CHAPTER 17

LOG ENTRY: SOL 192

Holy shit!

They're coming back for me!

I don't even know how to react. I'm choked up!

And I've got a shitload of work to do before I catch that bus home.

They can't orbit. If I'm not in space when they pass by, all they can do is wave.

I have to get to Ares 4's MAV. Even NASA accepts that. And when the nannies at NASA recommend a 3200-kilometer overland drive, you know you're in trouble.

Schiaparelli, here I come!

Well…not right away. I still have to do the aforementioned shitload of work.

My trip to *Pathfinder* was a quick jaunt compared to the epic journey that's coming up. I got away with a lot of shortcuts because I only had to survive eighteen sols. This time, things are different.

I averaged 80 kilometers per sol on my way to *Pathfinder*. If I do that well toward Schiaparelli, the trip'll take forty sols. Call it fifty to be safe.

But there's more to it than just travel. Once I get there, I'll need to set up camp and do a bunch of MAV modifications. NASA estimates they'll take thirty sols, forty-five to be safe. Between the trip and the MAV mods, that's ninety-five sols. Call it one hundred because ninety-five cries out to be approximated.

So I'll need to survive away from the Hab for a hundred sols.

“What about the MAV?” I hear you ask (in my fevered imagination). “Won’t it have some supplies? Air and water at the very least?”

Nope. It’s got dick-all.

It does have air tanks, but they’re empty. An Ares mission needs lots of O_2, N_2, and water anyway. Why send more with the MAV? Easier to have the crew top off the MAV from the Hab. Fortunately for my crewmates, the mission plan had Martinez fill the MAV tanks on Sol 1.

The flyby is on Sol 549, so I’ll need to leave by 449. That gives me 257 sols to get my ass in gear.

Seems like a long time, doesn’t it?

In that time, I need to modify the rover to carry the “Big Three”: the atmospheric regulator, the oxygenator, and the water reclaimer. All three need to be in the pressurized area, but the rover isn’t big enough. All three need to be running at all times, but the rover’s batteries can’t handle that load for long.

The rover will also need to carry all my food, water, and solar cells, my extra battery, my tools, some spare parts, and *Pathfinder*. As my sole means of communication with NASA, *Pathfinder* gets to ride on the roof, Granny Clampett style.

I have a lot of problems to solve, but I have a lot of smart people to solve them. Pretty much the whole planet Earth.

NASA is still working on the details, but the idea is to use both rovers. One to drive around, the other to act as my cargo trailer.

I’ll have to make structural changes to that trailer. And by “structural changes” I mean “cut a big hole in the hull.” Then I can move the Big Three in and use Hab canvas to loosely cover the hole. It’ll balloon out when I pressurize the rover, but it’ll hold. How will I cut a big chunk out of a rover’s hull? I’ll let my lovely assistant Venkat Kapoor explain further:

[14:38] JPL: I'm sure you're wondering how to cut a hole in the rover.

Our experiments show a rock sample drill can get through the hull. Wear and tear on the bit is minimal (rocks are harder than carbon composite). You can cut holes in a line, then chisel out the remaining chunks between them.

I hope you like drilling. The drill bit is 1 cm wide, the holes will be 0.5 cm apart, and the length of the total cut is 11.4 m. That's 760 holes. And each one takes 160 seconds to drill.

Problem: The drills weren't designed for construction projects. They were intended for quick rock samples. The batteries only last 240 seconds. You do have two drills, but you'd still only get 3 holes done before needing to recharge. And recharging takes 41 minutes.

That's 173 hours of work, limited to 8 EVA hours per day. That's 21 days of drilling, and that's just too long. All our other ideas hinge on this cut working. If it doesn't, we need time to come up with new ones.

So we want you to wire a drill directly to Hab power.

The drill expects 28.8 V and pulls 9 amps. The only lines that can handle that are the rover recharge lines. They're 36 V, 10 amp max. Since you have two, we're comfortable with you modifying one.

We'll send you instructions on how to step down the voltage and put a new breaker in the line, but I'm sure you already know how.

I'll be playing with high-voltage power tomorrow. Can't imagine anything going wrong with that!

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I managed to not kill myself today, even though I was working with high voltage. Well, it's not as exciting as all that. I disconnected the line first.

As instructed, I turned a rover charging cable into a drill power source. Getting the voltage right was a simple matter of adding resistors, which my electronics kit has in abundance.

I had to make my own nine-amp breaker. I strung three three-amp breakers in parallel. There's no way for nine amps to get through that without tripping all three in rapid succession.

Then I had to rewire a drill. Pretty much the same thing I did with *Pathfinder*. Take out the battery and replace it with a power line from the Hab. But this time it was a lot easier.

Pathfinder was too big to fit through any of my airlocks, so I had to do all the rewiring outside. Ever done electronics while wearing a space suit? Pain in the ass. I even had to make a workbench out of MAV landing struts, remember?

Anyway, the drill fit in the airlock easily. It's only a meter tall, and shaped like a jackhammer. We did our rock sampling standing up, like Apollo astronauts.

Also, unlike my *Pathfinder* hatchet job, I had the full schematics of the drill. I removed the battery and attached a power line where it used to be. Then, taking the drill and its new cord outside, I connected it to the modified rover charger and fired it up.

Worked like a charm! The drill whirled away with happy abandon. Somehow, I had managed to do everything right the first try. Deep down, I thought I'd fry the drill for sure.

It wasn't even midday yet. I figured why not get a jump on drilling?

> [10:07] Watney: Power line modifications complete. Hooked it up to a drill, and it works great. Plenty of daylight left. Send me a description of that hole you want me to cut.
>
> [10:25] JPL: Glad to hear it. Starting on the cut sounds great. Just to be clear, these are modifications to Rover 1, which we've been calling "the trailer." Rover 2 (the one with your modifications for the trip to Pathfinder) should remain as is for now.
>
> You'll be taking a chunk out of the roof, just in front of the airlock in the rear of the vehicle. The hole needs to be at least 2.5 m long and the full 2 m width of the pressure vessel.

Before any cuts, draw the shape on the trailer, and position the trailer where Pathfinder's camera can see it. We'll let you know if you got it right.

[10:43] Watney: Roger. Take a pic at 11:30, if you haven't heard from me by then.

The rovers are made to interlock so one can tow the other. That way you can rescue your crewmates if all hell breaks loose. For that same reason, rovers can share air via hoses you connect between them. That little feature will let me share atmosphere with the trailer on my long drive.

I'd stolen the trailer's battery long ago; it had no ability to move under its own power. So I hitched it up to my awesomely modified rover and towed it into place near *Pathfinder*.

Venkat told me to "draw" the shape I plan to cut, but he neglected to mention how. It's not like I have a Sharpie that can work out on the surface. So I vandalized Martinez's bed.

The cots are basically hammocks. Lightweight string woven loosely into something that's comfortable to sleep on. Every gram counts when making stuff to send to Mars.

I unraveled Martinez's bed and took the string outside, then taped it to the trailer hull along the path I planned to cut. Yes, of course duct tape works in a near-vacuum. Duct tape works anywhere. Duct tape is magic and should be worshiped.

I can see what NASA has in mind. The rear of the trailer has an airlock that we're not going to mess with. The cut is just ahead of it and will leave plenty of space for the Big Three to stand.

I have no idea how NASA plans to power the Big Three for twenty-four and a half hours a day and still have energy left to drive. I bet they don't know, either. But they're smart; they'll work something out.

[11:49] JPL: What we can see of your planned cut looks good. We're assuming the other side is identical. You're cleared to start

drilling.

[12:07] Watney: That's what she said.

[12:25] JPL: Seriously, Mark? Seriously?

First, I depressurized the trailer. Call me crazy, but I didn't want the drill explosively launched at my face.

Then I had to pick somewhere to start. I thought it'd be easiest to start on the side. I was wrong.

The roof would have been better. The side was a hassle because I had to hold the drill parallel to the ground. This isn't your dad's Black & Decker we're talking about. It's a meter long and only safe to hold by the handles.

Getting it to bite was nasty. I pressed it against the hull and turned it on, but it wandered all over the place. So I got my trusty hammer and screwdriver. With a few taps, I made a small chip in the carbon composite.

That gave the bit a place to seat, so I could keep drilling in one place. As NASA predicted, it took about two and a half minutes to get all the way through.

I followed the same procedure for the second hole and it went much smoother. After the third hole, the drill's overheat light came on.

The poor drill wasn't designed to operate constantly for so long. Fortunately, it sensed the overheat and warned me. So I leaned it against the workbench for a few minutes, and it cooled down. One thing you can say about Mars: It's *really* cold. The thin atmosphere doesn't conduct heat very well, but it cools everything, eventually.

I had already removed the drill's cowling (the power cord needed a way in). A pleasant side effect is the drill cools even faster. Though I'll have to clean it thoroughly every few hours as dust accumulates.

By 17:00, when the sun began to set, I had drilled seventy-five holes. A good start, but there's still tons to do. Eventually

(probably tomorrow) I'll have to start drilling holes that I can't reach from the ground. For that I'll need something to stand on.

I can't use my "workbench." It's got *Pathfinder* on it, and the last thing I'm going to do is mess with that. But I've got three more MAV landing struts. I'm sure I can make a ramp or something.

Anyway, that's all stuff for tomorrow. Tonight is about eating a *full* ration for dinner.

Awww yeah. That's right. I'm either getting rescued on Sol 549 or I'm dying. That means I have thirty-five sols of extra food. I can indulge once in a while.

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I average a hole every 3.5 minutes. That includes the occasional breather to let the drill cool off.

I learned this by spending all damn day drilling. After eight hours of dull, physically intense work, I had 137 holes to show for it.

It turned out to be easy to deal with places I couldn't reach. I didn't need to modify a landing strut after all. I just had to get something to stand on. I used a geological sample container (also known as "a box").

Before I was in contact with NASA, I would have worked more than eight hours. I can stay out for ten before even dipping into "emergency" air. But NASA's got a lot of nervous Nellies who don't want me out longer than spec.

With today's work, I'm about one-fourth of the way through the whole cut. At least, one-fourth of the way through the drilling. Then I'll have 759 little chunks to chisel out. And I'm not sure how well carbon composite is going to take to that. But NASA'll do it a thousand times back on Earth and tell me the best way to get it done.

Anyway, at this rate, it'll take four more sols of (boring-ass) work to finish the drilling.

I've actually exhausted Lewis's supply of shitty seventies TV. And I've read all of Johanssen's mystery books.

I've already rifled through other crewmates' stuff to find entertainment. But all of Vogel's stuff is in German, Beck brought nothing but medical journals, and Martinez didn't bring anything.

I got really bored, so I decided to pick a theme song!

Something appropriate. And naturally, it should be something from Lewis's godawful seventies collection. It wouldn't be right any other way.

There are plenty of great candidates: "Life on Mars?" by David Bowie, "Rocket Man" by Elton John, "Alone Again (Naturally)" by Gilbert O'Sullivan.

But I settled on "*Stayin' Alive"* by the Bee Gees.

LOG ENTRY: SOL 195

Another day, another bunch of holes: 145 this time (I'm getting better). I'm halfway done. This is getting really old.

But at least I have encouraging messages from Venkat to cheer me on!

> [17:12] Watney: 145 holes today. 357 total.
>
> [17:31] JPL: We thought you'd have more done by now.

Dick.

Anyway, I'm still bored at night. I guess that's a good thing. Nothing's wrong with the Hab. There's a plan to save me, and the physical labor is making me sleep wonderfully.

I miss tending the potatoes. The Hab isn't the same without them.

There’s still soil everywhere. No point in lugging it back outside. Lacking anything better to do, I ran some tests on it. Amazingly, some of the bacteria survived. The population is strong and growing. That’s pretty impressive, when you consider it was exposed to near-vacuum and subarctic temperatures for over twenty-four hours.

My guess is pockets of ice formed around some of the bacteria, leaving a bubble of survivable pressure inside, and the cold wasn’t quite enough to kill them. With hundreds of millions of bacteria, it only takes one survivor to stave off extinction.

Life is amazingly tenacious. They don’t want to die any more than I do.

LOG ENTRY: SOL 196

I fucked up.

I fucked up big-time. I made a mistake that might kill me.

I started my EVA around 08:45, same as always. I got my hammer and screwdriver and started chipping the trailer’s hull. It’s a pain in the ass to make a chip before each drilling, so I make all the day’s chips in a single go.

After chipping out 150 divots (hey, I’m an optimist), I got to work.

It was the same as yesterday and the day before. Drill through, relocate. Drill through, relocate. Drill through a third time, then set the drill aside to cool. Repeat that process over and over till lunchtime.

At 12:00, I took a break. Back in the Hab, I enjoyed a nice lunch and played some chess against the computer (it kicked my ass). Then back out for the day’s second EVA.

At 13:30 my ruination occurred, though I didn’t realize it at the time.

The worst moments in life are heralded by small observations. The tiny lump on your side that wasn’t there

before. Coming home to your wife and seeing two wineglasses in the sink. Anytime you hear “We interrupt this program…”

For me, it was when the drill didn’t start.

Only three minutes earlier, it was working fine. I had finished a hole and set the drill aside to cool. Same as always.

But when I tried to get back to work, it was dead. The power light wouldn’t even come on.

I wasn’t worried. If all else failed, I had another drill. It would take a few hours to wire it up, but that’s hardly a concern.

The power light being off meant there was probably something wrong with the line. A quick glance at the airlock window showed the lights were on in the Hab. So there were no systemic power problems. I checked my new breakers, and sure enough, all three had tripped.

I guess the drill pulled a little too much amperage. No big deal. I reset the breakers and got back to work. The drill fired right up, and I was back to making holes.

Doesn’t seem like a big deal, right? I certainly didn’t think so at the time.

I finished my day at 17:00 after drilling 131 holes. Not as good as yesterday, but I lost some time to the drill malfunction.

I reported my progress.

> [17:08] Watney: 131 holes today. 488 total. Minor drill issue; it tripped the breakers. There may be an intermittent short in the drill, probably in the attachment point of the power line. Might need to redo it.

Earth and Mars are just over eighteen light-minutes apart now. Usually, NASA responds within twenty-five minutes. Remember, I do all my communication from Rover 2, which relays everything through *Pathfinder*. I can’t just lounge in the

Hab awaiting a reply; I have to stay in the rover until they acknowledge the message.

> [17:38] Watney: Have received no reply. Last message sent 30 minutes ago. Please acknowledge.

I waited another thirty minutes. Still no reply. Fear started to take root.

Back when JPL's Nerd Brigade hacked the rover and *Pathfinder* to be a poor man's IM client, they sent me a cheat sheet for troubleshooting. I executed the first instruction:

> [18:09] Watney: system_command: STATUS
>
> [18:09] SYSTEM: Last message sent 00h31m ago. Last message received 26h17m ago. Last ping reply from probe received 04h24m ago. WARNING: 52 unanswered pings.

Pathfinder was no longer talking to the rover. It had stopped answering pings four hours and twenty-four minutes ago. Some quick math told me that was around 13:30 today.

The same time the drill died.

I tried not to panic. The troubleshooting sheet has a list of things to try if communication is lost. They are (in order):

1. Confirm power still flowing to *Pathfinder*.
2. Reboot rover.
3. Reboot *Pathfinder* by disconnecting/reconnecting power.
4. Install rover's comm software on the other rover's computer, try from there.
5. If both rovers fail, problem is likely with *Pathfinder*. Check connections very closely. Clean *Pathfinder* of Martian dust.
6. Spell message in Morse code with rocks, include things attempted. Problem may be recoverable with remote update of *Pathfinder*.

I only got as far as step 1. I checked *Pathfinder*'s connections and the negative lead was no longer attached.

I was elated! What a relief! With a smile on my face, I fetched my electronics kit and prepared to reattach the lead. I pulled it out of the probe to give it a good cleaning (as best I could with the gloves of my space suit) and noticed something strange. The insulation had melted.

I pondered this development. Melted insulation usually means a short. More current than the wire could handle had passed through. But the bare portion of the wire wasn't black or even singed, and the positive lead's insulation wasn't melted at all.

Then, one by one, the horrible realities of Mars came into play. The wire wouldn't be burned or singed. That's a result of oxidization. And there's no oxygen in the air. There likely was a short after all. But with the positive lead being unaffected, the power must have come from somewhere else.…

And the drill's breaker tripped around the same time.…

Oh…shit…

The internal electronics for *Pathfinder* included a ground lead to the hull. This way it could not build up a static charge in Martian weather conditions (no water and frequent sandblasting can make impressive static charge).

The hull sat on Panel A, one of four sides of the tetrahedron which brought *Pathfinder* to Mars. The other three sides are still in Ares Vallis where I left them.

Between Panel A and the workbench were the Mylar balloons *Pathfinder* had used to tumble-land. I had shredded many of them to transport it, but a lot of material remained—enough to reach around Panel A and be in contact with the hull. I should mention that Mylar is conductive.

At 13:30, I leaned the drill against the workbench. The drill's cowling was off to make room for the power line. The workbench is metal. If the drill leaned against the workbench just right, it could make a metal-to-metal connection.

And that’s exactly what had happened.

Power traveled from the drill line’s positive lead, through the workbench, through the Mylar, through *Pathfinder*’s hull, through a bunch of extremely sensitive and irreplaceable electronics, and out the negative lead of *Pathfinder*’s power line.

Pathfinder operates on 50 milliamps. It got *9000* milliamps, which plowed through the delicate electronics, frying everything along the way. The breakers tripped, but it was too late.

Pathfinder’s dead. I’ve lost the ability to contact Earth.

I’m on my own.