CHAPTER 21

LOG ENTRY: SOL 431

I'm working out how to pack. It's harder than it sounds.

I have two pressure vessels: the rover and the trailer. They're connected by hoses, but they're also not stupid. If one loses pressure, the other will instantly seal off the shared lines.

There's a grim logic to this: If the rover breaches, I'm dead. No point in planning around that. But if the trailer breaches, I'll be fine. That means I should put everything important in the rover.

Everything that goes in the trailer has to be comfortable in near-vacuum and freezing temperatures. Not that I anticipate that, but you know. Plan for the worst.

The saddlebags I made for the *Pathfinder* trip will come in handy for food storage. I can't just store potatoes in the rover or trailer. They'd rot in the warm, pressurized environment. I'll keep some in the rover for easy access, but the rest will be outside in the giant freezer that is this planet. The trailer will be packed pretty tight. It'll have two bulky Hab batteries, the atmospheric regulator, the oxygenator, and my homemade heat reservoir. It would be more convenient to have the reservoir in the rover, but it has to be near the regulator's return air feed.

The rover will be pretty packed, too. When I'm driving, I'll keep the bedroom folded up near the airlock, ready for emergency egress. Also, I'll have the two functional EVA suits in there with me and anything that might be needed for emergency repairs: tool kits, spare parts, my nearly depleted supply of sealant, the other rover's main computer (just in case!), and all 620 glorious liters of water.

And a plastic box to serve as a toilet. One with a good lid.

•••

“HOW’S WATNEY doing?” Venkat asked.

Mindy looked up from her computer with a start. “Dr. Kapoor?”

“I hear you caught a pic of him during an EVA?”

“Uh, yeah,” Mindy said, typing on her keyboard. “I noticed things would always change around 9 a.m. local time. People usually keep the same patterns, so I figured he likes to start work around then. I did some minor realignment to get seventeen pics between 9 and 9:10. He showed up in one of them.”

“Good thinking. Can I see the pic?”

“Sure.” She brought up the image on her screen.

Venkat peered at the blurry image. “Is this as good as it gets?”

“Well, it is a photo taken from orbit,” Mindy said. “The NSA enhanced the image with the best software they have.”

“Wait, what?” Venkat stammered. “The NSA?”

“Yeah, they called and offered to help out. Same software they use for enhancing spy satellite imagery.”

Venkat shrugged. “It’s amazing how much red tape gets cut when everyone’s rooting for one man to survive.” He pointed to the screen. “What’s Watney doing here?”

“I think he’s loading something into the rover.”

“When was the last time he worked on the trailer?” Venkat asked.

“Not for a while. Why doesn’t he write us notes more often?”

Venkat shrugged. “He’s busy. He works most of the daylight hours, and arranging rocks to spell a message takes time and energy.”

“So…,” Mindy said. “Why’d you come here in person? We could have done all this over e-mail.”

“Actually, I came to talk to you,” he said. “There’s going to be a change in your responsibilities. From now on, instead of managing the satellites around Mars, your sole responsibility is watching Mark Watney.”

“What?” Mindy said. “What about course corrections and alignment?”

“We’ll assign that to other people,” Venkat said. “From now on, your only focus is examining imagery of Ares 3.”

“That’s a demotion,” Mindy said. “I’m an orbital engineer, and you’re turning me into a glorified Peeping Tom.”

“It’s short-term,” Venkat said. “And we’ll make it up to you. Thing is, you’ve been doing it for months, and you’re an expert at identifying elements of Ares 3 from satellite pics. We don’t have anyone else who can do that.”

“Why is this suddenly so important?”

“He’s running out of time,” Venkat said. “We don’t know how far along he is on the rover modifications. But we do know he’s only got sixteen sols to get them done. We need to know exactly what he’s doing. I’ve got media outlets and senators asking for his status all the time. The President even called me a couple of times.”

“But seeing his status doesn’t help,” Mindy said. “It’s not like we can do anything about it if he falls behind. This is a pointless task.”

“How long have you worked for the government?” Venkat sighed.

LOG ENTRY: SOL 434

The time has come to test this baby out.

This presents a problem. Unlike on my *Pathfinder* trip, I have to take vital life support elements out of the Hab if I’m going to do a real dry run. When you take the atmospheric regulator and oxygenator out of the Hab, you’re left with…a tent. A big round tent that can’t support life.

It's not as risky as it seems. As always, the dangerous part about life support is managing carbon dioxide. When the air gets to 1 percent CO_2, you start getting symptoms of poisoning. So I need to keep the Hab's mix below that.

The Hab's internal volume is about 120,000 liters. Breathing normally, it would take me over two days to bring the CO_2 level up to 1 percent (and I wouldn't even put a dent in the O_2 level). So it's safe to move the regulator and oxygenator over for a while.

Both are way too big to fit through the trailer airlock. Lucky for me, they came to Mars with "some assembly required." They were too big to send whole, so they're easy to dismantle.

Over several trips, I moved all of their chunks to the trailer. I brought each chunk in through the airlock, one at a time. It was a pain in the ass reassembling them inside, let me tell you. There's barely enough room for all the shit the trailer's got to hold. There wasn't much left for our intrepid hero.

Then I got the AREC. It sat outside the Hab like an AC unit might on Earth. In a way, that's what it is. I hauled it over to the trailer and lashed it to the shelf I'd made for it. Then I hooked it up to the feed lines that led through the "balloon" to the inside of the trailer's pressure vessel.

The regulator needs to send air to the AREC, then the return air needs to bubble through the heat reservoir. The regulator also needs a pressure tank to contain the CO_2 it pulls from the air.

When gutting the trailer to make room, I left one tank in place for this. It's supposed to hold oxygen, but a tank's a tank. Thank God all the air lines and valves are standardized across the mission. That's no mistake. It was a deliberate decision to make field repairs easier.

Once I had the AREC in place, I hooked the oxygenator and regulator into the trailer's power and watched them power up. I ran both through full diagnostics to confirm they were

working correctly. Then I shut down the oxygenator. Remember, I'll only use it one sol out of every five.

I moved to the rover, which meant I had to do an annoying ten-meter EVA. From there, I monitored the life support situation. It's worth noting that I can't monitor the actual support equipment from the rover (it's all in the trailer), but the rover can tell me all about the air. Oxygen, CO_2, temperature, humidity, etc. Everything seemed okay.

After getting back into the EVA suit, I released a canister of CO_2 into the rover's air. I watched the rover computer have a shit fit when it saw the CO_2 spike to lethal levels. Then, over time, the levels dropped to normal. The regulator was doing its job. Good boy!

I left the equipment running when I returned to the Hab. It'll be on its own all night and I'll check it in the morning. It's not a true test, because I'm not there to breathe up the oxygen and make CO_2, but one step at a time.

LOG ENTRY: SOL 435

Last night was weird. I knew *logically* that nothing bad would happen in just one night, but it was a little unnerving to know I had no life support other than heaters. My life depended on some math I'd done earlier. If I dropped a sign or added two numbers wrong, I might never wake up.

But I did wake up, and the main computer showed the slight rise in CO_2 I had predicted. Looks like I'll live another sol.

Live Another Sol would be an awesome name for a James Bond movie.

I checked up on the rover. Everything was fine. If I don't drive it, a single charge of the batteries could keep the regulator going for over a month (with the heater off). It's a pretty good safety margin to have. If all hell breaks loose on my trip, I'll have time to fix things. I'll be limited by oxygen

consumption rather than CO_2 removal, and I have plenty of oxygen.

I decided it was a good time to test the bedroom.

I got in the rover and attached the bedroom to the outer airlock door from the inside. Like I mentioned before, this is the only way to do it. Then I turned it loose on an unsuspecting Mars.

As intended, the pressure from the rover blasted the canvas outward and inflated it. After that, chaos. The sudden pressure popped the bedroom like a balloon. It quickly deflated, leaving both itself and the rover devoid of air. I was wearing my EVA suit at the time; I'm not a fucking idiot. So I get to…

Live Another Sol! (Starring Mark Watney as…probably Q. I'm no James Bond.)

I dragged the popped bedroom into the Hab and gave it a good going-over. It failed at the seam where the wall met the ceiling. Makes sense. It's a right angle in a pressure vessel. Physics hates that sort of thing.

First, I patched it up, then I cut strips of spare canvas to place over the seam. Now it has double-thickness and double sealing resin all around. Maybe that'll be enough. At this point, I'm kind of guessing. My amazing botany skills aren't much use for this.

I'll test it again tomorrow.

LOG ENTRY: SOL 436

I'm out of caffeine pills. No more Martian coffee for me.

So it took a little longer for me to wake up this morning, and I quickly developed a splitting headache. One nice thing about living in a multibillion-dollar mansion on Mars: access to pure oxygen. For some reason, a high concentration of O_2 will kill most headaches. Don't know why. Don't care. The important thing is I don't have to suffer.

I tested out the bedroom again. I suited up in the rover and released the bedroom, same as last time. But this time it held. That's great, but having seen the fragile nature of my handiwork, I wanted a good long test of the pressure seal.

After a few minutes standing around in my EVA suit, I decided to make better use of my time. I may not be able to leave the rover/bedroom universe while the bedroom is attached to the airlock, but I can stay in the rover and close the door.

Once I did that, I took off the uncomfortable EVA suit. The bedroom was on the other side of the airlock door, still fully pressurized. So I'm still running my test, but I don't have to wear the EVA suit.

I arbitrarily picked eight hours for the test duration, so I was trapped in the rover until then.

I spent my time planning the trip. There wasn't much to add to what I already knew. I'll beeline out of Acidalia Planitia to Mawrth Vallis, then follow the valley until it ends. It'll take me on a zigzag route which will dump me in to Arabia Terra. After that, things get rough.

Unlike Acidalia Planitia, Arabia Terra is riddled with craters. And each crater represents two brutal elevation changes. First down, then up. I did my best to find the shortest path around them. I'm sure I'll have to adjust the course when I'm actually driving it. No plan survives first contact with the enemy.

•••

MITCH TOOK his seat in the conference room. The usual gang was present: Teddy, Venkat, Mitch, and Annie. But this time there was also Mindy Park, as well as a man Mitch had never seen before.

"What's up, Venk?" Mitch asked. "Why the sudden meeting?"

“We’ve got some developments,” Venkat said. “Mindy, why don’t you bring them up to date?”

“Uh, yeah,” Mindy said. “Looks like Watney finished the balloon addition to the trailer. It mostly uses the design we sent him.”

“Any idea how stable it is?” Teddy asked.

“Pretty stable,” she said. “It’s been inflated for several days with no problems. Also, he built some kind of…room.”

“Room?” Teddy asked.

“It’s made of Hab canvas, I think,” Mindy explained. “It attaches to the rover’s airlock. I think he cut a section out of the Hab to make it. I don’t know what it’s for.”

Teddy turned to Venkat. “Why would he do that?”

“We think it’s a workshop,” Venkat said. “There’ll be a lot of work to do on the MAV once he gets to Schiaparelli. It’ll be easier without an EVA suit. He probably plans to do as much as he can in that room.”

“Clever,” Teddy said.

“Watney’s a clever guy,” Mitch said. “How about getting life support in there?”

“I think he’s done it,” Mindy said. “He moved the AREC.”

“Sorry,” Annie interrupted. “What’s an AREC?”

“It’s the external component of the atmospheric regulator,” Mindy said. “It sits outside the Hab, so I saw when it disappeared. He probably mounted it on the rover. There’s no other reason to move it, so I’m guessing he’s got life support online.”

“Awesome,” Mitch said. “Things are coming together.”

“Don’t celebrate yet, Mitch,” Venkat said. He gestured to the newcomer. “This is Randall Carter, one of our Martian meteorologists. Randall, tell them what you told me.”

Randall nodded. “Thank you, Dr. Kapoor.” He turned his laptop around to show a map of Mars. “Over the past few weeks, a dust storm has been developing in Arabia Terra. Not a big deal in terms of magnitude. It won’t hinder his driving at all.”

“So what’s the problem?” Annie asked.

“It’s a low-velocity dust storm,” Randall explained. “Slow winds, but fast enough to pick up very small particles on the surface and whip them into thick clouds. There are five or six of them every year. The thing is, they last for months, they cover huge sections of the planet, and they make the atmosphere thick with dust.”

“I still don’t see the problem,” Annie said.

“Light,” Randall said. “The total sunlight reaching the surface is very low in the area of the storm. Right now, it’s twenty percent of normal. And Watney’s rover is powered by solar panels.”

“Shit,” Mitch said, rubbing his eyes. “And we can’t warn him.”

“So he gets less power,” Annie said. “Can’t he just recharge longer?”

“The current plan already has him recharging all day long,” Venkat explained. “With twenty percent of normal daylight, it’ll take five times as long to get the same energy. It’ll turn his forty five-sol trip into two hundred and twenty-five sols. He’ll miss the *Hermes* flyby.”

“Can’t *Hermes* wait for him?” Annie asked.

“It’s a flyby,” Venkat said. “*Hermes* isn’t going into Martian orbit. If they did, they wouldn’t be able to get back. They need their velocity for the return trajectory.”

After a few moments of silence, Teddy said, “We’ll just have to hope he finds a way through. We can track his progress and—”

“No, we can’t,” Mindy interrupted.

“We can’t?” Teddy said.

She shook her head. “The satellites won’t be able to see through the dust. Once he enters the affected area, we won’t see anything until he comes out the other side.”

“Well…,” Teddy said. “Shit.”

LOG ENTRY: SOL 439

Before I risk my life with this contraption, I need to test it.

And not the little tests I’ve been doing so far. Sure, I’ve tested power generation, life support, the trailer bubble, and the bedroom. But I need to test all aspects of it working together.

I’m going to load it up for the long trip and drive in circles. I won’t ever be more than 500 meters from the Hab, so I’ll be fine if shit breaks.

I dedicated today to loading up the rover and trailer for the test. I want the weight to match what it’ll be on the real trip. Plus if cargo is going to shift around or break things, I want to know about it now.

I made one concession to common sense: I left most of my water supply in the Hab. I loaded twenty liters; enough for the test but no more. There are a lot of ways I could lose pressure in this mechanical abomination I’ve created, and I don’t want all my water to boil off if that happens.

On the real trip, I’m going to have 620 liters of water. I made up the weight difference by loading 600 kilograms of rocks in with my other supplies.

Back on Earth, universities and governments are willing to pay millions to get their hands on Mars rocks. I’m using them as ballast.

I’m doing one more little test tonight. I made sure the batteries were good and full, then disconnected the rover and trailer from Hab power. I’ll be sleeping in the Hab, but I left the rover’s life support on. It’ll maintain the air overnight, and

tomorrow I'll see how much power it ate up. I've watched the power consumption while it's attached to the Hab, and there weren't any surprises. But this'll be the true proof. I call it the "plugs-out test."

Maybe that's not the best name.

•••

THE CREW of *Hermes* gathered in the Rec.

"Let's get through status quickly," Lewis said. "We're all behind in our science assignments. Vogel, you first."

"I repaired the bad cable on VASIMR 4," Vogel reported. "It was our last thick-gauge cable. If another such problem occurs, we will have to braid lower-gauge lines to carry the current. Also, the power output from the reactor is declining."

"Johanssen," Lewis said, "what's the deal with the reactor?"

"I had to dial it back," Johanssen said. "It's the cooling vanes. They aren't radiating heat as well as they used to. They're tarnishing."

"How can that happen?" Lewis asked. "They're outside the craft. There's nothing for them to react with."

"I think they picked up dust or small air leaks from *Hermes* itself. One way or another, they're definitely tarnishing. The tarnish is clogging the micro-lattice, and that reduces the surface area. Less surface area means less heat dissipation. So I limited the reactor enough that we weren't getting positive heat."

"Any chance of repairing the cooling vanes?"

"It's on the microscopic scale," Johanssen said. "We'd need a lab. Usually they replace the vanes after each mission."

"Will we be able to maintain engine power for the rest of the mission?"

"Yes, if the rate of tarnishing doesn't increase."

"All right, keep an eye on it. Beck, how's life support?"

“Limping,” Beck said. “We’ve been in space way longer than it was designed to handle. There are a bunch of filters that would normally be replaced each mission. I found a way to clean them with a chemical bath I made in the lab, but it eats away at the filters themselves. We’re okay right now, but who knows what’ll break next?”

“We knew this would happen,” Lewis said. “The design of *Hermes* assumed it would get an overhaul after each mission, but we’ve extended Ares 3 from 396 days to 898. Things are going to break. We’ve got all of NASA to help when that happens. We just need to stay on top of maintenance. Martinez, what’s the deal with your bunk room?”

Martinez furrowed his brow. “It’s still trying to cook me. The climate control just isn’t keeping up. I think it’s the tubing in the walls that brings the coolant. I can’t get at it because it’s built into the hull. We can use the room for storage of non-temperature-sensitive cargo, but that’s about it.”

“So did you move into Mark’s room?”

“It’s right next to mine,” he said. “It has the same problem.”

“Where have you been sleeping?”

“In Airlock 2. It’s the only place I can be without people tripping over me.”

“No good,” Lewis said, shaking her head. “If one seal breaks, you die.”

“I can’t think of anywhere else to sleep,” he said. “The ship is pretty cramped, and if I sleep in a hallway I’ll be in people’s way.”

“Okay, from now on, sleep in Beck’s room. Beck can sleep with Johanssen.”

Johanssen blushed and looked down awkwardly.

“So…,” Beck said, “you know about that?”

“You thought I didn’t?” Lewis said. “It’s a small ship.”

“You’re not mad?”

“If it were a normal mission, I would be,” Lewis said. “But we’re way off-script now. Just keep it from interfering with your duties, and I’m happy.”

“Million-mile-high club,” Martinez said. “Nice!”

Johanssen blushed deeper and buried her face in her hands.

LOG ENTRY: SOL 444

I’m getting pretty good at this. Maybe when all this is over I could be a product tester for Mars rovers.

Things went well. I spent five sols driving in circles; I averaged 93 kilometers per sol. That’s a little better than I’d expected. The terrain here is flat and smooth, so it’s pretty much a best-case scenario. Once I’m going up hills and around boulders, it won’t be nearly that good.

The bedroom is awesome. Large, spacious, and comfortable. On the first night, I ran into a little problem with the temperature. It was fucking cold. The rover and trailer regulate their own temperatures just fine, but things weren’t hot enough in the bedroom.

Story of my life.

The rover has an electric heater that pushes air with a small fan. I don’t use the heater itself for anything because the RTG provides all the heat I need, so I liberated the fan and wired it into a power line near the airlock. Once it had power, all I had to do was point it at the bedroom.

It’s a low-tech solution, but it worked. There’s plenty of heat, thanks to the RTG. I just needed to get it evenly spread out. For once, entropy was on my side.

I’ve discovered that raw potatoes are disgusting. When I’m in the Hab, I cook my taters using a small microwave. I don’t have anything like that in the rover. I could easily bring the Hab’s microwave into the rover and wire it in, but the energy required to cook ten potatoes a day would actually cut into my driving distance.

I fell into a routine pretty quickly. In fact, it was hauntingly familiar. I did it for twenty-two miserable sols on the *Pathfinder* trip. But this time, I had the bedroom and that makes all the difference. Instead of being cooped up in the rover, I have my own little Hab.

After waking up, I have a potato for breakfast. Then, I deflate the bedroom from the inside. It's kind of tricky, but I worked out how.

First, I put on an EVA suit. Then I close the inner airlock door, leaving the outer door (which the bedroom is attached to) open. This isolates the bedroom, with me in it, from the rest of the rover. Then I tell the airlock to depressurize. It thinks it's just pumping the air out of a small area, but it's actually deflating the whole bedroom.

Once the pressure is gone, I pull the canvas in and fold it. Then I detach it from the outer hatch and close the outer door. This is the most cramped part. I have to share the airlock with the entire folded-up bedroom while it repressurizes. Once I have pressure again, I open the inner door and more or less fall into the rover. Then I stow the bedroom and go back to the airlock for a normal egress to Mars.

It's a complicated process, but it detaches the bedroom without having to depressurize the rover cabin. Remember, the rover has all my stuff that doesn't play well with vacuum.

The next step is to gather up the solar cells I laid out the day before and stow them on the rover and trailer. Then I do a quick check on the trailer. I go in through its airlock and basically take a quick look at all the equipment. I don't even take off my EVA suit. I just want to make sure nothing's obviously wrong.

Then, back to the rover. Once inside, I take off the EVA suit and start driving. I drive for almost four hours, and then I'm out of power.

Once I park, it's back into the EVA suit for me, and out to Mars again. I lay the solar panels out and get the batteries

charging.

Then I set up the bedroom. Pretty much the reverse of the sequence I use to stow it. Ultimately, it's the airlock that inflates it. In a way, the bedroom is just an extension of the airlock.

Even though it's possible, I don't rapid-inflate the bedroom. I did that to test it because I wanted to find where it'll leak. But it's not a good idea. Rapid inflation puts a lot of shock and pressure on it. It would eventually rupture. I didn't enjoy that time the Hab launched me like a cannonball. I'm not eager to repeat it.

Once the bedroom is set up again, I can take off my EVA suit and relax. I mostly watch crappy seventies TV. I'm indistinguishable from an unemployed guy for most of the day.

I followed that process for four sols, and then it was time for an "Air Day."

An Air Day turns out to be pretty much the same as any other day, but without the four-hour drive. Once I set up the solar panels, I fired up the oxygenator and let it work through the backlog of CO_2 that the regulator had stored up.

It converted all the CO_2 to oxygen and used up the day's power generation to do it.

The test was a success. I'll be ready on time.

LOG ENTRY: SOL 449

Today's the big day. I'm leaving for Schiaparelli.

The rover and trailer are all packed. They've been mostly packed since the test run. But now I even have the water aboard.

Over the last few days, I cooked all the potatoes with the Hab's microwave. It took quite a while, because the microwave can only hold four at a time. After cooking, I put them back out on the surface to freeze. Once frozen, I put them back in the rover's saddlebags. This may seem like a

waste of time, but it's critical. Instead of eating raw potatoes during my trip, I'll be eating (cold) precooked potatoes. First off, they'll taste a lot better. But more important, they'll be cooked. When you cook food, the proteins break down, and the food becomes easier to digest. I'll get more calories out of it, and I need every calorie I can get my hands on.

I spent the last several days running full diagnostics on everything. The regulator, oxygenator, RTG, AREC, batteries, rover life support (in case I need a backup), solar cells, rover computer, airlocks, and everything else with a moving part or electronic component. I even checked each of the motors. Eight in all, one for each wheel, four on the rover, four on the trailer. The trailer's motors won't be powered, but it's nice to have backups.

It's all good to go. No problems that I can see.

The Hab is a shell of its former self. I've robbed it of all critical components and a big chunk of its canvas. I've looted that poor Hab for everything it could give me, and in return it's kept me alive for a year and a half. It's like the Giving Tree.

I performed the final shutdown today. The heaters, lighting, main computer, etc. All the components I didn't steal for the trip to Schiaparelli.

I could have left them on. It's not like anyone would care. But the original procedure for Sol 31 (which was supposed to be the last day of the surface mission) was to completely shut down the Hab and deflate it, because NASA didn't want a big tent full of combustible oxygen next to the MAV when it launched.

I guess I did the shutdown as an homage to the mission Ares 3 could have been. A small piece of the Sol 31 I never got to have.

Once I'd shut everything down, the interior of the Hab was eerily silent. I'd spent 449 sols listening to its heaters, vents, and fans. But now it was dead quiet. It was a creepy kind of quiet that's hard to describe. I've been away from the noises of

the Hab before, but always in a rover or an EVA suit, both of which have noisy machinery of their own.

But now there was nothing. I never realized how utterly silent Mars is. It's a desert world with practically no atmosphere to convey sound. I could hear my own heartbeat.

Anyway, enough waxing philosophical.

I'm in the rover right now. (That should be obvious, with the Hab main computer offline forever.) I've got two full batteries, all systems are go, and I've got forty-five sols of driving ahead of me.

Schiaparelli or bust!