating as expected as of Martian day, or sol, 1618 (July 22, 2008).

Sol-by-sol summary

In addition to daily, panoramic-camera measurements of atmospheric opacity caused by dust, Spirit completed the following activities:

Sol 1615 (July 19, 2008): Spirit received new instructions from Earth via the rover's high-gain antenna.

Sol 1616: Spirit monitored dust accumulation on the panoramic-camera mast assembly.

Sol 1617: Spirit recharged the batteries.

Sol 1618: Spirit received instructions from Earth over the rover's high-gain antenna and relayed data to Earth via NASA's Mars Odyssey orbiter.

Sol 1619: Spirit took spot images of the sky for calibration purposes with the panoramic camera and acquired movie frames in search of clouds with the navigation camera.

Sol 1620 (July 24, 2008): Spirit recharged the batteries.

Odometry:

As of sol 1618 (July 22, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1608-1614, July 11-18, 2008: *A Juggling Act*

Winter planning for Spirit requires human operators to perform a complex juggling act to maintain overall rover health. They must manage engineering activities, such as receiving science and engineering data from Mars and sending new operation plans from Earth,

as well as try to fit in science observations when possible. But they must also give the rover sufficient downtime between these activities to recharge the batteries. In recent months, the team's juggling skills have continued to improve.

Meanwhile, Mars has been helping out with steady temperatures and low levels of atmospheric dust, providing stability when it comes to allocating energy for heating and predicting the amount of sunlight reaching the rover's solar panels to generate electricity. Solar energy has been steady between 225 watt-hours to 230 watt-hours, of which about 65 to 75 watt-hours is required for heating the batteries and the miniature thermal emission spectrometer.

The overall state of charge on the battery has dropped slightly as a result of the timing of engineering and science activities. To restore the state of charge, the rover team will be making adjustments in upcoming plans.

Spirit is healthy and all subsystems are performing as expected as of sol 1610 (July 13, 2008).

Sol-by-sol summary

During the past week, in addition to making daily measurements of atmospheric opacity caused by dust with the panoramic camera, Spirit completed the following activities:

Sol 1608 (July 11, 2008): Spirit received new instructions from Earth via the rover's high-gain antenna.

Sol 1609: Spirit acquired column 17, part 3 of the so-called "Bonestell panorama" using all 13 color filters of the panoramic camera. The rover acquired six, time-lapse, movie frames in search of clouds with the navigation camera.

Sol 1610: Spirit relayed science and engineering data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1611: Spirit received instructions from Earth over the rover's high-gain antenna and sent a timing beep to Earth at X-band frequencies.

Sol 1612: Spirit acquired column 15, part 3 of the full-color Bonestell panorama.

Sol 1613: Spirit recharged the battery.

Sol 1614 (July 18, 2008): Spirit relayed science and engineering data to Odyssey for transmission to Earth.

Odometry:

As of sol 1610 (July 13, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1601-1607, July 04-10, 2008: *Solar Energy Evens Out*

A week after the winter solstice, NASA's Mars rover Spirit is experiencing stable solar energy levels of between 225 watt-hours and 230 watt-hours. (One hundred watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Spirit continues to perform light science activities every three to four Martian days, or sols. Science activities this week included acquiring additional frames of the so-called "Bonestell panorama" of Spirit's overwintering locale.

The rover continues to relay data to NASA's Odyssey orbiter every four sols. The reduced level of activity has allowed Spirit to maintain a healthy battery charge despite the low level of solar energy input.

Spirit is healthy and all subsystems were performing as expected as of the downlink of fresh data from Odyssey on Sol 1606 (July 9, 2008).

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1601 (July 4, 2008): Spirit assessed atmospheric dust levels based on the darkness of the sky with the panoramic camera.

Sol 1602: Spirit assessed atmospheric dust, monitored the dune field known as "El Dorado," and took spot images of the sky for calibration purposes with the panoramic camera. The rover relayed data to Odyssey for transmission to Earth.

Sol 1603: Spirit recharged the battery and measured atmospheric dust opacity with the panoramic camera.

Sol 1604: Spirit received a new activity plan from Earth via the rover's high-gain antenna and assessed atmospheric dust levels with the panoramic camera.

Sol 1605: Spirit again gauged atmospheric dust levels and also surveyed the horizon with the panoramic camera. The rover acquired Column 16, Part 4 of the Bonestell panorama, using all 13 color filters of the panoramic camera.

Sol 1606: Spirit assessed atmospheric dust with the panoramic camera and sent fresh data to Odyssey for transmission to Earth.

Sol 1607 (July 10, 2008): Spirit recharged the battery and measured atmospheric dust with the panoramic camera.

Odometry:

As of sol 1606 (July 9, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1594-1600, June 27-July 03, 2008: *Biding Time*

Spirit continues to ride out the Martian winter by doing minimal activities to conserve power. The rover conducts very light science activities every three to four Martian days, or sols, and relays data to NASA's Odyssey orbiter for transmission to Earth every 4 sols. The rest of the time, Spirit mostly sleeps.

As it has been some time since Spirit's operators were able to synchronize the spacecraft clock to Earth time, they wished to determine how far the spacecraft clock had drifted (how much it had changed over time). Synchronization of the clock is a process that requires a power-intensive, two-way, X-band communications link. When the power situation allowed it, they decided to perform an X-band "beep" (a five-minute, low-gain communication session) to estimate the amount of drift. The transmission of plans to do so on sol 1594 (June 27, 2008) were not detected by the ground station. Engineers hoped to make another attempt on sol 1604 (July 7, 2008).

Spirit is healthy and all subsystems were performing as expected as of the Odyssey downlink on sol 1598 (July 1, 2008). Solar-array energy has been steady within the range of 225 watt-hours to 230 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1594 (June 27, 2008): Plans called for Spirit to perform a five-minute "beep" at X-band frequencies after relaying data to Earth via the Odyssey orbiter.

Sol 1595: Spirit recharged the battery and measured atmospheric dust opacity, known as Tau, using the panoramic camera.

Sol 1596: Spirit recharged the battery and measured atmospheric dust opacity with the panoramic camera.

Sol 1597: Spirit recharged the battery and measured atmospheric dust opacity with the panoramic camera.

Sol 1598: Spirit received new instructions from Earth via the rover's high-gain, X-band antenna and relayed data to Odyssey at UHF frequencies for transmission of the latest Martian data to Earth. The rover measured atmospheric darkness caused by suspended dust particles with the panoramic camera.

Sol 1599: Spirit conducted light remote sensing.

Sol 1600 (July 3, 2008): Spirit recharged the battery and again measured atmospheric dust with the panoramic camera.

Odometry:

As of sol 1598 (July 1, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1587-1594, June 20-27, 2008: *Here Comes the Sun*

With this week's passage of the longest night and shortest day of the year, also known as the winter solstice, Spirit's solar power levels should slowly but steadily increase. The winter solstice occurred on Martian day, or sol, 1591 (June 24, 2008, Pacific time).

In fact, Spirit's solar array energy and battery state of charge have already improved in recent days to the point where rover operators have begun adding some planning features back into the rover's schedule. The first change, adopted as of sol 1592 (June 25, 2008), was to return to a planning schedule covering every 3 or 4 sols. The plans themselves remain quite spartan at this time. In particular, rover operators are still planning to have Spirit relay data to Earth only every 4 sols. To do this, the rover sends data to NASA's Odyssey spacecraft, in orbit above Mars. To save power, engineers are keeping the data relays short in duration. Spirit has begun measuring dust-related atmospheric darkness every sol instead of every other sol.

Because it has been some time since engineers have been able to synchronize the spacecraft clock to Earth time, they decided to determine how much the clock had "drifted" -- that is, changed with time. To do this usually requires a power-intensive, two-way, X-Band communication session. This time, to save energy, they decided to perform an X-band "beep," a five-minute communication session using the rover's low-gain antenna, on sol 1594 (June 27, 2008). Accuracy will not be as good, but they expect to get an estimate of drift that is accurate to within about a minute.

Spirit is healthy and all subsystems are performing as expected as of the Odyssey downlink on sol 1590 (June 23, 2008). Solar array energy has been steady at 230 watt-hours, enough energy to light a 100-watt bulb for 2.5 hours.

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1587 (June 20, 2008): Spirit recharged the battery.

Sol 1588: Spirit recharged the battery and received new instructions direct from Earth via the rover's high-gain dish antenna. Spirit measured atmospheric dust opacity, known as Tau, with the panoramic camera.

Sol 1589: Spirit recharged the battery.

Sol 1590: Spirit recharged the battery, measured atmospheric opacity caused by dust with the panoramic camera, and relayed data to Odyssey for transmission to Earth.

Sol 1591: Spirit recharged the battery and received a backup relay of commands from Earth via the rover's high-gain antenna.

Sol 1592: Spirit recharged the battery and conducted light remote sensing.

Sol 1593: Spirit recharged the battery.

Sol 1594 (June 27, 2008): Plans called for Spirit to send data to Odyssey for relay to Earth and transmit a five-minute signal to Earth to allow spacecraft operators to estimate drift in the spacecraft clock.

Odometry

As of sol 1586 (June 19, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1580-1586, June 13-19, 2008: *Battery Power on the Rise*

Spirit's battery is recharging nicely now that rover planners have reduced the frequency of communications to and from the rover during the darkest days of Martian winter. Most measures of battery health are showing an increase of about 2 amp-hours in the battery state of charge (an amp-hour is equivalent to the amount of charge flowing for one hour from a current of 1 amp). The minimum state of charge has improved from 10.92 amp-hours to 12.97 amp-hours, the maximum from 16.77 amp-hours to 18.17 amp-hours, which is fairly close to the battery's full capacity of 19.5 amp-hours.

Because battery energy increased sufficiently, the team added 12 minutes of remote sensing science to Spirit's to-do list for Sol 1586 (June 19, 2008). Spirit was to monitor atmospheric dust with the panoramic camera as well as dust on the panoramic-camera mast assembly and acquire seven, time-lapse movie frames in search of clouds with the navigation camera. Engineers anticipate that the additional activities will have no significant effect on the battery's state of charge.

Skies remain remarkably clear. Solar array energy is up slightly, averaging 229 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Atmospheric darkness caused by dust (known as Tau) increased by an insignificant amount, going from an average of 0.193 the previous week to 0.205 this week. The dust factor, the fraction of sunlight hitting the arrays that penetrates the dust layer, also rose insignificantly, from 0.349 to 0.352.

Rover planners are generating new activity plans for Spirit only once a week to minimize uplink time and therefore the length of time the rover must stay awake. Spirit relays data to Earth only every fourth sol to minimize battery usage.

In addition to estimating the amount of scattering and absorption of sunlight by atmospheric dust, Spirit received one transmission of new instructions direct from Earth to the rover's high-gain antenna on Sol 1581 (June 14, 2008). Spirit sent two transmissions of data to Earth via Odyssey on sols 1582 and 1586 (June 15 and June 19, 2008). Data from the sol 1582 downlink showed that the backup uplink on sol 1584 (June 17, 2008) was not needed and the communications link was shortened to save energy.

Spirit remains healthy and all subsystems were performing as expected as of the downlink to Earth via NASA's Odyssey Mars orbiter on sol (Martian day) 1582 (June 15, 2008).

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1580 (June 13, 2008): Spirit recharged the battery and measured atmospheric opacity caused by dust (Tau) using the panoramic camera.

Sol 1581: Spirit recharged the battery and received new instructions direct from Earth to the rover's high-gain dish antenna.

Sol 1582: Spirit soaked up the sunlight to recharge the battery, assessed atmospheric darkness caused by dust particles with the panoramic camera, and sent data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1583: Spirit recharged the battery.

Sol 1584: Spirit recharged the battery, surveyed atmospheric dust with the panoramic camera, and received new commands from Earth over the rover's high-gain antenna.

Sol 1585: Spirit recharged the battery.

Sol 1586 (June 19, 2008): Plans called for Spirit to recharge the battery, conducted remote sensing, and send data to Odyssey for relay to Earth.

Odometry

As of sol 1578 (June 11, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1574-1579, June 06-12, 2008: *New Tricks for an Old Rover*

To conserve energy and protect one of the on-board spectrometers, spacecraft operators have established the first major change to planning for the Mars Exploration Rover mission since the end of the primary mission, which lasted for 90 days in early 2004.

Spirit's scientists have declared that their highest priority for the winter is preserving the miniature thermal emission spectrometer, an instrument that identifies minerals in rocks from a distance. To do this, the rover heats the instrument overnight and into the morning of every sol. These heaters have been running longer as winter temperatures have dropped and are now averaging about 55 watt-hours per sol.

Heating for Spirit's batteries has increased as well and is now averaging 29 watt-hours per sol. Together, the two heaters account for 84 watt-hours or about 37 percent of Spirit's total energy usage. Everything else, including on-board computers and memories, radios, cameras, sensors and actuators, gets by on about 140 watt-hours -- enough energy to run a microwave oven for a scant 7 minutes.

In response, rover operators have further reduced Spirit's activity levels. The rover now transmits data to Odyssey to be relayed to Earth only every fourth sol. Instead of spending 20 minutes each sol using the rover's high-gain antenna to listen for new instructions from Earth, Spirit spends five minutes listening for instructions using the low-gain antenna on all but two sols per week.

Rover operators create new activity plans once a week, on Fridays, that cover seven sols at a time. Because Spirit isn't engaged in activities that require rover operators to have new images or other data for planning, the rover does not have to relay data to Odyssey just before a planning day. Despite changes to multiple procedures and software tools, the transition has been remarkably smooth.

For the time being, Spirit is basically just hanging out, charging the batteries.

Recent Events

Initially, the uplink team deleted virtually all science activities except for tau measurements of atmospheric dust. They then limited transmission of rover data to NASA's Odyssey orbiter, which consumes about 30 watt-hours, to every other sol. Still, the batteries continued to use more energy than they could replenish.

Prior to this change, Spirit received new plans three times a week and listened for new instructions for 20 minutes every sol. The 20-minute, high-gain-antenna communication window was costing the rover a lot of unnecessary awake time. On the other hand, engineers on Earth needed Spirit to be awake for at least 15 minutes every sol. By changing some of the unneeded 20-minute communication windows to shorter, five-minute, low-gain-antenna communication windows, and by having the windows overlap with the required awake time, Spirit's operators have shortened the overall awake time from 39 minutes to 16 minutes and saved another 15 watt-hours per sol.

Engineers have also gotten more strategic about how they communicate with Spirit. They send a new activity plan to Spirit every week (after the Friday planning session). Because Odyssey downlinks happen only every fourth sol, they can't guarantee they'll have a communication from Odyssey showing whether an uplink actually made it to the rover. So they send the same activity plan a second time. If the first uplink is successful, software on the rover automatically changes the second, high-gain communication window to a five-minute, low-gain window, saving 15 watt-hours. When this occurs, the second uplink fails and flight software generates a bunch of warnings, known as event reports. The warnings tell engineers that the plan is on board. If the first uplink fails, the instructions to change the second uplink window don't take place.

Why do engineers do the planning on Fridays? A new schedule of communication opportunities, called a "strategic load," goes into effect every other Friday. Rover operators plan activities on Friday so they can include the strategic load in the uplink.

The new strategy is working. Battery states of charge are up about two amp-hours (an amp-hour is a measure of electrical current flowing for one hour) above the rather scary levels of two weeks ago and other indicators of battery health are similarly improving. Spirit now has some margin of protection against further increases in heating power or unpleasant changes in the Martian environment. One concern is the possibility that thin, water-ice clouds could form overhead during the Martian winter. Such clouds are nearly invisible without image enhancement but they're thick enough to noticeably lower solar array energy. Fortunately, there's been no evidence of water-ice clouds so far.

Turning the Corner

The Martian winter solstice will be on June 25, 2008 (sol 1591). During the winter solstice, the Sun is as low in the sky as it ever gets. From there, it will rise higher each sol until the summer solstice in May 2009. For Spirit, solar power levels are expected to increase in a few weeks. Unlike Earth, where the coldest temperatures arrive 4-6 weeks after the solstice, Martian temperatures will begin to rise again almost immediately -- but slowly, very, very slowly.

With little dust overhead, Spirit is seeing very little additional dust settling out on the rover's solar arrays. The dust factor, a measure of the proportion of sunlight penetrating the coating of dust on the solar arrays, has remained almost unchanged at 0.349 (meaning that 34.9 percent of the sunlight, direct and scattered, that reaches the arrays penetrates the dust layer to generate electricity).

Energy has been steady, averaging about 226 watt-hours each Martian day, or sol, and varying by only a couple of watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). This is due in large part to a clear and stable atmosphere.

Tau, a measure of dust in the atmosphere, has ranged from 0.178 to 0.207 and averaged 0.193. As a result, between 81 percent and 84 percent of the sunlight reaching Mars continues down through the atmosphere to Spirit's solar array. (The remaining 16 percent to 19 percent is either scattered or absorbed by dust particles in the atmosphere. The portion of sunlight that's scattered also contributes to Spirit's solar array energy.)

A Tau this low means the skies above Spirit are remarkably clear. Not only that, Tau has decreased by an average of about 0.01 per week over the last month. (Though scattering and absorption are different and not exactly comparable, a clear mountain day on Earth has a Tau of 0.1-0.2.)

Spirit is healthy and all subsystems are performing as expected as of the Odyssey downlink on Sol 1578 (June 11, 2008). The next planned Odyssey downlink will be on Sol 1582 (June 15, 2008).

What Do You Say When You Call Home?

One of the key ways engineers monitor Spirit is through "event records." These are messages generated by the flight software -- basically, the rover's operating system -- telling Earth how Spirit is doing and why. Most modern operating systems store such information in log files; Spirit transmits it over long distances.

Spirit's event records come in five "flavors." Activity event records note that some event has occurred. Command event records log the issuance and success or failure of commands. Warning event records indicate unexpected events. Fault event records indicate more serious problems the flight software must address, usually by disabling further use of some device or capability. Fatal event records indicate problems so severe they invoke the fault protection features of the operating system. At that point, the whole rover is "disabled" and goes into so-called "safe" mode by shutting down all activities while waiting for instructions from home.

Whether such warnings indicate a problem depends on the context. For example, every time a motor stalls (stops turning while still powered), Spirit's flight software generates a warning event record. Sometimes, the stall is intentional. For example, engineers calibrate the position of an actuator by slowly driving it into a mechanical "hardstop" at a known position. When the hardstop is reached, the motor stalls and issues a warning event record. If one of the motors stalls unexpectedly, that same event record could indicate a problem.

It's like easing into a parking space until your wheels hit the parking bumper. The resulting jolt says you are correctly parked. On the other hand, a similar jolt could mean a fender bender, depending on the context.

Spirit's operators are sending two copies of new command sequences and then sending it twice again on a backup uplink one or two sols later. Data relays are so sparse, they don't always know if the first attempt succeeded and want to minimize the risk of not getting a new sequence on board.

Typically, the first attempt is successful and the second is rejected. Flight software generates event records telling engineers that the rover received the files correctly and copied them into the primary and secondary file systems. The software then rejects the same files later because their names conflict with existing files of the same name.

Rover operators don't actually read all the event reports in text form. An identification number encodes the "flavor" of the event report and a time tag called SCLK for "spacecraft clock" translates the time into readable format. Ground software decodes these and a few other parameters and converts them into readable words.

Sol-by-sol summary

Spirit completed the following activities:

Sol 1574 (June 6, 2008): Spirit recharged the batteries, listened to instructions from Earth for five minutes using the low-gain antenna, measured atmospheric opacity caused by dust using the panoramic camera, and relayed data to the Odyssey orbiter as it passed overhead.

Sol 1575: Spirit recharged the batteries and listened to instructions from Earth for 20 minutes using the high-gain antenna.

Sol 1576: Spirit recharged the batteries, listened to instructions from Earth for five minutes using the low-gain antenna, and measured atmospheric opacity caused by dust using the panoramic camera.

Sol 1577: Spirit recharged the batteries and listened to instructions from Earth for five minutes using the low-gain antenna.

Sol 1578: Spirit recharged the batteries, listened to instructions from Earth for five minutes using the low-gain antenna, measured atmospheric opacity caused by dust using the panoramic camera, and relayed data to Odyssey during the overhead pass of the orbiter.

Sol 1579 (June 12, 2008): Spirit recharged the batteries and listened to instructions from Earth for five minutes using the low-gain antenna.

Odometry:

As of sol 1578 (June 11, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1567-1573, May 30-June 5, 2008: *Not Quite Hibernation*

To save energy, engineers on Earth are sending new instructions to Spirit once every seven Martian days, or sols, with an additional 10 sols of "runout" instructions in the event of an interruption in communications.

The reason for the reduced workload is that rover engineers are trying to avoid having the state of charge in Spirit's battery go below 8.0 amp-hours (an amp-hour is equivalent to the amount of charge flowing for one hour from a current of 1 amp). By doing so, they hope to avoid a low-power fault condition, during which the rover goes to sleep until it senses that it has enough energy to wake up and communicate with Earth.

Spirit has come close to tripping a low-power fault a couple of times recently, but for the most part, the minimum battery state of charge has hovered around 8.5 amp-hours. Should the battery state of charge drop below that level, engineers would have to consider another course of action, such as further reducing the load or turning off the heater to the miniature thermal emission spectrometer, one of Spirit's scientific instruments.

Rover operators selected Friday as the day for building weekly activity plans for Spirit, because it naturally fits within the two-week cycle of updates to communications "windows" -- opportunities to transmit to and receive data from the rover via NASA's Odyssey spacecraft in orbit above Mars.

Spirit received the first seven-sol plan without a glitch. Preliminary reports indicate power and battery levels remain somewhat steady, but the team will be monitoring those numbers closely.

To further reduce Spirit's workload, engineers could continue to curtail communications via Odyssey as well as direct-from-Earth transmissions to the rover's high-gain antenna. Another approach would be to build activity plans lasting 14 sols, using only one high-gain uplink every two weeks for sending new plans to Spirit (with backups to make sure the rover receives them). Because the high-gain uplinks occur during peak solar power levels on the rover, reducing their frequency would not save as much energy as using fewer Odyssey transmissions.

The other downside is that, while a 14-sol plan would reduce the load on Spirit's battery, it would also result in receiving data less often from the spacecraft. Rover planners could try to listen for direct-to-Earth transmissions indicating potential problems, such as low-power faults or spacecraft clock issues. Still, listening for an indication of trouble does not compare to getting fresh data on a regular basis, making longer planning cycles undesirable.

Spirit is healthy and all subsystems are performing within normal range. Current solar array energy has been around 223 watt-hours per Martian day, or sol (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary

During the past week, Spirit completed the following activities:

Sol 1567 (May 30, 2008): Spirit received new commands from Earth and recharged the batteries.

Sol 1568: Spirit measured atmospheric opacity caused by dust (Tau) with the panoramic camera, sent data to NASA's Odyssey orbiter to be relayed to Earth, and recharged the batteries.

Sol 1569: Spirit soaked up the sunlight to recharge the batteries.

Sol 1570 (June 2, 2008): Spirit measured atmospheric opacity caused by dust (Tau) with the panoramic camera, sent data to NASA's Odyssey orbiter to be relayed to Earth, and recharged the batteries.

Sol 1571: Spirit received new commands from Earth and recharged the batteries.

Sol 1572: Spirit measured atmospheric opacity caused by dust (Tau) with the panoramic camera and recharged the batteries.

Sol 1573 (June 5, 2008): Spirit recharged the batteries.

Odometry:

As of sol 1570 (June 2, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1559-1566, May 22-29, 2008: *Energy Levels Reach Record Low*

Energy production reached a record low for Spirit this past week. On Sol 1560 (May 23, 2008), solar array input was 220 watt-hours (enough energy to light a 100-watt bulb for two hours and 12 minutes). On sol 1563, Spirit expended the highest amount of energy yet on running heaters to maintain minimum temperatures for batteries (30.6 watt-hours) and the miniature thermal emission spectrometer (54.0 watt-hours). Activity levels on Spirit have been kept low this week to compensate for the reduced energy production.

As was the case last week, Spirit had insufficient energy to transmit data to Earth each day. As a result, the operations team selected which Martian days, or sols, would be used for data downlinks to Earth.

Uplinks of communications from Earth have also been curtailed. Spirit typically has a daily communications window when the rover wakes up and points its High-Gain Antenna toward Earth and listens for new commands. By passing up on some of these uplink opportunities, the rover is able to stay awake for shorter periods of time each sol. Rover operators still have the ability to send new commands if necessary.

Despite low energy levels, Spirit continues to be in good health. The rover continues to conduct atmospheric observations, especially measurements of atmospheric opacity. As explained in last week's report, these Tau measurements of the amount of dust in the atmosphere provide valuable data for science and operations planning because they affect the amount of solar energy that reaches the rover's solar panels.

All subsystems are performing as expected.

Sol-by-sol summary:

In addition to receiving direct-from-Earth instructions over the rover's high-gain antenna, Spirit completed the following activities:

Sol 1559 (May 22, 2008): Spirit received new commands from Earth, measured atmospheric opacity caused by dust (Tau) with the panoramic camera and sent data to NASA's Odyssey orbiter to be relayed to Earth.

Sol 1560: Spirit again measured atmospheric dust with the panoramic camera and recharged the batteries.

Sol 1561: Spirit received new commands from Earth. The rover measured atmospheric darkness caused by dust with the panoramic camera.

Sol 1562: Spirit recharged the batteries.

Sol 1563: Spirit measured atmospheric dust with the panoramic camera and transmitted data to Odyssey.

Sol 1564: Spirit received new commands from Earth.

Sol 1565: Spirit recharged the batteries.

Sol 1566 (May 29, 2008): Spirit measured atmospheric opacity caused by dust with the panoramic camera and sent data to Odyssey to be relayed to Earth.

Odometry:

As of sol 1566 (May 29, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1552-1558, May 15-21, 2008: *Some Data Fly First Class, Others Fly Coach and Standby*

Lately, Spirit has begun assigning seating priorities to data traveling to Earth. The highest-priority, critical data are like first-class passengers who get to board first, followed by other critical data, who fly coach. These data are guaranteed a seat because they must be returned to Earth to enable engineers to plan the next round of activities.

Non-critical data are like standby passengers. They get to board only if there's room after all the critical data have been seated.

The reason for the seating arrangement is that Spirit's energy levels are so low that the rover has to miss out on some opportunities to transmit data to NASA's Odyssey orbiter, which relays data from the rover to Earth. Odyssey usually passes overhead twice a day, once in the very early morning and again in the afternoon. Spirit hasn't had enough energy to stay awake for a very-early-morning pass in nearly a year, and now is missing some afternoon passes as well.

Uplinks to Odyssey use more energy than the solar arrays have been able to provide, even during peak output at noon. Because Odyssey overflights occur late in the afternoon, they require even more battery power. By deleting some of the Odyssey passes, Spirit saves energy, though doing so limits the amount and "freshness" of the data.

In addition, not all Odyssey passes are created equal. When Odyssey passes directly overhead, communication is excellent, enabling transmission of a large volume of data. When the orbiter is lower in the sky (nearer the horizon), communication can be harder and data volumes smaller.

Last week, a combination of deleted communication links and low data volumes created a problem. The rover wasn't transmitting Tau measurements of sunlight-blocking dust in the Martian atmosphere. Spirit can go a few days without updating Tau measurements, but the longer engineers on Earth go without an update, the greater their uncertainty about actual conditions on Mars. To improve the timeliness of the data, they assigned a much higher priority to new Tau measurements. Spirit used the new priority on Sol 1555 (May 18, 2008).

Overall, Spirit remains healthy and all subsystems are performing as expected.

Energy production was down slightly during the past week, dropping from the previous week's average of 231 watt-hours to an average of 229 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Instead of remaining constant, energy declined by a watt-hour or two each Martian day, or sol. By the end of the week, power levels were down to 226 watt-hours.

Spirit has been a bit more active, using a little more battery energy and lowering the battery voltage. The lower voltage explains the lower energy production, because environmental factors such as Tau and the dust factor have remained nearly constant.

Tau, a measurement of the loss of sunlight as it passes through the atmosphere, averaged 0.23 the previous week and 0.24 this past week. The 0.01 change represents random fluctuations and is not significant. In both cases, 79 percent of the sunlight hitting Mars' atmosphere reached Spirit's solar arrays.

Spirit measures Tau by taking pictures of the Sun and calculating its brightness. A bright Sun means a low Tau, a dimmer Sun means a higher Tau. The time of day when Tau is measured makes a difference. A noontime Tau measures sunlight through the minimum depth of atmosphere. A sunset Tau measures sunlight as it travels along a slanting path through a thicker swath of atmosphere. By combining the measurements, the rover cancels out losses of sunlight caused by dust on the camera lens.

Tau measures direct sunlight only. As on Earth, dust both blocks and scatters light, and the scattered light changes direction and makes the whole sky seem to "glow." On Earth, the glow is bluish and causes the sky to appear blue. On Mars, the glow is pinkish. Without scattered light, the sky would look pitch black. Scattered light provides some of the rover's solar energy.

Spirit's other measure of energy loss is the dust factor, or the percentage of sunlight reaching the solar arrays that penetrates the dust to make electricity. The average dust factor dropped from 36 percent to 35 percent during the past week, though this, too, was not statistically significant.

Besides foregoing some of the Odyssey uplinks, Spirit has begun eliminating occasional higher-frequency links, known as X-band windows, as well. A communications window is a specific time interval when either the X-band or UHF radio is to be used to send data. When no communications window is active, the system defaults to using the X-band receiver with the low-gain antenna. Because the X-band receiver is always on when the rover is awake, Spirit doesn't save energy simply by deleting a communications window but is able to wake up later in the day, reducing overall energy use.

On Sols 1557 and 1558 (May 20-21, 2008), Spirit reset the on-board system of fiber-optic gyroscopes and solid-state accelerometers that help the rover keep track of where and how it moves. Known as the inertial measurement unit, the system measures changes in the

rover's orientation (yaw, pitch, and roll) and changes in the rover's location. (Activity plans run from roughly noon of one sol to noon of the next sol.)

Because each measurement has a small error, the sum of the measurements can accumulate a significant error (called "drift"). Normally, engineers correct this error by finding the Sun and comparing its actual position to where it would be if the inertial measurement system measurements were exact. Staying up to do that correction (called a "quick fine attitude") takes more energy than Spirit can spare and isn't necessary. Because Spirit hasn't moved since the last time the rover completed a quick fine attitude, engineers are able to use the values measured at that time.

Sol-by-sol summary:

In addition to receiving direct-from-Earth instructions over the rover's high-gain antenna, Spirit completed the following activities:

Sol 1552 (May 15, 2008): Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. The rover transmitted data to Odyssey during its afternoon pass.

Sol 1553: In the morning, Spirit acquired column 14, part 1 of the full-color "Bonestell panorama," using all 13 filters of the panoramic camera. Spirit measured atmospheric opacity caused by dust (Tau) with the panoramic camera. The rover checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument.

Sol 1554: In the morning, Spirit watched the sky for clouds with the navigation camera and acquired spot images of the sky for calibration purposes with the panoramic camera. Later, the rover measured atmospheric dust with the panoramic camera. Spirit checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument.

Sol 1555: In the morning, Spirit surveyed the external calibration target with the miniature thermal emission spectrometer, acquired six movie frames in search of clouds with the navigation camera, measured atmospheric dust with the navigation camera, and watched for dust devils. Spirit completed its first critical-priority Tau measurement of atmospheric dust and relayed data to the Odyssey orbiter.

Sol 1556: Spirit conducted no morning science activities and did not receive X-band radio instructions direct from Earth. The rover spent the day recharging the batteries.

Sol 1557: Spirit measured atmospheric dust opacity with the panoramic camera. The rover checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit transmitted data to Odyssey in the afternoon.

Sol 1558 (May 21, 2008): First thing in the morning, Spirit reset the inertial measurement unit and scanned the sky for clouds with the navigation camera. Later, the rover measured atmospheric dust opacity. Spirit checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Plans for the next morning called for Spirit to acquire column 16, part 1 of the full-color Bonestell panorama.

Odometry:

As of sol 1557 (May 20, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1546-1551, May 09-14, 2008: *Rover Hindered by Moon over Madrid*

Though Martian skies have been quite clear, the Moon recently prevented Spirit from having a clear view of Earth. Such events are rare, but during the past week, a lunar occultation prevented instructions from Earth from reaching the rover. In fact, they are so rare that the mission has never before had its communications blocked by a lunar occultation. There have been only two lunar occultations since the rover landed, but because they last only about 30 minutes, there is only a slight chance that they might interfere with a 20-minute uplink from Earth. If Spirit is on an energy-saving communications diet, as it is now, interference is even less likely. Spirit will not see another lunar occultation at least through the end of 2009.

At first, mission planners thought that light rainfall at NASA's Deep Space Network station near Madrid, Spain, might have absorbed the microwaves used to transmit the instructions. But the rain in Spain wasn't enough to stop the uplink. They also wondered if something was amiss at the station or on board the rover but found nothing wrong. Then someone had a brilliant idea: Where was the Moon? Sure enough, the Moon was directly between Spain and Spirit during the failed uplink on sol 1547 (May 10, 2008).

Winter Wattage

Overall, Spirit remains healthy and all subsystems are performing as expected. Power values have remained remarkably steady and energy has averaged 231 watt-hours, varying by only a single watt-hour (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau, a measure of atmospheric opacity, was 0.23 (resulting in 79 percent of direct sunlight passing through the atmosphere). The other 21 percent was either absorbed or scattered. (The scattered portion contributes to power levels but is not part of the tau measurement.)

The dust factor, too, has been steady at 0.36, meaning that only 36 percent of the sunlight that reaches the rover has been penetrating the dust to make electricity. It is this dust that has made life difficult for Spirit.

Mars passed its aphelion -- the farthest point from the Sun in its orbit -- on Sol 1549 (May 12, 2008) at 10:00 a.m. Local Solar Time, which happened to be 5:14 a.m. Pacific Daylight Time. In the southern hemisphere, where Spirit is located, Mars will be at its winter solstice -- the same day as the summer solstice in the red planet's northern hemisphere -- on Sol 1591 (June 24, 2008) at 22:13 LST

(10:30 p.m. Pacific Daylight Time). The winter solstice is effectively the "peak" or mid-point of winter, when the Sun is lowest in the northern sky. Weather conditions for Spirit are expected to improve after that time.

Mars Time

Local Solar Time (LST) is like ordinary civil time on Earth. Sixty Mars seconds make a Mars minute, 60 Mars minutes make a Mars hour, and 24 Mars hours make a Mars day, or sol. Because a sol is as long as 24.66 Earth hours, Mars time intervals are $24.66/24$ or 1.027 (2.7 percent) longer than corresponding time intervals on Earth. And, as on Earth, Martian time varies depending on location. Instead of universal time (UTC) or Pacific Daylight Time (PDT), Local Solar Time denotes the time at each rover's site. And just as different locations on Earth can be in different time zones, the rovers are in different time zones denoted "LSTA" or "LSTB."

Sequencing Blackout

Because Spirit is a robot, it needs to be told what to do and when to do it. The time-tagged series of commands for each sol's activities is known as a "sequence." Because it's hard to prepare more than three sequences in a single planning session, the rover's operators limit advance planning to no more than three sols at a time.

Shortly before planning Spirit's schedule of activities for sols 1547-1549 (May 10-12, 2008), engineers learned that their normal uplink session for sol 1550 (May 13, 2008) was needed by another mission. Because it was too late to adjust the sequencing plan and they couldn't create a four-sol plan, they decided to let sol 1550 be a "runout sol," during which the rover conducts very limited and standardized activities while awaiting a new set of instructions. If no new sequences arrive, the rover drops into "automode," waking up only for pre-programmed information exchanges, known as communication windows.

Spirit's operators expected the rover to attempt a standard "handover" from the old sequence for Sol 1549 (May 12, 008) to a new sequence for Sol 1550 (May 13, 2008) and then execute another runout for sol 1549 and attempt a handover to the sequence for sol 1551 (May 14, 2008), which by then would be on board the spacecraft.

Things don't always go as expected. The uplink of instructions on Sol 1547 (May 10, 2008) failed and the sequences for sols 1547-1549 did not get on board. Spirit began executing the runout on sol 1546 (May 9, 2008). Because this occurred on a weekend and the rover was safe, rover operators decided to wait until Monday to retransmit the sequences.

Again, things didn't go as expected. As a result of a lot of complexity, the sequences weren't transmitted on Sol 1549, either! All this time, Spirit continued to execute the sol 1546 runout, trying to hand over first to the Sol 1547 sequence, then the Sol 1548 sequence, and finally the Sol 1549 sequence. None were on board. Finally, after the third attempt, the Sol 1546 sequence ran out and Spirit dropped into automode on Sol 1549 at 11:51 LST.

Spirit remained in automode until the Sol 1551 sequence arrived along with a real-time activate command. The activate command started the Sol 1551 sequence and Spirit was resumed normal operations.

Interestingly, rover operators had planned to delete communications with the Odyssey orbiter to save energy. But Spirit didn't receive those instructions and went ahead and sent data to Earth on sols 1547 and 1549 (May 10 and May 12, 2008). Given the low level of activity during runout and automode, power levels were not adversely affected.

Robotic Arm Hibernation

To conserve power, Spirit's operators originally planned to stow the robotic arm in a winter hibernation position on Sol 1547. It turned out the arm would have been too cold to move without heating and team members had concerns about heating the robotic arm. Rover operators postponed the hibernation date to sol 1551 (May 14, 2008), when startup time would be later in the morning and temperatures would be warmer. They transmitted commands to move the arm. Confirmation would have to wait until sol 1552 (May 15, 2008).

The arm will remain in hibernation for several months. Members of the science team considered leaving the Mössbauer spectrometer in place on the soil until they realized they wouldn't have enough power to use it. They were also concerned about the possibility that a joint could fail. If that happened, they couldn't drive the following spring. They chose Spirit's winter hibernation position because it preserved the rover's ability to continue driving if the robotic arm "froze" in place, with the alpha-particle X-ray spectrometer in position to acquire atmospheric argon measurements. (Argon is a trace gas in the atmosphere. By measuring it, scientists can infer changes in barometric pressure).

With the arm in hibernation, Spirit will be ready for the worst of winter. The rover will still be active, acquiring more frames of the "Bonestell panorama" as well as other images and measurements, but activity levels will decrease as the winter solstice approaches. Engineers think they may be able to support limited science activities every sol or two.

Sol-by-sol summary:

In addition to receiving direct-from-Earth instructions over the rover's high-gain antenna, Spirit completed the following activities:

Sol 1546 (May 9, 2008): Spirit measured atmospheric opacity caused by dust -- known as tau -- with the panoramic camera, checked for drift (changes with time) in the miniature thermal emission spectrometer, and completed a mini-survey of the sky and ground with the spectrometer. Spirit did not relay data to Odyssey.

Sol 1547: In the morning, Spirit acquired column 16, part 2 of the Bonestell panorama, using all 13 filters of the panoramic camera, and monitored dust accumulation on the panoramic-camera mast assembly. The attempted uplink of a new sequence of activities to the rover was unsuccessful, causing Spirit to execute runout activities. The rover relayed data to Odyssey.

Sol 1548: In the morning, Spirit spent 10 minutes measuring atmospheric opacity caused by dust with the panoramic camera and again conducted runout activities, which included sending data to Odyssey and spending 10 minutes the next morning assessing atmospheric dust with the panoramic camera. The rover did not, as planned, acquire thumbnail images of the sky or complete a horizon survey with the panoramic camera.

Sol 1549: Spirit conducted runout activities and dropped into automode.

Sol 1550: Spirit remained in automode. The rover's only activity was the transmission of data to Odyssey.

Sol 1551 (May 14, 2008): Spirit was to move the robotic arm to the winter hibernation position. The rover was not instructed to communicate with Odyssey.

Odometry:

As of sol 1551 (May 14, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles)

sol 1532-1538, Apr 24-30, 2008: *"Catch-22": Staying Awake vs. Going to Sleep*

Spirit's Tau measurements of atmospheric dust have remained steady, but solar array input has dropped a bit to 235 watt-hours per sol. Spirit still has enough energy to squeeze in Mössbauer studies of iron-bearing minerals at a time of year when the rover's handlers expected Spirit to be concerned only with survival. At present, the rover's target of scientific interest is a soil exposure nicknamed after Arthur C. Harmon, a former Tuskegee airman. Spirit conducted 8 more hours of Mössbauer integration, for a total of 12 hours. Scientists hope the rover will be able to collect 36 more hours' worth of data from the same target. Meanwhile, Spirit continued to acquire panoramic-camera images, using all 13 color filters, of the "Bonestell panorama," informally named in honor of famed space artist Chesley Bonestell.

Concerned that cold winter temperatures on Mars might trigger the survival heaters on the rover electronics module, rover planners took the extra precaution of disabling those particular heaters on sol 1533 (April 25, 2008) to conserve power. With the heaters turned off, the rover's handlers must monitor temperatures carefully to make sure the module doesn't get too cold. Besides the survival heaters, the remaining means of keeping the module warm enough during the night is to generate more heat during the day by keeping the rover awake for about one additional hour. Of late, 39 minutes is the shortest possible awake time for conducting minimal activities. Another 20-plus minutes of awake time are needed on days when the rover transmits data to NASA's Odyssey orbiter during its overhead pass. On other sols, rover planners may arbitrarily increase the rover's awake time to 50 minutes or longer to generate enough heat to keep the electronics module alive, even if science activities do not require Spirit to be awake that long.

In summary, the challenge for Spirit's handlers during each planning cycle is to recharge the battery enough to do significant science, then recharge the battery again to transmit data to Odyssey for downlink to Earth. By keeping the rover awake for shorter periods, they conserve energy but generate less thermal inertia (heat) for keeping the rover electronics module alive. The more consecutive sols that go by without transmitting temperature and power updates to Odyssey and from there to Earth, the more Spirit's handlers must rely on margin ("wiggle room") from earlier predictions and keep the rover awake longer to protect the electronics module. As a result, Spirit is caught in a "catch-22" set of tradeoffs among power, heat, communications, and science. This delicate balance will become increasingly more precarious as the rover moves closer to the winter solstice, with its even colder temperatures and lower solar array input.

Sol-by-sol summary:

In addition to measuring atmospheric dust levels with the panoramic camera and receiving direct-from-Earth instructions via the rover's high-gain antenna, Spirit completed the following activities:

Sol 1532 (April 24, 2008): Spirit spent 8 hours acquiring data from Arthur C. Harmon with the Mössbauer spectrometer.

Sol 1533: In the morning, Spirit took spot images of the sky with the panoramic camera for calibration purposes and acquired panoramic-camera images of the dune field known as "El Dorado." The rover recharged the battery, disabled the survival heaters on the rover electronics module, and shortened the "Up_Too_Long" computer sequence to 30 minutes.

Sol 1534: Spirit recharged the battery and relayed data to NASA's Odyssey orbiter for transmission to Earth.

Sol 1535: Spirit recharged the battery.

Sol 1536: Spirit recharged the battery and relayed data to the Odyssey orbiter. The rover checked for drift (changes with time) in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. The rover was awake for a total of 61 minutes.

Sol 1537: In the morning, Spirit acquired full-color images, using all 13 filters of the panoramic camera, of column 12, part 2 of the Bonestell panorama. The rover recharged the battery, checked for drift in the miniature thermal emission spectrometer, and surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit was awake for a total of 39 minutes.

Sol 1538 (April 30, 2008): Spirit checked for drift in the miniature thermal emission spectrometer and surveyed the sky and ground with the instrument. After sending data to Odyssey, the rover used the alpha-particle X-ray spectrometer to measure argon gas in the Martian atmosphere. Plans for the next morning called for Spirit to complete work on column 12, part 3 of the Bonestell panorama.

Odometry:

As of sol 1538 (April 30, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1525-1531, Apr 17-23, 2008: *Rover "Spirit" High Despite Low Power Levels*

Given the substantial coating of dust on the solar array, Spirit continues to enjoy energy levels that are higher than expected for this time of year, at around 240 watt-hours per sol (enough energy to light two 100-watt bulbs and one 40-watt bulb for one hour).

Spirit continues to make progress on the full-color "Bonestell panorama" of the rover's winter surroundings. Of 27 columns of stacked images needed for a complete mosaic, Spirit has completed work on 11 columns, each comprising three parts. Each Martian day, or sol, Spirit has enough energy to complete one part. Science team members have nicknamed the panorama after Chesley Bonestell (1888-1986), considered the father of modern space art.

Analysis of iron-bearing minerals in a patch of undisturbed soil will require an estimated 24 hours of data collection during the coming week with the Mössbauer spectrometer. The soil target is known informally as "Arthur C. Harmon." Spirit can complete 4 to 8 hours of integration with the spectrometer before needing to recharge the batteries. To conserve power, Spirit is on a communications diet, in which the rover limits data transmissions to Earth to, at most, every other sol.

Spirit is healthy and all systems are operating as expected.

Sol-by-sol summary:

In addition to communication activities that include direct-from-Earth instructions via the rover's high-gain antenna and, power permitting, data relays to Earth via the Odyssey orbiter, Spirit continues to monitor atmospheric dust levels with the panoramic camera, check for drift (changes with time) in the miniature thermal emission spectrometer, and survey the sky and ground with the spectrometer. During the past week, Spirit also completed the following activities:

Sol 1525 (April 17, 2008): Spirit acquired column 10, part 1 of the Bonestell panorama, using all 13 filters of the panoramic camera.

Sol 1526: In the morning, Spirit surveyed the external calibration target with the miniature thermal emission spectrometer and parked the panoramic camera mast assembly with the panoramic camera pointed below the horizon to minimize dust accumulation.

Sol 1527: In the morning, Spirit completed work on column 10, part 2 of the Bonestell panorama, then parked the panoramic camera mast assembly with the panoramic camera pointed below the horizon to minimize dust accumulation. The rover exchanged tools to put the Mössbauer spectrometer in position to study Arthur C. Harmon.

Sol 1528: Spirit spent the morning working on column 10, part 3 of the Bonestell panorama. The rover relayed data to Odyssey for transmission to Earth.

Sol 1529: Spirit acquired column 11, part 1 of the Bonestell panorama and spent 4.5 hours acquiring data from Arthur C. Harmon with the Mössbauer spectrometer.

Sol 1530: In the morning, Spirit monitored dust on the panoramic camera mast assembly and acquired column 11, part 2 of the Bonestell panorama. The rover then completed work on column 11, part 3 of the panorama and relayed data to Odyssey.

Sol 1531: (April 23, 2008): Spirit recharged the battery. The following morning, Spirit was to acquire column 12, part 1 of the Bonestell panorama.

Odometry:

As of sol 1531 (April 23, 2008), Spirit's total odometry remained at 7,528.0 meters (4.7 miles).

sol 1517-1524, Apr 09-16, 2008: *Spirit Still "Sitting Pretty" for This Time of Year*

Despite a slight increase in atmospheric opacity caused by dust, Spirit is still enjoying higher-than-expected energy levels for this time of year. Solar array input has been approximately 240 watt-hours per Martian day, or sol (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Clear skies have had the unfavorable effect, however, of causing a drop in temperatures at the surface of Mars, increasing the bitter cold experienced by Spirit's rover electronics module. Nighttime temperatures are creeping closer to the point where they will trigger the survival heaters, which draw a large amount of power. A much more desirable strategy is to keep Spirit awake long enough each day to keep the electronics module sufficiently warm with heat from normal operations, providing more time for science observations. "Awake time" vs. heating time is just one of the many trade-offs the team makes each day to keep Spirit going through the Martian winter.

Sol-by-sol summary:

In addition to daily communications that include direct-from-Earth instructions via the rover's high-gain antenna and, as power permits, data relays to Earth via the Odyssey orbiter, Spirit continues to monitor atmospheric dust levels each day with the panoramic camera. In addition, during the past week, Spirit completed the following activities:

Sol 1517 (April 9, 2008): Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer; acquired column 8, part 3 of the full-color "Bonestell Panorama" using all 13 filters of the panoramic camera; and shot movie frames in search of clouds with the navigation camera.

Sol 1518: Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer; acquired a 2-by-1-by-1 stack of microscopic images of the rover's solar array; acquired column 9, part 1 of the Bonestell panorama; and took spot images of the

sky for calibration purposes with the panoramic camera.

Sol 1519: Spirit surveyed the rover's external calibration target with the miniature thermal emission spectrometer and acquired column 9, part 2 of the Bonestell panorama. To conserve energy, the rover did not relay data to Odyssey.

Sol 1520: Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer; measured atmospheric opacity caused by dust with the navigation camera (as well as the panoramic camera); and acquired movie frames in search of clouds with the navigation camera. The rover took spot images of the sky and surveyed the horizon with the panoramic camera. Spirit did not relay data to Odyssey.

Sol 1521: Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer; calibrated the elevation of the miniature thermal emission spectrometer; and acquired column 9, part 3 of the Bonestell panorama.

Sol 1522: Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer; took thumbnail images of the sky and surveyed the horizon with the panoramic camera; and acquired lossless-compression images of wind-blown deposits next to the rover with the hazard-avoidance cameras. Spirit did not relay data to Odyssey.

Sol 1523: Spirit recharged the battery and did not relay data to Odyssey.

Sol 1524: (April 16, 2008): Spirit recharged the battery.

Odometry:

As of sol 1524 (April 16, 2008), Spirit's total odometry remained at 7,528.07 meters (4.68 miles).

sol 1511-1516, Apr 03-08, 2008: *Clear Skies at "Home Plate"*

Spirit is currently experiencing the clearest skies seen by either of NASA's two Mars Exploration Rovers. On sol 1511 (April 3, 2008), Tau measurements of atmospheric dust hit an all-time low of 0.127. By sol 1516 (April 8, 2008), this measurement had increased slightly to 0.170. The low Tau values have held power levels at around 250 watt-hours (enough energy to light a 100-watt bulb for about 2.5 hours). If Tau were not so cooperative, Spirit would be getting only about 200 watt-hours of energy, compelling the rover's handlers to disable the heaters on the miniature thermal emission spectrometer and take other measures to conserve power.

The engineering team still expects to implement energy-conservation strategies, but not for several weeks. Meanwhile, Spirit continues to make progress on remote-sensing activities, scientific investigations, and the "Bonestell panorama" of the rover's view from the north rim of "Home Plate."

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera and survey the sky and ground with the miniature thermal emission spectrometer. In addition, during the past week, Spirit completed the following activities:

Sol 1511 (April 3, 2008): Spirit took thumbnail images of the sky with the panoramic camera.

Sol 1512: Spirit gathered compositional data from the soil target known as "Arthur C. Harmon" using the alpha-particle X-ray spectrometer. The rover used the panoramic camera to acquire super-resolution images of a target informally named "Arthur C. Clarke."

Sol 1513: Spirit acquired column 7, part 3 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera.

Sol 1514: Spirit pointed the alpha-particle X-ray spectrometer skyward to measure argon gas in the Martian atmosphere and acquired stability images of the rover's 30-degree tilt. The rover transmitted data to Odyssey and spent about 4.5 hours measuring atmospheric argon. Spirit also acquired column 8, part 1 of the Bonestell panorama and took spot images of the sky for calibration purposes with the panoramic camera.

Sol 1515: Spirit surveyed the sky with the panoramic camera and monitored dust on the panoramic camera mast assembly.

Sol 1516: (April 8, 2008): Spirit acquired column 8, part 2 of the Bonestell panorama and surveyed the horizon with the panoramic camera.

Odometry:

As of sol 1516 (April 8, 2008), Spirit's total odometry remained at 7,528.07 meters (almost 4.68 miles).

sol 1504-1510, Mar. 27 - Apr 02, 2008: *Spirit Advances Toward Midwinter*

Seasons are about twice as long on Mars as on Earth and are offset relative to Earth because Mars takes about twice as long to complete one orbit around the Sun. At Spirit's location, the fall equinox -- the start of fall, when night and day are equal in length -- arrived Dec. 12, 2007. The winter solstice -- the time of year with the shortest day -- will arrive June 25, 2008.

Solar array energy has varied from 244 watt-hours to 256 watt-hours, averaging 250.4 watt-hours for this period (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau, the measure of atmospheric dust, has averaged 0.16, varying by only a hundredth. The dust factor has been nearly constant at 0.35, meaning 35 percent of the sunlight reaching the arrays penetrates

the dust layer to make electricity. A low Tau is good because it means the skies are fairly clear; a low dust factor is bad because it means the solar arrays are coated with a fair amount of dust.

Astronomers use the symbol L(s) -- pronounced L-sub-s -- to denote how far Mars has progressed in its orbit around the Sun. If you imagine looking down at the solar system, with the Sun in the middle and Mars orbiting around it, L(s) gives the location of Mars. By definition, L(s) = 0 degrees when the Sun crosses the Martian equator. This is the first day of Martian spring, the vernal equinox, when night and day are equal in length, in the northern hemisphere. It's also the first day of fall, the autumnal equinox, in the southern hemisphere. At Spirit's location in Mars' southern hemisphere, the season is currently mid- to late fall, and L(s) is about 55 degrees, roughly equivalent to Nov. 17 in Earth's northern hemisphere and May 18 in Earth's southern hemisphere. L(s) will equal 90 degrees at the time of the winter solstice.

Spirit is healthy and all subsystems are performing as expected.

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera, check for drift (changes with time) in the miniature thermal emission spectrometer, and survey the sky and ground with the instrument. In addition, during the past week, Spirit completed the following activities:

Sol 1504 (March 27, 2008): Spirit calibrated the miniature thermal emission spectrometer and acquired a microscopic image of the capture magnet.

Sol 1505: Upon awakening, Spirit took spot images of the sky for calibration purposes with the panoramic camera and acquired column 6, part 1 of the full-color "Bonestell panorama" using all 13 filters of the panoramic camera. The rover also recharged the battery.

Sol 1506: Spirit acquired column 6, part 2 of the Bonestell panorama and monitored dust on the panoramic-camera mast assembly. Spirit looked at the miniature thermal emission spectrometer for calibration purposes, acquired microscopic images of the solar panel, and acquired images of the external magnets, which capture magnetic dust particles, using the panoramic camera.

Sol 1507: Spirit acquired column 6, part 3 of the full-color Bonestell panorama and recharged the battery.

Sol 1508: Spirit acquired column 7, part 1 of the full-color Bonestell panorama and relayed data to Odyssey during the orbiter's afternoon pass overhead.

Sol 1509: Spirit surveyed the sky at high Sun with the panoramic camera and completed a "runout" of previously loaded activities after not being able to receive new instructions from Earth. The rover recharged the battery and relayed data to Odyssey.

Sol 1510: (April 2, 2008): Spirit acquired a 1-by-1-by-3 stack of microscopic images of a soil target known informally as "Arthur_C_Hammon" and placed the alpha-particle X-ray spectrometer on the soil target. Plans for the following morning called for Spirit to acquire column 7, part 2 of the full-color Bonestell panorama.

Odometry:

As of sol 1509 (April 1, 2008), Spirit's total odometry was 7,528 meters (almost 4.7 miles).

sol 1498-1503, Mar. 20-26, 2008: *Spirit Sees Clearest Skies Since Landing on Mars!*

Like a calm after the recent Martian dust storms, atmospheric dust above Spirit's overwintering site has reached the lowest levels the rover has seen since arriving on Mars. To be sure, sunblocking dust that has settled on the rover's solar panels and low-angle winter sunlight have combined to reduce Spirit's energy levels. But clear skies mean more sunlight penetrates the atmosphere, making rover planners optimistic that Spirit will have a slim but adequate amount of energy to survive until Martian spring.

Earlier estimates predicted a near-starvation energy diet for Spirit during the darkest days of winter. The coming winter solstice, the peak of Martian winter, will be June 25, 2008. To conserve energy, Spirit may have to disable some heaters and curtail communications and other activities, but is expected to be able to conduct limited scientific investigations.

Solar-array energy during the past week has varied between 244 watt-hours and 254 watt-hours, averaging 249.5 watt-hours for the period (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Tau, the measure of atmospheric dust, has averaged 0.2, varying by only a few hundredths. The dust factor has been nearly constant at 0.36 (meaning 36 percent of the sunlight reaching the arrays penetrates the dust layer to make electricity). A low Tau is good; a low dust factor is bad.

Because dust is constantly settling out from the Martian atmosphere onto the solar arrays, Tau and the change in the dust factor are related. When Tau is high, the dust factor rapidly decreases as dust from the atmosphere rains onto the arrays. When Tau is low (as it is now), the atmosphere carries less dust and the dust factor decreases more slowly. The clearer atmosphere doesn't affect dust already on the solar arrays, but it does affect the rate at which new dust is added.

The atmosphere above the Spirit site is remarkably clear at present and Tau has been as low as 0.170 -- the lowest seen by Spirit in the entire mission. Not surprisingly, the dust factor has been virtually unchanged.

Spirit also analyzed material on the external capture magnet. Spirit has several magnets of which two, the capture and filter magnets, are mounted at the front of the solar array. The capture magnet is relatively strong, the filter magnet only half as strong.

Viking data from the 1970s showed that Martian dust was slightly magnetic, comprising 1 to 7 percent magnetic material. Spirit's filter and capture magnets winnow the dust for this material. The capture magnet, being stronger, gathers all magnetic materials while the filter magnet retains only the most magnetic particles. Using the alpha-particle X-ray spectrometer, Spirit can determine the chemical composition of the captured particles. The observations will help scientists ascertain whether the magnetic material is uniform or has more than one constituent. The dust composition provides insight into whether the magnetic material is the product of weathering in the presence of water or weathering of dry bedrock.

Spirit continued to scale back the frequency of afternoon communications with the Odyssey orbiter to save energy. Overhead passes by Odyssey happen late in the day when little solar energy is available, requiring the use of significant battery power. By deleting some of the passes, Spirit can conserve energy acquired earlier in the day to provide power for subsequent science observations. The downside is that fewer passes slow the rate at which pictures and other data can be downlinked to Earth.

Spirit continued work on the Bonestell (Bon-ES-tell) panorama, a high-resolution, 360-degree mosaic of images divided into wedges (columns) spanning roughly 5 compass degrees and extending from near the rover to just above the horizon. Each column typically has three or four separate images or "parts." The panorama is named for Chesley Bonestell (1888-1986), considered the "father of modern space art."

Spirit is healthy and all subsystems are performing as expected.

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera, check for drift (changes with time) in the miniature thermal emission spectrometer, and survey the sky and ground with the instrument. In addition, during the past week, Spirit completed the following activities:

Sol 1498 (March 20, 2008): Spirit placed the alpha-particle X-ray spectrometer on the capture magnet, took images with the hazard avoidance cameras, took images with the navigation camera for lossless-compression visual odometry, and relayed data to Odyssey.

Sol 1499: Spirit acquired column 4, part 2 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera.

Sol 1500: Spirit acquired column 4, part 3 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera.

Sol 1501: Spirit acquired column 5, part 1 of the full-color Bonestell panorama and relayed data to Odyssey during the orbiter's afternoon pass.

Sol 1502: Spirit took six movie frames in search of clouds with the navigation camera and acquired column 5, part 2 of the Bonestell panorama. Using the alpha-particle X-ray spectrometer, Spirit acquired data on the elemental composition of magnetic particles on the external capture magnet.

Sol 1503 (March 26, 2008): Spirit acquired column 5, part 3 of the Bonestell panorama and relayed data to Odyssey. Plans for the following morning called for Spirit to acquire super-resolution images of a rock target informally named "Roger_Zelazny" (after the science fiction author) with the panoramic camera.

Odometry:

As of sol 1501 (March 23, 2008), Spirit's total odometry was 7,528.07 meters (4.68 miles).

sol 1491-1497, Mar. 13-19, 2008: *Spirit Phones Home to Set Clock*

Spirit is feeling the strain of juggling activities on Mars in the face of declining power levels as the winter Sun sinks lower on the horizon. After acquiring compositional data from a rock target informally named "Wendell Pruitt," Spirit had to wait a few sols (Martian days) to have enough energy to conduct atmospheric studies and move the robotic arm out of the way for a panoramic-camera portrait of a rock target known as "Freeman." First, the rover had to make a "phone call" to Earth to correct for drift -- changes in time -- in the spacecraft clock.

When Spirit phones home using a direct-to-Earth, X-band communications link, the rover's transmitter has to be running, which requires a fair amount of energy. During more typical, direct-from-Earth communications, only the rover's receiver has to be on. To set the spacecraft clock, Spirit transmits a data product called a time packet. The time packet is used to synchronize the rover's clock back to Earth time (also known as Universal Time). A previous attempt to relay the time packet was unsuccessful, causing Spirit's clock to be off by as much as a minute and a half.

In addition to resetting the clock, Spirit completed a light schedule of activities on sols 1493-1494 (March 15-16, 2008). By sol 1496 (March 18, 2008), Spirit had generated enough solar power to proceed with measurements of argon gas in the Martian atmosphere and studies of the Freeman rock target. Interspersed with those activities, Spirit continued to work on the "Bonestell panorama" and take panoramic-camera images of a target dubbed "C.S. Lewis." The rover spent sols 1492, 1494, and 1497 (March 14, 16, and 19, 2008) recharging the battery, conducting only minimal science activities, and storing data for later transmission to Earth.

Spirit continued to have difficulty receiving spacecraft commands via the rover's high-gain, X-band, dish antenna as a result of the mast that holds the panoramic and navigation cameras getting in the way and partially obscuring the signal. To help address this challenge, rover planners had Spirit complete a self-assessment to see if the rover could independently recognize an occlusion of the high-gain signal and respond by swiveling the high-gain antenna to a different position. The self-assessment, on sol 1493 (March 15, 2008), was successful. Spirit used the technique prior to an actual uplink session on sol 1496 (March 18, 2008), when the rover's handlers were

expecting a particularly severe occlusion. The activity was successful and the uplink did not appear to be impeded in any way. Currently, this activity involves having the rover use a temporary parameter that then goes away when the rover shuts down for a nap. Rover planners are considering making the temporary parameter permanent.

Looking forward, Spirit will go increasingly into "hibernate" mode as the Sun continues to dim. Rover planners predict Spirit will be able to conduct science activities until about late April.

Spirit is healthy and all subsystems are performing as expected. The latest available power readings from sol 1496 (March 18, 2008) showed power at 249 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Spirit has no plans to move before the next Martian spring and is hard at work accomplishing as much as possible before power levels drop to a point that temporarily precludes use of the scientific instruments on the rover's arm.

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera, check for drift (changes with time) in the miniature thermal emission spectrometer, and survey the sky and ground with the instrument. In addition, during the past week, Spirit completed the following activities:

Sol 1491 (March 13, 2008): After communicating with Odyssey, Spirit studied the elemental composition of "Wendell Pruitt" with the alpha-particle X-ray spectrometer.

Sol 1492: In addition to monitoring atmospheric dust and conducting surveys with the miniature thermal emission spectrometer, Spirit recharged the battery.

Sol 1493: Spirit initiated a direct-to-Earth communications link using the X-band antenna and transmitted a data packet to correct the spacecraft clock.

Sol 1494: In addition to monitoring atmospheric dust and conducting surveys with the miniature thermal emission spectrometer, Spirit recharged the battery.

Sol 1495: In the morning, Spirit acquired column 3, part 1 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera. Spirit positioned the alpha-particle X-ray spectrometer to measure argon gas in the Martian atmosphere. The rover took a single-frame image with the navigation camera. After communicating with Odyssey, Spirit measured argon with the alpha-particle X-ray spectrometer.

Sol 1496: Spirit monitored dust accumulation on the rover mast and acquired column 3, part 3 of the full-color Bonestell panorama. The rover acquired full-color images, using all 13 filters of the panoramic camera, of the Freeman rock target.

Sol 1497 (March 19, 2008): Spirit looked for changes in the "El Dorado" dune field with the panoramic camera and acquired column 4, part 1 of the Bonestell panorama. The rover recharged the battery. The following morning, Spirit was to acquire movie frames in search of clouds with the navigation camera, acquire super-resolution, panoramic-camera images of a target dubbed "C.S. Lewis half," and survey the horizon with the panoramic camera.

Odometry:

As of sol 1496 (March 18, 2008), Spirit's total odometry was 7,528 meters (almost 4.7 miles).

sol 1484-1490, Mar. 6-12, 2008: *Spirit Begins Preparing for "Hibernation" Mode*

Spirit has reached its final position for the coming Martian winter and has no plans to move before the next Martian spring. During the next few months, the rover will increasingly go into a "hibernate" mode as the sun continues to dim.

Spirit is currently wrapping up a campaign of scientific studies of the rock target known as "Wendell Pruitt," interspersed with remote science observations of targets nicknamed "Lucius Theus" and "Theopolis Johnson." These targets were all named in honor of distinguished members of the "Tuskegee Airmen," the popular name for the 332nd Fighter Group, an all African-American unit of the U.S. Army Air Corps that served in the European Theater during World War II.

Spirit's previous attempt to use the wire brush on the rock abrasion tool on sol (Martian day) 1479 (March 1, 2008) failed to sufficiently brush the surface of Wendell Pruitt. The rover repeated the effort on sol 1484 (March 6, 2008) with greater success. On sol 1486 (March 8, 2008), Spirit acquired a 2-by-2-by-5 stack of stereo microscopic images of Wendell Pruitt. The rover placed the alpha-particle X-ray spectrometer on the target on sol 1489 (March 11, 2008) but postponed data collection with the instrument to conserve power for an operational readiness test in support of the Phoenix mission scheduled for the late morning of sol 1491 (March 13, 2008). At that time, the rover was to send a tone at UHF frequencies directly to the Green Bank radio telescope in West Virginia. The tone was to serve as a beacon; the rover would not be transmitting data.

Spirit continued to take panoramic-camera images for the 360-degree "Bonestell panorama." The rover recharged its battery on sols 1485, 1487, 1488, and 1490 (March 7, 9, 10, and 12, 2008). On recharge days, the rover typically conducts minimal science activity and does not relay Earthbound data to the Odyssey orbiter as it passes overhead.

A complication in Spirit's current circumstances is that the mast holding the panoramic and navigation cameras is partially obscuring the X-band, high-gain antenna that Spirit's handlers use to command the spacecraft from Earth. Engineers have been experimenting with "parking" these instruments in positions that minimize this obscuration.

Spirit is healthy and all subsystems are performing as expected. The latest available power readings from sol 1489 (March 11, 2008) showed power at 254 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera, check for drift (changes with time) in the miniature thermal emission spectrometer, and survey the sky and ground with the instrument. In addition, during the past week, Spirit completed the following activities:

Sol 1484 (March 6, 2008): Spirit brushed the surface of Wendell Pruitt, acquired a single-frame, lossless-compression (high-resolution) image of the area in front of the rover with the navigation camera, and took stereo images with the front hazard avoidance cameras.

Sol 1485: Spirit acquired super-resolution images of half of Lucius Theus and recharged the battery.

Sol 1486: Spirit surveyed the horizon and took spot images of the sky for calibration purposes with the panoramic camera. Spirit monitored dust on the rover mast and acquired a 2-by-2-by-5 stack of stereo microscopic images of Wendell Pruitt. The rover acquired a single-frame, lossless-compression image of the area in front of the rover with the navigation camera as well as stereo images with the front hazard avoidance cameras.

Sol 1487: In the morning, Spirit acquired column 2, part 3 and column 3, part 1 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera, then spent much of the Martian day recharging the battery.

Sol 1488: In the morning, Spirit used the navigation camera to take images of the sky (called "sky flats") for calibration purposes and used the panoramic camera to take super-resolution images of Theopolis Johnson. The rover turned the panoramic camera mast assembly to prepoint the camera, then recharged the batteries.

Sol 1489: Spirit placed the alpha-particle X-ray spectrometer on Wendell Pruitt and, after relaying data to Odyssey, acquired data with the instrument.

Sol 1490 (March 12, 2008): Spirit acquired column 3, part 2 of the Bonestell panorama and recharged the batteries. Plans for the next morning called for Spirit to acquire thumbnail panoramic-camera images of the sky looking starboard (to the rover's right) for calibration purposes.

Odometry:

As of sol 1489 (March 11, 2008), Spirit's total odometry remained at 7,528.07 meters (4.68 miles).

sol 1478-1483, Feb. 29- Mar. 05, 2008: *Work Continues on 360-Degree View of Spirit's Winter Perch*

Spirit continued work on the "Bonestell panorama," a full-color, 360-degree view of the rover's surroundings from its overwintering perch on the north-facing edge of "Home Plate." Spirit acquired images for the panoramic mosaic on sols 1478, 1479, 1480 and 1483 (Feb. 29, March 1-2, and March 5, 2008). By the time the final product is ready, the rover will have completed an estimated 60 separate pointings of the panoramic camera in all different directions. Rover planners have nicknamed the panorama in honor of Chesley Bonestell (1888-1986), considered the father of modern space art.

Spirit has also been engaged in efforts to brush away dust from a rock target known as "Wendell Pruitt." The rover used the rock abrasion tool to brush the surface on sol 1479 (March 1, 2008), but the brushing cleared only about half the expected area. On the basis of the results, the rover's handlers adjusted the command sequence to have Spirit perform a "grind scan" to locate the surface of Wendell Pruitt on sol 1482 (March 4, 2008). The goal of this maneuver was to get the rock abrasion tool in place for another attempted brushing, scheduled for sol 1484 (March 6, 2008).

Spirit is healthy and all subsystems are performing as expected.

Sol-by-sol summary:

To conserve energy, mission planners have restricted the number of sols on which Spirit receives direct-from-Earth instructions via the rover's high-gain antenna and transmits data to Earth via the Odyssey orbiter. Spirit continues, on a daily basis, to monitor atmospheric dust levels with the panoramic camera, check for drift (changes over time) in the miniature thermal emission spectrometer, and survey the sky and ground with the instrument. In addition, during the past week, Spirit completed the following activities:

Sol 1478 (Feb. 29, 2008): Spirit acquired column 1, part 2 of the full-color, panoramic camera images, using all 13 filters of the camera, that will make up the Bonestell panorama. Spirit also recharged the batteries.

Sol 1479: Using the wire brush on the rock abrasion tool, Spirit brushed the surface of Wendell Pruitt. The rover acquired a single-frame, lossless-compression (highly detailed) image of the area in front of the rover using the navigation camera. Spirit relayed data at UHF frequencies to NASA's Odyssey orbiter for transmission to Earth.

Sol 1480: Spirit acquired column 1, part 3 of the Bonestell panorama and measured argon gas in the Martian atmosphere with the alpha-particle X-ray spectrometer.

Sol 1481: Spirit acquired column 2, part 1 of the Bonestell panorama, and recharged the batteries.

Sol 1482: Spirit acquired an image with the panoramic camera pointing south, then completed "Grind Scan2" of the surface of "Wendell Pruitt." The rover acquired a single-frame, lossless-compression image of the area in front of the spacecraft with the navigation camera.

Spirit relayed data at UHF frequencies to NASA's Odyssey orbiter for transmission to Earth.

Sol 1483 (March 5, 2008): Early in the day, Spirit acquired a super-resolution image of the target nicknamed "FredericBrown half" with the panoramic camera. The rover recharged the batteries. The following morning, Spirit was to acquire full-color, panoramic camera images of column 2, part 2 of the Bonestell panorama.

Odometry:

As of sol 1482 (March 4, 2008), Spirit's total odometry remained at 7,528.07 meters (4.68 miles).

sol 1471-1477, Feb. 22-28, 2008: *Sturdy Rover Gets No Penalty for Tilting*

Scarcely a pinball wizard on Earth could tilt the machine nearly 30 degrees without ending play, yet engineers tilted NASA's Spirit rover 29.9 degrees and completed the robotic equivalent of a one-armed toe-touch to test its stability. The rover remained in play, racking up scientific data points after remaining perfectly balanced even while pressing the ground with the Möessbauer spectrometer at the end of its robotic arm.

During the past week, Spirit began work on a 360-degree, full-color panorama of the rover's winter surroundings as viewed from the north edge of the elevated, volcanic plateau known as "Home Plate." The resulting mosaic of high-resolution images, to be acquired during approximately 60 individual pointings of the panoramic camera, will be nicknamed the "Bonestell panorama" in honor of Chesley Bonestell (pronounced BON-es-tell), a science fiction illustrator and designer. (Last year's spectacular image mosaic of Spirit's winter haven was called the "McMurdo panorama.")

Spirit took microscopic images of dust that has settled out of the Martian sky onto the solar panels. The rover also made two attempts to complete the first of a two-part process for brushing the surface of a rock target dubbed "Wendell Pruitt" with the rock abrasion tool, another of the instruments on the rover's robotic arm. Because the results were inconclusive after the first try, Spirit's handlers decided to have the rover repeat the procedure, known as a "grind scan," during which the rover locates the surface by touching it with the brush and the grinding bit, two days later. The second attempt was successful, clearing the way for actual brushing of Wendell Pruitt.

Spirit is healthy and all subsystems are performing as expected.

Sol-by-sol summary:

In addition to measurements of atmospheric dust levels with the panoramic camera and daily communications activities, which include morning direct-from-Earth uplinks over the rover's high-gain antenna and evening relays to Earth via the UHF antenna on the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1471 (Feb. 22, 2008): Spirit completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer, touched the ground and exerted 10 newtons of force with the Möessbauer spectrometer to test the rover's stability at the new tilt of 29.9 degrees, and acquired super-resolution images of a target dubbed "Gekko." Spirit took spot images of the sky for calibration purposes using the panoramic camera.

Sol 1472: Spirit checked for drift (changes over time) in the miniature thermal emission spectrometer, surveyed the external calibration target and completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer, and acquired super-resolution images of a rock target known as "Monolith" with the panoramic camera.

Sol 1473: Spirit acquired full-color images, using all 13 filters of the panoramic camera, of a rock target dubbed "William A. Johnston," a deceased member of the Tuskegee Airmen. Spirit checked for drift in the miniature thermal emission spectrometer, completed a mini-survey of the sky and ground with the instrument, and acquired a 2-by-2-by-1 stack of microscopic images of a target on the rover's solar panels as well as microscopic images of the external capture magnet and filter magnet. The rover acquired single-frame, lossless-compression (high-definition) images of the area directly in front of the rover with the navigation camera.

Sol 1474: Spirit monitored dust on the rover mast, surveyed the sky at varying elevations and the ground with the miniature thermal emission spectrometer, completed another mini-survey of the sky and ground, and checked for drift in the spectrometer.

Sol 1475: Spirit took full-color images, using all 13 filters of the panoramic camera, of a rock target nicknamed "Bennett Hardy" (also a Tuskegee Airman). The rover checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit made the first attempt to use a grind-scan procedure to contact the surface of Wendell Pruitt. The rover took single-frame, lossless-compression (high-definition) images with the navigation camera.

Sol 1476: Spirit acquired super-resolution images of a rock target dubbed "Reuben C. Franklin" (a Tuskegee Airman) with the panoramic camera, checked for drift in the miniature thermal emission spectrometer, and completed a mini-survey of the sky and ground with the instrument. The rover took diagnostic images of the rock abrasion tool and recharged the batteries.

Sol 1477 (Feb. 28, 2008): Spirit acquired column 1 of part 1 of the full-color Bonestell panorama, using all 13 filters of the panoramic camera. The rover checked for drift in the miniature thermal emission spectrometer and completed a mini-survey of the sky and ground with the instrument. Spirit completed the second, successful attempt to locate the surface of Wendell Pruitt using the grind-scan procedure with the rock abrasion tool. The rover acquired single-frame, lossless-compression images with the navigation camera. Plans for the following morning called for Spirit to point the panoramic camera starboard and take thumbnail images of the sky.

Odometry:

As of sol 1476 (Feb. 27, 2008), Spirit's total odometry remained at 7,528.07 meters (4.68 miles).

sol 1464-1470, Feb. 14-21, 2008: *Tenacious Rover Just Might Make It*

Spirit has achieved a northerly tilt of 29.9 degrees! As a result, based on power projections, Spirit has a fighting chance of surviving another winter on Mars, if the weather and environment cooperate.

Plans for sol 1471 (Feb. 22, 2008) called for a test of the stability of Spirit's new perch prior to using the rock abrasion tool by having the rover touch the Martian surface with the Mössbauer spectrometer and apply 10 newtons of pressure (called a pre-load).

Sol-by-sol summary:

In addition to measurements of atmospheric dust levels with the panoramic camera and daily communications activities, which include morning direct-from-Earth uplinks over the rover's high-gain antenna and evening relays to Earth via the UHF antenna on the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1464 (Feb. 14, 2008): Spirit edged downslope another 4 centimeters (about 1.5 inches). The rover took thumbnail images of the sky for calibration purposes with the panoramic camera.

Sol 1465: Spirit took mid-field images and spot images of the sky for calibration purposes with the panoramic camera.

Sol 1466: Spirit acquired images for updating the rover's precise attitude relative to the Sun, surveyed the horizon and took spot images of the sky with the panoramic camera, and surveyed the external calibration target with the miniature thermal emission spectrometer.

Sol 1467: Spirit acquired images of the "El Dorado" dune field with the panoramic camera and snapped movie frames in search of dust devils with the navigation camera. The rover took thumbnail images of the sky with the panoramic camera.

Sol 1468: Spirit surveyed the sky at high Sun using the panoramic camera.

Sol 1469: Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and took before-and-after stereo images with the navigation camera to enable the on-board visual odometry software to determine the rover's position. Spirit acquired a 5-by-1 mosaic of forward-looking images and a 5-by-1 mosaic of rearward-looking images with the navigation camera. Also with the navigation camera, the rover assessed atmospheric opacity caused by dust and scanned the sky for clouds.

Sol 1470 (Feb. 21, 2008): Spirit unstowed the robotic arm and moved it to test the rover's stability. Spirit measured atmospheric opacity caused by dust using both the panoramic and navigation cameras. The rover took spot images of the sky with the panoramic camera and surveyed the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1470 (Feb. 21, 2008), Spirit's total odometry was 7,528.07 meters (4.68 miles).

sol 1457-1463, Feb. 7-13, 2008: *Spirit Inches Downward*

Spirit is tiptoeing ever so carefully down the north edge of the elevated volcanic plateau known as "Home Plate." Having completed a 4-centimeter (1.6-inch) drive on sol 1463 (Feb. 13, 2008), the rover's current northerly tilt is 27.1 degrees. Spirit's handlers plan to have the rover drive another 4 centimeters on sol 1464 (Feb. 14, 2008).

They expect Spirit to be at the rover's final winter perch by the end of next week, following a few more 4-centimeter drives. Given recent progress, Spirit may achieve a northerly, Sun-facing tilt of 30 degrees, higher than originally anticipated. Spirit remains healthy.

Sol-by-sol summary:

In addition to measurements of atmospheric dust levels with the panoramic camera and daily communications activities, which include morning direct-from-Earth uplinks over the rover's high-gain antenna and evening relays to Earth via the UHF antenna on the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1457 (Feb. 7, 2008): Spirit surveyed the Martian sky and ground using the miniature thermal emission spectrometer, stowed the rover's robotic arm, and drove downslope.

Sol 1458: Spirit acquired images of the dune field known as "El Dorado," surveyed the Martian horizon, and took spot images of the sky for calibration purposes using the rover's panoramic camera. Spirit acquired movie frames in search of dust devils using the navigation camera.

Sol 1459: Spirit drove 12 centimeters (4.7 inches) further down the north edge of Home Plate. The rover surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1460: Spirit surveyed the sky and ground using the miniature thermal emission spectrometer and took thumbnail images of the sky with the panoramic camera.

Sol 1461: Spirit acquired mid-field and far-field images using the panoramic camera.

Sol 1462: Spirit acquired a second set of mid-field images as well as thumbnail images of the sky using the panoramic camera.

Sol 1463 (Feb. 13, 2008): Spirit drove another 4 centimeters (1.6 inches) downslope. Using the panoramic camera, Spirit surveyed the horizon, monitored changes in the El Dorado dune field, and took spot images of the sky.

Odometry:

As of sol 1463 (Feb. 13, 2008), Spirit's total odometry was 7,528.01 meters (4.68 miles).

sol 1450-1456, Jan. 31 - Feb 6, 2008: *Dust on Spirit's Solar Panels Increases as Dust in the Atmosphere Decreases*

Spirit is healthy and all subsystems are operating as expected. Energy has been steady at about 260 watt-hours per Martian day, or sol (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). On Sol 1450 (Jan. 31, 2008), measurements of atmospheric opacity caused by dust -- known as Tau -- increased by 0.02 to 0.4, then fell back to 0.38, then drifted lower still to 0.333. Small changes such as these are typical of sol-by-sol variations during Martian fall and winter. As the atmosphere cleared, however, a different measurement known as the dust factor -- an estimate of the ability of sunlight to penetrate the layer of dust on the solar arrays -- also dipped slightly and continued to slowly decline, causing overall energy levels to remain about constant.

The dust factor is now 0.374, meaning that only about three-eighths of the sunlight reaching the arrays penetrates the dust layer to generate electricity. The dust factor continues to set new lows nearly every sol. The good news is that the decline has been slower than predicted, resulting in absolute values that are higher than predicted. The difference isn't great -- about 10 to 15 watt-hours, or enough energy to light a 15-watt sewing machine bulb for one hour -- but every bit is welcome.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, measuring atmospheric dust levels with the panoramic camera, checking for drift (changes in time) in the miniature thermal emission spectrometer, and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1450 (Jan. 31, 2008): Spirit brushed the surface of the rock target known as "Freeman" (commemorating the Freeman Field Mutiny, a series of attempts in 1945 by African-Americans in the U.S. Air Force to integrate an all-white officers' club) using the wire brush on the rock abrasion tool. Spirit took high-resolution images with the navigation camera to verify on-board software measurements of rover slippage based on comparison of before-and-after stereo images of the terrain (the software is known as the visual odometry system). After communicating with the Odyssey orbiter, the rover acquired panoramic-camera images of the sunset.

Sol 1451: Spirit acquired data from a rock known as "Fuzzy Smith" using the miniature thermal emission spectrometer.

Sol 1452: Spirit took measurements of the external calibration target with the miniature thermal emission spectrometer and acquired a 2-by-2-by-5 mosaic of stereo microscopic images of the brushed surface of Freeman. The rover then placed the alpha-particle X-ray spectrometer on Freeman.

Sol 1453: Spirit took measurements of the external calibration target, a rock target known as "Winston_Gaskins3," and the background of Fuzzy Smith (the specific target was nicknamed "Fuzzy Smith bg2") using the miniature thermal emission spectrometer. After sending data to the Odyssey orbiter, Spirit spent about 6.3 hours integrating data from the brushed surface of Freeman with the alpha-particle X-ray spectrometer.

Sol 1454: Spirit took measurements of the external calibration target with the miniature thermal emission spectrometer.

Sol 1455: Spirit surveyed the external calibration target with the miniature thermal emission spectrometer and, after communicating with Odyssey, spent about 6.3 hours collecting additional data from Freeman with the alpha-particle X-ray spectrometer.

Sol 1456 (Feb. 6, 2008): Spirit took measurements of the external calibration target with the miniature thermal emission spectrometer. The following morning, the rover was to acquire full-color images, using all 13 filters of the panoramic camera, of a rock target known as "Samuel_Hughes."

Odometry:

As of sol 1455 (Feb. 5, 2008), Spirit's total odometry remained at 7,527.83 meters (4.68 miles).

sol 1445-1449, Jan. 26-30, 2008: *Spirit Takes Steps to Conserve Energy During Martian Winter*

Spirit is responding to declining winter power levels by dipping into the batteries on one sol (Martian day), then recharging them on the next. In addition, one of the first things the rover did to conserve energy was eliminate afternoon data transfers to the Odyssey orbiter on days when the batteries were being recharged. Though this approach meant the rover wouldn't be able to send data on those sols, it saved enough energy to be worth the sacrifice. As Martian winter deepens, it's possible that, as the Opportunity rover did during the depth of the dust storm a few months ago, Spirit will use only every third Odyssey pass or adopt even more stringent power-conserving measures.

Meanwhile, Spirit remains healthy. For the most part, all subsystems are performing as expected. Energy has been holding steady in the range of 260 watt-hours. Tau (atmospheric opacity) continues to decline slightly, but the dust factor (the ability of sunlight to penetrate dust on the solar panels) also continues to decline slightly.

The winter Sun continues to dip lower in the sky. As of sol 1450 (Jan. 31, 2008), the noontime Sun was 64.6 degrees above the northern horizon, indicating that the optimal northern tilt of the rover deck would be 25.4 degrees from vertical ($90 - 64.6 = 25.4$). Spirit's current northward tilt is 22 degrees, relatively close to optimal. By mid-February, the optimal tilt will increase to about 28 degrees, the maximum Spirit is anticipated to be able to achieve. That's about the time when rover drivers plan to have the rover complete one more short drive to get into position for the winter.

The orbiting Odyssey spacecraft continues to provide a relay from the rovers to Earth. Each rover sends data to Odyssey via a UHF link. (UHF is "Ultra High Frequency" and represents the same band of frequencies used by the UHF channels on a TV set, channels 14-83,

which transmit signals at roughly 400-500 megahertz.) Odyssey stores the data until it can transmit it to Earth using the X-band link. X-band is a microwave frequency that operates at roughly 7-8 gigahertz (megahertz and gigahertz refer, respectively, to millions of cycles per second and billions of cycles per second).

Originally, the Mars rover mission was intended to be an X-band mission, with the rovers using their X-band transmitters to return data directly to Earth. The UHF radio was intended to serve as a backup. But because relay operations via Odyssey proved wildly successful, Odyssey became the preferred avenue for returning data. For one thing, the UHF link can accommodate data at either 128 kilobits per second or 256 kilobits per second (in these cases, "kilo" actually means 1,024 rather than the usual 1,000). The highest X-band data rate for the rovers is only 28.4 kilobits per second, and most of the time, even that rate is unachievable. Odyssey, however, can return data at up to 124.4 kilobits per second using the X-band link. In fact, the lowest rate of data transmission from Odyssey is the same as the highest rate for the rovers.

During the past week, Spirit twice conducted a "grind scan" procedure with the rock abrasion tool. After the tool's encoder failed some time ago, engineers redesigned how the tool is used. Part of that redesign includes doing a "scan" before the rover grinds or brushes any surface (except, of course, that Spirit is no longer grinding into rock surfaces -- after performing more than 10 times longer than expected and contributing a great deal of science data to the mission, the grind bit wore out.)

During the "scan" procedure, the rover pushes the brush and bit into a targeted surface until it measures an increase in electrical current, which implies contact with the rock surface. Detecting the exact location of a possibly irregular surface is important for safely operating the rock abrasion tool.

The only reason Spirit is using the rock abrasion tool at this time is that the rover has moved to a new location as of sol 1440 (Jan. 21, 2008). As Spirit inches down the north-facing slope of "Home Plate," the rover will sample each new location for insight into how the rocks change and how Home Plate was formed.

As Spirit is stationed on a fairly steep slope, engineers have been concerned that moving the robotic arm might cause the rover to slip. The arm is very light and represents only a percent or two of Spirit's weight, but on a slope, it's always possible that even a slight shift could cause a slide. On top of that, the "grind scan" function requires the rover to press down on ("preload") the target. The pressure isn't much, only 15 newtons (not quite 3.5 pounds), but that, too, could conceivably cause a slip. The rover's handlers have created a plan that includes some safety checks.

The first time around, based on receipt of erroneous data, they had to double-check that the slope beneath the rover didn't exceed 20 degrees, the maximum slope previously allowed. Because Spirit was already tilted 22.4 degrees, the safety check tripped immediately and the rover did not conduct any of the planned activities with the rock abrasion tool. Rover handlers re-planned the activities and successfully completed the "scan" procedure on sol 1448 (Jan. 29, 2008).

The next step will be to actually brush the surface. But that's a story for another week.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, measuring atmospheric dust levels with the panoramic camera, and checking for drift (changes in time) in the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1445 (Jan. 26, 2008): Spirit conducted a grind scan procedure at a target called "Freeman." Spirit took high-resolution images with the navigation camera to verify on-board software measurements of rover slippage based on comparison of before-and-after stereo images of the terrain (the software is known as the visual odometry system).

Sol 1446: Spirit re-took part 12 of a mosaic of images of the rover deck and took thumbnail images of the sky with the panoramic camera. The rover acquired data from rock targets known as "Fuzzy_Smith_2" and "Winston_Gaskins_2" using the miniature thermal emission spectrometer.

Sol 1447: Spirit monitored dust accumulation on the rover mast, completed a survey of rock clasts with the panoramic camera, and surveyed the external calibration target, the sky, and the ground with the miniature thermal emission spectrometer.

Sol 1448: Spirit took spot images of the sky and surveyed the horizon with the panoramic camera and scanned the sky for clouds with the navigation camera. The rover monitored changes in the distant dune field known as "El Dorado" with the panoramic camera. Spirit conducted a grind scan at Freeman with the rock abrasion tool. Spirit took high-resolution images with the navigation camera to verify on-board software measurements of rover slippage based on comparison of before-and-after stereo images of the terrain.

Sol 1449: (Jan. 30, 2008): Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and acquired movies in search of dust devils using the navigation camera. The following day, plans called for the rover to survey the external calibration target using the miniature thermal emission spectrometer.

Odometry:

As of sol 1448 (Jan. 29, 2008), Spirit's total odometry remained at 7,527.83 meters (4.68 miles).

sol 1437-1444, Jan. 18-25, 2008: *Atmospheric Dust Levels Decline Slightly for Spirit*

Spirit received some welcome news, as atmospheric dust levels decreased slightly, enabling power levels to remain fairly steady at 260 watt-hours to 270 watt-hours, even as the Martian sun continued to sink toward the northern horizon. (One hundred watt-hours is the amount of energy needed to light a 100-watt bulb for one hour.) Tau measurements of atmospheric opacity decreased from 0.44 to 0.36.

The dust factor -- representing the fraction of predicted solar power actually generated after blocking of sunlight by dust on the solar panels -- was nearly steady, declining only 0.05 from 0.39 to 0.385.

Spirit remained perched on the north edge of "Home Plate," a slightly bowl-shaped surface feature with a raised rim that, along its northern edge, is roughly 2 meters (6 feet) above the surrounding area. Directly below Spirit, the slope is about 28 degrees. As Martian winter approaches and the Sun gets lower and lower in the sky, engineers will direct Spirit farther and farther down the slope, increasing the rover's tilt to follow the sun.

As of Sol 1444 (Jan. 25, 2008), Spirit's 22.4-degree northerly tilt was almost perfectly matched to the position of the Sun, which is about 22 degrees below the zenith (the point in the Martian sky directly above the rover). In roughly two to three weeks, Spirit will be adjusted to a final winter position with an expected tilt of about 28 degrees to the north. This will be the best Spirit can do, given the absence of steeper slopes in the vicinity. Even if there were steeper slopes nearby, safety concerns would probably preclude their use.

With more dust on the solar arrays than ever before in the mission, Spirit's third winter will be especially challenging. Estimates indicate that at the winter solstice, the point where the noontime sun will be lowest in the sky, Spirit's energy production will be near the edge of survival. But with Tau and dust accumulation both slightly better than expected and with careful management, the rover's handlers are hopeful that Spirit will ride out the winter and begin roving again in the spring.

While parked for the winter, Spirit will not be idle. Except for the period of very lowest power, the rover will be studying the atmosphere, watching for clouds, monitoring the dust accumulation, checking for frost, and surveying the immediate surroundings, along with completing other tasks.

One of the ways the rover maximizes efficiency is by replacing a large amount of redundant data with a smaller amount of data. This is known as image compression. A simple, everyday analogy is multiplication, in which the mathematical operation, $(5 * 4)$, takes fewer characters than $(4 + 4 + 4 + 4 + 4)$. The rover uses a process called lossless compression, or LOCO for short. There are two classes of compression, lossless and lossy. Lossy compression is sort of like standard television, producing images that are usually sufficient. Lossless compression is analogous to high-definition television and is used for a few images that need to be mathematically processed to include all the detail the cameras can capture. For Spirit, lossless compression is particularly important for collecting detailed images of the area in front of the rover directly after moving to a new location. It is used to generate maps of surfaces reachable with the robotic arm and each of the instruments, called "reachability maps," as well as mathematical models of the area around the rover that are used to simulate the rover's motion during planning, called "terrain meshes." Lossless compression is also used to create slope maps that show steepness and orientation toward the Sun.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1437 (Jan. 18, 2008): Spirit communicated with the Odyssey orbiter while surveying the background of the rock known as "Fuzzy Smith" with the miniature thermal emission spectrometer.

Sol 1438: Spirit surveyed the sky and ground with the miniature thermal emission spectrometer, surveyed the horizon with the panoramic camera, and checked for drift -- changes with time -- in the miniature thermal emission spectrometer.

Sol 1439: Spirit acquired full-color images of the external dust capture magnets using all 13 filters of the panoramic camera, took spot images of the sky with the panoramic camera, and checked for drift in the miniature thermal emission spectrometer. The rover studied Fuzzy Smith and a rock known as "Winston Gaskins" with the miniature thermal emission spectrometer.

Sol 1440: Spirit acquired several panoramic camera images of the rover deck, scanned the sky for clouds with the navigation camera, and took spot images of the sky with the panoramic camera. The rover checked for drift in the miniature thermal emission spectrometer and adjusted position to achieve a greater northerly tilt. After adjusting position, Spirit took images with the hazard avoidance cameras and a single-frame LOCO image with the navigation camera.

Sol 1441: Spirit surveyed the horizon with the panoramic camera, surveyed the external calibration target with the miniature thermal emission spectrometer, and watched for dust devils. The rover also checked for drift in the miniature thermal emission spectrometer.

Sol 1442: Spirit acquired a 1-by-1 panoramic camera mosaic of the work volume reachable with the robotic arm and took thumbnail images of the sky with the panoramic camera. Spirit checked for drift in the miniature thermal emission spectrometer, unstowed the robotic arm, acquired diagnostic images of the rock abrasion tool with the hazard avoidance and panoramic cameras, and exchanged tools to the alpha-particle X-ray spectrometer. The rover sent data to Odyssey during the overhead pass of the orbiter.

Sol 1443: Spirit acquired a 5-by-1 standard tier of images as well as a 5-by-1, rearward-looking mosaic of images with the navigation camera. The rover conducted a horizon survey and acquired more images of the rover deck with the panoramic camera. Spirit checked for drift in the miniature thermal emission spectrometer, communicated with the Odyssey orbiter, and spent 6.75 hours acquiring data with the alpha-particle X-ray spectrometer.

Sol 1444 (Jan. 25, 2008): Spirit surveyed the sky at high Sun with the panoramic camera and checked for drift in the miniature thermal emission spectrometer. The following morning, the rover was to scan the sky for clouds with the navigation camera and take spot images of the sky with the panoramic camera.

Odometry:

As of sol 1444 (Jan. 25, 2008), Spirit's total odometry was 7,527.83 meters (4.68 miles).

sol 1430-1436, Jan. 11-17, 2008: *Spirit Continues to Increase Northerly Tilt*

Spirit is currently engaged in a campaign of short bumps -- adjustments in position -- that will incrementally increase the rover's northerly tilt to 22 degrees and eventually to 29 degrees by month's end. Spirit is healthy and all subsystems are operating as expected. The latest power levels measured on sol 1436 (Jan. 17, 2008) were 261 watt-hours (by definition, 100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

After successfully adjusting position on sol 1429 (Jan. 9, 2008) to achieve a northerly tilt of about 16 degrees, Spirit completed scientific studies of the rock target known as "Chanute." From sols 1431-1433 (Jan. 12-14, 2008), Spirit acquired a microscopic image mosaic of the brushed surface, placed the alpha-particle X-ray spectrometer on the target, and collected compositional data for about six hours. Sol 1433 was a recharge sol with no UHF-band communication. After reviewing the data, scientists agreed there was too much dust and debris in the alpha-particle X-ray spectrometer measurements. They thus decided to move the instrument to a "cleaner" location in the activity plan for sols 1434-1435 (Jan. 15-16, 2008) and collect another six hours worth of data. They documented the new site with a single-frame microscopic image.

Following sol 1435, also a recharge sol with no UHF communication, the rover's handlers planned another bump on sol 1436 (Jan. 17, 2008). Because of power limitations, they delayed a plan to inspect some strange-appearing brush patterns that may indicate normal brush wear or possible damage. They planned to use the miniature thermal emission spectrometer on sol 1437 (Jan. 18, 2008) at the start of a three-part imaging campaign on a rock known as "Fuzzy Smith."

Spirit's bump on sol 1436 was successful and put the rover at a new northerly tilt of approximately 18 degrees. The impact on power will not be known until receipt of data on sol 1437. The science team's goal is to achieve a northerly tilt of 22 degrees as soon as possible, at which point they will likely pause to perform scientific studies of a new target.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, Spirit completed the following activities:

Sol 1430 (Jan. 11, 2008): Spirit monitored atmospheric dust with the panoramic camera.

Sol 1431: Spirit took full-color images of Chanute using all 13 filters of the panoramic camera. The rover monitored atmospheric dust, unstowed the robotic arm, and acquired navigation camera images. Spirit acquired a 2-by-2-by-5 mosaic of stereo microscopic images of the brushed surface of Chanute and placed the alpha-particle X-ray spectrometer on the target. The rover took images following instrument placement with the navigation camera.

Sol 1432: Spirit measured atmospheric opacity caused by dust with the panoramic and navigation cameras and scanned the sky for morning clouds with the navigation camera. The rover acquired compositional data from the brushed surface of Chanute with the alpha-particle X-ray spectrometer.

Sol 1433: Spirit monitored atmospheric dust levels using the panoramic and navigation cameras and scanned the sky for clouds with the navigation camera.

Sol 1434: Spirit measured atmospheric dust with the panoramic and navigation cameras and scanned the sky for clouds with the navigation camera. The rover acquired a 1-by-1-by-1 mosaic and a 1-by-1-by-3 mosaic of microscopic images of the brushed surface of Chanute and placed the alpha-particle X-ray spectrometer on the target. Spirit acquired navigation camera images after placing the spectrometer on the target. The rover communicated with the Odyssey orbiter and acquired data from the brushed target with the alpha-particle X-ray spectrometer.

Sol 1435: Spirit measured atmospheric dust opacity with the panoramic camera and acquired a 5-by-1 mosaic of navigation camera images of the rover deck, a 2-by-1 mosaic of panoramic camera images, and two views of the rover deck with the panoramic camera.

Sol 1436 (Jan. 17, 2008): Spirit took thumbnail images of the sky with the panoramic camera, measured atmospheric dust with the panoramic camera, took images of the brush on the rock abrasion tool, and bumped into a new position to increase northerly tilt. The rover took images with the hazard avoidance and navigation cameras after the bump. Spirit also acquired navigation camera images of Fuzzy Smith after the bump. The rover took a 1-by-1 image mosaic of the work volume with the panoramic camera. The following day's plans called for Spirit to measure atmospheric dust with the panoramic camera, monitor dust accumulation on the rover mast, and acquire additional images of the rover deck as well as spot images of the sky with the panoramic camera.

Odometry:

As of sol 1436 (Jan. 17, 2008), Spirit's total odometry was 7,527.71 meters (4.68 miles).

sol 1423-1429, Jan. 3-9, 2008: *Spirit Tilts Toward the Sinking Sun*

After directing the rover to brush the surface of the rock target known as "Chanute," engineers placed continued studies on hold while they adjusted Spirit's position to achieve a greater northerly tilt, in the direction of the sinking winter Sun. The latest available power levels measured on sol 1429 (Jan. 9, 2008) were 268 watt-hours, a sobering reminder of the onset of winter. Spirit was in the middle of a campaign of scientific studies with the brush on the rock abrasion tool, alpha-particle X-ray spectrometer, and microscopic imager. The move was successful and gave the rover a new northerly tilt of about 16 degrees.

Spirit is healthy and all subsystems are nominal.

After Spirit had completed acquisition of the "Tuskegee panorama" on sol 1423 (Jan. 3, 2008), planned science activities included brushing the surface of Chanute prior to continued investigation with the alpha-particle X-ray and Mössbauer spectrometers. To locate the surface, the rover performed a "seek scan" with the rock abrasion tool on sol 1424 (Jan. 4, 2008). This activity is a work-around procedure that compensates for a broken encoder and allows the rover to stall the motor of the rock abrasion tool when it makes contact with the surface.

The next two Martian days were recharge sols. Spirit brushed the surface of Chanute on sol 1427 (Jan. 7, 2008). This was also followed by another recharge sol. The rover's handlers then made two significant changes to the strategic plan to address the deteriorating power situation. First, because recharge sols were becoming less and less effective, they decided to begin deleting the UHF passes on these sols, starting on sol 1428 (Jan. 8, 2008). Second, they decided to proceed sooner than anticipated with plans to achieve a steeper northerly tilt of 20 degrees. Activities on sol 1429 (Jan. 9, 2008) involved a bump of 10 centimeters (4 inches) downslope. Sol 1430 (Jan. 11, 2008) was to be a recharge sol with no UHF.

The impact of the new, 16-degree northerly tilt on power will not be known until receipt of further data on sol 1431 (Jan. 12, 2008). The science team's goal is to reach 20 degrees as soon as possible, meaning they will likely execute additional short bumps similar to those of sol 1429 in the very near future. In the meantime, Spirit will complete work on Chanute.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels, Spirit completed the following activities:

Sol 1423 (Jan. 3, 2008): Spirit acquired a 2-by-1 mosaic of the Tuskegee panorama.

Sol 1424: Spirit acquired a 4-by-1 mosaic of the Tuskegee panorama, performed a seek-scan maneuver to locate the surface of Chanute with the rock abrasion tool, and took navigation camera images following the procedure.

Sol 1425: Spirit acquired a 4-by-1 mosaic of the Tuskegee panorama.

Sol 1426: Spirit acquired morning thumbnail images of the sky with the panoramic camera.

Sol 1427: Spirit acquired spot images of the sky with the panoramic camera, monitored dust on the panoramic camera mast assembly, and scanned the sky for clouds with the navigation camera. The rover brushed the surface of Chanute, stowed the robotic arm, and acquired navigation camera images of the brushed surface.

Sol 1428: Spirit acquired a 4-by-1 mosaic of images of the Tuskegee panorama.

Sol 1429 (Jan. 9, 2008): Spirit surveyed the sky at low Sun with the panoramic camera, bumped downslope, took images with the hazard avoidance cameras, and acquired a navigation camera image after the change in position. The following day's plans called for the rover to survey the horizon with the panoramic camera and acquire movie frames in search of dust devils spaced at 8-minute intervals using the navigation camera.

Odometry:

As of sol 1429 (Jan. 9, 2008), Spirit's total odometry remained at 7,527.52 meters (4.68 miles).

sol 1416-1422, Dec. 27, 2007 - Jan. 2, 2008: *After Four Years on Mars, Spirit Faces Toughest Test Yet*

Four years ago on Jan. 4 (Pacific time), Spirit landed on the surface of Mars, in search of habitable environments. Now the rover is facing perhaps its greatest challenge so far -- surviving the third winter on Mars with substantial amounts of dust from last year's global storms on the solar arrays. As of sol 1406 (Dec. 17, 2007), the solar arrays were about 60 percent obscured by dust (a dust factor of 0.4), the most obscuration ever. By the time of the winter solstice on sol 1593 (June 26, 2008), the solar arrays are expected to be about 70 percent obscured (a dust factor of 0.3).

To increase Spirit's chances of survival, engineers have positioned the rover on a steep, north-facing slope to maximize exposure to sunlight. Still, even with an expected north-facing tilt of greater than 25 degrees, Spirit will likely need more energy than available each sol without additional changes, according to Project Manager John Callas. These changes may include disabling the survival heater on the miniature thermal emission spectrometer, putting the instrument at risk, and disabling the survival heater of the rover's electronic module. The module was successfully tested down to minus 55 degrees C. using brand-new electronics; disabling the heater would likely result in temperatures dipping below minus 40 degrees C., a significant dip given that the rover has now completed more than 1,400 thermal cycles.

Other survival strategies include tightly managing Spirit's energy budget each sol and minimizing operating time and communication sessions. During the darkest days of winter, Spirit may spend months facing the risk of low-power faults, when the rover takes the batteries off-line and goes to sleep due to inadequate power levels.

Meanwhile, Spirit remains healthy and all subsystems are operating as expected. The rover continues to study a rock feature dubbed "Chanute," so far gathering more than 60 hours of data about iron-bearing minerals using the Mössbauer spectrometer. Energy is around 255 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). As of sol 1421 (Jan. 1, 2008), atmospheric dust levels, known as Tau, were at 0.487 and the dust factor was at 0.49.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels, Spirit completed the following activities:

Sol 1416 (Dec. 27, 2007): Spirit re-started the Mössbauer spectrometer and spent 23 hours integrating data from Chanute with the instrument. The rover acquired panoramic camera images of the dune field known as "El Dorado."

Sol 1417: Spirit acquired a 4-by-1 mosaic of the so-called "Tuskegee panorama," monitored dust accumulation on the panoramic mast assembly, and re-started the Mössbauer spectrometer for 5 hours of data integration from Chanute.

Sol 1418: Spirit acquired another 4-by-1 mosaic of the Tuskegee panorama, followed by a 2-by-1 mosaic.

Sol 1419: Spirit acquired a 4-by-1 mosaic of the Tuskegee panorama and re-started the Mössbauer spectrometer for 5 hours of data collection from Chanute. The rover watched for dust devils and acquired another 4-by-1 mosaic of the Tuskegee panorama.

Sol 1420: Spirit re-started the Mössbauer spectrometer and acquired 4 hours worth of data from Chanute with the instrument. After communicating with the Odyssey spacecraft, Spirit acquired new measurements of atmospheric dust levels.

Sol 1421: Spirit acquired a 4-by-1 and a 2-by-1 mosaic of the Tuskegee panorama.

Sol 1422 (Jan. 2, 2008): Spirit acquired a 4-by-1 mosaic of the Tuskegee panorama, re-started the Mössbauer spectrometer, and spent 4 hours studying Chanute with the instrument. The rover acquired a 2-by-1 and a 4-by-1 mosaic of the Tuskegee panorama.

Odometry:

As of the rover's last drive on sol 1406 (Dec. 17, 2007), Spirit's total odometry was 7,527.52 meters (4.68 miles).

sol 1409-1415, December 26, 2007: *Spirit Conducts Detailed Studies of Rocks First Encountered in 2006*

Spirit is tilted about 13 degrees to the north at a site known as "WinterHaven 3" on the northern edge of "Home Plate." During the holidays, Spirit performed studies of a rock feature called "Chanute" with instruments on the robotic arm, including the microscopic imager, alpha-particle X-ray spectrometer, and Mössbauer spectrometer. In addition, Spirit has been acquiring a panoramic view of "Home Plate" known as the "Tuskegee panorama."

Energy is currently around 277 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for 1 hour), with Tau measurements of atmospheric dust opacity at 0.502 and a dust factor of 0.4008 as of sol 1414 (Dec. 25, 2007).

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna and sending data to Earth at UHF frequencies via the Odyssey orbiter, Spirit completed the following activities:

Sol 1409 (Dec. 20, 2007): Spirit unstowed and extended the robotic arm to test its stability, acquired a 2-by-2-by-5 mosaic of microscopic images, and placed the alpha-particle X-ray spectrometer on target. The rover acquired documentation imaging of the robotic arm with the navigation camera and took panoramic camera images of the rover's tracks as well as a rock known as "Fuzzy Smith," which the rover first encountered on approaching Home Plate in 2006.

Sol 1410: Spirit scanned the sky and ground with the miniature thermal emission spectrometer and integrated data from Chanute using the alpha-particle X-ray spectrometer.

Sol 1411: Spirit switched tools on the robotic arm from the alpha-particle X-ray spectrometer to the Mössbauer spectrometer using visual odometry software, collected data from Chanute with the Mössbauer spectrometer, and surveyed the horizon and took spot images of the sky with the panoramic camera.

Sol 1412: Spirit measured atmospheric dust levels with the panoramic camera, re-started the Mössbauer spectrometer for additional integration of data from Chanute, and acquired part of the Tuskegee panorama.

Sol 1413: In the morning, Spirit continued work on the Tuskegee panorama, monitored atmospheric dust levels with the panoramic camera, and re-started the Mössbauer spectrometer for continued study of Chanute.

Sol 1414: Spirit acquired additional frames of the Tuskegee panorama, measured atmospheric dust with the panoramic camera, and re-started the Mössbauer spectrometer for additional integration of data from Chanute.

Sol 1415 (Dec. 26, 2007): Spirit surveyed the morning sky, measured atmospheric dust, took spot images of the sky, and completed a sky survey at high Sun with the panoramic camera.

Odometry

As of sol 1414 (Dec. 25, 2007), Spirit's total odometry was about 7,527 meters (4.7 miles).

sol 1404-1408, December 21, 2007: *Spirit Makes It to a North-Facing Slope*

Spirit has achieved 13 degrees of northerly tilt after backing the rear and middle wheels over the north edge of "Home Plate," where the rover will remain during the coming holidays. Power levels have already increased significantly from 260 watt-hours on sol 1404 (Dec. 15, 2007) to 291 watt-hours on sol 1408 (Dec. 19, 2007).

Spirit's ideal northerly tilt at present would be 16 degrees, and the rover's handlers plan to have the rover creep farther down the slope in mid-January to increase the northerly tilt. On Spirit's current track, they expect to see an ultimate northerly tilt of 25 degrees to 30 degrees.

In the meantime, Spirit will perform studies using instruments on the rover's robotic arm, including the microscopic imager, alpha-particle X-ray spectrometer, and Mössbauer spectrometer. Spirit's handlers still have a huge challenge ahead, but after three weeks of working on Mars time and on weekends, they are, like the rover, enjoying a long-awaited and well-deserved sigh of relief.

The science team is nicknaming features in the area after the Tuskegee Airmen, the first black pilots to serve in the U.S. military.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1404 (Dec. 15, 2007): Spirit drove to the rover's last perch before descending over the north edge of Home Plate.

Sol 1405: Spirit acquired images with the navigation camera, drove the rear wheels over the rim, and acquired post-drive images with the navigation camera.

Sol 1406: Spirit drove the middle wheels over the rim of Home Plate and acquired post-drive images with the navigation camera.

Sol 1407: Spirit acquired a "quick fine attitude," a calibration activity to compensate for changes in time in the inertial measurement unit. Spirit acquired a 360-degree panorama of images with the navigation camera, images with the front and rear hazard avoidance cameras, and spot images of the sky with the panoramic camera.

Sol 1408 (Dec. 19, 2007): Spirit acquired full-color images, using all 13 filters of the panoramic camera, of the work volume reachable by instruments on the rover's robotic arm. The rover completed a survey at high sun with the panoramic camera.

Odometry:

As of sol 1408 (Dec. 19, 2007), Spirit's total odometry was 7527.52 meters (4.6 miles).

sol 1398-1403, December 17, 2007: *Final Winter Haven Selection Near*

To make the most of waning sunlight during the approach of Martian winter, Spirit's handlers have returned to "Mars time." This means their working hours coincide with the Martian day, as they did for the first three months after the rover landed on the red planet. Because a Martian day is about 40 minutes longer than an Earth day, Mars time can coincide with all hours of the day and night on Earth. The alarm might go off the same time one day, 40 minutes later the next day, an hour and 20 minutes later the next day, and so on.

Spirit's solar power levels continue to drop, with solar array energies recently ranging from 293 watt-hours to 254 watt-hours, depending on the vehicle's orientation relative to the Sun. (One hundred watt-hours is the amount of energy needed to light a 100-watt bulb for one hour.)

All members of the rover science team -- drivers, engineers, and scientists -- are evaluating data to select a place where the rover will attempt to survive another Martian winter, focusing on areas that will tilt the rover's solar panels to the north more than 25 degrees. They will select a final location from a narrowed list of choices based on proximity to the rover's current position and the characteristics of the terrain, with an eye for accessibility as well as continued exploration in the spring.

Spirit reached the northern edge of "Home Plate" after driving 13.24 meters (43.44 feet) on Martian day, or sol, 1397 (Dec. 8, 2007). Three Martian days later, on sol 1400 (Dec. 11, 2007), Spirit finished collecting reconnaissance images of the northern exposure of the elevated plateau.

During the past week, rover planners got a special visit from two Tuskegee Airmen, the first black pilots to serve in the U.S. military. The pilots shared stories about serving in World War II while learning about rover operations.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1398 (Dec. 9, 2007): Spirit drove 6.5 meters (21.3 feet) in a path nearly parallel to the northern edge of Home Plate. The rover acquired post-drive images with the hazard avoidance cameras and a mosaic of images with the navigation camera.

Sol 1399: Spirit drove 7.19 meters (23.6 feet) toward a small promontory to acquire images of the slopes below. The rover acquired post-drive images with the hazard avoidance cameras and a mosaic of images with the navigation camera. The following morning, Spirit acquired a series of navigation camera images to complete a 360-degree view of the rover's location after completing the drive.

Sol 1400: Spirit nudged 0.75 meter (2.5 feet) closer to the edge of Home Plate for a better view of what lay below. The rover acquired post-drive images with the hazard avoidance cameras and a mosaic of images with the navigation camera.

Sol 1401: Spirit took a break from driving and acquired images with the panoramic camera before turning around to back down the steep slope where the rover will spend the winter. After turning, the rover's solar arrays blocked the view of the slope by cameras on the rover

mast assembly. Following the maneuver, Spirit acquired two image mosaics with the panoramic camera.

Sol 1402: Spirit acquired a pre-drive image of a pointy rock known as "General B.O. Davis" before backing up 2.5 meters (8.2 feet) and turning 180 degrees. The rover acquired post-drive images using the hazard avoidance cameras and a mosaic of images using the navigation camera. The following morning, Spirit monitored dust on the panoramic camera mast assembly and completed a systematic ground survey and a survey of rock clasts with the panoramic camera.

Sol 1403 (Dec. 14, 2007): Plans called for Spirit to approach the edge of Home Plate backward and acquire post-drive images with the hazard avoidance cameras as well as an image mosaic with the panoramic camera.

Odometry:

As of sol 1402 (Dec. 13, 2007), Spirit's total odometry was 7523.31 meters (4.67 miles).

sol 1390-1397, December 14, 2007: *Spirit Scouts "Home Plate" for Safe Haven*

Spirit has arrived at the north edge of "Home Plate." The rover will spend the next few Martian days, or sols, scouting the edge of Home Plate and acquiring images of the slopes to determine the best site for "Winter Haven 3," where Spirit will try to survive another season of minimal sunlight. Once the team selects a site, Spirit will drive down the north-facing edge of Home Plate and maneuver into position to achieve the highest northerly tilt possible.

Power levels are dropping rapidly, partly because the sun continues its retreat north on its way to winter solstice, and partly because the landscape tilts slightly southward near the rim. Drive sols are so precious and few, the team has been working long hours and weekends to make the most of the remaining sunlight.

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1390 (Nov. 30, 2007): Spirit drove in search of Winter Haven 3 and acquired post-drive images with the navigation camera. Spirit acquired full-color images, using all 13 filters of the panoramic camera, of the low, sandy area nicknamed "Tartarus." The rover surveyed Tartarus with the miniature thermal emission spectrometer and surveyed the horizon with the panoramic camera.

Sol 1391: Spirit continued to drive in search of Winter Haven 3 and acquire post-drive images with the navigation camera. The rover assessed atmospheric opacity caused by suspended dust with the navigation camera. Spirit acquired a mosaic of images with the panoramic camera and monitored dust accumulation on the rover mast assembly.

Sol 1392: Spirit drove in search of Winter Haven 3 and acquired a post-drive image mosaic and a rearward-looking image mosaic with the navigation camera.

Sol 1393: Spirit continued to drive in search of Winter Haven 3. Spirit acquired a post-drive image mosaic and a rearward-looking image mosaic with the navigation camera. The rover also completed a survey of rock clasts and a systematic ground survey with the panoramic camera.

Sol 1394: Spirit drove in search of Winter Haven 3 and acquired post-drive and rearward-looking image mosaics with the navigation camera. Spirit also acquired an image mosaic of Home Plate with the panoramic camera.

Sol 1395: Spirit drove in search of Winter Haven 3 and acquired post-drive images with the navigation camera. Spirit acquired a mosaic of panoramic camera images of a target known as "Hummock" and a rearward-looking mosaic of navigation camera images.

Sol 1396: Spirit continued driving in search of Winter Haven 3. The rover acquired post-drive and rearward-looking image mosaics with the navigation camera. Spirit completed a survey of rock clasts and a systematic ground survey with the panoramic camera.

Sol 1397 (Dec. 8, 2007): Plans called for Spirit to continue driving in search of Winter Haven 3, acquire post-drive images with both the navigation and panoramic cameras, and conduct a systematic ground survey as well as acquire spot images of the sky with the panoramic camera.

Odometry:

As of sol 1397 (Dec. 8, 2007), Spirit's total odometry was 7495.15 meters (4.66 miles).

sol 1384-1389, November 30, 2007: *Spirit Breaks Free in Race for Survival*

In typical unflagging fashion, Spirit has managed to break free of piles of soil built up around the wheels in a low, sandy area that the rover's handlers have nicknamed "Tartarus," after a deep, underworld dungeon in Greek mythology. Team members are pulling out all the stops to get Spirit to a winter location where, based on solar power projections, the rover has a chance at survival.

As the crow flies, that spot is about 25 meters (82 feet) away. During the next few weeks, Spirit's journey to "Winter Haven 3" is expected to be no less difficult, requiring the rover to maneuver across a sandy, rocky valley along the western edge of "Home Plate."

During Spirit's 14 Martian days in Tartarus, the rover's trials were reminiscent of those of the previous Martian winter, when Spirit spent 12 sols churning up white material in a sandy area while trying to reach the slopes of "McCool Hill."

Guided by experienced, interplanetary drivers, the robotic geologist Spirit escaped Tartarus on sol 1388 (Nov. 28, 2007) and drove 3.43 meters (11.3 feet). This was a significant distance, given that Spirit's previous two drives were measured in centimeters (inches). The drive took the rover south away from Tartarus to look for another path around the area before driving north once again.

Spirit's handlers will be working non-stop during the weekend to take advantage of seasonal sunlight available for driving before solar power levels drop further. At present, the rover has about 310 watt-hours of power each day (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary:

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1384 (Nov. 24, 2007): Spirit managed to drive 6.98 meters (22.9 feet). The rover took post-drive images with the hazard avoidance cameras and a mosaic of images with the navigation camera. The next morning, Spirit measured atmospheric dust with the navigation camera and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1385: Spirit spent the day recharging the battery. The following morning, Spirit acquired movie frames in search of dust devils with the navigation camera and completed a survey of rock clasts with the panoramic camera.

Sol 1386: Spirit drove only 0.25 meters (10 inches) and took images with the hazard avoidance cameras. The following morning, the rover acquired full-color images of Tartarus using all 13 filters of the panoramic camera.

Sol 1387: Spirit drove only 0.14 meter (5.5 inches) and acquired post-drive images with the navigation camera. The next morning, Spirit surveyed atmospheric dust with the navigation camera and acquired additional, full-color images of Tartarus with the panoramic camera.

Sol 1388: Spirit drove 3.43 meters (11.3 feet), finally breaking free from the piles of soil built up around each of its wheels. The rover acquired post-drive images with the hazard avoidance cameras.

Sol 1389 (Nov. 29, 2007): After a morning of surveying atmospheric dust and taking additional full-color images of Tartarus, plans called for Spirit to complete a photo shoot with the navigation and hazard avoidance cameras, survey atmospheric dust with the navigation camera, and acquire thumbnail images of the sky with the panoramic camera.

Odometry:

As of sol 1388 (Nov. 28, 2007), Spirit's total odometry was 7438.82 meters (4.62 miles).

sol 1377-1383, November 26, 2007: *Rover Slips in Sandy Terrain*

On the way to "Winter Haven 3," the spot on the north face of "Home Plate" where NASA's Spirit rover is headed, the rover has driven into an area below a hummock (elevated area). Spirit has tried unsuccessfully during the past week to climb onto the hummock and make progress toward Winter Haven 3. Because it is critical to reach the north face while enough solar energy is available to get there, Spirit spends every available day driving. In-between drives, Spirit recharges the batteries and conducts very light remote sensing.

The rover's drive on sol 1378 (Nov. 18, 2007) ended early when Spirit's unusable, right front wheel got snagged on a buried rock, causing the rover to turn and drive into a "keep-out zone." Two Martian days later, on sol 1380 (Nov. 20, 2007), the drive faulted out again when the rover experienced more than 90-percent slip after traveling 3.6 meters (11.8 feet). The rover's handlers continue to work on strategies for enabling Spirit to drive away from the outcrop.

Spirit's top priority is to reach the north-facing slope of "Home Plate," where the rover plans to hunker down during the coming cold, winter season of waning sunlight. Spirit is healthy and all subsystems are nominal. Energy is currently around 305 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1377 (Nov. 17, 2007): Spirit acquired an image mosaic of "West Valley" and thumbnail images of the sky with the panoramic camera.

Sol 1378: Spirit drove toward the hummock known as "Site 7," took images just before and after ending the drive with the hazard avoidance cameras, and acquired post-drive image mosaics with the navigation and panoramic cameras. The images indicated that the right front wheel had slipped off a buried rock and turned away from the targeted drive region. The rover acquired full-color foreground images, using all 13 filters of the panoramic camera.

Sol 1379: Spirit acquired a post-drive, rearward-looking mosaic of images using the navigation camera.

Sol 1380: Spirit drove 3.6 meters (11.8 feet), took images before and after the drive with the hazard avoidance cameras, and acquired post-drive image mosaics with the navigation and panoramic cameras. Early the next morning, the rover completed a survey of rock clasts and took images of the rover's tracks (to look for compositional changes revealed by trenching) and the Martian horizon with the panoramic camera.

Sol 1381: Plans called for Spirit to recharge the batteries.

Sol 1382: Plans called for Spirit to monitor dust on the miniature thermal emission spectrometer, acquire panoramic camera images of a target known as "Sorbet" near the center of Home Plate, and acquire movie frames in search of dust devils using the navigation camera.

Sol 1383 (Nov. 24, 2007): Plans called for Spirit to calibrate the panoramic camera by taking images in darkness, acquire spot images of the sky with the panoramic camera, check for drift (changes over time) in the miniature thermal emission spectrometer, and survey the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1380 (Nov. 20, 2007), Spirit's total odometry was 7,428.01 meters (4.62 miles).

sol 1370-1376, November 26, 2007: *Spirit in a Race Against the Clock*

With autumn only 24 Mars days away and the Sun sinking toward the northern horizon, Spirit is in a race against the clock to survive another Martian winter. As a result of dust inhibiting sunlight from reaching the solar panels, the rover must get to a suitable, north-facing location on the north rim of "Home Plate" and be safely parked for the winter by Martian day, or sol, 1412 (Dec. 23, 2007).

Spirit is already drawing more power for the drive than can be provided by the solar arrays alone. After each sol of driving, the rover spends a day recharging the batteries. That cuts potential drive time in half. In addition, the rover will not be driving on some weekend days, the Thanksgiving holidays, or days when no new instructions are being sent to the rover. Altogether, Spirit has about a dozen potential drive sols between now and the holiday season. To reach the north rim in time, Spirit must drive an average 10 meters (33 feet) per day. So far, the rover is on schedule.

Meanwhile, power is expected to decline during the next six weeks from about 325 watt-hours to about 260 watt-hours, the minimum safe power level for driving on level ground. This is due both to continued dust accumulation on the solar arrays and the lower sun angle as the Martian season moves toward winter. (One hundred watt-hours is the amount of energy needed to light a 100-watt bulb for one hour.)

Spirit's destination has been nicknamed "Winter Haven 3." Along the way, the rover will continue to measure atmospheric dust, monitor dust accumulation on the panoramic mast assembly, and measure the chemical and geologic composition of rock outcrops and sand ripples using the Mössbauer spectrometer and panoramic cameras.

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, and measuring atmospheric dust levels with the panoramic camera, Spirit completed the following activities:

Sol 1370 (Nov. 10, 2007): Spirit restarted the Mössbauer spectrometer and spent 23 hours collecting data on iron-bearing minerals in a rock target known as "Pecan Pie." The next morning, the rover acquired images of ripples with the panoramic camera.

Sol 1371: Spirit stowed the robotic arm and acquired full-color images, using all 13 filters of the panoramic camera, of Pecan Pie. The rover then drove 17.5 meters (57.4 feet) toward "Site 6," also known as "Site A," on Home Plate. The rover took images with the hazard avoidance camera just before and after ending the drive as well as post-drive images with the navigation and panoramic cameras.

Sol 1372: Spirit measured atmospheric dust and spent the day recharging the batteries.

Sol 1373: Spirit drove approximately 9 meters (30 feet) to Site 6, took hazard-avoidance camera images before and after finishing the drive, and acquired post-drive images with both the navigation and panoramic cameras. The following morning, Spirit acquired additional post-drive images with the navigation camera as well as panoramic cameras of an area known as "West Valley."

Sol 1374: Spirit measured atmospheric dust and spent the day recharging the batteries. The following morning, Spirit took full-color images of the rover's tracks using all 13 filters of the panoramic camera.

Sol 1375: Plans called for Spirit to drive another 15 meters (49 feet), take hazard-avoidance camera images before and after finishing the drive, and acquire post-drive images with both the navigation and panoramic cameras. The next morning, the rover was to take spot images of the sky with the panoramic camera and acquire additional post-drive images with the navigation camera. Spirit was to complete a survey of rock clasts with the panoramic camera and monitor dust on the panoramic-camera mast assembly.

Sol 1376 (Nov. 16, 2007): Plans called for Spirit to measure atmospheric dust and recharge the batteries. The following morning, Spirit was to acquire images of a hummock with the panoramic camera.

Odometry:

As of sol 1374 (Nov. 14, 2007), Spirit's total odometry was 7,415.4 meters (4.6 miles).

sol 1363-1369, November 12, 2007: *Spirit Continues Drive As Power Levels Decline*

Spirit has been gradually losing power, with energy levels dropping to 320 watt-hours per Martian day (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Measurements of atmospheric dust, known as Tau, have been averaging 0.65. That dust level is typical of levels measured throughout most of the mission, but power levels are lower than in previous years because of higher dust accumulation on the solar panels. (The rover estimates dust levels by measuring opacity -- the degree to which the atmosphere is impenetrable by light. During most of Spirit's mission on Mars, except during the recent dust storms, tau values have fallen between 0 and 1.)

During the trek to reach the north edge of "Home Plate" before the next Martian winter, Spirit had time to conduct only one scientific campaign. Scientists selected a rock target nicknamed "Pecan Pie" (investigators are nicknaming targets on top of Home Plate for things served in bowls) for closer investigation, at a location known as "Site 5." Spirit brushed Pecan Pie, took pictures of it with the microscopic imager, and analyzed its composition with the alpha-particle X-ray spectrometer. Planned measurements over the weekend included an analysis of iron-bearing minerals with the Mössbauer spectrometer before resuming the drive.

The successful brush of Pecan Pie marked the first time that Spirit had used the new, two-sol brushing procedure that enabled continued use of the rock abrasion tool following the failure of the grind encoder.

Spirit continued to collect images of the west side of Home Plate (known as "West Valley" to science team members) while advancing northward. The images are important for understanding the geology as well as for planning the hoped-for, post-winter drive to a hill known as "von Braun" south of Home Plate.

Spirit remains healthy. On Sol 1369 (Nov. 9, 2007), plans called for Spirit to run a diagnostic of the rock abrasion tool by pointing it at the hazard avoidance camera for photo documentation while running the motor at various voltages. The resulting measurements of the spinning of the tool will provide a baseline for eventual failure of the motor and for comparison with Spirit's twin, Opportunity, on the other side of Mars.

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, measuring atmospheric dust levels with the panoramic camera, and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1363 (Nov. 3, 2007): Spirit acquired pre-drive, panoramic camera images of targets known as "Posole," "Green Chile," and "Flan," then drove 24.83 meters (84.46 feet) to Site 5 on Home Plate. The rover acquired post-drive image mosaics with the navigation and panoramic cameras. The next morning, Spirit completed a survey of rock clasts with the panoramic camera and took a mosaic of images with the navigation camera.

Sol 1364: Spirit acquired images of the distant dune field known as "El Dorado" with the panoramic camera, and after communicating with the Odyssey orbiter during its overhead pass, measured atmospheric argon with the alpha-particle X-ray spectrometer. In the morning, Spirit completed a full-color, systematic ground survey using all 13 filters of the panoramic camera.

Sol 1365: Spirit spent the day recharging the battery. The following morning, Spirit searched for dust devils using the navigation camera.

Sol 1366: Spirit placed the rock abrasion tool on Pecan Pie and acquired a mosaic of images known as the "West Valley View" with the panoramic camera. The next morning, the rover took spot images of the sky with the panoramic camera and acquired movie frames in search of dust devils with the navigation camera.

Sol 1367: Spirit acquired another mosaic of images of West Valley View with the panoramic camera. In the morning, Spirit acquired full-color images, using all 13 filters of the panoramic camera, of the rover's tracks.

Sol 1368: Spirit conducted scientific studies of Pecan Pie, including brushing the surface of the rock target with the brush on the rock abrasion tool, acquiring stereo microscopic images of the brushed surface, and collecting 9 hours of compositional data with the alpha-particle X-ray spectrometer. The rover also acquired a mosaic of images of West Valley View with the panoramic camera. The following morning, Spirit took thumbnail images of the sky with the panoramic camera.

Sol 1369 (Nov. 9, 2007): Plans called for Spirit to run diagnostic tests of the rock abrasion tool and acquire a mosaic of images of West Valley View with the panoramic camera. The rover was to spend 22 _ hours acquiring data with the Mössbauer spectrometer, be on the lookout for morning dust devils, and acquire movie frames at 8-minute intervals to record the progress of dust devils if they occurred.

Odometry:

As of sol 1367 (Oct. 30, 2007), Spirit's total odometry was 7,383.75 meters (4.59 miles).

sol 1355-1362, November 02, 2007: *Spirit to Head North for the Winter*

With Martian winter approaching, the science and engineering teams have been hard pressed to select a site where Spirit can spend the winter. After previously narrowing the list of candidates to two sites, Spirit's handlers decided to send the rover to the northern edge of the elevated plateau known as "Home Plate," which Spirit has been exploring for many months now.

Previously considered sites included "von Braun," "South Promontory," "Batter's Box" ("West Knoll"), and "North Home Plate." The decision means the rover will move farther away from tantalizing, new terrain to the south, but maximizes the rover's chances of surviving another winter given the excessive coating of dust on the solar arrays.

As Project Manager John Callas announced in an e-mail, "the principal discriminator was the achievable slope at each site. The north side of 'Home Plate' offers slopes of 25 degrees of northerly tilt, while 'South Promontory' offers 20 degrees of northerly tilt. That difference is about 10 watt-hours per sol, which can mean the difference between surviving and not surviving the cold, dark winter."

Meanwhile, Spirit remains healthy and all subsystems are nominal. Energy has been averaging 355 watt-hours (100 watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour) and atmospheric dust measurements (Tau) have been steady at about 0.63.

Plans called for Spirit to head in a northerly direction, toward an area known as "Site 5" on top of Home Plate, starting on sol 1362 (Nov. 2, 2007). Once there, Spirit may investigate some targets with instruments on the robotic arm before continuing to the north end of Home Plate.

Meanwhile, engineers working on the rover's miniature thermal emission spectrometer have determined that degradation in performance of the spectrometer on both Spirit and its twin, Opportunity, is the result of dust deposition on the scan mirror or in the panoramic camera mast assembly. They have decided not to use the instrument on Opportunity and to use it only for high-priority targets and weekly atmospheric measurements on Spirit while they try to develop strategies for removing the dust.

In addition, tests run on sols 1355, 1358, and 1360 (Oct. 25, Oct. 29, and Oct. 31) determined that the grind motor on Spirit's rock abrasion tool failed on sol 1341 (Oct. 11, 2007), as it did previously on Opportunity on sol 1045 (Jan. 1, 2007). However, because the rover's handlers have devised an alternate technique for grinding and brushing that takes two Martian days, they are still able to use the brushes on both rock abrasion tools.

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, measuring atmospheric dust levels with the panoramic camera, and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1355 (Oct. 25, 2007): Spirit unstowed the robotic arm, conducted imaging diagnostics of the rock abrasion tool, and took microscopic images of the capture magnet. The rover placed the alpha-particle X-ray spectrometer on the capture magnet, took panoramic camera images of the rover deck, and transmitted data overnight via the Odyssey orbiter. Spirit monitored dust on the panoramic camera mast assembly, surveyed the horizon with the panoramic camera, acquired a mosaic of images with the navigation camera, and acquired movie frames in search of dust devils with the navigation camera.

Sol 1356: Spirit acquired panoramic camera images of the rover deck and of rock targets nicknamed "Grays Peak," "Elk," and "San Juan." The rover acquired 6 hours worth of data with the alpha-particle X-ray spectrometer and took thumbnail images of the sky with the panoramic camera.

Sol 1357: Spirit used the navigation camera to survey the surface darkened by the rover's shadow. The rover acquired full-color images of its tracks using all 13 filters of the panoramic camera. Spirit acquired another 6 hours of data with the alpha-particle X-ray spectrometer and took spot images of the sky with the panoramic camera.

Sol 1358: Spirit took images of the filter magnet with the microscopic imager, performed diagnostic tests on the rock abrasion tool, and used the panoramic camera to take images of the rover deck and survey the horizon.

Sol 1359: Spirit turned in place for communications relays and performed a "get quick fine attitude" to check for changes in the inertial measurement unit to determine the rover's precise location. Spirit acquired post-drive images with both the navigation and panoramic cameras. In the morning, the rover completed a systematic ground survey with the panoramic camera.

Sol 1360: Spirit unstowed the robotic arm, performed diagnostic tests of the rock abrasion tool, and acquired a mosaic of microscopic images of a soil target known as "Pumpkin Pie" before placing the alpha-particle X-ray spectrometer on the target. Spirit acquired full-color images, using all 13 filters of the panoramic camera, of another soil target known as "Candy Corn." The rover collected data from Pumpkin Pie with the alpha-particle X-ray spectrometer and in the morning, scanned the sky for clouds with the navigation camera. Spirit also surveyed the horizon with the panoramic camera and acquired movie frames in search of dust devils with the navigation camera.

Sol 1361: Spirit stowed the robotic arm in preparation for the next day's drive and took full-color images, using all 13 filters of the panoramic camera, of Elk and San Juan. The rover acquired a mosaic of images with the navigation camera as part of a 360-degree panorama for drive planning. Spirit surveyed the sky at both low sun and high sun with the panoramic camera.

Sol 1362 (Nov. 2, 2007): Plans called for Spirit to drive toward Site 5, acquire full-color, mid-drive images of Pumpkin Pie with all 13 filters of the panoramic camera, and acquire post-drive images with both the navigation and panoramic cameras. The following morning, Spirit was to complete a survey of rock clasts with the panoramic camera and scan the sky for clouds with the navigation camera.

Odometry:

As of sol 1359 (Oct. 30, 2007), Spirit's total odometry was 7,339.70 meters (4.56 miles).

sol 1348-1354, October 30, 2007: *Spirit Considers Options for Surviving Another Winter on Mars*

Spirit's handlers are currently confronted with the decision of where to send the rover for the winter. Dust deposition on the rover's solar panels, a product of the recent dust storms, has made power predictions for the upcoming winter even worse than those experienced during Spirit's last Martian winter. Members of the science team hope to find a place where Spirit can achieve a tilt of 20 degrees or more toward the north, facing the sun.

During the week, Spirit drove approximately 50 meters (164 feet) in a southerly and southeasterly direction toward a potential off-ramp from the top of the elevated plateau known as "Home Plate."

Proposed locations for a winter haven include driving south down the off-ramp and making a break for "von Braun," a hill approximately 120 meters (390 feet) away; heading north across Home Plate and driving down the north-facing edge; or driving west of Home Plate to a hill tentatively identified as "West Knob."

On sols 1349 and 1351 (Oct. 19 and Oct. 21, 2007), Spirit acquired long-baseline stereo images of von Braun, to the south of Home Plate.

Spirit has been generating approximately 345 watt-hours of solar array energy (enough to run a 100-watt bulb for almost 3 1/2 hours) per Martian day (or sol). Measurements of atmospheric dust opacity, known as Tau, have been approximately 0.7 (higher Tau measurements correspond to more dust).

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, sending evening data to Earth at UHF frequencies via the Odyssey orbiter, measuring atmospheric dust levels with the panoramic camera, and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1348 (Oct. 18, 2007): Spirit drove approximately 14 meters (46 feet) to get into position for the first "eye," or vantage point, of the long-baseline stereo panorama. The rover took a 7-by-1, post-drive image mosaic, measured the thermal characteristics of the external calibration target with the miniature thermal emission spectrometer, and acquired thumbnail images of the sky with the panoramic camera.

Sol 1349: Spirit created a list of files on board and then proceeded to acquire the left-eye portion of the long-baseline stereo panorama. The rover relayed data to Earth during the overnight pass of the Odyssey orbiter, completed a systematic ground survey using all 13 filters of the panoramic camera, and took spot images of the sky with the panoramic camera.

Sol 1350: Spirit drove approximately 8 meters (26 feet) to the second vantage point for the long-baseline stereo view and then acquired a post-drive image mosaic (a 6-by-1 panel) with the navigation camera. The rover acquired images of the external magnets through all filters of the panoramic camera.

Sol 1351: Spirit acquired the right-eye portion of the long-baseline stereo panorama and spent 6 1/2 hours collecting measurements of atmospheric argon with the alpha-particle X-ray spectrometer. The rover surveyed the horizon with the panoramic camera and watched for dust devils.

Sol 1352: Spirit acquired pre-drive images with the panoramic camera to fill in portions of the right-eye view of the stereo image mosaic. The rover drove approximately 6 meters (20 feet) south-southeast toward the potential south off-ramp of Home Plate and acquired a 5-by-1 mosaic of images with the navigation camera as well as a 4-by-1 mosaic of images with the panoramic camera. Spirit took spot images of the sky, conducted a survey of rock clasts with the panoramic camera, and searched for dust devils with the navigation camera.

Sol 1353: Spirit drove approximately 10 meters (33 feet) south-southeast toward the potential south off-ramp and acquired a 5-by-1, post-drive image mosaic with the navigation camera and a 4-by-1, post-drive image mosaic with the panoramic camera. The rover surveyed the horizon and completed a survey of rock clasts with the panoramic camera. Spirit watched for dust devils.

Sol 1354 (Oct. 24, 2007): Spirit acquired a 4-by-1, pre-drive panel of images of "West Knob" with the panoramic camera and drove approximately 12 meters (39 feet) south-southeast toward the potential off-ramp. The rover acquired a 5-by-1, post-drive image mosaic with the navigation camera and a 4-by-1 image mosaic with the panoramic camera. Spirit tested communications with the Mars Express orbiter, a European Space Agency mission, in preparation for next year's arrival of NASA's Phoenix lander. The rover completed a systematic ground survey and horizon survey with the panoramic camera.

Odometry:

As of sol 1354 (Oct. 24, 2007), Spirit's total odometry was 7,338.78 meters (4.56 miles).

sol 1343-1347, October 29, 2007: *Spirit Continues Studies of Rocks on "Home Plate"*

Spirit is healthy and continues to investigate "Home Plate." After completing extensive studies of "Site 3" using the Mössbauer spectrometer and other instruments, the rover proceeded toward "Site 4."

Meanwhile, it's already time for Spirit to start thinking about winter again. Over the coming weekend, the rover was scheduled to acquire long-baseline stereo images of Home Plate and surrounding areas in search of a safe winter haven.

The grinding encoder on Spirit's rock abrasion tool appears to have suffered the same fate as that of Spirit's twin, Opportunity, on the other side of Mars. An investigation is under way, but all indications are that activities using the rock abrasion tool will now require two Martian days, or sols.

On sol 1346 (Oct. 16, 2007), Spirit drove approximately 10 meters (33 feet) toward Site 4 and added another 12 meters (39 feet) of driving on sol 1347 (Oct. 17, 2007).

Sol-by-sol summary

In addition to receiving morning instructions directly from Earth via the high-gain antenna, returning data in the evening at UHF frequencies via the Odyssey orbiter, measuring atmospheric dust levels (known as tau measurements) with the panoramic camera, and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1343 (Oct. 13, 2007): Spirit restarted the Mössbauer spectrometer and collected data for 22 hours with the instrument from a target called "Humboldt Peak." The rover acquired remote data from a rock target known as "Mt. Eolus" with the miniature thermal emission spectrometer and a 6-by-1 image mosaic with the panoramic camera.

Sol 1344: Spirit restarted the Mössbauer spectrometer and resumed data collection from Humboldt Peak for 23 hours. The rover acquired spot images of the sky and a 4-by-1 image mosaic with the panoramic camera and collected remote data from a rock known as "Pikes Peak" using the miniature thermal emission spectrometer.

Sol 1345: Spirit resumed collecting Mössbauer data from Humboldt Peak for another 23 hours. The rover acquired remote data from a target dubbed "Mt. Sneffels" with the miniature thermal emission spectrometer and spot images of the sky with the panoramic camera. Spirit monitored dust on the rover mast assembly.

Sol 1346: Spirit ran tests on the rock abrasion tool and stowed the robotic arm before taking pre-drive images with the panoramic camera and driving about 10 meters (33 feet) toward Site 4 on Home Plate. The rover acquired a 5-by-1, post-drive image mosaic with the navigation camera as well as a 4-by-1 mosaic with the panoramic camera. The rover took spot images of the sky and foreground images with the panoramic camera.

Sol 1347 (Oct. 17, 2007): Spirit conducted a pre-drive survey of the rover's surroundings with the panoramic camera and drove another 12 meters (39 feet) toward Home Plate Site 4. The rover acquired a 7-by-1, post-drive image mosaic with the navigation camera. Spirit also took images of dust in the sky, conducted a survey of rock clasts, and acquired images of a rock target called "Conundrum Peak" using the panoramic camera.

Odometry:

As of sol 1347 (Oct. 17, 2007), Spirit's total odometry was 7,286 meters (4.5 miles).

sol 1337-1342, October 11, 2007: *Hardy Rover Continues to Celebrate Milestones*

After enduring seasonal dust storms much stronger than the rover was designed to survive, Spirit has now been exploring the Red Planet for two Martian years. That is a period of time longer than three years on Earth and more than 10 times the duration of the original 90-day mission. In fact, on Oct. 1, 2007, the rover entered the fifth extension of its original mission!

Spirit has arrived at a field of boulders that the science team is nicknaming after Colorado 14'ers -- Earth peaks taller than 14,000 feet. Atmospheric dust levels continue to wane, and Spirit took advantage of additional sunlight by using solar power to transmit data to Earth at night when the Odyssey orbiter passed overhead. These transmissions will free up more of Spirit's on-board computer memory.

Spirit began studies of a rock known as "Humboldt Peak" at "Site 3a." This particular rock is dark and angular and appears to be similar to "Comanche"-class rocks encountered by the rover earlier in the mission on "Husband Hill."

On sol 1339 (Oct. 9, 2007), the rover conducted a communications test with the European Space Agency's Mars Express orbiter. Mars Express will provide backup communications during the entry, descent, and landing of the Phoenix mission, due to arrive near the north pole of Mars on the United States' Memorial Day weekend of 2008.

The relays with Mars Express are a prime example of the value of having multiple spacecraft at Mars -- by using the same UHF radio frequencies as those used by the rovers and Mars Express, Phoenix will benefit from tried-and-true communications links already in place. Another example is Spirit's ability to take thermal measurements looking up into the atmosphere that fill in data that cannot be collected from above by orbiters looking down. The result is a more complete profile of the Martian atmosphere.

Sol-by-sol summary

In addition to measuring atmospheric dust levels (known as tau measurements) with the panoramic camera and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1337 (Oct. 7, 2007): Spirit acquired full-color images, using all 13 filters of the panoramic camera, of boulders at Site 3a. The rover approached Humboldt Peak and acquired post-drive images with the hazard avoidance and navigation cameras.

Sol 1338: Spirit completed a survey of rock clasts and acquired thumbnail images of the sky with the panoramic camera. The rover calibrated the miniature thermal emission spectrometer and acquired data from "Mt. Elbert" with the miniature thermal emission spectrometer. The rover transmitted data to Earth overnight via the Odyssey orbiter.

Sol 1339: Spirit calibrated the miniature thermal emission spectrometer and performed late-night tests of communications with the Mars Express orbiter.

Sol 1340: Spirit searched for morning dust devils with the navigation camera and checked for drift (changes with time) in the miniature thermal emission spectrometer. Spirit acquired a stereo mosaic of microscopic images of Humboldt Peak and placed the alpha-particle X-ray spectrometer on the target for overnight studies prior to brushing the surface. The rover surveyed a target known as "Crestone Needle" with the miniature thermal emission spectrometer and then conducted an 18-hour, overnight study of Humboldt Peak with the alpha-particle X-ray spectrometer, while also relaying data to Earth via the Odyssey orbiter.

Sol 1341: Spirit took spot images of the sky with the panoramic camera, checked for drift in the miniature thermal emission spectrometer, and brushed the surface of Humboldt Peak with the rock abrasion tool. The rover placed the alpha-particle X-ray spectrometer on the newly brushed surface. Spirit surveyed targets dubbed "Snowmass" and "Castle Peak" with the miniature thermal emission spectrometer. The rover conducted a 19-hour, overnight study of the brushed surface of Humboldt Peak with the alpha-particle X-ray spectrometer.

Sol 1342 (Oct. 12, 2007): Plans called for Spirit to look for morning clouds with the navigation camera and check for drift in the miniature thermal emission spectrometer. The rover was to switch tools to the Mössbauer spectrometer and spend 23 hours collecting data from

the brushed surface of Humboldt Peak with the instrument. Spirit was also scheduled to relay data to Earth during the overnight pass of the Odyssey orbiter and acquire data from a target known as "Mt. Evans" using the miniature thermal emission spectrometer. The next morning, the rover was expected to survey the sky with the panoramic camera.

Odometry:

As of sol 1337 (Oct. 7, 2007), Spirit's total odometry was 7,261.29 meters (4.5 miles).

sol 1329-1336, October 08, 2007: *Rover Experiences Data Backlog*

Spirit is in good health and on the move toward an appealing field of boulders at the southwest corner of "Home Plate." Preliminary data from the miniature thermal emission spectrometer indicates these boulders may be compositionally related to "Comanche"-class rocks first encountered on "Husband Hill."

Flash memory limited the rover's activities as the volume of memory in use edged up to more than 70 percent of capacity. After completing work on a 360-degree panorama from "site 3," Spirit had more than 711 megabits of unsent data in flash memory, 453 of which were data from the panoramic camera. Spirit now has enough power to transmit data to Earth during overnight Odyssey passes and took advantage of two of those opportunities this week.

Sol-by-sol summary

In addition to starting and ending each day by measuring atmospheric dust levels (known as a tau measurement) and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1329 (Sept. 29, 2007): Spirit restarted the Mössbauer spectrometer and collected data for 22 hours from a target known as "Texas Chili." The rover acquired a 3-by-2-frame mosaic of images of site 3 with the panoramic camera.

Sol 1330: Spirit acquired a microscopic image mosaic of Texas Chili and a bore sight of the microscopic imager with the panoramic camera to check the accuracy of its alignment. The rover then stowed the robotic arm, surveyed the external calibration target, and acquired a 5-point survey of the sky and ground with the miniature thermal emission spectrometer. During the afternoon overpass of the Odyssey orbiter, Spirit acquired data from a target known as "Harmony Point2" with the miniature thermal emission spectrometer.

Sol 1331: Spirit acquired a 5-by-1 image mosaic of site 3 with the panoramic camera and completed acquisition of the 360-degree panorama of the rover's surroundings as viewed from site 3. Spirit also acquired a 6-by-1 mosaic of images with the navigation camera and took thumbnail images of the sky with the panoramic camera. During the afternoon Odyssey overpass, the rover surveyed a target known as "Ohridski2" with the miniature thermal emission spectrometer.

Sol 1332: Spirit acquired a 5-by-1 image mosaic of site 3 and a 4-by-1, pre-drive image mosaic with the panoramic camera. The rover bumped backward 50 centimeters (20 inches) and acquired full-color images of the work volume studied by instruments on the robotic arm using all 13 filters of the panoramic camera. Spirit drove 10.1 meters (33.1 feet) toward a target area known as "site 3a," pausing to take mid-drive images with the navigation camera. The rover acquired a 5-by-1, post-drive image mosaic with the navigation camera and a 4-by-1 image mosaic with the panoramic camera.

Sol 1333: Martian winds cleared away some dust from the solar panels, resulting in a 1-percent increase in solar power, or about 10 watt-hours. Total solar output for the day was 361 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt light bulb for 1 hour). Spirit surveyed the horizon with the panoramic camera and completed a full-color, systematic ground survey using all 13 filters of the panoramic camera.

Sol 1334: Spirit completed a survey of rock clasts using the panoramic camera and then continued to drive toward site 3a. After the drive, the rover acquired images with the hazard avoidance cameras and a 4-by-1 image mosaic with the navigation camera. Spirit transmitted data to Odyssey during the overnight pass of the orbiter.

Sol 1335: Spirit completed a 5-point survey and then a 7-point survey of the sky and ground using the miniature thermal emission spectrometer.

Sol 1336 (Oct. 6, 2007): Spirit monitored dust on the panoramic camera mast assembly and acquired images with the navigation camera in support of observations with the miniature thermal emission spectrometer. The rover then completed a 7-point survey of the sky and ground as well as a systematic foreground survey with the miniature thermal emission spectrometer. Spirit transmitted data to the Odyssey orbiter during its overnight pass. The rover was slated to conduct a 5-point survey of the sky and ground the next morning with the miniature thermal emission spectrometer.

Odometry:

As of sol 1333 (Oct. 3, 2007), Spirit's total odometry was 7,244.32 meters (4.5 miles).

sol 1321-1328, September 27, 2007: *Spirit Arrives at "Stratigraphic Wonderland"*

Spirit completed the rover's longest 5-wheel drive to date en route to a platy rock surface nicknamed "Texas Chili" in an area scientists are calling a "stratigraphic wonderland." The platy outcrop is at site 3 on top of "Home Plate" and is the focus of in-depth scientific investigation.

Two sols after not receiving a scheduled data transmission, Spirit drove 19.21 meters (63.02 feet) to the rover's current location about 15 meters (49 feet) away from a field of boulders.

Meanwhile, atmospheric dust levels continued to decline. Tau measurements of atmospheric opacity dropped to 1.06 on sol 1327 (Sept. 27, 2007), with a dust factor of 0.48. Spirit has been averaging 350 watt-hours per Martian day (100 watt-hours is the amount of electricity needed to light a 100-watt bulb for one hour).

Scientific studies of the platy outcrop included alpha-particle X-ray spectrometer measurements both before and after brushing the surface, analysis with the Mössbauer spectrometer, and acquisition of microscopic images as well as a 360-degree panorama.

Sol-by-sol summary

Spirit began each Martian day by measuring atmospheric dust with the panoramic camera, checking for drift (changes with time) in the miniature thermal emission spectrometer, and surveying the sky and ground with the miniature thermal emission spectrometer. In addition to those tasks, Spirit completed the following activities:

Sol 1321 (Sept. 21, 2007): Rather than completing the drive toward Home Plate as intended, Spirit executed the previous sol's activities. As a result of an internal failure in a station at the Deep Space Network in Madrid, rover handlers were unable to transmit instructions to Spirit via the rover's high-gain antenna.

Sol 1322: Spirit spent the first sol of a three-sol weekend collecting remote science data, including panoramic camera images of a target known as "Ambrosia" and miniature thermal emission spectrometer measurements of Ambrosia as well as targets known as "Bisque" and "Cobbler."

Sol 1323: Spirit acquired panoramic camera images of Bisque and Cobbler before completing the 19.21-meter (63.02-foot) drive to site 3 on Home Plate. The rover took images with the hazard avoidance cameras before and after ending the drive and acquired post-drive image mosaics with the navigation and panoramic cameras.

Sol 1324: Spirit acquired near-field panoramic camera images and spent the third sol of a three-sol weekend collecting untargeted remote sensing data. Observations included movie frames in search of dust devils with the navigation camera and a systematic foreground survey with the miniature thermal emission spectrometer.

Sol 1325: Spirit surveyed rock clasts with the panoramic camera and scanned the sky for clouds with the navigation camera. The rover began work on a 360-degree panorama as well as scientific studies of Texas Chili. Spirit acquired navigation camera images in support of observations with the miniature thermal emission spectrometer, completed a full-color, systematic, foreground survey using all 13 filters of the panoramic camera, and acquired a mosaic of images of site 3 with the panoramic camera. Spirit studied targets known as "Hardy Point," "Harmony Point," and "Ohridski" with the miniature thermal emission spectrometer. The rover unstowed the robotic arm and placed the alpha-particle X-ray spectrometer on Texas Chili.

Sol 1326: In the morning, Spirit monitored dust on the rover mast. Later, the rover acquired more panoramic camera images of site 3, brushed the surface of Texas Chili with the rock abrasion tool, and acquired images of the microscopic imager with the front hazard avoidance camera to monitor dust accumulation. Spirit placed the alpha-particle X-ray spectrometer back on the target and collected data for about 18 hours.

Sol 1327: In the morning, Spirit received communications via the European Space Agency's Mars Express orbiter. The rover acquired more panoramic camera images of site 3, switched tools from the alpha-particle X-ray spectrometer to the Mössbauer spectrometer, and collected Mössbauer data from Texas Chili for about 21 hours.

Sol 1328 (Sept. 28, 2007): Spirit took thumbnail images of the sky with the panoramic camera, re-started the Mössbauer spectrometer, and collected Mössbauer data from Texas Chili for about 25 hours. The rover took more panoramic camera images of site 3 and was slated to continue doing so the following morning.

Odometry:

As of sol 1327 (Sept. 27, 2007), Spirit's total odometry was 7,234.09 meters (4.49 miles).

sol 1315-1320, September 25, 2007: *Spirit Makes Progress Across "Home Plate"*

Spirit is healthy after finishing a remote sensing campaign at Site 2 on "Home Plate." The work included collecting long-baseline stereo images of "Husband Hill," studying a possible fracture in the bedrock, and conducting reconnaissance looking west, southwest, and south in search of drive paths and geological information.

On Sol 1315 (Sept. 14, 2007), Spirit began driving toward Site 3, about 30 to 40 meters (100 to 130 feet) away from Site 2 at the southern end of Home Plate. Scientists wanted to gain elevation for a better view of the southern part of Home Plate and "Low Ridge." They planned to use instruments at the end of the rover's robotic arm to document alteration trends from northwest to southeast across Home Plate and get a better look at vesicular basalts and potential "Comanche"-class rocks (so named for rocks examined earlier in the mission while Spirit was crossing Husband Hill).

Later the same day, after the rover completed the drive, the Odyssey orbiter went into safe mode, and Spirit stayed put to perform remote sensing. On sols 1318 and 1319 (Sept. 17-18, 2007), Spirit communicated directly with Earth via the high-gain antenna, enabling the operations team to confirm that the rover was still healthy and had successfully completed the sol 1315 drive. On Wednesday, September 19th, Odyssey resumed relaying data from Spirit via UHF radio transmissions, clearing the way for Spirit to continue driving to Site 3.

Sol-by-sol summary

In addition to measuring atmospheric opacity with the panoramic camera, surveying the sky and ground with the miniature thermal emission spectrometer, and checking for drift (changes with time) in the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1315 (Sept. 14, 2007): Spirit surveyed a soil target known as "Broth" and rock targets known as "Vichyssoise" and "Cioppino" with the miniature thermal emission spectrometer. The rover drove toward Home Plate Site 3, acquiring images along the way with the hazard avoidance cameras. After the drive, Spirit took images of the surroundings with the navigation and panoramic cameras.

Sol 1316: Spirit acquired 8 minutes worth of movie frames in search of dust devils using the navigation camera. Spirit acquired a panel of navigation camera images looking to the rear and a mosaic of panoramic camera images of the fracture. The rover surveyed the external calibration target with the miniature thermal emission spectrometer.

Sol 1317: Spirit monitored dust accumulation on the rover mast with the panoramic camera and acquired full-color images of the foreground using all 13 filters of the panoramic camera. The rover completed a survey of rock clasts with the panoramic camera. Spirit scanned the foreground using both the navigation camera and miniature thermal emission spectrometer. Spirit recalibrated the panoramic camera's measurements of atmospheric opacity.

Sol 1318: Spirit took thumbnail images of the sky with the panoramic camera and checked the external calibration target with the miniature thermal emission spectrometer. The rover spent most of the sol taking measurements of atmospheric dust.

Sol 1319: Spirit continued to check the external calibration target with the miniature thermal emission spectrometer and acquired movie frames in search of dust devils with the navigation camera.

Sol 1320 (Sept. 20, 2007): Spirit took thumbnail images of the sky with the panoramic camera and monitored dust accumulation on the mast with the miniature thermal emission spectrometer.

Odometry:

As of sol 1315 (Sept. 14, 2007), Spirit's total odometry was 7,214 meters (4.48 miles).

sol 1309-1314, September 18, 2007: *Spirit Explores Top of "Home Plate"*

After spending some time getting used to the terrain on top of "Home Plate," Spirit began driving across the top of the elevated plateau, en route to taking more images and examining a possible fracture in the bedrock.

On the rover's 1,310th Martian day, or sol, of exploration (Sept. 9, 2007), Spirit completed a drive characterization to determine how the rover responded on Home Plate terrain. After passing that test, Spirit proceeded toward a destination known as "Site 2." Plans called for the rover to acquire the second portion of a long-baseline, stereo view of "Husband Hill" and study the potential fracture. In addition, Spirit was slated to collect remote sensing data looking to the west, southwest, and south in search of possible drive paths as well as geological information.

Sol-by-sol summary

In addition to measuring atmospheric opacity with the panoramic camera, surveying the sky and ground with the miniature thermal emission spectrometer, and checking for drift (changes with time) in the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1309 (Sept. 8, 2007): Spirit examined targets known as "Gumbo," "Goulash," "Stew," and "Pudding" with the miniature thermal emission spectrometer. Spirit took wide-range atmospheric dust measurements using the panoramic camera and then, after the evening pass of the Odyssey orbiter, recalibrated the dust measurements of the panoramic camera.

Sol 1310: Spirit acquired panoramic camera images of Gumbo and Goulash. The rover turned in place to characterize the drive toward Site 2 and started driving in that direction. Spirit took images with the hazard avoidance cameras just before and after completing the drive as well as post-drive images with the panoramic camera.

Sol 1311: Spirit surveyed the horizon with the panoramic camera.

Sol 1312: Spirit monitored dust accumulation on the rover's mast with the panoramic camera and continued driving. The rover acquired images with the hazard avoidance cameras before and after completing the drive and acquired post-drive images with the panoramic and navigation cameras. Spirit acquired a rearward-looking mosaic of navigation camera images, surveyed the external calibration target with the miniature thermal emission spectrometer, and completed a systematic ground survey using all 13 filters of the panoramic camera.

Sol 1313: Spirit surveyed the horizon with the panoramic camera.

Sol 1314 (Sept. 13, 2007): Spirit acquired full-color views, using all 13 filters of the panoramic camera, of the fracture on Home Plate. The rover acquired forward-looking images with the panoramic camera and acquired data from targets dubbed "Tapioca," "Bouillabaisse," and "Dumplings" with the miniature thermal emission spectrometer. Spirit acquired wide-range measurements of atmospheric dust with the panoramic camera and measured atmospheric argon with the alpha-particle X-ray spectrometer. After the overpass of the Odyssey orbiter, Spirit recalibrated dust measurements with the panoramic camera. The following morning, the rover was to acquire panoramic camera images of Dumplings and complete a survey of rock clasts.

Odometry:

As of sol 1312 (Sept. 11, 2007), Spirit's total odometry was 7,206 meters (4.48 miles).

sol 1303-1308, September 10, 2007: *Spirit Finally Arrives at Home Plate!*

After remaining beyond the margins of Home Plate ever since exiting its northeast edge on Sol 774 (March 7, 2006) to survive the first winter on Mars, Spirit finally climbed on top of the elevated, circular plateau that scientists believe is volcanic in origin.

Before completing the final drive, however, Spirit returned to the soil patch nicknamed "Gertude Weise," made of nearly pure silicon dioxide, to acquire data that will help scientists characterize how much dust has accumulated on the instrument optics of the miniature thermal emission spectrometer.

The miniature thermal emission spectrometer is inside the boxy body of the rover, below the mast. Mirrors inside the mast allow the instrument to see outside. The rover has been using the spectrometer to measure changes in the atmosphere during the recent dust storm on Mars. When the instrument is not in use, a cover protects it from dust floating in the atmosphere but it isn't air-tight.

After completing measurements of Gertrude Weise, Spirit was once again on the move. The rover attempted to "thread the needle" by driving between two rocks on sol 1304 (Sept. 3, 2007) and place the rear two wheels on the top of Home Plate (Spirit must drive backward to drag the frozen right front wheel).

As it turned out, the drive was more difficult than anticipated. On the first attempt, Spirit immediately stopped driving when the rover's wheels entered an area designated as a keepout zone. This occurred as the rover was attempting to compensate for drag from the right front wheel by turning slightly in the opposite direction. Normally, the dragging wheel causes Spirit to yaw counter-clockwise (as viewed from above), but the amount of counter-clockwise spin depends on the amount of drag encountered by the right front wheel. Rocky surfaces cause less drag than soil. In this case, the drag was less than anticipated.

On sol 1306 (Sept. 5, 2007), Spirit tried again and executed the drive flawlessly! Now that the rover's two rear wheels are on top of the eastern edge of Home Plate, Spirit is in position to explore the top of the elevated plateau along its eastern and southern edges. The next planned stop is a few meters away in an area known as "Site 2," located midway along the eastern scarp of Home Plate east scarp and several meters to the west of the scarp. (If you compared the roughly circular shape of the top of Home Plate to a clock, Site 2 would be at 3:30.)

After that, scientists plan to have Spirit proceed to "Site 3," at the southern end of Home Plate (6 o'clock position) and "Site 4," at the southwestern corner of Home Plate (7:30 position).

By collecting data at all these sites, scientists hope to interpret the geologic structure of Home Plate, determine how the rock chemistry changes from one side to the other, and elucidate a fracture that crosses the plateau from west to east. Along the way, the rover will take images of the south face of "Husband Hill" to the north and outcrops known as "Goddard" and "von Braun" to the south.

In recent months, rover handlers have been naming local features and targets around Home Plate for deceased members of the All-American Girls Professional Baseball League. Because Home Plate is bowl-shaped, scientists have decided to name features on top of Home Plate after things served in bowls. Stay tuned for upcoming yummy descriptions!

Sol-by-sol summary:

In addition to measuring atmospheric opacity with the panoramic and navigation cameras, surveying the sky and ground with the miniature thermal emission spectrometer, and checking for drift (changes with time) in the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1303 (Sept. 2, 2007): Spirit studied a target known as "Gertrude Weise14," the background of the target, a soil target labeled "Innocent Bystander Disturbed Area 1," and a target known as "Mary Dailey3" as well as its background with the miniature thermal emission spectrometer. Spirit recalibrated the panoramic camera and acquired miniature thermal emission spectrometer data on a target dubbed "Joanne Winter2."

Sol 1304: Spirit acquired full-color images of the disturbed soil area using all 13 filters of the panoramic camera before driving 2.42 meters (7.94 feet) toward Home Plate. The rover took images just before and after completing the drive with the hazard avoidance cameras as well as post-drive images with the navigation and panoramic cameras.

Sol 1305: Spirit surveyed the rover's external calibration target using the miniature thermal emission spectrometer and acquired movie frames in search of dust devils using the navigation camera. The rover recalibrated the panoramic camera.

Sol 1306: Before beginning the sol's drive, Spirit acquired full-color images of the rover's external calibration target as well as the disturbed soil area of Innocent Bystander using all 13 filters of the panoramic camera. After completing the 8.21-meter (26.9-foot) drive, the rover took images of the surrounding terrain with the navigation camera and forward-looking images with the panoramic camera.

Sol 1307: Spirit completed a survey of rock clasts with the panoramic camera and assessed the calibration target with the miniature thermal emission spectrometer.

Sol 1308 (Sept. 7, 2007): Spirit acquired images of dust in the sky with the panoramic camera, calibrated the miniature thermal emission spectrometer, and listed files in the rover's flash memory (a type of rewritable electronic memory that retains information even when power is off). Spirit completed a systematic foreground survey using all 13 filters of the panoramic camera and measured albedo (surface reflectivity) using the panoramic camera. With the miniature thermal emission spectrometer, the rover surveyed a soil target known as "Beef_Chili," a rock target known as "Cajun_Chili," and the external calibration target.

Odometry:

As of sol 1306 (Sept. 5, 2007), Spirit's total odometry was 7,182.49 meters (4.46 miles).

sol 1295-1302, August 30, 2007: *Spirit Slowly Emerges from Blanket of Dust*

Spirit remains healthy as the rover slowly picks up more solar energy. The dust storms appear to be over, at least for now, and the skies are slowly clearing. Unfortunately, what energy Spirit has gained from cleaner skies has been offset by losses to dustier solar arrays. Still, Spirit has the energy, about 325 watt-hours, to finally be roving again.

Tau, a measure of atmospheric dustiness, declined slightly. As of Sol 1299 (Aug. 29, 2007), the Sun was at about 8 percent of its full brightness, an increase of a little more than 2 percent compared with five sols earlier. Dust on the rover's solar arrays increased by about 3 percent and only about 59 percent of the sunlight hitting the arrays gets through to make electricity.

But rather than getting a 1-percent boost in solar power, the rover has been just about breaking even. The reason is that Tau measures direct sunlight but there's also scattered sunlight and it, too, increased by about 1 percent.

Much of the dust previously seen on the turret has blown or fallen off. Dust contamination remains a concern, particularly for the microscopic imager, where some of the dust clumps visible in earlier images have fallen out or moved out of the line of sight.

On Sol 1296 (Aug. 25, 2007), Spirit resumed driving to "Home Plate" and more specifically, to a location with gentle slopes and few rocks known as "the on-ramp." This drive was a turn-in-place, given Spirit's frozen right front wheel, to get the rover pointed in the right direction.

After two sols of remote sensing with emphasis on characterizing whatever dust had accumulated on the panoramic camera, Spirit's handlers decided to have the rover retrace its tracks to assess what dust contamination might be present on the miniature thermal emission spectrometer. To do this, they needed to measure a known target.

With a blanket of dust everywhere, scientists needed a way to distinguish dust on targets of scientific interest from dust on the optics. The best target for that was "Gertrude Weise," a patch of nearly pure-silica soil uncovered by Spirit's wheels. Rover planners decided to have the rover drag its wheels through it again to scrape off newly acquired dust and expose the same pure silica as before. Differences between old and new measurements would be due to dust on the instrument itself; once that signature was known, it could be subtracted from future measurements.

The first drive to Gertrude Weise was a little short and didn't uncover the silica as hoped. Spirit's handlers planned a second drive on Sol 1300 (Aug. 30, 2007), during which the rover was to scuff the soil with a half-turn of the left front wheel, then scuff it more by locking both left and right front wheels and driving them backward across Gertrude Weise. They then planned to have the rover back up some more to take images and move toward the Home Plate on-ramp.

Spirit was expected to resume the long-awaited trek to Home Plate on sol 1303 (Sept. 2, 2007).

Sol-by-sol summary:

In addition to daily direct-from-Earth uplinks over the rover's high-gain antenna, relays to Earth at UHF frequencies via the Odyssey orbiter, surveys of the sky and ground with the miniature thermal emission spectrometer, measurements of atmospheric opacity with the panoramic and navigation cameras, and image acquisition with the front and rear hazard avoidance cameras, Spirit completed the following activities:

Sol 1295 (Aug. 25, 2007): Spirit conducted remote sensing and acquired panoramic camera images of targets known as "Eileen Dean," "Dorothy Mueller," and "Stealing Third."

Sol 1296: Spirit drove and turned in place 156 degrees to point toward the on-ramp of Home Plate. The rover assessed dust accumulation on the lenses of the panoramic camera and measured atmospheric opacity (Tau) at different times of day.

Sol 1297: Spirit conducted remote sensing and general atmospheric science, including characterizing dust on the panoramic camera.

Sol 1298: Spirit drove, returning to Gertrude Weise.

Sol 1299: Spirit conducted remote sensing and general atmospheric science, including characterizing dust on the panoramic camera.

Sol 1300: Plans called for Spirit to drive, scuff and drag its wheels over Gertrude Weise, and acquire images of the target. The rover was to conduct atmospheric science.

Sol 1301: Plans called for Spirit to conduct remote sensing and general atmospheric science, including characterizing dust on the panoramic camera. The rover was to measure atmospheric argon with the alpha-particle X-ray spectrometer.

Sol 1302 (Sept. 1, 2007): Plans called for Spirit to conduct remote sensing and general atmospheric science, including characterizing dust on the panoramic camera.

Odometry:

As of sol 1298 (Aug. 28, 2007), Spirit's total odometry was 7,169 meters (4.45 miles).

sol 1288-1294, August 23, 2007: *Spirit Tries to Coax Dust from Microscopic Imager*

For the first time since arriving on Mars in 2004, Spirit attempted to remove dust from the microscopic imager in a "blobs away" campaign to help the rover recover from a series of dust storms. The rover remained healthy as the Gusev Crater region continued to emerge from the recent storms. Gloominess caused by suspended dust in the atmosphere remained high but continued its downward trend. Dust falling out of the atmosphere continued to accumulate on the solar panels, limiting power gains from decreasing atmospheric opacity, known as Tau.

Between the rover's 1,288th and 1,291st Martian days, or sols, of exploration (Aug. 18 and Aug. 21, 2007), Tau values went down from 3.2 to 3.0. During the same time, the accumulation of dust on the solar arrays rose from 0.664 to 0.640 (a dust factor of 1.0 corresponds to a perfectly clean array). Solar energy on sol 1291 (Aug. 21, 2007) was 313 watt-hours (100 watt-hours is what it takes to light a 100-watt bulb for 1 hour).

The "blobs away" campaign, designed to dump dust from the surface of the microscopic imager lens, involved repeatedly taking images, opening and closing the dust cover, pointing the instrument slightly upward at an angle of 20 degrees (with the hinge down to avoid dumping caked dust on the lens), and taking more images and opening and closing the dust cover. Improved image quality after the procedure indicated that either some dust fell out or simply moved around. Dust decontamination efforts continue.

Spirit acquired microscopic images of mobile surface ripples and a soil target nicknamed "Norma Luker" on Sol 1291 (Aug. 21 2007). Despite dust motes on the lens, the images were useful to the science team.

Engineers were investigating the cause of a failed transmission on sol 1292 (Aug. 22, 2007), in which planned activities did not get on board the spacecraft. Potential causes being investigated included an uplink glitch or interference from a simultaneous uplink to the Mars Reconnaissance Orbiter.

Spirit "drove" 42 centimeters (16 ½ inches) to a new position. Weekend plans called for the first multi-meter drive toward the elevated plateau known as "Home Plate" as well as test transmissions to the European Mars Express orbiter in support of next year's arrival of the Phoenix spacecraft now en route to Mars.

Martian weather reports as of Aug. 22 indicated a lull in afternoon storm activity on the red planet, with no new storm activity visible within a few thousand kilometers of either Mars rover site. Skies remained dusty and were expected to continue to clear slowly.

Sol-by-sol summary:

In addition to daily direct-from-Earth uplinks over the rover's high-gain antenna, relays to Earth at UHF frequencies via the Odyssey orbiter, surveys of the sky and ground with the miniature thermal emission spectrometer, measurements of atmospheric opacity with the panoramic and navigation cameras, and image acquisition with the front and rear hazard avoidance cameras, Spirit completed the following activities:

Sol 1288 (Aug. 18, 2007): Spirit studied Norma Luker with the alpha-particle X-ray spectrometer.

Sol 1289: Spirit monitored dust accumulation on the rover mast, collected data on the external calibration target with the miniature thermal emission spectrometer, and completed a survey at high sun with the panoramic camera.

Sol 1290: Spirit surveyed the horizon with the panoramic camera and performed dust ejection maneuvers with the microscopic imager.

Sol 1291: Spirit took thumbnail images of the sky with the panoramic camera, checked for drift (changes with time) in the miniature thermal emission spectrometer, and acquired stereo microscopic images of Norma Luker. The rover moved the microscopic imager and acquired stereo microscopic views of surface ripples, stowed the robotic arm, and acquired hazard avoidance camera images to document the stowing of the arm.

Sol 1292: Plans for a day of remote sensing and acquisition of full-color images of a target known as "Eileen Dean" failed to get on board.

Sol 1293: Spirit checked for drift in the miniature thermal emission spectrometer, acquired movie frames in search of dust devils using the navigation camera, and took full-color images using all 13 filters of the panoramic camera of a target known as "Gertrude Weise12." The rover acquired miniature thermal emission spectrometer data from the same target before rolling a short distance away. After the short drive, the rover took images of its new location with the navigation camera and hazard avoidance cameras.

Sol 1294 (Aug. 24, 2007): Plans called for Spirit to check for drift in the miniature thermal emission spectrometer, acquire movie frames in search of dust devils with the navigation camera, and survey the horizon with the panoramic camera.

Odometry:

As of sol 1293 (Aug. 23, 2007), Spirit's total odometry was 7,154 meters (4.45 miles).

sol 1284-1287, August 20, 2007: *Dust from Martian Sky Accumulates on Solar Panels*

Even though the Martian sky above Gusev Crater continued to clear, solar power levels on NASA's Spirit rover remained fairly constant as dust settling from the atmosphere accumulated on top of the solar panels. Activities remained restricted. Measurements of atmospheric opacity, known as Tau, dropped from 3.6 on Martian day, or sol, 1283 (Aug. 12, 2007) to 3.3 on sol 1286 (Aug. 16, 2007), generating power levels of 301 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

During recent wind storms on Mars, some dust appears to have gotten past the cover of the microscopic imager, based on images Spirit acquired on sols 1279 and 1284-1286 (Aug. 8, 2007 and Aug. 14-16, 2007). Engineers conducting tests with a surrogate rover on Earth

hoped to position the instrument in a downward-facing position as early as sol 1290 (Aug. 20, 2007) in an attempt to get accumulated dust to fall out.

While assessing the well-being of the microscopic imager, Spirit completed an analysis of a crushed rock target known as "Innocent Bystander" with the Mössbauer spectrometer and continued to make observations of the ground and atmosphere. The rover remains healthy and is parked just east of the elevated plateau known as "Home Plate."

The forecast for the next week is for no new dust storm activity, based on weather reports provided by Malin Space Science Systems, the builder of the Mars Color Imager on board the Mars Reconnaissance Orbiter. The camera is being used to monitor conditions on the red planet. Skies are expected to continue to clear over the next couple of months.

Sol-by-sol summary:

Except where noted, daily communications included morning, direct-from-Earth uplinks over the rover's high-gain antenna and evening relays of data to Earth at UHF frequencies via the Odyssey orbiter. In addition, Spirit completed the following activities:

Sol 1284 (Aug. 13, 2007): Spirit placed the Mössbauer spectrometer back on Innocent Bystander and began analysis with the instrument. The rover also acquired images of ripples using the front and rear hazard avoidance cameras and microscopic images looking toward the sky through the dust cover of the microscopic imager. Spirit measured atmospheric opacity with the panoramic camera and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1285: Spirit surveyed atmospheric opacity with the panoramic and navigation camera and acquired images of ripples using the front and rear hazard avoidance cameras. The rover acquired microscopic images looking through the dust cover of the microscopic imager and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1286: Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and measured atmospheric dust with the panoramic and navigation cameras. The rover continued with Mössbauer analysis of Innocent Bystander and took diagnostic images at different times of day looking skyward through the dust cover with the microscopic imager. Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and acquired images with the front and rear hazard avoidance cameras.

Sol 1287 (Aug. 17, 2007): Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and measured atmospheric dust with the panoramic and navigation cameras. The rover continued with Mössbauer analysis of Innocent Bystander and acquired images with the front and rear hazard avoidance cameras. Spirit took more skyward-oriented images through the dust cover with the microscopic imager and surveyed the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1287 (Aug. 16, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1274-1283, August 16, 2007: *Gloomy Skies Show Signs of Clearing*

Spirit is healthy as the amount of dust hoisted into the atmosphere by recent wind storms has leveled off and solar energy levels have held steady at about 280 to 300 watt-hours of energy (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour). Since the rover's 1,271st Martian day, or sol, of exploration (July 31, 2007), atmospheric opacity, a measurement known as Tau, has stabilized at about 3.8. Given the apparent relative stability of the atmosphere, the rover's handlers have returned to somewhat more normal planning procedures, allowing the rover to take on more science activities. Spirit studied a crushed rock target known as "Innocent Bystander" using the Mössbauer spectrometer on sols 1275, 1278, and 1281 (Aug. 4, Aug. 7, and Aug. 10, 2007).

Spirit appears to have accumulated some dust contamination on the optics of the microscopic imager at some point during a period of 10 Martian days between sol 1257 (July 17, 2007) and sol 1277 (Aug. 6, 2007). On sol 1282 (Aug. 11, 2007), Spirit got a look at the microscopic imager with the dust cover closed using the panoramic and hazard avoidance cameras. The rover's handlers are considering using the front hazard avoidance cameras to try to get a better look at the microscopic imager with the dust cover open. They are also considering strategies for removing dust if necessary.

Spirit remains parked just to the east of the elevated plateau known as "Home Plate" with the Mössbauer spectrometer placed on Innocent Bystander.

Sol-by-sol summary:

Except where noted, daily communications included morning, direct-from-Earth uplinks over the rover's high-gain antenna and evening relays of data to Earth at UHF frequencies via the Odyssey orbiter. In addition, Spirit completed the following activities:

Sol 1274 (Aug. 3, 2007): Spirit acquired wide-range, panoramic camera images for measuring atmospheric dust, searched for clouds using the navigation camera, acquired movie frames in search of dust devils, and acquired images of surface ripples to the front and rear of the rover with the hazard avoidance cameras. The rover surveyed the external calibration target with the miniature thermal emission spectrometer.

Sol 1275: Spirit conducted studies with the Mössbauer spectrometer, acquired a 3x1 mosaic of images of ripples with the navigation camera, acquired wide-range, panoramic camera images for measuring atmospheric dust, and took images of ripples with the front and rear hazard avoidance cameras. The rover scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 1276: Spirit acquired images of ripples with the front and rear hazard avoidance cameras, acquired wide-range, panoramic camera images for measuring atmospheric dust, acquired a 360-degree panorama of the rover's surrounding with the navigation camera, and

searched for clouds with the navigation camera.

Sol 1277: Spirit acquired a stack of microscopic images of targets known as "Stealing Second" and "Stealing Third," a microscopic image of Innocent Bystander, and both wide-range, panoramic camera images and navigation camera images for measuring atmospheric dust. The rover monitored dust on the rover mast, acquired images of ripples with the front and rear hazard avoidance cameras, and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1278: Spirit studied Innocent Bystander using the Mössbauer spectrometer, acquired images of ripples using the navigation camera, and measured atmospheric dust by acquiring wide-range, panoramic camera images as well as navigation camera images. The rover took thumbnail images of the sky and acquired movie frame images in search of dust devils with the navigation camera.

Sol 1279: Spirit acquired images of surface ripples using the rear and front hazard avoidance cameras, acquired a microscopic image looking through the dust cover, and acquired images of the microscopic imager from the outside using the panoramic and navigation cameras. The rover acquired wide-range, panoramic camera images as well as navigation camera images for measuring atmospheric dust, took spot images of the sky, and surveyed the horizon.

Sol 1280: Spirit measured atmospheric properties using the alpha-particle X-ray spectrometer and measured atmospheric opacity with the panoramic and navigation cameras. The rover took images of ripples with the front and rear hazard avoidance cameras, searched for clouds with the navigation camera, and conducted a mini-survey of the sky and ground with the miniature thermal emission spectrometer.

Sol 1281: Spirit acquired wide-range, panoramic camera images and navigation camera images to measure atmospheric dust. The rover conducted studies with the Mössbauer spectrometer, completed a survey at high sun with the panoramic camera, and took images of surface ripples using the navigation and panoramic cameras.

Sol 1282: Spirit extended the robotic arm for panoramic camera images, retracted the robotic arm for hazard avoidance camera images, and extended the rock abrasion tool into ready position. The rover acquired images of ripples using the front and rear hazard avoidance cameras, acquired wide-range, panoramic camera images to measure atmospheric dust, and monitored dust on the rover mast. Spirit conducted a mini-survey of the sky and ground using the miniature thermal emission spectrometer.

Sol 1283 (Aug. 12, 2007): Spirit acquired wide-range, panoramic camera images and navigation camera images for measuring atmospheric dust, took spot images of the sky, surveyed the horizon, acquired a 3x1 mosaic of navigation camera images of surface ripples, and completed a mini-survey of the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1283 (Aug. 12, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1268-1273, August 8, 2007: *Martian Dust Begins to Settle -- Right on Top of the Solar Arrays*

Spirit is healthy and continues to ride out the dust storms on Mars. In fact, atmospheric dreariness has improved in the last few Martian days, or sols, but as dust settles out of the atmosphere, it settles onto the solar arrays, keeping power levels relatively low.

Measurements of the amount of sunlight blocked from reaching the rover, known as Tau, dropped from a record high of 4.738 on sol 1265 (July 25, 2007) to 3.813 on sol 1273 (Aug. 2, 2007). Solar power levels leveled off at around 260 to 300 watt-hours per sol (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Weather reports from the Mars Color Imager on the Mars Reconnaissance Orbiter indicate the storms may be in the early stages of decay. Spirit continues to use power conservatively in view of the recent jump in dust levels and the struggle for survival by Spirit's twin, the Opportunity rover, on the opposite side of the red planet.

Spirit remains parked just east of the elevated plateau known as "Home Plate," with the Mössbauer spectrometer placed on the target known as "Innocent Bystander." On sol 1273 (Aug. 2, 2007), Spirit performed a 5-hour study with the Mössbauer spectrometer.

After the dust settles, Spirit's handlers on Earth plan to have the rover continue collecting Mössbauer data from Innocent Bystander for a few sols, acquire microscopic images of the new dust layer on the soil, and drive onto Home Plate.

Sol-by-sol summary:

Except where noted, daily communications activities included morning, direct-from-Earth uplinks over the rover's high-gain antenna and evening relays of data to Earth at UHF frequencies via the Odyssey orbiter. In addition, Spirit completed the following activities:

Sol 1268: Spirit measured atmospheric Tau with both the panoramic camera and navigation camera. The rover did not relay data to Earth to conserve power.

Sol 1269: Spirit measured Tau and completed a sky survey using the panoramic camera. The rover's handlers on Earth did not send instructions to the rover to conserve power.

Sol 1270: Spirit measured Tau and completed a sky survey using the panoramic camera. The rover's handlers on Earth did not send instructions to the rover to conserve power.

Sol 1271: Spirit measured Tau and completed a sky survey using the panoramic camera. The rover measured Tau using the navigation camera and acquired images of sand ripples on the surface with the front hazard avoidance camera.

Sol 1272: Spirit took more images of sand ripples with the front hazard avoidance camera as well as with the rear hazard avoidance camera. The rover acquired a mosaic of sand ripple images with the navigation camera. Spirit measured atmospheric dust, acquired images of the sky, completed a horizon survey, and acquired images of the "El Dorado" dune field with the panoramic camera. To conserve power, Spirit did not send data to Earth.

Sol 1273 (Aug. 2, 2007): Spirit studied Innocent Bystander with the Mössbauer spectrometer.

Odometry:

As of sol 1265 (July 25, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1261-1267, August 8, 2007: *Atmospheric Gloom Reaches Record Levels*

Despite setting new personal records for atmospheric opacity, Spirit is healthy and riding out the dust storm on Mars. Though science activity has been minimal, the rover was able to collect data on storm activity. On Spirit's 1,265th Martian day, or sol, of exploration (July 25, 2007), the rover reported an atmospheric opacity measurement, known as Tau, of 4.73 -- a record high for this vehicle. Solar power levels dropped to a corresponding record low of 261 watt-hours (100 watt-hours is the amount of energy needed to light a 100-watt bulb for one hour).

Meanwhile, Spirit's handlers on Earth modified the rover's activities to reflect the reduced amount of power available. In some cases, this meant foregoing communications with the Mars Odyssey spacecraft.

Sol-by-sol summary:

Sol 1261-1263 (July 21-23, 2007): Spirit measured atmospheric opacity, known as Tau, once each sol using the panoramic camera. On sol 1261 (July 21, 2007), the rover transmitted a beep confirming the handover of a new master sequence of activities. There was no downlink of information from Spirit via UHF frequencies on sol 1263 (July 23, 2007).

Sol 1264: Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer, acquired a micro-mini survey of the sky and ground using the miniature thermal emission spectrometer (meaning the scan lasted 6 1/2 minutes instead of 8 1/2 minutes), and measured atmospheric opacity using the panoramic camera.

Sol 1265: In the morning, Spirit measured atmospheric opacity with the panoramic camera and took images with the hazard avoidance cameras. Spirit checked for drift in the miniature thermal emission spectrometer and acquired a micro-mini survey of the sky and ground using the miniature thermal emission spectrometer.

Sol 1266: Spirit greeted the day by measuring atmospheric opacity with the panoramic camera and taking images with the hazard avoidance cameras. After receiving news of record-breaking tau, Spirit's handlers on Earth deleted a planned overnight study with the Mössbauer spectrometer. They transmitted activities for sol 1267.

Sol 1267 (July 27, 2007): Spirit measured atmospheric opacity with the panoramic camera, checked for drift in the miniature thermal emission spectrometer, and acquired a micro-mini survey of the sky and ground using the miniature thermal emission spectrometer. The rover surveyed the horizon with the panoramic camera. The next day, Spirit was to acquire images with the front hazard avoidance camera, measure atmospheric opacity with the panoramic camera, take images of the sky with the panoramic camera, and survey the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1265 (July 25, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1253-1260, August 8, 2007: *Spirit Monitors Dust Storm While Studying Martian Terrain*

Spirit is healthy and is parked next to a cluster of rock fragments known as "Innocent Bystander," which the rover has been studying "Innocent Bystander" using instruments on the rover's robotic arm, including a long analysis with the Mössbauer spectrometer. This target is of interest because it is high in silica, a feature suggesting water may have been present during formation. The rocks are also low in nanophase oxide, a possible product of weathering.

On the rover's 1,253rd Martian day, or sol, of exploration (July 13, 2007), Spirit took microscopic images of the aperture of the miniature thermal emission spectrometer while holding the microscopic imager itself, which is located at the end of the robotic arm, at different elevations. Spirit performed this experiment in preparation for running it again on Spirit's twin, the Opportunity rover, on the opposite side of Mars.

On sol 1,257 (July 17, 2007), Spirit acquired a super-resolution mosaic of microscopic images of Innocent Bystander to get a better look at the unusual granular texture of the surface.

Spirit recorded dust storm activity using the panoramic and navigation cameras.

The sky above Spirit continued to darken as a result of dust storm activity. Measurements of atmospheric opacity, known as Tau, are an estimate of how much sunlight cannot penetrate the atmosphere. During the week, Spirit recorded a Tau of 4.017 on sol 1,259 (July 19, 2007), the largest Tau to date at the rover's location. Spirit experienced a 6-percent dust cleaning of the rover's solar arrays on sol 1,258 (July 18, 2007), which left the solar arrays the cleanest they had been since sol 427 (March 16, 2005).

Sol-by-sol summary:

Sol 1253 (July 13, 2007): Spirit monitored atmospheric opacity using the panoramic camera, checked for drift (changes over time) in the miniature thermal emission spectrometer, and scanned the sky and ground using the miniature thermal emission spectrometer. Spirit took images of the miniature thermal emission spectrometer with the microscopic imager, exchanged tools to the Mössbauer spectrometer for an offset view of Innocent Bystander, and took thumbnail images of the sky using the panoramic camera. The rover acquired data from a target known as "Somp" using the miniature thermal emission spectrometer.

Sol 1254: In the morning, in addition to monitoring atmospheric opacity using the panoramic camera, Spirit took navigation cameras of the Sun, surveyed the horizon with the panoramic camera, and surveyed a target known as "Korus" using the miniature thermal emission spectrometer. Spirit checked for drift in the miniature thermal emission spectrometer and scanned the sky and ground using the miniature thermal emission spectrometer. The rover conducted Mössbauer studies of a target dubbed "Innocent Bystander Offset2," acquired full-color panoramic camera images of a target known as "Tangor," and acquired super-resolution panoramic camera images of a target known as "Gooli." Spirit surveyed a target called "Gooli3" using the miniature thermal emission spectrometer.

Sol 1255: In the morning, Spirit took navigation camera images of the Sun, conducted a horizon survey with the panoramic camera, and acquired data from a target known as "Alice DeCambra," in addition to monitoring atmospheric opacity with the panoramic camera, checking for drift in the miniature thermal emission spectrometer, and scanning the sky and ground with the miniature thermal emission spectrometer. Spirit continued to collect Mössbauer data from Innocent Offset2, took thumbnail images of the sky with the panoramic camera, and acquired a mosaic of images of the dune field known as "El Dorado" with the panoramic camera. The rover used the miniature thermal emission spectrometer to collect data on targets known as "Mona Denton" and "Faget2."

Sol 1256: In the morning, Spirit took navigation camera images of the Sun and scanned Tangor with the miniature thermal emission spectrometer, in addition to monitoring atmospheric opacity with the panoramic camera, checking for drift in the miniature thermal emission spectrometer, and scanning the sky and ground with the miniature thermal emission spectrometer. Spirit continued Mössbauer studies of Innocent Bystander.

Sol 1257: In the morning, Spirit took navigation camera images of the Sun and used the miniature thermal emission spectrometer to study a target known as "Lenora Mandella2," in addition to monitoring atmospheric opacity with the panoramic camera, checking for drift in the miniature thermal emission spectrometer, and scanning the sky and ground with the miniature thermal emission spectrometer. Spirit acquired super-resolution, microscopic images of Innocent Bystander Offset2 and restarted the Mössbauer spectrometer for continued analysis of the same target.

Sol 1258: In the morning, Spirit monitored dust accumulation on the rover mast, took thumbnail images of the sky with the panoramic camera, checked for drift in the miniature thermal emission spectrometer, and scanned the sky and ground with the miniature thermal emission spectrometer. Spirit restarted the Mössbauer spectrometer for continued analysis of Innocent Bystander Offset2.

Sol 1259: Spirit started the day by acquiring thumbnail images of the sky in addition to checking for drift in the miniature thermal emission spectrometer and scanning the sky and ground with the miniature thermal emission spectrometer. Spirit acquired images with the hazard avoidance camera.

Sol 1260 (July 20, 2007): Shortly after sunup, Spirit scanned for dust devils by acquiring movie frames with the navigation camera. Spirit checked for drift in the miniature thermal emission spectrometer and scanned the sky and ground using the miniature thermal emission spectrometer. The next day, Spirit was to acquire a survey of the sky at high sun using the panoramic camera.

Odometry:

As of sol 1252 (July 12, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1247-1252, July 14, 2007: *Spirit Examines Rocks Possibly Formed In Volcanic Gases or Hot Springs*

Spirit is healthy after driving to a cluster of rock fragments known as "Innocent Bystander" (so named because Spirit accidentally ran over it when another rock, "Virginia Bell," was the intended target. The aim had been to crush Virginia Bell to expose a fresh surface for examination).

It was a fortuitous encounter, though, because indications are that Innocent Bystander may have been formed by either a fumarole or hot spring. A fumarole is a vent in the Earth's surface that emits steam and volcanic gases. Volcanic gases leach the original rock and leave silica-rich rock behind. If Innocent Bystander was created in a hot spring environment, then it could be siliceous sinter, a kind of silica-rich rock that precipitates directly from water.

Spirit had a solar-array dust-cleaning event on the rover's 1,252nd day, or sol, of Martian exploration (July 12, 2007). Even though Tau, a measurement of atmospheric opacity caused by dust, has been trending upward for the past several days, Spirit's solar power levels have risen slightly due to wind-related cleaning of the solar panels.

Sol-by-sol summary:

In addition to daily remote science observations of the atmosphere and terrain using the panoramic camera and the miniature thermal emission spectrometer, and communication activities including morning direct-from-Earth uplinks via the rover's high-gain antenna and evening downlinks at UHF frequencies via the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1247 (July 6, 2007): Spirit monitored atmospheric dust with the panoramic camera, scanned the sky and ground with the miniature thermal emission spectrometer, stowed the robotic arm, and drove to Innocent Bystander. Along the way, Spirit acquired mid-drive, full-color images of the work volume using all 13 filters of the panoramic camera as well as images with the hazard avoidance cameras.

After transmitting data to the Odyssey orbiter, Spirit again measured atmospheric dust and took images of the sun with the navigation camera.

Sol 1248: In the morning, Spirit monitored atmospheric dust and surveyed the horizon with the panoramic camera, monitored dust on the rover mast, and acquired thumbnail images of the sky. Spirit then continued to measure atmospheric dust and scan the sky and ground with the miniature thermal emission spectrometer. The rover completed a calibration of the miniature thermal emission spectrometer as well as a survey of the sky and ground with the instrument. Spirit completed a survey at high Sun with the panoramic camera. After communicating with the Odyssey spacecraft, Spirit measured atmospheric dust.

Sol 1249: In the morning, Spirit monitored atmospheric dust with the panoramic camera, watched for dust devils, and acquired movie frames of potential dust devils with the navigation camera. Spirit continued to measure atmospheric dust opacity with the panoramic camera and scan the sky and ground with the miniature thermal emission spectrometer. After the uplink to the Odyssey orbiter, Spirit continued to measure atmospheric opacity with the panoramic camera.

Sol 1250: In the morning, Spirit measured atmospheric opacity with the panoramic camera and surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit checked for drift (changes with time) in the miniature thermal emission spectrometer. Spirit drove closer to Innocent Bystander and acquired post-drive images with the hazard avoidance cameras and a 360-degree panorama with the navigation camera. The rover continued to measure atmospheric opacity with the panoramic camera and scan the sky and ground with the miniature thermal emission spectrometer. After communicating with Odyssey, Spirit acquired navigation camera images of the Sun and again monitored atmospheric dust with the panoramic camera.

Sol 1238: In the morning, Spirit monitored dust build-up on the rover's mast, surveyed the horizon with the panoramic camera, and acquired movie frames with the navigation camera in search of dust devils. Spirit acquired microscopic images of the solar arrays, capture magnet, and filter magnet to document dust levels since the most recent dust-cleaning events on sols 1233 and 1234 (June 22-23, 2007). The rover acquired microscopic images of Eileen Dean and collected data on the target using the alpha-particle X-ray spectrometer. Spirit acquired four sets of comparative measurements with the miniature thermal emission spectrometer early in the day, in the afternoon, overnight, and early the next sol. Spirit observed the Sun with the navigation camera in support of the Mars Science Laboratory rover scheduled for launch in 2009. The goal of these observations is to see if navigation camera images of the sun can be used to orient the rover.

Sol 1251: Upon awakening, Spirit acquired images of the Sun using the navigation camera, measured atmospheric opacity with the panoramic camera, completed a survey of clasts using the panoramic camera, and surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit continued to monitor atmospheric dust and scan the surroundings, then unstowed the robotic arm and acquired a 2x1x7 mosaic of microscopic images of Innocent Bystander. Spirit placed the alpha-particle X-ray spectrometer on Innocent Bystander, measured atmospheric dust and completed a survey at high Sun with the panoramic camera, and continued to monitor atmospheric dust and survey the surroundings. Spirit acquired thumbnail images of the sky using the panoramic camera, measured late atmospheric dust opacity, and scanned the calibration target and surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit took a nap and awoke at 11:10 p.m. local Mars time to begin an alpha-particle X-ray study that was to last just under 12 hours.

Sol 1252 (July 12, 2007): After solar array wakeup, Spirit was slated to continue measuring atmospheric opacity with the panoramic camera, acquire images of the Sun with the navigation camera, and survey the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1250 (July 10, 2007), Spirit's total odometry remained at 7,153 meters (4.44 miles).

sol 1240-1246, July 14, 2007: *Spirit Encounters First Big Dust Storm of the Season*

Spirit has been dealing with the first big dust storm of the season. Tau, a measure of atmospheric opacity as an indicator of how much dust is in the atmosphere, jumped significantly, with a corresponding (and dismaying) drop in power.

At the start of the week, Tau was 1.076, corresponding to 34 percent direct sunlight and 750 watt-hours of energy. (A watt-hour is the amount of energy in one watt of power working for one hour.) By the rover's 1,245th Martian day, or sol, of exploration (July 4, 2007), Tau had jumped to 2.437, corresponding to only 8.7 percent direct sunlight and 490 watt-hours of energy. Though there was little direct sunlight, there was a fair amount of scattered light to help augment the rover's power levels.

The storm resulted in several small cleaning and "dirtying" events, some of which removed and others of which deposited dust on the solar arrays. Individual changes have been small, though overall, slightly more dust accumulated than blew away.

To a person standing on Mars, the atmosphere would look somewhat like an overcast sky on Earth, perhaps with some dusty haze. The view would be noticeably darker than normal, with gray and slightly fuzzy shadows instead of the crisp shadows of a sunny day.

Despite the lower power levels -- and the even more conservative power estimates used for activity planning -- Spirit has managed to continue to investigate the silica-rich scuff in the rover's tracks nicknamed "Eileen Dean." The rover re-acquired microscopic images to replace the first, which were out of focus, and completed an analysis with both the Mössbauer spectrometer and the alpha-particle X-ray spectrometer.

Spirit is healthy. The rover's next destination is a target known as "Innocent Bystander," where the rover is slated to conduct further scientific analysis.

Sol-by-sol summary:

Sol 1240 (June 29, 2007): Spirit measured atmospheric dust opacity using the panoramic camera, acquired photometric data looking east toward the equator with the panoramic camera, acquired panoramic camera images of the external calibration target, acquired photometric data looking north (directly) toward the equator, and acquired panoramic camera images looking west toward the equator. Spirit again measured atmospheric dust opacity using the panoramic camera, acquired thumbnail images of the sky using the panoramic camera, and repeated the earlier scans of equatorial atmospheric conditions and the calibration target.

Sol 1241: Spirit measured atmospheric dust opacity using the panoramic camera, acquired photometric data looking east toward the equator with the panoramic camera, acquired panoramic camera images of the external calibration target, acquired photometric data looking north (directly) toward the equator, and acquired panoramic camera images looking west toward the equator. Spirit again measured atmospheric dust opacity using the panoramic camera, acquired thumbnail images of the sky using the panoramic camera, and repeated the earlier scans of equatorial atmospheric conditions and the calibration target.

Sol 1242: Spirit measured atmospheric dust opacity using the panoramic camera, acquired photometric data looking east toward the equator with the panoramic camera, acquired panoramic camera images of the external calibration target, acquired photometric data looking north (directly) toward the equator, and acquired panoramic camera images looking west toward the equator. Spirit again measured atmospheric dust opacity using the panoramic camera, acquired thumbnail images of the sky using the panoramic camera, and repeated the earlier scans of equatorial atmospheric conditions and the calibration target.

Sol 1243: Spirit measured atmospheric dust opacity using the panoramic camera, checked for drift (changes over time) in the miniature thermal emission spectrometer, surveyed the sky and ground with the miniature thermal emission spectrometer, and took thumbnail images of the sky using the panoramic camera. The rover made additional measurements of atmospheric dust opacity at different times of day using the panoramic camera, surveyed the ground and sky at different elevations using the miniature thermal emission spectrometer, and surveyed the sky at low sun with the panoramic camera.

Sol 1244: Upon the awakening of the rover's solar arrays, Spirit surveyed the sky and horizon with the panoramic camera, acquired movie frames with the navigation camera in search of dust devils, and surveyed the sky and ground with the miniature thermal emission spectrometer. The rover measured atmospheric opacity with the panoramic camera, checked for drift in the miniature thermal emission spectrometer, re-surveyed the sky and ground with the instrument, and acquired a 2x1x7 panorama of stereo microscopic images of Eileen Dean. Spirit changed tools to the Mössbauer spectrometer and used it to study Eileen Dean. Spirit acquired full-color images, using all 13 filters of the panoramic camera, of a target known as "Sorak." Spirit acquired images of the dune field known as "El Dorado" using the panoramic camera. The rover again measured atmospheric opacity with the panoramic camera, scanned the sky and ground with the miniature thermal emission spectrometer, surveyed Sorak and a target known as "Palthon2" with the miniature thermal emission spectrometer, and acquired photometric measurements with the panoramic camera. The rover again measured atmospheric opacity using the panoramic camera, acquired images of the sun with the navigation camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and took more photometric measurements as well measurements of atmospheric opacity with the panoramic camera. Spirit acquired a mosaic of images of the sun with the navigation camera.

Sol 1245: After solar array wakeup, Spirit measured atmospheric opacity and acquired photometric measurements with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and acquired thumbnail images of the sky with the panoramic camera. Spirit continued to measure atmospheric opacity with the panoramic camera, check for drift in the miniature thermal emission spectrometer, and survey the sky and ground with the miniature thermal emission spectrometer. The rover re-started the Mössbauer spectrometer for continued investigation of Eileen Dean, acquired full-color images of Palthon2 using all 13 filters of the panoramic camera, and surveyed targets known as "Sorapus" and "Manitalia" with the miniature thermal emission spectrometer. The rover continued to measure atmospheric opacity at different times of day and make photometric observations with the panoramic camera. Spirit took images of the sun with the navigation camera and surveyed the ground and sky at different elevations using the miniature thermal emission spectrometer.

Sol 1246 (July 5, 2007): Upon awakening, Spirit measured atmospheric opacity and acquired thumbnail images of the sky using the panoramic camera. Spirit surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit surveyed a target known as "Naomi Meier" and checked for changes in measurements of darkness with the miniature thermal emission spectrometer. In addition to collecting ongoing measurements of atmospheric opacity and surveying the surroundings with the miniature thermal emission spectrometer, Spirit acquired stereo microscopic images of a target known as "Eileen_Dean2." Spirit switched tools to the alpha-particle X-ray spectrometer and placed it on Eileen_Dean2 before taking a nap. Upon re-awakening, the rover continued to measure atmospheric opacity and survey the surroundings. Spirit then took another nap, woke up at 11:10 p.m. local Mars time, and began a 12-hour analysis of Eileen_Dean2 using the alpha-particle X-ray spectrometer. Plans called for the rover to stop the analysis, measure atmospheric opacity, and scan the sky and ground the following morning.

Odometry:

As of sol 1246 (July 5, 2007), Spirit's total odometry remained at 7,147.93 meters (4.44 miles).

sol 1234-1239, July 02, 2007: *Spirit Independently Approaches and Studies A Rock Outcrop*

Spirit remains healthy after attempting to wrap up scientific studies on an outcrop that contains several tantalizing, high-silica targets. High-silica targets are of interest to scientists because water might have been involved in forming them. Spirit still has some work to do on two targets, known as "Eileen Dean" and "Innocent Bystander," before moving on to the elevated, circular plateau known as "Home Plate."

On Spirit's 1,235th sol, or Martian day of exploration (June 24, 2007), the rover successfully completed Step 4 of a new computer sequence called "IDD Autoplace." (IDD stands for Instrument Deployment Device, the technical name for the rover's robotic arm.) During the test, Spirit drove to a pre-selected target and autonomously gathered scientific data. The sequence enables the rover to select a substitute "target of opportunity" if the pre-selected target is out of range, which is exactly what happened during the first two tests.

Over the next month, Spirit will collect data in support of future Mars rover missions by taking images of the Sun each day with the navigation camera. These images are being used to develop an alternate method for orienting the rover.

Sol-by-sol summary:

In addition to daily remote science observations of the atmosphere and terrain using the panoramic camera and the miniature thermal emission spectrometer, and communication activities including morning direct-from-Earth uplinks via the rover's high-gain antenna and evening downlinks at UHF frequencies via the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1234 (June 23, 2007): Spirit acquired full-color images, using all 13 filters of the panoramic camera, of outcrop exposures known as "Virginia Bell," "Nancy Warren," and "Innocent Bystander." The rover acquired panoramic camera images of a target known as "Eileen Dean." Spirit surveyed several targets using the miniature thermal emission spectrometer, including "Mary Dailey," "NancyWarren3," "Dolores Moore," "Louella Daetweiler," "NancyWarren_background," "MaryDailey2," and "Eileen Dean."

Sol 1235: Upon awakening, Spirit surveyed the sky with the panoramic camera. Spirit then moved slightly closer to Eileen Dean. The rover completed Step 4 of the automatic targeting test by touching a spot that was offset from the target by about 5 centimeters (2 inches) with the Mössbauer spectrometer, acquiring a 1-by-1-by-seven mosaic of microscopic images, and placing the alpha-particle X-ray spectrometer on the spot and collecting data with the instrument. Spirit acquired navigation camera images and conducted a sky survey at low sun with the panoramic camera. Prior to the overpass of the Odyssey orbiter, the rover took images of the sky, known as "sky flats," for calibration purposes.

Sol 1236: Spirit used on-board software to watch for dust devils in addition to completing standard remote-science observations.

Sol 1237: Spirit rotated in place toward Eileen Dean, completing a final yaw, or pivot, of 42.8 degrees. Working autonomously, Spirit touched Eileen Dean with the Mössbauer spectrometer, acquired a 1-by-1-by-7 mosaic of microscopic images of the target, and completed alpha-particle X-ray spectrometer studies on the target. Spirit acquired images with the navigation camera. Spirit examined the rover's external calibration target with the miniature thermal emission spectrometer to verify that there was no dust contamination on the mirror as a result of recent dust-cleaning events related to Martian winds. Spirit acquired full-color images, using all 13 filters of the panoramic camera, of the rover's solar arrays, also to characterize changes in dust accumulation on the surface. Prior to the overpass of the Odyssey spacecraft, Spirit observed the Sun with the navigation camera in support of the Mars Science Laboratory rover scheduled for launch in 2009. The goal of these observations is to see if navigation camera images of the sun can be used to orient the rover.

Sol 1238: In the morning, Spirit monitored dust build-up on the rover's mast, surveyed the horizon with the panoramic camera, and acquired movie frames with the navigation camera in search of dust devils. Spirit acquired microscopic images of the solar arrays, capture magnet, and filter magnet to document dust levels since the most recent dust-cleaning events on sols 1233 and 1234 (June 22-23, 2007). The rover acquired microscopic images of Eileen Dean and collected data on the target using the alpha-particle X-ray spectrometer. Spirit acquired four sets of comparative measurements with the miniature thermal emission spectrometer early in the day, in the afternoon, overnight, and early the next sol. Spirit observed the Sun with the navigation camera in support of the Mars Science Laboratory rover scheduled for launch in 2009. The goal of these observations is to see if navigation camera images of the sun can be used to orient the rover.

Sol 1239 (June 28, 2007): The activities for this day were mostly a repeat of those of the previous sol, except for the four sets of measurements with the miniature thermal emission spectrometer. Spirit acquired 15 hours and 23 minutes of data from Eileen Dean using the alpha-particle X-ray spectrometer.

Odometry:

As of sol 1237 (June 26, 2007), Spirit's total odometry was 7,147.93 meters (4.44 miles).

sol 1226-1233, June 27, 2007: *Spirit's Solar Power Levels Continue to Rise*

Spring cleaning continued on NASA's Spirit rover, as atmospheric turbulence on Mars cleared away more dust from the solar panels on the rover's 1,233rd sol, or Martian day, of exploration (June 22, 2007). As a result of this most recent dust-clearing event, Spirit out-produced the electrical energy of Spirit's twin, the Opportunity rover on the opposite side of Mars, by about 50 watt-hours. (That's the amount of electricity needed to burn a 50-watt light bulb for one hour.) Tau measurements estimating the amount of dust in the atmosphere rose from 0.69 to 0.75. (Perfectly clean solar arrays would have a dust factor of 1.0, so the larger the dust factor, the cleaner the arrays.) Electrical energy rose to 738 watt-hours.

In addition, Spirit investigated an unbrushed rock outcrop known as "Nancy Warren," a candidate high-silica target. On sols 1226, 1227, and 1228 (June 15-17, 2007), the rover worked on a second investigation intended to study the brushed surface of the rock. Because the rover did not complete the brushing operation, Spirit ended up taking a second set of measurements that was identical to the first.

On the rover's 1,232nd sol of exploration (June 21, 2007), Spirit attempted to scuff a rock target known as "Virginia Bell" but didn't quite reach it and ended up scuffing a soil exposure about 15 centimeters (6 inches) away, creating a new target that scientists dubbed "Innocent Bystander."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels using the panoramic camera, surveys of the sky and ground using the miniature thermal emission spectrometer, and communication activities including morning direct-from-Earth uplinks via the rover's high-gain antenna and evening downlinks at UHF frequencies via the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1226: Spirit placed the rock abrasion tool on Nancy Warren, placed the alpha-particle X-ray spectrometer on the target, collected data with the instrument, and completed an overnight transmission of data to the Odyssey orbiter.

Sol 1227: Spirit acquired a mosaic of microscopic images of Nancy Warren, placed the Mössbauer spectrometer on the target, and acquired data with the instrument. The rover acquired images of the spacecraft deck with the navigation camera. Spirit conducted reconnaissance and surveyed targets known as "Patricia Courtney," "Lenora Mandella," "Barbara Rotvig," and "Pauline Crawley" with the miniature thermal emission spectrometer. The rover scanned for clouds using the navigation camera and monitored dust on the rover mast.

Sol 1228: Spirit continued to study Nancy Warren using the Mössbauer spectrometer. The rover acquired a full-color panorama of light-colored wheel tracks using all 13 filters of the panoramic camera. Spirit conducted reconnaissance and surveyed the tracks as well as targets known as "Shirley Crites," "Betty McKenna," and "Naomi Meier" using the miniature thermal emission spectrometer. The rover completed an overnight transmission of data to the Odyssey orbiter and acquired an eastward-looking mosaic of images using the navigation camera.

Sol 1229: Spirit continued analysis of Nancy Warren using the Mössbauer spectrometer. The rover acquired images of the spacecraft deck with the panoramic camera to document the previous week's dust-cleaning event that occurred on sol 1224 (June 13, 2007). Spirit acquired movie frames with the navigation camera in search of dust devils.

Sol 1230: Spirit acquired microscopic images of the solar arrays, the dust capture magnet, and the filter magnet, along with panoramic camera images of the solar arrays, to document the dust-cleaning event of sol 1224 (June 13, 2007). The rover acquired microscopic images of undisturbed soil near the silica-rich outcrop known as Nancy Warren along with data using the alpha-particle X-ray spectrometer. Members of the science team hope to use the data to characterize local soil that might be contaminating the outcrop.

Sol 1231: Spirit resumed measurements of Nancy Warren using the Mössbauer spectrometer. The rover surveyed targets on Nancy Warren known as "Gertrude Weise," "Naomi Meier," "Rykors," "Silian," "Sith," "Skeel," "Sompus," and "Betty Jane Comet" using the miniature thermal emission spectrometer.

Sol 1232: Spirit acquired microscopic images of a target called "Darlene Mickelson" and attempted to crush the outcrop in the vicinity of Virginia Bell by driving over it to expose more silica-rich outcrop material. The rover acquired post-drive images of the target area using the navigation camera.

Sol 1233: Spirit acquired movie frames in search of morning dust devils using the navigation camera and surveyed the post-crush target area using the miniature thermal emission spectrometer.

Odometry:

As of sol 1232 (June 21, 2007), Spirit's total odometry was 7,143.87 meters (4.44 miles).

sol 1219-1225, June 18, 2007: *Spirit's Solar Panels Get Spring Cleaning*

Spirit got a second spring cleaning on Mars with a dust-cleaning event that increased power from the rover's solar arrays by 120 watt-hours (a 100-watt light bulb that burns for one hour uses 100 watt-hours of electricity). Spirit previously experienced dust-lifting winds in 2005. Energy from the rover's solar arrays is now higher than 600 watt-hours.

After completing scientific studies of rock exposures known as "Betty Wagoner" and "Elizabeth Emery," Spirit drove to another rock target called "Nancy Warren" to conduct studies with instruments on the rover's robotic arm, including the microscopic imager, the alpha-particle X-ray spectrometer, the brush on the rock abrasion tool, and the Mössbauer spectrometer. The next destination on Spirit's itinerary is the "on-ramp" of the elevated plateau-like feature known as "Home Plate."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels using the panoramic camera, surveys of the sky and ground using the miniature thermal emission spectrometer, and communication activities including morning direct-from-Earth uplinks via the rover's high-gain antenna and evening downlinks at UHF frequencies via the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1219 (June 8, 2007): Spirit touched a rock exposure adjacent to Betty Wagoner known as "Betty Wagoner's Daughter" with the rock abrasion tool, brushed it, acquired a mosaic of microscopic images, touched the target with the Mössbauer spectrometer, and acquired more microscopic images. The rover placed the Mössbauer spectrometer back on Elizabeth Emery and collected data with the instrument, watched for dust devils, and completed an overnight relay of data to the Odyssey orbiter.

Sol 1220: Spirit acquired full-color images of the work area reachable by the robotic arm using all 13 filters of the panoramic camera and watched for morning dust devils. The rover also acquired full-color images using all 13 filters of the panoramic camera of targets known as "Melba Alspaugh," "Helen St. Aubin," and "Ruth Lessing." The rover acquired data using the miniature thermal emission spectrometer from targets known as "Melba Alspaugh2," "Betty Whiting2," "Joan Chiancola," and "Helen St. Aubin2." Spirit watched for dust devils, surveyed a target called "Jean Gilchrist" with the miniature thermal emission spectrometer, and completed an overnight transfer of data to the Odyssey spacecraft.

Sol 1221: Spirit acquired spot images of the sky with the panoramic camera and drove toward Nancy Warren. The rover acquired image mosaics with the navigation camera and panoramic camera and completed an overnight transmission of data to Odyssey.

Sol 1222: Spirit conducted a survey of rock clasts with the panoramic camera, scanned the sky for clouds with the navigation camera, and acquired movie frames in search of dust devils with the navigation camera. The rover acquired systematic foreground images using all 13 filters of the panoramic camera and a systematic foreground raster with the miniature thermal emission spectrometer. Spirit again watched for dust devils and acquired movie frames with the navigation camera. The rover measured atmospheric argon using the alpha-particle X-ray spectrometer. Spirit surveyed the horizon with the panoramic camera and monitored dust on the rover's mast.

Sol 1223: Spirit completed a reconnaissance study of the rover's tracks using the miniature thermal emission spectrometer. The rover surveyed Nancy Warren with the miniature thermal emission spectrometer, approached Nancy Warren, and acquired post-drive image mosaics with the navigation camera. The rover completed an overnight relay of data to the Odyssey orbiter.

Sol 1224: Spirit acquired thumbnail images of the sky using the panoramic camera and conducted a high-sun survey with the panoramic camera. Spirit conducted reconnaissance with the miniature thermal emission spectrometer and completed an overnight relay of data to the Odyssey spacecraft.

Sol 1225 (June 14, 2007): Spirit unstowed the robotic arm, acquired a mosaic of microscopic images of Nancy Warren, placed the alpha-particle X-ray spectrometer on the target, and acquired data with the instrument. Spirit relayed data overnight to Odyssey.

Odometry:

As of sol 1225 (June 14, 2007), Spirit's total odometry was 7,141.67 meters (4.44 miles).

sol 1207-1218, June 11, 2007: *Spirit Studies Layered Rocks at 'Home Plate'*

Having completed studies of bright, silica-rich soil deposits at a target known as "Gertrude Weise," Spirit drove to a perch on the eastern edge of the circular, plateau-like feature known as "Home Plate" and began studying its stratigraphy. Spirit will next drive back in the direction of Gertrude Weise to study another nearby outcrop. The nearby outcrop, known as "Nancy Warren," appears similar to a previously studied outcrop known as "Elizabeth Mahon" that had a silica content of approximately 72 percent, somewhat lower than the 90-percent silica measured at Gertrude Weise.

A layer of dark soil on Elizabeth Mahon likely affected the measurement of silica content with the alpha-particle X-ray spectrometer, which measures the abundance of chemical elements. Nancy Warren is interesting because it appears to have less of the dark soil coating than Elizabeth Mahon and could help scientists characterize the silica found at Gertrude Weise.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels using the panoramic camera, surveys of the sky and ground using the miniature thermal emission spectrometer, and communication activities including morning direct-from-Earth uplinks via the rover's high-gain antenna and evening downlinks at UHF frequencies via the Mars Odyssey orbiter, Spirit completed the following activities:

Sol 1207 (May 26, 2007): Spirit re-started the Mössbauer spectrometer and continued analysis of a rock target known as "Pesapallo," representing one of the lowest stratigraphic units of Home Plate. Spirit surveyed targets known as "Margaret Brown" and "Edythe Keating" with the miniature thermal emission spectrometer. Spirit acquired movie frames in search of dust devils with the navigation camera in coordination with orbital scans of the terrain by the High Resolution Science Imaging Experiment on board the Mars Reconnaissance Orbiter. The rover acquired an image mosaic of a target called "Bullpen2" using the panoramic camera and searched for clouds using the navigation camera.

Sol 1208: Spirit acquired data from targets known as "Mary Reynolds" and "Eleanor Callow" with the miniature thermal emission spectrometer and re-started analysis of Pesapallo using the Mössbauer spectrometer. The rover completed an overnight relay of data to the Odyssey orbiter and acquired an image mosaic of a target called "Bullpen3" with the panoramic camera.

Sol 1209: Spirit used the rock abrasion tool to brush the surface of "Superpesis," a rock target on another fin-shaped outcrop of Home Plate, acquired stereo microscopic images of the target, and analyzed the target with the alpha-particle X-ray spectrometer. Spirit acquired movie frames in search of dust devils using the navigation camera.

Sol 1210: Spirit stowed the robotic arm, bumped backward, and acquired full-color images of Pesapallo using all 13 filters of the panoramic camera. Spirit drove 3 meters (10 feet) to a rock target known as "June Emerson," acquired post-drive images with the navigation camera, and took spot images of the sky with the panoramic camera.

Sol 1211: Spirit unstowed the robotic arm, brushed the surface of June Emerson with the rock abrasion tool, acquired microscopic images of June Emerson, and placed the alpha-particle X-ray spectrometer on the target. The rover surveyed additional targets known as "Dorothy Cameron" and "Adeline Kerrar" using the miniature thermal emission spectrometer. Spirit then acquired data from June Emerson using the alpha-particle X-ray spectrometer. The rover completed an overnight relay of data to the Odyssey orbiter, acquired full-color images of Dorothy Cameron using all 13 filters of the panoramic camera, and scanned the sky for clouds using the navigation camera.

Sol 1212: Spirit acquired microscopic images of rock targets called "Dorothy Key" and "Betty Foss." The rover placed the Mössbauer spectrometer on June Emerson and collected data. Spirit used the miniature thermal emission spectrometer to study rock targets known as "Helen Staubin" and "Dorothy Chapman" and completed an overnight relay of data to the Odyssey orbiter. Spirit acquired panoramic camera images of the solar array to monitor dust accumulation.

Sol 1213: Spirit acquired more data from June Emerson using the Mössbauer spectrometer and acquired data using the miniature thermal emission spectrometer from Pesapallo and targets known as "Joan Chiancola," "Jaynie Krick," and "Jean Gilchrist." Spirit acquired panoramic camera images of the rover's tracks and full-color images using all 13 filters of the panoramic camera of Jean Gilchrist and Jaynie Krick. The rover completed an overnight relay of data to the Odyssey orbiter and watched for dust devils.

Sol 1214: Spirit continued to acquire data from June Emerson using the Mössbauer spectrometer. Using the panoramic camera and the miniature thermal emission spectrometer, the rover acquired full-color images and thermal data to characterize rock targets known as "Irene Kotowicz," "Audrey Seitzinger," "Lucille Colacio," and "Mary Kustra." Spirit watched for dust devils and completed an overnight relay of information to the Odyssey orbiter. Spirit stowed the robotic arm and acquired full-color images of the reachable work volume using the panoramic camera. The rover took spot images of the sky using the panoramic camera and conducted reconnaissance using the miniature thermal emission spectrometer.

Sol 1215: Spirit drove 1.2 meters (3.9 feet) to a finely crossbedded rock target dubbed "Elizabeth Emery" and acquired post-drive navigation camera images. The rover watched for dust devils, relayed data overnight to the Odyssey spacecraft, surveyed the horizon with the panoramic camera, and did reconnaissance using the miniature thermal emission spectrometer.

Sol 1216: Spirit unstowed the robotic arm and conducted a study of Elizabeth Emery with the brush on the rock abrasion tool, the microscopic imager, and the alpha-particle X-ray spectrometer. The rover surveyed targets known as "Clara Cook" and "Ruth Lessing" with the miniature thermal emission spectrometer, relayed data overnight to the Odyssey orbiter, and acquired thumbnail images of the sky using the panoramic camera.

Sol 1217: Spirit brushed a finely crossbedded rock target known as "Jane Stoll" using the rock abrasion tool and took microscopic images of the brushed target. The rover placed the Mössbauer spectrometer back on Elizabeth Emery and collected more data. Spirit acquired full-color, 13-filter images of Dorothy Chapman with the panoramic camera and data from Jaynie Krick using the miniature thermal emission spectrometer. The rover completed an overnight relay to the Odyssey spacecraft.

Sol 1218 (June 7, 2007): Spirit acquired early-morning panoramic camera images and movie frames in search of dust devils. The rover used the rock abrasion tool to brush the surface of rock targets called "Mildred Deegan" and "Betty Wagoner" and took microscopic images of the brushed surfaces. Spirit surveyed Irene Kotowicz with the miniature thermal emission spectrometer, completed an overnight relay of data to the Odyssey orbiter, searched for clouds using the navigation camera, and acquired images of a target known as "Donna Cook" with the panoramic camera.

Odometry:

As of sol 1218 (June 7, 2007), Spirit's total odometry was 7,124.92 meters (4.43 miles).

sol 1200-1206, May 31, 2007: *Remarkable Rover Continues to Astonish*

Spirit is still making new discoveries despite dragging its feet, so to speak, after losing use of the right front wheel 426 sols, or Martian days, ago. In the process of creating small trenches while traversing Martian terrain, the dragging right front wheel revealed one of the most astonishing discoveries so far -- exceptionally high silica content in Martian soil, indicative of water at some point in the past. Two of Spirit's scientific instruments -- the alpha-particle X-ray spectrometer and the miniature thermal emission spectrometer -- measured a composition of about 90 percent pure silica in a soil target known as "Gertrude Weise."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels using the panoramic camera and surveys of the sky and ground using the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1200 (May 19, 2007): Spirit started a 23.25-hour study with the Mössbauer spectrometer and surveyed the rover's tracks as well as targets known as "Josephine Kabick," "Nalda Phillips1," "Nalda Phillips2," "Marilyn Olinger," and "Eileen Burmeister" with the miniature thermal emission spectrometer.

Sol 1201: Spirit watched for morning dust devils, stowed the robotic arm, and bumped backward in 60-centimeter (24-inch) "steps," or intervals. After each step, Spirit scuffed the soil with the left front wheel by rotating the wheel 180 degrees. The rover did this for a distance of 4.19 meters (13.8 feet). After the drive, Spirit acquired images of the scuffed terrain and the terrain ahead with the navigation camera.

Sol 1202: Spirit completed a survey at high sun using the panoramic camera. Spirit acquired panoramic camera images of the scuffed area and surveyed Gertrude Weise with the miniature thermal emission spectrometer. The rover searched for dust devils by acquiring navigation camera movies in coordination with overhead observations by the High Resolution Science Imaging Experiment on board the Mars Reconnaissance Orbiter.

Sol 1203: Spirit monitored dust on the rover mast and watched for dust devils in the morning. Spirit acquired navigation camera images before driving 6.68 meters (21.9 feet) around obstacles en route to "Home Plate." After the drive, Spirit acquired images with the hazard avoidance cameras and navigation camera.

Sol 1204: Spirit spent the first part of the sol analyzing the rover's external calibration target with the miniature thermal emission spectrometer, searching for clouds with the navigation camera, and acquiring movies in search of dust devils with the navigation camera. The rover then acquired image mosaics of the dune field known as "El Dorado" with the panoramic camera in addition to systematic foreground data with the miniature thermal emission spectrometer. Spirit acquired navigation camera images, searched again for dust devils, and acquired more panoramic camera images.

Sol 1205: Spirit completed a systematic ground survey with the panoramic camera, unstowed the robotic arm, brushed the surface of a target known as "Pesapallo," acquired stereo microscopic images of the surface, then placed the alpha-particle X-ray spectrometer on it. Spirit acquired data with the alpha-particle X-ray spectrometer for 18.75 hours.

Sol 1206 (May 25, 2007): Spirit searched for morning dust devils, retracted the robotic arm, and placed the Mössbauer spectrometer on Pesapallo. The rover acquired Mössbauer spectrometer data for 23 hours. Spirit acquired panoramic camera images of a target known as "Bullpen" and miniature thermal emission spectrometer data from a target known as "Joyce Steel." The following morning, Spirit was scheduled to conduct a survey of the horizon with the panoramic camera in addition to studies with the miniature thermal emission spectrometer.

Odometry:

As of sol 1204 (May 23, 2007), Spirit's total odometry was 7,120.34 meters (4.42 miles).

sol 1193-1199, May 24, 2007: *Spirit Continues Soil Analysis*

Spirit is healthy and spent the last week studying light and dark soil in and around the rover's tracks between "Home Plate" and "Mitcheltree Ridge." Spirit collected additional soil data, including about 24 hours of data using the alpha-particle X-ray spectrometer and 70 hours of data using the Mössbauer spectrometer. The primary soil targets examined during the week are known as "Kenosha Comets" and "Lefty Ganote."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels using the panoramic camera and surveys of the sky and ground using the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1193 (May 12, 2007): Spirit acquired alpha-particle X-ray spectrometer data from Kenosha Comets, miniature thermal emission spectrometer data from a target called "Alice Blaski," and panoramic camera images of Alice Blaski and another target known as "Mantalia." Following those tasks, Spirit napped until 11 p.m. local Mars time. Spirit then conducted a 12-hour analysis of Kenosha Comets using the alpha-particle X-ray spectrometer.

Sol 1194: Spirit started the day with acquisition of full-color images of light-colored tracks using all 13 filters of the panoramic camera. The rover acquired thumbnail images of the sky with the panoramic camera. Spirit replaced the alpha-particle X-ray spectrometer with the Mössbauer spectrometer and acquired 23.3 hours of Mössbauer data from Kenosha Comets. The rover studied a target known as "Palthon" using the miniature thermal emission spectrometer and took thumbnail images of the Martian sky with the panoramic camera.

Sol 1195: Spirit acquired another 23.3 hours worth of Mössbauer data from Kenosha Comets as well as a movie in search of dust devils using the navigation camera. The rover studied Mantalia and another target known as "Orluk" using the miniature thermal emission spectrometer.

Sol 1196: Spirit's first task of the day was to complete a sky survey using the panoramic camera. The rover stowed the robotic arm, drove backward 0.85 meters (2.8 feet), and autonomously put the alpha-particle X-ray spectrometer in position for further studies. Spirit acquired hazardous avoidance camera images prior to and after stopping and acquired navigation camera images of the terrain. Starting at 11 p.m. local Mars time, Spirit conducted an 11-hour study of the Martian atmosphere using the alpha-particle X-ray spectrometer.

Sol 1197: Spirit began the day by searching the Martian sky for clouds using the navigation camera and surveying the horizon with the panoramic camera. Spirit acquired full-color, 13-filter images of "Gertrude Weise background 3" using the panoramic camera. The rover surveyed Kenosha Comets and targets known as "Gertrude Weise background 2," "Kay Blumetta," and Gertrude Weise background 3 using the miniature thermal emission spectrometer.

Sol 1198: In the morning, Spirit acquired full-color images of Kenosha Comets using all 13 filters of the panoramic camera. The rover acquired a 360-degree panorama using the navigation camera. Spirit unstowed the robotic arm, acquired microscopic images of Lefty Ganote, and placed the alpha-particle X-ray spectrometer on Lefty Ganote. Spirit surveyed a target known as "Audrey Wagner," Kenosha Comets, and two targets in the rover's tracks known as "Tracks No. 1" and "Tracks No. 2" using the miniature thermal emission spectrometer. The rover completed a sky survey at low sun with the panoramic camera. After napping, Spirit awoke at 11 p.m. local Mars time and conducted an overnight study using the alpha-particle X-ray spectrometer that lasted 11 hours and 52 minutes.

Sol 1199 (May 18, 2007): Plans called for Spirit to begin the day with a search for dust devils using the navigation camera and a survey of a target called "Margaret Jones" using the miniature thermal emission spectrometer. After that, the rover was to place the Mössbauer spectrometer on Lefty Ganote and conduct a 23 1/4 - hour analysis, acquire full-color images of targets called "Ethel Boyce" and "Joanne Weaver" using all 13 filters of the panoramic camera, and conduct another search for dust devils the following morning by collecting movie frames with the navigation camera.

Odometry:

As of sol 1198 (May 17, 2007), Spirit's total odometry was 7,109.47 meters (4.42 miles).

sol 1186-1192, May 14, 2007: *Spirit Continues Studies of Interesting Material Near 'Home Plate'*

Spirit is healthy and has finished investigating a patch of churned-up, white-toned, silica-rich material known as "Gertrude Weise."

Meanwhile, the rover's first attempt to autonomously place the Mössbauer spectrometer on a target was successful. Spirit backed up over Gertrude Weise to a spot 2 meters (6.6 feet) beyond it and placed the Mössbauer spectrometer on the target. Spirit did not

immediately follow up with placement of the microscopic imager on the target to avoid potential collisions.

Plans called for Spirit to coordinate searching for dust devils on the ground with overhead scans of terrain by the Mars Reconnaissance Orbiter on sol 1191 (May 10, 2007). Also on sol 1191, the rover was to combine searching for dust devils with searching for clouds. This activity was meant as a stress test, as Spirit has already successfully completed such searches independently.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels with the panoramic camera and surveys of the sky and ground using the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1186 (May 5, 2007): Spirit acquired full-color, 13-filter images of a target called "Kathryn Beare" using the panoramic camera and studied Kathryn Beare and targets known as "GertrudeWeise2" and "Janice Ohara" using the miniature thermal emission spectrometer.

Sol 1187: Spirit acquired full-color, 13-filter images of Gertrude Weise, drove 5 meters (16 feet) to approach the soil target, and autonomously placed the Mössbauer spectrometer on target. The rover acquired a 360-degree panorama of the terrain using the navigation camera and also acquired a mosaic of images using the panoramic camera.

Sol 1188: Spirit took thumbnail images of the sky using the panoramic camera before spending the afternoon recharging the battery with energy from the rover's solar array.

Sol 1189: Spirit acquired movies and searched for dust devils using the navigation camera and touched a surface with the Mössbauer spectrometer. Spirit then began analysis of a target called "Kenosha Comets," collecting microscopic images and placing the alpha-particle X-ray spectrometer on the target. The rover acquired data from targets known as "Virginia Bell" and "Nancy Warren" using the miniature thermal emission spectrometer. After exchanging data with the Odyssey orbiter, Spirit conducted a 12-hour, overnight analysis of Kenosha Comets using the alpha-particle X-ray spectrometer.

Sol 1190: Spirit began the day acquiring a full-color, 13-filter panorama of Virginia Bell using the panoramic camera. The rover switched tools from the alpha-particle X-ray spectrometer to the Mössbauer spectrometer for continued study of Kenosha Comets. The rover acquired data from a target known as "Thelma Hundebly" before conducting a 23-hour, overnight study of Kenosha Comets with the Mössbauer spectrometer.

Sol 1191: Plans called for Spirit to acquire panoramic-camera movies in search of dust devils in tandem with overhead scans of terrain by the High-Resolution Imaging Science Experiment on the Mars Reconnaissance Orbiter. Plans also called for the rover to search for clouds, study Gertrude Weise with the Mössbauer spectrometer, and acquire full-color, 13-filter images of a target known as "Muriel Bevis" and of the horizon with the sun halfway below it.

Sol 1192 (May 11, 2007): Plans called for Spirit to stop the Mössbauer spectrometer, survey the rover's calibration target and tracks with the miniature thermal emission spectrometer, conduct a low-sun survey, analyze Gertrude Weise and another target known as "Elizabeth Mahon" with the Mössbauer spectrometer, and survey Muriel Bevis using the miniature thermal emission spectrometer. The rover was to acquire panoramic camera images of the calibration target and conduct a low-sun survey of "McCool Hill." The following morning, Spirit was to acquire thumbnail images of the sky using the panoramic camera and survey a target known as "Marie Wegman" using the miniature thermal emission spectrometer.

Odometry:

As of sol 1187 (May 6, 2007), Spirit's total odometry was 7,108.60 meters (4.42 miles).

sol 1179-1185, May 6, 2007: *Spirit Examined Light--Colored Material Near 'Home Plate'*

Spirit is healthy and has completed its investigation of a knobby rock target known as "GoodQuestion."

Next on Spirit's itinerary is a drive to the north and an attempt to climb onto "Home Plate." On the way, Spirit will examine white--toned material where one of the rover's wheels disturbed the soil. Observations using the miniature thermal emission spectrometer suggest it may be enriched in silica, similar to the "Elizabeth Mahon" rock outcrop the rover studied last week. Science team members have nicknamed the soil target "Gertrude Weise."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground using the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1179 (April 28, 2007): Spirit acquired panoramic camera images of targets known as "Gooli" and "Joyce Ricketts," surveyed Gooli and a target known as "Yolande Schick" with the miniature thermal emission spectrometer, and studied GoodQuestion using the alpha-particle X-ray spectrometer.

Sol 1180: Spirit surveyed the horizon with the panoramic camera, watched for dust devils, studied GoodQuestion with the Mössbauer spectrometer, and acquired panoramic camera images of GoodQuestion. The rover also surveyed a target known as "Joan Sindelar."

Sol 1181: Spirit acquired panoramic camera images of a target known as "Everett" and studied GoodQuestion using the Mössbauer spectrometer. The rover acquired panoramic camera images of a target called "Yolanda Schick."

Sol 1182: Spirit recorded a movie in search of dust devils using the navigation camera and studied light--toned soil using the miniature thermal emission spectrometer. Spirit drove 1.9 meters (6.2 feet) to the new science target, Gertrude Weise. The rover acquired mid--

drive images with the navigation camera in support of observations of GoodQuestion with the miniature thermal emission spectrometer, then made those same observations. After the drive, the rover acquired more images with both the navigation and panoramic cameras.

Sol 1183: Spirit monitored dust on the rover mast, surveyed Gertrude Weise with the miniature thermal emission spectrometer, and acquired full-color images of GoodQuestion using all 13 filters of the panoramic camera. Spirit acquired super-resolution images of a target known as "Fern Shollenberger" with the panoramic camera. The rover studied targets nicknamed "Philomena Zale," "Alma Ziegler," and "Ruth Heverly" using the miniature thermal emission spectrometer.

Sol 1184: Spirit watched for dust devils in the morning and checked for drift (changes over time) in the miniature thermal emission spectrometer. Spirit drove 6.7 meters (22 feet) to a target called "White Soil." The rover acquired post-drive images with both the navigation camera and the panoramic camera.

Sol 1185 (May 4, 2007): Plans called for Spirit to watch for dust devils in the morning and complete a systematic foreground study with the miniature thermal emission spectrometer. The rover was also to acquire navigation camera images in support of observations with the miniature thermal emission spectrometer, conduct a study of atmospheric argon using the alpha-particle X-ray spectrometer, and watch for dust devils and take panoramic images of the sky the next morning.

Odometry:

As of sol 1184 (May 3, 2007), Spirit's total odometry was 7,103 meters (4.4 miles).

sol 1172-1178, May 1, 2007: *Spirit Discovers Changes in Soil Near 'Home Plate'*

Spirit remains healthy after completing scientific investigation of a light-toned soil patch nicknamed "Everett." Everett is interesting because scientists thought it would be rich in sulfur like other soil exposures they've investigated. Instead, it turned out to be low in sulfur and ultramafic in composition -- made of iron- and magnesium-rich silicate, a chemistry often associated with volcanic rocks. Everett appears to be different from other materials the rover has encountered around "Home Plate."

On sol 1175 (April 23, 2007), Spirit bumped back approximately 60 centimeters (24 inches) to position the robotic arm for analysis of some light-toned nodules called "Slide." Scientists were hoping Slide would be high in silica, but after the investigation discovered that it looked like a still cleaner version of "Everett." The rover is now working on a scientific analysis of a new target known as "Good Question."

Spirit surveyed rocks known as "Charlene Barnett," "Fern Battaglia," and "Joyce Ricketts" as well as an area above a landslide on "Husband Hill" known as "Headscarp" and a vesicular basalt known as "Dorothy Wind."

Spirit completed work on a big-picture mosaic of the Home Plate area called the "Ballpark Panorama."

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground using the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1172 (April 20, 2007): Spirit acquired microscopic images of Everett, acquired columns 8 and 9 of the Ballpark Panorama with the panoramic camera, surveyed Charlene Barnett with the miniature thermal emission spectrometer, and studied Everett with the alpha particle X-ray spectrometer.

Sol 1173: Spirit studied Everett using the Mössbauer spectrometer and acquired columns 10 and 11 of the Ballpark Panorama.

Sol 1174: In the morning, Spirit searched for clouds using the navigation camera. The rover then resumed Mössbauer analysis of Everett, acquired column 12 of the Ballpark Panorama, and surveyed Fern Battaglia with the miniature thermal emission spectrometer.

Sol 1175: Spirit took panoramic images of the sky and crushed surface nodules and acquired movies in search of dust devils using the navigation camera. Spirit then stowed the robotic arm, rolled backward slightly to be able to reach Slide, acquired post-drive images with the navigation camera, and acquired panoramic camera images of the drive ahead.

Sol 1176: Spirit acquired movies in search of dust devils using the navigation camera, acquired panoramic camera images of the sky, stowed the robotic arm, acquired microscopic images of Slide, brushed the surface of Slide with the rock abrasion tool, and acquired microscopic images of the newly brushed surface. The rover studied Slide with the alpha-particle X-ray spectrometer and surveyed Dorothy Wind using the miniature thermal emission spectrometer.

Sol 1177: Spirit acquired panoramic camera images of Everett, searched for dust devils, and studied Slide with the Mössbauer spectrometer.

Sol 1178 (April 27, 2007): In the morning, Spirit acquired panoramic camera images of the "El Dorado" dune field, a landslide area on "Husband Hill" known as "Landslide," and the horizon. The rover continued to study Slide using the Mössbauer spectrometer, acquired panoramic camera images of Dorothy Wind, and acquired data from Joyce Ricketts using the miniature thermal emission spectrometer. The rover prepared to acquire microscopic images and alpha-particle X-ray spectrometer data from Good Question the following morning.

Odometry:

As of sol 1177 (April 26, 2007), Spirit's total odometry was 7,095 meters (4.4 miles).

sol 1164-1171, April 23, 2007: *Spirit Continues Studies of Rocks Near 'Home Plate'*

After a few attempts, Spirit finally made it to the outcrop called "Madeline English," where the rover is performing scientific studies. Madeline English is interesting because of the apparent presence of clasts -- rock fragments -- in the outcrop. Scientists are interested in determining whether the clasts have a different composition from surrounding material. If it is different, it would be one factor supporting the hypothesis that Madeline English is one of the lowest stratigraphic layers in the region.

Spirit also performed a remote sensing campaign on rocks nicknamed "Elise Harney," "Carol Habben," "Senaida Wirth," "Charlene Barnett," "Alice Haylett," and "Clara Zaph." These and other rock targets are currently being named after deceased members of the All-American Girls Profession Baseball League.

Another rock known as "Elizabeth Mahon" is interesting because it has the highest silica level of any rock analyzed on Mars. Processes that elevate the silica content in a rock generally involve liquid water.

Spirit also began acquiring a large mosaic, known as the "Ballpark Panorama," of images of the "Home Plate" area using the panoramic camera.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground with the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1164 (April 12, 2007): Spirit made a second attempt to bump into position next to Madeline English and acquired end-of-drive navigation camera images.

Sol 1165: Spirit started the day by acquiring panoramic camera images of Carol Habben, then acquired panoramic camera images of Elise Harney.

Sol 1166: Spirit watched for dust devils in the morning and then attempted for a third time to bump into position next to Madeline English. The rover acquired end-of-drive images using the navigation camera.

Sol 1167: Spirit acquired early morning images of Elise Harney with the panoramic camera, then acquired panoramic camera images of Carol Habben. The rover surveyed Senaida Wirth, Charlene Barnett, and Alice Haylett with the miniature thermal emission spectrometer.

Sol 1168: Spirit searched for dust devils in the morning, then unstowed the robotic arm and acquired microscopic images of a particular exposure of Madeline English known as "Belles." The rover surveyed Clara Zaph with the miniature thermal emission spectrometer and studied Belles using the alpha particle X-ray spectrometer.

Sol 1169: Spirit scanned the sky for clouds using the navigation camera and acquired data from Belles using the Mössbauer spectrometer. The rover acquired panoramic camera images of Home Plate.

Sol 1170: Spirit acquired panoramic images of the sky and watched for dust devils. Spirit then restarted the Mössbauer spectrometer for continued analysis of Belles before beginning work on the Ballpark Panorama.

Sol 1171 (April 19, 2007): Spirit scanned the sky for clouds using the navigation camera and acquired microscopic images of rock targets known as "Peaches" and "BlueSox" in addition to Madeline English, along with a light-colored soil target known as "Everett." The rover continued work on the Ballpark Panorama and prepared to start work the following day on a survey of white material in the rover's tracks using the miniature thermal emission spectrometer.

Odometry:

As of sol 1169 (April 17, 2007), Spirit's total odometry was 7,093 meters (4.4 miles).

sol 1159-1163, April 13, 2007: *Spirit Continues Studies En Route to 'Home Plate'*

Spirit is healthy and has completed a campaign of scientific studies of a rock outcrop known as "Elizabeth Mahon," on the edge of "Home Plate." Spirit is now en route to another outcrop nicknamed "Madeline English." The route involves driving backward, turning around, backing up, parking in parallel between two sizable rocks flanking the target, pivoting clockwise on the stuck right front wheel, and finally "crabbing" forward to the target. Spirit performs crabbing by steering the two rear wheels toward the stuck right front wheel, thus opposing resistance from the right front wheel and keeping yawing (swinging from side to side) to a minimum.

Spirit executed the "parallel parking" portion of the trip on the rover's 1,162nd Martian day, or sol, of exploration (April 10, 2007). The final "crab" portion was planned for sol 1164 (April 12, 2007). After the investigation of Madeline English, plans called for the rover to head north to one of several possible "on-ramps" for driving onto Home Plate.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground with the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1159 (April 7, 2007): Spirit acquired data from Elizabeth Mahon using the Mössbauer spectrometer, acquired panoramic camera images of a target known as "Tars Tarkas," and studied a rock known as "Johanna Hargraves" using the miniature thermal emission spectrometer.

Sol 1160: Spirit acquired full-color images using all 13 filters of the panoramic camera of Elizabeth Mahon before driving south and taking a mosaic of navigation camera images.

Sol 1161: Spirit acquired a survey of rock clasts using the panoramic camera, a survey at high sun with the panoramic camera, data using the Mössbauer spectrometer from a target known as "Muriel Coben" and a rock called "Elise Harney," and data on atmospheric density of argon gas using the alpha-particle X-ray spectrometer.

Sol 1162: Spirit drove north toward Madeline English and acquired a mosaic of navigation camera images.

Sol 1163: Spirit watched for dust devils using the WATCH computer program, acquired full-color images of Madeline English using all 13 filters of the panoramic camera, studied a rock exposure known as "Phyllis Wise 2" using the miniature thermal emission spectrometer, and acquired full-color panoramic camera images of the rock known as "Phyllis Wise."

Odometry:

As of sol 1162 (April 10, 2007), Spirit's total odometry was 7,092.29 meters (4.41 miles).

sol 1152-1158, April 10, 2007: *Spirit Studies Rocks En Route to "Home Plate"*

Spirit is healthy and performing scientific studies of an outcrop of light-toned clasts and cobbles nicknamed "Elizabeth Mahon" on the edge of "Home Plate" as well as a pockmarked rock outcrop nicknamed "Madeline English."

To get around obstacles and make progress over rough terrain using only five wheels, Spirit drove backward a few meters, pivoted around the front wheel, drove backward another few meters, pivoted again to face Madeline English, and finally pushed forward to reach the rock with scientific instruments on the robotic arm.

After investigating Madeline English, the rover will head back north to one of several possible "on-ramps" for driving onto Home Plate.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground with the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1152 (March 31, 2007): Spirit acquired panoramic camera images of a rock exposure known as "Clara Zaph" in addition to miniature thermal emission spectrometer data from "Clara Zaph 1," "Clara Zaph 2," and "Clara Zaph 3." The rover surveyed the sky and ground and targets known as "Rita Briggs" and "Twila Shively" using the miniature thermal emission spectrometer and completed a survey with the sun low in the sky using the panoramic camera.

Sol 1153: Spirit turned southeast and drove backward 4 meters over the target Elizabeth Mahon to place it within the work volume of the rover's scientific instruments. Spirit acquired post-drive images using the navigation camera and relayed data to the Odyssey orbiter overnight.

Sol 1154: Spirit acquired thumbnail images of the sky using the panoramic camera and measured argon using the alpha-particle X-ray spectrometer.

Sol 1155: Spirit unstowed the robotic arm, placed the Mössbauer spectrometer on Elizabeth Mahon, and acquired data overnight. The rover acquired a mosaic of panoramic camera images facing the drive direction and relayed data to Odyssey overnight.

Sol 1156: Spirit continued to acquire overnight data from Elizabeth Mahon using the Mössbauer spectrometer. Spirit acquired full-color images using all 13 filters of the panoramic camera of a target known as "Madeline English 2." The rover acquired miniature thermal emission spectrometer data from Madeline English 2 and targets known as "Betty Hill" and "Madeline English 3."

Sol 1157: Spirit changed tools from the Mössbauer spectrometer to the microscopic imager and acquired a mosaic of microscopic images of Elizabeth Mahon. The rover placed the alpha-particle X-ray spectrometer on the target and collected data overnight while also relaying relayed data to the Odyssey orbiter. Spirit scanned the sky for clouds using the navigation camera and acquired full-color images of white soil using all 13 filters of the panoramic camera.

Sol 1158 (April 6, 2007): Plans called for Spirit to acquire overnight data using the Mössbauer spectrometer, panoramic camera images of Madeline English, and miniature thermal emission spectrometer data on targets known as "Noreen Arnold," "Carol Habben," and "Phyllis Wise."

Odometry:

As of sol 1153 (April 1, 2007), Spirit's total odometry was 7,077.10 meters (4.40 miles).

sol 1145-1151, April 03, 2007: *Spirit Begins to Look for Best Access to 'Home Plate'*

Spirit is healthy and has finished her science campaign at "Mitcheltree Ridge." The rover is now heading south along the outside edge of "Home Plate" toward an outcrop named "Madeline English." After the investigation of Madeline English the rover will head back north to one of several possible "on-ramps" for making its way onto Home Plate. In the early morning of sol 1151 Spirit will perform its first overnight communications relay with Mars Odyssey since before winter (sol 846)!

Sol-by-sol summary:

In addition to specific daily activities, Spirit's conducted routine atmospheric observations, which include: panoramic camera tau measurements, miniature thermal emission spectrometer sky and ground stares, and panoramic camera sky spots.

Sol 1145 (March 24, 2007): On this sol, the rover continued Mössbauer spectrometer observations on targets "Torquas 2," and completed Mini-TES stares on "Throxus," "Arbok," "Malagor," "Glorestre," "Syl" and "Polodona." Spirit also began a panoramic camera image of Mitcheltree Ridge (North).

Sol 1146: Spirit took a microscopic stereo image of target "John Carter" and completed miniature thermal emission spectrometer stares on targets "Forandus," "Iss" and "Thavas." The rover took an alpha particle X-ray spectrometer reading on John Carter and continued its panoramic camera image of Mitcheltree Ridge (North).

Sol 1147: Spirit captured a navigation camera dust devil sequence and continued on dust devil watch. The rover also began a panoramic camera 13-Filter of Mitcheltree Ridge. The miniature thermal emission spectrometer was used to stare at targets "Darseen" and "Faget." The rover also conducted some panoramic camera photometry experiments.

Sol 1148: The rover stowed its instrument deployment device ("arm"), drove towards Home Plate and then conducted post-drive navigation and panoramic camera imaging. The panoramic camera captured sky thumbnails and the navigation camera shot another dust devil sequence.

Sol 1149: On this sol, the panoramic camera conducted a high sun survey. The rover also took a miniature thermal emission spectrometer 5-point sky & ground stare and a navigation camera dust devil sequence.

Sol 1150: Spirit used its panoramic camera to image nearby outcrop, then drove 8 meters (26 feet) south-southeast toward Madeline English. After the drive, the navigation camera and the panoramic cameras took images.

Sol 1151: Overnight, there was an Odyssey data relay. The panoramic camera conducted a clast survey (looking at rock fragments) and then monitored for dust.

Odometry:

As of sol 1150, Spirit's total odometry was 7,066 meters (4.39 miles).

sol 1141-1144, March 23, 2007: *Spirit Studies Rocks in Vicinity of "Home Plate"*

Spirit remains healthy and spent much of the week studying a new rock target on "Mitcheltree Ridge" called "Torquas." Scientists are trying to understand what relationship Mitcheltree Ridge has to "Home Plate" -- for example, whether it is an extension of Home Plate or an entirely different rock layer, and whether it has similar composition or morphology.

Torquas is nicknamed after a dried-up seabed covered with moss in the Barsoom science fiction saga by Edgar Rice Burroughs.

Sol-by-sol summary:

In addition to daily observations of atmospheric dust levels and surveys of the sky and ground with the miniature thermal emission spectrometer, Spirit conducted the following activities:

Sol 1141 (March 20, 2007): Spirit acquired panoramic camera images of Torquas, nudged closer to the outcrop, took post-drive images with the navigation camera, acquired images of the sky with the panoramic camera, and watched for dust devils.

Sol 1142: This was a runout sol, or Martian day, meaning the rover completed pre-loaded activities resulting from an only partially successful uplink of new instructions. The uplink was only partially successful because the rover's best-lock frequency was out of range. Runout activities included monitoring atmospheric dust, measuring light looking east and west, imaging the calibration target, and taking thumbnail images of the sky.

Sol 1143: Spirit acquired a 360-degree panorama of images with the navigation camera, stereo microscopic images of Torquas prior to brushing the surface with the rock abrasion tool, and more stereo images after brushing the rock. The rover placed the alpha-particle X-ray spectrometer on the rock and then collected data using the instrument.

Sol 1144 (March 23, 2007): Spirit's first planned task was to acquire panoramic images of Mitcheltree Ridge. Other planned activities included studies of Torquas using the Mössbauer spectrometer, surveys of layered outcrops known as "Zanor," "Banth," "Okar," and "Dor" using the miniature thermal emission spectrometer, and photometric measurements using the panoramic camera.

Odometry:

As of sol 1142 (March 21, 2007), Spirit's total odometry was 7,046 meters (4.38 miles).

sol 1132-1140, March 20, 2007: *Spirit Loses, Re-Establishes Contact with Orbiter*

Spirit is healthy but had to sit out a Martian day waiting to send data to Earth while the Mars Reconnaissance Orbiter was in safe mode. Both the rover and the orbiter share the same X-band frequency with Earth and must coordinate communications. Ultimately, Spirit sent data to Earth while the Mars Reconnaissance Orbiter was on the other side of Mars, out of reach of Earth.

Spirit drove 21.26 meters (69.75 feet) on the rover's 1,132nd and 1,136th sols, or Martian days, of exploration (March 10 and March 14, 2007), en route to rock targets on "Mitcheltree Ridge."

Sol-by-sol summary:

Sol 1132 (March 10, 2007): Spirit touched a soil target with the Mössbauer spectrometer, acquired microscopic images, and surveyed the sky and ground as well as a vesicular basalt known as "Faye Dancer" using the miniature thermal emission spectrometer. The rover drove 10.2 meters (33.5 feet), took images with the hazard avoidance and panoramic cameras, and acquired a 360-degree mosaic with the navigation camera.

Sol 1133: Spirit began the day by imaging the sky with the panoramic camera. The rover then pointed the navigation camera at the surrounding terrain and acquired a movie in search of dust devils. Spirit surveyed the sky and ground with the miniature thermal emission spectrometer and monitored dust on the rover mast.

Sol 1134: Spirit searched for dust devils in the morning and spent much of the day engaged in remote targeted sensing. Spirit acquired full-color images of a knob known as "Pitchers Mound" using all 13 filters of the panoramic camera. The rover acquired images of an outcrop known as "Backstop" and conducted a survey of rock clasts using the panoramic camera. Spirit acquired data on targets known as "Shirley Jameson," "Connie Wisniewski," "Margaret Stephani," and "Tjanath" using the miniature thermal emission spectrometer. The rover monitored atmospheric dust using the panoramic camera and surveyed the sky and ground as well as targets known as "Phundahl" and "Panar" using the miniature thermal emission spectrometer.

Sol 1135: Spirit began the day by examining scattered light and searching for dust devils with the navigation camera. The rover surveyed targets known as "Ptarth" and "Thark," a large slab of rock called "Torquas," and the sky and ground with the miniature thermal emission spectrometer.

Sol 1136: Spirit's first task of the day was surveying the rover's calibration target and a target known as "Toonal" using the miniature thermal emission spectrometer. Spirit then drove 11.06 meters (36.29 feet) toward an outlying outcrop associated with "Home Plate" (called "outlier 2") and acquired post-drive images using the hazard avoidance and navigation cameras. The rover surveyed the sky and ground using the miniature thermal emission spectrometer.

Sol 1137: In the morning, Spirit acquired thumbnail images of the sky using the panoramic camera and acquired a movie in search of dust devils using the navigation camera. When Spirit did not receive the next day's instructions as a result of being unable to establish a link with Earth while the Mars Reconnaissance Orbiter was in safe mode, the rover instead executed "runout" science activities for the first time in 321 sols. The pre-loaded runout activities included monitoring atmospheric dust, measuring light looking east and west, imaging the calibration target, and taking thumbnail images of the sky.

Sol 1138 (March 9, 2007): Spirit acquired full-color images of targets known as "Ompt" and "Shador" using all 13 filters of the panoramic camera. The rover studied Ompt, Shador, and additional targets known as "Zor" and "Zodanga" using the miniature thermal emission spectrometer. Spirit monitored atmospheric dust using the panoramic camera and conducted an argon experiment using the alpha-particle X-ray spectrometer.

Sol 1139: Spirit's first activities of the day included acquiring full-color images of Zodanga and Zor using all 13 filters of the panoramic camera and searching for clouds using the navigation camera. Spirit acquired hazard avoidance camera images and navigation camera images of potential scientific targets as well as a 360-degree view of the rover's surroundings using the navigation camera. Spirit monitored atmospheric dust using the panoramic camera.

Sol 1140 (March 19, 2007): Spirit took snapshots of the sky using the panoramic camera and acquired a dust devil movie using the navigation camera. The rover measured atmospheric dust, scanned the sky and ground using the miniature thermal emission spectrometer, and looked for clouds using the navigation camera.

Odometry:

As of sol 1136 (March 14, 2007), Spirit's total odometry was 7,033.61 meters (4.37 miles).

sol 1125-1131, March 12, 2007: *Spirit Studies "Home Plate" from the West*

Spirit is healthy after wrapping up a week of remote sensing observations on the west side of the elevated circular plateau known as "Home Plate."

Sol-by-sol summary:

Sol 1125 (March 3, 2007): Spirit took images of darkness, when the panoramic camera is exposed to no light, for calibration purposes. Spirit acquired microscopic images of the dust capture and filter magnets and surveyed several targets known as "Lothar," "Manator," "Morbus," "Ombra," "Otz Valley," and "Pankor" using the miniature thermal emission spectrometer. The rover monitored atmospheric dust levels with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and searched for clouds using the navigation camera.

Sol 1126: Spirit's first task of the day was acquiring panoramic camera images of the dune field known as "El Dorado." The rover then drove 3.5 meters toward "Home Plate," acquired images using the front and rear hazard avoidance cameras and navigation camera, and monitored atmospheric dust with the panoramic camera. The rover scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 1127: The first thing in the morning, Spirit scanned the sky for clouds using the navigation camera. The rover surveyed the sky at high sun using the panoramic camera. Spirit scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 1128: Spirit started the day by looking for Martian dust devils with the navigation camera. The rover re-acquired images with the front hazard avoidance camera and tested the switch on the contact plate of the Mössbauer spectrometer by touching the filter magnet with

the instrument. Spirit acquired navigation camera images and a panoramic camera mosaic of Home Plate. Spirit acquired remote sensing data from targets known as "Irene Hickson," "Joanne Winter," "Bette Trezza," and "Carolyn Morris." The rover surveyed the sky and ground with the miniature thermal emission spectrometer and measured atmospheric dust levels with the panoramic camera.

Sol 1129: Spirit started the day by looking for morning clouds. The rover conducted a survey using the panoramic camera at high sun. Spirit scanned the sky and ground with the miniature thermal emission spectrometer and used the same instrument to acquire remote sensing data from targets known as "Anna Mae Hutchison," "Faye Dancer," "Dorothy Hunter," and "Velma Abbott."

Sol 1130: Spirit searched for morning clouds with the navigation camera and acquired images, using all 13 filters of the panoramic camera, of Home Plate. The rover also acquired data from targets known as "Fredda Acker" and "Jean Gilchrist" with the miniature thermal emission spectrometer. The rover took calibration images of darkness and monitored atmospheric dust with the panoramic camera. Spirit acquired data from a target known as "Betty Warfel" using the miniature thermal emission spectrometer.

Sol 1131 (March 9, 2007): Spirit took images of the sky with the panoramic camera and surveyed the sky and ground with the miniature thermal emission spectrometer. The rover acquired miniature thermal emission spectrometer data and panoramic camera images of a target known as "Evelyn Adams." Spirit took full-color images, using all 13 filters of the panoramic camera, of a target called "Joanne Winter." The rover acquired miniature thermal emission spectrometer data from targets known as "Bethany Goldsmith," "Betty Whiting," and "Melba Alspaugh." Spirit took panoramic camera images and prepared to spend the next morning acquiring two movies in search of dust devils using the panoramic camera.

Odometry:

As of sol 1130 (March 8, 2007), Spirit's total odometry was 7,012.34 meters (4.36 miles).

sol 1118-1124, March 08, 2007: *Spirit Studies Rock Outcrops, Drives Near 'Home Plate'*

Spirit is healthy and making progress on the return trip to "Home Plate." The rover headed north along Home Plate to fill in gaps in imagery left behind when Spirit rushed to find a winter haven.

Use of the rover's robotic arm remains on hold until more diagnostics can be performed.

Sol-by-sol summary:

In addition to daily observations that included measuring atmospheric opacity caused by dust with the panoramic camera, scanning the sky for clouds with the navigation camera, surveying the sky and ground with the miniature thermal emission spectrometer, and taking reference images of the sky, Spirit conducted the following activities:

Sol 1118 (Feb. 24, 2007): Spirit took panoramic camera images of rock outcrops "Dorothy Kamenshek" and "Olive Little" as well as Home Plate. The rover surveyed Olive Little and targets known as "Kamtol" and "Korvas" with the miniature thermal emission spectrometer.

Sol 1119: Spirit drove 7.94 meters (26.1 feet) toward Home Plate, took navigation camera images after the drive, acquired navigation camera movies in search of dust devils, and monitored atmospheric dust.

Sol 1120: Spirit searched for clouds using the WATCH computer sequence.

Sol 1121: Spirit acquired panoramic camera images of Home Plate, drove 14.24 meters (46.72) feet, acquired post-drive navigation camera images, surveyed the horizon with the panoramic camera, and searched for clouds using the WATCH computer sequence.

Sol 1122: Spirit measured atmospheric argon using the alpha particle X-ray spectrometer and monitored atmospheric dust.

Sol 1123: Spirit acquired panoramic camera images of Home Plate, surveyed a target known as "Madeline English" with the miniature thermal emission spectrometer, drove 7.95 meters (26.1 feet) toward Home Plate, and acquired post-drive images, including looking toward the rear, with the navigation camera.

Sol 1124 (March 2, 2007): Spirit completed a survey of rock clasts using the panoramic camera.

Odometry:

As of sol 1123 (March 1, 2007), Spirit's total odometry was 7007.84 meters (4.35 miles).

sol 1113-1117, February 23, 2007: *Spirit Continues Driving While Engineers Check Robotic Arm*

Spirit is healthy and making progress on the return trek to "Home Plate." Rover handlers have put use of the robotic arm on hold in order to run diagnostic tests of apparent positioning errors in the placement of instruments on the arm. Meanwhile, Spirit continues driving, searching for dust devils and clouds using WATCH computer commands, and acquiring other remote sensing data.

Sol-by-sol summary

In addition to daily observations that included measuring atmospheric opacity caused by dust with the panoramic camera, scanning the sky for clouds with the navigation camera, surveying the sky and ground with the miniature thermal emission spectrometer, and taking reference images of the sky, Spirit conducted the following activities:

Sol 1113 (Feb. 19, 2007): Spirit acquired full-color images, using all 13 filters of the panoramic camera, of a knobby rock known as "Fabien" and targets known as "Kadabra" and "Kaol."

Sol 1114: Spirit rolled slightly backward, turned, and drove 8.61 meters (28.3 feet) toward Home Plate. Spirit searched for dust devils using the WATCH commands.

Sol 1115: Spirit acquired movie frames in search of dust devils and searched for clouds using the WATCH commands.

Sol 1116: Spirit drove 8 meters (26 feet), acquired westward-looking and northward-looking images after the drive, and acquired thermal data from a soil target known as "Kabal" using the miniature thermal emission spectrometer.

Sol 1117 (Feb. 23, 2007): Spirit acquired full-color images of the area in front of the rover using all 13 filters of the panoramic camera.

Odometry

As of sol 1114 (Feb. 20, 2007), Spirit's total odometry was 6,969.03 meters (4.33 miles).

sol 1104-1112, February 16, 2007: *Spirit Perfects the Art of Driving on Five Wheels*

Rover drivers have now refined their techniques for maneuvering on only five wheels. All of Spirit's drives during the past week ended within centimeters (inches) of the targeted endpoint. Spirit is healthy and has arrived at the rock outcrop known as "Bellingshausen" on the way back to "Home Plate."

On Feb. 10, 2007, the rover's 1,104th Martian day, or sol, of exploration, Spirit experienced a warm reset, during which the rover's computer rebooted and the rover went into auto mode, canceling activities for the weekend and awaiting instructions from Earth. This is the third time Spirit has experienced this anomaly; Spirit's twin, Opportunity, has experienced it twice. The anomaly is attributed to a well-known condition in the flight software. The rover's handlers sent new commands that activated the master sequence of activities for sol 1107 (Feb. 13, 2007).

During scientific studies of targets known as "Mount Darwin" and "Puenta Arenas" in soil disturbed by the rover's tracks, Spirit's handlers noticed positioning errors in the placement of instruments on the rover's robotic arm. In response, they scheduled diagnostic tests for sol 1110 (Feb. 16, 2007). This left the team with a tough decision: remain at Bellingshausen during the long President's Day holiday weekend or head toward Home Plate with a day of driving on sol 1114 (Feb. 20, 2007).

Tau measurements of atmospheric dust levels were 0.6, while solar power levels were 312 watt-hours (100 watt-hours is the amount of electrical energy needed to light a 100-watt bulb for one hour).

Sol-by-sol summary:

Except for the sols spent in auto mode, Spirit made daily observations that included measuring atmospheric opacity caused by dust with the panoramic camera, scanning the sky for clouds with the navigation camera, and surveying the sky and ground with the miniature thermal emission spectrometer. Spirit also conducted the following activities:

Sol 1104 (Feb. 10, 2007): Spirit went into auto mode.

Sol 1105: Spirit remained in auto mode.

Sol 1106: Spirit remained in auto mode.

Sol 1107: Spirit drove to the Bellingshausen outcrop.

Sol 1108: Spirit acquired panoramic camera images of Bellingshausen and navigation camera movie frames in search of clouds.

Sol 1109: Spirit turned and approached a rock target known as "Fabian" and acquired stereo images following the drive using the navigation camera. The rover also acquired images with the panoramic camera.

Sol 1110: Plans called for a "rover tai-chi," which involves taking images of the contact ring of the Mössbauer spectrometer with the front hazard avoidance camera before placing the instrument on a target, and for acquiring panoramic camera images of Bellingshausen.

Sol 1111: Planned activities included collecting data on targets known as "Amhor," "Bantoom," "Dusor," "Ghasta," and "Gooli" with the miniature thermal emission spectrometer.

Sol 1112 (Feb. 18, 2007): Planned activities included collecting data on targets known as "Horz," "Hastor," and "Invak" with the miniature thermal emission spectrometer.

Odometry:

As of sol 1109 (Feb. 15, 2007), Spirit's total odometry was 6,965 meters (4.3 miles).

sol 1097-1103, February 09, 2007: *It's Officially Spring on Mars*

Spring is in the thin, Martian atmosphere once again as NASA's Mars Exploration Rover Spirit scans the local terrain for dust devils expected this time of year. The rover remains healthy and has completed remote sensing studies of a soil target known as "Tyrone," conducted from a distance of about 10 meters (33 feet) away. Tyrone has bright soil upturned in wheel tracks.

Because Spirit is now limited to driving on five wheels, Spirit's handlers did not feel comfortable sending the rover any closer to the soft soil surrounding Tyrone. On the rover's 1,102nd Martian day, or sol, of exploration (Feb. 7, 2007), the rover turned and retraced its tracks toward the layered rock exposure known as "Montalva" en route to the circular plateau known as "Home Plate."

Engineers planned to have Spirit drive approximately 8 meters (26 feet) early on sol 1103 (Feb. 8, 2007). Planned weekend activities included remote sensing observations in addition to the long drive back to Home Plate. Estimated dust levels, known as Tau measurements, appeared to be holding steady at around 0.55. Scientists are hopeful that Martian winds will clear dust from Spirit's solar panels and boost the rover's power levels as they did at around this time last year.

Sol-by-sol summary:

In addition to daily observations that included using the panoramic camera to measure atmospheric opacity, using the navigation camera to scan the sky for clouds, and using the miniature thermal emission spectrometer to survey the sky and ground, Spirit completed the following activities:

Sol 1097 (Feb. 2, 2007): Spirit used the miniature thermal emission spectrometer to acquire data on Tyrone and a rock target known as "Korolev." Spirit placed the alpha-particle X-ray spectrometer on an exposure of white soil known as "Mount Darwin" and collected compositional data. Spirit also acquired images of Tyrone using the panoramic camera.

Sol 1098: Spirit continued to gather miniature thermal emission spectrometer data from Tyrone and alpha-particle X-ray spectrometer data from Mount Darwin.

Sol 1099: Spirit acquired microscopic images of Mount Darwin, scanned a target known as "Russkaya" with the miniature thermal emission spectrometer, and acquired more panoramic camera images of Tyrone.

Sol 1100: Spirit studied Mount Darwin with the Mössbauer spectrometer, continued to acquire data from Tyrone using the miniature thermal emission spectrometer, and acquired panoramic camera images of a sinuous feature in the dirt called "Hermite" and of the distant "El Dorado" dune field.

Sol 1101: Spirit acquired microscopic images of "Punta Arenas," a pebble in one of the rover's tracks. The panoramic camera photographed Tyrone. The miniature thermal emission spectrometer scanned distant "McCool Hill." Spirit also used the panoramic camera for images of Mount Darwin and Puente Arenas.

Sol 1102: Spirit acquired images of McCool Hill with the panoramic camera. Then it turned to drive back toward Home Plate and updated the rover's knowledge of its position relative to the sun.

Sol 1103 (Feb. 8, 2007): Plans called for Spirit to take images of "Tyrone Vista" (the rover's view of the upturned soil known as Tyrone along with the surrounding terrain) and drive toward Montalva.

Odometry:

As of sol 1102 (Feb. 7, 2007), Spirit's total odometry was 6,926.42 meters (4.3 miles).

sol 1091-1096, February 01, 2007: *Spirit Examines Churned-Up Martian Soil*

Spirit is healthy and continues to scan the Martian terrain for the dust devils of spring. The rover has completed its scientific studies of a layered rock exposure known as "Montalva" on an outcrop called "Troll."

The rover is now en route toward a patch of bright soil churned up by the rover's wheels in March 2007. Known as "Tyrone," the patch of bright material, white and yellow in color, is possibly analogous to salty soils discovered by the rover earlier in the mission. Scientists plan to have the rover conduct remote sensing from a distance of about 10 meters (33 feet) in order to avoid getting mired in the sand. The rover will use its scientific instruments to get a better look at the soil exposure and determine whether it contains sulfates.

Spirit acquired movies with the navigation camera in search of dust devils on the rover's 1091st, 1093rd, and 1095th sols, or Martian days (Jan. 27, Jan. 29, and Jan. 31, 2007). The risk of dust storms is predicted to increase through mid-October 2007.

The rover drove 12 meters (39 feet) between sols 1092 (Jan. 28, 2007) and 1094 (Jan. 30, 2007).

Sol-by-sol summary:

In addition to daily observations that included measuring atmospheric dust with the panoramic camera and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1091 (Jan. 27, 2006): Spirit acquired panoramic camera images of a rock target known as "Zucchelli" as well as images for building a digital elevation model of the terrain between the rover and a rock of vesicular basalt known as "Esperanza." Spirit acquired movie frames with the navigation camera in search of dust devils and used the miniature thermal emission spectrometer to acquire data on rock targets known as "Troll 1," "Macquarie," and "Troll 2."

Sol 1092: Spirit acquired navigation camera images following the day's drive and panoramic camera images of the sky for calibration purposes.

Sol 1093: Spirit acquired movie frames with the navigation camera in search of dust devils and navigation camera images in support of observations to be made with the miniature thermal emission spectrometer. Spirit scanned the foreground with the miniature thermal emission spectrometer, monitored for dust on the rover mast with the panoramic camera, and conducted a survey of rock clasts with the panoramic camera.

Sol 1094: Spirit acquired panoramic camera images of a rock target called "Druzhnaya," drove closer to Tyrone, and acquired post-drive images of the rover's surroundings using the navigation camera.

Sol 1095: Spirit acquired data on Tyrone using the miniature thermal emission spectrometer, acquired movie frames with the navigation camera in search of dust devils, acquired data on a rock outcrop known as "Oberth," and acquired full-color images of Tyrone using all 13 filters of the panoramic camera.

Sol 1096 (Feb. 1, 2007): Spirit "bumped," or rolled a short distance, toward a scientific target to be examined with instruments on the rover arm, acquired post-drive images with the navigation camera, scanned the sky for clouds with the navigation camera, and acquired thumbnail images of the sky with the panoramic camera.

Odometry:

As of sol 1094 (Jan. 30, 2006), Spirit's total odometry was 6,915 meters (4.3 miles).

sol 1085-1090, January 27, 2007: *Spirit Studies Layered Rocks and Wind-Blown Drifts*

With the rover's third Martian spring just around the corner, Spirit is healthy and has started acquiring movies with the navigation camera in search of dust devils wheeling across the terrain. Spring officially begins on Martian day, or sol 1103 (Feb. 8, 2007).

During the past week, Spirit acquired microscopic images of a soil target called "Londonderry," which is an active wind drift shaped by the motion of bouncing sand grains. Spirit also acquired super-resolution panoramic camera images of an exposure of layered bedrock with rounded rock fragments known as "Zucchelli." Scientists hope the images will reveal information about color, structure, grain size, and mineralogical composition of the rock.

Spirit continued to make progress on scientific studies of a rock exposure known as "Montalva" on the lower stratigraphic unit of an outcrop known as "Troll." On the rover's 1,085th sol (Jan. 21, 2007) of exploration, Spirit used the wire brush on the rock abrasion tool to reveal more surface area and enable clean measurements with the miniature thermal emission spectrometer. Spirit then backed up to conduct analysis of the newly brushed area.

In the coming week, scientists plan to have Spirit retrace its tracks toward a soil exposure known as "Tyrone" for additional panoramic camera images and miniature thermal emission spectrometer measurements to be taken from a distance of about 10 meters (30 feet).

Sol-by-sol summary:

In addition to daily observations that included measuring atmospheric dust with the panoramic camera and surveying the sky and ground with the miniature thermal emission spectrometer, Spirit completed the following activities:

Sol 1085 (Jan. 21, 2006): Spirit acquired stereo microscopic images of Londonderry, as well as a target known as "Contact" and used the wire brush on the rock abrasion tool to brush the surface of Montalva. Spirit acquired panoramic camera images of layered rock targets known as "Los Estados," "Wollaston," and "Monte Dinero."

Sol 1086: Spirit acquired miniature thermal emission spectrometer data on rock targets called "Svea" and "Maudhem." Spirit acquired navigation camera movies in search of dust devils and acquired panoramic camera images of the Martian horizon and sky.

Sol 1087: Spirit stowed the robotic arm and backed up before taking navigation camera images in support of observations to be made with the miniature thermal emission spectrometer. Spirit acquired navigation camera images after backing up and acquired panoramic camera images of the drive direction.

Sol 1088: Spirit acquired panoramic camera images of the rock target now called "Montalva Daisy," in honor of the daisy-like arrangement of circular brushed areas on the rock's surface. The rover acquired data on Montalva Daisy and the background area around the target using the miniature thermal emission spectrometer. The rover surveyed the sky for calibration purposes using the panoramic camera.

Sol 1089: Plans called for Spirit to acquire long-baseline stereo images, using the panoramic camera, of the circular, plateau-like feature known as "Home Plate" in preparation for going back there after having survived the Martian winter. To do this, the rover moves laterally from one point to another between taking images with the left and right eyes of the camera. Plans also called for the rover to take super-resolution panoramic camera images, as well as navigation camera images of the rock target "Zucchelli," and to acquire data on Montalva using the miniature thermal emission spectrometer. The rover was also to acquire post-drive images of the terrain using the navigation camera and take thumbnail images of the sky using the panoramic camera.

Sol 1090 (Jan. 20, 2007): Plans called for Spirit to use the navigation camera to watch for dust devils and take images in support of investigations with the miniature thermal emission spectrometer. The rover was also slated to collect data with the miniature thermal emission spectrometer and complete a survey of rock clasts using the panoramic camera.

Odometry:

As of sol 1087 (Jan. 23, 2006), Spirit's total odometry was 6,896 meters (4.28 miles).

sol 1079-1084, January 19, 2007: *Spirit Studies Distinctive Rock Layers with Granules and Platy Beds*

Spirit is healthy and continues to make progress on scientific studies of a rock exposure known as "Montalva," which is one of the lower layers of an outcrop known as "Troll." Compositional data that Spirit collected using the alpha-particle X-ray spectrometer suggest the rock has high potassium content. To confirm this, scientists selected an adjacent exposure for further scrutiny.

In addition, Spirit began scientific analysis of an exposure known as "Riquelme" within the middle stratigraphic units of the "Troll" outcrop. Riquelme is composed of spherical particles that may be lapilli, which are pebble- to granule-size rocks ejected during a

volcanic eruption. Spirit is also acquiring data about an upper exposure, nicknamed "Zucchelli," of thin platy beds in the outcrop using the panoramic camera and alpha-particle X-ray spectrometer.

During the week, Spirit acquired stereo panoramic camera images of the raised, circular plateau known as "Home Plate" for use in creating a digital elevation model. The navigation camera acquired movie frames in search of dust devils on the rover's 1082nd and 1084th sols, or Martian days of exploration (Jan. 18, 2007 and Jan. 20, 2007).

Science team members plan to have Spirit observe a transit of the Martian moon Phobos as it passes between the rover and the sun on sol 1083 (Jan. 19, 2007) and attempt to acquire panoramic camera images of comet McNaught at sunrise. It is possible that predawn sunlight will make the comet hard to see.

Dust levels have been returning to normal levels, with tau (a measure of how obscured the sun is when viewed through the atmosphere) dropping to 0.549 on sol 1081 and resulting in increased solar energy of 343 watt-hours. After recent dust storm activity on Mars, tau peaked at 1.136 on sol 1066 (Jan. 1, 2007), resulting in solar array energy of 276 watt-hours.

Sol-by-sol summary:

Sol 1079 (Jan. 15, 2006): Spirit placed the alpha-particle X-ray spectrometer on a new, offset target near Montalva, acquired miniature thermal emission spectrometer data on rock targets known as "Guillaume" and "von Neumayer," surveyed the sky and ground using the miniature thermal emission spectrometer, and spent 5 hours collecting data with the alpha-particle X-ray spectrometer.

Sol 1080: The panoramic camera acquired a full-color image of Zucchelli using all 13 filters of the panoramic camera. The microscopic imager inspected "Montalva Offset." The rover swung the robotic arm out of the way to take panoramic camera images of both that target and Riquelme. Spirit acquired microscopic images of Riquelme before placing the alpha-particle X-ray spectrometer on the target. The rover surveyed a rock target known as "Lazarev" using the miniature thermal emission spectrometer.

Sol 1081: Spirit acquired panoramic camera images of Home Plate and the dune field known as "El Dorado." Spirit checked the calibration target and surveyed a target known as "Maud Land" with the miniature thermal emission spectrometer. Spirit acquired data using the alpha-particle X-ray spectrometer, images of the sky using the panoramic camera, and movie frames of potential dust devils using the navigation camera.

Sol 1082: Plans called for Spirit to measure atmospheric dust, survey the sky and ground with the miniature thermal emission spectrometer, and acquire data on "Riquelme3" using the Mössbauer spectrometer. Plans also called for Spirit to take images of the sky for calibration purposes using the panoramic and navigation cameras; survey the sky, ground, and a rock outcrop known as "d'Unville" using the miniature thermal emission spectrometer; and take panoramic camera images of the Phobos transit.

Sol 1083: Plans called for Spirit to measure atmospheric dust opacity, acquire navigation camera and panoramic camera images of the sky for calibration purposes, and survey the sky and ground with the miniature thermal emission spectrometer. Plans also called for continued work on Riquelme3, during which Spirit was to acquire additional data about iron composition with the Mössbauer spectrometer. The rover was also to study "Zucchelli3" using the miniature thermal emission spectrometer.

Sol 1084 (Jan. 20, 2007): Plans called for Spirit to measure atmospheric dust, scan the sky and ground with the miniature thermal emission spectrometer, continue Mössbauer analysis of Riquelme3, conduct miniature thermal emission spectrometer analysis of "Zucchelli4," and acquire navigation camera frames in search of dust devils. The next morning's activities were to include panoramic camera images of a soil slip known as "Lennox" and continued miniature thermal emission spectrometer analysis of "Zucchelli5."

Odometry:

As of sol 1081 (Jan. 17, 2006), Spirit's total odometry was 6,895 meters (4.28 miles).

sol 1070-1078, January 12, 2007: *Spirit Continues to Test New Computer Smarts*

On the rover's 1,068th sol, or Martian day of exploration on Mars (Jan. 4, 2007), Spirit used its new computer smarts to autonomously acquire images of the terrain using the hazard avoidance camera, construct a three-dimensional model of the terrain, identify rock or soil exposures of interest, and generate plans for placing the Mössbauer spectrometer and microscopic imager on 10 of those targets. Spirit's twin, the Opportunity rover on the other side of Mars, completed the same exercise. The next step of the testing process for both rovers will be to actually place scientific instruments on a target of interest.

Spirit spent much of the past week studying a layered rock exposure known as "Montalva." During the study, the rover used the brush on the rock abrasion tool, the microscopic imager, the alpha-particle X-ray spectrometer that collects information about elemental composition, and the Mössbauer spectrometer that identifies iron-bearing minerals.

Plans called for Spirit to observe three transits of the Martian moon Phobos as it passed between the rover and the sun on sols 1075 (Jan. 11, 2007), 1077 (Jan. 13, 2007), and 1078 (Jan. 14, 2007).

Sol-by-sol summary:

Sol 1070 (Jan. 6, 2006): Spirit unstowed the robotic arm and brushed the surface of Montalva, acquired a microscopic image of the rock, and placed the alpha-particle X-ray spectrometer on it for elemental analysis. Before shutting down for the evening, Spirit measured atmospheric dust using the panoramic camera.

Sol 1071: Spirit acquired a full-color image, using all 13 filters of the panoramic camera, of a boulder nicknamed "Davis." It also used the navigation camera for images of scientific targets, and used the miniature thermal emission spectrometer to measure atmospheric dust

and to surveyed the sky and ground, while communicating with the Odyssey orbiter in the afternoon.

Sol 1072: Spirit scanned the foreground using the miniature thermal emission spectrometer, acquired 4 hours worth of data using the alpha-particle X-ray spectrometer, monitored atmospheric dust with the panoramic camera, and took images of the sky for calibration purposes.

Sol 1073: Spirit swung the robotic arm out of view to collect full-color, 13-filter images of Montalva with the panoramic camera and acquired 4 hours of worth of data using the Mössbauer spectrometer. The rover scanned the sky and ground using the miniature thermal emission spectrometer, monitored dust accumulation on the rover mast, measured atmospheric dust, and imaged the sky for calibration purposes.

Sol 1074: Spirit used the navigation camera and the miniature thermal emission spectrometer observe a nearby rock known as "Kohnen" and another target known as "Amundsen." Spirit fired up the Mössbauer spectrometer for another 3 hours worth of analysis of Montalva. The rover turned off the Mössbauer spectrometer and monitored atmospheric dust.

Sol 1075: Spirit observed the morning transit of Phobos using the miniature thermal emission spectrometer, fired up the Mössbauer for an overnight observation, acquired thumbnail images of the sky using the panoramic camera, and searched for dust devils by acquiring video frames using the navigation camera.

Sol 1076: Plans called for Spirit to use the Mössbauer spectrometer for another 3 hours of study of Montalva and to take images of the sky for calibration purposes with the navigation and panoramic cameras. Spirit was also to monitor atmospheric dust and pre-position the panoramic camera to acquire images of the next day's transit of Phobos.

Sol 1077: Plans called for Spirit to acquire images of the sky for calibration purposes while communicating directly with Earth using the high-gain antenna. Plans also called for Spirit to use the Mössbauer for 12 hours of analysis of Montalva, heat up the electronics inside the panoramic camera, and acquire images of the Phobos transit with the panoramic camera.

Sol 1078 (Jan. 14, 2007): Plans called for Spirit to scan the sky for clouds using the navigation camera, study a target known as "Svarthammaren," and survey the sky and ground during the Phobos transit at 1:45 p.m. local solar time using the miniature thermal emission spectrometer. The rover was to survey targets known as "Sejong" and "Amery" and search the sky for clouds again the following morning using the navigation camera.

Odometry:

As of sol 1075 (Jan. 11, 2006), Spirit's total odometry was 6,895 meters (4.28 miles).

sol 1063-1069, January 05, 2007: *Martian Weather Delays Travel Plans*

The dust storm season has apparently arrived at Gusev, causing delays in Spirit's fourth Earth year of exploring the Red Planet. Spirit spent most of the holiday season of 2006 and 2007 keeping an eye on the sky, measuring atmospheric dust that could prevent sunlight from reaching the rover's solar panels.

During the past week, atmospheric dust levels have been typical for this time of year on Mars, measuring about 1 on the scale used by the rover. The rover estimates dust levels by measuring opacity -- the degree to which the atmosphere is impenetrable by light. This value is known as tau and varies on a continuous scale from 0 on up. During most of Spirit's mission on Mars, tau values have fallen between 0 and 1. Values between 1 and 2 can greatly limit the activities the rover can perform. Values of 2 or greater could be fatal.

In addition to measuring atmospheric dust, Spirit continued to watch for dust devils and successfully retested step No. 3 of new computer smarts that will enable the rover to autonomously place scientific instruments of the rover's robotic arm onto a target of scientific interest. During the test, Spirit was able to take images of the workspace, unstow the arm, and plan a path of approach for reaching a target.

Next up for Spirit will be an attempt to approach and conduct scientific analysis of a layered rock exposure known as "Montalva," part of a larger outcrop known as "Troll."

Sol-by-sol summary:

In addition to daily observations that included measuring atmospheric dust with the panoramic camera, searching for clouds with the navigation camera, scanning the sky and ground with the miniature thermal emission spectrometer, and imaging the sky with the panoramic camera, Spirit completed the following activities.

Sol 1063 (Dec. 29, 2006): After completing a short drive the previous day to a north-facing slope that tilted the rover's solar panels toward the sun, Spirit monitored atmospheric dust, acquired panoramic camera images of a place (called "Desolacion") where the rover's tracks cross each other, surveyed the Martian horizon with the panoramic camera, and monitored dust accumulation on the rover mast.

Sol 1064: Spirit monitored atmospheric dust and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1065: Spirit monitored atmospheric dust.

Sol 1066: Spirit monitored atmospheric dust.

Sol 1067: Spirit monitored atmospheric dust and searched for dust devils by acquiring successive navigation camera images that could be made into a movie.

Sol 1068 (Third Earth-year anniversary of Spirit's landing): Spirit monitored atmospheric dust, surveyed surrounding rocks with the panoramic camera, acquired full-color images of Desolacion with the panoramic camera, and retested step No. 3 of the robotic arm

autonomous placement code.

Sol 1069 (Jan. 5, 2006): Plans called for Spirit to approach Montalva, acquire full-color panoramic camera images of a spongy-looking lava rock known as "Esperanza," and acquire panoramic camera images of Montalva and another layered rock exposure known as "Riquelme."

Odometry:

As of sol 1062 (Dec. 28, 2006), Spirit's total odometry was 6,891.34 meters (4.28 miles)

sol 1058-1062, January 02, 2007: *Spirit Rests During Dust Storm*

A sudden dust storm cut short Spirit's investigation of a volcanic rock and kicked enough dust into the Martian atmosphere to drive solar power levels to an all-time low. Spirit's team of scientists and engineers decided to move the rover to a spot where the solar panels would be tilted toward the sun to increase the amount of electrical power available.

The southern hemisphere dust storm lowered power levels to 267 watt-hours on Spirit's 1,061st sol, or Martian day, of exploring Mars (Dec. 27, 2006). Spirit had been using its Mössbauer spectrometer to analyze the mineral composition of a rock nicknamed "Esperanza," a piece of lava full of tiny holes and known as vesicular basalt. Due to concern about low power, the team prepared to drive Spirit to a north-tilted spot on the way toward a new target, a layered outcrop known as "Troll."

Spirit spent the New Year's weekend in one place, monitoring dust and actually resting on a holiday.

Sol-by-sol summary:

Sol 1058 (Dec. 24, 2006): Spirit completed 4 hours and 42 minutes of analysis of a target known as "Palma" on the rock Esperanza using the Mössbauer spectrometer. The rover tested Step No. 2 of a software program to watch for dust devils and studied a target known as "Boudouin" with the miniature thermal emission spectrometer.

Sol 1059: Spirit spent an additional 3 hours and 48 minutes collecting information about Palma with the Mössbauer spectrometer, scanned rock outcrops known as "Gurruchaga" and "Oberth" with the miniature thermal emission spectrometer, and acquired super-resolution images of a rock target known as "Molodezhnaya."

Sol 1060: Spirit acquired an additional 4 hours and 47 minutes worth of Mössbauer spectrometer data from Palma and surveyed the Martian horizon with the panoramic camera.

Sol 1061: Spirit completed 3.5 hours of Mössbauer spectrometer analysis of Palma, bringing the total number of hours spent collecting data about the rock to 25. Spirit then acquired data from a rock target known as "Scott_Base" with the miniature thermal emission spectrometer and acquired a full-color image of a soil target known as "Tyrone" using all 13 filters of the panoramic camera.

Sol 1062 (Dec. 28, 2006): The team prepared to send Spirit driving about 4 meters (13 feet) to a shallow slope selected because it would tilt the rover's solar arrays toward the sun, which was still fairly low above the northern horizon and dimmed by atmospheric dust.

Odometry:

On sol 1062 (Dec. 28, 2006), Spirit's total odometry reached 6,891.34 meters (4.28 miles).

sol 1051-1057, December 22, 2006: *Spirit Tests New Computer Smarts, Studies Rocks and Terrain*

Spirit is healthy and conducting scientific analysis of a rock target known as "Palma." During the past week, Spirit tested some new software sequences, including a "watch for dust devil" command and an automatic placement command.

On the rover's 1052nd Martian day, or sol, of exploring Mars (Dec. 18, 2006), Spirit ran part of the dust devil watch, acquiring six images during the process, but did not run the dust-devil detection part of the program. Rover handlers planned to rerun the test on sol 1058 (Dec. 24, 2006).

On sol 1053 (Dec. 19, 2006), Spirit terminated a test run of a command sequence for autonomous placement of the rover's robotic arm on a scientific target. The sequence involved touching a target with the Mössbauer spectrometer, changing tools to the microscopic imager and suspending it 10 centimeters (4 inches) above the target, changing tools to the alpha-particle X-ray spectrometer, and placing the alpha-particle X-ray spectrometer on the target. Spirit made preparations to run the test again on a new target on the same day that some Earthlings celebrate as Christmas Eve.

Sol-by-sol summary:

Sol 1051 (Dec. 17, 2006): Spirit turned to face a rock outcrop known as "Esperanza," acquired images with the hazard avoidance cameras and a 360-degree panorama with the panoramic camera, and scanned the sky for clouds with the navigation camera. The rover measured atmospheric dust, looked at the sky, examined the terrain, and completed a survey of individual rock grains, known as clasts, using the panoramic camera.

Sol 1052: Spirit conducted step No. 2 of the new capability to watch for dust devils and scanned the sky for clouds with the navigation camera.

Sol 1053: Spirit acquired microscopic images of Palma, conducted step No. 2 of the autonomous placement test, monitored dust in the atmosphere with the panoramic camera, scanned the sky and ground with the miniature thermal emission spectrometer, scanned the sky for clouds with the navigation camera, and monitored the rover mast for dust accumulation.

Sol 1054: Spirit scanned the sky and ground with the miniature thermal emission spectrometer and collected miniature thermal emission spectrometer data from a ground target known as "Melchior." The rover continued to measure atmospheric dust opacity and take images of the sky with the panoramic camera.

Sol 1055 (Dec. 21, 2006): Because the rover was not stationed at the appropriate distance from the target for the automatic placement test, Spirit prepared to run the test with the alpha-particle X-ray spectrometer a second time, followed by six hours of measurement with the instrument. Spirit was slated to scan the sky, ground, and a target known as "Druzhnaya" using the miniature thermal emission spectrometer as well as acquire frames for a dust devil movie.

Sol 1056: Plans called for four hours of analysis of Palma using the Mössbauer spectrometer, measurements of atmospheric dust with the panoramic camera, a check for changes over time in the miniature thermal emission spectrometer, and a scan of the ground and sky at various elevations using the miniature thermal emission spectrometer. Spirit was also to acquire panoramic camera and stereo images of a rock nicknamed "Orcadas."

Sol 1057 (Dec. 23, 2006): Plans called for Spirit to conduct an additional 3.5 hours of study of Palma using the Mössbauer spectrometer, measure atmospheric dust with the panoramic camera, check for drift (changes in time) in the miniature thermal emission spectrometer, scan the sky and ground with the miniature thermal emission spectrometer, check the calibration target of the same instrument, and use it to scan a rock target known as "Gueslaga."

Odometry:

As of sol 1054 (Dec. 20, 2006), Spirit's total odometry was 6,886.80 meters (4.28 miles).

sol 1043-1050, December 18, 2006: *Relay Link Restored After Orbiter's Recovery*

After Spirit drove on sol 1041 (Dec. 7, 2006), NASA's Mars Odyssey orbiter went into safe mode before the rover's could relay data to Earth about results of the drive. (Safe mode is a protective state during which only the systems essential to spacecraft health continue operating. This incident of Odyssey temporarily going into safe mode has been attributed to a burst of solar activity.) Since the rover team didn't have current information about Spirit's position and state, the rover spent eight successive Martian days, or sols, collecting untargeted remote sensing data.

Data transmission directly to Earth from Spirit on sol 1046 (Dec. 12, 2006) confirmed that Spirit was healthy. Odyssey recovered the following day and resumed relaying data from Spirit, transmitted from the rover to the orbiter in the UHF radio band.

Sol-by-sol summary:

Sol 1043 (Dec. 9, 2006): Spirit surveyed the rover's tracks using the miniature thermal emission spectrometer and measured atmospheric dust opacity with the panoramic camera. The rover surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 1044: Spirit surveyed the area where the rover spent the past Martian winter with the miniature thermal emission spectrometer and took panoramic camera images of the area.

Sol 1045: Spirit took thumbnail images of the sky with the panoramic camera and scanned the sky for clouds with the navigation camera. Spirit monitored the rover mast for dust and relayed the first bits of scientific data collected and stored on sol 1040 (Dec. 6, 2006).

Sol 1046: Spirit surveyed the rover's winter haven with the miniature thermal emission spectrometer and monitored atmospheric dust with the panoramic camera. The rover scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 1047: Spirit collected miniature thermal emission spectrometer data from a soil target known as "Tyrone" and continued acquiring panoramic camera images of the rover's winter haven.

Sol 1048: Spirit acquired thumbnail images of the sky with the panoramic camera and scanned the sky for clouds with the navigation camera. The rover monitored atmospheric dust with the panoramic camera, and surveyed the sky, ground, and calibration target with the miniature thermal emission spectrometer.

Sol 1049: Spirit acquired navigation camera images in support of miniature thermal emission spectrometer measurements of the rover's surroundings. The rover monitored atmospheric dust with the panoramic camera and acquired panoramic images of the area ahead.

Sol 1050 (Dec. 16, 2006): Spirit's instructions call for scanning for clouds and dust devils with the navigation camera, surveying the mast for dust accumulation and observing the sky and ground with the miniature thermal emission spectrometer.

Odometry:

As of sol 1048 (Dec. 14, 2006), Spirit's total odometry was 6,885.62 meters (4.28 miles).

sol 1039-1042, December 08, 2006: *Spirit Slowly Resumes Driving on Martian Terrain*

Despite a non-functioning right front wheel, Spirit is healthy and on the move. The rover completed short drives on Martian days, or sols, 1039 (Dec. 5, 2006) and 1041 (Dec. 7, 2006) on its way toward a rock target informally named "Esperanza."

Sol-by-sol summary:

Sol 1039 (Dec. 5, 2006): Spirit drove 1 meter (3.3 feet) and acquired images after the drive using the hazard avoidance and navigation cameras. The rover took a super-resolution image with the panoramic camera and scanned the Martian sky for clouds with the

navigation camera.

Sol 1040: Spirit scanned the sky, ground, and Esperanza using the miniature thermal emission spectrometer. The rover surveyed the sky and the horizon with the panoramic camera.

Sol 1041: Spirit turned in the direction of Esperanza, then drove another 1.5 meters (5 feet) toward the rock. Spirit acquired more detailed images after the drive with the hazard avoidance camera and a 360-degree view of the rover's surroundings with the navigation camera. The rover searched the sky for clouds with the navigation camera and took panoramic images of the "El Dorado" dune field and the Martian sky.

Sol 1042 (Dec. 8, 2006): Spirit panoramic camera took images for a full-color, 13-filter mosaic of the area studied by the rover during the last Martian winter. Spirit also scanned the area with the miniature thermal emission spectrometer.

Odometry:

As of sol 1039 (Dec. 5, 2006), Spirit's total odometry was 6,880.86 meters (4.28 miles).

sol 1024-1038, December 05, 2006: *Spirit Slowly Begins Driving Again*

Spirit is healthy and preparing to drive away from the rover's winter station after completing scientific investigation of a rock nicknamed "King George Island." The rock, according to principal investigator Steve Squyres, contains some of the best-rounded grains ever seen in a Martian rock. Scientists will try to determine how the grains formed -- perhaps with help from wind or water.

Spirit arrived at King George Island on Sol 1022 (Dec. 17, 2006) after a short bump (very short drive) from a disturbed soil target nicknamed "Bear Island." Upon arrival, Spirit took a mosaic of microscopic images of King George and collected data using the alpha-particle X-ray and Mössbauer spectrometers. Spirit then brushed the target with the wire bristles on the rock abrasion tool before collecting more alpha-particle X-ray and Mössbauer data for comparison with data from the unbrushed surface.

Spirit's next planned target is a rock aptly nicknamed "Esperanza," the Spanish word for hope. The first of several drives to reach that goal began on Sol 1037 (Dec. 3, 2006). On Sol 1030 (Nov. 25, 2006), the Mars Reconnaissance Orbiter used its high-resolution camera to acquire images of Spirit's "Winter Haven," where the rover has spent its second Martian winter, and of Spirit's lander, which arrived on Mars Jan. 4, 2004.

Sol-by-sol summaries:

In addition to Spirit's daily science observations, which include measuring atmospheric dust opacity with the panoramic camera, surveying the sky and ground using the miniature thermal emission spectrometer, and scanning the Martian sky for clouds using the navigation camera, the Mars rover did the following work:

Sol 1024 (Nov. 19, 2006): Spirit collected data about the Martian atmosphere using the alpha-particle X-ray spectrometer and monitored dust accumulation on the panoramic camera mast.

Sol 1025: Spirit acquired super-resolution panoramic camera images of the circular plateau-like feature known as "Home Plate" and measured the amount of light detectable at night and during Martian twilight.

Sol 1026: Spirit coordinated daily science observations with an overflight of the Mars Reconnaissance Orbiter. The rover measured surface reflectivity using the panoramic camera.

Sol 1027: Spirit acquired a mosaic of images of King George Island and collected data from the same rock target using the alpha-particle X-ray spectrometer.

Sol 1028: Spirit studied King George Island using the Mössbauer spectrometer.

Sol 1029: Spirit studied Esperanza and two other rock targets known as "Zhong Shan" and "Korolev" using the miniature thermal emission spectrometer.

Sol 1030: Spirit continued to assess King George Island using the Mössbauer spectrometer and investigated a distant rock outcrop known as "Oberth" using the miniature thermal emission spectrometer.

Sol 1031: Spirit brushed the surface of King George Island using the rock abrasion tool and acquired microscopic images and alpha-particle X-ray data of the freshly brushed surface.

Sol 1032: Spirit acquired Mössbauer data from the brushed surface of King George Island.

Sol 1033: Spirit acquired information about rock targets known as "Syowa" and "Wiltgen" using the miniature thermal emission spectrometer.

Sol 1034: Spirit collected microscopic images of two soil targets known as "Clarence" and "Deception" and recommenced analysis of the brushed surface of King George Island using the Mössbauer spectrometer.

Sol 1035: Spirit analyzed a spot on the same rock surface but offset from the target known as King George Island by acquiring microscopic images and collecting corresponding compositional data with the alpha particle X-ray spectrometer.

Sol 1036: Spirit acquired a 13-filter, full-color panorama of the soil target known as "Tyrone" and again analyzed Korolev and Esperanza from a distance using the miniature thermal emission spectrometer.

Sol 1037: Spirit stowed the robotic arm carrying scientific instruments and began driving toward Esperanza.

Sol 1038 (Dec. 4, 2006): Spirit tested new capabilities for automated placement of the robotic arm.

Odometry:

As of sol 1036 (Dec. 2, 2006), Spirit's total odometry was 6,877.63 meters (4.27 miles).

sol 1017-1023, December 04, 2006: *More Remote Science for Spirit*

Spirit is healthy. Downlink of information from the rover resumed after a 48-hour gap in downlink that resulted from NASA's Mars Odyssey releasing most of its Deep Space Network coverage earlier in the week to Mars Global Surveyor to support efforts to recover communications with Global Surveyor.

This week, Spirit changed robotic-arm targets from "Berkner Island" to "Bear Island" and executed a microscopic image mosaic, five hours of data collection with the alpha particle X-ray spectrometer and nearly 48 hours with the Mössbauer spectrometer. The engineering team planned and commanded Spirit's second drive of the season on sol 1022.

Sol-by-sol summaries:

Sol 1017 (Nov. 12, 2006): Spirit used its microscopic imager to take exposures for a stereo mosaic of target Bear Island, then placed the alpha particle X-ray spectrometer on that target. After the Mars Odyssey pass, the rover took a tau (atmospheric clarity) measurement and then began a five-hour reading with the alpha particle X-ray spectrometer.

Sol 1018: The panoramic camera took thumbnail images of the sky, and the navigation camera scanned for clouds. The team changed tools to the Mössbauer spectrometer and used it for a 10-hour integration on Bear Island.

Sol 1019: In the morning, the miniature thermal emission spectrometer assessed the sky and ground, and the panoramic camera examined the sky. The miniature thermal emission spectrometer then stared at target "Baudoin." Some engineering maintenance was done and then the Mössbauer spectrometer was restarted on target Bear Island.

Sol 1020: In the morning, the miniature thermal emission spectrometer assessed the sky and ground, and the panoramic camera examined the sky. The rover restarted the Mössbauer data-collection on Bear Island for a 23-hour, overnight integration.

Sol 1021: Spirit's miniature thermal emission spectrometer assessed light-toned material in the rover's tracks in the morning. The Mössbauer spectrometer was restarted on Bear Island. The panoramic camera conducted a light experiment by taking multiple images throughout the day. The miniature thermal emission spectrometer assessed target "Allan Hills" during the communications pass with Mars Odyssey. After the Odyssey pass, the Mössbauer observation was completed and the panoramic camera took a tau measurement at sunset.

Sol 1022: Spirit's arm was stowed before the rover began a short drive to a nearby outcrop. After the drive the navigation and hazard avoidance cameras took images. A tau measurement was taken as well.

Sol 1023 (Nov. 28): The panoramic camera took images of targets "El Dorado" and "Prat" as well as thumbnail images of the sky. The miniature thermal emission spectrometer conducted a sky and ground observation.

Odometry:

As of sol 1023, Spirit's odometry is 6,877.63 meters (4.27 miles).

sol 1013-1016, November 13, 2006: *Spirit's 'Arm' Busy Checking New Targets*

After Spirit's successful 0.71-meter (28-inch) bump on sol 1010, the team has new targets in the robotic arm's work volume for the first time in 204 sols. There is some interesting light and dark material within arm's reach and this week the team planned a robotic arm campaign including a microscopic imager mosaic, four hours of alpha particle X-ray spectrometer integration and 43 hours of Mössbauer spectrometer integration. Spirit is receiving a little over 320 Watt-hours now and is able to occasionally use the Mössbauer or alpha particle X-ray spectrometer overnight.

Sol-by-sol summary:

Sol 1013 (Nov. 8, 2006): This sol began with the usual engineering block tau (atmospheric clarity) measurement, then a calibration of the miniature thermal emission spectrometer before that instrument was used to stare at the sky and ground. Spirit then used its front hazard avoidance cameras to look at the robotic arm's work volume, then unstowed the arm and took a stereo microscopic image of target "Berkner Island." The rover then placed the alpha particle X-ray spectrometer on Berkner Island and integrated for four hours. Spirit used its miniature thermal emission spectrometer to stare at target "Davis" during the afternoon when NASA's Mars Odyssey spacecraft passed overhead.

Sol 1014: The rover changed tools to the Mössbauer spectrometer and integrated for 23 hours.

Sol 1015: During the morning of this sol, Spirit conducted dust monitoring of its panoramic camera mast assembly (its neck and head). The rover then restarted the Mössbauer on target Berkner Island for a 10-hour integration. A panoramic camera tau measurement and a miniature thermal emission spectrometer observation of sky and ground were conducted around the Odyssey pass.

Sol 1016: On this sol, Spirit took images with its navigation camera. It then restarted the Mössbauer spectrometer on Berkner Island for a 10-hour integration. Total integration time is 43 hours at this target. The rover then conducted a panoramic camera sky observation.

Odometry:

As of sol 1016 (Nov. 11, 2006), Spirit's odometry is 6,876.89 meters (4.27 miles).

sol 1006-1012, November 07, 2006: *Spirit Passes 1000 Sols and Continues its Winter Campaign*

Spirit is healthy and is starting to stir from its winter resting spot.

Sols 1006 through 1009 were spent working on winter campaign observations; Spirit is entering the final phase of these observations.

Sol 1010 saw Spirit stir from its winter resting spot with a 33-degree turn and a 0.71-meter (28-inch) bump. This was done so that Spirit could reach the bright soil pushed up by its right front wheel when the rover arrived here about 200 sols ago.

On Sol 1011 Spirit performed a coordinated experiment with NASA's Mars Reconnaissance Orbiter. This test was performed to characterize performance of the orbiter's UHF Electra radio. Mars Reconnaissance Orbiter will provide data relay services for NASA's Phoenix Mars Lander, which is scheduled to arrive at Mars in May 2008.

Sol-by-sol summary:

Sol 1006 (Nov. 1, 2006): Spirit assessed atmospheric clarity (a "tau" measurement) with its panoramic camera, calibrated its miniature thermal emission spectrometer and then used that instrument to stare at the sky and ground. The rover's microscopic imager was used to image the rover's magnet array and a solar panel. During the communication window with NASA's Mars Odyssey, the rover again used the miniature thermal emission spectrometer to look at the sky and ground. After the Odyssey pass, the panoramic camera imaged the sunset.

Sol 1007: In the morning of this sol, Spirit's miniature thermal emission spectrometer measured a dust spot. A tau measurement was taken by the panoramic camera and the miniature thermal emission spectrometer checked out the sky and ground. The microscopic imager took images for stereo mosaics and the miniature thermal emission spectrometer was calibrated.

Sol 1008: This morning Spirit used its navigation camera to look for clouds and then used its miniature thermal emission spectrometer to look at the sky and ground. The rover then used its panoramic camera to do a tau measurement before the miniature thermal emission spectrometer was used again. The microscopic imager was then used on targets "Palmer" and "Mawson." The arm was stowed and then the panoramic camera did a light check before it imaged the sunset.

Sol 1009: Spirit used its navigation camera this morning to look for clouds and then took thumbnail images of the sky with its panoramic camera. The panoramic camera also surveyed the horizon. The miniature thermal emission spectrometer completed a sky and ground observation before the Odyssey pass. During the communication window with Odyssey, the spectrometer stared at target "Casey Station." After the Odyssey pass the rover did a tau measurement with the panoramic camera and began to use the alpha particle X-ray spectrometer on "Argon."

Sol 1010: During the morning of this sol, Spirit used its panoramic camera to image "El Dorado." The hazard avoidance cameras were aimed at some fine ripples to assess them. The miniature thermal emission spectrometer stared at some Martian dust and the panoramic camera assessed the atmosphere. Again, the miniature thermal emission spectrometer was used to stare at the sky and ground. The rover was commanded to do a "bump," or very short movement. Post-bump images were taken with the navigation camera and the hazard avoidance cameras.

Sol 1011: Spirit used its panoramic camera to have a look at the sky before it began to take a large panoramic image. The miniature thermal emission spectrometer was used to look at the sky and ground before Spirit interacted with its Martian partner overhead, the Mars Reconnaissance Orbiter.

Sol 1012 (Nov. 7, 2006): On this sol, the panoramic camera was used to finish the panorama it began "yestersol." The panoramic camera took a tau measurement before the miniature thermal emission spectrometer had a look at the sky and ground.

Odometry:

As of sol 1010 (Nov. 5, 2006), Spirit's total odometry is 6,976.89 meters (4.34 miles).

sol 982-987, October 16, 2006: *Approaching Solar Conjunction*

As Spirit enters a period known as solar conjunction, when the sun interferes with transmissions between Mars and Earth, mission planners sent a complete set of plans for science activities during solar conjunction to Spirit on the rover's 982nd sol, or Martian day, of exploring inside Gusev Crater (Oct. 7, 2006). During that time, the rover will achieve a new milestone: exploring Mars for 1,000 consecutive days.

Solar conjunction will begin on sol 991 (Oct. 16, 2006) and end on sol 1015 (Nov. 10, 2006). During this period, both NASA rovers, Spirit and Opportunity, will not receive any new command loads, but they will send daily downlinks to Earth, averaging 15 megabits of data per transmission. The data will be relayed to Earth via NASA's Mars Odyssey spacecraft in orbit above Mars.

Each day during conjunction, Spirit will spend 3 hours analyzing dust collected on the rover's filter magnet using the Mössbauer spectrometer and 24 minutes conducting a variety of early morning science observations. The morning science activities are designed to

monitor the atmosphere and to search for any possible surface changes. The workload will make optimum use of solar power levels available with the retreat of Martian winter.

Spirit is healthy and continues to make progress on the winter science campaign of experiments. The rover's solar energy levels continue to rise slowly. Solar power is currently about 300 watt-hours. One hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour.

Sol-by-sol summary:

Sol 982 (Oct. 7, 2006): Spirit measured atmospheric dust opacity with the panoramic camera and surveyed the sky, ground, and dark soil in the rover's tracks using the miniature thermal emission spectrometer. Spirit took panoramic camera images of the rover's tracks and analyzed rock targets known as "Gueslaga" and "Tor" with the miniature thermal emission spectrometer. The rover measured the brightness of the morning sky in the west using the panoramic camera.

Sol 983: Spirit measured atmospheric dust opacity with the panoramic camera and surveyed the sky, ground, and dark soil in the rover's tracks using the miniature thermal emission spectrometer. Spirit took a look at the elemental chemistry of the atmosphere with the alpha particle X-ray spectrometer. The rover acquired super-resolution panoramic camera images of a target called "Mitcheltree Ridgecrest 11."

Sol 984: Spirit measured atmospheric dust opacity with the panoramic camera and surveyed the sky, ground, and soil in the rover's tracks using the miniature thermal emission spectrometer. Spirit analyzed a rock target dubbed "O'Higgins" with the miniature thermal emission spectrometer and referenced instrument measurements to the calibration target on the rover. The rover scanned the sky for clouds with the navigation camera, measured morning sky brightness with the panoramic camera, and monitored dust on the panoramic camera mast assembly.

Sol 985: Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and restarted analysis of dust collected by the filter magnets using the Mössbauer spectrometer. Spirit scanned the sky for clouds using the navigation camera and acquired thumbnail images of the sky with the panoramic camera.

Sol 986: Spirit measured atmospheric opacity using the panoramic camera, checked for drift (changes with time) in the miniature thermal emission spectrometer, and surveyed the sky and ground with the miniature thermal emission spectrometer. Spirit scanned the sky for clouds using the navigation camera and acquired thumbnail images of the sky with the panoramic camera.

Sol 987 (Oct. 12, 2006): Spirit measured atmospheric dust opacity using the panoramic camera, checked for drift in the miniature thermal emission spectrometer, and surveyed the sky and ground with the miniature thermal emission spectrometer. The rover restarted Mössbauer analysis of dust on the filter magnets. Spirit surveyed the sky during high sun using the panoramic camera.

Odometry:

As of sol 986 (Oct. 11, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 977-981, October 13, 2006: *Spirit Studies Layers of Volcanic Rock*

Spirit is healthy and continues to make progress on a winter science campaign of experiments.

In parallel with normal planning, a special team has been developing plans to be executed during solar conjunction, when the sun obscures the line of sight between Earth and Mars and severely limits radio communication. Rover handlers will upload the plans to be executed by Spirit during solar conjunction prior to the beginning of conjunction. This year's solar conjunction period begins on the rover's 991st Martian day, or sol, (Oct. 16, 2006) and ends on sol 1005 (Oct. 30, 2006). Planning for future activities on sols 1006 and 1007 (Oct. 31 to Nov. 1, 2006) will resume Oct. 30.

Spirit continued to produce atmospheric profiles of dust, temperature at different heights, ice, and water vapor, as well as surface and sub-surface temperatures using the miniature thermal emission spectrometer. Plans also called for a scan of the sky for clouds, which, if found, could be incorporated into a multi-frame movie for observing cloud movement.

Spirit acquired super-resolution panoramic camera images of volcanic outcrops called "Marambio," "Jubany," and "Mitcheltree Ridge" on sols 979 and 981 (Oct. 4 and Oct. 6, 2006). The outcrops consist of basalt, a dense, dark rock that hardens from lava and often has a glassy appearance. These basalts were also vesicular, meaning they are porous because there were gas bubbles in the lava when it solidified.

The purpose of the super-resolution imaging campaign is to identify and map characteristics of the local geology. In particular, scientists hope to determine the relative stratigraphy of Mitcheltree Ridge, "Low Ridge," and the raised, circular plateau known as "Home Plate." Stratigraphy is the study of rock layers.

Spirit's solar energy levels continued to rise, ending the week at around 300 watt-hours. One hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour.

Sol-by-sol summary:

Sol 977 (Oct. 2, 2006): Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, used the Mössbauer spectrometer to analyze dust collected by the filter magnets, acquired panoramic camera images of the work volume accessible by the robotic arm, and collected images of the rover's tracks with the miniature thermal emission spectrometer.

Sol 978: Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and collected thermal data from targets known as "Casey Station" and "Sobral." The rover acquired super-resolution images of volcanic rock outcrops called Marambio and Jubany and measured morning sky brightness in the west with the panoramic camera.

Sol 979: Spirit measured atmospheric dust opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and restarted integration of data from the Mössbauer spectrometer's inspection of dust on the filter magnets. In addition, Spirit acquired morning images of the dune field known as "El Dorado" as well as images of the Martian horizon using the panoramic camera, measured morning sky brightness in the west with the panoramic camera, and scanned the sky for clouds using the navigation camera.

Sol 980: Spirit measured atmospheric dust opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, surveyed the sky with the panoramic camera, and acquired super-resolution images of Mitcheltree Ridge with the panoramic camera.

Sol 981 (Oct. 6, 2006): Spirit measured atmospheric dust opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, restarted integration of data from the filter magnets with the Mössbauer spectrometer, and acquired super-resolution panoramic camera images of the soil target known as "Tyrone."

Odometry:

As of sol 981 (Oct. 6, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 970-976, September 29, 2006: *Solar Power Is on the Rise as Spirit 'Follows the Water'*

Solar power levels on Spirit are slowly beginning to rise again following a winter low of 275 watt-hours on Martian day, or sol, 933 (Aug. 18, 2006). One hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour. This week, the rover's power levels rose to about 296 watt-hours.

Spirit spent much of the week analyzing atmospheric dust attracted to magnets on the spacecraft. The rover identifies iron minerals in the dust using the Mössbauer spectrometer. One of the two magnets, the filter magnet, is weaker than the capture magnet, allowing scientists to separate mineral grains that have the highest magnetic susceptibility, particularly minerals that contain iron.

During the week, Spirit studied rock targets known as "Juan Carlos," "Gueslaga," and "Tor" using the miniature thermal emission spectrometer. Juan Carlos and Tor are vesicular rocks filled with tiny holes that formed during the cooling of a froth of magma and gas. Scientists hope to determine whether these rocks are similar to or different from nearby smooth-textured volcanic rocks known as basalts. Gueslaga, meanwhile, is an entirely different kind of rock known as an "exotic," meaning it came from somewhere else and may have been emplaced during an impact event.

Spirit continued to make scientific observations of the soil target known as "Tyrone." Tyrone is a patch of bright material, white and yellow in color, that is possibly analogous to salty soils examined earlier in the mission known as "Arad" and "Paso Robles." Spirit's dragging right front wheel churned up the bright material on the rover's 784th sol of exploration of Mars (March 18, 2006). Some science team members have speculated that some component in this material is hydrated. If moisture enters or leaves the material, the miniature thermal emission spectrometer would be able to detect it. Scientists are also monitoring the soil with the rover's panoramic camera for any color changes, because variability in water content could affect the color. These observations are ongoing to account for seasonal variability.

The rover continues to operate successfully with the new flight software package.

Sol-by-sol summaries:

Sol 970 (Sept. 25, 2006): Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, analyzed dust on the filter magnet with the Mössbauer spectrometer, acquired morning images of the spacecraft deck with the panoramic camera, and scanned the sky for clouds with the navigation camera.

Sol 971: Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, collected data from the rock target known as Juan Carlos, and surveyed the horizon using the panoramic camera.

Sol 972: Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, restarted integration of data from the filter magnets with the Mössbauer spectrometer, acquired panoramic camera images of the work volume accessible by the robotic arm, and measured morning sky brightness in the west with the panoramic camera.

Sol 973: Spirit measured atmospheric opacity using the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, studied the rock targets Gueslaga and Tor using the miniature thermal emission spectrometer, and used the panoramic camera to take images of rover tracks and measure morning sky brightness in the west.

Sol 974: Plans called for Spirit to measure atmospheric opacity using the panoramic camera, survey the sky and ground with the miniature thermal emission spectrometer, restart integration of data from the filter magnets with the Mössbauer spectrometer, survey the sky and ground with the miniature thermal emission spectrometer, scan the sky for clouds, measure morning sky brightness, and take a morning measurement of dust on the panoramic camera mast assembly with the miniature thermal emission spectrometer.

Sol 975: Plans called for Spirit to measure atmospheric opacity using the panoramic camera, survey the sky and ground with the miniature thermal emission spectrometer, and acquire morning images of the rover's tracks with all 13 filters of the panoramic camera.

Sol 976 (Oct. 1, 2006): Plans called for Spirit to measure atmospheric opacity using the panoramic camera, survey the sky and ground using the miniature thermal emission spectrometer, continue analysis of dust on the filter magnets with the Mössbauer spectrometer, and complete a morning sky survey with the panoramic camera.

Odometry:

As of sol 973 (Sept. 28, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 964-969, September 22, 2006: *Spirit Activates New Software*

Following some dramatic scrambling by rover handlers to command both Mars Exploration Rovers to switch to new flight software during a bit of a traffic jam at the Red Planet, Spirit successfully woke up and began operating with the new software. The X-band frequency for communicating directly with Earth had become unavailable while being used by NASA's Mars Reconnaissance Orbiter during critical events for that mission. As in the past, engineers were able to use the UHF-band frequency to relay commands indirectly to the rovers via NASA's Mars Odyssey orbiter. Time was of the essence in order to begin running and testing the new software before solar conjunction in October, when Mars will be on the opposite side of the sun from Earth and radio communication will be intermittent for a couple of weeks.

The new software gives the rover enhanced autonomous operational capabilities to be tested in coming months.

Sol-by-sol summary:

Sol 964 (Sept. 19, 2006): Spirit halted operations temporarily while awaiting instructions from Earth. Rover handlers originally planned to have the rover reboot using the new flight software by sending a command over the X-band uplink. The X-band became unavailable when it was needed by the Mars Reconnaissance Orbiter. The team sent the reboot command via the UHF-band antenna on the Odyssey orbiter later the same day.

Sol 965: At 11 a.m. local solar time on Mars, Spirit woke up for the first time running the new flight software, known as version R9.2. Later the same sol, or Martian day, Spirit ran a series of engineering sequences to establish operating parameters for data products and imaging.

Sol 966: Spirit set operating parameters for driving and operating the rover's robotic arm. The rover measured atmospheric dust using the panoramic camera.

Sol 967: Plans called for Spirit to continue to test the new software. Science activities remained light as the uplink team waited for both Spirit and Spirit's twin, Opportunity, on the other side of Mars, to reboot using the new software.

Sol 968: Plans called for Spirit to return to relatively normal science operations without moving the robotic arm, while team members awaited confirmation that the rover had established the correct operating parameters for the arm. Spirit was to complete 5 hours of analysis of dust on the rover's capture magnet using the alpha particle X-ray spectrometer.

Sol 969 (Sept. 24, 2006): Plans called for Spirit to measure surface reflectivity with the panoramic camera, measure atmospheric dust, and complete a morning scan of the sky and ground with the miniature thermal emission spectrometer, followed by similar observations in the afternoon. Spirit was also instructed to measure sky brightness, check for changes over time in the panoramic camera, and study a soil target known as "Tyrone" with the miniature thermal emission spectrometer.

Odometry:

As of sol 965 (Sept. 20, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 957-963, September 14, 2006: *The Martian Sun Also Rises as Winter Retreats*

Spirit is beginning to see an upward trend in electrical power as winter slowly recedes and the sun ascends higher in the sky each day. Electrical power from the rover's solar array rose to 287 watt-hours on the rover's 958th Martian day, or sol (Sept. 12, 2006) of exploration, compared with 277 watt-hours on sol 944 (Aug. 29, 2006). One hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour.

During the past week, Spirit conducted 10 hours of analysis of the elemental composition of dust on the rover's magnets using the alpha particle X-ray spectrometer. Spirit also finished taking images of the spacecraft deck.

Sol-by-sol summaries:

Sol 957 (Sept. 11, 2006): Spirit continues to complete the same set of observations each sol in parallel with engineering activities such as data management. The engineering block of activities includes monitoring atmospheric dust with the panoramic camera, and surveying the sky and ground with the miniature thermal emission spectrometer. On this particular sol, Spirit demonstrated additional multi-tasking abilities by acquiring data on a rock target known as "Vostok" using the miniature thermal emission spectrometer while transmitting data to the Odyssey spacecraft as it passed overhead.

Sol 958: Spirit acquired part 13 of the 15-part image mosaic of the spacecraft deck with the panoramic camera. Spirit spent about five hours acquiring data on the elemental composition of dust on the rover's filter magnets using the alpha particle X-ray spectrometer.

Sol 959: Spirit acquired panoramic camera images of a soil target consisting of bright material in the rover's tracks known as "Tyrone."

Sol 960: Plans called for Spirit to continue to acquire panoramic images of the rover deck, restart the alpha particle X-ray spectrometer following the overhead pass of the Odyssey spacecraft, and spend 4 hours and 50 minutes collecting elemental data of dust on the filter magnets. Plans also called for a morning measurement of sky brightness in the west with the panoramic camera (known as a pancam skyspot), a search for clouds using the navigation camera, a horizon survey with the panoramic camera, imaging of the "El Dorado" dune field with the panoramic camera, and imaging of ripples with the rear hazard avoidance camera.

Sol 961: Plans called for Spirit to acquire data from a target known as "Macquarie" with the miniature thermal emission spectrometer, acquire data from the calibration target with the miniature thermal emission spectrometer, and search for clouds with the navigation camera.

Sol 962: Plans called for Spirit to acquire the last segment of the 15-part panoramic mosaic of the spacecraft deck and conduct a 4-hour and 35-minute alpha particle X-ray spectrometer analysis of the filter magnets. Plans also called for Spirit to acquire sky images with the panoramic camera and validate measurements of complete darkness by the panoramic camera.

Sol 963 (Sept. 18, 2006): Plans called for Spirit to acquire images of the rover's tracks with the navigation camera, take microscopic images of the filter and capture magnets, and place the alpha particle X-ray spectrometer on the capture magnet. Plans also called for the rover to acquire hazard avoidance camera images of the work volume reached by the rover's robotic arm, monitor dust on the panoramic camera mast assembly, survey the horizon with the panoramic camera, and search for morning clouds with the navigation camera.

Odometry:

As of sol 958 (Sept. 12, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 950-956, September 08, 2006: *Spirit Monitors Dust and Searches for Clouds*

Spirit is healthy and continues to make progress on the rover's winter science campaign. During the past week, Spirit continued filling in sections of the rover's deck as part of the "Deck Pan" mosaic of panoramic images.

Electrical power from the rover's solar array has continued to hold steady at approximately 280 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 950 (Sept. 4, 2006): Spirit collected images of the rover deck with the panoramic camera, checked the atmosphere for opacity caused by dust, and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 951: Spirit collected images of the rover deck with the panoramic camera, checked the atmosphere for opacity caused by dust, and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 952: Spirit collected images of the rover deck with the panoramic camera, checked the atmosphere for opacity caused by dust, and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 953: Plans called for Spirit to acquire images of the sun high in the sky and acquire data from rock targets known as "Primero" and "Castilla" using the miniature thermal emission spectrometer. Plans also included checking the atmosphere for opacity caused by dust and scanning the sky and ground with the miniature thermal emission spectrometer.

Sol 954: Plans called for Spirit to acquire panoramic camera images of the capture and filter magnets (two dust-collecting magnets on the rover deck), search for clouds using the navigation camera, check the atmosphere for opacity caused by dust, and scan the sky and ground with the miniature thermal emission spectrometer.

Sol 955: Plans called for Spirit to acquire images of the rover deck, microscopic images of the capture magnet, and miniature thermal emission spectrometer data on a rock target known as "Signy." The rover was also slated to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 956 (Sept. 11, 2006): Plans called for Spirit to collect images of the rover deck with the panoramic camera and microscopic images of the filter magnet, as well as make the usual daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Odometry:

As of sol 952 (Sept. 6, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 943-949, September 05, 2006: *Spirit Recovers from Software Reset, Makes Finishing Touches to Winter Panorama*

Spirit experienced a software reset during the evening overpass of the Odyssey orbiter on sol 944 (Aug. 29, 2006). The rover was in the process of receiving command sequences for the following two Martian days, sols 945 and 946 (Aug. 30-31, 2006). As a result of the reset, the rover went into automode, meaning the rover did not attempt to execute a master sequence of activities for the day. The apparent cause was that the rover's central processing unit was overworked as several tasks were running in parallel at the time. Engineers transmitted a new, abbreviated plan of activities on sol 946 along with the plan of activities for sol 947 (Sept. 1, 2006).

Spirit is healthy and continues to make progress on the rover's winter science campaign. The rover spent part of the week filling in sections of the rover deck for the "McMurdo panorama." Electrical power from the rover's solar array has been holding steady at about 280 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 943 (Aug. 28, 2006): Spirit acquired sky images with the navigation camera. The rover scanned the atmosphere for opacity caused by dust and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 944: Spirit acquired microscopic images of the soil target known as "Halley Brunt." Spirit scanned the atmosphere for opacity caused by dust and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 945: Spirit experienced a software reset and went into automode, meaning the rover did not attempt to execute a master sequence of activities for the day. The apparent cause was that the rover's central processing unit was overworked.

Sol 946: Spirit remained in automode. Engineers transmitted an abbreviated plan of activities for the sol along with the plan of activities for sol 947.

Sol 947: Plans called for Spirit to acquire fill-in images for the McMurdo panorama and to continue to make daily observations of the sky and ground with the panoramic camera and the miniature thermal emission spectrometer.

Sol 948: Plans called for Spirit to acquire Mössbauer data on the soil target called "Halley Brunt" and to continue to make daily observations of the sky and ground with the panoramic camera and the miniature thermal emission spectrometer.

Sol 949 (Sept. 3, 2006): Plans called for the rover to acquire fill-in frames for the McMurdo panorama and to continue to make daily observations of the sky and ground with the panoramic camera and the miniature thermal emission spectrometer.

Odometry:

As of sol 945 (Aug. 30, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 933-942, August 25, 2006: *Spirit Continues Mid-Winter Studies of Martian Rocks and Soil*

Spirit continued to make progress on the rover's winter campaign of science observations, acquiring microscopic images and data about rock composition with the alpha particle X-ray spectrometer and the miniature thermal emission spectrometer. Spirit took images of the spacecraft deck for incorporation into the "McMurdo panorama."

Spirit remains healthy. Electrical power from the rover's solar array has been holding steady at about 280 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 933 (Aug. 18, 2006): Spirit acquired super-resolution images of a basalt hill nicknamed "Dome Fuji" with the panoramic camera and monitored dust on the pancam mast assembly. Spirit scanned the atmosphere for opacity caused by dust and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 934: Spirit acquired touch-up images for the McMurdo panorama with the panoramic camera. Spirit scanned the atmosphere for opacity caused by dust and scanned the sky and ground with the miniature thermal emission spectrometer.

Sol 935: Spirit acquired panoramic camera images of a rock target called "Prat" and measured the magnitude of sunlight in addition to scanning the horizon and sky with the panoramic camera and miniature thermal emission spectrometer.

Sol 936: Spirit acquired data from a rock target called "Wasa" with the miniature thermal spectrometer. The rover continued to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 937: Spirit acquired microscopic images of a ripple called "Palmer" and scanned for wind-related changes in a sand target known as "Rothera." Spirit continued to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 938: Spirit acquired super-resolution, panoramic camera images of a possible meteorite candidate known as "Vernadsky." The rover continued to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 939: Spirit acquired super-resolution, panoramic camera images of a target known as "Scott Base." Spirit continued to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 940: Plans called for Spirit to acquire images of the rover deck with the panoramic camera and acquire miniature thermal emission spectrometer data on a rock target known as "Law-Racovita." Plans called for continued daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 941: Plans called for Spirit to acquire panoramic camera images of the rover deck as well as continue to make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Sol 942 (Aug. 27, 2006): Plans called for Spirit to continue acquiring panoramic camera images of the rover deck, collect data about elemental composition of the rock target called "Halley Brunt," and make daily observations of the sky and ground with the panoramic camera and miniature thermal emission spectrometer.

Odometry:

As of sol 938 (Aug. 23, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 929-932, August 18, 2006: *Spirit Checking 'Korolev'*

Spirit is healthy and continues to make progress on its winter science campaign.

Spirit is finishing the "McMurdo mega-panorama" by acquiring touch-up images (dubbed "grout" by engineers). Spirit is nearly complete with the coverage of the ground around the rover.

Spirit continues making a series of atmospheric observations at the same time each day.

Spirit is collecting about 280 watt-hours of electrical power each sol from the rover's solar array (100 watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 929 (Aug. 14, 2006): Spirit studied a target called "Halley Brunt" with the panoramic camera and microscopic imager.

Sol 930: Spirit took a tau measurement, an observation during which the rover evaluates atmospheric opacity to estimate dust height.

Sol 931: Spirit took pictures with the panoramic camera of targets named "Korolev" and "McMurdo grout 10." Spirit also used the panoramic camera to take a tau measurement.

Sol 932 (Aug. 17, 2006): Spirit took a tau measurement with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and took measurements of a target named "Vernadsky" along with a background stare with the miniature thermal emission spectrometer.

Odometry:

As of sol 932 (Aug. 17, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 922-928, August 11, 2006: *Spirit Survives Second Winter Solstice on Mars*

Spirit has now survived the rover's second Martian winter solstice -- the shortest day of the year with the least amount of sunlight and solar energy. The solstice arrived on the rover's 923rd Martian day, or sol (Aug. 8, 2006). Spirit is healthy and continues to make progress on its winter science campaign.

Having completed the "McMurdo mega-panorama," Spirit is currently filling cracks between frames by acquiring touch-up images (dubbed "grout" by engineers). The rover is also spending this week and next making a series of atmospheric observations at the same time each day.

Spirit continues to collect about 280 watt-hours of electrical power each sol from the rover's solar array (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 922 (Aug. 7, 2006): Spirit measured atmospheric dust opacity (known as a tau measurement) with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and acquired fill-in images with the panoramic camera for column 24A (a single frame) of the McMurdo pan.

Sol 923: Spirit took a tau measurement with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and acquired morning fill-in images for the McMurdo pan with the panoramic camera.

Sol 924: Spirit took a tau measurement with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and acquired panoramic camera images of the "El Dorado" dune field (a two-by-one mosaic). The rover acquired images of fine ripples with the hazard avoidance cameras and a rearward-looking view with the left eye of the right rear hazard avoidance camera. Spirit also acquired morning fill-in images for the McMurdo pan.

Sol 925: Spirit took a tau measurement with the panoramic camera, surveyed the sky and ground with the miniature thermal emission spectrometer, and acquired morning fill-in images for the McMurdo pan with the panoramic camera. Spirit also took a sunset tau measurement, an observation during which the rover evaluates atmospheric opacity at sunset to estimate dust height.

Sol 926: Plans called for Spirit to take a tau measurement with the panoramic camera, survey the sky and ground with the miniature thermal emission spectrometer, and acquire morning fill-in images for the McMurdo pan.

Sol 927: Plans called for Spirit to take a tau measurement with the panoramic camera, survey the sky and ground with the miniature thermal emission spectrometer, and acquire compositional data on a rock-and-soil target known as "Halley Brunt Offset 2" using the alpha particle X-ray spectrometer. Plans also called for Spirit to complete a morning sky survey using the panoramic camera.

Sol 928 (Aug. 13, 2006): Plans called for Spirit to take a tau measurement with the panoramic camera, survey the sky and ground with the miniature thermal emission spectrometer, and acquire morning fill-in images for the McMurdo pan.

Odometry:

As of sol 924 (Aug. 9, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 915-921, August 04, 2006: *Spirit Completes Camera Check-Up, Puts Finishing Touches on Panorama*

Spirit has finished acquiring images for the "McMurdo panorama" and began adding some finishing touches around the edges. The rover is healthy and continues to make progress on its winter science campaign of observations on Mars.

Plans called for Spirit to complete a winter check-up of all the rover's cameras by calibrating the microscopic imager. To accomplish this procedure, known as a photon transfer observation, Spirit acquired 20 pairs of images, each pair taken during a different exposure time. Engineers used these images to form a baseline for estimating unwanted electronic signals using a Poisson distribution.

The Poisson curve measures probability over a fixed time interval based on a known average. Using this probability, engineers correlated the signal measured by the camera with differences in signals acquired in the image pairs to calculate the efficiency with which the camera's imaging sensors convert photons from sunlight into electrical energy. They used the same approach to characterize the electrical system's ability to translate measurements of voltage into digital numbers.

Spirit is collecting about 280 watt-hours of electrical power each sol from the rover's solar array (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summary:

Sol 915 (July 30, 2006): Spirit acquired flat-field images for calibrating variations in the field of light in the McMurdo panorama.

Sol 916: Spirit surveyed the sky and ground using the miniature thermal emission spectrometer.

Sol 917: Spirit searched for clouds using the navigation camera.

Sol 918: Spirit added some finishing touches to the McMurdo panorama.

Sol 919: Spirit added more finishing touches to the McMurdo panorama.

Sol 920: Plans called for Spirit to conduct a photon transfer observation to measure electronic noise (unwanted signals) picked up by CCDs (charge-coupled devices -- imaging sensors that convert light into electrical current) in the microscopic imager.

Sol 921 (Aug 5, 2006): Plans called for Spirit to acquire panoramic camera images of a soil target known as "Tyrone."

Odometry

As of sol 918 (Aug. 2, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 908-914, July 29, 2006: *NASA's Spirit Rover Survives Record Cold on Mars*

Spirit remains healthy and continues to make progress on computer upgrades and scientific research, despite winter temperatures colder than any yet experienced during the rover's two and a half years on Mars. Models show that at the coldest part of the Martian night, around 5:00 a.m. Mars time, temperatures near the surface have dipped to approximately minus 97 degrees Celsius (minus 143 degrees Fahrenheit).

With the deepest part of the Martian winter just around the corner, Spirit is collecting about 284 watt-hours of electrical power each sol from the rover's solar array (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour). The shortest day, winter solstice in Mars' southern hemisphere, will arrive on Aug. 8, 2006. The lowest amount of solar energy the rover is expected to receive is about 275 watt-hours per sol.

Spirit has put the finishing touches on a new version of its flight software -- assembling, checking, and saving 200 sections of computer code transmitted from Earth in recent weeks. The software upgrade will give the rover enhanced autonomous operational capabilities. NASA plans for Spirit to switch from its current flight software to the new version in coming weeks.

Meanwhile, Spirit is only one frame away from completing the long-anticipated "McMurdo panorama," a full-color, 360-degree view of the rover's winter haven amid the "Columbia Hills" in Gusev Crater on Mars. The collection of images from the panoramic camera, as with all scientific data, has taken extra time to complete with the sun lower on the horizon and solar power levels on the wane. During the week, Spirit also used the microscopic imager to get a closer look at a small ripple nicknamed "Palmer."

For the next several weeks until Labor Day, Spirit will communicate with Earth only using UHF-band relay via NASA's Mars Odyssey orbiter. The X-band Spirit uses for communicating directly with Earth will not be available while that frequency is used intensively by NASA's Mars Reconnaissance Orbiter in the final stages of trimming its orbit around Mars.

Sol-by-sol summary:

Sol 908 (July 23, 2006): Spirit took microscopic images of Palmer.

Sol 909: Spirit continued work on the McMurdo panorama and used its miniature thermal emission spectrometer to study a rock target known as "Korolev2."

Sol 910: Spirit continued work on the McMurdo panorama and cleaned and calibrated the rock abrasion tool.

Sol 911: Spirit continued work on the McMurdo panorama and gathered remote-sensing information about a target known as "Druzhnaya."

Sol 912: Spirit continued work on the McMurdo panorama.

Sol 913: Spirit took microscopic images of a target known as "Palmer2."

Sol 914 (June 29, 2006): Plans call for Spirit to continue work on the McMurdo panorama.

Odometry

As of sol 911 (July 26, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 904-907, July 21, 2006: *Spirit Clears Away Dust, Gets New Software Upgrade*

Beginning July 22, 2006, in the early hours of the rover's 907th Martian day, Spirit is scheduled to begin knitting together and testing all 200 pieces of a new flight software package transmitted to the rover in recent weeks. Spirit remains healthy despite experiencing lower amounts of solar energy during the Martian winter.

The deepest part of the Martian winter - that is, the Martian winter solstice - will be on Aug. 8, 2006. The lowest amount of solar energy the rover is expected to receive is 275 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour). The rover typically spends at least one sol recharging the batteries following each sol of heavy science activities.

During sols 904 through 907, Spirit continued work on the "McMurdo panorama," examined rock target "Halley Brunt" with the microscopic imager, and took atmospheric measurements with the miniature thermal emission spectrometer.

Spirit also completed a test of the rock abrasion tool. Rover handlers ran the grind motor on the rock abrasion tool backward three times to remove a clod of dust that was thought to be interfering with the operation of the device. After running the motor backward for three seconds at three different voltages -- 5 volts, 8 volts, and 10 volts -- engineers concluded that the tool was operating normally and that it either never had a problem or dislodged whatever was stuck beneath the bit.

Sol-by-sol summary:

Sol 904 (July 19, 2006): Spirit monitored atmospheric dust with the panoramic camera and acquired a mosaic of microscopic images of a rock and soil target known as "Halley Brunt Offset1." The rover ran the rock abrasion tool backward to remove dust. In preparation for traversing and collecting data from a laminated patch of soil known as "Palmer," the rover suspended the Mössbauer spectrometer above the target and documented the position of the instrument with the hazard avoidance cameras. Spirit continued to make progress on the McMurdo mosaic, acquiring one frame of column 24.

Sol 905: Spirit monitored atmospheric dust with the panoramic camera, acquired another frame of column 24 of the McMurdo panorama, checked for drift (changes with time) in the pointing of the miniature thermal emission spectrometer, and surveyed the sky and ground with the miniature thermal emission spectrometer.

Sol 906: Commands for uplink on sol 906 call for Spirit to monitor atmospheric dust with the panoramic camera. The plan also includes Spirit's task for the morning of sol 907, before that morning's uplink. This task is for Spirit to build the rover's new flight software package, a process that entails assembling, validating, and saving many thousands of lines of computer code sent from Earth in small packages during the past few weeks.

Sol 907 (July 22, 2006): Plans called for Spirit to monitor atmospheric dust with the panoramic camera and check for drift (changes with time) in the pointing of the miniature thermal emission spectrometer. Spirit was also scheduled to conduct surveys of the sky and ground with the miniature thermal emission spectrometer and acquire the first frame of column 25 of the McMurdo pan.

Odometry

As of sol 904 (July 19, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 897-904, July 14, 2006: *Spirit to Get New Robotic Capabilities As Martian Winter Turns to Spring*

This week Spirit greeted the 900th day, or sol, of exploration on Mars. Spirit is healthy and continues to make science observations despite winter power limitations. One file of a new software upgrade remains to be transmitted to the rover. Rover handlers plan to have Spirit start using the new software sometime in mid-August. The upgrade will enable the rover to process images more quickly and focus on a single target more efficiently and, when solar power levels increase again, demonstrate new robotic autonomous capabilities.

While studying images from the panoramic and hazard avoidance cameras to characterize dirt buildup on the rock abrasion tool, science and engineering team members discovered a possible small clod of dirt lodged in the device. They are considering running the rock abrasion tool backward in an attempt to dislodge it.

Solar array input was down to about 280 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summary:

Sol 897 (July 12, 2006): Spirit acquired panoramic camera images of a rock believed to be a meteorite known as "Zhong Shan."

Sol 898: Spirit acquired panoramic camera images of a dark rock known as "Orcadas."

Sol 899: Spirit acquired images with the panoramic camera for the "McMurdo panorama."

Sol 900: Plans called for Spirit to monitor atmospheric dust with the panoramic camera.

Sol 901: Plans called for continued analysis of the soil target known as "Halley" with the alpha particle X-ray spectrometer.

Sol 902: Spirit was scheduled to collect more images for the McMurdo panorama.

Sol 903: Plans called for Spirit to recharge the batteries.

Sols 904 (July 19, 2006): Plans called for reverse operation of the rock abrasion tool to attempt to dislodge something that looks like a clod of dirt.

Odometry:

As of sol 898 (July 13, 2006), Spirit's total odometry was at 6,876.18 meters (4.27 miles).

sol 889-896, July 07, 2006: *Spirit Continues Work As Martian Days Grow Shorter*

Spirit has been busy receiving new flight software upgrades, both directly from Earth via the rover's high-gain antenna and indirectly via relay from NASA's Odyssey spacecraft. Engineers anticipated that all flight software upgrades would be on board the rover by early in the week of July 10, 2006.

Spirit also successfully completed a procedure to correct for drift in the inertial measurement unit, resulting in more accurate pointing of the miniature thermal emission spectrometer. Spirit remains healthy and continues to make progress on the rover's winter science campaign of experiments.

Spirit's handlers planned to have the rover spend part of the weekend calibrating the brush on the rock abrasion tool, using images from the panoramic camera and hazard avoidance cameras to characterize dirt buildup on the instrument.

Solar array input was down to about 290 watt-hours per sol (a hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour).

Sol-by-sol summaries:

Sol 889 (July 4, 2006): Spirit studied the rock target "Halley" with the Mössbauer spectrometer.

Sol 890: Spirit calibrated the elevation actuator (a motor that controls horizontal tilt) in the miniature thermal emission spectrometer.

Sol 891: Spirit made observations with the miniature thermal emission spectrometer.

Sol 892: Engineers transmitted an uplink of flight software files via X-band radio to the rover's high-gain antenna.

Sol 893: Plans call for Spirit to calibrate and take images of the rock abrasion tool.

Sols 894 to 896 (July 9 to 11, 2006): Plans call for Spirit to continue acquiring panoramic camera images for the "McMurdo Panorama."

Odometry:

As of sol 891 (July 6, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 881-888, July 06, 2006: *Spirit Copes with Decreasing Solar Energy*

With electrical power from Spirit's solar array down to about 300 watt-hours per Martian day, or sol, the science team is able to plan only one major activity per sol and often needs to devote one sol to recharging the rover's batteries. (A hundred watt-hours is the amount of electricity needed to light one 100-watt bulb for one hour.) Spirit remains healthy and continues to make progress on the winter science campaign.

Engineers successfully uploaded half of a new flight software upgrade and planned to take advantage of overflights by NASA's Odyssey orbiter to transmit more flight software files via UHF frequencies.

The rover team created a new technique for correcting drift (changes with time) in the rover's inertial measurement unit, which affects the pointing accuracy of the miniature thermal emission spectrometer. The IMU provides roll, pitch, and yaw information to the rover. Typically, rover handlers minimize error by having the rover complete a sequence of steps known as a "get fine attitude" based on the changing position of the sun relative to the rover. The rover then takes images with the hazard avoidance and navigation cameras, which provide guidance for positioning the robotic arm and driving as well as documenting the correction. The entire process takes about one hour, which at present is roughly equivalent to a week of winter science operations. Between these updates, the rover's onboard computer keeps track of attitude changes, but error builds up in this calculation over time.

The new process involves sending a command to Spirit with the position reported by the rover after the last quick "get fine attitude," on sol 855 (May 30, 2006). Rover drivers confirmed that the rover had not moved since then by checking images from the hazard avoidance cameras. Following the usual attitude adjustment, the team planned to direct the rover to take two new images with the navigation camera and compare those to images from sol 855 as an additional means of verifying the accuracy of the adjustment.

Sol-by-sol summaries

Sol 881 (June 25, 2006): Rover handlers spent one hour transmitting flight software files to Spirit via X-band frequencies using the rover's high-gain antenna.

Sol 882: Spirit completed a "bitty cloud" search designed to look for changes in the Martian sky, a photon transfer observation to measure electronic noise (unwanted signals) picked up by CCDs (charge-coupled devices -- imaging sensors that convert light into electrical current) in the left eye of the rover's panoramic camera, and observations of ground targets and atmosphere with the miniature thermal emission spectrometer.

Sol 883: Spirit conducted a 5-hour observation of the rock target "Halley" with the Mössbauer spectrometer. The rover also conducted morning atmospheric studies.

Sol 884: Spirit completed a photon transfer observation of the right eye of the panoramic camera.

Sol 885: Plans called for Spirit to conduct atmospheric studies of the Martian sky and ground using the panoramic camera and miniature thermal emission spectrometer. The rover's schedule also included another 5-hour study of Halley with the Mössbauer spectrometer.

Sol 886: Plans called for Spirit to conduct more "bitty cloud" observations, collect remote observations of the sky and ground with the miniature thermal emission spectrometer, set the rover attitude, and calibrate the high-gain antenna.

Sol 887: Plans called for Spirit to acquire a single frame of column 21 of the "McMurdo panorama."

Sol 888 (July 3, 2006): Plans called for Spirit to recharge the batteries and make morning atmospheric studies.

Odometry:

As of sol 884 (June 28, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 874-880, June 23, 2006: *Spirit "Warms up the Engines," Continues Work on Mars*

Since the beginning of Spirit's winter science campaign, the science and engineering teams have held joint meetings every few weeks to track campaign progress and come up with a strategic plan that balances engineering resources with science productivity. This week, Spirit began acquiring the 22nd column of the 27-column "McMurdo panorama" and completed the seventh of nine photon transfer calibrations - procedures designed to measure electronic noise (unwanted signals) picked up by imaging sensors that convert light into electrical current in the rover's cameras.

Spirit also conducted studies of a soil target nicknamed "Halley Brunt," which is an undisturbed exposure of bright, sparkly bits of soil near the rover's left front wheel. The work included 5 hours of examination with the alpha particle X-ray spectrometer, 10 hours of examination with the Mössbauer spectrometer, and acquisition of microscopic images.

For the first time on either rover, Spirit's battery heaters turned on at 8:15 a.m. local solar time on Mars on Sol 865 (June 9, 2006). The heaters activate automatically when local temperatures drop to about minus 19 degrees Celsius (minus 2 degrees Fahrenheit). The lowest allowable operating temperature is minus 20 degrees C (minus 4 degrees F.).

Sol-by-sol summaries:

Sol 874 (June 18, 2006): Spirit acquired Part A of column 22 of the McMurdo panorama.

Sol 875: Spirit studied soil target "Halley Brunt" with the alpha particle X-ray spectrometer.

Sol 876: Spirit completed a photon transfer calibration of the microscopic imager. Spirit also acquired a panoramic view of a dune field called "El Dorado" and conducted remote studies using the miniature thermal emission spectrometer.

Sol 877: Spirit acquired navigation camera images of the rover's tracks and continued to make remote observations using the miniature thermal emission spectrometer. While communicating with the Odyssey spacecraft as it passed overhead, Spirit calibrated the miniature thermal emission spectrometer, took images of a sand ripple using the hazard avoidance cameras, and made observations of the sky and ground using the miniature thermal emission spectrometer.

Sol 878: Spirit completed a dust monitoring assessment of the panoramic camera's mast assembly, acquired panoramic camera images to measure atmospheric dust opacity (known as a tau measurement), and conducted sky and ground observations using the miniature thermal emission spectrometer.

Sol 879: Plans called for Spirit to complete acquisition of Part B of column 22 of the McMurdo panorama and make more observations with the miniature thermal emission spectrometer.

Sol 880 (June 24, 2006): Plans called for Spirit to take microscopic images of Halley Brunt and then switch tools to the Mössbauer spectrometer for a 10-hour study of the same target.

Odometry:

As of sol 877 (June 21, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 867-873, June 21, 2006: *Spirit Continues Work Even As Martian Winter Deepens*

Spirit continues to be productive, even as winter conditions harshen. Spirit now receives about one-third as much solar energy as the rover received in mid-2005 while on "Husband Hill." That is, the rover now receives about 310 watt-hours per Martian day, or sol, compared with 900 watt-hours per sol last summer. (A hundred watt-hours is the amount of electricity needed to light one 100-watt bulb

for one hour.) The power supply limits how much work Spirit can do each sol. Even so, Spirit acquired two more columns of the "McMurdo panorama" plus a mosaic of microscopic images of a third layer of soil in a target known as "Progress 3." In addition, Spirit completed six targeted studies using the miniature thermal emission spectrometer, all while the rover was also communicating with the Odyssey spacecraft during its overhead pass.

The rover team also planned to begin sending new flight software, known as version R9.2, to Spirit. Two previous flight-software upgrades were sent solely via Spirit's high-gain, X-band antenna. The new uplink plan, however, calls for use of both X-band and UHF antennas because X-band communications with Spirit are often unavailable due to use of that frequency to support NASA's Mars Reconnaissance Orbiter during its aerobraking around the planet.

Sol-by-sol summaries:

Sol 867 (June 11, 2006): Spirit acquired the first portion of column 20 (a one-by-two mosaic) of the McMurdo panorama.

Sol 868: Spirit completed a "photon transfer calibration" of the front hazard-avoidance cameras. This procedure is designed to measure electronic noise (unwanted signals) picked up by imaging sensors that convert light into electrical current in the rover's cameras.

Sol 869: Spirit acquired the second portion of column 20 (a one-by-three mosaic) of the McMurdo panorama. The rover made targeted observations with the miniature thermal emission spectrometer on rock targets nicknamed "Riquelme" and "Zucchelli" while communicating with the Odyssey spacecraft as it passed overhead.

Sol 870: Spirit acquired microscopic images of the soil target known as "Progress 3" and made remote observations of the sky and ground using the miniature thermal emission spectrometer.

Sol 871: Spirit acquired images of the rock abrasion tool and spent 60 minutes communicating with Odyssey while conducting remote observations of rock targets nicknamed "Law-Ricovita," "Tor," "Scott Base," and "Arctowski" using the miniature thermal emission spectrometer.

Sol 872: Plans called for transmission of new flight software, version R9.2, to Spirit.

Sol 873 (June 17, 2006): Plans called for Spirit to acquire super-high-resolution images of a rock target known as "Korolev" using the panoramic camera.

Odometry:

As of sol 869 (June 13, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 860-866, June 09, 2006: *Progress on Long-Term Experiments*

Spirit is healthy and continues to make progress on the rover's winter science experiments. Spirit has begun work on a new "photon transfer calibration" experiment designed to measure electronic noise (unwanted signals) picked up by CCDs (charge-coupled devices -- imaging sensors that convert light into electrical current) in the rover's cameras. This week the rover conducted the calibration experiment on the panoramic camera and rear hazard-avoidance cameras.

Spirit also began an experiment to look for wind-driven changes in the Martian surface by making the first of several monthly checks, using all 13 filters of the panoramic camera, of a bright soil target nicknamed "Tyrone." In addition, that camera acquired column 18 of the "McMurdo panorama." Rover science team members prepared to have the rover remove another 2 millimeters of soil as part of a soil analysis experiment. The newly exposed soil target will be called "Progress 3."

Sol-by-sol summaries:

Sol 860 (June 4, 2006): Spirit completed 30 minutes of remote sensing and conducted the photon transfer calibration on the panoramic camera. Demonstrating that the rover is capable of multi-tasking, Spirit spent 60 minutes communicating with NASA's Mars Odyssey spacecraft as Odyssey passed overhead while Spirit also studied Martian terrain targets with the miniature thermal emission spectrometer.

Sol 861: Spirit collected images with the microscopic imager and transmitted 70 megabits of data over UHF frequencies during a morning telecommunications link with Odyssey. Spirit also checked the three-dimensional movement of the rock abrasion tool at the end of the rover's instrument arm. This process involves taking measurements from encoders, which resemble dials on a safe. The encoders tick off the distance traveled by motor shafts and convert the mechanical motion into electronic signals. The results enable engineers to check for slippage or sticking that would necessitate changes in the amount of movement needed to position the instrument as desired.

Sol 862: Spirit acquired the first part of Column 18 (a 1-by-3 mosaic) of the McMurdo panorama. The rover spent 60 minutes communicating with Odyssey as it passed overhead, while also conducting remote targeted sensing using the miniature thermal emission spectrometer.

Sol 863: Spirit acquired the second half of Column 18 (a 1-by-3 mosaic) of the McMurdo panorama and took a picture of the Martian sunset.

Sol 864: Spirit took a 13-filter color image of the Tyrone soil target using the panoramic camera and conducted analysis of the ground and sky at different elevations using the miniature thermal emission spectrometer.

Sol 865: Spirit completed the photon transfer calibration experiment on the rover's rear hazard-avoidance cameras.

Sol 866 (June 10, 2006): Plans called for Spirit to use the rock abrasion tool to brush away a third layer of soil 2 millimeters thick from the soil target called Progress. Spirit was to spend 54 minutes on the task as part of a progressive soil brushing experiment before documenting the spot with images from the panoramic camera using all 13 color filters.

Odometry:

As of sol 863 (June 7, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 855-859, June 01, 2006: *Spirit Perfects Pointing Parameters, Collects Images Large and Small*

Since arriving at the rover's current location on the 807th sol, or Martian day, of exploration (April 10, 2006), Spirit's knowledge of its attitude relative to the sun has drifted. The rover uses an onboard computer to keep track of attitude changes, but error builds up in this measurement over time. On sol 855 (May 30, 2006), rover planners transmitted an attitude update of 1.97 degrees to correct for the drift. After the update, Spirit re-acquired images from the same location to allow the science team to accurately target future observations.

Meanwhile, Spirit continued acquisition of the "McMurdo panorama" and removed another 2 millimeters of soil as part of a layer-by-layer soil study.

Sol-by-sol summaries:

Sol 855 (May 30, 2006): Spirit completed a quick get-fine attitude, which is a procedure completed every couple of weeks to correct any error in the rover's knowledge of its attitude relative to the sun. Spirit also took a 360-degree view of its surroundings with the navigation camera and a forward-looking view through the front hazard avoidance camera. The rover conducted remote sensing with the miniature thermal emission spectrometer during the overhead pass of the Mars Odyssey spacecraft.

Sol 856: Spirit acquired column 16 (a one-by-five mosaic) of the McMurdo panorama.

Sol 857: Spirit spent 80 minutes brushing away another 2 millimeters of soil from the soil target "Progress." This layer of the study is known as "Progress 3."

Sol 858: Plans called for Spirit to take microscopic images of Progress 3, conduct remote sensing with the miniature thermal emission spectrometer during the afternoon overhead pass of the Odyssey spacecraft, and take two panoramic-camera images during the Martian sunset.

Sol 859 (June 3, 2006): Plans call for Spirit to acquire column 17 (a one-by-three mosaic) of the McMurdo panorama.

Odometry:

As of sol 857 (June 1, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 847-854, May 26, 2006: *Spirit Continues Studies of Martian "Winter Haven"*

Spirit continued to collect images for the 360-degree panorama, now under construction, of the rover's "Winter Haven" on Mars. Rover planners anticipated that by the end of the Memorial Day weekend, Spirit would complete 15 of the 27 columns for the final product. Spirit also continued scientific studies of the soil target called "Progress" after brushing away about 6 millimeters (a quarter of an inch) of soil to reveal a second layer, dubbed "Progress 2." Rover team members prepared commands for the next round of scientific measurements, to include a 49.5-hour study divided over three Martian days, or sols, using the Mössbauer spectrometer.

Five of seven opportunities to transmit signals to Mars at higher-frequency X-band wavelengths were needed for higher-priority communications in support of aerobraking activities of NASA's Mars Reconnaissance Orbiter, so engineers continued sending commands to Spirit via the UHF link on the Mars Odyssey spacecraft.

Sol-by-sol summaries:

Sol 847 (May 21, 2006): Spirit acquired a one-by-three mosaic for column 14 of the "McMurdo Panorama" and studied Progress 2 with the alpha particle X-ray spectrometer.

Sols 849 to 851: In the absence of an uplink for new commands, Spirit executed the master sequence from sol 848. Spirit continued downlinking data to Earth and charged the battery.

Sol 852: Plans called for Spirit to place the Mössbauer spectrometer on Progress 2 and start overnight collection and integration of data.

Sol 853: Plans called for Spirit to re-start analysis with the Mössbauer spectrometer for 3.5 hours, acquire all three frames of column 15 of the McMurdo panorama, and make targeted observations with the miniature thermal emission spectrometer.

Sol 854 (May 29, 2006): Plans called for an overnight study of Progress 2 with the Mössbauer spectrometer.

Odometry:

As of sol 850 (May 25, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 842-846, May 19, 2006: *Spirit Continues Winter Studies of Soil, Sky and Terrain*

Spirit is healthy and making progress on a winter science campaign of experiments in Gusev Crater on Mars. Spirit has completed the first phase of a layer-by-layer soil study by collecting a mosaic of images with the microscopic imager and analyzing composition of

undisturbed soil with the Mössbauer and alpha particle X-ray spectrometers. Spirit used the rock abrasion tool to brush away the top soil layer on Martian day, or sol, 830 (May 4, 2006). After that, the rover studied the brushed spot with the microscopic imager and Mössbauer and alpha particle X-ray spectrometers.

Before telling the rover to brush away a second layer, rover planners performed a test on sol 842 (May 16, 2006) to better characterize the position of the rock abrasion tool above the soil. The robotic arm performed as expected during the test. Removal of the second layer was planned for sol 845 (May 20, 2006).

Spirit also collected two additional columns of a 360-degree view called the "McMurdo panorama" and completed four targeted studies with the miniature thermal emission spectrometer.

Sol-by-sol summaries:

Sol 842 (May 16, 2006): Spirit conducted a positioning test of the rover's robotic arm, including touching the Mössbauer spectrometer to the soil, collecting a two-by-two mosaic of images with the microscopic imager, and suspending the rock abrasion tool just above the soil surface. The test was successful. Spirit also conducted remote analysis of two targets, known as "Allan Hills" and "Dome Fuji," with the miniature thermal emission spectrometer.

Sol 843: Spirit acquired column 12 of the "McMurdo panorama" and conducted atmosphere studies with the miniature thermal emission spectrometer.

Sol 844: Spirit acquired column 13 of the "McMurdo panorama" and conducted remote sensing analysis of targets called "VonNeumayer" and "d'Urville" with the miniature thermal emission spectrometer.

Sol 845: Plans called for Spirit to begin brushing away a second, 1-millimeter layer of soil from the target labeled "Progress" using the rock abrasion tool.

Sol 846 (May 21, 2006): Plans called for Spirit to recharge its batteries and transmit communications during an overnight pass of NASA's Mars Odyssey orbiter.

Odometry:

As of sol 836 (May 11, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 835-841, May 11, 2006: *Spirit Continues Studying Soil and Collecting Images*

Spirit continued to make progress on collecting panoramic images of Martian terrain and conducting detailed studies of soil targets using the Mössbauer spectrometer. The rover acquired another column of the "McMurdo panorama" and continued to relay new data to Earth via the UHF antenna on NASA's Mars Odyssey orbiter.

Sol-by-sol summary

Sol 835 (May 9, 2006): Spirit conducted scientific analysis of the soil target "Halley" using the Mössbauer spectrometer. Spirit also acquired panel 11 of the planned 27-panel, 360-degree, full-color view of the rover's surroundings known as the McMurdo panorama.

Sol 836: Spirit conducted remote sensing observations.

Sol 837: Spirit continued acquisition of scientific data from Halley using the Mössbauer spectrometer.

Sol 838: Spirit continued acquisition of scientific data from Halley using the Mössbauer spectrometer.

Sol 839 to 841 (May 13 to 15, 2006): Plans called for Spirit to move the rover's robotic arm back to the soil target nicknamed "Progress," where the rover previously brushed away a fine layer of soil. The next phase of the rover's detailed winter soil analysis experiment will be to conduct a three-day study of the brushed surface using the Mössbauer spectrometer. Plans for remote sensing were kept very light in order to devote resources to transmitting data acquired in recent weeks.

Odometry:

As of sol 836 (May 11, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 828-834, May 05, 2006: *Spirit Begins First Interplanetary Layer-by-Layer Soil Analysis*

Spirit is healthy and continuing to make progress on the rover's winter campaign of scientific experiments. This week Spirit continued work on the full-color, 360-degree "McMurdo panorama." The finished panorama will combine 27 columns of images. Scientists anticipate that Spirit will have finished collecting the first 10 of those columns by Martian day, or sol, 834 (May 8, 2006). Spirit also continued studies of two soil targets nicknamed "Progress" and "Halley."

A winter soil analysis experiment will involve a multi-step process of removing the Mössbauer spectrometer from the target, flipping the wrist joint at the end of the robotic arm to put it in a better position for exchanging tools, re-touching the target with the Mössbauer to confirm precise placement, and exchanging tools from the Mössbauer spectrometer to the rock abrasion tool. Using the brush at the end of the rock abrasion tool, Spirit will remove a layer of soil up to 1 millimeter thick (the thickness of a dime). During brushing, the rover will take a movie of the procedure with the right lens of the hazard-avoidance camera. After the brushing, the rover will acquire a microscopic image of the freshly exposed surface as well as a color image using all 13 filters of the panoramic camera. The rover will then start the process again and remove another layer of soil.

Spirit is also poised to begin a five-month, remote, photometric study of seasonal changes in surface properties of soil exposed in the rover's tracks.

As the newly arrived Mars Reconnaissance Orbiter continues the aerobraking phase of its mission (using friction from the Martian atmosphere to refine its orbit), high-frequency X-band communications directly between Spirit and Earth will not always be available. On sol 830 (May 4, 2006), NASA's Odyssey spacecraft began transmitting communications to Spirit at UHF frequencies.

Sol-by-sol summary

Sol 828 (May 2, 2006): Spirit conducted remote sensing and completed acquisition of column 8 of the McMurdo panorama.

Sol 829: Spirit conducted a third day of Mössbauer spectrometry of the Progress soil target, for a total of 69 hours of analysis of the target with the instrument.

Sol 830: Spirit began progressive brushing of loose soil for the first time and collected microscopic images.

Sol 831: Spirit conducted remote sensing, acquired column 9 of the McMurdo pan, and completed an 18-hour analysis of Progress with the alpha particle X-ray spectrometer.

Sol 832: Plans called for Spirit to acquire microscopic images of Halley.

Sol 833: Plans called for Spirit to conduct remote sensing, acquire column 10 of the McMurdo pan, and complete a second 18-hour study of Progress with the alpha particle X-ray spectrometer.

Sol 834 (May 8, 2006): Plans called for Spirit to continue remote sensing studies and begin monitoring changes in surface properties of soil exposed in the rover's tracks.

Odometry:

As of sol 831 (May 5, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 820-827, May 01, 2006: *Spirit Continues Winter Science Studies on Mars*

Spirit remains healthy and is making good progress on the rover's winter campaign of scientific experiments. This week Spirit continued collecting a full-color, high-resolution, 360-degree panorama called the "McMurdo pan." When complete, the panorama will be a mosaic of 27 columns of images. The product could be finished in about six weeks, given power and data limitations.

Spirit also conducted scientific analysis of a soil target nicknamed "Progress" using the instruments on the rover's robotic arm.

Sol-by-sol highlights:

Sol 820 (April 24, 2006): Spirit worked on acquiring column 4 of the McMurdo pan and made ground observations using the miniature thermal emission spectrometer.

Sol 821: Spirit continued work on acquiring column 4 of the McMurdo pan and making ground observations using the miniature thermal emission spectrometer.

Sol 822: Spirit began characterization of the undisturbed soil surface of Progress using the microscopic imager and the alpha particle X-ray spectrometer. The rover also began acquiring column 5 of the McMurdo pan and made observations with the miniature thermal X-ray spectrometer.

Sol 823: Spirit continued work on characterizing the undisturbed soil surface of Progress using the microscopic imager and the alpha particle X-ray spectrometer. The rover also continued acquiring column 5 of the McMurdo pan and making observations with the miniature thermal X-ray spectrometer.

Sol 824: Spirit continued work on characterizing the undisturbed soil surface of Progress using the microscopic imager and the alpha particle X-ray spectrometer. The rover also continued acquiring column 5 of the McMurdo pan and making observations with the miniature thermal X-ray spectrometer.

Sols 825-827 (April 29 to May 1, 2006): Plans called for analyzing Progress with the Mössbauer spectrometer and acquiring columns 6 and 7 of the McMurdo pan.

Odometry:

As of sol 824 (April 28, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 812-819, Apr 21, 2006: *Spirit Studies New Terrain*

Spirit remains healthy and is enjoying the winter sun on Mars. This week, Spirit began acquiring a full-color, high-resolution, 360-degree panorama nicknamed the "McMurdo Pan." The panorama campaign will take a few weeks because of power and data limitations. In addition, Spirit conducted a scientific study of a soil target called "Mawson" using instruments on the rover's robotic arm.

All the rock and soil targets in this area are being named after Antarctic research stations and explorers.

Sol-by-sol highlights:

Sol 812 (April 16, 2006): Spirit performed targeted remote sensing with the miniature thermal emission spectrometer and acquired microscopic images of undisturbed soil.

Sol 813: Spirit conducted targeted remote sensing with the panoramic camera.

Sol 814: Spirit began acquisition of the "McMurdo Pan." The rover studied a soil target called "Mawson" with the alpha particle X-ray spectrometer.

Sol 815: Spirit conducted targeted remote sensing with the panoramic camera and the miniature thermal emission spectrometer.

Sol 816: Rather than pause for new instructions, Spirit continued to acquire panoramic camera data following master sequences already transmitted to the rover.

Sols 817 to 819 (April 21-23, 2006): Plans called for Spirit to continue work on the "McMurdo panorama," complete overnight studies of the soil target called "Mawson" with the Mössbauer spectrometer, and conduct targeted remote sensing.

Odometry:

As of sol 816 (April 20, 2006), Spirit's total odometry remained at 6,876.18 meters (4.27 miles).

sol 803-811, Apr 14, 2006: *Spirit Finally Reaches a Potential Winter Haven*

Spirit is basking in the sun, relatively speaking, on a 10.8-degree, north-facing slope in Gusev Crater on Mars. After turning away from the rover's previous heading toward "McCool Hill" last week, Spirit started driving toward a nearby area known as "Low Ridge Haven" and arrived there over the weekend. Because rover drivers were able to get Spirit to a place where the solar panels tilt more steeply toward the sun, the rover's power output increased by 50 to 60 watt-hours per sol (a sol is one day on Mars). That gives the rover enough energy for about one hour of daytime remote science.

So far in this location, Spirit has collected a 360-degree panorama with the navigation camera, a smaller panorama with the panoramic camera, two targeted observations with the miniature thermal emission spectrometer, and five targeted images with the panoramic camera. Spirit also collected data with instruments on the robotic arm, including the microscopic imager, the alpha particle X-ray spectrometer, and the Mössbauer spectrometer. All the rock and soil targets in this area are being informally named after Antarctic research stations and explorers.

Sol-by-sol highlights:

Sol 803 (April 6, 2006): Spirit drove about 9 meters (30 feet) closer to "Low Ridge Haven," approaching a break in the north-facing slopes of the small outcrop.

Sol 804: Spirit recharged the batteries and conducted atmospheric remote sensing.

Sol 805: Spirit spent as much of the weekend as possible driving toward a north-facing slope to allow the rover's solar panels to soak up more energy from the sun. After advancing slightly more than 10 meters (33 feet), Spirit ended up in a nice, sunny spot, with a northerly tilt of 10.8 degrees.

Sol 806: Spirit recharged the batteries and used the panoramic camera to view the surrounding terrain from the new location reached by the sol 805 drive.

Sol 807: Spirit's weekend drive placed the rover at a potentially safe place to spend the winter on Mars. Activities included a "get fine attitude," a procedure completed every couple of weeks to correct any error in the rover's knowledge of its attitude relative to the sun. (Between updates, the rover uses the onboard computer to keep track of attitude changes, but error builds up in this measurement over time.) The rover also used the navigation camera and panoramic camera for additional and higher-resolution images of the terrain surrounding the current location.

Sol 808: Spirit observed rock targets called "Marambio" and "Orcadas" using the miniature thermal emission spectrometer and collected images of a target called "Maitri" using the panoramic camera.

Sol 809: Spirit deployed the robotic arm for the first time since the week of sols 769 to 772 (March 2 to March 5, 2006), when the rover conducted scientific observations near "Home Plate." Spirit acquired microscopic images of a target called "Halley" and completed an overnight analysis with the alpha particle X-ray spectrometer. The rover also acquired panoramic-camera images of "Troll" and "Mirny."

Sols 810-811 (April 13-14, 2006): Plans for the weekend called for continued work on "Halley," including measurements with the Mössbauer spectrometer, and targeted remote sensing, including panoramic camera images of "Orcadas" and "Marambio."

Odometry:

As of sol 811 (April 14, 2006), Spirit's total odometry was 6,876.18 meters (4.27 miles).

sol 796-804, Apr 06, 2006: *Spirit Seeks Alternate Winter Science Station*

On the way to north-facing slopes on "McCool Hill" between outcrops nicknamed "Oberth" and "Korolev," Spirit ran into an impassable, sandy area. To increase solar power output, Spirit's handlers redirected the rover to a closer north-facing slope in an area known as "Low Ridge" or "Low Ridge Haven," about 20 meters away from the rover's position on sol 802 (April 5, 2006). Spirit continued to make progress in that direction after successfully exiting the sandy area on sol 799 (April 2, 2006).

Sol-by-sol highlights:

Sol 796 (March 30, 2006): In an attempt to get the rover out of some slippery sand, engineers planned a 5-meter (16-foot) drive. Spirit terminated the drive after less than one meter (3 feet) due to excessive slip.

Sol 797: Spirit recharged the batteries and conducted atmospheric remote sensing.

Sol 798: Spirit conducted targeted remote sensing, which included observations of the rover's own tracks using the miniature thermal emission spectrometer and 13 filters of the panoramic camera.

Sol 799: Rover planners designed a drive that finally got Spirit out of the sandy stuff. Spirit drove 5.8 meters (19 feet) to firmer ground.

Sol 800: Spirit recharged the batteries and conducted atmospheric remote sensing.

Sol 801: Rover handlers transmitted drive commands to Spirit via the Odyssey spacecraft. Uplink time, however, was shorter than expected, and only 10 of 16 drive sequences made it on board. The rover remained healthy but did not execute the plan.

Sol 802: Spirit successfully drove 8.2 meters (27 feet), experiencing maximum slip of only 11 percent.

Sol 803: Drive plans call for moving the rover closer to "Low Ridge Haven," using post-drive images to design a safe approach.

Sol 804 (April 7, 2006): Planned activities include recharging the batteries, monitoring dust and observing clouds.

Odometry:

As of sol 802 (April 5, 2006), Spirit's total odometry was 6,853.98 meters (4.26 miles).

sol 790-797 , Mar 31, 2006: *Difficult progress with five-wheel drive*

NASA's Mars Odyssey orbiter resumed communication-relay support of the Mars Exploration Rovers on March 25, 2006. Spirit executed drives on sols 792 and 794 (March 26 and 27), but has been having trouble making progress given the current terrain and driving conditions. The team is developing new drive strategies for five-wheel driving in the test facility at the Jet Propulsion Laboratory. The new techniques for turning the rover to face waypoints are proving successful on Mars, but soft soil and inclines in Spirit's current location make uphill progress difficult to achieve. At the end of the week, the team decided to stop trying to advance along a route Spirit had been attempting in recent sols and, instead, to drive back downhill a few meters and then begin a different route toward a north-facing slope for surviving the Martian winter.

Right-front wheel status

Diagnostic tests run on the drive motor for Spirit's right-front wheel at various voltage levels resulted in no motion. These tests were consistent with results in the test facility, and they indicate an open connection in the motor. As a result, the team has precluded further use of this motor, so Spirit will continue driving with five wheels.

Sol-by-sol highlights:

Sol 790 (March 24): Spirit completed its usual morning science observations of assessing the clarity of the sky (a variable called "tau") with the panoramic camera, and checking the sky and ground with the miniature thermal emission spectrometer. Before shutting down for this light-activity sol, the rover used 13 different filters of the panoramic camera to examine soil that had been churned up in wheel tracks.

Sol 791: The Mars Odyssey orbiter, which had been unavailable for communication-relay support for three days because it went into a precautionary "safe" mode temporarily, resumed relay work. Spirit used the panoramic camera for assessing sky clarity and for surveying some rocks. It used the miniature thermal emission spectrometer for sky and ground observations and to examine the disturbed soil in the wheel tracks.

Sols 792 and 793: With a new downlink from Odyssey, the team came in on Saturday to plan a two-hour drive for sol 792. Spirit turned about 125 degrees to face a new drive target and began to drive toward it. The drive ended a few meters later when Spirit detected 71-percent slippage. On sol 793, Spirit completed a light schedule of remote-sensing observations.

Sols 794 and 795: Spirit drove 5.7 meters (19 feet) on sol 794, but most of the odometry change was a part of the heading change, rather than progress toward a destination. Again, high slip terminated the drive. As in the previous two-sol plans, there was light remote sensing on the second sol.

Sols 796 and 797: Spirit's sol 796 uplink time was during a Mars Reconnaissance Orbiter aerobraking maneuver and the two spacecraft cannot use the same radio band at the same time, so the rover team used forward commanding relayed via Odyssey to uplink Spirit's sequences of commands for sols 796 and 797. The plan for sol 796 was to turn 60 degrees clockwise toward a new waypoint and drive toward it using visual odometry to help check for slip. The rover drove 4 meters (13 feet) before the drive stopped due to excessive (61 percent) slippage. As on the previous drive attempt, most of the added odometry was in the turning, not forward progress. After the drive, Spirit acquired images to help the uplink team analyze possible alternative routes to north-tilted slopes.

As of sol 796 (March 30, 2006), Spirit's total odometry was 6,836.48 meters (4.25 miles).

sol 782-789, Mar 28, 2006: *Flight Team Investigates Right Front Wheel Anomaly*

The flight team continues to investigate the right front wheel anomaly on Spirit. A diagnostic test conducted at a different temperature than earlier testing continued to indicate an open circuit condition for the wheel. Team members are conducting testbed experiments at the Jet Propulsion Laboratory to understand the new characteristics of five-wheel driving.

On March 21, 2006, NASA's Mars Odyssey orbiter went into a precautionary safe mode as a result of action by on-board fault protection. Odyssey was unavailable for three days to relay data from either Spirit or Opportunity to Earth. Spirit's flight team held a special Saturday planning session to make up for lost sols. Because of the approaching winter, it is imperative to move Spirit to north-facing slopes to insure the rover has adequate power during the deepest part of the winter.

Spirit was in restricted sols, which occur when the timing of downlinks is too late in the planning day to provide vital location and health information about the rover after it executes the previous day's commands. Therefore, drives could be planned for only every second sol.

Sol-by-sol highlights:

Sol 782 (March 16, 2006): Spirit drove more than 9 meters (30 feet).

Sol 784: Challenged by a mound with a modest slope, Spirit stopped the drive after only 0.85 meters (2.8 feet) because of excessive slip.

Sol 787: Spirit moved away from the sticky mound with a 4.5-meter (15-foot) drive.

Sol 788 (March 22, 2006): The flight team planned to have Spirit drive approximately 11 meters (36 feet) to a new waypoint.

Odometry:

As of sol 787 (March 21, 2006), Spirit's total odometry was 6,812.16 meters (4.23 miles).

sol 778-783, Mar 16, 2006: *Spirit Continues Driving on Five Wheels*

Spirit continued to make progress toward "McCool Hill" despite a reduction in solar energy and problems with the right front wheel. The team plans to have the rover spend the winter on the hill's north-facing slopes, where the tilt toward the sun would help maximize daily output by the solar panels. On Spirit's 779th sol, or Martian day (March 13, 2006), the drive actuator on the right front wheel stalled during a turn to adjust the position of the rover's antennas. The stall ended the day's drive, which brought Spirit 29 meters (95 feet) closer to McCool, still approximately 120 meters (390 feet) away.

Engineers conducted tests on sols 781 and 782 (March 15 and 16, 2006) on a testbed at the Jet Propulsion Laboratory as well as remotely on Spirit. Further analysis is needed to determine what caused the right front actuator to stop working. Meanwhile, the operations team has successfully commanded Spirit to drive using only 5 wheels. Engineers plan to have Spirit continue driving backward with five healthy wheels while dragging the right front wheel.

Sol-by-sol summaries:

Sol 778 (March 12, 2006): Spirit spent the day conducting remote atmospheric sensing.

Sol 779: Spirit drove about 29 meters (95 feet) and acquired post-drive images. A fault in the right front wheel drive actuator terminated the drive.

Sol 780: Spirit spent the day recharging batteries and re-transmitting information about the previous day's drive to Earth. Spirit collected additional imagery of the right front wheel.

Sol 781: Spirit completed diagnostic tests and drove 3.9 meters (13 feet) using only five wheels. Diagnostic tests showed that the right-front-wheel problem involved the drive actuator, not the steering.

Sol 782: Rover drivers planned a drive of approximately 12 meters (40 feet) using only five wheels.

Sol 783 (March 17, 2006): The operations team planned to have Spirit spend the day sleeping to charge up the batteries.

As of sol 781 (March 15, 2006), Spirit's total odometry was 6,797 meters (4.22 miles).

sol 771-777, Mar 11, 2006: *Spirit Studies Surface and Atmosphere on Way to 'McCool'*

Since backing down from the top of "Home Plate" on Martian day, or sol, 764 (Feb. 25, 2006), Spirit has driven southeast 103 meters (338 feet) toward "McCool Hill." Along the way, the rover used its robotic arm to analyze a rock target dubbed "Fuzzy Smith" and conducted remote scientific studies of outcrops along the side of Home Plate and on "Mitcheltree Ridge." Scientists plan to acquire long-baseline stereo images of McCool Hill before driving too close to the hillside. The images will provide measurements of surface features necessary for planning the rover's path.

During the week, NASA's Odyssey spacecraft has been relaying commands from Earth to Spirit via the UHF link. Communications over X-band frequencies have been allocated for use by the Deep Space Network to track the Mars Reconnaissance Orbiter during its approach to the red planet. Next week, Spirit is expected to resume operations via X-band uplinks.

Sol-by-sol summaries:

Sol 771 (March 4, 2006): Spirit completed an analysis of targets dubbed "Rube Foster" and "Willie Wells" using the Mössbauer spectrometer and 13 filters on the panoramic camera. During the afternoon Odyssey pass, Spirit collected data with the miniature thermal emission spectrometer. Spirit then began a study of a rock target called Fuzzy Smith with the Mössbauer spectrometer.

Sol 772: Spirit stowed the robotic arm and took panoramic camera images of Fuzzy Smith, then drove 27 meters (89 feet) southeast across Home Plate. After the drive, Spirit conducted opacity observations of afternoon dust and measurements of the sky and ground using the miniature thermal emission spectrometer.

Sol 773: After waking, Spirit continued atmospheric studies by taking thumbnail images of the sky with the panoramic camera and images of both the sky and ground with the miniature thermal emission spectrometer. In the afternoon, Spirit acquired images with both the panoramic and navigation cameras to provide essential data for selecting targets and planning routes. The rover also completed a systematic ground survey and survey of rock clasts using the panoramic camera.

Sol 774: Spirit drove off of Home Plate and back into the "Dugout" - a gully near the southeast edge of Home Plate. The rover acquired mid-drive images and post-drive images of surrounding terrain, then completed opacity observations and measurements of the sky and ground with the miniature thermal emission spectrometer.

Sol 775: In the morning, Spirit took thumbnail images of the sky with the panoramic camera and miniature thermal emission spectrometer measurements of the sky and ground. With the robotic arm still stowed, Spirit spent 30 minutes collecting temperature data using the alpha particle X-ray spectrometer. In the afternoon, Spirit conducted reconnaissance with the miniature thermal emission spectrometer.

Sol 776: Plans for this sol call for Spirit to begin collecting a long-baseline stereo mosaic of images of the hill by taking panoramic camera images from one site, driving 8 meters (26 feet), and then acquiring the part of the second half of the stereo mosaic.

Sol 777 (March 11, 2006): Plans for this sol include morning atmospheric studies, finishing the long-baseline stereo mosaic, and taking pictures of a target called "Bitty Cloud."

As of sol 775 (March 9, 2006), Spirit's total odometry was 6,756 meters (4.2 miles).

sol 763-770, Mar 03, 2006: *Spirit Studies Geology While Preparing for Martian Winter*

Spirit successfully completed four Martian days, or sols, of driving clockwise around the rim of "Home Plate" toward the south and east. The rover is currently spending three sols studying a rock target called "Fuzzy Smith" using three instruments on the robotic arm: the microscopic imager, Mössbauer spectrometer, and alpha particle X-ray spectrometer.

During the coming week, Spirit will communicate with Earth in UHF-only mode while NASA's Mars Reconnaissance Orbiter arrives at the red planet.

Sol-by-sol summaries:

Sol 763 (Feb. 25, 2006): Spirit completed scientific studies of a rock target called "Crawfords."

Sol 764: Spirit drove 22.7 meters (74.4 feet) and acquired post-drive images with the panoramic and navigation cameras.

Sol 765: Spirit acquired panoramic camera images of a transit of the Martian moon, Phobos, and recharged the batteries for the next day of driving.

Sol 766: Spirit drove 37 meters (121 feet), acquired post-drive images, and conducted atmospheric observations.

Sol 767: Spirit drove 29 meters (95 feet), acquired post-drive images, and conducted atmospheric observations.

Sol 768: Spirit drove 14.26 meters (47 feet) to the top of white outcrops on the rim of "Home Plate."

Sol 769: Plans are for Spirit to began a 3-day campaign of scientific observations on a rock target dubbed "Al 'Fuzzy' Smith," using instruments on the rover's robotic arm, including the microscopic imager, alpha particle X-ray spectrometer, and Mössbauer spectrometer.

Sol 770 (March 3, 2006): Plans are for Spirit to continue scientific studies of "Al 'Fuzzy' Smith."

As of sol 770 (March 3, 2006), Spirit's total odometry was 6,693 meters (4.16 miles).

sol 758-763, Feb 24, 2006: *Spirit Races Against Time and Dwindling Sunlight*

In a race to collect as much scientific data as possible before the onset of Martian winter, Spirit climbed to the top of "Home Plate" and acquired images of the surrounding terrain. Each day, Spirit logs a reduction in the total amount of solar energy collected as the sun sinks lower on the planet's northern horizon.

The science team's objective is to do as much science as possible while concentrating on a drive campaign that will move the rover to the north-facing slopes of "McCool Hill." The team has already begun mapping routes to McCool, where Spirit will attempt to survive a second Martian winter with its solar panels tilted toward the sun.

Sol-by-sol summaries:

Sol 758 (Feb. 19, 2006): Spirit conducted targeted remote sensing and acquired 13-filter images of a target dubbed "Wilmington," as well as mosaics of the surrounding terrain, with the panoramic camera.

Sol 759: Spirit edged closer to a rock nicknamed "James 'Cool Papa' Bell."

Sol 760: Spirit acquired images of its work area with the navigation and panoramic cameras. The rover also conducted atmospheric observations.

Sol 761: Spirit used the microscopic imager to acquire images of a rock target called "Stars." Then the rover brushed that target with the rock abrasion tool and examined it again with the microscopic imager after the brushing. Spirit then began checking the mineral composition of the Stars target with the Mössbauer spectrometer.

Sol 762 (Feb. 23): Spirit continued the Mössbauer study of Stars. Following an overhead pass of the Odyssey orbiter, Spirit began an analysis of Stars with the alpha particle X-ray spectrometer. Scientists planned to have the rover continue collecting scientific data over the weekend from another target, nicknamed "Crawfords."

As of sol 762 (Feb. 23, 2006), Spirit's total odometry was 6,589.83 meters (4.09 miles).

sol 750-755, Feb 17, 2006: *Spirit Studies Layered Rocks*

Spirit will soon be on top of the rugged plateau known as "Home Plate," which features the most spectacular layering Spirit has yet encountered, and begin taking images of the surrounding terrain. Spirit had a productive week investigating two rock targets, "Barnhill" and "Posey." A restricted planning period (resulting from periodic, limited opportunities to communicate with overhead satellites) gave Spirit an opportunity to spend a few sols (Martian days) engaged in untargeted remote sensing and atmospheric science. The rover also charged its batteries. The science team is assigning nicknames to surface features honoring star players and managers of the Negro Leagues of baseball in the first half of the 20th century.

Sol-by-sol summaries:

Sol 750 (Feb. 11, 2006): Spirit examined a rock target dubbed "Pitcher" with the microscopic imager, then completed an overnight study of a rock target dubbed "Fastball" with the alpha particle X-ray spectrometer.

Sol 751: Spirit stowed the robotic arm and executed a commanded, 5.3-meter (17-foot) drive to Posey using visual odometry. The drive went exactly as planned and ended with the rover in place to immediately begin scientific studies with the robotic arm without further adjustment of the rover's position.

Sol 752: Spirit conducted light remote sensing and recharged the rover's batteries.

Sol 753: Spirit acquired images of a rock target dubbed "Gray" using the microscopic imager, brushed a surface target known as "Manager" using the rock abrasion tool, and completed an 18-hour analysis of Manager using the Mössbauer spectrometer. The science team opted to complete an overnight Mössbauer study before conducting an overnight alpha particle X-ray spectrometer study in order to decide how long to stay at this location. Because the Mössbauer spectrum was similar to that of an earlier un-brushed target nicknamed Barnhill, the team directed the rover to resume driving after collecting the alpha particle X-ray spectrometer data.

Sol 754: Spirit took after-brushing images of Manager with the microscopic imager, finished the analysis of Manager with the alpha particle X-ray spectrometer, and took panoramic camera images of Barnhill.

Sol 755 (Feb. 16, 2006): Before moving on, Spirit rolled back from Manager and collected data from the site with the miniature thermal emission spectrometer. The rover paused to take mid-drive images with the navigation camera before "sliding into" Home Plate after driving 10 meters (33 feet) using visual odometry and 1.5 meters (4.9 feet) using autonomous navigation.

Odometry:

As of sol 755, Spirit's total odometry was 6,575 meters (4.09 miles).

sol 743-749, Feb 10, 2006: *Spirit Reaches "Home Plate"*

After several months of driving, Spirit finally reached the semicircular geologic feature dubbed "Home Plate" in Gusev Crater. Spirit first got a good view of Home Plate in late August, after cresting "Husband Hill." After that, the rover made scientific observations near the summit before commencing an ambitious drive of 848 meters (2,782 feet, a little more than half a mile) in 94 Martian days, or sols, to get to Home Plate. Spirit is now studying a rock target called "Barnhill" just below the tabletop-like surface of Home Plate using instruments on the rover's robotic arm. Science team members have begun calling Home Plate the "Burns Cliff of Gusev" because of its layered appearance and steep slopes, which is reminiscent of, but smaller than, "Endurance Crater," explored by Spirit's twin, Opportunity, on the opposite side of Mars in 2004.

Sol-by-sol summaries:

Sol 743 (Feb. 4, 2006): Spirit performed untargeted remote sensing and drove 45.7 meters (150 feet), navigating with the guidance of engineers.

Sol 744: Spirit completed an autonomous drive of 17.5 meters (57.4 feet), checked its orientation, and took post-drive images of surrounding terrain.

Sol 745: Spirit completed light remote sensing and recharged the battery for the coming week.

Sol 746: Spirit moved 9 meters (29.5 feet) closer to the target nicknamed "Barnhill." Following the approach, Spirit was perched at a tilt of 27 degrees.

Sol 747: Spirit carefully unstowed the robotic arm, continuously checking the rover's own tilt, which changes when the arm is deployed. Engineers expected a change in tilt of less 0.3 degrees; the actual change was minus 0.048 degrees. Spirit then performed scientific analysis as planned with the microscopic imager and Mössbauer spectrometer.

Sol 748: Spirit continued conducting scientific studies using the Mössbauer instrument and began acquiring a large mosaic of images with the panoramic camera.

Sol 749: The team proceeded with plans to have the rover change tools to the alpha particle X-ray spectrometer, continue to acquire panoramic images, and conduct other remote sensing.

As of sol 749 (Feb. 11, 2006), Spirit's total odometry was 6.559 meters (4.08 miles).

sol 735-742, Feb 06, 2006: *Spirit Completes Mile No. 4 on Mars*

Spirit is healthy and continues to make progress toward "Home Plate" after driving more than 150 meters (492 feet), taking images, making atmospheric observations, and analyzing geology.

Spirit completed two diagnostic tests of the dynamic brakes on sol 735 (Jan. 27, 2006) after the team detected a dynamic brake fault associated with the left-front and right-rear steering actuators on Sol 733. The tests were copies of tests that were run after a similar anomaly on sol 265 for Spirit. Also on sol 735, the rover performed a small wheel wiggle after its drive to test the dynamic brakes. The wheel wiggle steered the wheels slightly, then steered them straight. No dynamic brake warnings were observed. The intermittent behavior of the relay status that controls the dynamic brakes, as well as the results of the diagnostic activities, are consistent with the behavior observed after the sol 265 anomaly. The team continued with the same resolution, which was to instruct the rover to ignore the dynamic brake error status. Driving has continued with normal steering function.

Sol-by-sol summaries:

Sol 735 (Jan. 27, 2006): Rover planners had a busy day of preparing and executing a dynamic brake diagnostic test in addition to a day of driving. Spirit drove 26.3 meters (86.3 feet) without using the steering motors on the left-front and right-rear wheels. Results of the diagnostic testing were consistent with behavior following an anomaly on sol 265 (Oct. 1, 2004). Spirit also acquired panoramic camera images of "Allegheny Ridge" and "YuGong."

Sol 736: Rover science team members discovered an interesting rock and decided to spend a couple of days studying it with instruments on Spirit's robotic arm. Spirit collected a mosaic of microscopic images and collected spectrographic information with the Mössbauer instrument. Spirit took panoramic camera images of rock targets called "Xing Tian," "GongGong," "Luo Zu," "Sui Ren," "Cang Jie," and used the miniature thermal emission spectrometer to examine "Cang Jie," "Sui Ren," "Ho Ji," and "Luo Zu."

Sol 737: Spirit made remote sensing observations of Ho Ji and atmospheric observations using the rover's panoramic camera.

Sol 738: Spirit began driving around a rocky ridge that separated the rover from Home Plate, traveling an additional 33.7 meters (111 feet). Following a complete analysis of diagnostic tests run on sol 735, rover drivers decided to follow the same recovery plan used after the sol 265 anomaly, and Spirit continued to drive without incident.

Sol 739: Spirit drove 30.5 meters (100 feet). The rover stopped after 5 meters (49 feet) of autonomous navigation because of a sequencing error. Rover drivers added an automated flight check to the sequence to catch future errors of a similar nature. Spirit was unable to complete most of the planned post-drive imaging.

Sol 740: Rather than wait another day for Spirit to take a set of post-drive images, rover drivers gave Spirit the go-ahead to navigate independently using onboard instruments. Spirit drove 17 meters (56 feet) autonomously.

Sol 741: Spirit drove 43.5 meters (143 feet) to the top of a gently sloping ridge, providing an excellent view of the path to Home Plate.

Sol 742 (Feb. 3, 2006): Spirit prepared for a day of driving 30 meters as directed by rover drivers plus driving 15 meters to 20 meters autonomously.

Odometry:

As of sol 741 (Feb. 2, 2006), Spirit's total odometry was 6,430 meters (exactly 4 miles).

sol 730-735, Jan 27, 2006: *Spirit Nears 'Home Plate'*

Spirit continues to make progress toward "Home Plate," a conspicuous circular feature scientists hope to investigate before the Martian winter, in search of layered rock outcrops that may provide additional information about the geology of the "Columbia Hills." During the past week, the rover has driven nearly 100 meters (328 feet), and has still had time to do some targeted remote sensing. Spirit is currently just less than 170 meters (560 feet) from Home Plate.

During the past week, engineers noticed some anomalies in dynamic braking on two of the steering motors, similar to previous events on Spirit. Based on analysis and testing, they were able to continue the drive without incident.

Sol-by-sol summaries:

Sols 730 and 731 (Jan. 22 and 23, 2006): The weekend plan included a 10.8-meter (35.4-foot) drive to the crest of "Lorre Ridge." Spirit acquired targeted pre-drive and post-drive images. The rover spent most of Sunday recharging the battery to allow a longer drive on Monday.

Sol 732: Spirit drove 40 meters (131 feet), using a combination of commanded and autonomous navigation along with a parallel obstacle-check sequence to keep from getting too close to potential hazards. The rover acquired a pre-drive image of a target called "FuYi." After the drive, the panoramic camera and navigation camera acquired forward-looking mosaics. The next morning, Spirit acquired rear-looking images with the navigation camera and forward-looking mosaics with the panoramic camera using two more filters.

Sol 733: Spirit completed an autonomous drive of approximately 40 meters (131 feet). Just before beginning autonomous navigation, Spirit experienced a dynamic brake error in the left front and right rear steering actuators, at which point engineers halted the drive.

On the surface, this appeared to be similar to dynamic brake anomalies experienced on sols 265 (Oct. 1, 2004) and 277 (Oct. 13, 2004), which involved the right front and left rear steering motors. Analysis and testing at the time indicated that the problem was consistent with a delayed contact on the status relay. The rover engineering team sent a command to ignore the relay status, and since then, the rover has driven (with all steering motors enabled) without incident.

In the meantime, the team determined that it was safe to continue driving, but without using the left front and right rear steering motors.

Sol 734: Spirit drove approximately 9 meters (30 feet) autonomously. Engineers conducted the same diagnostic tests they ran following the sol 265 incident in the testbed, to verify that the procedures worked with the current flight software. While awaiting dynamic brake diagnostics, they disabled Spirit's left front and right rear steering motors and allowed Spirit to drive only where they could clearly see the surrounding terrain and it was not necessary to steer around any obstacles.

Sol 735 (Jan. 27, 2006): Planned activities included a short, autonomous drive with the left front and right rear steering motors disabled, following a short diagnostic activity to characterize the behavior of the dynamic brakes and the dynamic brake relay switch.

Odometry:

As of sol 735, Spirit's total odometry was 6,279.01 meters (3.9 miles).

sol 723-729, Jan 25, 2006: *Spirit Completes Studies of 'Arad,' Moves On*

Spirit is healthy and continues to pursue the short-term goal of driving to "Home Plate." Results from scientific instruments on the rover's robotic arm indicate that the white soil target called "Arad" has a salty chemistry dominated by iron-bearing sulfates. The composition is similar to that of a more silica-rich target, "Paso Robles," encountered earlier in the rover's journey through the "Columbia Hills." The presence of salt can be considered another clue to the existence of past water on Mars.

Spirit had a bit of difficulty driving out of the sandy area near Arad. Rover instruments recorded slip rates as high as 92 percent on the wheels before Spirit's drivers designed a command strategy that took Spirit away from the sand dunes and closer to Home Plate.

Spirit's engineering team broke a record the previous week, on sol 720 (Jan. 12, 2006), by taking only 2 hours and 35 minutes to plan and validate the uplink commands for the rover. To put that in perspective, at the beginning of the mission, when all of the rover's systems and science team members were brand new, the process took more than 13 hours.

Sol-by-sol summaries:

Sols 723 to 725 (Jan. 14 to 17, 2006): Spirit began a campaign to study different targets of the feature named Arad, using instruments on the robotic arm, including the microscopic imager, Mössbauer spectrometer, and alpha particle X-ray spectrometer.

Sol 726: Spirit terminated the sol's drive early because of high slippage on sandy surfaces. The rover took images and conducted atmospheric observations using the miniature thermal emission spectrometer.

Sol 727: Spirit drove 26 meters (85 feet), took images with the navigation and panoramic cameras after the drive, and conducted atmospheric studies using the miniature thermal emission spectrometer.

Sol 728: Rover planners successfully designed a drive that took Spirit away from the sand dunes and closer to Home Plate. Spirit took images following the drive.

Sol 729 (Jan. 21, 2006): Spirit conducted untargeted atmospheric remote sensing.

Odometry:

As of sol 728 (Jan. 20, 2006), Spirit's total odometry was 6178.96 meters (3.94 miles).

sol 715-722, Jan 18, 2006: *Spirit at 'Arad'*

Spirit is healthy and is driving as efficiently as possible toward "Home Plate." On the way to Home Plate, Spirit stopped to look at "Arad," where scientists encountered a cluster of white, powdery soil. Researchers decided to stop for a few days and use the robotic arm to conduct some measurements on it. Results are expected soon.

Sol-by-sol summaries:

Sol 715 (Jan. 6, 2006): Spirit performed untargeted remote sensing.

Sol 716: Spirit drove 54 meters (177 feet), using a combination of commanded and autonomous navigation.

Sol 717: Spirit drove only 1.38 meters (4.5 feet) on slippery terrain, experiencing slippage of 80 percent as the wheels were turning.

Sol 718: Spirit conducted untargeted remote sensing.

Sol 719: Spirit drove 9.3 meters (30.5 feet). The rover stopped when the slip rate of its wheels exceeded 80 percent in an area of sandy, unfamiliar terrain.

Sol 720: Spirit conducted untargeted remote sensing and atmospheric studies.

Sol 721: Spirit adjusted position to place the robotic arm next to Arad for a weekend of scientific measurements. The rover also used its panoramic camera and miniature thermal emission spectrometer to take images of targets called "Arad1" and "Arad2."

Sol 722: Spirit conducted untargeted remote sensing and took panoramic camera images of tracks created by the rover's wheels.

As of sol 722 (Jan. 14, 2006), Spirit's total odometry was 6,096 meters (3.79 miles).

sol 708-714, Jan 06, 2006: *Spirit Heading to 'Home Plate'*

This week Spirit completed robotic-arm work on "El Dorado." The rover used all three of its spectrometers plus the microscopic imager for readings over the New Year's weekend. The team planned drive sols the following four days, and Spirit successfully made 198 meters (650 feet) of progress on the way to "Home Plate." On sol 715, Spirit enters restricted sols and will be able to drive only every other day, so the team made a large effort to maximize driving prior to this. (Restricted sols occur when the timing of the communications pass from NASA's Mars Odyssey orbiter is too late in the day to gather vital location and health information about the rover after it executed recent commands. The team back on Earth must wait until the next sol to find out where and how the rover is.)

Sol-by-sol summaries:

Sol 708 (Dec. 30, 2006): Spirit used the Mössbauer spectrometer, miniature thermal emission spectrometer and panoramic camera to study El Dorado.

Sol 709: Spirit used the Mössbauer spectrometer, microscopic imager and alpha particle X-ray spectrometer to study El Dorado.

Sol 710: Spirit took pictures of "Edgar" with the microscopic imager, placed the alpha particle X-ray spectrometer on Edgar, and studied El Dorado with the panoramic camera and alpha particle X-ray spectrometer.

Sol 711 and 712: On sol 711, Spirit drove 56 meters (184 feet) toward Home Plate using blind driving and autonomous navigation. The autonomous-navigation portion of the drive terminated early because the rover could not find a safe path, and a limit cycle was detected. Due to the limit cycle check and automatic drive termination on sol 711, Spirit did not resume driving on sol 712.

Sol 713: Spirit drove 80 meters (263 feet). Spirit received stall warnings on the left front steer motor on hard left turns, however this did not end the drive.

Sol 714: Spirit drove 62 meters (203 feet). The team performed a steering test of the left front steering actuator because of the prior stall warnings. Preliminary results show no more stall warnings.

As of sol 714 (Jan. 5, 2006), Spirit's total odometry is 6,031 meters (3.75 miles).

sol 701-707, Jan 05, 2006: *Spirit Meets 'Gallant Knight'*

Spirit is in excellent health after a busy holiday weekend. The rover team made several three-sol plans in single working days so that while the rover was busy, the crew could take the holidays off (though with a few late nights on the work days).

After completing work on an outcrop called "Comanche," Spirit entered a dune field called "El Dorado," where the rover began digging in a little and looking closely for evidence about whether the deposited material there originated locally or globally. All of the week's objectives were achieved, including some ambitious drive sols that exceeded the team's expectations.

Sol-by-sol summaries:

Sols 701 to 703 (Dec. 23 to Dec. 25, 2005): Spirit completed a long Mössbauer spectrometer integration on the brushed target "Palomino," along with an overnight reading by the alpha particle X-ray spectrometer on the same target. The panoramic camera took a 16-frame mosaic from Comanche over two sols. That camera and the miniature thermal emission spectrometer observed targets in the immediate vicinity with informal names "Cheyenne," "Apache," "Kickapoo," "Chickasaw," and "Winnebago." On sol 703, microscopic images were taken of a fin-shaped feature on Comanche.

Sol 704 and 705: Sol 704's activities wrapped up the work on Comanche. Spirit drove toward El Dorado on both sols 704 and 705 as part of a three-sol plan starting on sol 703. The first driving sol began with 22 meters (72 feet) of directed driving followed by autonomous navigation toward the dune fields. The second driving sol would not have the benefit of humans in the loop, and so was purely autonomous navigation, picking up on the heels of the previous sol to get Spirit within striking range of El Dorado. The team expected to get perhaps 80 to 90 meters (263 to 295 feet) from the two sols of driving. However, by the end of Sol 705, Spirit had driven 118 meters (387 feet), and was about a one-sol drive away from El Dorado.

Sol 706: This was the week's only normal, single-sol plan, which allowed engineers and scientists to plan a drive into El Dorado and to respond on the next sol with a plan to attack the science objectives there. The team expected to use the subsequent three-sol plan to trench in El Dorado and the three-sol plan after that to examine the trench. In order to prepare for the trench, the team planned a scuff at the end of the drive. The scuff was to be just a third of a wheel turn to push up some of the sandy material. That would give engineers some data on the consistency of the material so the team would know how long to trench.

Again the rover drivers came through, and Spirit successfully drove 38 meters (125 feet) right into the dunes of El Dorado on sol 706. The rover got a nice little mound and cut into a dune with the wheel scuff. The science team took a look at the scuff and decided it was in fact good enough for the science objectives without a need for trenching, so the team ended up three sols ahead of the game.

Sol 707 (Dec. 29): The microscopic imager inspected the scuff in El Dorado on the targets "Gallant Knight" and "Pilgrim." Spirit also began a long Mössbauer spectrometer integration on Pilgrim.

As of sol 707, Spirit's total odometry was 5,829 meters (3.62 miles).

sol 695-702, Dec 29, 2005: *Spirit on 'Horseback'*

Spirit is healthy. The rover drove 8.3 meters (27 feet) and perfectly positioned itself in front of a rock informally named "Comanche." Spirit performed work with the instruments on the robotic arm on a target called "Horseback" at Comanche. The rock abrasion tool's brush was only partially successful in making contact with Horseback, so the team moved the robotic arm to different target informally called "Palomino." Spirit performed a successful brushing and continued with more investigations using the other instruments on the robotic arm.

Sol-by-sol summaries:

Sol 695 (Dec. 17, 2005): Spirit performed targeted remote sensing.

Sol 696: Spirit performed targeted remote sensing.

Sol 697: Spirit approached "Comanche Spur" by driving 8.3 meters (27 feet).

Sol 698: Spirit took a picture of the target Horseback on Comanche Spur with the microscopic imager. The plan was for Spirit then to brush the target area with the rock abrasion tool's brush and afterwards perform observations with the Mössbauer spectrometer and microscopic imager. The brushing did not occur due to the rock abrasion tool losing contact with the target.

Sol 699: Spirit performed a short Mössbauer spectrometer integration and tried again to use the rock abrasion tool's brush on Horseback. The brush only cleared off roughly 20 percent of the target.

Sol 700: Spirit successfully brushed another area on Comanche, called Palomino. After the brushing, Spirit took pictures of Palomino using the microscopic imager. Spirit also studied Palomino with the alpha particle X-ray spectrometer.

Sol 701: Spirit studied Palomino with the Mössbauer spectrometer and performed remote sensing.

Sol 702 (Dec. 24, 2005): Spirit studied Palomino with the Mössbauer spectrometer and performed remote sensing again.

As of sol 700 (Dec. 22, 2005), Spirit's total odometry is 5,673 meters (3.53 miles).

sol 689-694, Dec 29, 2005: *Spirit Approaching 'Comanche'*

Spirit's main focus was to reach the target informally named "Comanche." Spirit successfully progressed 113 meters (371 feet). Spirit also performed three observations at night of the moons, Phobos and Deimos.

Sol-by-sol summaries:

Sol 689 (Dec. 11, 2005): Spirit performed a 22-hour integration with the Mössbauer spectrometer, took images with the panoramic camera, imaged dust devils with the navigation camera, and performed stares with the miniature thermal emission spectrometer.

Sol 690: Spirit drove for 37 meters (121 feet) toward Comanche using a combination of "blind" driving and autonomous navigation. Spirit observed Phobos and Deimos at night.

Sol 691: Spirit performed untargeted remote sensing using the panoramic camera and miniature thermal emission spectrometer. Spirit observed Deimos at night.

Sol 692: Spirit drove 38 meters (125 feet) toward Comanche. Spirit observed Phobos and Deimos at night.

Sol 693: Spirit took pre-drive imaging of targets informally named "Miami," "Paiute," and "Teepee." Spirit drove 38 meters (125 feet) toward Comanche.

Sol 694: The plan is to drive about 40 meters (131 feet) toward Comanche. At the time of this report, the sol 694 sequence had not executed yet.

As of sol 693 (Dec. 15, 2005), Spirit's total odometry is 5,624 meters (3.49 miles).

sol 680-688, Dec 12, 2005: *Spirit Studying 'Algonquin'*

This week Spirit drove to an outcrop area informally named "Algonquin." On sol 685, Spirit successfully drove for 15 meters (49 feet) and prepared for a series of robotic-arm activities planned for sol 687 to 690 at Algonquin. Plans are to proceed downhill to "Comanche" after that.

Sol-by-sol summaries:

Sol 680 (Dec. 1, 2005): Spirit drove 30 meters (98 feet) toward a feature between "Miami" and Comanche.

Sol 681: Spirit performed remote sensing during the day and observed the moon Phobos at night.

Sol 682: Spirit took images of Algonquin, "Miami," "Pima," and "Yaqui" with the panoramic camera. Spirit observed Yaqui, Pima, Algonquin, "Meentwioni," and "Myammia" with the miniature thermal emission spectrometer.

Sol 683: A planned drive toward Algonquin was not executed.

Sol 684: Spirit took images of a dust devil, did a near-field survey with the panoramic camera, and used the miniature thermal emission spectrometer during the day and at night.

Sol 685: Spirit successfully drove 16 meters (52 feet) to the Algonquin outcrop.

Sol 686: Spirit performed remote sensing during the day and observed the moon Phobos at night.

Sol 687: Spirit used the microscopic imager and alpha particle X-ray spectrometer to study a feature informally called "Iroquet," which is located on the Algonquin outcrop.

Sol 688: Spirit used the rock abrasion tool's brush on Iroquet for 25 minutes, and then continued observations of Iroquet with the microscopic imager and alpha particle X-ray spectrometer.

As of the end of sol 686, (Dec. 8, 2005), Spirit had driven 5,510 meters (3.42 miles).

sol 668-680, Dec 01, 2005: *Downhill Progress*

Spirit is healthy and making good progress downhill. The short-term goal is to drive toward couple of interesting features dubbed "Comanche" and "Miami." A decision on which target to choose for close examination will be made after the drive images come down from sol 680 (Dec. 1, 2005).

Over the Thanksgiving weekend, Spirit used all four devices on its robotic arm -- the alpha particle X-ray spectrometer, the Mössbauer spectrometer, the microscopic imager, and the rock abrasion tool (the brush on the abrasion tool) -- to study an outcrop area called "Seminole. The two targets for use of those tools on this outcrop were informally named "Abiaka" and "Osceola". The names refer to native American tribes in Florida. The investigations of the targets' composition identified abundant olivine and indicated that the outcrop is mafic (bearing a class of usually dark-colored minerals rich in magnesium and iron).

As of sol 679 (Nov. 30, 2005), Spirit has driven 5,463 meters (3.39 miles).

sol 660-667, Nov 18, 2005: *Spirit Observing Meteor Shower*

Spirit is healthy and making good progress downhill. The rover performed an extensive campaign with the tools on the robotic arm at an outcrop called "Larry's Bench" and made targeted observations with other instruments. The team has been taking advantage of every drive sol, averaging about 40 meters (131 feet) per sol.

Mars is currently passing through a debris trail of Halley's comet, and Spirit is attempting to observe resulting meteor showers with the panoramic camera at night.

Sol-by-sol summaries:

Sol 660 (Nov. 11, 2005): Spirit performed robotic-arm work on Larry's Bench. Spirit took pictures of Larry's Bench with the microscopic imager before and after the rock abrasion tool brushed the area. Spirit used the panoramic camera to take pictures of the eastern part of the hill and took images in the direction Spirit plans to drive. Spirit used the alpha particle X-ray spectrometer and attempted to observe the Odyssey orbiter at night.

Sol 661: Spirit performed a long integration with the Mössbauer spectrometer, targeted observations with the panoramic camera (pointed towards "Husband Hill" summit), and targeted stares with the miniature thermal emission spectrometer.

Sol 662: Spirit performed a long integration with the Mössbauer spectrometer, targeted observations with the panoramic camera, atmospheric science, and more stares with the miniature thermal emission spectrometer.

Sol 663: Spirit performed a long integration with the Mössbauer spectrometer, made targeted observations with the panoramic camera and miniature thermal emission spectrometer, and did a meteor search at night.

Sol 664: Spirit stowed the robotic arm, took panoramic-camera images of the arm's work area, and drove 38 meters (125 feet) downhill.

Sol 665: Spirit drove 42 meters (138 feet) downhill.

Sol 666: Spirit drove 40 meters (131 feet) downhill.

Sol 667: No scientifically outstanding targets for the robotic arm were seen near the rover's current location, so the team planned a long drive. The team does not have good images that show the view over the ridge, so the rover will use autonomous navigation and drive with a reduced tilt limit to traverse safely downhill.

As of the end of sol 667, (Nov. 18, 2005), Spirit has driven 5,392 meters (3.35 miles).

sol 655-659, Nov 11, 2005: *Spirit Coordinating with Hubble*

Spirit is healthy. The rover is out of restricted sols and has been making excellent progress. On sol 655, Spirit drove 94.5 meters (310 feet)! The total drive distance from sol 655 to sol 659 was 126 meters (413 feet). Spirit also took a large panoramic camera mosaic looking back at the "East Basin" for a long-baseline stereo observation. Spirit made other observations with the panoramic camera for coordinated science with the Hubble Space Telescope.

Sol-by-sol summaries:

Sol 655 (Nov. 5, 2005): Spirit drove 94.5 meters (310 feet) southeast down onto "Lower Haskin Ridge." The maximum uphill slip was 10 percent at the beginning of the drive. The maximum downhill slip was three percent.

Sol 656: Spirit performed untargeted remote sensing and began observations in coordination with Hubble Space Telescope. The observations included a sky survey, an atmospheric opacity reading, calibration target readings and a horizon survey.

Sol 657: Spirit took a targeted panoramic camera mosaic back at East Basin for the second observation of the long-baseline stereo view. Spirit also performed targeted stares with the miniature thermal emission spectrometer.

Sol 658: Spirit drove 24 meters (79 feet) at a heading of 180 degrees, with an average slip of three percent.

Sol 659: Spirit drove back 8 meters (26 feet) to an outcrop of interest for inspecting with tools on the robotic arm.

As of the end of sol 659, (Nov. 10, 2005), Spirit has driven 5,273 meters (3.28 miles).

sol 647-654, Nov 04, 2005: *Spirit Imaging "East Basin"*

Spirit is healthy. The team operated in "restricted sols" from sol 647 to 654. (Restricted sols occur when the timing of the communications pass from the Odyssey orbiter is too late in the day to gather vital location and health information about the rover after it executed recent commands. The team back on Earth must wait until the next sol to find out where and how the rover is.)

The team planned two long Mössbauer integrations and drove 34 meters (112 feet). On sols 653 and 654, the team planned targeted remote sensing of the "East Basin." This is one of the last opportunities to image it before the basin is no longer in sight.

Spirit also completed three overnight observations. The team returns to standard planning sols the week of Nov. 7, intending to continue driving downhill.

Sol-by-sol summaries:

Sol 647 (Oct. 28, 2005): Spirit performed a 22-hour reading with the Mössbauer spectrometer and made night sky observations.

Sol 648: Spirit performed a 23-hour Mössbauer reading.

Sol 649: Spirit drove 18 meters (59 feet).

Sol 650: Spirit performed remote sensing and made night sky observations with the miniature thermal emission spectrometer.

Sol 651: Spirit drove 16 meters (52 feet).

Sol 652: Spirit performed untargeted remote sensing and made night sky observations.

Sol 653: Spirit performed targeted remote sensing of the East Basin.

Sol 654 (Nov. 4, 2005): Spirit performed targeted remote sensing.

As of sol 654, Spirit has driven 5,143.63 meters (3.20 miles)

sol 641-646, Nov 04, 2005: *Spirit in "Kansas"*

Spirit drove to an outcrop informally named "Kansas" to prepare for a series of robotic arm activities on a target called "Kestrel."

Engineers tested a new UHF-only operation for Spirit. Throughout the mission, NASA's Mars Odyssey orbiter has been successfully receiving data from the rovers using its UHF (ultra-high frequency) antenna and relaying the data to Earth. In the new UHF-only operation, the team attempted to demonstrate how Spirit could also receive commands from Mars Odyssey via UHF antennas. Spirit usually receives commands through its high gain antenna, which collects radio waves in the X-band sent directly from Deep Space Network antennas on Earth.

During sols 641 through 645, Mars Odyssey attempted both to send commands to Spirit and to collect data from Spirit. The commanding was successful on sols 640 and 645, but on sol 644, during receipt of the command bundles, Spirit's computer reset due to flight software difficulties with handling the command loads at the rate of 8 kilobits per second. As a result, all the active sequences were deactivated and Spirit went to automode.

On sol 646, Spirit recovered from automode and continued the robotic arm work on Kestrel.

Sol-by-sol summaries:

Sol 641 (Oct. 22, 2005): Spirit performed targeted remote sensing.

Sol 642: Spirit drove toward the outcrop Kansas to prepare for using tools on its robotic arm to study the outcrop. The drive was successful.

Sol 643: Spirit performed untargeted remote sensing and attempted to observe meteors at night. The team could not confirm any meteors in the pictures from sol 643.

Sol 644: The original plan for sol 644 was to deploy the robotic arm, then to take images of the target area Kestrel with the microscopic imager both before and after brushing the area with the rock abrasion tool. The plan also included an alpha particle X-ray spectrometer reading of the brushed surface at night. A computer reset occurred during the morning Odyssey communications pass of sol 644, and the rover went into automode, so it did not carry out the original plan.

Sol 645: Spirit remained in automode on sol 645, but data indicated that the rover was healthy. Commands were then sent successfully via the Odyssey spacecraft's UHF antenna.

Sol 646: Spirit carried out the science activities from sol 644's plan. The rover is back to normal operation.

As of the end of sol 646, (Oct. 27, 2005), Spirit has driven 5,113 meters (3.18 miles).

sol 634-640, Oct 21, 2005: *Spirit Begins Downhill Drive*

Spirit is healthy and has begun driving downhill from the top of "Husband Hill" toward the south basin. Elevation maps produced from the panoramic camera imagery taken at and near the summit of Husband Hill showed a safe traverse (with vehicle tilts under about 20 degrees) across ridge lines east of the summit. These ridge lines (informally called "Haskin upper ridge" and "Haskin east ridge") are the planned traverse paths for coming weeks. When possible, Spirit will drive each day.

Sol-by-sol summaries:

Sol 634 (Oct. 15, 2005): Spirit finished investigating a rock outcrop called "Hillary" near the summit of Husband Hill. Spirit used the alpha particle X-ray spectrometer and the microscopic imager to study Hillary, then Spirit stowed the robotic arm. Spirit bumped back about 2 meters (7 feet) from the outcrop to complete remote imaging. Spirit used the miniature thermal emission spectrometer and panoramic camera to study targets on Hillary.

Sol 635: Spirit drove 47 meters (154 feet) east from the summit.

Sol 636: Spirit took images with the navigation camera and performed atmospheric observations.

Sol 637: Spirit drove 20 meters (66 feet) during the first of a series of drives toward Haskin upper ridge. There is an apparent drop-off near this ridge; therefore, each drive begins with a short 10-meter (33-foot) "blind" drive, followed by drives using hazard-avoidance cameras and decreased limits on how far the rover can tilt in any direction. The intent is to stop a drive short of any significant change in local elevation.

Sol 638: Spirit drove 29 meters (95 feet) during the second drive to the Haskin upper ridge. Spirit also observed the moons Phobos and Deimos at night.

Sol 639: Spirit covered 17 meters (56 feet) during the third drive of the approach to Haskin upper ridge. This left Spirit about 15 meters (49 feet) from the drop-off and near an area with rock outcrops.

Sol 640: Spirit's planned activities for sol 640 were devoted to remote sensing of the east basin, expected to be within view after the third leg of the sol 639 drive.

As of the end of sol 639, (Oct. 20, 2005), Spirit has driven 5,107 meters (3.17 miles).

sol 626-633, Oct 17, 2005: *Spirit Wiggles into a Sturdy Workspace*

Spirit is healthy and spent the week examining a rock called "Hillary" at the true summit of "Husband Hill." The first attempt to approach Hillary ended with a small pebble under Spirit's left front wheel, and the stability of the rover was uncertain. A set of wheel wiggles was performed to stabilize the rover before deployment of the robotic arm. Once the wheel was in good contact with the ground, Spirit began a conservative robotic-arm campaign, started with Mössbauer spectrometer and alpha particle X-ray spectrometer integrations.

Sol-by-sol summaries:

Sol 626 (Oct. 6, 2005): Spirit began sol 626 on a steep slope, with Hillary in the work area. However, the right front wheel did not look like it was in stable contact with the ground. A set of three wheel wiggles and a final move to steer the wheels against the slip direction reduced Spirit's overall tilt by two degrees.

After looking at several images, rover meshes and RSVP simulations, the planning team was able to determine that the wheel was in a more stable area than it had been earlier. Rover meshes are three-dimensional terrain maps that are created by rover team members by "gluing" together multiple pieces of data from the hazard-avoidance cameras (up-close images), navigation cameras (middle distance images), and panoramic cameras (far-away images) to give a view of the Martian landscape for multiple tactical purposes. RSVP stands for Rover Sequencing and Visualization Program. The rover planners use this software tool to plan sequences of commands for driving and robotic arm work. It can simulate the sequence, showing a model of the rover superimposed on actual images of the Martian terrain.

Sol 627: Spirit deployed the robotic arm. When the arm is deployed while the rover is on a slope, the degree to which the rover is tilting may change. The team expected a change of less than 0.3 degrees and saw only a 0.005 degree change.

Sol 628: Robotic arm work continued with a Mössbauer spectrometer placement on the first of two targets. Targeted remote sensing was also performed.

Sol 629: Spirit continued Mössbauer spectrometer integration and remote sensing.

Sol 630: Spirit changed tools to the alpha particle X-ray spectrometer and made observations with the navigation camera.

Sol 631: Spirit placed the Mössbauer spectrometer on a second target, performed targeted remote sensing and made nighttime observations with the panoramic camera.

Sol 632: Spirit continued the Mössbauer spectrometer integration and remote sensing. The rover also used the miniature thermal emission spectrometer at night.

Sol 633: Spirit took pictures of targets on Hillary using the microscopic imager, performed an alpha particle X-ray spectrometer integration at night and checked for dust devils.

As of the end of sol 633, (Oct. 13, 2005), Spirit has driven 4,993 meters (3.10 miles).

sol 620-626, Oct 10, 2005: *Spirit Preparing for Robotic Arm Work*

Spirit is healthy and still performing science in the summit area of "Husband Hill." The rover has acquired a 360-degree panorama from the top of Husband Hill, and has performed remote sensing of other targets of interest. Spirit drove back down to the clean face of the rock outcrop called "Hillary" to find a good position to perform work with the robotic arm.

Sol-by-sol summaries:

Sol 620 to 622 (Sept. 30 to Oct. 2, 2005): While perched on the summit of Husband Hill, Spirit spent the weekend acquiring a 360-degree color mosaic. Team members took this opportunity to place the Mössbauer spectrometer on Spirit's compositional calibration target for a three-sol integration.

The compositional calibration target provides an independent, external reference source for calibrating the alpha particle X-ray spectrometer and Mössbauer spectrometer. Both instruments also have their own internal calibration reference targets. The compositional calibration target is made of a piece of magnetite rock from Earth, bonded to an aluminum base plate and covered by a protective coating that the Mössbauer spectrometer cannot detect.

The science team also wanted new measurements of the compositional calibration target with the alpha particle X-ray spectrometer to supplement measurements from sols 614 to 619, but rover planners saw a rock under the rover. If the alpha particle X-ray spectrometer were on the compositional calibration target, the rock abrasion tool would be too close to this hazard. The resolution was to do only a Mössbauer spectrometer integration.

Sol 623: There is a fascinating outcrop at the summit called Hillary. From the panoramic camera position on top of the summit, Spirit could access only very dusty areas of Hillary. On sol 623, Spirit began the approach to the clean face. However, the drive did not take place due to a sequencing error.

Sol 624: The second approach attempt succeeded, with a 12-meter (39-foot) drive. From the new location, Spirit imaged potential workspace for the robotic arm. The images allowed rover planners to determine the best way to bump into position for robotic arm work.

Sol 625: A 3.4-meter (11.15-foot) bump put the desired target into the work space. However, the left front wheel is perched upon a small rock and not in full contact with the ground.

Sol 626: Since engineers could not tell if the rover was 100-percent stable, the team decided not to deploy the robotic arm. Instead, the plan is for Spirit to perform small maneuvers. The hazard-avoidance cameras will take images at every step to stabilize the rover and confirm that it is in a safe position to perform robotic arm work.

As of the end of sol 626, (Oct. 6, 2005), Spirit has driven 4,993 meters (3.10 miles).

sol 614-619, Sept 29, 2005: *Spirit Reaches True Summit*

Spirit is healthy and has provided a spectacular view from the top of "Husband Hill." The rover has acquired numerous panoramas from both the navigation camera and panoramic camera. Spirit took coordinated observations with the panoramic camera and the miniature thermal emission spectrometer, and observed the moons Phobos and Deimos at night. Spirit has reached the true summit, which is in the eastern portion of the nearly level hilltop crest that Spirit reached in late August. Plans are to drive to a good imaging location. From the new location, Spirit will acquire a panorama of the plains and valleys below.

Sol-by-sol summaries:

Sol 614 (Sept. 24, 2005): Spirit took a panorama of "Tennessee Valley," and performed targeted remote sensing and atmospheric science. A planned Mössbauer spectrometer reading was not completed, due to a sequencing error.

Sol 615: Spirit used the alpha particle X-ray spectrometer on the compositional calibration target and took a picture of the compositional calibration target with the microscopic imager. The compositional calibration target provides an independent, external reference source for calibrating the alpha particle X-ray spectrometer and Mössbauer spectrometer. Both instruments also have their own internal calibration reference targets. The compositional calibration target is made of a piece of magnetite rock from Earth, bonded to an aluminum base plate and covered by a protective coating that the Mössbauer spectrometer cannot detect. On sol 615, Spirit also performed targeted remote sensing.

Sol 616: Spirit drove about 10 meters (33 feet) towards the true summit and observed Phobos and Deimos at night.

Sol 617: Spirit took pictures from "Position 2" for a stereo panorama. Spirit also observed Phobos and Deimos at night.

Sol 618: Spirit drove 14 meters (46 feet) closer to "True Summit." Mid-drive, Spirit stopped to take a picture of a target called "Hillary." The informal name is in honor of Edmund Hillary. Hillary and Tenzing Norgay were the first to climb to the top of Mount Everest. They reached the summit on May 29, 1953. That summit, at 8,850 meters (29,035 feet) above sea level, is the highest place on Earth. The summit of Husband Hill is 106 meters (about 348 feet) above the Spirit landing site.

Sol 619: The plan is for Spirit to drive about 3.5 meters (11.5 feet) to the summit imaging location. Once at the new location, the plan is for Spirit to take a 360-degree panorama using the navigation camera.

As of the end of sol 618, (Sept. 29, 2005), Spirit has driven 4,973 meters (3.09 miles).

sol 606-613, Sept 23, 2005: *Looking over Tennessee Valley*

Spirit completed a campaign of using the tools on its robotic arm to examine the feature "Cliffhanger." Spirit scuffed the soil using its wheels in the area around Cliffhanger, and then observed both the scuffed and undisturbed soil. In addition, Spirit imaged the moons Phobos and Deimos at night. Spirit also acquired part one of a stereo panorama.

Sol-by-sol summaries:

Sol 606 (Sept. 16, 2005): Spirit performed untargeted remote sensing and took images overnight of Phobos and Deimos.

Sol 607: Spirit performed remote sensing and used the microscopic imager, alpha particle X-ray spectrometer, and Mössbauer spectrometer on the scuff feature of Cliffhanger.

Sol 608: Spirit began a long Mössbauer spectrometer campaign on the exterior of Cliffhanger.

Sol 609: Spirit continued the Mössbauer spectrometer campaign.

Sol 610: Spirit once again continued the Mössbauer spectrometer campaign. The rover also proceeded with a panorama of Tennessee Valley.

Sol 611: Spirit used the Mössbauer spectrometer in the interior of Cliffhanger. Spirit then used the microscopic imager and alpha particle X-ray spectrometer on the exterior of Cliffhanger. Spirit also took overnight images of the moons.

Sols 612 and 613: Spirit is on a two-sol plan, consisting of microscopic imager work and a 2.5-hour drive toward "Hillary" to obtain a better look over Tennessee Valley. This new drive position will set up Spirit for the second position to create the stereo panorama. Plans for sol 613 call for Spirit to perform untargeted remote sensing.

As of the end of sol 613, (Sept. 23, 2005), Spirit has driven 4,949 meters (3.08 miles).

sol 599-605, Sept 16, 2005: *Testing Command Communications*

Spirit has continued observations on the top of "Husband Hill," using the microscopic imager, alpha particle X-ray spectrometer and Mössbauer spectrometer on a target informally called "Irvine." Spirit has also completed three complicated drive sols. It is in position for doing work with the tools on the robotic arm in upcoming sols. During two nights, Spirit observed the moons Phobos and Deimos.

Also this week, Spirit performed two tests to validate the ability to send commands to Spirit via the Mars Odyssey orbiter through the rover's UHF (ultra-high frequency) radio. Downlink through the Odyssey UHF relay has been the principal means for getting data from Spirit. The new tests are for communicating the other direction: sending commands to Spirit via Odyssey UHF relay. The first test was similar to a 1-sol plan; the second contained multiple sequences that simulated a more complicated 3-sol planning day. The team sent old sequences and confirmed that the commands made it onboard the rover, and then the team deleted the files. The first test was successful, and the team is anticipating data to come down from the second test.

Sol-by-sol summaries:

Sol 599 (Sept. 9, 2005): Spirit approached the target Irvine on the feature "Putative Dike." The drive was complex because the rover planners needed to make sure Spirit stayed out of the mast occlusion (or stop) zone.

Sol 600: Spirit deployed the robotic arm, took pictures with the microscopic imager, then placed the alpha particle X-ray spectrometer on a target. Spirit switched to the Mössbauer spectrometer at 10:30 in the morning, Mars local solar time, for continued observations.

Sol 601: Spirit performed a 24-hour Mössbauer spectrometer integration and made overnight observations of Phobos and Deimos.

Sol 602: Spirit performed another 24-hour Mössbauer spectrometer integration.

Sol 603: Spirit drove 16 meters (53 feet), followed by a 4-meter (13-foot) drive using autonomous navigation. Spirit then performed an Odyssey UHF (ultra-high frequency) relay test.

Sol 604: Spirit performed targeted remote sensing operations.

Sol 605: Spirit successfully completed a complicated drive, including scuffing and turning. This was followed by another UHF (ultra-high frequency) test, and then overnight miniature thermal emission spectrometer observations. Spirit also entered restricted sols. (Restricted sols occur when the timing of the communications pass from the Odyssey orbiter is too late in the Earth day to gather vital location and health information about the rover after it executed recent commands. The team back on Earth must wait until the next day to find out where and how the rover is.)

As of the end of sol 605, (Sept. 15, 2005), Spirit has driven 4,935 meters (3.07 miles).

sol 591-598, Sept 09, 2005: *Moonstruck*

Spirit is in good health, power positive, and has no issues. This week the telecom team changed Spirit's uplink rate from 1000 bits per second to 2000 bits per second. In its orbit around the Sun, Mars comes close to Earth for a few months once every two years. Mars is now close enough to Earth that the one-way communication travel time from the spacecraft at Mars to the Deep Space Network antennas on Earth is only about 5 minutes away (at light speed). This shorter communication travel time means that the rover team has plenty of communication-link margin to support the higher uplink rate. The new uplink rate was successful during the sol 598 uplink session.

Between Sept. 2 and Sept. 8, Spirit drove to another imaging location and completed the second stereo imaging campaign. Spirit returned to "Irvine" in order to explore what might be a dike, which is a crack-like cut that often forms when magma from a volcano travels through or over another rock. Spirit also performed more observations of the moons Phobos and Deimos, and completed three days of Mössbauer spectrometer readings on the capture magnets.

Sol-by-sol summaries:

Sol 592 (Sept. 2, 2005): Spirit drove to the second hilltop location for stereo imaging.

Sol 593: Spirit performed remote sensing observations.

Sol 594 and 595: On both sols, Spirit performed a Mössbauer spectrometer reading on a capture magnet, observed Phobos and Deimos, and did stereo imaging.

Sol 596: Spirit performed a Mössbauer spectrometer reading on a capture magnet and took images with 13 filters on the panoramic camera.

Sol 597: Spirit finished the panoramic camera imaging. Spirit used the microscopic imager to take pictures of the capture and filter magnets, and used the alpha particle X-ray spectrometer on the capture magnet.

Sol 598: Spirit drove back to Irvine.

As of the end of sol 598, (Sept. 8, 2005), Spirit has driven 4,895 meters (3.04 miles).

sol 584-591, Sept 02, 2005: *Studying the Summit*

Perched on the crest "Husband Hill," Spirit took images for a summit panorama and used instruments on the robotic arm to investigate soil targets.

Science team has compiled a list of experiments they would like Spirit to execute while the rover is on the summit. This list includes:

- Assess the inner basin and image potential drive paths
- Assess the surrounding terrain and image "Cumberland Ridge"
- Routinely observe the atmosphere during the day and the moons at night
- Study undisturbed soils, scuffed soils, and drift deposits
- Study the structural geology of Husband Hill, including dips
- Observe outcrops and rocks
- Take images for a rover self-portrait
- Complete a panorama on top of the "Columbia Hills"
- Finalize exit strategy

Spirit has already completed some of the above observations. It has taken frames for the self-portrait, looked at soil targets, and imaged the two moons of Mars -- Phobos and Deimos -- twice. After completing the initial summit imaging, Spirit drove southeast to another point in the crest area to assess more of the Cumberland Ridge and surrounding terrain.

Sol-by-sol summaries:

Sol 585 (Aug. 25, 2005): Spirit performed remote sensing operations, did a Mössbauer spectrometer integration, and imaged Phobos and Deimos.

Sol 586: Spirit performed remote sensing operations, did a Mössbauer spectrometer integration, and imaged the rover deck.

Sol 587: Spirit changed tools from the Mössbauer spectrometer to the alpha particle X-ray spectrometer.

Sol 588: Spirit continued with robotic arm operations using the microscopic imager and alpha particle X-ray spectrometer.

Sol 589: Spirit retracted the alpha particle X-ray spectrometer and stowed the robotic arm. The rover backed away to image the area where the robotic arm had been working, then drove to the southeast. Drive distance for the sol was 21 meters (69 feet).

Sol 590: Spirit continued the drive in the east-southeast direction for another 14.2 meters (47 feet).

Sol 591: Spirit turned to point the UHF antenna for better communications with the Odyssey orbiter. Spirit performed remote sensing at "South Point 1."

As of the end of sol 591, (Sept. 1, 2005), Spirit has driven 4,862 meters (3.02 miles).

sol 579-584, Aug 30, 2005: *On Top of the Hill*

After 581 sols and 4,810 meters (2.99 miles), Spirit reached the crest of "Husband Hill."

The top of the hill is moderately flat and fairly easy to navigate. Even though sol 581 (Aug. 21, 2005) marked a major accomplishment for Spirit, the "little rover that could" had no time to rest. On sol 582, the team commanded the rover to drive to a better location for taking images in all directions. This spot was about 20 meters (66 feet) along the crest, and it was from this location that Spirit started acquiring frames with the panoramic camera for a 360-degree, full-color, panorama.

The panoramic imaging will take about 12 hours to complete. In Mars time this means about four sols. On sols 583, 584 and 585, Spirit will image the martian landscape, and the team will wait until sol 586 to image the rover equipment deck.

Since Spirit will be in the same location for a while, Spirit placed its robotic arm onto an undisturbed soil target and started a long Mössbauer spectrometer integration on sol 584.

Sol-by-sol summaries:

Spirit was in restricted sols during sols 570 to 581. (Restricted sols occur when the timing of the communications pass from the Odyssey orbiter is too late in the day to gather vital location and health information about the rover after it executed recent commands. The team back on Earth must wait until the next sol to find out where and how the rover is.)

Sol 579 (Aug. 19, 2005): Spirit performed remote sensing operations.

Sol 580: Spirit performed more remote sensing operations.

Sol 581: Spirit drove toward the summit.

Sol 582: Spirit drove to a better location to take the panoramic camera images.

Sol 583: Spirit turned to get the antenna well-placed for communications with the Odyssey orbiter. The rover took images with the panoramic camera.

Sol 584: Spirit continued taking images with the panoramic camera for a complete 360-degree panoramic image. The rover placed the Mössbauer spectrometer on a target.

As of the end of sol 584, (Aug. 24, 2005), Spirit had driven 4,827 meters (3.00 miles).

sol 572-578, Aug 19, 2005: *Onward and Upward*

Spirit has made 54 meters (177 feet) of forward progress towards the summit of "Husband Hill" this past week. This is excellent progress considering Spirit is on restricted sols, so it can only drive every other sol. (Restricted sols occur when the timing of the communications pass from the Odyssey orbiter is too late in the sol to gather vital location and health information about the rover after it executed recent commands. The team back on Earth must wait until the next sol to find out where and how the rover is.) After sol 576's drive, the team was able to determine highest summit point, which is informally named "Summit 1." Previously, the team believed "Summit 2" was slightly higher. Furthermore, traversing to Summit 2 was deemed difficult, so Spirit is headed towards Summit 1, which is roughly 70 meters (230 feet) away.

Power has been extremely healthy at about 875 to 900 watt-hours per sol. Spirit has been consistently using both morning and evening UHF communications passes with the Odyssey orbiter every sol, which allows the team to acquire and downlink more data.

Sol-by-sol summaries:

Sol 572 (Aug. 12, 2005): Spirit performed targeted remote sensing, including panoramic camera observations with 13 filters and miniature thermal emission spectrometer stares.

Sol 573: The rover completed a 33.5-meter (109.9-foot) drive, driving backwards towards the summit. Spirit also acquired a panoramic camera mosaic.

Sol 574: Spirit performed untargeted remote sensing, including panoramic camera and navigation camera dust devil observations, pre-sunset panoramic camera imaging, and miniature thermal emission spectrometer readings.

Sol 575: Spirit did more untargeted remote sensing, including panoramic camera and navigation camera dust devil observations, panoramic camera images of the filter magnets, and miniature thermal emission spectrometer readings.

Sol 576: Spirit completed a 18.5-meter (60.7-foot) drive backwards and uphill towards the summit. After the drive, the rover made observations with its navigation camera and its miniature thermal emission spectrometer.

Sol 577: The rover looked for dust devils with its navigation camera and made other observations with the panoramic camera and miniature thermal emission spectrometer.

Sol 578 (Aug. 18, 2005): The team prepared a plan for a drive of 20 meters (66 feet) toward Summit 1.

As of the end of its 578th sol on Mars, Spirit has driven 4,742 meters (2.95 miles).

sol 565-571, Aug 16, 2005: *Spirit Continues to Climb*

Spirit has completed investigations with its robotic arm on "Assemblée" rock. The investigation included pictures taken with the microscopic imager, 92 hours of Mössbauer spectrometer integration, and alpha particle X-ray spectrometer work on the target "Gruyere." Other observations included dust devil movies and a panoramic camera image of the rock abrasion tool bit (which has worn down from extensive use because Spirit has exceeded its intended lifespan by more than 480 sols).

As of sol 571 (Aug. 11, 2005), Spirit is still approximately 100 meters (328 feet) from the summit, and the rover will continue driving towards it.

Sol-by-sol summaries:

Sol 565 (Aug. 5, 2005): Spirit took a picture of the bit on the rock abrasion tool and drove 2.35 meters (7.71 feet) to Assemblée.

Sol 566: Spirit did remote sensing and used the microscopic imager and alpha particle X-ray spectrometer to investigate Gruyere on Assemblée.

Sol 567: Spirit used the Mössbauer spectrometer on Assemblée for 23 hours and 5 minutes. Spirit also performed targeted remote sensing, including miniature thermal emission spectrometer stares on four targets and imaging with the panoramic camera.

Sol 568: Spirit took another Mössbauer spectrometer reading on Assemblée for 23 hours and 5 minutes. It also completed panoramic camera imaging with 13 filters on four targets, and it took a dust devil movie.

Sol 569 and 570: Spirit took more Mössbauer spectrometer readings on Assemblée and performed remote sensing.

Sol 571 (Aug. 11, 2005): Spirit used the alpha particle X-ray spectrometer and microscopic imager on two targets on Assemblée.

As of the end of its 571st sol on Mars, Spirit has driven 4,691 meters (2.91 miles).

sol 559-565, Aug 09, 2005: *Spirit 100 Meters from the Top*

Spirit has been busy performing investigations with the tools on its robotic arm. It studied two targets on the rock dubbed "Bourgeoisie," and did a small bump to "Hausmann" to take some microscopic images. The plan was to drive away the next day, but the uplink did not happen correctly. The drive was replanned for Aug. 5 (sol 565). As of sol 564, Spirit is approximately 100 meters (328 feet) from the summit, and the rover will continue driving towards it.

Sol-by-sol summaries:

Sol 559 (July 29, 2005): Spirit continued Mössbauer spectrometer investigations on "Chic" (a target on the rock Bourgeoisie).

Sol 560: Spirit took pictures with the microscopic imager, brushed with the rock abrasion tool, and performed an alpha particle X-ray spectrometer reading on "Gentil Matrice" (another target on Bourgeoisie).

Sol 561: Spirit used the Mössbauer spectrometer on Gentil Matrice and did targeted remote sensing.

Sol 562: Spirit finished its Mössbauer spectrometer investigations on Gentil Matrice, and drove to Hausmann (the rock next door).

Sol 563: Spirit took pictures of Hausmann with the microscopic imager. A drive to "Assemblée" (the next target) was desired, but there was not enough time. A nap was required to keep rover internal temperatures below the allowable limit, so the drive was eliminated from the plan.

Sol 564: The plan was for Spirit to drive a small "bump" to Assemblée. This plan did not make it to the rover. Before the communications uplink window started, the sweep into the low-gain antenna failed, and the Deep Space Network antenna did not lock up on the high-gain antenna until after all sequences were sent. The default science plan already onboard ran studies of the atmosphere with the panoramic camera.

Sol 565 (Aug. 5, 2005): This sol's plan was a repeat of the plan for sol 564, and all commands were sent to Spirit twice. As of the beginning of its 565th sol on Mars, Spirit had driven 4,689 meters (2.91 miles).

sol 551-558, Aug 02, 2005: *Spirit Investigating 'Chic'*

Spirit has reached a target-rich area of the Columbia Hills. In the week of July 21 to 28, 2005, Spirit performed extensive investigations on two rocks, "Descartes" and "Bourgeoisie." Spirit has also acquired coordinated panoramic camera and miniature thermal emission spectrometer observations of several nearby rock targets.

Sol-by-sol summaries:

Sol 551 (July 21): Spirit made a short approach to a rock informally named "Descartes."

Sol 552: Spirit used the microscopic imager and alpha particle X-ray spectrometer on "Discourse", which is a target on Descartes. It also performed general remote sensing.

Sol 553: Spirit brushed the target with the rock abrasion tool, then examined the brushed area with the microscopic imager and the alpha particle X-ray spectrometer. It also made other remote-sensing observations.

Sol 554-555: Spirit performed a long integration with the Mössbauer spectrometer and made remote-sensing observations.

Sol 556: The rover finished using its microscopic imager on Descartes and rolled to the next target, Bourgeoisie.

Sol 557: Spirit took images with its microscopic imager and took readings with its alpha particle X-ray spectrometer on Bourgeoisie. It then used the microscopic imager to shoot frames for mosaics of three areas -- "Gallant," "Gentil" and "Chic" -- and placed the alpha particle X-ray spectrometer on Chic.

Sol 558 (July 28): Researchers sought to have Spirit brush Chic with the rock abrasion tool, but due to the geometry of the target, Chic was deemed un-brushable. Instead, Spirit proceeded with a two-day Mössbauer spectrometer integration on Chic and more remote sensing.

Total odometry as of July 28, 2005 (sol 558) is 4,688 meters (2.91 miles).

sol 546-551, July 25, 2005: *Spirit in Target-Rich Environment*

Spirit had an excellent week, driving every planning cycle. The rover drove more than 70 meters (230 feet) closer to the summit of Husband Hill.

The science team has identified an outcrop suitable for inspecting with instruments on the robotic arm. On Sol 550 (July 20, 2005), Spirit approached that target. The following sol the rover "bumped" forward to get into good position for extending the arm to the target.

Sol-by-sol summaries:

Sols 546 and 547 (July 16 and 17, 2005): Spirit drove about 12.5 meters (41 feet) on sol 547.

Sol 548: Spirit drove about 20 meters (66 feet).

Sols 549: Spirit drove about 30 meters (98 feet).

Sols 550: Spirit drove about 10 meters (33 feet).

Sols 551 (July 21, 2005): Spirit drove about 1 meter (three feet) to get into position for using the robotic arm's tools on an outcrop target. As of sol 551, Spirit has an odometer total of 4,685 meters (2.91 miles).

sol 538-545, July 14, 2005: *Spirit Investigating 'Independence'*

Spirit is healthy. On sol 538 (July 8, 2005), Spirit attempted its rock abrasion tool to brush the rock called "Independence." The tool's contact switches did not engage the rock face, and the brushing did not occur. A safety check precluded further use of the robotic arm. The prescribed operation should have been:

- brush with rock abrasion tool;
- place the alpha particle X-ray spectrometer;
- observe with the microscopic imager;
- place the Mössbauer spectrometer.

From this particular down position for the rock abrasion tool (and the fact that use of the arm was precluded), the rover would not have been able to switch to the Mössbauer spectrometer. The entire weekend's worth data collection by the Mössbauer spectrometer would have been lost. However, the arm preclusion was discovered Friday evening and the team had enough time to modify the robotic arm sequence and recover the weekend's Mössbauer integration time. The sequence of events became:

- enable robotic arm activity
- move the joint angles to avoid an arm position that would prompt collision-avoidance software to halt to arm movements;
- observe with the microscopic imager;
- place the Mössbauer spectrometer.

The recovery plan ran well. The Mössbauer spectrometer was placed and it collected data all weekend.

On later sols the tool turret on the arm was rotated to the alpha particle X-ray spectrometer. That instrument examined the same target for about 17 hours, recovering the alpha particle X-ray spectrometer integration time lost on July 8 (sol 538). Spirit also found time during the weekend to fill in the remaining panoramic camera images for an "Independence" color panorama.

Sol-by-sol summaries:

Sols 538 and 539 (July 8 and 9): The rover team recovered a long reading with Spirit's Mössbauer spectrometer after a planned brushing with the rock abrasion tool did not occur. The rover also took images of the target rock, "Independence" with the microscopic imager and continued taking component images for a large color panorama of the "Independence" scene.

Sols 540 and 541 (July 10 and 11): Spirit continued collecting data with the Mössbauer spectrometer and taking images for the "Independence" panorama.

Sols 542 and 543 (July 12 and 13): Spirit continued the Mössbauer spectrometer integration, then changed the tool to the alpha particle X-ray spectrometer late in the afternoon and collected data with that instrument overnight. In the morning of sol 543, Spirit changed back to the Mössbauer spectrometer for its final few hours of integration. Spirit stowed the robotic arm and bumped back about 80 centimeters (2.6 feet) to a good position for observing "Independence" with the miniature thermal emission spectrometer, now back in use.

Sols 544 and 545 (July 14 and 15): The plans for these sols are for a 25-meter (82-foot) drive followed by a sol of remote-sensing observations from the new location.

sol 532-537, July 11, 2005: *Spirit Scuffs*

Over the Fourth of July weekend, Spirit completed a robotic-arm campaign which had some surprising results. It turned out that targets at "Independence Rock" seem to have less iron than expected. This result prompted the science team to take a closer look. On sol 536 (July 6), because the grinding teeth on the rock abrasion tool are worn, the rover team decided to remove some of the surface area by scuffing it with the front left wheel.

The scuff worked as follows:

1. Spirit moved into position with a turn in place.
2. Rotated only the front left wheel -- reverse 1 radian.
3. Rotated only the front left wheel -- forward 2 radians.
4. Rover used onboard visual odometry.
5. Repeated steps 2 through 4, two more times.
6. Turned in place back to the starting position in order to present the "scuff" to the robotic-arm workspace.

Since the rover gets better alpha particle X-ray spectrometer and Mössbauer spectrometer spectral readings when we let them run long (more than 10 hours for the alpha particle X-ray spectrometer and more than 20 hours for the Mössbauer spectrometer). The rest of the weekend (sols 538 to 541) will be dedicated to work using the instruments on the robotic arm.

Sol-by-sol summaries:

Sol 532 to 535 (July 2 to July 5, 2005): Over this period, Spirit took data with the alpha particle X-ray spectrometer and the Mössbauer spectrometer and made observations with the microscopic imager and remote-sensing instruments. The results motivated a decision to do more work with the robotic arm.

Sol 536: The scuff today worked nicely, except that it did not seem to remove a whole lot of material from the place Spirit scuffed. Overall, the rover only scuffed 9 radians on the rock surface, which is less than 1.5 wheel revolutions. Engineers received no errors during the drive, and it looked like all drive-related telemetry was within acceptable parameters.

After the scuff and before Spirit moved back to its original position, the rover took a picture with the hazard avoidance camera in order to see the effect the scuff had on the wheel treads.

The rover team favored the forward wheel rotation because this creates a torque that needs to work against gravity in order to rotate the rover body.

Sol 537 (July 7, 2005): Spirit started an "Independence" 360-degree color panorama. This mosaic will be run all weekend.

sol 524-531, July 1, 2005: *Spirit Observes 'Independence'*

Spirit has had an extremely successful week. On June 24, 2005 (sol 524), the rover drove 26 meters (85 feet). The following two sols, Spirit performed remote sensing. On June 27 (sol 527), Spirit completed another tricky drive and progressed 22.5 meters (74 feet). At this new site, scientists found an intriguing rock target they informally named "Independence Rock." Spirit will observe this layered rock with instruments on the robotic arm over the long Fourth of July weekend. The rover team commanded a small move positioning Spirit in front of this target, and the rover has begun the science observations. The first attempt to brush Independence Rock with the rock abrasion tool was unsuccessful because contact switches didn't connect. However, the rover team picked a new target in the same general area for Spirit to brush with the rock abrasion tool and analyze with the alpha particle X-ray spectrometer and Mössbauer spectrometer over the weekend.

Sol-by-sol summaries:

Sol 524 (June 24, 2005): Spirit completed an extremely successful drive, advancing 26 meters (85 feet).

Sol 525: On this remote sensing sol, Spirit made observations with the panoramic camera and miniature thermal emission spectrometer.

Sol 526: Spirit checked for dust devils with the navigation camera, took readings with the miniature thermal emission spectrometer and observed the sunset with the panoramic camera.

Sol 527: Spirit drove 22.5 meters (74 feet), evidence of successful work by rover planners.

Sol 528: Spirit executed a small drive of 2.8 meters (9 feet) to position itself to have an interesting rock target, dubbed "Franklin," within the work volume of the robotic arm.

Sol 529: The team planned a sol of using the microscopic imager, rock abrasion tool brush, and alpha particle X-ray spectrometer in preparation for the long weekend plan. However, the rock abrasion tool's contact switches didn't trip, and software responded properly by precluded the robotic arm from doing the subsequent work with the alpha particle X-ray spectrometer.

Sol 530: This plan was difficult and long because it was part of a three-sol plan in preparation for the weekend. Engineers had to re-enable the robotic arm quickly. Spirit performed a 22.5-hour Mössbauer spectrometer integration on Franklin.

Sol 531 (July 1, 2005): This will be the second sol of a three-sol plan, with another long Mössbauer spectrometer integration (23 hours) on Franklin.

Total odometry as of the end of sol 528 (June 28, 2005) is 4,583.38 meters (2.85 miles).

sol 518-524, June 24, 2005: *On the Move*

Spirit started this week by completing two remote sensing sols on June 18 and 19 (sols 518 and 519). The rover made observations with its panoramic camera, navigation camera, and miniature thermal emission spectrometer.

Spirit completed a complex drive plan on June 20 (sol 520), and drove 38 meters (125 feet)!

Spirit continued to drive on June 21 (sol 521) using visual odometry, and drove 9 meters (30 feet).

On June 22 (sol 522), Spirit performed remote sensing including panoramic camera observations with 13 different filters, navigation camera observations of dust devils, panoramic and navigation camera images of the rear tracks, and miniature thermal emission spectrometer observations after the afternoon communication session with the Mars Odyssey orbiter.

Spirit drove again on June 23 (sol 523) for 12 meters (39 feet).

More driving is planned for June 24, 2005.

Total odometry as of the end of sol 523 (June 23, 2005) is 4,530.51 meters (2.82 miles).

sol 511-517, June 17, 2005: *Scenic Stop*

This week Spirit finished examining an area on the rock "Backstay" that was brushed away with the rock abrasion tool. Using the microscopic imager and the alpha particle X-ray spectrometer, the rover also looked closely at an undisturbed area on the rock. Spirit then drove away, pulled over to a scenic overlook to take some high-resolution imaging of "Methuselah," and drove onward. Spirit's next goal is to drive to the top of the next ridge.

Sol-by-sol summaries:

Sol 511 (June 11, 2005): Robotic arm work on Backstay: Post-Brush microscopic images, alpha particle X-ray spectrometer integration on brushed spot. Targeted remote sensing.

Sol 512: Robotic arm work on Backstay, microscopic images and alpha particle X-ray spectrometer integration on un-brushed spot, targeted remote sensing.

Sol 513: Drive towards "Methuselah scenic overlook" (15 meters or 48 feet).

Sol 514: Bump, high-resolution panoramic camera images of Methuselah area, drive on (20 meters or 66 feet).

Sol 515: Driving (18 meters or 59 feet).

Sol 516: More driving (12 meters or 39 feet).

Sol 517: Even more driving planned.

Total Distance as of sol 516 (June 16, 2005): 4,470.26 meters (2.78 miles).

sol 504-510, June 13, 2005: *Browsing at 'Backstay'*

After last week's robotic arm work at "Larry's Outcrop," Spirit headed over to a rock called "Backstay." The rover paused over the weekend to take a closer look at its solar panels and magnets. Spirit arrived at Backstay on Tuesday (June 7, 2005), and has performed a small microscopic image mosaic, rock abrasion tool brush, and Mössbauer spectrometer integration on the rock. Over the weekend (of June 11-12, 2005), the rover will finish robotic arm work and drive on toward the next target.

Sol Details:

Sol 504:
remote sensing/atmospheric science.

Sol 505:
robotic arm work: microscopic image of solar panel and magnets, and Mössbauer spectrometer on capture magnet, targeted remote sensing.

Sol 506:
continue Mössbauer on magnets, targeted remote sensing.

Sol 507:
drive about 4 meters (about 13 feet) to Backstay.

Sol 508:
Bump forward to Backstay.

Sol 509:

robotic arm work on Backstay: microscopic image pre- and post-brush, Mössbauer integration.

Sol 510:

continue Mössbauer, "Tennessee Valley Panorama," targeted miniature thermal emission spectrometer.

Total Odometry: 4404.37 meters (2.73 miles).

sol 497-503, June 03, 2005: *Spirit Hits the 500-Sol Mark!*

Spirit has been working on Mars for more than 500 sols! This week the rover completed its close-up observations of "Larry's Outcrop" and drove back toward "Methuselah," looking for a passable way up to the summit. The rover will continue to drive around the perimeter of "Husband Hill" until it finds a good pathway.

Sol-by-sol summaries:

Sols 497 and 498 (May 27 and 28, 2005):

Spirit used tools on its robotic arm at west Larry's Outcrop and made remote-sensing observations.

Sols 499 to 501:

Spirit continued using the tools on the arm to examine the outcrop and soils. It also made more observations with tools on the camera mast.

Sol 502:

Soil observation; remote sensing.

Sol 503 (June 2, 2005):

Finished soil work, took microscopic images of outcrop, drove toward Methuselah.

sol 490-498, May 27, 2005: *Spirit is Power Positive*

Spirit is healthy and power positive. Spirit is doing some remarkable science at "Larry's Outcrop," moving along the edge of this spot that looks stereotypically Mars-like. As Spirit drives from place to place, the rover reaches out with its robotic arm and samples rocks.

Sol-by-sol summaries:

Sols 490 to 493 (May 19 to 22, 2005):

Over the weekend, Spirit traveled to a location informally called "Paros." On Earth, Paros is one of the Cyclades Islands and lies 96 miles southeast from Athens, Greece. While stopped at Paros on Mars, Spirit used the microscopic imager, the alpha particle X-ray spectrometer and the Mössbauer spectrometer to examine surface details.

Sols 494 to 496:

Spirit finished up observing Paros with the microscopic imager, stowed the robotic arm, and moved to a new spot. While making a final approach, Spirit typically takes images with the hazard-identification cameras. Spirit uses these images to determine whether or not it is safe to deploy the robotic arm. Fortunately, this time, not only did Spirit discover that it was safe to deploy the robotic arm, but the camera also captured a lone dust devil far off in the image.

Sol 495-498 (May 24 - May 27, 2005):

With Spirit now secure in a new location, the team's plan is for the rover to take pictures with the microscopic imager, brush rocks with the rock abrasion tool, use the alpha particle X-ray spectrometer, and place the Mössbauer spectrometer on a target to read it for about 46 hours.

sol 483-489, May 20, 2005: *Spirit Drives to 'Larry's Outcrop'*

Spirit finished work at the target "Reef." Over the weekend (May 14 and 15), Spirit performed work using the instruments on the robotic arm on a target informally called, "Davis" on "Jibsheet." Work included use of the microscopic imager, the rock abrasion tool brush, a long alpha particle X-ray spectrometer integration, and a long Mössbauer spectrometer integration. Spirit spent 2 sols (May 17 and 18) driving to "Larry's Outcrop." Upon arrival, Spirit took detailed navigation camera and panoramic camera observations in support of possible robotic arm work on Larry's Outcrop. Spirit remains in excellent health.

Total odometry as of May 19, 2005, is 4,368.07 meters (2.71 miles).

sol 477- 482, May 17, 2005: *Spirit Observing 'Reef'*

Spirit remains in excellent health. On sols 477, 478 and 479 (May 7 to May 9, 2005), Spirit made observations with remote-sensing instruments and analyzed soil targets with its alpha particle X-ray spectrometer and Mössbauer spectrometer. Spirit then performed a short drive to a target called "Keel," on the outcrop called "Jibsheet." On sol 481, Spirit was able to begin observing a target called "Reef," using the microscopic imager and performing a 16-hour integration with the alpha particle X-ray spectrometer. On sol 482 (May 12), Spirit continued work on Reef with instruments on the robotic arm, and performed a 21-hour integration with the Mössbauer spectrometer.

Spirit's total odometry as of May 12, 2005, is 4,341.19 meters (2.70 miles).

sol 471-476, May 11, 2005: *Spirit Checking Out Pittsburgh*

After finishing robotic-arm work at a rock called "Keystone" in the "Methuselah" outcrop, Spirit backed off to image the rock with the panoramic camera and miniature thermal emission spectrometer. Spirit then scooted forward and to the left to another Methuselah target, informally called "Pittsburgh" (taking the name from Pennsylvania, the "Keystone State"). The rover executed the drive perfectly, however the left front wheel was not quite in contact with the ground, and was presumably perched on a pebble. Since there was a possibility of slipping off of this pebble during work with the robotic arm, the engineering team reworked the sol's plan to bump backwards 5 centimeters (2 inches, the shortest planned drive on Mars) and wiggle the wheels. Work using the instruments on the robotic arm commenced the next sol, when the rover was stable once again. For sol 476 (May 6, 2005), the team planned a bump back to image Pittsburgh with the miniature thermal emission spectrometer and a drive towards "Jibsheet." Since Jibsheet is at least a 2-sol drive away, the team planned the drive to a standoff distance to collect panoramic camera images and do robotic arm work on a soil target.

Sol-by-sol summaries:

Sol 471 (May 1, 2005):

Spirit took pictures of Keystone with its microscopic imager and its panoramic camera after the rock was scrubbed with the brush on the rock abrasion tool. Spirit also took a reading of Keystone with the Mössbauer spectrometer.

Sol 472:

Spirit took more Mössbauer spectrometer readings on Keystone.

Sol 473:

Spirit stowed the robotic arm, drove a short distance backwards and finished imaging Keystone. Then, Spirit drove to the target dubbed Pittsburgh.

Sol 474:

Spirit bumped back 5 centimeters (2 inches) to a stable configuration, and then made coordinated observations with the panoramic camera and the miniature thermal emission spectrometer.

Sol 475:

Spirit took pictures of Pittsburgh with the microscopic imager both before and after the target area was brushed with the rock abrasion tool. Spirit then took a reading on Pittsburgh with the alpha particle X-ray spectrometer.

Sol 476 (May 6, 2005):

Spirit stowed the robotic arm, bumped backwards and finished imaging Pittsburgh, then drove toward Jibsheet.

Total odometry as of the end of sol 476 (May 6, 2005) is 4,339 meters (2.70 miles).

sol 462-470, May 03, 2005: *Spirit Analyzing 'Keystone'*

Spirit is in excellent health. The rover has spent this week (April 22 to April 30, 2005) studying an outcrop called "Methuselah," focusing on the "Keystone" rock. Before Spirit drives away next week, it will have analyzed this feature with every tool in the science payload.

Sol-by-sol summaries:

Sol 462 (April 22, 2005):

Spirit drove 3.8 meters (12.7 feet) to reach a place to stop for the weekend and perform remote sensing.

Sol 463:

Spirit performed light remote sensing to save space in the flash memory for the weekend.

Sols 464-466:

Spirit took extensive imaging of Methuselah. It used its panoramic camera to shoot frames that will be joined together into a mosaic view. Spirit also took images with its miniature thermal emission spectrometer and made atmosphere observations.

Sol 467:

Spirit did a 4.75-meter (16-foot) drive to Keystone, a rock that is part of the Methuselah outcrop. The rover also used its miniature thermal emission spectrometer to examine a target informally called "Abigail."

Sol 468:

Spirit used the panoramic camera and the miniature thermal emission spectrometer to takes images of Abigail and another target called "Priscilla."

Sol 469:

Spirit took pictures of Keystone with the microscopic imager and performed an overnight alpha particle X-ray spectrometer integration on Keystone.

Sol 470:

Spirit finished acquiring mosaic pictures of Keystone with the microscopic imager, dusted the target with the rock abrasion tool brush, and performed another overnight alpha particle X-ray spectrometer integration.

As of sol 470 (ending on April 30, 2005), Spirit's odometry total is 4,310.68 meters (2.68 miles).

sol 456-462, April 21, 2005: *Spirit Drives to 'Methuselah'*

Spirit has had a great week. The rover has completed some soil studies, taken lots of images, done a little driving, and captured a dust devil image with its panoramic camera. Late in the week, Spirit drove over to a piece of outcrop called "Methuselah." Spirit is healthy and doing fine!

Sol-by-sol summaries:

Sol 456 (April 15, 2005):

Spirit drove toward a soil target to perform a maneuver that engineers and scientists call a "scuff." To scuff the soil, Spirit rotates and backspins one of its front wheels, creating a very shallow trench.

Sol 457, 458, 459:

The scuffmark that Spirit created gave the science team a chance to do some soil studies. Spirit used its full complement of science instruments over the weekend (April 16 and 17, 2005) to learn about the soil.

Sol 460:

Spirit took some additional images of the scuff with the microscopic imager, and then drove toward a piece of outcrop in the neighborhood, which attracted the eye of science team. The science team thinks the outcrop is pretty old and has given it the informal name Methuselah.

Sol 461:

Using the panoramic camera, Spirit captured an image of a dust devil passing by.

Sol 462 (April 21, 2005):

The plan is for Spirit to drive about 4 meters (13 feet) closer to Methuselah in order to be in position for an extended imaging campaign during the weekend.

sol 449-456, April 18, 2005: *Spirit Gets Through a Rough Week*

Talk about a rough week! Spirit experienced a few software glitches, command sequencing errors, and particularly tough terrain from April 8 through April 15, 2005. After problems were solved, the rover picked up and continued exploring the "Columbia Hills."

Sol-by-sol summaries:

Sol 449 (April 8, 2005):

Spirit has been attempting to climb steep and rock-strewn slopes in the Columbia Hills. The rover automatically went into safe mode when the flight software rebooted on sol 449. Spirit then waited to get commands from engineers back on Earth.

Sol 450:

An overlooked condition caused more headaches for the beloved Spirit. When the software rebooted on Sol 449, Spirit lost knowledge of where its high-gain antenna was pointed. When Spirit tried to use the antenna during sol 450's uplink without knowing where it was pointed, a fault condition resulted. Since Spirit could not figure out where to point the antenna, the rover missed the uplink for the day.

Sol 451:

In order to get out of the fault condition, the rover uplink team came in on the weekend, and put the spacecraft into safe mode, a status in which only systems vital to the rover's health operate. The team commanded Spirit out of the high-gain antenna pointing error and left Spirit in auto mode. Auto mode occurs when the spacecraft is not running instructions from the Earth, but rather is taking care of itself.

Sol 452:

Because Spirit was in auto mode, with no sequence of commands running, Spirit just relaxed and took care of itself on sol 452.

Sol 453:

Before Spirit could drive, the rover needed to take fresh images of the surrounding terrain. Sol 453 was spent taking these images in preparation for driving on sol 454.

Sol 454:

Spirit made another attempt to drive uphill. The drive did not go very well. Spirit slipped quite a bit. Engineers and scientists decided to try a different tactic for Spirit to climb this hill.

Sol 455:

Rover team scientists and engineers decided that they had tried long enough to coax Spirit up this hill at this location and that it was time to try another approach. Instead of going up, Spirit would go down and cross the slope a bit. They will send Spirit cross slope until an easier path to the summit is identified.

Sol 456 (April 15, 2005):

This sol's plan consists of a small drive forward to a soil target where Spirit will use its front wheels to churn up a bit of Mars. The plan is to then examine this soil with instruments on the robotic arm.

sol 442-448, April 08, 2005: *Spirit Switchbacking Uphill*

Spirit continues slipping in sandy terrain but forges ahead using crafty techniques such as switchbacking and creating a zigzag course.

Sol-by-sol summaries:

Sol 442 (March 31, 2005):

Spirit drove successfully uphill for 12.6 meters (41.3 feet). At the start of the drive, Spirit averaged a 42.7 percent slip, but this quickly improved. In the last 3 meters (10 feet), Spirit only slipped 14.6 percent. The average slip for the drive was 17.6 percent.

Sol 443:

Spirit performed 4 hours of targeted remote sensing, which included panoramic camera images and miniature thermal emission spectrometer readings.

Sol 444:

The team planned a long drive through tricky terrain with switchbacks to help Spirit ascend. Spirit drove approximately 8.8 meters (29 feet).

Sol 445:

Spirit performed remote sensing in the afternoon, including an image brightness test with the navigation camera. The goal of this test is to establish the latest time when Spirit can take images prior to sunset and still have viable images to use in the rover drivers' planning tools. The image analysis may allow the rover team to use later times for post-drive imaging and thus increase Spirit's drive time every sol. This is part two of the testing.

Sol 446:

Spirit and Opportunity use NASA's Mars Odyssey orbiter as their main communications link between Mars and Earth. On April 2, Odyssey entered "safe mode," which is a protective state a spacecraft automatically enters when onboard fault protection software instructs the spacecraft to disregard its onboard sequence of commands and wait for instructions from the ground. As a result, relay communication with the rovers was suspended, and Spirit did not receive any data from sols 444 and 445. With an unknown status of the rover after its drive, the Spirit team restricted rover operations to remote sensing.

Sol 447:

The Odyssey flight team scrambled to recover the orbiter, but it remained in a safe state, not yet available to support relay communications. Spirit received very little information from its "direct-to-earth" communications link, so the rover team planned another basic remote sensing sol, which generated little data.

Sol 448 (April 7, 2005):

Spirit performed additional remote sensing, including panoramic camera and navigation camera imaging. The Odyssey team brought the orbiter back on-line, the Spirit team received all imaging needed for continuing to drive, and team members are planning to drive on sol 449 with a new appreciation for their orbiting partner! The Odyssey team is investigating the cause behind the fault protection software sending the orbiter into safe mode.

sol 436-441, April 04, 2005: *Spirit Slipping on New Terrain*

Spirit is heading toward the summit of "Husband Hill." The rover has been making slow progress recently due to slippage on new, sandy terrain, but it is persevering to reach the target. The rover team performed image brightness tests with the navigation camera to assess how late in the sol Spirit can use sunlight for imaging.

Sol-by-sol summaries:

Sol 436 (March 25, 2005):

Spirit took panoramic camera images of areas dubbed "Cottontail" and "Blanket." The rover also completed a 24-meter (79-foot) drive.

Sol 437:

Spirit took some post-drive images and performed other remote sensing. It took a sky survey, measured the opacity of the atmosphere, and looked for dust devils.

Sol 438:

Spirit did a lot of remote sensing on sol 438, taking three surveys of the sky, measuring the opacity of the atmosphere, searching for dust devils, and looking for clouds.

Sol 439:

Spirit drove 3 meters (10 feet). It also conducted an image brightness test with its navigation camera. The rovers can't take images when it is too late in the sol since they use the natural light from the Sun to illuminate features on Mars. The rover team experimented with taking pictures later and later this sol. Currently, the rover team does not usually take pictures after long drives, but if the images taken later in the sol come back clear and useful, then the team will start commanding the rover to take images later in the sol, after drives.

Sol 440:

Spirit completed a 1.7-meter (5.7-foot) drive.

Sol 441 (March 31, 2005):

The rover completed a 2.28-meter (7.48-foot) drive. On the new terrain that Spirit has reached, the rover slipped 45 percent on an 11-degree slope. In the past, when Spirit was on an 11-degree slope, the rover did not slip as much, but this terrain is much sandier than previous terrain Spirit has driven on. The rover used to have a slip limit at 40 percent, so the rover would automatically shut off if it slipped that much. The rover team increased the allowable slippage to 60 percent to enable the rover to progress and move forward.

sol 430-435, March 24, 2005: *Using Extra Energy to Head Uphill*

After a very busy weekend, Spirit packed up the robotic arm and headed away from an area dubbed "Paso Robles." Spirit should be able to make good progress towards the "Husband Hill" summit in the upcoming sols, using as much of the abundant solar energy as it can. Extra power comes courtesy of an early-March windstorm that blew off year-old dust from Spirit's electricity-producing solar panels.

Sol-by-sol summaries:

On sol 430 (March 19, 2005), Spirit took readings of a soil target called "Paso Dark" with the Mössbauer spectrometer, made atmospheric-science observations, shot targeted panoramic camera images and collected miniature thermal emission spectrometer readings. Then the rover performed an overnight alpha particle X-ray spectrometer reading on an area of soil that had a mix of light and dark colors.

On sol 431, Spirit took pictures of the solar panel, some undisturbed soil, and Paso Dark with the microscopic imager. Spirit also took another short reading of Paso Dark using the Mössbauer spectrometer before stowing the robotic arm. The rover then made a short drive backwards to get in good position for taking images of the area where it had used the instruments on the robotic arm. After taking those images, Spirit resumed its drive toward the summit of Husband Hill, rolling a total of 10 meters (33 feet) for the day. Then it took images from its new location.

On sol 432, Spirit took panoramic camera images of its own deck for a little self portrait and made atmospheric-science observations.

On sol 433, Spirit continued with atmospheric readings, took panoramic camera images of its magnets, and searched for dust devils.

On sol 434, Spirit drove 20 meters (66 feet), did post-drive imaging, and took atmospheric readings.

On sol 435, Spirit did more atmospheric readings and a survey of the ground. As of sol 435 (March 24, 2005), Spirit has driven a total of 4,197.5 meters (2.61 miles).

sol 422-429, March 21, 2005: *Busy with the Robotic Arm*

After some accumulated dust was blown off of Spirit's solar panels on sol 420 (March 9, 2005), the rover has been producing over 800 watt-hours of energy per sol, about twice as much as before the solar-array cleaning event. All that extra power has allowed Spirit to do a very aggressive scientific campaign at a soil patch dubbed "Paso Robles 2" with the instruments on the robotic arm. The rover team planned to wrap up the robotic arm work and send Spirit driving again on sol 431.

Between sols 416 and 418, the front hazard-avoidance cameras showed signs of dust contamination. Images from sol 420 indicate that the left front hazard-avoidance camera has been mostly cleaned off.

Sol-by-sol summaries:

On sol 421, Spirit drove and took images that caught a dust devil in action!

On sols 422 and 423, Spirit collected atmospheric-science and other remote-sensing observations. Spirit also performed a dust calibration with the alpha particle X-ray spectrometer.

On sol 424, Spirit drove to "Paso Robles2" and scuffed the surface with its wheels.

On sols 425 and 426, Spirit made some remote-sensing observations. On sol 426, Spirit also used the microscopic imager to take pictures of "Big Clod" and "Bitty Clod." Spirit also studied a target informally called "Paso Dark" with the Mössbauer spectrometer and a target called "Paso Light" with the alpha particle X-ray spectrometer.

On sol 427, Spirit used the alpha particle X-ray spectrometer and the Mössbauer spectrometer again on Paso Dark. Spirit also took pictures of Paso Light and Paso Dark with the microscopic imager.

On sol 428, Spirit did targeted remote sensing and placed the alpha particle X-ray spectrometer on "Ben's Clod" and the Mössbauer spectrometer on Paso Light.

On sol 429 (March 18, 2005), Spirit swept the surface of Ben's Clod with the brush of the rock abrasion tool and took before-and-after shots of the area with the microscopic imager. Spirit also completed a short Mössbauer spectrometer reading on Paso Dark and an alpha particle X-ray spectrometer reading on Ben's Clod.

sol 416-421, March 14, 2005: *High Winds Make Spirit Full of Energy*

Spirit is in good health and is successfully using a new version of flight software. After completing an investigation of a rock dubbed "Watchtower," Spirit is returning to a soil area of interest informally labeled "Paso Robles." Tau, a measure of how much sunlight cannot penetrate the atmosphere, rose to a high of 1.5 on the afternoon of sol 418, but the opacity of the atmosphere has since dropped off. Energy output from Spirit's solar panels is up as of sol 420, indicating that some cleaning of dust off of the solar arrays may have occurred naturally.

As Spirit and Opportunity are the first solar-powered vehicles on the surface of Mars during the dust storm season, this is a learning experience. There are likely large transient dust storm events that reduce solar energy due to dust deposition on the solar arrays and blocking some sunshine, but also may sometimes raise energy levels by cleaning dust from arrays, possibly by winds associated with dust storms. The impact on other rover systems, such as cameras, will also be closely monitored.

Sol-by-sol summaries:

On sol 416, which ended on March 5, 2005, Spirit awoke around 4 a.m. local solar time at Gusev Crater to start its alpha particle X-ray spectrometer and use a communication window with the Mars Odyssey orbiter passing overhead. Later, Spirit did a three-hour grind with its rock abrasion tool, digging about 7 millimeters (0.27 inch) into Watchtower. Spirit then placed the alpha particle X-ray spectrometer into the rock abrasion tool hole for an overnight integration.

On sol 417, Spirit gathered images of the rock abrasion tool hole with the microscopic imager, performed a variety of remote-sensing observations, and then placed the Mössbauer spectrometer in the hole for an overnight integration.

On sol 418, Spirit continued the Mössbauer spectrometer integration and acquired remote-sensing data. A regional dust storm caused tau the reach a new high if 1.5 in the afternoon and reduced solar energy for the day to roughly 350 watt-hours. After the dust storm, Spirit's front hazard-avoidance camera showed signs of dust contamination similar to that seen earlier on Opportunity's rear hazard-avoidance camera.

On sol 419, Spirit completed remote-sensing observations, including imaging to learn more about the contamination on the front hazard-avoidance camera. Slight mottling is visible in images from both eyes of the stereo camera. It is not enough to affect use of the camera or to have any direct impact on rover operations, but understanding how it happened might help the rover team minimize future occurrences. Spirit then moved backwards about 1 meter (3 feet) from Watchtower to use mast-mounted instruments for observing that rock. After that, it starting to drive toward the soil target Paso Robles. However, the planned 14-meter (46-foot) drive ended after just 1 meter (3 feet) due to a software sequence ordering issue.

On sol 420, Spirit drove 7 meters (23 feet) of a planned 14 meters (46 feet) towards Paso Robles. The drive ended prematurely due to a problem in visual odometry, which is part of the software that enables the rover to drive autonomously. Energy output from the solar array rose dramatically, to more than 600 watt-hours. In part, this is due to a favorable northerly tilt of the rover, which points the solar arrays toward the Sun. Also, tau is going back down, but it is possible that some cleaning event occurred that reduced the dust on the solar panels.

On sol 421, Spirit drove 7 meters (23 feet) and arrived close to the Paso Robles target. Spirit still needs another few meters to get into position to use the instruments on its robotic arm. Solar energy continues to be very high: more than 700 watt-hours. The last time Spirit had this much energy was around sol 80!

sol 408-415, March 07, 2005: *Spirit Perched at 'Larry's Lookout'*

Spirit's focus on sols 408 through 412 was the spectacular panorama from "Larry's Lookout." After completing that 4-sol effort, Spirit rolled to a nearby rock target called "Watchtower" and began examining it with tools on the robotic arm.

Spirit is in excellent health. Skies are clearing of dust and Spirit's solar panels are angled at a high northerly-tilt. So, as Mars approaches the spring season, Spirit has had ample power and a full battery at the start of each recent sol. Flash memory is also in good shape despite the large panorama acquired, thanks to good downlinks and data management.

Sol-by-sol summaries:

On sol 408, Spirit was unable to uplink due to a communications transmitter failure.

Sol 409 was a repeat plan of sol 408, and Spirit drove 2.7 meters (8.9 feet) to Larry's Lookout.

Sols 410 and 411 were the first of four days of using the panoramic camera to acquire frames for a panorama from Larry's Lookout.

On sols 412 and 413, Spirit continued acquiring the panorama and also made observations with the miniature thermal emission spectrometer.

On sol 414, Spirit moved slightly to put Watchtower into the work volume for the robotic arm.

On sol 415, Spirit brushed the dust off of an area on Watchtower with the rock abrasion tool and started an overnight integration with the alpha particle X-ray spectrometer.

Sol 415 ended on March 4, 2005.

Spirit's current total odometry is 4,161 meters (2.59 miles).

sol 402-407, February 28, 2005: *Spirit Taking in 'Tennessee Valley'*

Spirit has spent the last 70 sols climbing up the "Columbia Hills" to reach "Larry's Lookout," a point on "Cumberland Ridge." Having accomplished the trek up to Larry's Lookout, Spirit is getting into position to shoot a panorama of the "Tennessee Valley" located below. Spirit is still in excellent health.

Sol-by-sol summaries:

Sols 401 and 402 were planned in a single planning cycle. On sol 401, Spirit placed the Mössbauer spectrometer on a target of disturbed soil called "Paso Robles" and collected data for most of sols 401 and 402. Spirit also performed about three hours of remote-sensing observations, including imaging of Phobos, one of the moons of Mars.

Sols 403 through 405 were planned in another single planning cycle, to allow the Earthlings to take President's Day holiday off. Sol 403 was spent continuing the very long Mössbauer spectrometer integration on Paso Robles. Spirit stowed the rover arm, and then moved back about a meter (3 feet) to allow imaging of Paso Robles with the miniature thermal emission spectrometer and panoramic camera.

Spirit then began moving closer to Larry's Lookout, covering 16 meters (52 feet). On sol 405, Spirit spent over two hours performing remote-sensing observations and recharging the batteries.

Spirit moved still closer to Larry's Lookout on sol 406, driving another 14 meters (46 feet) uphill. By the end of the drive, Spirit was within 5 meters (16 meters) of the crest. Spirit also performed another Phobos observation.

On sol 407, Spirit reached Larry's Lookout, driving another 3.5 meters (11 feet). Spirit performed an hour of post-drive imaging and was ready to begin observations of Tennessee Valley.

Total odometry as of sol 407 is 4,157 meters (2.58 miles).

Sol 407 ended on Feb. 24, 2005.

sol 394-402, February 24, 2005: *Spirit's Intelligence Increasing*

Spirit is getting new software for increased brainpower, but the rover is not using it quite yet.

Sol-by-sol summaries:

On sol 394, Spirit drove to a safe spot for good communications with Earth during upload of new software. The rover team successfully loaded all of the new software modules on sol 395 and booted the spacecraft with the latest software on sol 397. At the end of sol 397, the rover team re-booted back into the old software. Opportunity (Spirit's sister) is running on the new software, and Spirit will start using it after the project team gets a chance to see the software's new capabilities in action.

On sol 398, Spirit continued climbing toward "Larry's Lookout" in the "Columbia Hills" with an 18-meter (59-foot) drive backward up the hill. During part of the drive, the rover slipped, and Spirit churned up some soil under the front right wheel. In the images taken after the drive, the rover team noticed some very bright spots in the soil.

On sol 399, Spirit placed the robotic arm down on the churned up soil and performed a quick reading of the soil's composition with the alpha particle X-ray spectrometer. Spirit then stowed the robotic arm and continued the drive toward the summit. However, the attempted drive failed due to slippage, and Spirit ended up only churning up more soil. This turned out to be fortuitous because the alpha particle X-ray spectrometer reading the rover team received on sol 400 from the sol 399 integration showed interesting results. Because the team had only a quick alpha particle X-ray spectrometer reading the sol before, the rover team decided to dedicate sol 400 to doing a more extensive integration with the same instrument.

For sols 401 and 402, Spirit's instructions were to complete more observations of the soil at this location. Spirit changed tools to the Mössbauer spectrometer for collecting data with that instrument more than 12 hours each day. The plan actually ended in the early morning hours of sol 403. During the morning of sol 403, Spirit attempted to image Phobos (one of the moons of Mars) as it eclipsed the Sun. Sol 402 ended on Feb. 18, 2005.

sol 388-393, February 15, 2005: *Spirit Braving the Dust on Mars*

Spirit's solar panels are collecting a fine layer of dust, which has reduced energy levels, but Spirit keeps on keeping on.

Sol-by-sol summaries:

Spirit completed an approximately 13-meter (43-foot) drive toward the "Cumberland Ridge" on sol 388. Spirit spent sol 389 performing the usual set of remote-sensing observations.

On sol 390, Spirit drove closer to "Larry's Lookout," about 13 meters (43 feet) backwards uphill. Spirit stopped when the rover reached the mobility time-of-day limit, which is a time of day that engineers program into the software to ensure the rover won't deplete all of its power at the end of a day's drive. Then, Spirit performed a set of remote sensing observations on sol 391.

Sol 392 was planned as a 23-meter (75-foot) drive toward Larry's Lookout, plus some post-drive imaging in the drive direction with the navigation camera and panoramic camera. The usual remote-sensing science was planned for various times throughout the sol. However, Spirit halted after completing the first segment of the drive, a distance of only about 12 meters (39 feet). The halt may have been due to rocks nearby considered too dangerous by the rover's autonomous navigation system. This left Spirit with more driving to do on the next drive opportunity. Spirit also has been taking energy from the batteries recently (due to increased dust in the atmosphere, which has covered the solar panels with a thin layer of dust, blocking some of the light that provides energy via the solar panels).

On sol 393, the rover team planned an easy remote-sensing day in order to try to put back some energy into the batteries.

The plan for sol 394 was to perform a careful drive of about 6.4 meters (21 feet) to park in a spot where the rover team can carry out an upload of new flight software. The spot was chosen for an orientation facilitating the high gain antenna to point to Earth for good communication during upload of the flight software. Sol 394 ended on Feb. 11.

As of sol 393, Spirit's total odometry is 4,108 meters (2.55 miles).

sol 381-388, February 07, 2005: *Spirit Encounters 'Alligator'*

Spirit has completed examination of a rock target called "Alligator," using every tool on the instrument deployment device (robotic arm). With Spirit's batteries recharged and atmospheric dust stable again, the rover is in excellent health and ready to approach "Cumberland Ridge," a crest on "Husband Hill."

Sol-by-sol summaries:

Having completed close-up observations of the rock named "Peace," Spirit stowed the robotic arm on sol 381, bumped back 1.2 meters (3.9 feet), imaged Peace, and then drove 17 meters (56 feet) toward the crest of Husband Hill. The amount of electric current drawn by the rear wheels rose higher than normal, most likely due to an 18-degree tilt during the drive. Spirit then performed 30 minutes of post-drive imaging.

On sol 382, Spirit made a 4-meter (13-foot) approach to the next target, informally named "Alligator." The drive succeeded as planned, putting Alligator perfectly in the workspace for rover-arm operations.

On sols 383 and 384, Spirit performed a couple hours of remote-sensing observations.

On sols 385 and 386, Spirit completed complicated rover-arm operations. During 80 minutes on sol 385, Spirit scoured some side-by-side patches of Alligator's surface with the wire bristles on the rover's rock abrasion tool, creating a brush mosaic. Spirit took readings with the Mössbauer spectrometer for 90 minutes, switched tools to the alpha particle X-ray spectrometer for 20 minutes of data-collection with that tool, then switched back to the Mössbauer spectrometer for more observations through 3:00 a.m. Mars local solar time on sol 386. Later on sol 386, Spirit took close-up pictures of the brush mosaic using the microscopic imager. Spirit then stowed the rover arm. The rover moved 1.2 meters (3.9 feet) back away from Alligator, and then performed an hour of post-drive imaging.

Sol 387, which ended on Feb. 3, was a restricted sol because information from the previous sol's operations could not be available in time for the team to plot further driving. So Spirit spent 2.5 hours performing remote-sensing observations using the panoramic camera and miniature thermal emission spectrometer.

Total odometry as of sol 357 is 4,070 meters (2.53 miles).

sol 374-380, February 02, 2005: *Spirit Productive with Peace Efforts*

Spirit had another productive week in the locale of a target called "Peace." Because of strong interest in the unusual character of "Peace," the team decided to throw the full science instrument payload at the rock.

Sol-by-sol summaries:

On sol 374, Spirit performed a successful 40-minute grind on Peace. The short grind time was due to energy limitations on the rover, which were a result of a dust storm that limited solar energy. The rock abrasion tool performed with no anomalies, and a 3.22- millimeter hole was made, removing some of the upper rock surface. Then, Spirit placed the alpha particle X-ray spectrometer in the hole drilled by the rock abrasion tool. The usual morning and evening remote-sensing science observations were conducted.

On sol 375, Spirit placed the Mössbauer spectrometer in the abraded hole. Again, the usual remote-sensing science observations were made.

On sol 376, Spirit continued the Mössbauer spectrometer integration, then Spirit changed tools to take pictures of the rock abrasion tool hole with the microscopic imager. Spirit performed more remote-sensing science.

On sol 377, Spirit completed a successful 1-hour-and-56-minute grind on Peace. This was the second attempt at grinding this rock target because the depth of first grind on sol 274 was deemed insufficient by the science team to really get inside the rock. The rock abrasion tool again performed the operation with no anomalies. It ground an additional 9.7 millimeters into the previously abraded surface. This additional depth did not necessarily add directly to the depth achieved on sol 374 due to potential rover arm placement errors, but it was the deepest rock abrasion tool hole created to date!

On sol 378, Spirit started the Mössbauer spectrometer reading at noon and integrated until 3:00 a.m. The usual atmospheric science was conducted.

On sol 379, Spirit restarted the Mössbauer spectrometer to get four hours of observations during the day, and an alpha particle X-ray spectrometer reading was taken overnight. Atmospheric science, miniature thermal emission spectrometer readings of "Boycott", and an alpha particle X-ray spectrometer reading were taken overnight.

On sol 380, the Science Operations Working Group (SOWG) decided that Spirit should remain at the location with "Peace." Spirit collected pictures of the deep rock abrasion tool hole with the microscopic imager. The microscopic imager images of the bottom of that hole were received on the ground. A short alpha particle X-ray spectrometer integration on a new "Peace" target was collected just before the Odyssey orbiter communications pass, and the data were sent down on that pass. A long alpha particle X-ray spectrometer integration (greater than eight hours) will come down later. Additional pictures of Peace from the microscopic imager were collected. The miniature thermal emission spectrometer monitored dust. The panoramic camera and hazard avoidance camera took images of the rock abrasion tool's magnets and grinding bit. The atmosphere has become slightly less dusty since the latest reporting. Sol 380 ended on Jan. 27.

sol 367-373, January 24, 2005: *Spirit at 'Peace'*

Spirit is healthy, but reduced sunlight has been reaching the rover through the atmosphere due to a possible dust storm identified from orbital data. Despite limited energy during the period from sol 367 through sol 373, Spirit made good progress by driving about 20 meters (66 feet) closer to top of "Cumberland Ridge." Spirit is investigating a rock called "Peace."

Sol-by-sol summaries:

During a two-sol plan on sols 367 and 368, Spirit traversed about 14 meters (46 feet) up the steep hillside toward the ridge and a target named "Larry's Lookout." The average slippage during the drive is estimated at 14 percent, indicating much firmer footing than previous drives. Sol 368 was a remote sensing sol. Spirit made observations with its panoramic camera and its miniature thermal emission spectrometer and performed a successful test of the right eye of the panoramic camera to find the Sun. The rover team usually uses the left panoramic camera to locate the Sun.

"Sun finding" is sometimes called "get fine attitude" or "attitude update," and is something engineers do every couple of weeks to correct error in the rover's knowledge of attitude -- mostly which way is north. This takes the same kind of images of the Sun that the atmospheric science team does, but the engineers use the data to determine attitude. Between the updates, the rover uses the onboard computer to keep track of attitude changes, but error builds up in this measurement over time. In general, most of the panoramic camera images of the Sun are acquired for atmospheric science. Many images are used to determine how much dust is in the atmosphere (atmospheric opacity or Tau). Usually engineers take these images three or four times during the day. With the current dust storms, the team is taking even more images of the Sun.

Sols 369, 370, and 371 were part of a three-sol plan. On sols 369 and 370, Spirit looked for more science targets en route to Larry's Lookout. On sol 371, Spirit completed a 6-meter (20-foot) drive to arrive at the rock target "Peace." Due to the slope and small rocks in area, Spirit sat at an overall tilt of 19 degrees to the north-northeast, which was very good for maximizing solar energy.

On sol 372, Spirit deployed the rover arm and acquired a set of images of Peace taken by the microscopic imager. A sequencing error prevented the alpha particle X-ray spectrometer from being placed on the rock, delaying the planned integration. The opacity of the sky, or Tau, which is the amount of light that cannot penetrate through the atmosphere, rose sharply from 0.8 to 1.1.

On sol 373, Spirit acquired more images with the microscopic imager and brushed Peace with the rock abrasion tool. The rover then placed the alpha particle X-ray spectrometer on Peace successfully for a nighttime integration. Tau continued upwards to 1.3, further reducing solar energy for Spirit.

Solar energy continues to be a precious resource because of the high Tau on sol 373. Although dust storms are more likely at this time of martian year, the start of the true dust storm season is still months away. Sol 373 ended on Jan. 20, 2005.

sol 360-366, January 14, 2005: *Spirit Close to the Crest*

Currently Spirit is approximately 50 meters (164 feet) from a target called "Larry's Lookout" on a ridge line in the "Columbia Hills." During the period from sol 360 through sol 366, engineers focused on maximizing the amount of time Spirit could drive every sol with limited power. The driving is slow and difficult; Spirit is encountering many rock obstacles and patches of soft sand that are causing Spirit to either slip or dig in. Just when it looked like Spirit might not be able to reach Larry's Lookout, the rover had three successful drive sols. Spirit is in excellent health as the team looks forward to celebrating the anniversary of Opportunity's landing on Jan. 24.

Sol-by-sol summaries:

Sol 360 was a repeat of sol 358's drive. Spirit performed an "S" turn and then drove straight for about 4 additional meters (13 feet). This was a refreshingly good result for the tough terrain where Spirit was located. Spirit experienced as much as 48 percent slippage during the drive, but ended up moving a total distance of 9.7 meters (31.8 feet). Spirit also performed 20 minutes of post-drive imaging.

Sol 361 was a restricted sol due to a late downlink of data needed for more extensive planning. That ruled out any driving or use of the instrument deployment device. Spirit completed almost 2 hours of remote sensing observations using the panoramic camera and miniature thermal emission spectrometer.

Sol 362 and 363 were planned in a single planning cycle. Sol 362 was another remote sensing sol. On sol 363, Spirit attempted a 10-meter (33-foot) drive. Spirit accomplished about 3 meters (10 feet) of the drive before stopping due to high wheel slippage. Spirit experienced slippage of up to 98 percent on portions of this drive. Spirit then performed 20 minutes of imaging.

On Sol 364, the rover planners devised a strategy that would attempt to recover when Spirit experienced slippage of greater than 60 percent. The drive sequence was complex and Spirit's planning team had a tight planning cycle, so engineers came painfully close to missing the uplink window. The payoff for the long day was a very good drive. Spirit accomplished 7 meters (23 feet).

Spirit performed another uphill drive on sol 365. The rover drove 9 meters (29 feet) and performed 20 minutes of post-drive imaging.

The plan on sol 366 was to continue the uphill drive toward Larry's Lookout, employing all the latest rover tricks. The drive was successful as Spirit traversed more than 12 meters (39 feet) with slip averaging less than 15 degrees. Spirit performed 30 minutes of post-drive observations. Sol 366 ended on Jan. 12.

Total odometry after sol 366 is 4,030 meters (2.5 miles).

sol 353-359, January 11, 2005: *Spirit Continues Climbing 'Husband Hill'*

With one eye on the weather, Spirit continued work on "Husband Hill," making detailed observations of a rock called "Champagne," using the full suite of instruments.

Engineers continue to have difficulty getting the rover to make significant progress toward a ridgeline destination due to high slippage that Spirit experiences on the sandy, sloped terrain. Spirit has been in roughly the same spot for the past 30 sols. Since temporarily getting a potato-sized rock caught in the right rear wheel on sol 339, engineers have been careful to monitor the slip as Spirit drives. If

the wheels slip too much, engineers stop the drive to avoid the possibility of picking up another rock as Spirit spins and digs with its wheels.

The opacity of the sky -- or how much light does not shine through the atmosphere -- has been higher than normal in the past week due to local dust disturbances. Higher opacity means less energy for the solar-powered rover. However, despite the recent increase in opacity, Spirit has had adequate energy (with a safe margin) to continue normal operations.

The rover's power bus return is a collection of wires designed to carry current back to the rover power source (battery or solar array). Electrical current between Spirit's chassis and the power bus return changed on sol 342 from zero volts to 0.1 volts. The small change in voltage coincided with powering of heater circuits on the instrument deployment device (or rover arm). This confirms that there is a short (unexpected metal-to-metal contact) between the power bus return and the chassis, as had been suspected since October. The short is somewhere on the return side of the rover arm heater circuits. The presence of this short does not affect daily operations. It does, however, take away one layer of protection should Spirit have a short to the chassis somewhere else on Spirit.

Sol Summaries:

On sol 353, Spirit continued inspecting the rock "Champagne" and performed a Mössbauer spectrometer integration on two Champagne targets.

On sol 354, Spirit used its rock abrasion tool to brush the dust off a target on Champagne, then used the microscopic imager and the alpha particle X-ray spectrometer to analyze the dust-free spot.

On sol 355, Spirit used the rock abrasion tool to grind into Champagne, then placed the alpha particle X-ray spectrometer in the hole for an overnight observation.

On sol 356, Spirit continued using its alpha particle X-ray spectrometer on the hole drilled by the rock abrasion tool hole.

On sol 357, Spirit changed tools to the Mössbauer spectrometer and placed it in the rock abrasion tool hole for a long integration.

On sol 358, Spirit took microscopic images of the rock abrasion tool hole, then stowed the rover arm. Engineers then attempted a short drive that would have allowed Spirit to image the rock abrasion tool hole from a distance. The drive did not reach the intended position because of slippage.

Sol 359 was a "restricted" sol, meaning that engineers had to plan this sol without knowing the results of the sol 358 sequence. Consequently, it was a relatively simple day that included routine atmospheric science and miniature thermal emission spectrometer observations. Sol 359 ended on Jan. 6.

sol 346-352, January 06, 2005: *Spirit Celebrates Year Anniversary on Mars*

Spirit landed on Mars one year ago on Jan. 3, 2004, (Pacific Time) and is still healthy and going strong!

On sol 346, Spirit confirmed that it had dumped a potato-shaped rock that had been plaguing Spirit's right rear wheel. Confirmation came by comparison of before and after images from the rear hazard-avoidance camera. The total distance driven on sol 346 was 0.33 meters (1.08 feet).

On sol 347, Spirit observed selected targets with its panoramic camera and miniature thermal emission spectrometer.

On sol 348 took pictures of a target called "Dreaming" with the microscopic imager, and then did a tool change to the alpha particle X-ray spectrometer. Spirit also made some remote-sensing observations of targets with holiday theme names.

On sol 349, Spirit did a tool change to the Mössbauer spectrometer and made more observations.

On sol 350, the plan was to drive Spirit 5 meters (16 feet) towards the rock named "La Brea." However, the drive achieved less than a meter (3 feet) due to slippage.

On sol 351, Spirit attempted to drive again. This drive involved a series of rearward and forward arcs to get to more favorable terrain. Most of the slip occurred during the forward arcs. The estimated slip on the rearward arcs was 15 per cent, but the estimated slip on the forward arcs was 39 per cent. The destination, a rock called "Dick Clark," was still about 4.2 meters away (14 feet).

On sol 352, the incomplete drive on the previous sol had left the rover team with a rock of interest right between the rover's front wheels. Spirit examined a target called "Bubbles" with its microscopic imager, then changed tools to the alpha particle X-ray spectrometer. Spirit also made sky observations with its thermal emission spectrometer and panoramic camera. Sol 352 ended on Dec. 29.

sol 333-345, December 23, 2004: *Spirit Eats a Potato-Sized Rock*

Spirit finished work at a rock called "Wishstone," then continued to make slow progress up "Husband Hill." Wishstone is different than any rock Spirit previously studied either on the plains or in the hills. Scientists and engineers used the miniature thermal emission spectrometer to find similar rocks for further study.

A potato-sized rock got caught in Spirit's right rear wheel on sol 339, causing the wheel to stall and ending the drive for that sol. Small moves of the wheel on subsequent sols dislodged the rock, but the rock remains close to the wheel, so the team is planning small, careful steps to move the wheel away from the rock so it will not become jammed again. Spirit remains in excellent health.

Sol-by-sol Summaries:

Atmospheric observations using the miniature thermal emission spectrometer, navigation camera, and panoramic camera continue on a daily basis.

On sol 333, Spirit used the brush of the rock abrasion tool brush to scrub a small section of Wishstone and took microscopic images of the spot. Spirit then placed the alpha particle X-ray spectrometer on the spot for collecting data overnight.

On sol 334, Spirit removed the alpha particle X-ray spectrometer and then used the rock abrasion tool to drill into Wishstone. After taking more microscopic images, Spirit placed the alpha particle X-ray spectrometer on the hole for an overnight observation.

On sol 335, Spirit removed the alpha particle X-ray spectrometer from the hole and replaced it with the Mössbauer spectrometer. Spirit also started a long series of Mössbauer observations that would last until the early morning of sol 337.

On sol 337, Spirit stowed its robotic arm, then bumped backwards to take final images of Wishstone and the rock abrasion tool hole. Spirit was commanded to drive 15 meters (49 feet), but drove only about 6 meters (20 feet) due to experiencing slippage of up to 80 percent on uphill portions of the drive.

On sol 338, Spirit drove 8 meters (26 feet) with 25 meters (82 feet) of commanded motion. Spirit saw up to 95-percent slip on some of the drive segments due to sandy terrain and the rover's tilt of 15 to 20 degrees.

On sol 339, the rover team attempted another 25-meter (82-foot) drive. This was cut short at the start when the right rear wheel ingested a potato-sized rock. The rock apparently jammed between the inner part of the wheel and the drive mechanism, causing the drive current to exceed a pre-set limit, resulting in a safe motor stall.

Sol 340 - Spirit made observations with the miniature thermal emission spectrometer to seek other rock targets similar to Wishstone. Turning the right rear wheel about 60 degrees successfully un-jammed the rock, but it remained inside the wheel.

Sols 341, 342 and 343 were planned as a combined three-sol plan that included observations with the miniature thermal emission spectrometer each sol. On sol 341, Spirit used its microscopic imager and its Mössbauer spectrometer to examine disturbed soil in front of the rover. It switched to the alpha particle X-ray spectrometer overnight to gather more compositional information about the same target. On sol 342, Spirit performed a mid-day tool change back to the Mössbauer spectrometer. On sol 343, the rover stowed the robotic arm and took images with the panoramic camera of targets that had been observed with the miniature thermal emission spectrometer. Spirit then performed a small maneuver but did not significantly change the position of the rock in the wheel.

Sol 344 - Spirit performed more remote sensing and did a maneuver that lifted the right rear wheel slightly out of a hole, but the rock remains partially in the wheel. The wheel is about one-third buried in the soft soil, making it difficult for the rock to escape until the wheel gets out of the hole.

Sol 345 - Spirit successfully executed another small maneuver to get the right rear wheel out of hole and get the rock out of the wheel, but more steps will be required. The rover also used the panoramic camera and miniature thermal emission spectrometer to acquire information about nearby targets. Sol 345 ended on Dec. 22.

sol 326-332, December 14, 2004: *Trekking Toward 'Husband Hill'*

Spirit drove five of the last seven days, continuing its trek towards the top of "Husband Hill." Spirit's intermediate goal is a ridge dubbed "Larry's Lookout," which is roughly 75 meters (246 feet) away. Getting there using Spirit's current path will be a challenge given the sand, slope, and rocks in this area. Spirit paused for a set of weekend observations of a rock called "Wishstone." Total odometry for the mission is now 3,944 meters (2.45 miles).

The amount of electric current drawn by the motor on the right front wheel is in the normal range. Near the end of Spirit's long series of drives from "Bonneville Crater" to the "Columbia Hills," the right front wheel began to draw roughly twice the current of the other five wheels. The increased current prompted engineers to limit the use of this wheel to preserve its life. Since arriving at the hills, Spirit has had relatively few driving days. The rover team's current working theory on this problem suggests that the recent rest periods have allowed the lubricant in this wheel to redistribute, causing the current draw to return to normal. Periodic rest days will be included in rover drivers' plans, and Spirit will alternate forward and backward driving to keep the lubricant in all of the wheels more evenly distributed.

sol 306-325, December 07, 2004: *The Holiday Spirit is on Mars*

During the 19 sols ending on sol 325 (Dec. 1), Spirit continued to explore in the "Columbia Hills." Spirit reached a position northeast of a ridge called "Machu Picchu" and began crossing a 200-meter-wide (656-foot-wide) flat saddle area.

The amount of electric current drawn by the motor of the right front wheel continues to be a concern. However, during a recent drive the current draw was closer to normal than it had been in preceding weeks. Engineers will continue to limit use of this wheel by driving backwards when terrain allows, dragging it 90 percent of the time.

Between sols 306 and 325, Spirit finished shooting a Thanksgiving panorama with the panoramic camera; investigated new rock targets "Corn," "Cocomama," and "Butter" with the science instruments; and continued to drive eastward between the "West Spur" and an area where the terrain slopes back upward toward "Husband Hill."

Spirit successfully completed about 80 meters (262 feet) of driving, bringing the total mission traverse to 3.82 kilometers (2.37 miles).

sol 292-305, November 18, 2004: *Three hundred sols and counting!*

Spirit remains in excellent health and has survived more than 300 martian days on the red planet.

With the Sun still relatively low on the horizon in the early spring season on Mars, rover drivers are forced to seek driving routes that keep the rover and its solar panels tilted northward for energy reasons. That constraint, plus the rocky terrain, will challenge rover drivers in the coming weeks.

Over the last few weeks, the electrical "brakes" on Spirit's right-front and left-rear steering actuators (motors) apparently failed to disengage during drive attempts. The most likely cause of this anomaly is the buildup of insulating material on the electronic relay contacts that indicate that the brakes are disengaged. To help ensure successful future drives, engineers decided to permanently ignore the "brake-disengaged" indicator. If their theory is correct, the brake will actually be disengaged despite the "failure-to-disengage" indication. If they are wrong, a fuse in the brake circuit will safely blow when they attempt to move the steering actuators. In either case, driving operations will not be adversely affected.

A few sols ago, Spirit's engineering team discovered an electric-circuit grounding problem between the rover chassis and the power bus return. This incident occurred at the exact time the Spirit team was performing an inspection of the instrument deployment device, or robotic arm. The inspection sequence commanded one of the arm joints to a position beyond where it had previously been. That particular joint, joint number 5, is the rover arm turret, which rotates the four rover arm instruments into position. This coincidence may indicate that the joint 5 move somehow created the electrical short; it could also just be coincidence. The mechanical team has not found any reason to suspect a failure in the joint 5 cabling. To be safe, the engineering team has constrained the use of joint 5 on Spirit and Opportunity to avoid this extreme position. The constraint is not expected to significantly impact normal operations. The apparent short may also be the result of a failed measurement circuit. The short, if real, has no immediate effect on the rover, but does remove one layer of protection against effects of future shorts should they occur.

Between sols 292 and 298, Spirit completed its studies of the rock called "Uchben" and drove west about 2 meters (almost 7 feet) to a rock called "Lutefisk."

Between sols 299-303, Spirit finished its investigation of Lutefisk. Lutefisk, a rock with some interesting nodules, lies a site roughly 40 meters (131 feet) above and 2700 meters (1.67 miles) away from Spirit's landing site on the Gusev plain. Team members should know more about the chemistry of Lutefisk and its nodules when they receive results from the alpha particle X-ray spectrometer and Mössbauer spectrometer.

For coming sols, Spirit is in an exploration and discovery mode, continuing the rover's ascent towards "Machu Picchu" in the Columbia Hills. Spirit will stop at interesting rocks along the way.

sol 285-291, November 03, 2004: *The engineering team is keeping Spirit moving*

Spirit employed its full instrument suite on Sols 285 through 291 to study "Uchben," an interesting rock encountered on the way into the Columbia Hills. The engineering team continued to diagnose and study work-arounds for a problem with the steering brake relay. An anomaly related to electric-circuit grounding came to light during this period and is also being studied by the engineering team. Neither problem has hampered Spirit's daily operations. Spirit is otherwise healthy and ready to continue its trek further into the Columbia Hills.

The engineering team has been studying recovery options for steering brakes that apparently failed to release on two previous sols. On Spirit and Opportunity, dynamic braking is accomplished using a relay switch to place a short across the motor windings of an actuator that is not being used. If that actuator starts to move unexpectedly, the motor acts as a generator and the short provides an electrical load that slows the motor down. The same principle is used to generate electrical energy for hybrid cars when the brakes are applied. Thanks to forethought on the part of the rover design team, it is possible to disable the dynamic braking function using ground commands. Those commands deliberately and safely blow a fuse that is in line with the brake relay circuit. The absence of the braking function for the steering actuators in question (right front and left rear steering) will not affect the accuracy of our drives or the rover's safety when we are stopped. Until this problem is fully resolved, we will continue to drive with the right front and left rear steering actuators disabled, using tank-like steering.

Regarding the grounding anomaly, the engineering team regularly receives telemetry that tells them the voltage difference between "rover chassis" and "power bus return". The rover chassis is the conductive structure of the rover akin to an automobile chassis. The power bus return is a collection of wires designed to carry current back to the rover power source (battery or solar array). Ideally, all rover current flows in a loop from the battery or solar array, returning by way of the power bus return wires. No current is supposed to flow in the rover chassis though, in reality, some leakage paths exist that allow current to return by way of the rover chassis. When these currents flow across the circuitry that separates the rover chassis and power bus return, they create a small voltage that is measured and reported in telemetry. Until sol 287, the reported voltage was typically in the range of 0.6 to 0.8 volts. On Sol 287, that voltage dropped to 0 volts. The 0 volt reading could indicate that there is a problem with the measurement circuit, or it could indicate that power bus return and rover chassis are now shorted (making direct contact). The rover can operate when the chassis and power bus return are shorted together or when they are separated from each other by electrical circuitry. In the shorted case, however, the rover is more susceptible to permanent damage if another short occurs somewhere else. Engineers are looking at when the short indication occurred for clues about its possible root cause.

Sol specifics:

On 285, Spirit continued systematic atmospheric observations on this and all sols during this period using the miniature thermal emission spectrometer and panoramic camera. The rock abrasion tool was employed to drill a shallow hole at "Koolik," a location on the rock Uchben.

On sol 286, Spirit took microscopic images of the Koolik rock abrasion tool hole and placed the alpha particle X-ray spectrometer on Koolik for an overnight observation. The alpha particle X-ray spectrometer works best when cold.

During sols 287 through 289, Spirit placed the Mössbauer spectrometer on the Koolik rock abrasion tool hole for several observations over the Earth weekend. The Mössbauer spectrometer radiation source has weakened significantly since landing, through normal decay, so longer integration times are now required to get acceptable data.

On sol 290, Spirit performed tests to diagnose the root cause of the indication that steering brakes had failed to release, but the tests were inconclusive. Spirit then used the rock abrasion tool to brush "Chiikbes," another location on Uchben. Spirit placed the alpha particle X-ray spectrometer on Chiikbes for an overnight observation.

On sol 291, which ended on Oct. 28, Spirit took microscopic images of the Chiikbes brush site, and then placed the Mössbauer spectrometer on Koolik to improve the data from that location.

sol 279-284, October 25, 2004: *Spirit's been mulling over 'Uchben'*

Spirit is healthy and currently investigating a layered rock called "Uchben." Spirit is farther from the equator than its twin, Opportunity is, and it has much less available solar energy. Spirit's solar panels are pointed to the northern Sun, but Spirit is still only getting about 400 watt-hours of energy per day - enough to run a 100-watt bulb for four hours. Opportunity has been getting more than 700 watt-hours a day. The lower power supply for Spirit limits the rover's daily activities.

On sol 279, Spirit was parked at the location where a second occurrence of a problem with the rover's dynamic brake relay anomaly had halted a planned drive on sol 277. Scientists took the opportunity to analyze disturbed soil in front of the rover. Spirit deployed its robotic arm, acquired images of the soil with the microscopic imager, and placed the alpha particle X-ray spectrometer on a new target, named "TakeABreak," for an overnight integration.

Sols 280, 281, and 282 were built as a single three-sol plan to execute over Earth's weekend. On sol 280, Spirit acquired morning observations of sky and ground with its miniature thermal emission spectrometer, took a panoramic camera image to assess atmospheric quality, and completed the overnight alpha particle X-ray spectrometer measurement. After a midday nap, Spirit did a tool change from the alpha particle X-ray spectrometer to the Mössbauer spectrometer and began an overnight integration on the same soil patch.

On sol 281, Spirit completed the Mössbauer spectrometer measurement, took a midday nap, acquired three images of a nearby target called "Coffee" with the microscopic imager, and stowed the robotic arm. Spirit then successfully drove about 4 meters (13 feet) backwards, putting the target "Uchben" into the workspace of the robotic arm. The drive included straightening the right front and left rear steering wheels, which are the two impacted by a problem with the relay that is used in turning the steering motors on and off. The drive also successfully tested driving without use of the right front and left rear steering wheels to limit use of these motors while investigation of the malfunction continues.

On sol 282, Spirit acquired measurements of the sky and ground in the morning with the miniature thermal emission spectrometer, took the usual midday nap, and then made remote-sensing observations in the afternoon, including some navigation camera images for use in planning of future driving.

On sol 283, after receiving its daily commands and acquiring a panoramic camera assessment of atmospheric quality and miniature thermal emission spectrometer measurements of the sky and ground, Spirit took a midday nap. In the afternoon, Spirit deployed the robotic arm and acquired 20 images of a target region called "Koolik" on Uchben with the microscopic imager. Spirit then deployed the alpha particle X-ray spectrometer for an overnight integration.

On sol 284, which ended on Oct. 25, Spirit completed the alpha particle X-ray spectrometer measurement and then did a tool change to the Mössbauer spectrometer for a nighttime integration on Koolik.

sol 272-278, October 20, 2004: *Spirit investigating ancient rocks*

Spirit had a productive week investigating the rock "Tetl." On sol 277, Spirit attempted a drive to the next rock target, "Uchben," which means "ancient" in the old Mayan language. Halfway into that drive, Spirit experienced a repeat problem in the steering motor control system that engineers first saw on sol 265. Engineers repeated diagnostic tests for the problem on sol 278. Those tests showed that the electronics relay in question is still functional, but appears to operate intermittently. Spirit is otherwise healthy and is in a safe location.

On sol 272, Spirit took images with the microscopic imager to create a mosaic of Tetl's layered rock face.

On sol 273, Spirit captured more microscopic images of Tetl's layered face, then put the alpha particle X-ray spectrometer in place for an early morning observation.

On sol 274, Spirit woke up at 4:00 a.m. to start the alpha particle X-ray spectrometer observation. The alpha particle X-ray spectrometer stayed on until the start of normal morning atmospheric science observations. Spirit also used its miniature thermal emission spectrometer to observe nearby rocks named "Zackuk" and "Palenque," which are possible future targets for in-depth observations. Later, Spirit changed tools on its robotic arm, placing the Mössbauer instrument on Tetl for an observation the next morning.

On sol 275, Spirit completed a 6-hour Mössbauer integration and performed daily atmospheric observations. This was the final sol of Spirit's weekend plan and was purposely simple to enable the sequencing team to complete a 3-day plan on Friday.

On sol 276, Spirit restarted the Mössbauer instrument at 4:00 a.m. for another 10 hours of integration time on the same spot. Spirit also took a few final microscopic images of Tetl, then stowed the robotic arm in preparation for the next sol's drive.

On sols 277 and 278, Spirit attempted a drive to Uchben, another layered rock roughly 6 meters (20 feet) northeast of Tetl. About 2.5 meters (8 feet) into the drive, the mobility software attempted to move a steering motor by first commanding open a relay (electronic switch) that releases a dynamic brake. The feedback from that command indicated that the relay was still closed, so the motor control software declared an error. Due to the error, the rover ignored that steering command and all subsequent driving commands. The root cause of the failed relay command is under investigation. A diagnostic test last run on sol 270 was repeated on sol 278, which ended on Oct. 14. That test showed that the steering motor's dynamic brake relay can still be opened and closed, but does occasionally (5 out of 10 times) indicate that it is still closed after being commanded open.

More diagnostics tests are needed before the source of the problem can be positively identified. Until then, engineers will continue to drive, but will steer the rover in a tank-like fashion, not using the steering actuator in question.

Future plans are to clear the drive error and attempt another drive to Uchben on sol 281. Engineers are also planning to run more diagnostic tests starting on sol 282.

sol 263-271, October 11, 2004: *Spirit investigating 'Tetl'*

After working on Mars for three times as long as its primary three-month mission, Spirit is healthy and currently investigating the rock called "Tetl" in the "Columbia Hills." In the language of the ancient Mayans, tetl means stone.

On sol 263, Spirit successfully drove approximately 7 meters (23 feet) and acquired images to build a digital elevation map of the hills. This put Spirit on the south side of a 2-meter-diameter (7-foot-diameter) depression, with Tetl on the opposite side.

On sol 264, Spirit drove about 4 meters (13 feet) around the edge of the depression to keep the rover's solar panels (which are the rover's main power source) tilted toward the Sun. Since the Sun moves low across the northern sky over Gusev Crater at this time of year, rover planners are attempting to keep the solar panels tilted toward the north. The drive included use of the five-wheel mode to minimize use of the sticky right front wheel, which inefficiently pulls too much power when it is activated. Spirit also gathered additional about potential science targets, using the miniature thermal emission spectrometer and panoramic camera at the end of the rover's robotic arm.

On sol 265, Spirit attempted to approach Tetl, but the drive ended early because the flight software detected that a steering brake control function did not work. Remote sensing data was still acquired.

On sol 266, with an ongoing investigation of the steering anomaly, no further driving was planned. Several targets in front of the rover were selected for the alpha particle X-ray spectrometer and Mössbauer spectrometer. Spirit completed alpha particle X-ray spectrometer readings on two different locations.

On sol 267, Spirit successfully acquired remote sensing data and moved its robotic arm to put the alpha particle X-ray spectrometer at a third position during the day and a fourth position overnight.

On sol 268, Spirit acquired additional remote sensing data and performed a tool change to the Mössbauer spectrometer, then started an overnight integration with that instrument.

On sol 269, Spirit continued the Mössbauer spectrometer integration and performed a diagnostic test on the steering brake. The test indicated that there was no problem with the commanding process at that time.

On sol 270, Spirit acquired remote sensing data, stowed its arm, and ran another steering diagnostic test. The cause of the steering brake issue has not been identified, but tests indicate that electronics related to the brake function and the overall steering capabilities of Spirit are healthy. Engineers are proceeding with normal operations, including mobility.

On sol 271, which ended on Oct. 7, Pacific Time, Spirit successfully drove approximately 2 meters (6.6 feet). This put Tetl within reach of the robotic arm. After the drive, Spirit used its navigation camera to view the scene from the rover's new location.

Spirit has driven a total of 3,641 meters (about 2.3 miles) since landing nine months ago.

Future plans for Spirit include more intense investigations of Tetl and a 20-meter (66-foot) drive to a target called "Machu Picchu."

sol 243-262, September 29, 2004: *Spirit back to normal operations*

Spirit has successfully transitioned back to normal operations from conjunction operations, when Mars and Earth were on opposite sides of the Sun. During conjunction (sols 244 through 255), engineers and scientists did not attempt normal operations due to the low probability of successful communications. From sols 244 to 249, the rover team did transmit several "no operation" commands to test the communications link. On Spirit's sol 249, Opportunity experienced an unexpected software reset, apparently triggered by a corrupted "no operation" command. As a result of that problem, engineers ceased all commanding on Spirit from sol 250 until sol 256, at which time the likelihood of receiving corrupted commands was once again very low.

From sols 244 through 255, pre-loaded sequences performed daily science, which included atmospheric studies (using the miniature thermal emission spectrometer and the panoramic camera) and Mössbauer spectrometer integration on the filter magnet, which is one of two dust-collecting magnets on Spirit's main deck. Spirit relayed data to the Mars Odyssey orbiter every afternoon throughout conjunction. Odyssey in turn attempted to relay that data back to Earth with limited success due to solar conjunction. As a result of the difficulties getting data off of the rover, the memory available for science data storage shrunk to roughly 100 megabits by sol 261, but has recovered as of sol 262 to roughly 400 megabits.

Sol highlights:

Sol 243 was the last sol of normal commanding for Spirit before conjunction. The rover team successfully re-transmitted four conjunction sequences that had not made it on-board during the sol 242 uplink. The team saw no transmission errors (but commanded everything twice just in case), and the rovers performed the commanded remote sensing science.

On sol 244, the rover team transitioned into conjunction operations and did the first "no-op" commanding tests during midday to see how effective the command link was as Mars moved further behind the Sun. The team received data from the Odyssey orbiter indicating that Spirit was healthy and proceeding normally with on-board conjunction sequences.

Sols 245 through 255 were the solar conjunction quiet period. No commanding was done. Spirit automatically took daily atmospheric science measurements and made filter magnet observations with the Mössbauer spectrometer.

During sols 256 through 257, Spirit took 48 more hours of Mössbauer observations on the filter magnet. A dirt clod from a previous Mössbauer soil touch was inadvertently placed on the perimeter of the filter magnet on sol 240. As a result, engineers believed this could have been the rover team's last best chance to collect Mössbauer data on the uncontaminated dust sample from that magnet. This is because when the Mössbauer instrument was removed, there was a chance that dirt from the clod would sprinkle or spread to the center area of the magnet.

On sol 258, the team removed the Mössbauer instrument from the filter magnet and took microscopic images of the both magnets. From the image thumbnails, the team could see that some dirt from the clod was indeed deposited on the outer area of the filter magnet. Front hazard-avoidance camera images taken after the Mössbauer spectrometer was removed clearly showed dirt still attached to the Mössbauer contact plate.

After finishing with the magnets, engineers moved the rover arm back down to the soil, to the same spot that had been touched by the Mössbauer instrument on sol 240. The rover team then repeated a microscopic imager sequence of that soil to see if winds had deposited anything there during conjunction. The team then centered the alpha particle X-ray spectrometer on the same soil and started an integration later that night.

On sol 259, Spirit changed tools to the Mössbauer spectrometer and started a 24-hour integration on the same disturbed soil spot. Spirit also started a three-sol thermal investigation, using panoramic camera and miniature thermal emission spectrometer observations of soil targets several times during each sol.

On sol 260, Spirit completed the Mössbauer integration of the disturbed soil.

On sol 261, Spirit stowed its arm then drove backwards 1.5 meters (4.9 feet) to take post-conjunction panoramic camera pictures of the soil underneath the rover as part of the conjunction wind experiment. Spirit also took navigation camera images of the road ahead in preparation for future drives.

On sol 262, due to the limited amount of available science data storage, planned activities were limited to a Mössbauer spectrometer integration on a rock, limited remote sensing, and routine atmospheric observations. That plan did not make it on board due to a problem during the communications uplink session. The deep space network antenna was pointed a few degrees below its lower safety limit when the transmitter was supposed to turn on, causing an interlock mechanism to turn off the transmitter. By the time the antenna was reconfigured, not enough time remained to get the full sequence load transmitted. Fortunately, one sequence did make it to the rover and was successfully executed, freeing up roughly 250 megabits of memory for future sols. Sol 262 ended on Sept. 28.

sol 239-242, September 09, 2004: *Spirit on Autopilot*

Spirit is in safe place to continue daily science observations automatically throughout the solar conjunction period when engineers and scientists will be unable to send commands reliably to the rover. An 18-day period began a transition into solar conjunction on sol 241, when the Sun partially obscured the communications path between Earth and Mars, making communications sessions unreliable. Engineers were able to successfully command Spirit on sol 241, and they had partial commanding success on sol 242.

Engineers will attempt to command Spirit on sol 243 also. From sol 244 through sol 255, sequences already safely on board will perform a set of science activities on a daily basis. On sols 256 through 258, the last three days of conjunction, the rover team will attempt normal operations again.

On sol 242, engineers sent Spirit a set of coordinated commands to use the miniature thermal emission spectrometer and panoramic camera for observations of possible future science targets. A new set of 12 conjunction master sequences was also transmitted successfully to Spirit. This new set of conjunction master sequences will use less energy than previous sequences.

For the conjunction period, the rover team has placed the Mössbauer spectrometer on one of the two magnets on the rover deck. Spirit will activate the Mössbauer instrument every day during conjunction in order to characterize the dust that has collected on the magnet. However, a wrinkle has developed in this plan. Before placing the Mössbauer spectrometer on the magnet, Spirit placed it on the soil in front of its current location. That soil touch was done to leave a soil impression that would be studied after conjunction for changes. Images taken after the touch indicate that Spirit inadvertently picked up some soil and likely sandwiched that soil onto the magnet with the Mössbauer. It's the team's first inadvertent sample acquisition!

Engineers and scientists decided to leave the Mössbauer in place on the magnet and will evaluate the status and effect of the dirt clod after conjunction. The dirt does not pose any threat to the rover from an engineering perspective.

Since Spirit arrived at its solar-conjunction resting place, its science activities have focused on gathering data from the surrounding area for use in planning post-conjunction sols. Navigation camera images in Spirit's drive direction have been used to develop traverse maps.

These maps show areas that allow Spirit to maintain a north-facing tilt; these areas will provide significantly more solar energy and will therefore be favored as the team plans the traverse to Spirit's next science target.

During conjunction, Spirit will transmit five-minute "beep" tones, and engineers will send "No-operation" commands to the rover to characterize effects that the conjunction has on radio transmissions between Mars and Earth.

sol 232-238, September 07, 2004: *Spirit finishes observing 'Ebenezer' and moves on to 'Tikal'*

Spirit found a comfortable location on a rock outcrop and spent cold autumn days performing observations of a rock called "Ebenezer" with the rover's science instruments. Spirit finished observations of Ebenezer and moved over to the next location, "Tikal," about nine meters (30 feet) away. Spirit will spend solar conjunction at Tikal. Solar conjunction is when Earth and Mars are on opposite sides of the Sun. Due to the interference with the Sun, communications between Earth and the spacecraft at Mars will be minimal during solar conjunction, which occurs during Spirit's sols 244 through 255.

On sol 232, Spirit completed an overnight reading with its alpha particle X-ray spectrometer on a target dubbed "Cratchit 2," where the rover had earlier used its rock abrasion tool to cut a hole exposing the rock's interior. Spirit took images of the same target with the microscopic imager. Spirit then placed the Mössbauer spectrometer on Cratchit 2 and started a very long, two-sol integration.

After the two-sol Mössbauer spectrometer activity, Spirit spent sol 234 performing 90 minutes of remote sensing. On sol 235, Spirit changed tools from the Mössbauer spectrometer to the microscopic imager and took pictures. Then Spirit used the alpha particle X-ray spectrometer for thirty minutes. After completing the alpha particle X-ray spectrometer reading, the arm was stowed so that on sol 236 the rock abrasion tool brushings could be imaged using the panoramic camera without the arm blocking any part of the image.

Spirit spent sols 236 to 238 brushing eight adjoining patches on Ebenezer to create a large enough scrubbed area for analyzing with the miniature thermal emission spectrometer, then drove up to the rover's designated vacation spot for solar conjunction.

Spirit bumped backwards on sol 237, and took some navigation camera images of the brushed area of Ebenezer to support miniature thermal emission spectrometer observations on the next sol. A navigation camera panorama was taken in the expected drive direction, toward Tikal.

In the morning of sol 238, the panoramic camera imaged the brushed area of Ebenezer. A little after noon, the miniature thermal emission spectrometer took spectral readings of both the brushed area and a hole that rock abrasion tool hole had cut into Ebenezer on sol 231. At 2 p.m. Gusev time, Spirit took an afternoon drive to Tikal, about nine meters (30 feet) away.

sol 219-231, August 31, 2004: *Spirit has been etching into 'Ebenezer'*

During sols 219 through 223, Spirit completed science observations at the "Clovis" rock outcrop. So Spirit packed up and slowly moved on. Winter is approaching and temperatures continue to drop. Power is always a major concern as available energy fluctuates between 300 and 400 watt-hours per sol, but Spirit continues the quest, climbing ever higher into the Columbia Hills. Spirit has climbed more than 13 meters (43 feet) in elevation from Hank's Hollow, at the base of Columbia Hills, but currently is at an elevation of 37 meters (121 feet) above its landing site on the plains of Gusev Crater!

On sol 224, operators became concerned that Spirit's batteries might be entering a very low state of charge, so Spirit shut down to charge the batteries.

Sol 225 was truly a mega-activity sol. Spirit awoke at 11:20 a.m., Gusev local solar time and stayed awake well past the afternoon communication session with NASA's Mars Odyssey orbiter without taking a nap. Spirit hasn't done that in a long time. The rover extended its arm and used its rock abrasion tool to brush seven circular patches on Clovis. After the first five brushings, the arm was moved out of the way and an image was taken of the circles. These five brushing circles resemble the Olympic rings.

After completing the brushing, Spirit performed a 30-minute reading with its alpha particle X-ray spectrometer, imaged the seven rings using its microscopic imager, stowed its arm and drove one meter (three feet) backward, farther off of the Clovis outcrop. Spirit's day was far from over. The rover performed post-drive observations with its navigation camera, observations with its miniature thermal emission spectrometer concurrent with the afternoon Odyssey pass, and panoramic camera observations before shutting down. Another gold medal performance for Spirit!

Total odometry after sol 225 was 3,605 meters (2.24 miles), a Mars record.

From sols 226-229, Spirit stopped at a rock dubbed "Ebenezer" for several sols of intense science. Ebenezer is roughly 8 meters (26 feet) from Clovis.

While at Ebenezer, Spirit was facing south of east, with its nose pitched up 21 degrees. This orientation was very favorable from a power perspective since the sun tracks to the north. Spirit's daily solar energy input increased about 10 percent as a result. Spirit also had a great view of the Gusev plain from this location.

On Sol 230, Spirit used the rock abrasion tool to brush a target on Ebenezer and took an overnight alpha particle X-ray spectrometer reading on the brushed area. On Sol 231, which ended on Aug. 27, the abrasion tool ground for two hours into the same spot it had brushed. An alpha particle X-ray spectrometer reading in the resulting hole began the morning of Sol 232.

Over the next few sols, the plan is for Spirit to drive to its next target, which is yet to be determined.

sol 209-218, August 23, 2004: *Spirit probes deeper into 'Clovis' outcrop*

Spirit continued work over the past nine sols at a rock called "Clovis." The rover used its rock abrasion tool, microscopic imager, alpha particle X-ray spectrometer, and Mössbauer spectrometer to probe deeper into the history of this rock. Clovis is the most altered rock encountered by Spirit to date. It is part of a rock outcrop located on the "West Spur" of the "Columbia Hills," roughly 55 meters (180 feet) higher than Spirit's landing site about 3 kilometers (2 miles) away.

Spirit also successfully performed a couple of communications tests with the European Space Agency's Mars Express orbiter last week. The tests demonstrated the two spacecraft's ability to work together to transmit data collected by the rovers to Earth via the Mars Express communications relay. NASA's Mars Odyssey and Mars Global Surveyor orbiters also have this capability. More than 85 percent of the data from the rovers has been transmitted to Earth via the Odyssey orbiter.

On sol 209, Spirit experienced an unexpected reboot of the flight software. This incident was not a threat to the spacecraft. It is a known bug in the system that the rover team is working around.

On sol 210, Spirit drove up steep terrain to reach the exact spot on Clovis for work with the science instruments at the end of the robotic arm.

Between sols 211 and 216, Spirit completed an alpha particle X-ray spectrometer reading of a spot on Clovis called "Plano," which had been brushed off using the rock abrasion tool. Spirit then placed the rock abrasion tool on Plano again and drilled for 2.5 hours, creating a hole 8.9 millimeters (0.4 inch) deep, which is a new record! Spirit also continued a campaign to capture a color 360-degree panoramic camera image from this location. Spirit captured additional segments of the panorama on sols 217 and 218.

On sol 217, Spirit took microscopic images of the rock abrasion tool hole, and then placed the alpha particle X-ray spectrometer in the hole for an early morning observation.

On sol 218, Spirit placed the Mössbauer spectrometer in the rock abrasion tool hole and started a 48-hour observation. This is a longer than normal integration time, with a goal of resolving in more detail the makeup of this highly altered rock.

Spirit remains in excellent health.

sol 205-208, August 11, 2004: *Spirit is investigating 'Clovis' outcrop*

Over the last few sols, Spirit struggled mightily to reach a rock outcrop called "Clovis," overcoming the challenge of rough, steep terrain and subsequent backsliding. The site is near the crest of the "West Spur" of "Columbia Hills."

On sol 205, Spirit attempted to reach Clovis by climbing out of the sandy hollow in which it was sitting. Unfortunately, on a slope of more than 20 degrees, slippage caused Spirit to dance around the outcrop. The drive was finally cut off by a time-of-day limit on rover mobility.

The plan for sol 206 was designed to accommodate up to a 50 percent slip and still reach the outcrop target. However, due to challenging terrain near Clovis, Spirit again did not end up exactly where scientists and engineers wanted it to go. For part of its traverse, Spirit slipped about 125 percent, actually losing ground in its attempt to move uphill.

Late in the sol, internal software experienced a timing problem in which two instrument-related commands were given at nearly the same time, temporarily precluding further operation of the miniature thermal emission spectrometer and camera mast on Spirit.

Sol 207 became a recovery sol. While the timing issue was being analyzed, engineers decided not to use the mast, panoramic cameras, navigation cameras, Mössbauer spectrometer, alpha particle X-ray spectrometer, or the miniature thermal emission spectrometer. On the bright side, since the problem did not affect communications, a communications experiment with the European Space Agency's Mars Express orbiter was successfully conducted in the early morning hours of sol 208.

By sol 208, which ended on Aug. 3, Pacific Time, the mast had been declared usable. Operators commanded Spirit to drive 7.5 meters (25.6 feet) to Clovis, using a route avoiding the steepest terrain that had created problems for the rover in earlier sols.

Spirit is examining Clovis. This outcrop will likely be the subject of Spirit's most intensive investigation to date.

sol 201-204, August 03, 2004: *The quest for the top of the hills continues*

Mars has seasons like the Earth does, but the seasons are twice as long due to Mars' larger orbit around the Sun. Right now, Mars is approaching northern summer. That also means that it's approaching southern martian winter at the same time. So Spirit is headed for winter, being 14 degrees south of the equator. Because martian winter is setting in, solar array energy continues to be a concern for Spirit. If Spirit parks with a northerly tilt, the rover will see between 350 and 380 watt-hours of energy, but if Spirit stops on flat ground or with a southerly tilt, solar energy is as low as 280 watt-hours. So engineers make a concerted effort to find the north-facing islands along Spirit's path.

On Sol 201, Spirit was commanded to drive 98 feet (30 meters) across terrain that was pretty steep. Spirit accomplished 8.2 feet (2.5 meters) then stopped due to an excessive tilt angle of 25.6 degrees. Engineers had set the maximum tilt angle limit at 25 degrees. Spirit did complete pre-drive science observations and post-drive imaging.

On sol 202, Spirit repeated the drive plan from sol 201 with the maximum tilt angle set to 32 degrees. This time the rover completed the drive as planned, traveling 83.6 feet (25.5) meters up the hill. Spirit then performed post-drive imaging.

On sol 203, scientists' hope was to find rock outcropping in this location, but none were found. So the decision was made to continue the drive up the hill to find a better rock outcrop. Spirit performed another six-wheel, 62-foot (19-meter) drive. This drive was completed

successfully; however, at the end of the drive, Spirit drove into a small hollow. As a result, Spirit was pitched 15 degrees toward the southwest, and ended up with a southerly tilt.

Planning for sol 204 was very exciting due to the late downlink of information from sol 203. Very late in the planning cycle, available power on sol 204 was reduced from 370 watt-hours to 288 watt-hours. Ouch! Pre-drive observations were cut back to 17 minutes, during which the motors were heated for driving. Spirit drove only 0.82 feet (0.25 meters). Because the drive was so short, the power situation is not as bad as it could have been.

Total odometry after sol 204, which ended on July 30, is 2.21 miles (3,565.57 meters). Total elevation above the plains of Gusev Crater is estimated to be 30 feet (9 meters).

Over the next few sols, scientists and engineers hope to make it to "Clovis" rock outcrop and to recharge the batteries.

sol 198-200, July 28, 2004: *Spirit Survives 200 Sols!*

On sol 198, Spirit completed a long overnight reading by the Mössbauer spectrometer on a rock target called "Sabre," then ground a second rock abrasion tool hole on a target called "Mastodon." The alpha particle X-ray spectrometer was placed in the fresh hole in preparation for a reading, which was started during the overnight Odyssey communication pass.

On sol 199, Spirit completed a 6-hour early morning alpha particle X-ray spectrometer reading on Mastodon. After a midday nap to conserve energy, Spirit took pictures with the microscopic imager to create a mosaic of the rock abrasion tool hole. Spirit then placed the Mössbauer instrument in the hole and began a 20-hour overnight reading.

Sol 200, ending on July 26, was a busy day for Spirit. Spirit completed the overnight Mössbauer reading on the rock abrasion tool hole, took a midday nap, stowed the arm, bumped back to take pictures and readings of the hole with the panoramic camera and miniature thermal emission spectrometer, then drove about 52 feet (16 meters). Due to the nature of the terrain, the drive was done in 6-wheel mode to minimize errors (rather than the current standard 5-wheel mode to conserve the aging right front wheel). Engineers carefully targeted Spirit's drive to end in a location with favorable tilt to the north to point the solar panels toward the Sun, giving Spirit as much power as possible as the Sun hangs low in the sky during martian winter.

Spirit will continue to drive up the Columbia Hills and search for more rock outcroppings.

sol 194-197, July 26, 2004: *Spirit Investigates "Wooly Patch"*

On sol 194, Spirit took a large microscopic imager mosaic, consisting of 34 images at multiple positions, of a target called "Sabre" on an outcrop rock called "Wooly Patch." This was followed by a two-hour reading by the Mössbauer spectrometer and an overnight, seven-hour reading by the alpha particle X-ray spectrometer.

On sol 195, the rock abrasion tool dug a surprisingly deep hole in only two hours of grinding. The rock appears to be softer than what scientists and engineers have seen previously in Gusev Crater. The alpha particle X-ray spectrometer was placed in the rock abrasion tool hole at Sabre. However, due to uncertainties in how long the arm and grinding operations take, the sequence was terminated a few minutes too early and a planned overnight alpha particle X-ray spectrometer integration did not take place.

Spirit recovered the alpha particle X-ray spectrometer integration in the sol 196 plan. The sol began with a microscopic imager mosaic of the rock abrasion tool hole. The alpha particle X-ray spectrometer was put back in position in the hole, and reading lasting more than six hours was successfully performed, starting at about 4 a.m. Gusev time on sol 197.

The work on Sabre was completed with a very long, 21-hour Mössbauer integration, which was expected to be completed the morning of sol 198 (July 24). Before the integration was started on sol 197, a microscopic imager mosaic was taken of "Mammoth," the next rock abrasion tool target on Wooly Patch.

sol 190-193, July 26, 2004: *Spirit is Driving Backwards on Five Wheels*

On Sol 190, Spirit completed remote sensing and a 13-meter (43-foot) drive, which included driving on 5 wheels to minimize further degradation of the actuator on the sixth, aging, right front wheel. During the 5-wheel portion of drive, visual odometry was used to accurately estimate the rover position. The drive ended with a short 6-wheel drive to achieve the desired position. This approach worked well, and engineers will continue to do 5-wheel driving to preserve the right front wheel actuator life while still achieving the desired position.

On Sol 191, Spirit took pictures with the microscopic imager and used the Mössbauer spectrometer on soil, then successfully completed another 10-meter (33-foot), 5-wheel drive to the north. (As Spirit is driving backwards to 'drag' the right front wheel, the robotic arm is effectively now in the back of the rover.)

On Sol 192, Spirit turned east off of a planned northerly traverse route to investigate a potential rock outcropping. The 17-meter (56-foot) drive, which included two sections of 5-wheel driving, landed Spirit right on top of the outcrop. Unfortunately, the drive left the rover at a bad tilt angle for solar energy, decreasing the available energy.

On Sol 193, which ended on July 19, Spirit completed a series of microscopic images and a short Mössbauer reading on the outcrop. Spirit then moved into a better position to use the rock abrasion tool and to improve the tilt toward the Sun for solar energy.

In the upcoming sols, Spirit will use the rock abrasion tool and other science instruments to investigate Wooly-Patch. Then it will resume driving up the "Columbia Hills" to look for more outcrops.

sol 184-189, July 26, 2004: *Spirit Completes its 'Tune-up' and Begins Driving Backwards*

On sols 184 and 185, Spirit cycled heaters and attempted to lubricate the right front wheel's drive motor. Spirit also performed very short test drives. Spirit's orientation on "Engineering Flats" had the rover in a slight southerly tilt, away from the Sun. This low Sun angle, coupled with the power required to energize the heaters, put quite a strain on the batteries. The state of charge of the batteries after the test was very low, so science observations were not performed during these two sols.

On sol 186, Spirit used its instrument deployment device, or robotic arm, to validate a new front hazard-avoidance camera model. This new model will improve the positioning accuracy of the tools on the arm. The arm attempted to place the Mössbauer spectrometer at nine different locations. Seven targets were hit, and two targets were missed. The engineering team planned to repeat this operation on the two missed positions on a later sol. Spirit also performed a test drive to characterize the results of the lubrication activity. The beginning orientation of the vehicle had the right front wheel facing the Sun, so the starting temperature was much warmer than the original baseline test drive. This temperature difference makes it hard to accurately compare the pre and post test-drive results. Analysis indicates there is approximately a 20 percent increase in wheel drive performance, but engineers cannot attribute this gain to the four-sol wheel heating operation alone. Spirit sat mostly motionless for the about the last 30 sols, and that allowed some lubrication to re-flow naturally. The bottom line is that the right-front wheel's performance has improved, but it is still drawing about twice as much current as any other wheel.

After the tune-up, Spirit was free to begin its drive away from Engineering Flats and head to higher ground and a better solar orientation. On sol 187, with its batteries very low, Spirit limped 8 meters (26 feet) to a location with a slightly better tilt toward the Sun and performed about 50 minutes of science observations.

On sol 188, Spirit continued to drive away from Engineering Flats. As a strategy for dealing with the right-front wheel, Spirit is now driving backwards and dragging its right front wheel when it is on relatively flat terrain. This strategy aims to extend the lifetime of the wheel's drive motor for use when it is needed most. Spirit performed its first backward test drive of 4 meters (13 feet) on this sol. Spirit also performed about an hour and a half of remote-sensing observations using the panoramic camera, navigation camera and miniature thermal emission spectrometer.

On sol 189, which ended on July 15, Spirit's battery state of charge increased due to a better tilt of the solar arrays toward the Sun. Spirit performed a precision 6-meter (20-foot), 6-wheel drive, then drove another 3 meters (10 feet) doing the wheel drag. Spirit also imaged an interesting rock outcrop. The outcrop was directly beneath the vehicle and extending northward.

Total odometry after sol 189 is 3,450 meters (2.14 miles). Vehicle heading is 184.8 degrees.

sol 181-182, July 16, 2004: *Spirit Gets Into Position for a Tune-Up*

Sol 181:

On sol 181 the plan for Spirit was to deploy the instrument deployment device for microscopic imaging, then perform a two-hour Mössbauer integration. The rover was to conduct miniature thermal emission spectrometer and navigation camera observations of rover-disturbed soil. After this, the rover was to drive to a relatively flat area dubbed "Engineering Flats." This was to prepare for a multi-sol engineering activity to heat, and ideally re-lubricate, the right-front wheel actuator. After the drive, Spirit was to take a 360-degree navigation camera panorama, followed by miniature thermal emission spectrometer observations during the communications session with NASA's Mars Odyssey orbiter. Unfortunately, as Spirit began to execute the sol 181 plan, the onboard software predicted an instrument deployment device collision. This prevented further arm functions and the drive.

Sol 182:

On Sol 182, rover planners quickly determined the cause of the instrument deployment device error and continued to plan for sol 182 as normal. The intent for sol 182 was to complete the activities originally intended for sol 181. The sol 182 plan executed nominally, placing Spirit squarely in the middle of Engineering Flats.

sol 179-180, July 15, 2004: *Spirit Reaches 180 Sols!*

On sol 179, Spirit woke up at a new location and spent the day performing remote sensing with the miniature thermal emission spectrometer, including an overnight observation.

Sol 180 marked a grand accomplishment for Spirit. The rover has survived two times the original planned mission duration of 90 sols. On this notable sol, the rover continued with remote sensing, performing miniature thermal emission spectrometer observations on disturbed soil and rover tracks. Spirit then looked at the targets "Cookie Cutter" and "Julienned" with the panoramic camera. Because of power and timing issues, Spirit was not able to complete intended microscopic imaging, Mössbauer spectrometer, and alpha particle X-ray spectrometer measurements at this site. These operations were moved into the sol 181 plan. Total odometry after sol 180 is 3414 meters (2.1 miles).

sol 175-178, July 09, 2004: *Spirit Tries Out Visual Odometry*

On sol 175, Spirit analyzed the new targets "Breadbox" and "Sourdough" with its panoramic camera and miniature thermal emission spectrometer. Spirit then got an up-close look at Breadbox with the microscopic imager, and deployed the Mössbauer spectrometer on Sourdough for an overnight integration. In the middle of the martian night, Spirit did a tool change to the alpha particle X-ray spectrometer and completed a five-hour integration before the sol 176 plan began.

Spirit spent sol 176 getting a battery re-charge and a front hazard avoidance camera calibration. The evening of sol 176, engineers commanded Spirit to wake up and enable the panoramic camera mast actuator heater so they could determine when the thermostat turns the heater on. The heater turned on when expected, which will allow Spirit to conduct a night-time miniature thermal emission spectrometer observation in a few sols.

On sol 177, Spirit successfully performed a series of observations on an interesting and shiny feature called "String of Pearls." The rover acquired two microscopic images of the target and an overnight integration with the Mössbauer spectrometer and alpha particle X-ray spectrometer. As Mars' southern winter approaches, Spirit's energy resources become increasingly limited. Overnight tool changes and their associated heating take a big toll on the limited energy budget, and require some preparation and recovery to keep up Spirit's battery charge.

Spirit began sol 178 by stowing the robotic arm and then backing up 1.5 meters (about 5 feet) from "Hank's Hollow" in order to properly place the miniature thermal emission spectrometer to get a good view of "Pot of Gold" and nearby rover tracks. Engineers also took this opportunity to use visual odometry for the first time on Spirit. This is a technique in which the rover takes successive images of its surroundings during a drive and then matches features in those images on-board to compute how far and in what direction it has moved. Both the drive and the test went well, and ground verification showed that the matching worked quite nicely with the features in this terrain. Visual odometry will be important if and when Spirit starts driving on five wheels, since the actual drives can and will be rather different than what is commanded. The rover can use the visual odometry estimates while driving to compensate for the slipping and yawing that engineers expect with five-wheel driving.

sol 171-174, July 02, 2004: *Moving On From 'Pot-of-Gold'*

On sol 171, Spirit continued its investigation in "Hank's Hollow" and the rock target "Pot-of-Gold." The rover successfully completed observations of the abraded area with the microscopic imager and alpha particle X-ray spectrometer.

On sol 172, Spirit looked at the sky with the miniature thermal emission spectrometer and panoramic camera. The rover also acquired some thermal inertia observations of nearby soil with the miniature thermal emission spectrometer. Spirit finished up its Pot-of-Gold observations with some microscopic images and a final long Mössbauer integration of the abraded surface.

On sol 173, Spirit performed atmospheric observations with the miniature thermal emission spectrometer and panoramic camera. The rover also took some panoramic camera context images for the sol 172 thermal inertia observations. The rover finished the day's work by stowing the instrument deployment device and doing a "bump-back" to the "Bread Box" target. One last panoramic camera shot of Pot-of-Gold ended up a bit overexposed and will need to be retaken.

On sol 174, Spirit began the day acquiring atmospheric observations with the mini thermal emission spectrometer and panoramic camera. The rover then imaged the drive direction with the panoramic camera. Last but not least, Spirit took a look at a disturbed area of soil called "Bright Tracks" with the panoramic camera to help scientists learn more about the very bright material found here.

During the next 15 or more sols, rover planners will perform a "3,000 meter tune-up" on Spirit before the rover embarks on a climb up the hills.

The tune-up will include a number of elements including:

A front hazard avoidance camera calibration where a series of robotic arm poses and hazard avoidance camera images will be used to refine the rover planners' ability to target objects using stereo hazard avoidance camera images. The team is currently experiencing a 2 to 3 centimeter (slightly less or slightly greater than an inch) error in predicted versus actual target locations in the vicinity of the instrument deployment device.

Spirit's first deep sleep. Deep sleep is a mode that leaves the rover completely un-powered overnight, saving the energy that would be spent powering rover electronics and survival heaters that are normally on even when the rover is napping. Spirit needs deep sleep to save energy in the coming sols. Since deep sleep is potentially harmful to the mini thermal emission spectrometer instrument because its survival heater is not powered, rover planners have identified two observations that must be completed before the first deep sleep is attempted. Opportunity has been using deep sleep for several weeks now.

A right front wheel lubrication. Spirit's right front wheel continues to draw roughly twice the current of the other wheels. Spirit will drive to "Engineering Flats," a relatively flat, hazard-free area where rover planners will execute a series of diagnostic drive tests and heating sequences over the course of four to five sols. The intent is that the heating will re-flow the lubricants in this actuator, correcting the problem. Engineering Flats is roughly 7 meters (nearly 23 feet) from Spirit's current location.

Engineering tests of visual odometry. Visual odometry uses navigation camera images taken during a drive to determine the rover's location. This rover feature has been improved and is ready for trial runs now. Rover planners would like to use it on a regular basis to get Spirit where they want it to go more quickly. Due to slippage, Spirit sometimes needs two or more sols to make a short approach when using the blind drive technique.

sol 167-170, June 30, 2004: *Just a Little Rock Abrasion Tool*

On sol 167, Spirit looked at a bit of soil called "Jaws" with the alpha particle X-ray spectrometer and microscopic imager. Then the rover completed a drive intended to put it into position to analyze "Pot-of-Gold" with the instruments on its robotic arm. The drive moved Spirit farther than expected though, and the rover ended up directly over the rock. That position prevented any observations with the instrument deployment device.

On sol 168, rover planners commanded Spirit to "bump" backward, into a position where the rock abrasion tool could make contact with Pot-of-Gold. This was successful, and Spirit spent the rest of the time taking images of the surrounding area with its panoramic and navigation cameras.

On sol 169, Spirit successfully operated its rock abrasion tool on Pot-of-Gold, grinding away the top .2 millimeters (.008 inches) of rock from the high points. The procedure took 1 hour and 45 minutes. Pot-of-Gold posed a special challenge to the rover team because it is quite small -- only slightly larger than the rock abrasion tool instrument itself. The rock abrasion tool inflicts about 6.8 kilograms (15 pounds) of pressure on its rock targets, and smaller rocks aren't necessarily stable enough to resist this.

Before and after pictures of Pot-of-Gold showed that the rock was moved by the rock abrasion tool procedure. That movement, plus possible slippage where the tool contacts the rock, resulted in only intermittent contact during the grinding operation. After the grind was complete, Spirit placed the alpha particle X-ray spectrometer on the freshly exposed area in preparation for an operation later that night.

On Sol 170, Spirit awoke to stop the alpha particle X-ray integration, took miniature thermal emission spectrometer and panoramic camera images of some local track marks, took more microscopic images of the newly exposed Pot-of-Gold, then placed the Mössbauer instrument on the site for a 21-hour overnight observation.

sol 164-166, June 25, 2004: *Edging Up on 'Pot-of-Gold'*

Spirit spent the last few sols getting into position on the rock target "Pot-of-Gold" for an upcoming grind with the rock abrasion tool. This repositioning has not been easy due to slippage in the sandy-sloped terrain at the base of the "Columbia Hills."

On sol 164, Spirit completed an overnight alpha particle X-ray spectrometer observation on Pot-of-Gold and then gathered additional microscopic images of the rock. In the afternoon, rover planners tried to reposition Spirit from a heading of about 170 degrees to a heading of about 95 degrees to improve the instrument deployment device positioning on Pot-of-Gold for the upcoming rock abrasion tool work. The planned traverse sent Spirit past Pot-of-Gold, down a slope on the west side of "Hank's Hollow," then turned the rover to re-approach at the desired heading. The slope and slippage was greater than expected, leaving the rover at a westerly tilt of 19 degrees and almost 2 meters (6.6 feet) away from the target.

Spirit worked toward getting into position in front of Pot-of-Gold on sol 165, but given the slippage and need to avoid overshooting the target, engineers anticipated it would take at least two sols to get properly repositioned. Unfortunately, the drive made less progress than desired due in part to a collection of rocks encountered by the left rear wheel.

On sol 166, Spirit took advantage of its current position and used the gathered Mössbauer data and microscopic images of the soil in front of it before continuing the hill climb. Spirit's front wheels made it over the crest, leaving the rover at about a 13-degree tilt and still about 1 meter (3.3 feet) from Pot-of-Gold.

sol 161-163, June 23, 2004: *'Pot-of-Gold' Revealed*

Spirit currently sits at the base of the "Columbia Hills" in an area called the "Hank Moore Hollow." This area has a collection of intriguing rocks on its rim, one of which, "Pot-of-Gold," will be the first target for scientists' observations.

Spirit used the microscopic imager to get an up close view of Pot-of-Gold on sol 161, but unfortunately, the images were out of focus. Rover planners attribute the blurry shots to a lower than expected rock contact prior to the imaging sequence. Spirit did successfully acquire Mössbauer observations of Pot-of-Gold on this sol.

On sol 162, Spirit was commanded to retake the microscopic images of Pot-of-Gold and do extensive observations with the Mössbauer and alpha particle X-ray spectrometer instruments. The microscopic images were successfully obtained, but a positioning fault of the instrument deployment device prevented the Mössbauer and alpha particle X-ray spectrometer observations from executing.

Spirit successfully completed the work with its instrument deployment device on sol 163, and took some additional microscopic images of Pot-of-Gold.

sol 156-158, June 16, 2004: *Spirit Reaches the 'Columbia Hills!'*

On sol 156, Spirit roved 42 meters (138 feet) closer to a vantage point where it could observe the hill outcrops. Some of the images that Spirit sent back revealed a small and unusual rock that piqued scientists' interest and was informally named "End-of-Rainbow."

Part of the sol 157 plan was to observe End-of-Rainbow and use the alpha particle X-ray spectrometer, Mössbauer spectrometer and microscopic imager to study the "Shredded" soil target. However, the command load for sol 157 never made it to Spirit. Further analysis indicated that the problem had to do with the frequency drift associated with the colder temperatures on Mars as the planet moves into its southern winter season. This was an anticipated problem, and the rover team has already imposed some strategies that will help to prevent the problem in the future.

So, Spirit got a break on sol 157 and began sol 158 with nicely charged batteries. She executed the activities originally planned for sol 157, and then began to drive a bit closer to End-of-Rainbow. Although the direct path to End-of-Rainbow would be only a 4-meter (13 feet) drive, it was deemed too steep and hazardous by the rover team, so they planned a multi-stepped drive that could get the rover to the target safely. On sol 158, the first part of the drive was completed, putting Spirit a little farther away from the End-of-Rainbow target, but with a straight shot to the rock for sol 159.

sol 152-155, June 15, 2004: *Are We There Yet?*

On sol 152, Spirit continued its journey toward the "Columbia Hills" and completed an 83-meter (272 feet) drive that brought its total odometry to 3.2 kilometers (2 miles). After the drive, the rover completed some remote sensing that brought more details of the hills into view.

Spirit roved another 70 meters (230 feet) on sol 153, and 49 meters (161 feet) on sol 154. After the drive on sol 154, Spirit attained a miniature thermal emission spectrometer scan of the hills that will help scientists identify what the hills are made of.

As of sol 155, Spirit was roughly 50 meters (164 feet) from the base of the target location at the Columbia Hills. Spirit reached this location after a 23-meter (75 feet) drive that ended with the rover at a maximum tilt of 20 degrees. 20 degrees is well below the safe limit for tilt and was 3 to 4 degrees below the estimated tilt for this traverse.

sol 148-151, June 09, 2004: *Spirit Surpasses 3 Kilometer Mark!*

During sols 148 through 151, Spirit advanced significantly closer to the "Columbia Hills" and now sits only 220 meters (722 feet) from its first target at the base, a location informally named "Spur B."

Sol 148 was a driving sol, with Spirit completing a 64.7-meter (212.3 feet) engineer-directed drive. This put the rover in position for some sol 149 work with the robotic arm, and provided a great view of the Columbia Hills.

On Sol 149, Spirit took a break from driving and surveyed the Columbia Hills with the panoramic camera and mini thermal emissions spectrometer. After that, the rover attained an alpha particle X-ray spectrometer observation of the filter magnet and capture magnet. Spirit takes a look at its magnets every now and then to assess what magnetically susceptible materials have accumulated. The last magnet check was on sol 92.

Spirit used its alpha particle X-ray spectrometer and Mössbauer spectrometer to observe a rock called "Joshua" on sol 150. Unfortunately, the rest of the sol's planned work with the instrument deployment device did not take place because of a command anomaly, which made Spirit think that a collision between the rock abrasion tool and the forearm might occur. Therefore, the tool change and all subsequent arm motions were prevented for the rest of the sol.

Spirit was back to business on sol 151, and finished observing Joshua and the science magnets with the tools on the instrument deployment device. After that, the rover was off, and successfully completed a 73-meter (240 feet) drive toward the Columbia Hills.

sol 145-147, June 08, 2004: *Keep On Rovin'*

On sol 145, Spirit completed a 43-meter (141 feet) engineer-directed drive and then spent two hours roving another 55 meters (180 feet) using the autonomous navigation software.

Spirit roved 61 meters (200 feet) on sol 146, and 52 meters (171 feet) on sol 147. At its current rate, the rover is on schedule for a sol 160 arrival at the base of the "Columbia Hills."

Spirit currently has a total of 2.98 kilometers (1.85 miles) on its odometer.

sol 143-144, June 03, 2004: *Roving Toward the Hills*

Spirit began sol 143 using the panoramic camera to image its surroundings. After a restful nap, the rover began driving and advanced 69 meters (226.4 feet) in an engineer-directed drive toward the "Columbia Hills." After doing some mid-drive science imaging, Spirit attempted additional driving using its autonomous navigation software, but detected hazards in the immediate vicinity of the rover and therefore covered no additional ground.

On sol 144, Spirit covered 24.4 meters (80 feet) in another engineer-directed drive. Once again, the terrain was too rough to permit further driving beyond this point using the autonomous navigation software. On sol 145, Spirit will continue driving in its quest for the hills.

sol 140-142, June 02, 2004: *Back To Business*

Spirit spent most of sol 140 investigating the trench it dug on sol 135. It got an up-close look at the trench with the microscopic imager and then began a five-and-a-half hour integration with the Mössbauer spectrometer. Doing double duty, Spirit surveyed the "Columbia Hills" with the panoramic camera and miniature thermal emission spectrometer during the Mössbauer observation. Following the afternoon Odyssey communications window, Spirit changed tools and began an overnight integration on two targets with the alpha particle X-ray spectrometer.

On sol 141, Spirit continued to observe the trench with the Mössbauer spectrometer and microscopic imager. The rover also obtained panoramic camera images of its surroundings while doing work with the robotic arm. It then stowed the instrument deployment device and backed up 0.85 meters (2.8 feet). Spirit spent most of the afternoon observing the trench using the miniature thermal emission spectrometer.

Spirit got a chance to stretch its wheels and do some driving on sol 142, but before taking off, the rover finished the trench observations with some panoramic camera imaging. Then it was time to rove. Spirit completed a 30-minute, engineer-directed drive and then turned the wheel over to the autonomous navigation software for another hour and 15 minutes of driving. Spirit roved a total of 61 meters (200.1 feet) closer toward the Columbia Hills.

Spirit has 2,647.7 meters (1.65 miles) on its odometer, and just over 620 meters (.4 miles) to rove before reaching the base of the Columbia Hills.

sol 136-139, June 02, 2004: *Spirit Recovers from a Low Probability Software Error*

Spirit had plans to spend sols 136 through 139 observing its surroundings with the remote sensing instruments on its mast, and then exploring the trench it dug on sol 135 with the instruments on the robotic arm. However, an anomaly on sol 136 restricted the rover's activity, allowing Spirit to achieve only remote science objectives during the four-sol segment. Spirit has since fully recovered and has resumed normal science operations.

On sol 136, engineers sent Spirit its commands and received the beep confirming that they were running. However, the afternoon pass by NASA's Mars Odyssey orbiter did not provide any data, and the orbiter reported that it had not heard from Spirit's UHF antenna. Engineers first thought was that the signal might have been blocked by the "Columbia Hills" because of the low elevation pass of Odyssey. The telecommunications team disagreed with this hypothesis and thought something might be wrong. Scientists and engineers would have to wait until the afternoon of sol 137 for their next communications opportunity.

During sols 136 and 137, engineers executed a number of communication trials with Spirit, but did not receive any telemetry from the rover, or have any indication of what had gone wrong until finally data came back from a sol 137 afternoon pass by NASA's Mars Global Surveyor. That pass revealed that on sol 136, Spirit's software had experienced an extremely low probability error that rebooted the computer and terminated all the sequences. This error created a domino effect of communication difficulties and explained why engineers had not been able to make contact with the rover. All the anomaly events are understood.

Sol 138 was spent recovering the state of the rover, including reestablishing a master sequence, restoring high-gain antenna communications, and reinitializing the panoramic camera mast actuators whose positions had been marked as unknown.

On sol 139, Spirit performed the remote-sensing observations that had been lost along with some observations coordinated with Mars Global Surveyor that had been planned for sol 138. All activities on sol 139 completed successfully, which verified that Spirit had returned to normal science operations.

Engineers have developed a way to reduce even further the probability of encountering this particular error again and reported that on the bright side, Spirit was able to fully charge its batteries during the anomaly.

Sol 140 picked up with the original plan for Sol 137, performing in-situ work in the trench.

sol 134-135, May 27, 2004: *Taking Time to Trench*

Spirit roved an impressive 109.5 meters (359.3 feet) on sol 134. Two hours of the drive were guided by the autonomous navigation system. After the long traverse, Spirit completed an hour of post-drive science observations with the panoramic and navigation cameras and mini thermal emission spectrometer. The rover finished the sol healthy and ready for another day on Mars.

After so much driving on sol 134, Spirit got a break and spent sol 135 doing in-situ science investigations of its surroundings. It began the sol observing nearby soil with the alpha particle X-ray spectrometer and Mössbauer spectrometer. It then used the microscopic imager to see the soil up close. After stowing the instrument deployment device, Spirit used its wheels to dig a trench and then imaged the trench with the cameras on the mast.

Spirit's odometer now reads 2,585.52 meters (1.6 miles). The rover still has 680 meters (0.42 miles) to go before reaching the base of the "Columbia Hills," but will likely get there before sol 160.

sol 131-133, May 20, 2004: *Spirit Gets an Unexpected Break*

Spirit continued its trek to the "Columbia Hills" over the past four sols, but took an unplanned break on Sols 131 and 132 due to a software fault on sol 131. That fault left rover planners with some uncertainty about Spirit's final position and attitude, so Sol 132 was spent re-establishing that knowledge with panoramic, navigation and hazard avoidance camera imaging of the rover's surroundings. The unplanned break did have a silver lining though; it resulted in fully charged batteries, paving the way for a long drive on Sol 133. Spirit roved 113 meters (370.7 feet) on Sol 133, with a record 78-meter (256 feet) autonomous navigation segment. The previous record for an autonomous navigation drive was 62 meters (203.4 feet) on sol 125. Spirit's odometer now reads 2473 meters (1.53 miles) and it is roughly 780 meters (.5 miles) from the Columbia Hills and in excellent health.

So what went wrong on sol 131? The flight software team is uncovering the details, but it appears that the error occurred within a 3-microsecond window of vulnerability when a "write" command was attempted to a "write-protected" area of RAM. The flight software team believes this is an extremely low probability event, and has not adjusted the planning process to avoid the miniscule period of vulnerability. Opportunity has the same vulnerability to the fault.

sol 127-130, May 17, 2004: *Spirit Roving Right Along*

Spirit spent most of sol 127 continuing its drive toward the "Columbia Hills." The rover put approximately 70 more meters (229.7 feet) on its odometer and then took an hour-and-20-minute siesta. After the drive, Spirit took observations with the panoramic camera, navigation camera and mini thermal emission spectrometer.

Spirit began sol 128 by completing a panoramic camera observation of a rock target called "Flat Head." The rover then rested up for a couple of hours before embarking on a 90-meter (295 feet) drive toward the hills. Once the drive was complete, Spirit completed its

standard post-drive observations.

Sol 129 began successfully, but Spirit encountered a couple of difficulties before the martian day was over. After waking, Spirit performed 45 minutes of science observations and then settled down for a morning nap. With plenty of energy stored, it was time to drive. Spirit roved 31 meters (102 feet) across the surface in an engineer-directed drive and then spent 45 minutes using its autonomous navigation system to try to drive down the side of a small ridge. The backside slope of the ridge was too steep, and the autonomous navigation system had Spirit turn in an attempt to find another way down. Unfortunately, a couple of large rocks close to the ridge prevented Spirit from finding a safe path down. At the end of the drive sequence, Spirit was supposed to complete a "stutter step" to get in proper position to do work with the instrument deployment device on sol 130. Unfortunately, the rover was unable to complete this final positioning or the ultimate post-drive imaging, so sol 130 was mostly a drive sol.

Spirit has 2,291.92 meters (1.4 miles) on its odometer and is approximately 936 meters (.6 miles) from Columbia Hills. The rover is on track to reach the Columbia Hills by sol 160.

sol 124-126, May 12, 2004: *Spirit Speeds to 'Lead Foot'*

Spirit drove 80 meters (262.5 feet) on sol 124, bringing its total odometry to 1,909.52 meters (1.2 miles). Spirit has less than 1.2 kilometers (.75 mile) to go before reaching the base of the "Columbia Hills," and will reach them by sol 160. Later in the martian day, after completing the sol 124 drive, Spirit took a 360-degree afternoon panorama of its surroundings with the navigation camera.

On sol 125, Spirit continued driving and set a new one-sol driving record of 123.7 meters (405.8 feet). Science on Sol 125 included morning atmospheric sky and ground remote sensing, mini thermal emission spectrometer observation of the sol 126 instrument deployment device work volume, imaging with the panoramic camera, and cloud observations.

After the long sol 125 drive, Spirit was in perfect position to work with the instrument deployment device on sol 126. This included alpha particle X-ray spectrometer, Mössbauer and microscopic imager work on a target called "Lead Foot" (in honor of the big drive on sol 125). The Mössbauer was used as the feeler for all these activities but touched down on rocks rather than soil at the "Lead Foot" location, compromising the Mössbauer and microscopic imager data (images out of focus). Spirit also did some driving on this sol, and added 55.6 meters (182.4 feet) to the odometer, bringing Spirit's new drive total to 2,089 meters (1.3 miles). At the end of the sol, Spirit successfully executed a sequence that used the panoramic camera to find the Sun and correct for accumulated rover attitude errors.

sol 121-123, May 10, 2004: *Spirit Surpasses the One-Mile Mark!*

On sol 121, after a brief nap, Spirit conducted atmospheric measurements before continuing its trek toward the "Columbia Hills." A 96.8 meter (318 feet) drive that consisted of about half direct drive and half auto-navigational drive broke Spirit's last one-sol distance traveled. That drive brought the mission total to 1,669 meters (1.04 miles), flipping the rover's odometer over the one-mile mark.

Sol 122 was a touch-and-go day, starting with a half-hour alpha particle X-ray spectrometer integration, a one-hour Mössbauer integration and a set of four microscopic images all on the same patch of soil. Panoramic camera and miniature thermal emission spectrometer data were also obtained before an afternoon nap. The bulk of the afternoon was spent driving another 65 meters (213 feet).

Sol 123 started off with Panoramic camera and miniature thermal emission spectrometer observations for near-field surveys, atmospheric studies, and localization. Spirit then took a half-hour nap, followed by the day's drive. This sol consisted of another 48-meter (about 157-foot) direct drive, the mid-drive survey and localization remote sensing, and then 47-meters (about 154 feet) of driving using auto-navigation. The total was 95.2 meters (312 feet), bringing the mission total to 1830 meters (1.14 miles).

sol 118-120, May 6, 2004: *'Columbia Hills' on the Horizon*

Spirit is now approximately 1.7 kilometers (1 mile) away from the base of the "Columbia Hills" after three long sols of driving. Its odometer currently reads 1,566 meters (.97 miles) and counting.

Sol 118 was a record-breaking driving sol for Spirit. The Gusev Crater rover moved 92.4 meters (303 feet) across the surface in one sol, breaking its previous record of around 90 meters (295 feet). The Opportunity rover still has Spirit beat with a one-sol driving record of 140 meters (459.3 feet).

Sol 119 proved to be a more difficult sol for Spirit. An uplink configuration error prevented the sequence load from successfully getting on board the rover. Rover controllers took advantage of the down day by deleting afternoon communication sessions and enabling the rover to charge its battery during a long afternoon nap.

It was back to business as usual on sol 120. Before embarking on its drive, Spirit imaged a rock called "Tulula" with the panoramic camera. The rover then successfully executed a blind drive before using the autonomous navigation system to continue into uncharted territory. After reaching the time-of-day driving limit, Spirit turned and performed penultimate (next to last stop) imaging. The next move would have taken the rover 85 centimeters (33.5 inches) to its ultimate stopping point, but did not execute because Spirit was facing a small sand ridge that was perceived as a hazard. Without a penultimate/ultimate image pair, rover controllers could not be sure that the area underneath the rover was clear of hazards for instrument arm deployment. As a result, Sol 121 will be another driving sol that controllers hope will place Spirit in a suitable location to use the instruments on its instrument deployment device.

sol 114-117, May 3, 2004: *Spirit explores the 'Big Hole' trench*

On Sol 114, which ended at 9:49 a.m. April 29 PDT, Spirit performed a lot of science activities in the trench called "Big Hole" using the microscopic imager, Mössbauer spectrometer and alpha particle X-ray spectrometer. Opportunity also studied the rover tracks and the crater rim.

Sol 116 started with a repeat of the microscopic imaging of a target in the trench due to minor communication glitches on sol 115. Spirit then stowed the arm, backed away from Big Hole trench, and took panoramic camera images of the trench before it continued on its trek toward the Columbia Hills. The drive on sol 116, which ended at 11:08 a.m. May 1 PDT, established a new drive record of 90.8 meters (298 feet) for Spirit!

On sol 117, which ended at 11:47 a.m. May 2, Spirit drove 37 meters (121 feet) to a small ridge, where the vehicle experienced a pitch up of 12.2 degrees. Engineers believe that the change in tilt caused the vehicle to recompute its "goodness map," which helps the rover autonomously drive over the martian terrain, and the rover declared that it was not safe to continue its drive. One good thing that came out of this is that the end-of-drive tilt positioned the solar arrays to maximize afternoon solar exposure, and the rover's battery state of charge is in good health.

sol 112-113, Apr 29, 2004: *A Drive and a Dig*

Spirit took it easy the morning of sol 112, which ended at 8:30 a. m. PDT on April 27, , and didn't begin operations until 11:45 a.m. Mars Local Solar time, to conserve energy for an afternoon drive. Before taking off, Spirit gathered some soil and atmospheric observations with the mini thermal emission spectrometer and panoramic camera.

Then the drive began. Spirit's updated autonomous navigation software proved its worth again this sol. During a long auto-navigation segment, the rover encountered a hazard and was able to back up and find a way around it. Spirit continued to drive backwards towards its intended goal point, using the rear hazard avoidance cameras to navigate the way. When the allotted drive time was up, Spirit turned back around and made one last short drive to its resting place for the night. Spirit's odometer records backwards and forwards driving and logged another 88.6 meters (290.7 feet) for the sol 112 drive. The actual distance covered was about 60 meters (197 feet).

On Sol 113, which ended at 9:09 a.m. PDT on April 28, Spirit woke up earlier than normal, 9:00 a.m. Mars Local Solar time, to do morning atmospheric science. One objective of the early sky scan was to image morning clouds with the panoramic camera. Spirit then began an intense study of a soil spot called "MayFly." During her examination of the area, Spirit took panoramic camera and mini thermal emission spectrometer images in parallel, conducted a two-hour Mössbauer integration and finished off with a look through the microscopic imager. The rover then stowed the instrument arm to prepare for digging a trench.

Rover planners intended for Spirit to use its wheels to dig a trench at the MayFly spot, but hazard avoidance camera images of the area showed a potato-size rock that could have potentially fallen into the wheel hollow in the process. Rather than take that risk, controllers decided to back the rover up 10 centimeters (3.9 inches) to a clearer spot. After the final positioning, Spirit used its wheels to dig a 6-centimeter (2.4-inch) trench. Spirit finished the sol with hazard avoidance camera images of the trench, which was used to plan Mössbauer, alpha particle X-ray spectrometer and microscopic imager work on sol 114.

On sol 114, which ended at 9:49 a.m. PDT on April 29, 2004 Spirit continued to investigate the trenched area with the Mössbauer spectrometer, alpha particle X-ray spectrometer and the microscopic imager.

sol 110-111, Apr 27, 2004: *Spirit Continues to Drive*

After a successful weekend of driving on sols 108 and 109, Spirit kicked off its week with a 140-meter (459.3 feet) drive over sols 110 and 111 toward its destination at the base of the "Columbia Hills."

Spirit began sol 110, which ended at 7:10 a.m. PDT on April 25, 2004, with a stretch of its "arm" to take microscopic imager pictures of an area of soil called "Waffle Flats." It then placed the Mössbauer spectrometer instrument on that spot for a 90-minute integration. Spirit did double-duty and was able to get panoramic camera and mini thermal emission spectrometer images of the area for localization and science purposes while the Mössbauer was at work.

Spirit then stowed its instrument deployment device and began an 80-meter (262.5 feet) drive, half of it directed by rover planners and half using the autonomous navigation software. During the autonomous navigation portion, the rover detected a hazard and did not complete the final short-drive intended at the end of the journey. Images from the front hazard avoidance camera show no sign of a hazard, leaving rover controllers with a bit of a mystery to investigate.

Following the drive, Spirit took panoramic camera and navigation camera images in the drive direction and performed atmospheric science with the panoramic camera and mini thermal emission spectrometer.

Sol 111, which ended at 7:50 a.m. PDT on April 26, 2004, was also a sol full of driving for Spirit. After acquiring panoramic camera images of its surroundings and completing atmospheric science with the panoramic camera and mini thermal emission spectrometer, the rover began its drive.

Spirit successfully completed a 60.8-meter (199.5 feet) drive toward the Columbia Hills and then acquired navigation and panoramic camera images of the driving direction. Spirit ended the day with mini thermal emission spectrometer observations of the soil and then a coordinated mini thermal emission spectrometer and panoramic camera study of the atmosphere.

sol 106, Apr 23, 2004: *A Little Science, a Lot of Driving*

Spirit spent most of sol 106, which ended at 4:32 a.m. PDT on April 21, performing remote sensing on the inside of "Missoula Crater." It acquired panoramic camera and mini thermal emission spectrometer panoramas and navigation camera images of the crater, along with some panoramic camera images looking back toward "Bonneville" crater.

On the morning of sol 107, which ended at 5:12 a.m. PDT on April 22, Spirit got some atmospheric and cloud observations with the panoramic camera and mini thermal emission spectrometer. The rover then took a look with the panoramic camera at three targets called "Gratteri Piazza," "Wallula Gap," and "Clark Fork." Finally it was time to drive. Spirit completed a 73.8-meter (242-feet) traverse that included a jog around a sandy hollow to the east of Missoula. Most of the drive was in the southeast direction on course to the "Columbia Hills." After the drive, Spirit acquired additional panoramic camera and navigation camera observations. The total odometry at the end of sol 107 was 976.77 meters (.6 miles).

Spirit continued driving toward the Columbia Hills on sol 108, which ended at 5:51 a.m. PDT on April 23, and will drive some more on sol 109, which ends at 6:31 a.m. on April 24.

The wakeup song on sol 109 was "(Take me) Riding in my Car" by Woodie Guthrie.

sol 102-104, Apr 19, 2004: *'Missoula Crater' in Sight*

Spirit had a busy weekend, culminating with a 75-meter (246-feet) drive toward "Missoula Crater" on sol 103, which ended at 2:33 a.m. PST on April 18. The sol before the drive, Sol 102, which ended at 1:54 a.m. on April 17, was an easier day for Spirit. Its main objectives were to use the panoramic camera and mini thermal emission spectrometer to acquire photometric and atmospheric measurements.

Before beginning the drive on sol 103, Spirit took panoramic camera images to help planners localize the rover during the long traverse. It then used the panoramic camera and mini thermal emission spectrometer to take a look back at the wheel tracks. Once this information was onboard, the rover began to drive.

Rover controllers planned the first 37 meters (121.4 feet) of the drive, but Spirit used the updated autonomous navigation software to see it through the remaining 38 meters (124.7 feet). Between the two drives, Spirit imaged its surroundings with the panoramic and navigation cameras for context. At the end of the 75-meter (246-feet) drive, Spirit rested a mere 40 meters (131.2 feet) from its destination at the rim of "Missoula Crater." From that spot, it took mini thermal emission spectrometer observations of the sky and ground along with panoramic and navigation camera images to plan the next drive.

Sol 104, which ended at 3:13 a.m. PST on April 19, was a remote sensing day for Spirit. It included a search for dust devils and panoramic camera imaging of Mars' moon Phobos as it transits across the sun and sets.

sol 100, Apr 15, 2004: *A Century of Sols on the Surface*

With 100 sols under her belt and 706.5 meters (.44 miles) on her odometer, Spirit keeps on roving toward the Columbia Hills.

Spirit began sol 100, which ended at 12:35 a.m. PDT, on April 15, 2004, by closing the doors on the alpha particle X-ray spectrometer, stowing the robotic arm and backing up from the rock called "Route 66" in preparation for an afternoon drive. Before taking off, Spirit used the miniature thermal emission spectrometer to examine a patch of Route 66's surface that had been scrubbed in a daisy-shaped mosaic of brushings by the rock abrasion tool. In the early martian afternoon, the rover began a 64-meter (210 feet) drive, Spirit's longest one-sol drive so far. The final 24 meters (78.7 feet) of the drive were navigated with the enhanced autonomous navigation capabilities of Spirit's newly uploaded software. The new software has nearly doubled the meters-per-hour rate to 32 (105 feet-per-hour).

After the traverse, Spirit completed post-drive imaging and used the miniature thermal emission spectrometer on sky and ground targets.

Sol 101, which will end at 1:14 a.m. PDT on April 16, 2004, will be a remote science and driving sol for Spirit as she continues to make her way toward the Columbia Hills.

sol 99, Apr 14, 2004: *Brushing Down Route 66*

Spirit began Sol 99, which ended at 11:55 p.m. PDT on April 13, 2004, by doing a systematic ground survey with the miniature thermal emission spectrometer. After that, the rover completed a six-position brush mosaic on the rock "Route 66" with the rock abrasion tool. Once the brushing was complete, Spirit analyzed the area with the microscopic imager and Mössbauer spectrometer.

The afternoon science for the sol included imaging of rocks called "Back Lot" and "Cameo" with the panoramic camera and the miniature thermal emission spectrometer. Spirit took a short nap and woke up for the afternoon Odyssey pass.

During the martian night, Spirit changed from using the Mössbauer spectrometer to using the alpha particle X-ray spectrometer.

Sol 100, which will end at 12:35 a.m. PDT, April 15, 2004, will be a sol full of roving as Spirit continues toward the "Columbia Hills."

sol 98, Apr 13, 2004: *Refreshed and Ready to Rock and Rove*

On Sol 98, which ended at 10:36 p.m. PST on April 12, Spirit woke up to the song "Where Is My Mind?" by The Pixies in honor of its software transplant. The good news is that Spirit's "mind" is updated and operating as expected.

Controllers gave the go to reboot the rover's computer, which would then run the new software during the morning of sol 98. The command was sent, and a little over a half hour later, engineers saw the carrier beep that indicated that the command was received. Spirit went to sleep for several minutes after that, and then woke up, rebooting into the new software. It then initiated a high-gain antenna session at 12:30 p.m. Mars Local Solar time, and engineers saw that the new version of the rover software was running properly.

After confirmation that the new software was running as expected, engineers ran some clean-up activities and breathed a sigh of satisfaction.

The new software provides several improvements. It enhances the rovers' mobility, and should allow Spirit to go much farther each sol by reducing how often it has to take images and generate new three-dimensional maps. A deep-sleep mode has been added, mainly to resolve the heater that is stuck in the "on" position on the Opportunity rover. However, someday Spirit may find a use for this mode as well. The new software also mitigates the memory problem Spirit had on sol 18, and seems to be making a difference already. Spirit's unallocated memory jumped from 2.0 megabytes to 3.3 megabytes after the new software compacted the flash directories when it booted.

It's back to regular operations for Spirit on sol 99, ending at 11:15 p.m. PST on April 13, brushing a six-spot mosaic on the rock target "Route 66." Spirit will then take microscopic imager images and spectrometer measurements before the sol is complete.

sol 94, Apr 09, 2004: *Spirit Stands Down for Flight Software Update*

Spirit began a four-sol stand-down on sol 94, which ended at 8:37 p.m. on April 8, 2004. During this time, the rover will receive a flight software update that should make its remaining martian days even safer and more productive. The upload will run through sol 97 with a rover re-boot on sol 98, Monday, April 12. Opportunity will be receiving the same update package in upcoming sols.

Spirit is currently parked in front of the rock called "Route 66," and will remain there for the duration of the flight software update, with the Mössbauer spectrometer integrating on the rock, and the alpha particle X-ray spectrometer pointed up to the sky.

The flight software update package includes three key changes. First is an update to the autonomous navigation software that will allow Spirit to travel longer distances autonomously over the extremely rocky Gusev Crater terrain. The current autonomous navigation software sometimes gets stuck when it detects a hazard that it can't navigate around. The new version will allow Spirit to turn in place to find the best possible path.

The second part of the flight software update will allow Spirit to recover more easily from an anomaly like the one that occurred on sol 18. Although operational processes and software have already been updated to prevent something like this from ever happening again, engineers have included additional safety nets in the software that would allow the rover to autonomously react to a similar anomaly and recover to a more stable state.

The third portion of the update is specific to Opportunity and is intended to mitigate against energy loss associated with the stuck heater on Opportunity's instrument deployment device. The fix allows rover planners to put the rover in a deep sleep mode, where the batteries are totally removed from being able to power the stuck switch. Therefore, with no power reaching the stuck heater switch, the Opportunity rover battery will not be drained. Rover controllers will not initiate the deep sleep capability on Spirit unless it becomes necessary.

sol 93, Apr 08, 2004: *Last Sol for Spirit Science*

Spirit began sol 93, which ended at 7:57 p.m. PST on April 7, by heating the high gain antenna. Spirit then took some calibration measurements and navigation camera imaging of the alpha particle X-ray spectrometer's placement on the magnet.

Around 10:30 a.m. Mars Local Solar time, Spirit moved its instrument deployment device out of the way to take hazard avoidance camera images of the rock target called "Route 66." The rover then operated the Mössbauer spectrometer for a four-hour integration. During the integration, Spirit captured its current location with a panoramic camera mosaic toward the "Columbia Hills" and the rover tracks.

After a short nap, Spirit took mini thermal emission spectrometer observations of the rover tracks, and rock targets called "Everest" and "Pisa." The rover completed the Mössbauer integration and then placed it on Route 66 with the alpha particle X-ray spectrometer pointed up to the sky. The instrument deployment device will remain in this position during the flight software load time period, allowing for long integrations of the Mössbauer on Route 66 and the alpha particle X-ray spectrometer on the sky.

Sol 94, which ends at 8:37 p.m. PST on April 8, will be the beginning of the four-sol flight software upload. Before rover operators begin loading the updated software, they will command Spirit to perform a sunrise imaging operation. The flight software update will continue through sol 97 with a rover reboot on sol 98, Monday April 12.

sol 92, Apr 07, 2004: *Monitoring Magnets on Mars*

Spirit awoke on sol 92, which ended at 7:18 p.m. PST on April 6, and completed some early morning panoramic camera sky and ground measurements. Spirit also took a look at the capture and filter magnets with the panoramic camera prior to taking a short mid-morning nap. Upon wake-up around 12:30 p.m. Mars Local Solar Time, the rover opened the doors on the alpha particle X-ray spectrometer and took 3 images of each magnet. Spirit also placed the Mössbauer spectrometer on the capture magnet and began an integration.

In the afternoon, Spirit completed coordinated observations with the thermal emission spectrometer instrument on NASA's Mars Global Surveyor orbiter. The observations involved miniature thermal emission spectrometer pre-flight, simultaneous, and post-flight sky and ground measurements. Spirit also collected a panoramic camera opacity observation.

Early on Sol 93, which ends at 7:57 p.m. on April 7, the rover will switch the instruments on its instrument deployment device from the Mössbauer spectrometer to the alpha particle X-ray spectrometer. Sol 93 is the last day for newly planned science observations, as Spirit will be getting a flight software update during sols 94-98.

sol 91, Apr 05, 2004: *Spirit Achieves Mission Success*

Spirit woke up on sol 91, which ended at 6:38 p.m. PDT on April 5, 2004, as if it were any other martian day, but this one was special. Finishing 90 sols of surface operations since landing day marked completion of the last of the official success criteria for Spirit's prime mission. The rover team at JPL had checked off the next-to-last box for mission success two days earlier, when a drive of 50.2 meters (165 feet) took Spirit's total travel distance over the 600-meter (1,969 feet) mark.

The martian day for sol 91 started with some remote sensing observations of the sky and ground as well as navigation camera images of the landscape to the east. Then the rover completed miniature thermal emission spectrometer ground surveys and imaged the sky and ground with the panoramic camera. After a short nap, Spirit acquired some pre-drive imaging including a super-spectral look at an interesting spot in front of the rover.

Early in the martian afternoon, Spirit began a 1.35-meter (4.4-foot) drive to get closer to a rock called "Route 66." Once the drive was finished, the rover analyzed the instrument deployment device's work volume with hazard-avoidance camera images and a stare by the miniature thermal emission spectrometer. A quick adjustment of 0.8 meters (2.6 feet) put the rover in perfect position and completed the drive.

Spirit spent the afternoon taking a systematic soil survey with the panoramic camera, a 13-filter image of the destination informally named "Columbia Hills," and acquiring miniature thermal emission spectrometer data of the same locations.

Spirit will spend sol 92, which will end at 7:18 p.m. PDT on April 6, 2004, analyzing its capture magnet and filter magnet with its Mössbauer spectrometer and microscopic imager. The rover will also complete coordinated observations with the Mars Global Surveyor and switch tools to the alpha particle X-ray spectrometer for an overnight measurement.

sol 88, Apr 02, 2004: *Cruisin' Down the Crater Side*

Spirit spent most of Sol 88, which ended at 3:39 p.m. PST on April 2, driving toward the "Columbia Hills." Before beginning the drive, Spirit acquired some pre-drive remote sensing, which included panoramic camera photometry and a mini thermal emission spectrometer stare of the rock called "Carlsbad."

Spirit then began the 35-meter (114.8 feet) combination directed and autonomous navigation drive down the rocky, ejecta-covered side of "Bonneville Crater." Fifteen meters (49.2 feet) of the drive were directed by rover planners and did not require the rover to use its hazard avoidance software. The remaining 20 meters (65.6 feet) were navigated by Spirit autonomously and did cause the rover to make some back and forth adjustments as it avoided what it perceived to be a depression hazard in its path. Rover controllers will look at hazard avoidance camera images tomorrow to confirm the details of Spirit's behavior.

Spirit will begin Sol 89, which ends at 4:19 p.m. PST on April 3, using the instrument deployment device on a rock target in front of it, followed by another drive toward the Columbia Hills.

sol 87, Apr 02, 2004: *Bye-Bye 'Bonneville'*

Spirit began sol 87, which ended at 3:00 p.m. PST on April 1, with some morning atmospheric science, and then took a last look at the rock "Mazatzal" with the panoramic and navigation cameras. Then the rover was off, traveling 36.5 meters (119.8 feet) down the side of "Bonneville" Crater headed south toward the "Columbia Hills."

The drive was a combination of "blind" and autonomous navigation roving. The blind segments of the drive are used when rover planners can see all possible hazards and command the rover to just "go." The autonomous navigation portion allows the rover to make decisions based on the terrain presented. While the blind segments of the sol 87 drive were successful, the second to the last autonomous navigation sequence did not complete in the allotted time, causing a drive "goal" error. As a result, Spirit was not able to execute the complete commanded drive, and roved 36.5 meters (119.8 feet) of the 65-meter (213.3 feet) planned drive.

Following the drive, Spirit took navigation and panoramic camera pictures in her drive direction and performed atmospheric and soil science with the panoramic camera and mini thermal emission spectrometer.

Spirit will spend most of sol 88, which ends at 3:39 p.m. PST on April 2, driving toward the Columbia Hills.

sol 86, Mar 31, 2004: *Brushing the Dust Off 'Missouri'*

Spirit began sol 86, which ended at 2:20 p.m. PST on March 31, 2004, by waking up and heating the panoramic mast assembly to complete sky and ground stares with the miniature thermal emission spectrometer. Spirit completed the alpha particle X-ray spectrometer integration on the hole made by the rock abrasion tool and then took a 45-minute nap.

Once Spirit woke up, it began the 6-position rock abrasion tool brush mosaic on the target "Missouri" on the rock called "Mazatzal." Once this was completed successfully, the rover's arm was stowed.

Spirit then rolled backwards .9 meters (2.95 feet) to correctly position itself to acquire mini thermal emission spectrometer imaging of the newly brushed mosaic, and the previously ground hole. In addition, Spirit took sky and ground stares and panoramic camera images of the upcoming drive direction. The sol ended with mini thermal emission spectrometer stares at the "Columbia Hills" and an afternoon pass by NASA's Mars Odyssey orbiter.

Sol 87, which ends at 3:00 p.m. PST on April 1, 2004, will be a driving day for Spirit as it begins what could be a record-breaking journey toward the Columbia Hills.

sol 85, Mar 30, 2004: *Looking Inside Mazatzal*

Since the rock abrasion tool completed a full-circle grind into the "New York" and "Brooklyn" targets on the rock "Mazatzal," it was time for Spirit to do some analysis. Spirit spent much of Sol 85, which ended at 1:41 p.m. PST on March 30, successfully operating the instruments on its robotic arm to take a more detailed look inside Mazatzal.

Although all the operations were completed successfully on Mars, the rover team spent most of the morning and afternoon on Earth worrying. After the team sent the uplink to Spirit, they waited for the standard "beep" that confirms the sequence reached Spirit and was activated. This beep, and an expected one 10 minutes later were not acquired, and engineers proceeded to trouble-shoot what might have gone wrong. No errors could be found, and finally a successful afternoon Odyssey communications pass provided 75 megabits of data, indicating that all the sequences were in fact onboard the rover and that all the planned sol activities had completed successfully. Like worried parents, the rover team members breathed a collective sigh of relief, and are now looking into possible causes of the failure to detect the beep.

As planned, Spirit began sol 85 by receiving the uplink and then taking a one-hour nap. After waking, the rover took panoramic camera images of the rock abrasion tool and of the ratted hole in Mazatzal. Before the panoramic camera work was done, Spirit took some final shots of "Bonneville" crater. Some of those images might contribute to a super-resolution image of the heatshield remnants on the far wall. Spirit also took some images to try to catch a dust devil in action.

After the panoramic camera activity, Spirit used the microscopic imager to take a 5-position pseudo-color mosaic of the Mazatzal rock abrasion tool hole. Then the Mössbauer spectrometer was placed in the hole and began an overnight integration.

A little after 2 p.m. Mars Local Solar Time, the last miniature thermal emission spectrometer sections of Bonneville crater were acquired, followed by a set of panoramic camera images of the drive direction. In the late afternoon, Spirit used the mini thermal emission spectrometer to acquire ground and sky stares, which will be complemented by another set early tomorrow morning. Shortly after the 2 a.m. Mars Global Surveyor pass, the arm will change tools from the Mössbauer spectrometer to the alpha particle X-ray spectrometer for an integration in the rock abrasion tool hole through 9:20 a.m. Mars Local Solar Time on Sol 86.

The rock abrasion tool will be back to work on sol 86, which will end at 2:20 p.m. PST on March 31, 2004, brushing a 6-spot mosaic on another portion of the rock Mazatzal called "Missouri." The mini thermal emission spectrometer will analyze the brushed area and then Spirit will begin a 5-sol drive toward the Columbia Hills.

sol 84, Mar 30, 2004: *Rat Bears Down on "Brooklyn"*

The angular nature of the rock called "Mazatzal" required some extra rodent power over the weekend. The latest grind by Spirit's rock abrasion tool (the RAT) resulted in that tool's deepest hole yet, nearly 8 millimeters (0.31 inches). The rover was inspired to tackle the target "Brooklyn" right next to its "New York" bull's-eye by the Beastie Boys' "No Sleep Till Brooklyn" on its 83rd sol, which ended at 12:22 p.m. PST on March 28.

Spirit's 84th sol, which ended at 1:01 p.m. PST on March 29, was planned as a day of investigation. The miniature thermal emission spectrometer and panoramic camera made successful observations of the crater informally named "Bonneville," but planned operations of the rover arm were not executed due to a switch on the Mössbauer spectrometer getting momentarily stuck. After a successful Mössbauer integration, the instrument was pulled back from Mazatzal, but one of two contact switches did not indicate a no-contact condition. Although the instrument had been retracted, the rover's software interpreted this as an unexpected collision of the spectrometer with an object, so it terminated any further arm operations. The stuck switch flipped about three minutes later but the rover is programmed to wait until the false error is cleared by mission control.

On sol 85, Spirit will retake microscope images of areas on Mazatzal, and overnight Mössbauer and alpha particle X-ray spectrometer integrations will be repeated.

sol 81, Mar 26, 2004: *Rats in "New York"*

Spirit began sol 81, which ended at 11:02 a.m. PST on March 26, 2004, by stopping the alpha particle X-ray spectrometer integration and then imaging the instrument's placement with the hazard avoidance camera. The rest of this sol was all about grinding into the target "New York" on the rock named "Mazatzal."

The rock abrasion tool operated on the New York target for three hours and forty-five minutes and created an impression in the rock that was 3.79 millimeters (.15 inches) deep. The angular shape of Mazatzal and the fact that the rock is a little harder than previously abraded rocks allowed the more flat side of the circular target to receive a more intense grind. On sol 83, the science and engineering teams plan to again place Spirit's rock abrasion tool onto the rock, overlapping the already abraded area and reaching the area just to the left.

Spirit will spend most of sol 82, which will end at 11:42 a.m. PST on March 27, 2004, analyzing the rock abrasion tool impression with the microscopic imager, Mössbauer spectrometer and alpha particle X-ray spectrometer. The rover will also place the microscopic imager over a clean surface to the upper left of the ratted area and take some images.

The wake-up song today was "Boy from New York City" by The Manhattan Transfer, in honor of the grind on the New York target.

Spirit's odometer now reads: 492 meters - more than a quarter of a mile!

sol 80, Mar 25, 2004: *Open the Door*

On sol 80, which ended at 10:23 a.m. PST on March 25, NASA's Mars Exploration Rover Spirit repeated overnight measurements of "Illinois" and "New York," two targets on the rock "Mazatzal." The measurements needed to be repeated because the alpha particle X-ray spectrometer's doors inadvertently did not open during the prior sol. In honor of doors being stuck partially open, sol 80's wake up song was "Open the Door" by Otis Redding.

Mazatzal is one of an apparent class of "light-toned rocks," which may be common in the area where Spirit landed in Gusev. This rock appears to be a "ventifact," which means it may have been carved by the steady winds that scientists know come from the northwest into the top area of this crater rim.

The plan for sol 81, which will end at 11:02 a.m. on March 26 PST, is to grind into Mazatzal with the rock abrasion tool.

sol 79, Mar 24, 2004: *Sweep and Study the 'States'*

NASA's Mars Exploration Rover Spirit awakened at 9:35 a.m. Mars Local Solar Time on Sol 79, which ended at 9:43 a.m. PST on March 24. An early morning review of the alpha particle X-ray spectrometer data revealed that the instrument's doors were not fully open and that the tool did not completely engage at the intended "New York" target on the rock dubbed "Mazatzal." The alpha particle X-ray spectrometer integration on "New York" will be repeated on sol 80.

Spirit took a nap until 12:45 Mars Local Solar time to conserve power for the upcoming grind on Mazatzal on sol 81. Once the rover woke up, it began the sequences of brushing and analyzing two targets, "New York" and "Illinois," on Mazatzal. Each target was brushed with the rock abrasion tool and then imaged with the microscopic imager and panoramic camera. The entire sequence ended with a Mössbauer spectrometer integration on the New York target.

Rover controllers plan to let Spirit rest until 4 a.m. Mars Local Solar time on Sol 80, when the tools on the robotic arm will be changed to place the alpha particle X-ray spectrometer on the brushed New York target. The rest of sol 80, which will end at 10:23 a.m. on March 25, will be spent analyzing the brushed and unbrushed areas of Mazatzal with the instruments on the rover's robotic arm.

sol 78, Mar 23, 2004: *Preparing to Grind at Mazatzal*

NASA's Mars Exploration Rover Spirit woke up at 7:24 a.m. Mars Local Solar time on sol 78, which ended at 9:04 a.m. on March 23, 2004, and began a day of observations in preparation for the sol 79 grind on the rock called "Mazatzal."

After waking, Spirit warmed-up the mast actuators for some early morning soil and atmosphere miniature thermal emission spectrometer observations. It then went back to sleep before beginning the morning direct-to-earth communication session with the high gain antenna.

At 10:00 a.m. Mars Local Solar time, Spirit began analyzing the soil targets "Saber" and "Sandbox" with the mini thermal emission spectrometer. It also took panoramic camera images of "Skull" and Saber. Then it was time to unfold the instrument arm to capture microscopic imager images of three targets on Mazatzal: "Arizona," "Illinois," and "New York." The New York target was further analyzed with a 17-hour Mössbauer spectrometer integration.

While the Mössbauer was integrating, Spirit proceeded to execute several mini thermal emission spectrometer and panoramic camera observations of interesting features in the surrounding area. The observations included images of "Bonnevillie" crater, "Saber," "Sandbox" and "Orange Beach."

Spirit had completed all these activities by 2:40 p.m. Mars Local Solar time and then took a siesta until the afternoon Odyssey UHF pass. During that pass, the rover captured mini thermal emission spectrometer ground and sky images. Before shutting down at 5 p.m. Mars Local Solar time, Spirit positioned the panoramic camera for a nighttime observation of the moon Deimos.

Sol 79, which ends at 9:43 a.m. on March 24, 2004, will be a momentous day for Spirit's rock abrasion tool; it will complete brushings on two Mazatzal targets.

sol 77, Mar 22, 2004: *One Step Closer*

Spirit woke up on sol 77, which ended at 8:24 a.m. PST on March 22, 2004, to "One Step Closer" by the Doobie Brothers, since the rover was to make its final approach to the rock target named "Mazatzal" today.

Before beginning the .9-meter (2.95 feet) drive to Mazatzal, Spirit analyzed the soil target "Soil 1" at its current location with the microscopic imager and Mössbauer spectrometer. During the Mössbauer integration, Spirit also took panoramic camera images and performed miniature thermal emission spectrometer analysis of the atmosphere and Mazatzal work area.

At 1:25 p.m. Mars Local Solar Time, Spirit completed the Mössbauer integration, took a few microscopic imager images of the impression left on "Soil 1" by the Mössbauer spectrometer and then stowed the instrument arm. Spirit then proceeded the short distance toward Mazatzal and took hazard avoidance camera images to confirm that its final resting place put the intended rock targets in reach of the instrument arm.

Following the drive, the rover acquired more panoramic camera and mini thermal emission spectrometer observations of the atmosphere, and of interesting areas near the Mazatzal site including targets named "Sandbox," "Saber" and "Darksands."

Spirit finished up sol 77 by getting the mini thermal emission spectrometer in position for morning observations on sol 78.

Spirit will spend most of Sol 78, which will end at 9:04 a.m. PST on March 23, analyzing Mazatzal with the instruments on the robotic arm.

sol 74, Mar 19, 2004: *'Stub Toes' Won't Stop Spirit*

Spirit began the morning of Sol 74, which ended at 6:25 a.m. PST on March 19, 2004, by completing an alpha particle X-ray spectrometer integration on the target "Panda," inside the scuff on "Serpent" drift. Then Spirit placed the alpha particle X-ray spectrometer back down on the target "Polar" for a 30-minute integration. During that integration, Spirit took some images of disturbed soil with the panoramic camera, and acquired some ground temperatures with the miniature thermal emission spectrometer. Spirit then switched the tools on its robotic arm to the Mössbauer spectrometer for an hour-long integration on Polar. During that integration, the rover took some sky and ground measurements with the mini thermal emission spectrometer. Spirit finished its arm activities for the day by acquiring three microscopic images of Polar and three more of Panda.

Starting around 12:35 p.m. Mars Local Solar time, Spirit made a direct drive of about six meters (19.7 feet) to another section of the Serpent drift complex, called "Stub Toe." There the rover repeatedly scuffed the drift and advanced .15 meters (half a foot) in a series of five "scuff and drives." After the five scuffs and advances were made, Spirit roved forward another 3 meters (9.8 feet) and then looked back over its shoulder using the mini thermal emission spectrometer and navigation cameras to analyze the damage. The rover continued along the Bonneville crater rim with a 16-meter direct drive, and then an auto-navigation drive for 9 meters (29.5 feet). Spirit completed a final set of drives to set up for a touch and go on sol 75 at around 2:10 p.m. Mars Local Solar time. The total amount of driving for sol 74 was an impressive 34.3 meters (112.5 feet).

Spirit then took navigation camera and panoramic camera images of the drive directions for planning the sol 75 traverse. The rover acquired some mini thermal emission spectrometer reconnaissance images and then took a 30-minute siesta before the afternoon Odyssey relay pass. During that pass, Spirit used the mini thermal emission spectrometer to acquire a sky profile and ground temperature observations.

On sol 75, which will end at 7:05 a.m. PST on March 20, 2004, Spirit will place the microscopic imager on a soil target and drive about 22 meters (72.2 feet) around the Bonneville crater rim. Spirit will also conduct atmospheric observations with the mini thermal emission spectrometer and panoramic camera.

sol 73, Mar 18, 2004: *A Close-Up of 'Serpent'*

Spirit spent most of sol 73, which ended at 5:46 a.m. PST on March 18, 2004, analyzing targets in the drift dubbed "serpent" with the microscopic imager. But before the close-ups began, Spirit acquired miniature thermal emission spectrometer inertia measurements on a disturbed area of soil. It also captured panoramic camera images of the scuffed area, dubbed "Bear Paw," the wheel that did the digging, and a nearby rock target named "White Elephant."

The microscopic imager work began at 11:00 am Mars Local Solar Time and was targeted at four points within the scuffed area on Serpent. The targets were given the bear-type names of Polar, Spectacled, Kodiak and Panda. For each target, seven microscopic images were taken to assure proper focus. At the Spectacled and Kodiak targets, a microscopic image with the filter in place was also taken for pseudo-color. Then the Mössbauer was placed on Panda and started an overnight integration. The arm activities were completed by about noon Mars Local Solar time, and were followed by the second thermal inertia measurement on the disturbed soil.

The rover took a siesta until 1:00 p.m. Mars Local Solar time, and then woke up for a series of mini thermal emission spectrometer observations on the rocks named "White Elephant," "Fruitcake," and "Dihedral." Then the third and last thermal inertia measurement was taken on the disturbed soil.

Spirit took another quick nap in the afternoon, and then completed sky measurements with the mini thermal emission spectrometer and panoramic camera.

Spirit will have an early start on sol 74, which will end at 6:25 a.m. PST March 19, 2004. Sol 74 will include a tool change to the alpha particle X-ray spectrometer and the beginning of an integration on the drift target named Panda. Before the sol is over, Spirit will also analyze an undisturbed area of the Serpent drift before continuing to drive around the rim of "Bonneville" crater.

sol 72, Mar 17, 2004: *Spirit Digs with a Jig*

Sol 72, which ended at 5:06 a.m. PST on March 17, was a day full of digging for NASA's Mars Exploration Rover Spirit. Spirit began the day taking panoramic camera and miniature thermal emission spectrometer observations of the drift dubbed "Serpent" before creating the "scuff" that would reveal the inside material at this location.

Then it was time to get into position. The rover drove about two-and-a-half meters (8.2 feet) to put the left front wheel up onto the drift. It then turned right and left five degrees to dig the left front wheel into the drift. When the "shimmy" was complete, Spirit backed 10 centimeters (3.9 inches) out of the hole. The digging and backing process was repeated four times to thoroughly scuff Serpent's side. Then Spirit backed up another meter (3.28 feet) to attain miniature thermal emission spectrometer, panoramic camera and navigation camera observations of the scuffed area. These observations will aid in in-situ target selection. To prepare for the upcoming in-situ work, Spirit drove forward 0.4 meters (1.3 feet) for additional imaging, and then drove forward a final 0.45 meters (1.5 feet) to put the scuff in the arm work volume.

Spirit spent the rest of the day obtaining navigation camera and panoramic camera observations of the intended drive direction around part of the crater rim. Spirit will do some work overnight, taking miniature thermal emission spectrometer thermal inertia and atmosphere measurements.

On sol 73, which will end at 5:46 a.m. PST on March 18, Spirit will conduct extensive microscopic imaging of sections of the drift, and run an overnight Mössbauer and alpha particle X-ray spectrometer integration.

sol 71, Mar 16, 2004: *Steering to 'Serpent'*

Spirit began sol 71, which ended at 4:26 a.m. PST March 16, 2004, with a morning nap to re-charge after the record-breaking number of activities it accomplished on sol 70. After that, it was back to work. Spirit began by retracting the alpha particle X-ray spectrometer, closing the doors, and imaging the doors with the front hazard avoidance cameras to confirm that they were closed. Spirit then proceeded to observe a soil target with the microscopic imager, and it also used the panoramic camera to observe the magnets, do a sky survey and capture a dust devil movie.

Then it was time to drive. Spirit completed a 15-meter (49.2 feet) blind drive followed by a 3-meter (9.8 feet) auto-navigation drive around the south rim of "Bonneville" crater toward a drift named "Serpent." Once there, Spirit completed post-drive science observations and a miniature thermal emission spectrometer study of the atmosphere, ground and future drive direction.

Spirit's main objective on sol 72, which ends at 5:06 a.m. PST March 17, 2004, will be to disturb and analyze the material at Serpent. Spirit will drive over the dune and back up to an optimal observation position. It will then analyze the area with the panoramic camera and mini thermal emission spectrometer. Spirit will end the sol by driving back on top of the dune.

sol 70, Mar 15, 2004: *Spirit's Busiest Day*

Spirit began what would be a very busy sol 70, which ended at 3:47 a.m. PST March 15, by analyzing a soil target dubbed "Gobi 1" with the Mössbauer spectrometer. This was the first of 43 observations that Spirit would complete on sol 70, breaking the previous observation record of 31 observations in one sol.

After the successful Mössbauer integration, Spirit took panoramic camera images of the sky. Then the miniature thermal emission spectrometer analyzed rock and soil targets. Following this, Spirit turned its panoramic camera and miniature thermal emission spectrometer to a range surface and atmospheric observations. Before the sol ended, Spirit also took microscopic images of the Mössbauer footprint left on the soil target and switched instruments to the alpha particle X-ray spectrometer for a long integration starting early on sol 71 at the "Gobi 1" location.

Spirit will spend Sol 71, which will end at 4:26 a.m. PST March 16, completing the alpha particle X-ray spectrometer analysis, taking panoramic camera images and microscopic imager images of the area, and then driving 15 meters (49.2 feet) to a location dubbed "Serpent Dune" in the afternoon.

sol 69, Mar 14, 2004: *New Panorama on Board*

During its 69th sol on Mars, ending at 3:07 a.m. Sunday, PST, NASA's Spirit finished shooting frames with its panoramic camera for a full 360-degree color view of the surroundings visible from the crater rim where the rover is perched. Once the panorama frames are transmitted to Earth, scientists will use them and information from Spirit's miniature thermal emission spectrometer to assess the structures and composition of the crater interior and other surfaces in view.

Spirit did not move from its vantage point on the south rim of the crater nicknamed "Bonneville." An extra downlink session was added via relay by NASA's Mars Odyssey orbiter to accelerate getting the panoramic imaging data to Earth. The total amount of data received from Spirit during the sol through relays and direct-to-Earth transmission was 225 megabits.

In the martian afternoon, Spirit added a set of observations with the miniature thermal emission spectrometer in coordination with overhead passage of NASA's Mars Global Surveyor orbiter, which carries a similar spectrometer looking down. Events of the sol also included two camera sessions requested by engineers. The first was to get high-resolution images of Spirit's heat shield on the northern rim of "Bonneville." The other was to photograph wheel tracks to help rover mobility specialists assess slippage. For sol 69's wake-up music, the team spun John Lennon's "Watching the Wheels."

Plans for sol 70, ending at 3:47 a.m. Monday, PST, feature more remote sensing from the rover's current location, before a drive along the rim begins on sol 71.

sol 68, Mar 13, 2004: *Spirit Sits Still for Science*

Spirit spent all of sol 68, which ended at 2:28 a.m. PST on March 13, 2004, at the "Bonneville" crater location. It began the morning operating the panoramic camera to acquire the first images of what will be a 360-degree shot of "Bonneville's" rim and basin, and the "Columbia Hills" to the southeast.

Spirit also moved the instrument deployment device, or rover arm, into position to acquire panoramic camera images of the magnets on the rock abrasion tool. It then placed the Mössbauer spectrometer on soil for a short integration after taking five microscopic imager images.

Around 13:35 Mars Local Solar time, one of Mars' moons, Deimos, passed in front of the sun. Scientists and rover controllers took this opportunity to image the moon's transit with the panoramic camera before completing mini thermal emission spectrometer observations of the crater interior.

Spirit's work isn't over though. The Mössbauer will continue analyzing the soil at "Bonneville's" rim through the night.

Sol 69, which will end at 3:07 a.m. PST on March 14, 2004, will also be a no-drive sol during which Spirit will acquire the second half of the 360-degree panoramic camera image of Bonneville. Spirit will also perform remote sensing of the inside of the crater and analyze soil targets with the Mössbauer and alpha particle x-ray spectrometer.

sol 67, Mar 11, 2004: *Spirit is "On Top of the World"*

Spirit woke up on sol 67, which ended at 1:48 a.m. PST March 12, 2004, to "On Top of the World" by the Carpenters. The song was fitting, as yestersols's drive put Spirit at the rim of "Bonneville" crater, but it took some additional maneuvering to get the rover perfectly placed for the 360-degree panoramic camera images it will take on upcoming sols.

Before beginning the sol 67 drive, Spirit completed an overnight alpha particle x-ray spectrometer integration and a couple of small panoramic camera shots of its surroundings.

Then the rover traveled 13 meters (42.7 feet) in a direct drive around some obstacles followed by a 1.4-meter (4.6 feet) automatic navigation drive. Spirit spent the afternoon using the mini thermal emission spectrometer to look at targets that will be analyzed more fully on sol 67, and then driving 0.9 meters (3 feet) forward to be able to access that area with the arm tomorrow.

Spirit put a total of 24.8 meters (81.4 feet) on the odometer today, partly due to some back and forth maneuvering it had to do to ensure a safe path. The final location has proven to be just right, and Spirit will stay put for a couple sols while it continues to investigate "Bonneville" crater.

Before the day was over, Spirit looked at the sun for an attitude update and then took front hazard avoidance camera images of the arm work volume, and a small navigation panorama of the crater. The rover also completed some mini thermal emission spectrometer analysis of the far side of the crater and finished the day with some panoramic camera images of the sunset.

On sol 68, which will end at 2:28 a.m. PST March 13, 2004, Spirit will begin a two-sol panoramic camera session and complete selected mini thermal emission spectrometer observations. The rover will also begin a very long Mössbauer integration on a soil target.

sol 66, Mar 11, 2004: *Spirit is "Livin' on the Edge"*

Aerosmith wrote the song "Livin' on the Edge" long before Spirit reached the edge of Bonneville crater, and probably never imagined it would be the wake-up song for a rover on Mars. But its words are appropriate. After a 21-meter (68.9 feet) drive and an elevation gain of 1.5 meters (4.9 feet), Spirit is in fact at the edge of Bonneville crater.

Spirit began Sol 66, which ended at 1:09 a.m. PST March 11, 2004, by taking a look back at the lander with the panoramic camera, and then analyzing selected ground targets. At about 11:30 a.m. Gusev time, Spirit began a 30-minute directed drive of 16 meters (52.5 feet). It then turned right for a final auto-navigation drive that was intended for 6 meters (19.7 feet), but resulted in about 4 meters (13.1 feet). That drive put Spirit in perfect position to look inside "Bonneville" crater and send back stunning images from the navigation camera.

The camera mast was then positioned for a nighttime sky observation of the Orion Constellation. During NASA's Mars Global Surveyor pass tomorrow morning, the navigation camera and panoramic camera will take images of the Orion Constellation using long exposure times.

On Sol 67, which will end at 1:48 a.m. PST March 12, 2004, Spirit will drive about 14 meters (46 feet) to a better vantage point on the crater rim and continue to investigate Bonneville with the panoramic and navigation cameras.

sol 65, Mar 10, 2004: *Roving Toward the Rim*

Spirit spent sol 65, which ended at 12:29 a.m. PST on March 10, analyzing soil targets with the alpha particle x-ray spectrometer, Mössbauer spectrometer and microscopic imager before stowing its arm, doing some remote sensing of the trench dubbed "Serendipity Trench," and then finally setting off for the longest directed drive to date. That drive was 27 meters (88.6 feet) toward the edge of "Bonneville" crater.

Spirit then attempted to use auto navigation to reach a target that was an additional 6 meters (19.7 feet) away. Sensitive obstacle avoidance software prevented Spirit from reaching the destination, and like yestersol, the rover completed several drives forward and back. Those drives resulted in a final odometer reading of 40.7 meters (133.5 feet) for the day, even though the total straight-line distance traveled was 30 meters (98.4 feet).

The 30-meter (98.4 feet) drive put Spirit close enough to "Bonneville's" edge to take images with the navigation cameras that reveal the opposite rim of the crater.

On sol 66, which ends at 1:09 a.m. PST on March 11, 2004, Spirit will drive up to the summit of the rim and show us what's inside with a 180-degree navigation camera panorama.

sol 64, Mar 08, 2004: *Spirit Reaches the 300-Meter Mark!*

Spirit completed another 29 meters (94 feet) of its drive toward the rim of "Bonneville" crater on sol 64, which ended at 11:49 p.m. PST, bringing its total odometry to 314 meters (1,030 feet) - 14 meters (45.9 feet) past the minimum mission success criterion.

Spirit began the morning with an 18-meter (59 feet) direct drive that safely maneuvered the rover through a field of rocks. Spirit then traversed 11 more meters (35 feet) using autonomous navigation and at 11:30 a.m. Mars Local Solar Time completed the drive. Spirit had some difficulty finding a way around an obstacle during the last portion of the commanded drive. That resulted in some repeated forward and backward maneuvering which left an interesting "trench" for scientists to have the rover peer into.

Spirit is climbing up a very steep part of "Bonneville" now, and ended this sol's drive tilted at a forward pitch of about 15°.

For the next sol, the plan was to have Spirit perform some mini-thermal emission spectrometer sky and ground observations before waking up to do a touch-and-go and drive again!

sol 62, Mar 07, 2004: *Rolling Along*

During its 62nd sol on Mars, ending at 10:30 p.m. Saturday, PST, NASA's Spirit advanced about one-fifth of the remaining distance between where it began the sol and its mid-term destination, the rim of the crater nicknamed "Bonneville." In the martian afternoon, Spirit took images and infrared readings of the area right in front of its stopping place to support the following morning's close-up inspection of that new location with instruments on the rover's robotic arm.

Spirit drove 26.15 meters (85.8 feet) on sol 62, bringing its odometer total to 250.71 meters (822.5 feet). Some of the drive maneuvered around obstacles. The net gain in the northeasterly direction toward the crater rim was 22 meters (72 feet), and that destination was estimated to be about 88 meters (289 feet) away from Spirit's new location. The miniature thermal emission spectrometer was used for ground and sky observations both before and after the drive.

The wake-up song for the sol was "My First Trip to Mars," by Atticus Fault.

For sol 62, ending at 11:10 p.m. Sunday, PST, Spirit's agenda is to drive on toward the crater rim after using the microscope and spectrometers on its arm to inspect the site where it wakes up.

sol 61, Mar 06, 2004: *Leaving Middle Ground*

After more than a week of camping and field work at "Middle Ground," NASA's Spirit took a few last pictures from there then drove onward to the northeast on sol 61, which ended at 9:51 p.m. Friday, PST. In the martian morning, Spirit's panoramic camera took the final frames needed for the camera team to assemble a full-circle color panorama after all the data reaches Earth.

In the early afternoon, Spirit backed up 0.5 meter (20 inches), then edged forward 0.29 meters (11 inches) to sidestep a rock called "Ingrid." Then the rover advanced 28.5 meters (94 feet) toward its crater-rim destination. The drive took 45 minutes. From the new location, Spirit took forward-looking pictures for use in future drive planning. It also observed the ground and the sky with its miniature thermal emission spectrometer.

For the sol's theme tune in the morning, controllers at JPL played "Motor Away" by Guided by Voices.

Continued driving toward the crater nicknamed "Bonneville" is the plan for Spirit's 62nd sol, ending at 10:30 p.m. Saturday, PST.

sol 60, Mar 04, 2004: *Ready to Hit the Road Again*

Spirit completed its observations at "Middle Ground" on its 60th martian sol, ending at 9:11 p.m., PST on March 4. Waking up to "Pictures to Prove It," by the Mighty Mighty Bosstones, Spirit finished gathering data from the rock abrasion tool hole on "Humphrey" with the alpha particle X-ray spectrometer and the microscopic imager.

The panoramic camera then continued to acquire more images for the 360-degree view from the current rover position at "Middle Ground."

After backing up 0.85 meters (about 2.8 feet), the miniature thermal emission spectrometer and panoramic camera had their turn to collect data and images from both of the rock abrasion tool's latest efforts on "Humphrey" - the triple-brushed area and the depression.

As of this sol, Spirit has traveled 195.24 meters (about 641 feet).

Plans for next sol include backing up and turning to avoid "Ingrid," a 20-centimeter (about 8 inches) rock to the west of "Humphrey," and then driving approximately 25 meters (82 feet) toward "Bonneville" in the northeast. Spirit will also snap the final images that will make up the 360-degree panorama of "Middle Ground."

sol 59, Mar 03, 2004: *Rock Abrasion Tool Back in Action*

Waking up to "One More Time" by The Real McCoy, Spirit completed a successful, 2 millimeter-deep grind (.08 inches) into a target slightly left of the depression it made yestersol during its abbreviated operation. A five-minute brush to clean the hole followed.

Completing the sol, which ended at 8:31 p.m. Wednesday, March 03, Spirit's arm then switched instruments so the Mössbauer spectrometer could examine "Humphrey's" new shallow cavity.

Before this sol's four-hour grinding, the microscopic imager and the alpha particle X-ray spectrometer finished observations of yestersol's rock abrasion tool depression. To document Spirit's current position - about halfway to the "Bonneville" crater rim - the panoramic camera snapped the first of several images that, together, will provide a 360-degree view.

Engineers identified the software issue that caused the rock abrasion tool to terminate its original planned grinding on sol 58. The minor bug will be fixed when new flight software is loaded at the end of March.

In the coming sols, Spirit will complete the alpha particle X-ray spectrometer observations of the rock abrasion tool hole and get an up-close view with the microscopic imager. The final images will be obtained for the full panoramic view of Spirit's current position. After miniature thermal emission spectrometer and panoramic camera observations of the hole are conducted, Spirit will continue on toward "Bonneville" crater.

sol 58, Mar 02, 2004: *Grinding, Take Two*

On sol 58, which ends at 7:52 p.m., PST on March 2, the planned four-hour rock abrasion tool grind of "Humphrey" was limited to only 20 minutes. The intricate slopes and cracks of the rock make it a challenging target for instruments. When sensors indicated a loss of contact with surface material, the software perceived a problem and the rock abrasion tool was moved away from the rock. Engineers are amending the software limits to duplicate the rock abrasion tool's earlier operation on the rock "Adirondack," giving a higher likelihood of successful completion on the next sol.

The morning began with the completion of the alpha particle X-ray spectrometer integration on the previously brushed area. The panoramic camera then took a multi-spectral observation of the nearby ground, followed by a Mössbauer spectrometer integration on the same area.

Spirit's Sol 58 wake-up song was "I Still Haven't Found What I'm Looking For" by U2 to pay homage to its twin rover's amazing findings of water evidence at Meridiani Planum.

On sol 59, Spirit will attempt another rock abrasion tool grind on "Humphrey," followed by detailed observations of the hole.

sol 57, Mar 01, 2004: *Back to the Ol' Grind*

During its 57th sol on Mars, ending at 7:12 PST on March 1, Spirit observed the area on "Humphrey" that was thrice brushed by the rock abrasion tool. An area just to the right of the brushed area, where the team intends to grind, was also examined.

The morning hours found Spirit using its alpha particle X-ray spectrometer on the intended grinding target to verify its similarity to the pre-brushed areas of the rock. The arm then switched out tools to the microscopic imager to get close-up views of the grinding target and the area to the right of it. The Mössbauer spectrometer was then placed on the brushed area for another observation.

Panoramic camera images were taken of the rock abrasion tool magnets to study dust accumulation. The miniature thermal emission spectrometer performed a diurnal characterization on the nearby soil. This allows scientists to look at the temperature difference from day to night, revealing information about particle sizes within the soil.

Next sol, the plan calls for Spirit to grind into "Humphrey" and then use its arsenal of instruments to analyze the interior of the rock.

sol 56, Mar 01, 2004: *Grooming for the Grind*

On sol 56, which ended at 6:33 p.m. PST, February 29, Spirit completed the .55-meter (1.8 feet) re-approach to "Humphrey" to get into position for grinding with the rock abrasion tool. After the repositioning, the rover took panoramic camera and miniature thermal emission spectrometer data of its rear tracks and the path in front of it, leading the way to "Bonneville" crater.

The wake-up song for the sol was "Walking On Sunshine," performed by Jump 5.

In the coming sols, Spirit will use its rock abrasion tool to grind into "Humphrey," observe the results with the instruments on its arm, and then continue on toward "Bonneville."

sol 55, Feb 29, 2004: *Brush, Brush, Brush, Then Step Back*

Spirit used its rock abrasion tool for brushing the dust off three patches of a rock called "Humphrey," during its 55th sol on Mars, ending at 5:53 p.m. Saturday, PST. Before applying the wire-bristled brush, the rover inspected the surface of the rock with its microscope and with its alpha particle X-ray spectrometer, which identifies elements that are present. Brushing three different places on a rock one right after another was an unprecedented use of the rock abrasion tool, designed to provide a larger cleaned area for examining.

Afterwards, Spirit rolled backward 85 centimeters (2.8 feet) to a position from which it could use its miniature thermal emission spectrometer on the cleaned areas for assessing what minerals are present. Due to caution about potential hazards while re-approaching "Humphrey," the rover moved only part of the way back. Plans for sol 56, ending at 6:33 p.m. Sunday, PST, call for finishing that re-approach and further inspecting the brushed areas. If all goes well, the rock abrasion tool's diamond-toothed grinding wheel will cut into the rock on sol 57 to expose fresh interior material.

For wake-up music on sol 55, controllers chose "Brush Your Teeth," by Cathy Fink and Marcy Marxer, and "Knock Three Times," by Tony Orlando and Dawn.

sol 54, Feb 27, 2004: *Heading To "Humphrey"*

On sol 54, Spirit woke up to the song "Big Rock in the Road" by Pete Wernick and made its final approach to the imposing rock called "Humphrey" before the sol ended at 5:13 p.m. PST on Friday, Feb. 27. The initial 3.5 meter (11.5 feet) drive toward the rock was cut short at only 2.5 meters (8.2 feet) due to a built-in software safety. Rover engineers quickly adjusted the software restriction and drove the final meter of that planned drive, plus the 0.9 meters (about 3 feet) that put the rover in the best position for brushing "Humphrey" with the rock abrasion tool.

Before approaching the rock, Spirit used its alpha particle X-ray spectrometer to investigate the areas the rock abrasion tool will brush and grind. Unlike the last rock abrasion tool sequence on the rock called "Adirondack," the planned procedure for "Humphrey" will include brushing three separate areas of the rock. After brushing, Spirit will back up and examine the brushed areas with the instruments on its arm. The science team will then decide the best place to grind into "Humphrey" - it could be one of the three brushed areas or

another section altogether. The hope is to remove as much dust as possible so the instruments on Spirit's arm can get a pre-grinding "read" on the rock coating and then, after grinding, study beneath the coating and surface.

In the sols following the rock abrasion tool sequence, Spirit might investigate an interesting rock behind it, or continue on toward "Bonneville" crater.

sol 53, Feb 26, 2004: *Eyeing Martian Dust Devils*

On sol 53, which ends at 4:34 p.m. PST on February 26, Spirit woke up to the 70s ballad "Dust in the Wind" by Kansas, with the anticipation of possibly capturing dust devils spinning across the martian surface. The rear hazard avoidance camera was commanded to "roll tape" from 12:00 to 12:30 local solar time to record these so-called "mini-tornadoes." The behavior of dust devils helps scientists track the transfer of dust on the red planet.

A final, .85-meter (about 2.8 feet) drive brought Spirit to its exact target at the "Middle Ground" site. The rover also conducted an examination, using its microscopic imager and alpha particle X-ray spectrometer, of the magnet arrays that are collecting airborne dust.

In the coming sols Spirit will inspect the soil at its current position with the tools on its arm. Following that, the plans call for the rover to approach the rock called "Humphrey." After a thorough assessment of "Humphrey," the rock abrasion tool will be used to brush and then grind.

sol 52, Feb 25, 2004: *Spirit Looks Back at Earth*

On sol 52, which ended at 3:54 p.m. PST, February 25, rover engineers drove Spirit the short 4-meter (13.1 feet) drive to "Middle Ground" after finishing observations with the miniature thermal emission and Mössbauer spectrometers. Several stutter steps that would have put Spirit at the exact target location were not executed because they were programmed with built-in safeties. The rover detected slight hazards and stopped within its constraints. The final steps will be executed next sol.

Waking up to Foreigner's "Cold as Ice," Spirit's first job of the sol was to warm up its arm that was significantly colder than yestersol due to the rover's orientation to the northwest. The engineering team also took a moment to wave to Spirit as its panoramic camera faced and imaged Earth.

Spirit will remain at "Middle Ground" for the next several sols and continue observing targets with its spectrometers and microscopic imager. Plans also call for high-resolution images of rocks and an examination of the soil.

sol 51, Feb 24, 2004: *Making Ground*

To inspire a morning "run" on sol 51, which ended at 3:15 p.m. Tuesday, PST, Spirit woke up to Vangelis' "Chariots of Fire." The rover deployed its arm, took microscopic images of the soil in front of it and then proceeded toward its target, "Middle Ground." Spirit drove 30 meters (98.4 feet), breaking its own record for a single-sol traverse. Along the way, Spirit paused to image rocks on both sides of the drive path with its panoramic camera.

The auto-navigational software that drove the last 12 meters (39.4 feet) of the traverse to the "Middle Ground" target warned Spirit that the slope into the hollow that houses it was too steep (according to parameters set by rover engineers). Spirit then paced along the rim, looking for a safe way down. Unable to locate a secure path into the crater before the sol ended, Spirit ended up facing slightly west of north instead of northeast, as called for by the plan. This orientation will reduce the amount of data the rover can return (due to interference between the UHF antenna and items on the rover equipment deck), but it will be corrected in the coming sols.

As of today, Spirit has moved 183.25 meters (601.21 feet) and is now roughly 135 meters (442.91 feet) from its landing site, Columbia Memorial Station.

The intent for the next several sols will be to drive Spirit into "Middle Ground" and take a full panorama of the surrounding area to identify scientifically interesting rocks.

sol 50, Feb 23, 2004: *Heading for Middle Ground*

On Sol 50, ending at 2:35 p.m. PST, Spirit finished observations of the trench at "Laguna Hollow," then continued on its journey toward the crater called "Bonneville." Driving in a dog-leg pattern to avoid some bumpy terrain, Spirit traveled approximately 18.8 meters (61.7 feet) toward the halfway point, called "Middle Ground." The last 2.8 meters (9.2 feet) were covered using autonomous navigation software.

After completing the drive, Spirit gathered miniature thermal emission spectrometer data on the ground on both sides of the rover, and its panoramic camera and navigation camera took pictures.

The wake-up song this morning (Sunday evening Pacific time) was "Samba De Marte" by Beth Carvalho from her "Perolas Do Pagode" album. The lyrics include a verse about waking up the rover on Carnival Day. This song was written by Beth Carvalho after she heard that one of her songs was used to wake up Mars Pathfinder's Sojourner rover during the 1997 mission. This is quite appropriate, as this spirited sol 50 also began on Carnival day in Brazil!

In the coming sols, Spirit will complete the drive to "Middle Ground."

sol 49, Feb 22, 2004: *Trench Exam Continues*

Spirit continued its inspection of the trench dubbed "Road Cut" during the rover's 49th sol, ending at 1:56 p.m. Sunday, PST. It used three instruments on its robotic arm to examine the subsurface soil exposed by the sol 47 digging of the trench.

Before dawn on sol 49, Spirit switched from its Mössbauer spectrometer to its alpha particle X-ray spectrometer for analysis of soil on the trench floor. Later, controllers played "Coisinha do Pai," by Beth Carvalho, as wake-up music. The rover inspected targets on the wall and floor of the trench with its microscope, then placed the Mössbauer spectrometer against a target on the trench wall for identifying the iron-bearing minerals there. The miniature thermal emission spectrometer took remote readings on the rover's wheel tracks in the morning and afternoon.

Plans for sol 50 (ending at 2:35 p.m. Monday, PST) call for finishing inspection of the trench, then resuming the journey toward the rim of a crater dubbed "Bonneville," followed by a longer drive the following sol.

sol 48, Feb 21, 2004: *Down in the Trench*

On its 48th sol, ending at 1:16 p.m. Saturday, PST, Spirit maneuvered its robotic arm successfully within the challengingly tight confines of the trench that the rover had dug into the floor of "Laguna Hollow" the preceding sol.

Spirit used the microscopic imager on the arm to take pictures of details in the wall and floor of the trench during the morning. Then Spirit rotated the tool turret at the end of its arm and placed the Mössbauer spectrometer in position to read the mineral composition of the soil on the trench floor. That reading was designed to last about 12 hours, from mid-sol into the martian night. Spirit's panoramic camera and miniature thermal emission spectrometer were also used during the sol for studies of sky and rocks.

Spirit has been told to wake up and switch from the Mössbauer spectrometer to alpha particle X-ray spectrometer on the trench floor during the pre-dawn hours of the next sol. Later on sol 49 (which ends at 1:56 p.m. Sunday) and early on sol 50, plans call for using those spectrometers on the walls of the trench and making additional observations of the "Laguna Hollow" area. Then Spirit is slated to resume its trek toward the rim of the crater nicknamed "Bonneville," now estimated to be about 135 meters (443 feet) northeast of the rover's current location.

sol 47, Feb 20, 2004: *Spirit Digs a Trench*

On sol 47, ending at 12:36 p.m. February 20, 2004 PST, engineers woke Spirit up to the song "Dig Down Deep," by Hot Soup, and that's exactly what Spirit proceeded to do. The two-hour operation performed by Spirit's left front wheel resulted in a trench 7-8 centimeters deep (2.8 to 3.1 inches) that uncovers fresh soil and possibly ancient information.

Spirit dug this trench at "Laguna Hollow" the same way that Opportunity dug its 9-10 centimeter (3.5 to 3.9 inch) trench at Meridiani. However, because the ground at this location is harder, Spirit had to dig for twice as long as Opportunity - going back and forth over the surface 11 times instead of 6.

After the trench was completed, Spirit backed up one meter, or more than a yard, and analyzed the area with the miniature thermal emission spectrometer before driving forward 0.4 meters (15.7 inches) and imaging the excavation site with the panoramic camera. A final move forward of another 0.4 meters allowed Spirit to take front hazard avoidance camera images of the arm work volume which was then centered on the trench.

After stowing the arm, the rover did a series of miniature thermal emission spectrometer observations of several nearby rocks, "Buffalo," "Cherry," "Cotton," and "Jiminy Cricket," and a combined miniature thermal emission spectrometer and panoramic camera observation of "Beacon." Spirit also took panoramic camera images of its deck to observe dust accumulation on the instrumented solar cells and on the miniature thermal emission spectrometer calibration target.

Spirit then took a siesta from 2 p.m. to 3:45 p.m. Mars Local Solar time and woke up for some more panoramic camera and miniature thermal emission spectrometer observations of "Beacon," and miniature thermal emission spectrometer ground and sky stares. All activities up through the afternoon pass by the Mars Odyssey orbiter were completed successfully.

sol 46, Feb 19, 2004: *Halfway Through*

Sol 46, completed at 11:17 a.m. February 19, 2004 PST, marks the halfway point of Spirit's primary surface mission - sols 2 through 91. Spirit began this momentous morning by doing some remote sensing of the crater rim and imaging the surrounding soil with the panoramic camera and miniature thermal emission spectrometer. After all this work, Spirit took a break with a nap lasting slightly more than an hour. After waking, Spirit continued its observations of the ground and sky with the miniature thermal emission spectrometer. At about 1:34 p.m. Mars Local Solar Time, Spirit found itself analyzing a patch of the atmosphere with the miniature thermal emission spectrometer at the same time that Mars Global Surveyor's thermal emission spectrometer was looking down through the same chunk of atmosphere. This concurrent observation will enable a more thorough understanding of martian atmospheric conditions.

Spirit's afternoon activities began at about 4:00 p.m. Mars Local Solar Time after the Mars Global Surveyor pass. Spirit was expected to take stereo microscopic images of the target "Trout" in Laguna Hollow. This is the first time the microscopic imager will take pictures at Gusev Crater without the Mössbauer instrument first touching the surface of the soil. The observation will provide pictures of undisturbed soil. After this, Spirit will perform a calibration activity by imaging a location in the sky with the microscopic imager and the navigation camera simultaneously.

Spirit's day will stretch into the night this sol with an overnight Mössbauer spectrometer integration. After a brief sleep, Spirit will wake at about 2:00 a.m. Mars Local Solar time on sol 47 to end the integration, collect the data and turn on the arm heaters. It will prepare for

changing the tool from the Mössbauer to the alpha particle x-ray spectrometer, and begin observations with the new tool. Finally, the rover will leave the alpha particle x-ray spectrometer powered on and go back to sleep around 2:30 a.m. Mars Local Solar time.

On the morning of Sol 47, which will end at 11:57 a.m. February 20, 2004 PST, the plan is for Spirit to end the alpha particle x-ray observation and collect that data, and then perform some early mini-thermal emission spectrometer soil properties observations.

sol 45, Feb 18, 2004: *Spirit Does a "Wheel Wiggle"*

Spirit began sol 45, which ended at 11:17 a.m. February 18, 2004 PST, at its previous target, Halo, by conducting analysis with the alpha particle x-ray spectrometer, microscopic imager and Mössbauer spectrometer. Spirit also took panoramic camera images and miniature thermal emission spectrometer observations before its arm was stowed for the northeast drive toward a circular depression dubbed Laguna Hollow.

The first 19 meters of the drive toward Laguna Hollow was commanded using go-to waypoint commands with the hazard avoidance system turned off. This mode - which was used for the first time this sol - provides automatic heading correction during a blind drive. Some fine-tuning toward the target brought the total drive for this sol to 22.7 meters (74.5 feet).

After reaching Laguna Hollow, Spirit "wiggled" its wheels to disturb or scuff the fine dust-like soil at this location, which allows for more detailed observations with the instruments on the robotic arm. After adjusting position to put the disturbed soil in reach of the arm, Spirit backed up and completed a miniature thermal emission spectrometer scan of the new work area. Before the sol ended, Spirit made one more adjustment, putting it in perfect position to analyze the scuffed area beginning on sol 46

The plan for sol 46, which will end at 11:57 a.m., February 19, 2004 PST, is to conduct observations on Laguna Hollow with the instruments on the robotic arm, including some higher resolution analysis that will involve an overnight tool change.

sol 44, Feb 17, 2004: *Spirit Passes 100-Meter Mark*

Spirit controllers are calling sol 44 one of Spirit's most complicated and productive sols to date. Before commencing its record-breaking drive, Spirit began the sol, which ended at 10:38 a.m. February 17, 2004 PST, with an alpha particle x-ray spectrometer analysis of the soil target Ramp Flats. The analysis ran in parallel with a miniature thermal emission spectrometer observation of the martian sky. Spirit then continued observing "Ramp Flats" with the microscopic imager and Mössbauer spectrometer while operating the panoramic camera to get pictures of rocks in the distance called "V Ger" and "Broken Slate."

But this morning multi-tasking was only the beginning. After stowing the robotic arm, Spirit began a north-northeast drive that added a total of 21.6 meters (70.9 feet), bringing the rover's grand total to 108 meters (354 feet). That distance is about 6 meters (19.7 feet) more than Sojourner's mission record, set in 1997. Controllers remarked that Spirit's auto-navigation drives are consistently getting faster. These long drives are revealing new and interesting terrain, including more ridges, dunes, ripples and rocks with various appearances.

The plan for sol 45, which will end at 11:17 a.m. Feb. 18, 2004 PST, begins with analysis of a target at the current location, followed by a drive into a hollow between 15 meters (49 feet) and 18 meters (59 feet) away.

sol 43, Feb 16, 2004: *Mega Drive*

Spirit spent the wee morning hours of sol 43 gathering data about a wheel-track target with the Mössbauer spectrometer, then tucked its arm and drove. It used a two-session method engineers call a "mega drive" in order to make good progress toward the crater nicknamed "Bonneville." The first driving session covered 19 meters (62.3 feet) after long-running morning activities shortened the time for driving. After a rest, Spirit continued another 8.5 meters (27.9 feet) in the afternoon, resulting in a total drive of 27.5 meters (90.2 feet), a new one-sol record. Sol 43 ended at 9:58 a.m. Monday, PST. The remaining distance to "Bonneville" is about 245 meters (about 800 feet) from Spirit's new location.

For sol 44, which will end at 10:38 a.m. Tuesday, PST, controllers plan "touch-and-go" activities: deploying the arm on a target called "Ramp Flats" before continuing toward Bonneville.

sol 42, Feb 15, 2004: *A Wayside Stop, Then Back to Driving*

Spirit used instruments on its robotic arm to examine an unusual-looking rock called "Mimi" during the rover's 42nd sol on Mars, which ended at 9:15 a.m. Sunday, PST. Scientists will be examining images and spectra to understand this rock's structure and composition and what those can tell about the environment in which the rock formed.

For sol 43, which will end at 9:58 a.m. Monday, PST, controllers have planned what they are calling a "mega drive": commanding a morning drive of about 25 meters (82 feet), then taking pictures of the scene ahead and letting the rover have a brief rest before using those mid-day pictures to guide an optional afternoon drive. Spirit is currently about 270 meters from the crater nicknamed "Bonneville," its mid-term destination.

sol 41, Feb 14, 2004: *Spirit Gets the Drift*

On its 41st sol, which ended at 8:39 a.m. Saturday, PST, Spirit examined the crest and trough of a drift formation encountered on its journey, then moved to a nearby rock.

The rover used its microscopic imager, Mössbauer spectrometer and alpha particle X-ray spectrometer on the drift material. Then it backed up about 10 centimeters (4 inches), turned, and advanced about the same distance to be in position for thoroughly examining the

flaky rock called "Mimi" during sol 42, which will end at 9:18 a.m. Sunday, PST.

Plans call for resuming long daily drives on sol 43 toward the crater nicknamed "Bonneville" on the northeastern horizon.

sol 40, Feb 13, 2004: *Movin' Towards "Mimi"*

Spirit woke up to its 40th sol on Mars to the song "What a Wonderful World" by Louis Armstrong and then proceeded to have a wonderful sol which ended at 7:59 a.m. Friday, PST. After utilizing the miniature thermal emission spectrometer instrument on surrounding soil and completing some pre-drive imaging with the panoramic camera, Spirit proceeded 90 centimeters (2.95 feet) towards a collection of rocks called "Stone Council." The drive lasted less than five minutes. After completing the drive, Spirit imaged several rocks with the panoramic camera, and completed a mosaic of the area in front and to the left of itself.

On sol 41, which will end at 8:39 a.m. Saturday, PST, Spirit will be repositioned in front of the flaky rock called "Mimi" in preparation for placing its instrument deployment device on that rock during sol 42.

sol 39, Feb 12, 2004: *New driving record*

During its 39th sol on Mars, which ended at 7:20 a.m. Thursday, PST, Spirit broke its own driving record. It adding 24.4 meters (80 feet) to its odometer while getting near an interesting set of rocks dubbed "Stone Council." The drive lasted 2 hours, 48 minutes. While navigating itself to avoid hazards, Spirit stopped when it recognized an obstacle, which was the group of rocks that was the day's intended destination.

The flight team at JPL chose Buster Poindexter's version of "Hit the Road Jack," as Spirit's wake-up music. The day's commands were uplinked during the cool morning hours via Spirit's low-gain antenna, to bypass a problem diagnosed the preceding day as shade slowing the warm-up of motors that move the high-gain antenna.

Before rolling, Spirit took images with its microscopic imager and panoramic camera from the site where it started the day.

The plan for sol 40, which will end at 7:59 a.m. Friday, PST, is a short drive forward then using instruments on the robotic arm to study soil at Stone Council.

sol 38, Feb 11, 2004: *It's Cold in the Shadow*

On Spirit's sol 38, which ended at 6:40 a.m. Wednesday, PST, a failure to receive data during the morning high-gain communication window quickly led engineers to conclude that Spirit's high-gain antenna was not pointed toward Earth. Spirit's orientation after the previous sol's drive (45 degrees to the northeast) caused its camera mast to cast an early-morning shadow on the high-gain antenna's elevation actuator. The cold conditions caused the actuator to stall and fail to point to Earth while being calibrated. The afternoon high-gain communication session performed flawlessly.

The afternoon communication window with Mars Odyssey provided previously acquired images of the rocks Adirondack and White Boat and a miniature thermal emission spectrometer observation of the depression drilled by the rock abrasion tool on Adirondack.

In coming sols Spirit will perform daily "touch and go" maneuvers, inspecting the soil surrounding it with the instruments on its arm, then continuing its drive toward the crater nicknamed "Bonneville."

sol 37, Feb 10, 2004: *Record-breaking Sol*

On its 37th sol on Mars, which ends at 6 a.m. Tuesday, PST, Spirit broke the record for the farthest distance driven in one sol on Mars, traveling 21.2 meters (69.6 feet). Today's distance traveled shattered the Sojourner rover's previous record of 7 meters (23 feet) in one sol.

In the coming sols, Spirit will continue its drive towards the crater nicknamed "Bonneville."

sol 36, Feb 09, 2004: *Cruise Control on Mars*

On sol 36, which ended at 5:21 a.m. Monday, PST, Spirit drove 6.37 meters (20.9 feet), using the onboard navigation software and hazard avoidance system for the first time on Mars. The drive, intended to test the traverse commands, was extremely precise, taking Spirit to its intended goal – the rock called White Boat. Before leaving the rock Adirondack, Spirit took images and collected miniature thermal emission spectrometer data from the hole ground by the rock abrasion tool.

In the coming sols, Spirit will continue its drive toward Bonneville Crater.

sol 35, Feb 08, 2004: *Rock Interior Inspected*

NASA's Spirit examined the interior of a rock during Spirit's 35th sol on Mars, which ended at 4:41 a.m. Sunday, PST. Beginning late in the previous sol, Spirit took turns placing its Mössbauer spectrometer, alpha particle X-ray spectrometer and microscopic imager over the portion of the rock called Adirondack where Spirit's rock abrasion tool had cut away the rock's surface.

Spirit did not begin driving on sol 35, because a precautionary software setting to prevent driving was still in effect from the beginning of the anomaly two weeks ago. The rover is being commanded during sol 36, which ends at 5:21 a.m. Monday, PST, to back away from Adirondack, drive past the south side of the now-empty lander, and begin a trek northeast toward a crater nicknamed "Bonneville."

sol 34, Feb 07, 2004: *First Human-made Hole in a Rock on Mars...EVER!*

On Spirit's sol 34, which ended at 4:02 a.m. Saturday, PST, the rover's rock abrasion tool (RAT) successfully completed history's first grind into a rock on Mars. The rock of the day was Adirondack. Scientists and engineers were ecstatic when the afternoon communications relay from Mars Odyssey revealed a round and clean-surfaced depression.

Tomorrow, on sol 35, which ends at 4:41 a.m. Sunday, PST, Spirit is being told to inspect the newly exposed ancient rock material with her Mössbauer spectrometer, microscopic imager and alpha particle x-ray spectrometer before making a six-meter (20-foot) drive around the south side of the lander.

Current plans may keep Spirit in drive mode for the next few sols as she heads northeast towards a crater nicknamed "Bonneville."

sol 33, Feb 05, 2004: *First Interplanetary Brushing of a Rock!*

NASA's Spirit was back and accomplishing another "first" in interplanetary science on Thursday: It brushed the dust off a rock to clean its surface for inspection.

On the first day of operations after they reformatted Spirit's flash memory, engineers confirmed that the flash memory was stable and available for data storage. Spirit was cleared to conduct the sol's science activities. The rock abrasion tool on the rover's robotic arm brushed a portion of the surface of the rock called Adirondack for five minutes. Spirit's panoramic camera and microscopic imager took pictures to show the effect of the brushing. The Mossbauer spectrometer and alpha particle X-ray spectrometer were used overnight on the brushed area.

The plan for Spirit for sol 34 is to use the rock abrasion tool again, this time to grind away the brushed portion of Adirondack's surface for examination of the rock's interior.