CHAPTER 7

LOG ENTRY: SOL 63

I finished making water some time ago. I'm no longer in danger of blowing myself up. The potatoes are growing nicely. Nothing has conspired to kill me in weeks. And seventies TV keeps me disturbingly more entertained than it should. Things are stable here on Mars.

It's time to start thinking long-term.

Even if I find a way to tell NASA I'm alive, there's no guarantee they'll be able to save me. I need to be proactive. I need to figure out how to get to Ares 4.

Won't be easy.

Ares 4 will be landing at the Schiaparelli crater, 3200 kilometers away. In fact, their MAV is already there. I know because I watched Martinez land it.

It takes eighteen months for the MAV to make its fuel, so it's the first thing NASA sends along. Sending it forty-eight months early gives it plenty of extra time in case fuel reactions go slower than expected. But much more importantly, it means a precision soft landing can be done remotely by a pilot in orbit. Direct remote operation from Houston isn't an option; they're anywhere from four to twenty light-minutes away.

Ares 4's MAV spent eleven months getting to Mars. It left before us and got here around the same time we did. As expected, Martinez landed it beautifully. It was one of the last things we did before piling into our MDV and heading to the surface. Ahh, the good old days, when I had a crew with me.

I'm lucky. Thirty-two hundred km isn't that bad. It could have been up to 10,000 km away. And because I'm on the flattest part of Mars, the first 650 kilometers is nice, smooth terrain (Yay Acidalia Planitia!) but the rest of it is nasty, rugged, crater-pocked hell.

Obviously, I'll have to use a rover. And guess what? They weren't designed for massive overland journeys.

This is going to be a research effort, with a bunch of experimentation. I'll have to become my own little NASA, figuring out how to explore far from the Hab. The good news is I have lots of time to figure it out. Almost four years.

Some stuff is obvious. I'll need to use a rover. It'll take a long time, so I'll need to bring supplies. I'll need to recharge en route, and rovers don't have solar cells, so I'll need to steal some from the Hab's solar farm. During the trip I'll need to breathe, eat, and drink.

Lucky for me, the tech specs for everything are right here in the computer.

I'll need to trick out a rover. Basically it'll have to be a mobile Hab. I'll pick Rover 2 as my target. We have a certain bond, after I spent two days in it during the Great Hydrogen Scare of Sol 37.

There's too much shit to think about all at once. So for now, I'll just think about power.

Our mission had a 10-kilometer operational radius. Knowing we wouldn't take straight-line paths, NASA designed the rovers to go 35 kilometers on a full charge. That presumes flat, reasonable terrain. Each rover has a 9000-watt-hour battery.

Step one is to loot Rover 1's battery and install it in Rover 2. Ta-daa! I just doubled my full-charge range.

There's just one complication. Heating.

Part of the battery power goes to heating the rover. Mars is really cold. Normally, we were expected to do all EVAs in under five hours. But I'll be living in it twenty-four and a half hours a day. According to the specs, the heating equipment soaks up 400 watts. Keeping it on would eat up 9800 watt hours per day. Over half my power supply, every day!

But I do have a free source of heat: me. A couple million years of evolution gave me “warm-blooded” technology. I can just turn off the heater and wear layers. The rover has good insulation, too. It’ll have to be enough; I need every bit of power.

According to my boring math, moving the rover eats 200 watt hours of juice to go 1 kilometer, so using the full 18,000 watt hours for motion (minus a negligible amount for computer, life support, etc.) gets me 90 kilometers of travel. Now we’re talkin’.

I’ll never *actually* get 90 kilometers on a single charge. I’ll have hills to deal with, and rough terrain, sand, etc. But it’s a good ballpark. It tells me that it would take *at least* 35 days of travel to get to Ares 4. It’ll probably be more like 50. But that’s plausible, at least.

At the rover’s blazing 25 kph top speed, it’ll take me three and a half hours before I run the battery down. I can drive in twilight, and save the sunny part of the day for charging. This time of year I get about thirteen hours of light. How many solar cells will I have to pilfer from the Hab’s farm?

Thanks to the fine taxpayers of America, I have over 100 square meters of the most expensive solar paneling ever made. It has an astounding 10.2 percent efficiency, which is good because Mars doesn’t get as much sunlight as Earth. Only 500 to 700 watts per square meter (compared to the 1400 Earth gets).

Long story short: I need to bring twenty-eight square meters of solar cell. That’s fourteen panels.

I can put two stacks of seven on the roof. They’ll stick out over the edges, but as long as they’re secure, I’m happy. Every day, after driving, I’ll spread them out then…wait all day. Man it’ll be dull.

Well it’s a start. Tomorrow’s mission: transfer Rover 1’s battery to Rover 2.

Sometimes things are easy, and sometimes they're not. Getting the battery out of Rover 1 was easy. I removed two clamps on the undercarriage and it dropped right out. The cabling was easy to detach, too, just a couple of complicated plugs.

Attaching it to Rover 2, however, is another story. There's nowhere to put it!

The thing is *huge*. I was barely able to drag it. And that's in Mars gravity.

It's just too big. There's no room in the undercarriage for a second one. There's no room on the roof, either. That's where the solar cells will go. There's no room inside the cabin, and it wouldn't fit through the airlock anyway.

But fear not, I found a solution.

For emergencies completely unrelated to this one, NASA provided six square meters of extra Hab canvas and some really impressive resin. The same kind of resin, in fact, that saved my life on Sol 6 (the patch kit I used on the hole in my suit).

In the event of a Hab breach, everyone would run to the airlocks. Procedure was to let the Hab pop rather than die trying to prevent it. Then, we'd suit up and assess the damage. Once we found the breach, we'd seal it with the spare canvas and resin. Then reinflate and we're good as new.

The six square meters of spare canvas was a convenient one by six meters. I cut 10-centimeter-wide strips, then used them to make a sort of harness.

I used the resin and straps to make two 10-meter circumference loops. Then I put a big patch of canvas on each end. I now had poor man's saddlebags for my rover.

This is getting more and more *Wagon Train* every day.

The resin sets almost instantly. But it gets stronger if you wait an hour. So I did. Then I suited up and headed out to the rover.

I dragged the battery to the side of the rover and looped one end of the harness around it. Then I threw the other end over the roof. On the other side, I filled it with rocks. When the two weights were roughly equal, I was able to pull the rocks down and bring the battery up.

Yay!

I unplugged Rover 2's battery and plugged in Rover 1's. Then I went through the airlock to the rover and checked all systems. Everything was a-okay.

I drove the rover around a bit to make sure the harness was secure. I found a few largish rocks to drive over, just to shake things up. The harness held. Hell yeah.

For a short time, I wondered how to splice the second battery's leads into the main power supply. My conclusion was "Fuck it."

There's no need to have a continuous power supply. When Battery 1 runs out, I can get out, unplug Battery 1, and plug in Battery 2. Why not? It's a ten-minute EVA, once per day. I'd have to swap batteries again when I'm recharging them, but again, so what?

I spent the rest of the day sweeping off the solar cell farm. Soon, I shall be looting it.

LOG ENTRY: SOL 65

The solar cells were a lot easier to manage than the battery.

They're thin, light, and just lying around on the ground. And I had one additional bonus: I was the one who set them up in the first place.

Well, okay. It wasn't just me. Vogel and I worked together on it. And boy did we drill on it. We spent almost an entire *week* drilling on the solar array alone. Then we drilled more whenever they figured we had spare time. The array was mission-critical. If we broke the cells or rendered them

useless, the Hab wouldn't be able to make power, and the mission would end.

You might wonder what the rest of the crew was doing while we assembled the array. They were setting up the Hab. Remember, everything in my glorious kingdom came here in boxes. We had to set it up on Sols 1 and 2.

Each solar cell is on a lightweight lattice that holds it at a 14-degree angle. I'll admit I don't know why it's a 14-degree angle. Something about maximizing solar energy. Anyway, removing the cells was simple, and the Hab can spare them. With the reduced load of only supporting one human instead of six, a 14 percent energy production loss is irrelevant.

Then it was time to stack them on the rover.

I considered removing the rock sample container. It's nothing more than a large canvas bag attached to the roof. Way too small to hold the solar cells. But after some thought I left it there, figuring it would provide a good cushion.

The cells stacked well (they were made to, for transport to Mars), and the two stacks sat nicely on the roof. They hung over the left and right edges, but I won't be going through any tunnels, so I don't care.

With some more abuse of the emergency Hab material, I made straps and tied the cells down. The rover has external handles near the front and back. They're there to help us load rocks on the roof. They made perfect anchor points for the straps.

I stood back and admired my work. Hey, I earned it. It wasn't even noon and I was done.

I came back to the Hab, had some lunch, and worked on my crops for the rest of the sol. It's been thirty-nine sols since I planted the potatoes (which is about forty Earth days), and it was time to reap and resow.

They grew even better than I had expected. Mars has no insects, parasites, or blights to deal with, and the Hab

maintains perfect growing temperature and moisture at all times.

They were small compared to the taters you'd usually eat, but that's fine. All I wanted was enough to support growing new plants.

I dug them up, being careful to leave their plants alive. Then I cut them up into small pieces with one eye each and reseeded them into new dirt. If they keep growing this well, I'll be able to last a good long time here.

After all that physical labor, I deserved a break. I rifled through Johanssen's computer today and found an endless supply of digital books. Looks like she's a big fan of Agatha Christie. The Beatles, Christie…I guess she's an Anglophile or something.

I remember liking Hercule Poirot TV specials back when I was a kid. I'll start with *The Mysterious Affair at Styles*. Looks like that's the first one.

LOG ENTRY: SOL 66

The time has come (ominous musical crescendo) for some missions!

NASA gets to name their missions after gods and stuff, so why can't I? Henceforth, rover experimental missions will be "Sirius" missions. Get it? Dogs? Well if you don't, fuck you.

Sirius 1 will be tomorrow.

The mission: Start with fully charged batteries and solar cells on the roof, drive until I run out of power, and see how far I get.

I won't be an idiot. I'm not driving directly away from the Hab. I'll drive a half-kilometer stretch, back and forth. I'll be within a short walk of home at all times.

Tonight, I'll charge up both batteries so I can be ready for a little test drive tomorrow. I estimate three and a half hours of

driving, so I'll need to bring fresh CO_2 filters. And, with the heater off, I'll wear three layers of clothes.

LOG ENTRY: SOL 67

Sirius 1 is complete!

More accurately, Sirius 1 was aborted after one hour. I guess you could call it a "failure," but I prefer the term "learning experience."

Things started out fine. I drove to a nice flat spot a kilometer from the Hab, then started going back and forth over a 500-meter stretch.

I quickly realized this would be a crappy test. After a few laps, I had compressed the soil enough to have a solid path. Nice, hard ground, which makes for abnormally high energy efficiency. Nothing like it would be on a long trip.

So I shook it up a bit. I drove around randomly, making sure to stay within a kilometer of the Hab. A much more realistic test.

After an hour, things started to get cold. And I mean *really cold*.

The rover's always cold when you first get in it. When you haven't disabled the heater, it warms up right away. I expected it to be cold, but Jesus Christ!

I was fine for a while. My own body heat plus three layers of clothing kept me warm, and the rover's insulation is top-notch. The heat that escaped my body just warmed up the interior. But there's no such thing as perfect insulation, and eventually the heat left to the great outdoors, while I got colder and colder.

Within an hour, I was chattering and numb. Enough was enough. There's no way I could do a long trip like this.

Turning the heater on, I drove straight back to the Hab.

Once I got home, I sulked for a while. All my brilliant plans foiled by thermodynamics. Damn you, Entropy!

I'm in a bind. The damn heater will eat half my battery power every day. I could turn it down, I guess. Be a little cold but not freezing to death. Even then I'd still lose at least a quarter.

This will require some thought. I have to ask myself…What would Hercule Poirot do? I'll have to put my "little gray cells" to work on the problem.

LOG ENTRY: SOL 68

Well, shit.

I came up with a solution, but…remember when I burned rocket fuel in the Hab? This'll be more dangerous.

I'm going to use the RTG.

The RTG (radioisotope thermoelectric generator) is a big box of plutonium. But not the kind used in nuclear bombs. No, no. This plutonium is *way* more dangerous!

Plutonium-238 is an incredibly unstable isotope. It's so radioactive that it will get red hot all by itself. As you can imagine, a material that can *literally fry an egg* with radiation is kind of dangerous.

The RTG houses the plutonium, catches the radiation in the form of heat, and turns it into electricity. It's not a reactor. The radiation can't be increased or decreased. It's a purely natural process happening at the atomic level.

As long ago as the 1960s, NASA began using RTGs to power unmanned probes. They have lots of advantages over solar power. They're not affected by storms; they work day or night; they're entirely internal, so you don't need delicate solar cells all over your probe.

But they never used large RTGs on manned missions until the Ares Program.

Why not? It should be pretty damned obvious why not! They didn't want to put astronauts next to a glowing hot ball of radioactive death!

I'm exaggerating a little. The plutonium is inside a bunch of pellets, each one sealed and insulated to prevent radiation leakage, even if the outer container is breached. So for the Ares Program, they took the risk.

An Ares mission is all about the MAV. It's the single most important component. It's one of the few systems that can't be replaced or worked around. It's the *only* component that causes a complete mission scrub if it's not working.

Solar cells are great in the short term, and they're good for the long term if you have humans around to clean them. But the MAV sits alone for years quietly making fuel, then just kind of hangs out until its crew arrives. Even doing nothing, it needs power, so NASA can monitor it remotely and run self-checks.

The prospect of scrubbing a mission because a solar cell got dirty was unacceptable. They needed a more reliable source of power. So the MAV comes equipped with an RTG. It has 2.6 kilograms of plutonium-238, which makes almost 1500 watts of heat. It can turn that into 100 watts of electricity. The MAV runs on that until the crew arrive.

One hundred watts isn't enough to keep the heater going, but I don't care about the electrical output. I want the heat. A 1500-watt heater is so warm I'll have to tear insulation out of the rover to keep it from getting too hot.

As soon as the rovers were unstowed and activated, Commander Lewis had the joy of disposing of the RTG. She detached it from the MAV, drove four kilometers away, and buried it. However safe it may be, it's still a radioactive core and NASA didn't want it too close to their astronauts.

The mission parameters don't give a specific location to dump the RTG. Just "at least four kilometers away." So I'll have to find it.

I have two things working for me. First, I was assembling solar panels with Vogel when Commander Lewis drove off, and I saw she headed due south. Also, she planted a three-meter pole with a bright green flag over where she buried it. Green shows up extremely well against the Martian terrain. It's made to ward us off, in case we get lost on a rover EVA later on.

So my plan is: Head south four kilometers, then search around till I see the green flag.

Having rendered Rover 1 unusable, I'll have to use my mutant rover for the trip. I can make a useful test mission of it. I'll see how well the battery harness holds up to a real journey, and how well the solar cells do strapped to the roof.

I'll call it Sirius 2.

LOG ENTRY: SOL 69

I'm no stranger to Mars. I've been here a long time. But I've never been out of sight of the Hab before today. You wouldn't think that would make a difference, but it does.

As I made my way toward the RTG's burial site, it hit me: Mars is a barren wasteland and I am *completely* alone here. I already knew that, of course. But there's a difference between knowing it and really experiencing it. All around me there was nothing but dust, rocks, and endless empty desert in all directions. The planet's famous red color is from iron oxide coating everything. So it's not just a desert. It's a desert so old it's literally rusting.

The Hab is my only hint of civilization, and seeing it disappear made me way more uncomfortable than I like to admit.

I put those thoughts behind me by concentrating on what was in front of me. I found the RTG right where it was supposed to be, four kilometers due south of the Hab.

It wasn't hard to find. Commander Lewis had buried it atop a small hill. She probably wanted to make sure everyone could

see the flag, and it worked great! Except instead of avoiding it, I beelined to it and dug it up. Not exactly what she was going for.

It was a large cylinder with heat-sinks all around it. I could feel the warmth it gave off even through my suit's gloves. That's really disconcerting. Especially when you know the root cause of the heat is radiation.

No point in putting it on the roof; my plan was to have it in the cabin anyway. So I brought it in with me, turned off the heater, then drove back to the Hab.

In the ten minutes it took to get home, even with the heater off, the interior of the rover became an uncomfortably hot 37°C. The RTG would definitely be able to keep me warm.

The trip also proved that my rigging worked. The solar cells and extra battery stayed beautifully in place while traversing eight kilometers of random terrain.

I declare Sirius 2 to be a successful mission!

I spent the rest of the day vandalizing the interior of the rover. The pressure compartment is made of carbon composite. Just inside that is insulation, which is covered by hard plastic. I used a sophisticated method to remove sections of plastic (hammer), then carefully removed the solid foam insulation (hammer again).

After tearing out some insulation, I suited up and took the RTG outside. Soon, the rover cooled down again, and I brought it back in. I watched as the temperature rose slowly. Nowhere near as fast as it had on my trip back from the burial site.

I cautiously removed more insulation (hammer) and checked again. After a few more cycles of this, I had enough insulation torn out that the RTG could barely keep up with it. In fact, it was a losing battle. Over time, heat will slowly leach out. That's fine. I can turn on the heater for short bursts when necessary.

I brought the insulation pieces with me back into the Hab. Using advanced construction techniques (duct tape), I reassembled some of them into a square. I figure if things ever get really cold, I can tape that to a bare patch in the rover, and the RTG will be winning the "heat fight."

Tomorrow, Sirius 3 (which is just Sirius 1 again, but without freezing).

LOG ENTRY: SOL 70

Today, I write to you from the rover. I'm halfway through Sirius 3 and things are going well.

I set out at first light and drove laps around the Hab, trying to stay on untouched ground. The first battery lasted just under two hours. After a quick EVA to switch the cables, I got back to driving. When all was said and done, I had driven 81 kilometers in 3 hours and 27 minutes.

That's *very* good! Mind you, the land around the Hab is really flat, as is all of Acidalia Planitia. I have no idea what my efficiency would be on the nastier land en route to Ares 4.

The second battery still had a little juice left, but I can't just run it down all the way before I stop; remember, I need life support while recharging. The CO_2 gets absorbed through a chemical process, but if the fan that pushes it isn't working, I'll choke. The oxygen pump is also kind of important.

After my drive, I set up the solar cells. It was hard work; last time I had Vogel's help. They aren't heavy, but they're awkward. After setting up half of them, I figured out I could drag them rather than carry them, and that sped things up.

Now I'm just waiting for the batteries to recharge. I'm bored, so I'm updating the log. I have all the Poirot books in my computer. That'll help. It's going to take twelve hours to recharge, after all.

What's that, you say? Twelve hours is wrong? I said thirteen hours earlier? Well, my friend, let me set you straight.

The RTG is a *generator*. It's a paltry amount of power, compared to what the rover consumes, but it's not nothing. It's one hundred watts. It'll cut an hour off my total recharge time. Why not use it?

I wonder what NASA would think about me fucking with the RTG like this. They'd probably hide under their desks and cuddle with their slide rules for comfort.

LOG ENTRY: SOL 71

As predicted, it took twelve hours to charge the batteries to full. I came straight home as soon as they were done.

Time to make plans for Sirius 4. And I think it'll be a multiday field trip.

Looks like power and battery recharging are solved. Food's not a problem; there's plenty of space to store things. Water's even easier than food. I need two liters per day to be comfortable.

When I do my trip to Ares 4 for real, I'll need to bring the oxygenator. But it's big and I don't want to screw with it right now. So I'll rely on O_2 and CO_2 filters for Sirius 4.

CO_2 isn't a problem. I started this grand adventure with 1500 hours of CO_2 filters, plus another 720 for emergency use. All systems use standard filters (Apollo 13 taught us important lessons). Since then, I've used 131 hours of filter on various EVAs. I have 2089 left. Eighty-seven days' worth. Plenty.

Oxygen's a little trickier. The rover was designed to support three people for two days, plus some reserve for safety. So its O_2 tanks can hold enough to last me seven days. Not enough.

Mars has almost no atmospheric pressure. The inside of the rover has one atmosphere. So the oxygen tanks are on the inside (less pressure differential to deal with). Why does that matter? It means I can bring along other oxygen tanks, and equalize them with the rover's tanks without having to do an EVA.

So today, I detached one of the Hab's two 25-liter liquid oxygen tanks and brought it into the rover. According to NASA, a human needs 588 liters of oxygen per day to live. Compressed liquid O_2 is about 1000 times as dense as gaseous O_2 in a comfortable atmosphere. Long story short: With the Hab tank, I have enough O_2 to last 49 days. That'll be plenty.

Sirius 4 will be a twenty-day trip.

That may seem a bit long, but I have a specific goal in mind. Besides, my trip to Ares 4 will be at least forty days. This is a good scale model.

While I'm away, the Hab can take care of itself, but the potatoes are an issue. I'll saturate the ground with most of the water I have. Then, I'll deactivate the atmospheric regulator, so it doesn't pull water out of the air. It'll be humid as hell, and water will condense on every surface. That'll keep the potatoes well watered while I'm away.

A bigger problem is CO_2. The potatoes need to breathe. I know what you're thinking. "Mark, old chap! *You* produce carbon dioxide! It's all part of the majestic circle of nature!"

The problem is: Where will I put it? Sure, I exhale CO_2 with every breath, but I don't have any way to store it. I could turn off the oxygenator and atmospheric regulator and just fill the Hab with my breath over time. But CO_2 is deadly to me. I need to release a bunch at once and run away.

Remember the MAV fuel plant? It collects CO_2 from the Martian atmosphere. A 10-liter tank of compressed liquid CO_2, vented into the Hab, will be enough CO_2 to do the trick. That'll take less than a day to create.

So that's everything. Once I vent the CO_2 into the Hab, I'll turn off the atmospheric regulator and oxygenator, dump a ton of water on the crops, and head out.

Sirius 4. A huge step forward in my rover research. And I can start tomorrow.