# SpaceX tracking at Mt Pleasant with the 26m

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## 1 Introduction

The most recent version of this document should be in `/home/observer/spacex/doc` on newsmerd. I recommend that when you run the programs/scripts for any test tracks that you do it as observer on newsmerd. All the scripts are kept in `/home/observer/spacex`.

We are dependent upon the internet working properly to get updated predictions during the launch. I think that its is a good idea to check with either John Miezitis (John.Miezitis@utas.edu.au, ext 6181), or Michael Harlow (Michael.Harlow@utas.edu.au, ext 1818) that no network outages are planned for the launch window.

During the launch I recommend that you run no more than one antenna monitoring process on the 26m antenna and get rid of all unnecessary processes on newsmerd. This should reduce the chance of the problems at the worst possible time and reduce the general load on newsmerd.

The main telescope for Space X tracking is the 12m, although we also have the capacity for 26m tracking (although it is less well suited for any LEO tracking than the 12m). It is unlikely that you will encounter any serious problems, however, I have listed some which may occur and possible solutions in section 6.

## 2 Tracking prediction files

The tracking prediction files will be supplied by SpaceX prior to the launch. We expect them to be supplied by Hassan Khalil (Hassan.Khalil@spacex.com) or Jeremy Fields (Jeremy.Fields@spacex.com). They may be updated at relatively short notice prior to the track, so make sure that you are comfortable with the steps necessary extract the tracking files and prepare them for use.

### 2.1 Downloading the tracking files

An important thing to remember is that in some cases we have had issues with the line endings for the tracking file. Various programs (e.g. University web mail), will interpret the tracking files as a text file and convert the line-endings. The following process for extracting and transferring the files to `timehb.phys.utas.edu.au` is known to work, and is the recommended method. For tracking on the 26m `timehb` is not required, so you can directly download tracking files to `newsmerd` if desired. The `timehb` information has been supplied below as it provides a point and click interface and the passwords etc are stored.

1. The track files from SpaceX will be supplied via their sftp server. The IP address, login and password for this are stored in the SpaceX profile on the WinSCP client on `timehb`. Make sure prior to the important tracks that these are up to date. At present (May 2016) the server IP address is 23.21.238.4, the username/password is hobart/XnB1eAMjV/k

2. The tracking files are contained in the tracking/tracking_table subdirectory on the SpaceX SFTP server. You should download all the files in that directory to timehb (perhaps to an appropriately named subdirectory of Downloads).

3. For tracking on the 26m you then need to copy the tracking files to `newsmerd`, so that you can check the trajectory of the track, prepare a tracking file for the 26m etc.

If you want to download the files directly to `newsmerd` without going through `timehb`. You can to this as follows :

1. `sftp hobart@23.21.238.4`

   (password is given in the `timehb` instructions).

2. `cd tracking`

   `cd tracking_table`

   `get *.txt`

   `quit`

In the past (during some initial tests) the track files have been emailed as a zip file. If you ever get tracking files sent in this manner, extract the files from the zip archive and copy them to a dropbox folder. Then in a web browser on `timehb` login to the appropriate dropbox account and download the files required into the firefox downloads folder. More recently when there were problems with the sftp server I have received tracking files using the Space X secure mail website. To access this you have a click a link it takes you to a sign-in page. If you don't already have an account you have to register - use the email address the link was sent to and after going through the registration, creation of a password etc you should be able to retrieve the files. Alternatively, if you have the person send the email link to Simon.Ellingsen@utas.edu.au (and CC anyone else necessary in on the message, so they get the link), then you can access my account using my email address as the username and `LunchB0x` as the password.

## 2.2 Converting tracking files for the 26m

The supplied files from SpaceX will be in the format required for the 12m tracking system, not the 26m and they need to be converted to the appropriate format If the 26m is also (or instead) to be used in tracking then an prediction file in the appropriate format needs to be produced. This can be done with the script `satcnv_spacex.pl`. For example :

```
./satcnv_spacex.pl --input=hobart_falcon_2016_05_05_06_12_20_LET46.txt --output=jcsat_track.out
```

This script will report the start and stop times for the track. In addition to converting the format, this script also removes track points which are beyond the 26m antenna limits and if the required tracking rate exceeds the maximum $X$or $Y$ drive rate it modifies the track so that the antenna drives at the maximum rate and until it catches up with the requested position again. Nominally the maximum drive rate of the 26m antenna is 40 degrees per minute in each drive, however, during testing we found that it was necessary to use this catch-up mode if the drive rate exceeds 38 degrees per minute. The 26m is not as seamless when it catches up to the track and may oscillate, but this should damp out.

If you need to change the start time for the track (very unlikely) you can set a new MJD start time by specifying `--mjd_start` as an argument to `satcnv_spacex.pl`.

If you want to have a look at some of the details of the pass, when and where it will start and stop, the maximum rates etc, use the script `satplt.pl`. This will use PGPLOT to display the track path, so you will need to have X11 forwarding enabled to see this (if you aren't directly on newsmerd). A list of all the options can be viewed with the `--help` option, the most common usage would be something like :

```
./satplt.pl --list jcsat_track.out
```

the `--list` option gives information about the track start and stop UT time. The `--out` and `--full` options print out the X and Y positions and drive rates for the track in vary levels of detail (every tenth point and every point respectively). You can also plot either the azimuth and elevation X or Y positions and rates as a function of time in the track by specifying one of `--az_plot`, `--el_plot`, `--x_pos`, `--y_pos`, `--x_rate` or `--x_rate`.

There is an octave script `Countdown_26m.m` in the `/home/observer/spacex` directory on newsmerd which can be used to easily display some time parameters connected to the track. After starting octave in the `/home/observer/spacex` directory, you can run the Countdown script for a given track file with

```
Countdown('hobart_falcon_2016_05_05_06_12_20_LET46.txt')
```

**NOTE:** The filename you need to give here is the tracking file for the 12m telescope, not the 26m telescope. Because of that the start time may be inaccurate to some degree because of the different limits of the two antennas. The script will then report back the number of seconds until the start of the track (referred to here as AOS). Once commenced, it will report the elapsed and remaining time in seconds, and show a plot of azimuth and elevation which will be updated every second. Unexpired points will be shown in red, passed points in blue. The actual azimuth and elevation of the antenna will be plotted in near-real time with a green line.

# 3 SpaceX tracking on the 26m

## 3.1 Antenna tracking

In addition to the window for running `sattrk`, it is a good idea to have at least 4 other xterms/terminals running on newsmerd for the following programs :

1. `satplt.pl` so that you can see the predicted AOS, LOS, maximum elevation and maximum drive rates in each axis for the upcoming pass, as you will typically be asked to confirm the start time for the track by the SpaceX ground station command team.

2. `octave/Coundown_26m` so that you have a constant update to the time until the start of the track in the 20 minutes or so prior to the track and some realtime feedback on the azimuth and elevation, compared to the prediction during the track.

3. `spacex_log_26m.pl` with the command to extract the tracking log information typed in and ready to go at the end of the pass. We recommend that you set it up to extract the log information for the nominal track times with a 30 second buffer at each end. Don't worry about the warning messages that are produced by `spacex_log.pl`

4. A window with `sftp` running (its a good idea to use the `-oServerKeepAlive=60` option to stop it from timing out between passes) so that you can transfer the tracking log quickly at the end of the pass.

1. ssh as observer to `newsmerd`, making sure that X11 forwarding is enabled, or alternatively bring up a VNC viewer for `newsmerd`. Its a good idea to have both an antenna_monitor and a vdesk program running as well.

2. `cd /spacex` (then cd into the directory holding the tracking file converted into the 26m format).

3. The basic command for running sattrk should look something like :
   `./sattrk -b -d 1/xs -i <prediction file> sys26m`

4. If you have sufficient time prior to the actual track, I recommend that you do a test track. If you use the same command as above but add `-t 2` before `sys26m` then the antenna will run a test track for the same azimuth and elevation, but starting 5 minutes into the future. All the messages which appear in the log window are written to the file `/scratch/sattrk.log`

5. The display will start updating about 2 seconds prior to the nominal track start time and once its running it should look something like Figure 1. The predicted path for the antenna is shown in white in the left-hand panel of the display, the followed path is shown in red. The right-hand panel shows the difference between the requested and achieved position for the antenna (in degrees). It autoscales, so it is difficult to see small deviations if there has been a large one during the track. The `sattrk` text display also gives the X and Y position errors and drive rates. **NOTE:** Don't be concerned if `sattrk` gives messages like "Insufficient memory on the ACT to collect data at 10.0 Hz" and "Reducing the frequency of antenna monitoring to 1.47 Hz" or similar. This is just because if you have a long track (taking tens of minutes, or hours), the drive control PC doesn't have enough memory to store all the antenna parameters 10 times per second for that period of time. We no longer use the monitoring information collected directly by the drive PC anyway, we use the MoniCA logging for compatibility with the 12m tracking.

6. If the `sattrk` program crashes after the track has started (it has never happened, but its always possible), the antenna should continue with the track (check that `antenna_monitor` still reports `FSATTRK` as the function). If for some reason you don't start `sattrk` before the start of the track, or it has been aborted on the antenna, you can restart it with the original track file and it will attempt to catch up to the appropriate point in the track. This works reasonably well for slow tracks, but if its a Low-Earth-Orbit track, such as dragon going to the ISS then it is unlikely to be successful unless you are close to the start of the track (where the drive rates are modest) and the antenna is relatively near where it needs to be.

Sometimes all the 26m monitoring connections are in use and the `sattrk` can drive the antenna, but does not return real-time monitoring information on the text or graphical displays. If you have time prior to the track you can reboot the 26m antenna and that should fix the problem. If you do do that you need to make sure that the MoniCA logging for the 26m antenna is restarted (it doesn't recover automatically from a drive PC reboot). To restart the MoniCA monitoring for the 26m on `newsmerd` :

1. `ps -ef | grep monica_monitor`

2. kill any processes that are running (with the exception of the grep command).

3. Restart the MoniCA logging with the command `socket -w -b -p "/obs/bin/linux/monica_monitor sys26m" -s -l 60000`

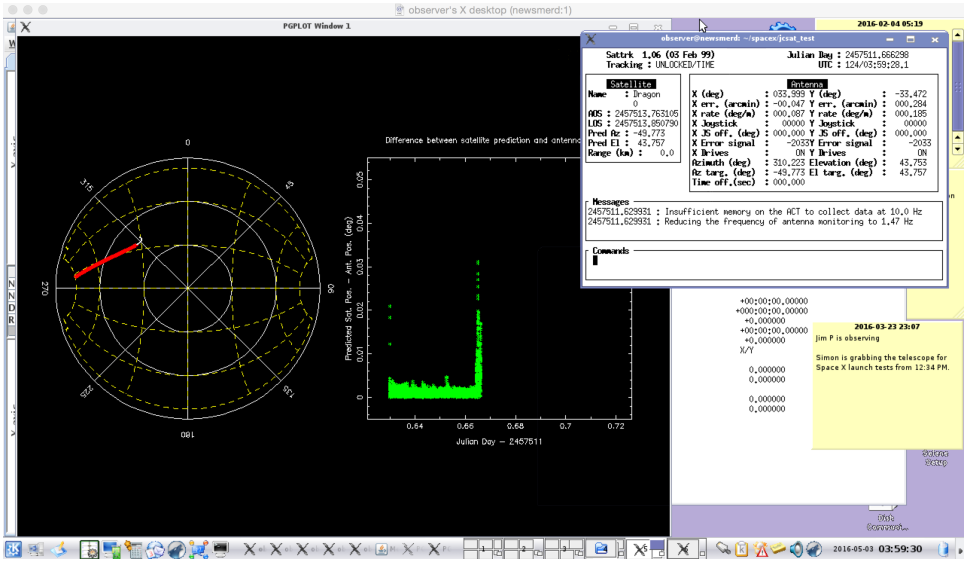


Figure 1: `sattrk` running on `newsmerd` VNC

4. You can then check that MoniCA is logging by running `omc_hobart.sh`, create a `Point Table` (Setup menu, Add panel option) and add points such as `ant.servo.leftDial` (26m X position) or `ant.sky.declination2000` and check that they are updating in the Display panel.

If you don't have time for a sys26m reboot then hopefully the `Countdown_26m` display will be operating and give you the information you require, otherwise `antenna_monitor` and the live pages will give you the azimuth and elevation of the antenna, and the position errors of the antenna.

### 3.1.1 Complete list of `sattrk` command line options

**NOTE:** Some of these options refer to features which are no longer really supported. In particular I don't recommend writing the antenna monitoring data to a separate file (we can use MoniCA to extract that information) and the joystick was something we had in place to enable real-time adjustments to the tracking for the Global star launches in the late 90's and early 2000's.

**-b** Dual axes mode of graphical monitoring of the antenna position and error (recommended).

**-d <PGPLOT device>** Specify the PGPLOT device for the antenna tracking graphical display (recommend `-d 1/xs`).

**-e <PGPLOT device>** Specify the extra PGPLOT device for the joystick offset graphical display (recommend `-e 2/xs`).

**-h** A list of the command line options.

**-i <prediction file>** The file containing the satellite predictions.

**-l** Graphical monitoring of the antenna position in azimuth (not recommended, use -b instead).

**-o <output file>** The file to output the tracking information to, should be written to a disk with space to hold files of several megabytes or more.

**-p** Panic mode. If sattrk should crash at a vital time, but the ACT is still running the tracking command then rerun sattrk with the same command line options as before (except for the output which should go to a different file) and add the -p flag.

**-r** Graphical monitoring of the antenna position in elevation (not recommended, use -b instead).

**-s** Switch off the "live" output for the WWW page (not recommended).

**-t <1 or 2>** Test mode 1 drives the antenna in a circle, test mode 2 takes the predictions from the input file and sends a track to the ACT which has the same path in azimuth and elevation as the input file, but the start time of the track is 5 minutes from the current time.

**-x <Native left offset>** Start the tracking with an offset in the native left coordinate (degrees).

**-y <Native right offset>** Start the tracking with an offset in the native right coordinate (degrees).

## 3.2 Generating tracking log files

If a log file of the antenna position and other parameters is required from the track you should use the `spacex_log_26m.pl` script on `newsmerd` (in the `spacex` directory). You need to give the script the UT start and stop times for the track information and the name of an output file. SpaceX request that the log file be given the same name as the tracking file it relates to (we will use a .log extension to help distinguish the prediction and log files), and be uploaded to the `logs` directory on the SFTP site. An example of the call to the log generating file is

```
./spacex_log_26m.pl --start=00:35:00.0/16/04/2012 --stop=00:44:00.0/16/04/2012
--output=Hobart_2012_04_16_00_37_25.log
```

To transfer the log from newsmerd to the SFTP site

`sftp hobart@23.21.238.4` login with the password given above and then `cd logs` and `put Hobart_2012_04_16_00_37_25.log` and finally `quit`

## 3.3 Communication with Control Center

SpaceX requires us to phone the "Ground Station Operations Voice Communications Bridge" ∼35 minutes prior to the start of the track. You do this on the phone connected to the spaceX rack using the US-Toll free phone number given (preceded by a 9 to dial out and then a 1). This phone number is 866-434-5269 (i.e. the full number to dial is 9-1-866-434-5269), but should be checked prior to each tracking session. The conference code doesn't seem to change from session to session and the number we have been using since 2012 is 5885737. There is also an international Toll number +01 216-706-7005, this should be used if there are issues getting to the voice communications bridge via the SpaceX phone. You can access this from the white UTAS IP phone (if necessary) by calling 0-0011-1-216-706-7005.

The SpaceX IP phone sometimes drops out, and if no one has been talking on it this isn't necessarily obvious. You can check if the SpaceX Cisco IP phone is connected by looking at the LCD display. If it shows "Connected" at the bottom

then it is working. If it shows "Cisco" on this display then it has dropped out and you should dial in again.

**NOTE:** For the new (2016) Space X rack the phone that comes with it has not yet been configured to work. We have used Skype and the US-Toll free number above to phone into the communications bridge.

Additional phone numbers for possible emergency contact (all US), are George Motter (1-310-363-6840, 1-610-392-3832, gmotter@spacex.com) and Steve Mance (1-310-363-6398, 1-913-449-3651, smance@spacex.com). I believe that the first numbers are the work numbers and the second ones are mobiles.

Prior to the bass the Ground station control centre will want to confirm with the person speaking to them the start time of the track (down to the second level) and the starting azimuth, the stop time of the track, and the name of the tracking file being used. They also require the person on the phone to indicate the start and stop of motion on the antenna and give 5° elevation calls (i.e. calls at elevation 10, 15 etc degrees).

## 3.4 RF setup

The new Space X rack is more secure than the previous version and cannot be accessed without permission and some security checks. We have two IF cables connecting it into the control room. One is for the RF input from the S-band receiver (currently labeled "Space X RF Input"), the other is the signal sent to a test transmitter for the boresight tests that Space X does to test levels/performance of the rack (currently labelled "Space X Test Tone Tx output"). When the 12m is being used for tracking the RF input is connected to the `to space ex/if op` BNC connector in rack 15. For tracking using the 26m Jamie has put an extra splitter in the LCP signal which is controlled by the `PalfreymansClient`. The additional signal goes through the intra-rack panels from 3A to 12A. The 3A connector in rack 12 then connects into one side of a high frequency mixer (3 GHz+), the other side takes the output from the Agilent on top of the space X rack (2.5 GHz, 7 dBm - manual change only). The output from the mixer is then connected to the "Space X RF Input" cable. The test tone transmit cable is attached to a helix radiator sitting in the front window of the control room.

The backend setup to send signal from the room-temperature S-band on the 26m to the space X rack is :

1. Put Rx 3 on axis
2. Set the focus cabin Agilent to 7.7 GHz, 16 dB
3. Set the space X rack Agilent to 2.5 GHz, 7 dBm.
4. Check `PalfreymansClient` has RCP/LCP selected and adjust attenuation to get input power roughly equivalent to the 12m (attenuation is between 0 and 10 dBm - final value not certain). The spectrum analyser has a stored trace in blue which shows this. For a 300 MHz span with RBW 3 MHz, VBW 10 MHz, SWT 2.5 ms, the level should be roughly -47 dBm at 2.23 GHz where the marker has been placed.
5. Reconnect the "SpaceX RF in" cable to the output of the mixer if you have been using the spectrum analyser to check the levels
6. If the power level is extremely low, check to make sure the ZFL amplifier on the output of the mixer (on top of SpaceX rack) is powered on. NB - it's running off a 110 V supply.

### 3.5 Boresight RF tests

The best boresight transmitter for the 26m is (currently) a helix sitting in the window of the control room pointing towards the 26m antenna. In `vdesk` with the antenna in X/Y coordinate mode (`coord xy`) set `dlongit -84.3` and `dlatit -55.5` and `slew`.

### 3.6 Monitoring the RF signal

The signal going into the SpaceX rack is split and can be monitored locally using the main spectrum analyser. The signal coming from the LCP front end which is being sent to the Mark IV rack can be used to monitor the RF signal which is going to the rack. To see the space craft signals set the spectrum analyser centre frequency to 300 MHz and the span to 50 MHz. For JCSAT14 we had telemetry signals visible on the spectrum analyser about 12 MHz from the left-hand edge of the spectrum analyser and at the start of the track these were about 25 dB above the noise.

## 4 Important or useful scripts

The following programs are likely to be of some interest :

**/obs/develop/sol/sattrk/sattrk** The program which controls the Mt Pleasant antenna and records the tracking information (see section **??**).

**/obs/develop/sol/sattrk/satcnv2.pl** The perl script for converting predictions from globalstar into the format required for sattrk (see section **??**).

**/obs/develop/sol/sattrk/satadj.pl** The perl script for adjusting the time field in a predictions file. This is useful if the actual launch time differs from that used in the initial predictions (provided you know what the launch time used was).

**/obs/develop/sol/sattrk/print_data** The program for extracting tracking information from the data file written by sattrk (see section **??**).

**/obs/develop/sol/sattrk/satplt.pl** The perl script for plotting the path of a satellite track with respect to the Mt Pleasant antenna coordinates (see section **??**).

**/usr/local/bin/sattrack** An externally written program which can convert NORAD two line element information into a list of azimuth and elevation versus time (see section **??**).

**/obs/develop/sol/sattrk/satcnv.pl** A perl script for converting the output from sattrack into the format required by sattrk (see section **??**).

**/obs/develop/sol/sattrk/satcmp.pl** A perl script for comparing two satellite tracking prediction files.

**/u/sellings/dosat.pl** A perl script for automating the production of tracking information for sattrk from NORAD two line elements (see section **??**).

# 5 A complete list of satplt.pl options

`satplt.pl` is the most useful of all the satellite tracking perl scripts, I recommend trying each of these options so that you are vaguely familiar with them.

–**az_plot** Produce a plot of the azimuth of the satellite as a function of time.

–**el_plot** Produce a plot of the elevation of the satellite as a function of time.

–**azel_plot** Produce a plot of the path of the satellite on an azimuth elevation grid. This option is on by default, use –noazel_plot to switch it off.

–**pgdev=<PGPLOT device>** The PGPLOT device to produce any plot output one. The default is /xs.

–**list** List the UT start and stop times for each of the tracks in the file.

–**extract=<track number>** Extract the information for the specified track number (it is printed to standard output).

–**out** Output information on X,Y position and rates. This is useful for making sure that the maximum rate during the pass doesn't exceed the antenna limits.

–**help** A brief list of the command line options.

# 6 Possible problems

I don't anticipate any serious problems, however, that doesn't necessarily mean that they wont happen. If sattrk crashes during the tracking the ACT should continue to track the satellite and respond to joystick commands (look on antenna_monitor to make sure an FSATTRK function is still in progress).