CHAPTER 22

LOG ENTRY: SOL 458

Mawrth Vallis! I'm finally here!

Actually, it's not an impressive accomplishment. I've only been traveling ten sols. But it's a good psychological milestone.

So far, the rover and my ghetto life support are working admirably. At least, as well as can be expected for equipment being used ten times longer than intended.

Today is my second Air Day (the first was five sols ago). When I put this scheme together, I figured Air Days would be godawful boring. But now I look forward to them. They're my days off.

On a normal day, I get up, fold up the bedroom, stack the solar cells, drive four hours, set up the solar cells, unfurl the bedroom, check all my equipment (especially the rover chassis and wheels), then make a Morse code status report for NASA, if I can find enough nearby rocks.

On an Air Day, I wake up and turn on the oxygenator. The solar panels are already out from the day before. Everything's ready to go. Then I chill out in the bedroom or rover. I have the whole day to myself. The bedroom gives me enough space that I don't feel cooped up, and the computer has plenty of shitty TV reruns for me to enjoy.

Technically, I entered Mawrth Vallis yesterday. But I only knew that by looking at a map. The entrance to the valley is wide enough that I couldn't see the canyon walls in either direction.

But now I'm definitely in a canyon. And the bottom is nice and flat. Exactly what I was hoping for. It's amazing; this valley wasn't made by a river slowly carving it away. It was

made by a mega-flood in a single day. It would have been a hell of a thing to see.

Weird thought: I'm not in Acidalia Planitia anymore. I spent 457 sols there, almost a year and a half, and I'll never go back. I wonder if I'll be nostalgic about that later in life.

If there is a "later in life," I'll be happy to endure a little nostalgia. But for now, I just want to go home.

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"WELCOME BACK to CNN's *Mark Watney Report*," Cathy said to the camera. "We're speaking with our frequent guest, Dr. Venkat Kapoor. Dr. Kapoor, I guess what people want to know is, is Mark Watney doomed?"

"We hope not," Venkat responded, "but he's got a real challenge ahead of him."

"According to your latest satellite data, the dust storm in Arabia Terra isn't abating at all, and will block eighty percent of the sunlight?"

"That's correct."

"And Watney's only source of energy is his solar panels, correct?"

"Yes, that's right."

"Can his makeshift rover operate at twenty percent power?"

"We haven't found any way to make that happen, no. His life support alone takes more energy than that."

"How long until he enters the storm?"

"He's just entered Mawrth Vallis now. At his current rate of travel, he'll be at the edge of the storm on Sol 471. That's twelve days from now."

"Surely he'll see something is wrong," Cathy said. "With such low visibility, it won't take long for him to realize his solar cells will have a problem. Couldn't he just turn around at that point?"

“Unfortunately, everything’s working against him,” Venkat said. “The edge of the storm isn’t a magic line. It’s just an area where the dust gets a little more dense. It’ll keep getting more and more dense as he travels onward. It’ll be really subtle; every day will be slightly darker than the last. Too subtle to notice.”

Venkat sighed. “He’ll go hundreds of kilometers, wondering why his solar panel efficiency is going down, before he notices any visibility problems. And the storm is moving west as he moves east. He’ll be too deep in to get out.”

“Are we just watching a tragedy play out?” Cathy asked.

“There’s always hope,” Venkat said. “Maybe he’ll figure it out faster than we think and turn around in time. Maybe the storm will dissipate unexpectedly. Maybe he’ll find a way to keep his life support going on less energy than we thought was possible. Mark Watney is now an expert at surviving on Mars. If anyone can do it, it’s him.”

“Twelve days,” Cathy said to the camera. “All of Earth is watching but powerless to help.”

LOG ENTRY: SOL 462

Another uneventful sol. Tomorrow is an Air Day, so this is kind of my Friday night.

I’m about halfway through Mawrth Vallis now. Just as I’d hoped, the going has been easy. No major elevation changes. Hardly any obstacles. Just smooth sand with rocks smaller than half a meter.

You may be wondering how I navigate. When I went to *Pathfinder*, I watched Phobos transit the sky to figure out the east-west axis. But *Pathfinder* was an easy trip compared to this, and I had plenty of landmarks to navigate by.

I can’t get away with that this time. My “map” (such as it is) consists of satellite images far too low-resolution to be of any use. I can only see major landmarks, like craters 50 kilometers across. They just never expected me to be out this far. The

only reason I had high-res images of the *Pathfinder* region is because they were included for landing purposes; in case Martinez had to land way long of our target.

So this time around, I needed a reliable way to fix my position on Mars.

Latitude and longitude. That's the key. The first is easy. Ancient sailors on Earth figured that one out right away. Earth's 23.5-degree axis points at Polaris. Mars has a tilt of just over 25 degrees, so it's pointed at Deneb.

Making a sextant isn't hard. All you need is a tube to look through, a string, a weight, and something with degree markings. I made mine in under an hour.

So I go out every night with a homemade sextant and sight Deneb. It's kind of silly if you think about it. I'm in my space suit on Mars and I'm navigating with sixteenth-century tools. But hey, they work.

Longitude is a different matter. On Earth, the earliest way to work out longitude required them to know the exact time, then compare it to the sun's position in the sky. The hard part for them back then was inventing a clock that would work on a boat (pendulums don't work on boats). All the top scientific minds of the age worked on the problem.

Fortunately, I have accurate clocks. There are four computers in my immediate line of sight right now. And I have Phobos.

Because Phobos is ridiculously close to Mars, it orbits the planet in less than one Martian day. It travels west to east (unlike the sun and Deimos) and sets every eleven hours. And naturally, it moves in a very predictable pattern.

I spend thirteen hours every sol just sitting around while the solar panels charge the batteries. Phobos is guaranteed to set at least once during that time. I note the time when it does. Then I plug it into a nasty formula I worked out and I know my longitude.

So working out longitude requires Phobos to set, and working out latitude requires it to be night so I can sight Deneb. It's not a very fast system. But I only need it once a day. I work out my location when I'm parked, and account for it in the next day's travel. It's kind of a successive approximation thing. So far, I think it's been working. But who knows? I can see it now: me holding a map, scratching my head, trying to figure out how I ended up on Venus.

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MINDY PARK zoomed in on the latest satellite photo with practiced ease. Watney's encampment was visible in the center, the solar cells laid out in a circular pattern as was his habit.

The workshop was inflated. Checking the time stamp on the image, she saw it was from noon local time. She quickly found the status report; Watney always placed it close to the rover when rocks were in abundance, usually to the north.

To save time, Mindy had taught herself Morse code, so she wouldn't have to look each letter up every morning. She opened an e-mail and addressed it to the ever-growing list of people who wanted Watney's daily status message.

"ON TRACK FOR SOL 494 ARRIVAL."

She frowned and added "Note: five sols until dust storm entry."

LOG ENTRY: SOL 466

Mawrth Vallis was fun while it lasted. I'm in Arabia Terra now.

I just entered the edge of it, if my latitude and longitude calculations are correct. But even without the math, it's pretty obvious the terrain is changing.

For the last two sols, I've spent almost all my time on an incline, working my way up the back wall of Mawrth Vallis. It

was a gentle rise, but a constant one. I'm at a much higher altitude now. Acidalia Planitia (where the lonely Hab is hanging out) is 3000 meters below elevation zero, and Arabia Terra is 500 meters below. So I've gone up two and a half kilometers.

Want to know what elevation zero means? On Earth, it's sea level. Obviously, that won't work on Mars. So lab-coated geeks got together and decided Mars's elevation zero is wherever the air pressure is 610.5 pascals. That's about 500 meters up from where I am right now.

Now things get tricky. Back in Acidalia Planitia, if I got off course, I could just point in the right direction based on new data. Later, in Mawrth Vallis, it was impossible to screw up. I just had to follow the canyon.

Now I'm in a rougher neighborhood. The kind of neighborhood where you keep your rover doors locked and never come to a complete stop at intersections. Well, not really, but it's bad to get off course here.

Arabia Terra has large, brutal craters that I have to drive around. If I navigate poorly, I'll end up at the edge of one. I can't just drive down one side and up the other. Rising in elevation costs a ton of energy. On flat ground, I can make 90 kilometers per day. On a steep slope, I'd be lucky to get 40 kilometers. Plus, driving on a slope is dangerous. One mistake and I could roll the rover. I don't even want to think about that.

Yes, I'll eventually have to drive down into Schiaparelli. No way around that. I'll have to be really careful.

Anyway, if I end up at the edge of a crater, I'll have to backtrack to somewhere useful. And it's a damn maze of craters out here. I'll have to be on my guard, observant at all times. I'll need to navigate with landmarks as well as latitude and longitude.

My first challenge is to pass between the craters Rutherford and Trouvelot. It shouldn't be too hard. They're 100 kilometers apart. Even I can't fuck that up, right?

Right?

LOG ENTRY: SOL 468

I managed to thread the needle between Rutherford and Trouvelot nicely. Admittedly, the needle was 100 kilometers wide, but hey.

I'm now enjoying my fourth Air Day of the trip. I've been on the road for twenty sols. So far, I'm right on schedule. According to my maps, I've traveled 1440 kilometers. Not quite halfway there, but almost.

I've been gathering soil and rock samples from each place I camp. I did the same thing on my way to *Pathfinder*. But this time, I know NASA's watching me. So I'm labeling each sample by the current sol. They'll know my location a hell of a lot more accurately than I do. They can correlate the samples with their locations later.

It might be a wasted effort. The MAV isn't going to have much weight allowance when I launch. To intercept *Hermes*, it'll have to reach escape velocity, but it was only designed to get to orbit. The only way to get it going fast enough is to lose a lot of weight.

At least that jury-rigging will be NASA's job to work out, not mine. Once I get to the MAV, I'll be back in contact with them and they can tell me what modifications to make.

They'll probably say, "Thanks for gathering samples. But leave them behind. And one of your arms, too. Whichever one you like least." But on the off chance I can bring the samples, I'm gathering them.

The next few days' travel should be easy. The next major obstacle is Marth Crater. It's right in my straight-line path toward Schiaparelli. It'll cost me a hundred kilometers or so to go around, but it can't be helped. I'll try to aim for the southern edge. The closer I get to the rim the less time I'll waste going around it.

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“DID YOU read today’s updates?” Lewis asked, pulling her meal from the microwave.

“Yeah,” Martinez said, sipping his drink.

She sat across the Rec table from him and carefully opened the steaming package. She decided to let it cool a bit before eating. “Mark entered the dust storm yesterday.”

“Yeah, I saw that,” he said.

“We need to face the possibility that he won’t make it to Schiaparelli,” Lewis said. “If that happens, we need to keep morale up. We still have a long way to go before we get home.”

“He was dead before,” Martinez said. “It was rough on morale, but we soldiered on. Besides, he won’t die.”

“It’s pretty bleak, Rick,” Lewis said. “He’s already fifty kilometers into the storm, and he’ll go another ninety kilometers per sol. He’ll get in too deep to recover soon.”

Martinez shook his head. “He’ll pull through, Commander. Have faith.”

She smiled forlornly. “Rick, you know I’m not religious.”

“I know,” he said. “I’m not talking about faith in God, I’m talking about faith in Mark Watney. Look at all the shit Mars has thrown at him, and he’s still alive. He’ll survive this. I don’t know how, but he will. He’s a clever son of a bitch.”

Lewis took a bite of her food. “I hope you’re right.”

“Want to bet a hundred bucks?” Martinez said with a smile.

“Of course not,” Lewis said.

“Damn right,” he smiled.

“I’d never bet on a crewmate dying,” Lewis said. “But that doesn’t mean I think he’ll—”

“Blah blah blah,” Martinez interrupted. “Deep down, you think he’ll make it.”

LOG ENTRY: SOL 473

My fifth Air Day, and things are going well. I should be skimming south of Marth Crater tomorrow. It'll get easier after that.

I'm in the middle of a bunch of craters that form a triangle. I'm calling it the Watney Triangle because after what I've been through, stuff on Mars should be named after me.

Trouvelot, Becquerel, and Marth form the points of the triangle, with five other major craters along the sides. Normally this wouldn't be a problem at all, but with my extremely rough navigation, I could easily end up at the lip of one of them and have to backtrack.

After Marth, I'll be out of the Watney Triangle (yeah, I'm liking that name more and more). Then I can beeline toward Schiaparelli with impunity. There'll still be plenty of craters in the way, but they're comparatively small, and going around them won't cost much time.

Progress has been great. Arabia Terra is certainly rockier than Acidalia Planitia, but nowhere near as bad as I'd feared. I've been able to drive over most of the rocks, and around the ones that are too big. I have 1435 kilometers left to go.

I did some research on Schiaparelli and found some good news. The best way in is right in my direct-line path. I won't have to drive the perimeter at all. And the way in is easy to find, even when you suck at navigating. The northwest rim has a smaller crater on it, and that's the landmark I'll be looking for. To the southwest of that little crater is a gentle slope into Schiaparelli Basin.

The little crater doesn't have a name. At least, not on the maps I have. So I dub it "Entrance Crater." Because I can.

In other news, my equipment is starting to show signs of age. Not surprising, considering it's way the hell past its expiration date. For the past two sols, the batteries have taken longer to recharge. The solar cells just aren't producing as

much wattage as before. It's not a big deal, I just need to charge a little longer.

LOG ENTRY: SOL 474

Well, I fucked it up.

It was bound to happen eventually. I navigated badly and ended up at the ridge of Marth Crater. Because it's 100 kilometers wide, I can't see the whole thing, so I don't know where on the circle I am.

The ridge runs perpendicular to the direction I was going. So I have no clue which way I should go. And I don't want to take the long way around if I can avoid it. Originally I wanted to go around to the south, but north is just as likely to be the best path now that I'm off course.

I'll have to wait for another Phobos transit to get my longitude, and I'll need to wait for nightfall to sight Deneb for my latitude. So I'm done driving for the day. Luckily I'd made 70 kilometers out of the 90 kilometers I usually do, so it's not too much wasted progress.

Marth isn't too steep. I could probably just drive down one side and up the other. It's big enough that I'd end up camping inside it one night. But I don't want to take unnecessary risks. Slopes are bad and should be avoided. I gave myself plenty of buffer time, so I'm going to play it safe.

I'm ending today's drive early and setting up for recharge. Probably a good idea anyway with the solar cells acting up; it'll give them more time to work. They underperformed again last night. I checked all the connections and made sure there wasn't any dust on them, but they still just aren't 100 percent.

LOG ENTRY: SOL 475

I'm in trouble.

I watched two Phobos transits yesterday and sighted Deneb last night. I worked out my location as accurately as I could,

and it wasn't what I wanted to see. As far as I can tell, I hit Marth Crater dead-on.

Craaaaap.

I can go north or south. One of them will probably be better than the other, because it'll be a shorter path around the crater.

I figured I should put at least a little effort into figuring out which direction was best, so I took a little walk this morning. It was over a kilometer to the peak of the rim. That's the sort of walk people do on Earth without thinking twice, but in an EVA suit it's an ordeal.

I can't wait till I have grandchildren. "When I was younger, I had to walk to the rim of a crater. Uphill! In an EVA suit! On Mars, ya little shit! Ya hear me? Mars!"

Anyway, I got up to the rim, and damn, it's a beautiful sight. From my high vantage point, I got a stunning panorama. I figured I might be able to see the far side of Marth Crater, and maybe work out the best way around.

But I couldn't see the far side. There was a haze in the air. It's not uncommon; Mars has weather and wind and dust, after all. But it seemed hazier than it should. I'm accustomed to the wide-open expanses of Acidalia Planitia, my former prairie home.

Then it got weirder. I turned around and looked back toward the rover and trailer. Everything was where I'd left it (very few car thieves on Mars). But the view seemed a lot clearer.

I looked east across Marth again. Then west to the horizon. Then east, then west. Each turn required me to rotate my whole body, EVA suits being what they are.

Yesterday, I passed a crater. It's about 50 kilometers west of here. It's just visible on the horizon. But looking east, I can't see anywhere near that far. Marth Crater is 110 kilometers wide. With a visibility of 50 kilometers, I should at least be able to see a distinct curvature of the rim. But I can't.

At first, I didn't know what to make of it. But the lack of symmetry bothered me. And I've learned to be suspicious of everything. That's when a bunch of stuff started to dawn on me:

1. The only explanation for asymmetrical visibility is a dust storm.
2. Dust storms reduce the effectiveness of solar cells.
3. My solar cells have been slowly losing effectiveness for several sols.

From this, I concluded the following:

1. I've been in a dust storm for several sols.
2. Shit.

Not only am I in a dust storm, but it gets thicker as I approach Schiaparelli. A few hours ago, I was worried because I had to go around Marth Crater. Now I'm going to have to go around something a lot bigger.

And I have to hustle. Dust storms move. Sitting still means I'll likely get overwhelmed. But which way do I go? It's no longer an issue of trying to be efficient. If I go the wrong way this time, I'll eat dust and die.

I don't have satellite imagery. I have no way of knowing the size or shape of the storm, or its heading. Man, I'd give anything for a five-minute conversation with NASA. Now that I think of it, NASA must be shitting bricks watching this play out.

I'm on the clock. I have to figure out *how* to figure out what I need to know about the storm. And I have to do it now.

And right this second nothing comes to mind.

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MINDY TRUDGED to her computer. Today's shift began at 2:10 p.m. Her schedule matched Watney's every day. She slept when he slept. Watney simply slept at night on Mars, while

Mindy had to drift forty minutes forward every day, taping aluminum foil to her windows to get any sleep at all.

She brought up the most recent satellite images. She cocked an eyebrow. He had not broken camp yet. Usually he drove in the early morning, as soon as it was light enough to navigate. Then he capitalized on the midday sun to maximize recharging.

But today, he had not moved, and it was well past morning.

She checked around the rovers and the bedroom for a message. She found it in the usual place (north of the campsite). As she read the Morse code, her eyes widened.

“DUST STORM. MAKING PLAN.”

Fumbling with her cell phone, she dialed Venkat’s personal number.