

“SOMETHING’S COMING IN...yes...yes! It’s *Pathfinder*!”

The crowded room burst into applause and cheers. Venkat slapped an unknown technician on the back while Bruce pumped his fist in the air.

The ad-hoc *Pathfinder* control center was an accomplishment in itself. Over the last twenty days, a team of JPL engineers had worked around the clock to piece together antiquated computers, repair broken components, network everything, and install hastily made software that allowed the old systems to interact with the modern Deep Space Network.

The room itself was formerly a conference room; JPL had no space ready for the sudden need. Already jam-packed with computers and equipment, the cramped space had turned positively claustrophobic with the many spectators now squeezing into it.

One Associated Press camera team pressed against the back wall, trying—and failing—to stay out of everyone’s way while recording the auspicious moment. The rest of the media would have to satisfy themselves with the live AP feed, and await a press conference.

Venkat turned to Bruce. “God damn, Bruce. You really pulled a rabbit out of your hat this time! Good work!”

“I’m just the director,” Bruce said modestly. “Thank the guys who got all this stuff working.”

“Oh I will!” Venkat beamed. “But first I have to talk to my new best friend!”

Turning to the headsetted man at the communications console, Venkat asked, “What’s your name, new best friend?”

“Tim,” he said, not taking his eyes off the screen.

“What now?” Venkat asked.

“We sent the return telemetry automatically. It’ll get there in just over eleven minutes. Once it does, *Pathfinder* will start high-gain transmissions. So it’ll be twenty-two minutes till we hear from it again.”

“Venkat’s got a doctorate in physics, Tim,” Bruce said. “You don’t need to explain transmission time to him.”

Tim shrugged. “You can never tell with managers.”

“What was in the transmission we got?” Venkat asked.

“Just the bare bones. A hardware self-check. It’s got a lot of ‘nonfunctional’ systems, ’cause they were on the panels Watney removed.”

“What about the camera?”

“It says the imager’s working. We’ll have it take a panorama as soon as we can.”

#### LOG ENTRY: SOL 97

It worked!

Holy shit, it worked!

I just suited up and checked the lander. The high-gain antenna is angled *directly* at Earth! *Pathfinder* has no way of knowing where it is, so it has no way of knowing where Earth is. The *only* way for it to find out is getting a signal.

They know I’m alive!

I don’t even know what to say. This was an insane plan and somehow it worked! I’m going to be talking to someone again. I spent three months as the loneliest man in history and it’s finally over.

Sure, I might not get rescued. But I won’t be alone.

The whole time I was recovering *Pathfinder*, I imagined what this moment would be like. I figured I’d jump up and down a bit, cheer, maybe flip off the ground (because this whole damn planet is my enemy), but that’s not what happened. When I got back to the Hab and took off the EVA

suit, I sat down in the dirt and cried. Bawled like a little kid for several minutes. I finally settled down to mild sniffing and then felt a deep calm.

It was a good calm.

It occurs to me: Now that I might live, I have to be more careful about logging embarrassing moments. How do I delete log entries? There's no obvious way.... I'll get to it later. I've got more important things to do.

I've got people to talk to!

...

VENKAT GRINNED as he took the podium in the JPL press room.

"We received the high-gain response just over half an hour ago," he said to the assembled press. "We immediately directed *Pathfinder* to take a panoramic image. Hopefully, Watney has some kind of message for us. Questions?"

The sea of reporters raised their hands.

"Cathy, let's start with you," Venkat said, pointing to the CNN reporter.

"Thanks," she said. "Have you had any contact with the Sojourner rover?"

"Unfortunately, no," he replied. "The lander hasn't been able to connect to Sojourner, and we have no way to contact it directly."

"What might be wrong with Sojourner?"

"I can't even speculate," Venkat said. "After spending that long on Mars, *anything* could be wrong with it."

"Best guess?"

"Our best guess is he took it into the Hab. The lander's signal wouldn't be able to reach Sojourner through Hab canvas." Pointing to another reporter, he said, "You, there."

"Marty West, NBC News," Marty said. "How will you communicate with Watney once everything's up and running?"

“That’ll be up to Watney,” said Venkat. “All we have to work with is the camera. He can write notes and hold them up. But how we talk back is trickier.”

“How so?” Marty asked.

“Because all we have is the camera platform. That’s the only moving part. There are plenty of ways to get information across with just the platform’s rotation, but no way to tell Watney about them. He’ll have to come up with something and tell us. We’ll follow his lead.”

Pointing to the next reporter, he said, “Go ahead.”

“Jill Holbrook, BBC. With a thirty-two-minute round-trip and nothing but a single rotating platform to talk with, it’ll be a dreadfully slow conversation, won’t it?”

“Yes it will,” Venkat confirmed. “It’s early morning in Acidalia Planitia right now, and just past three a.m. here in Pasadena. We’ll be here all night, and that’s just for a start. No more questions for now. The panorama is due back in a few minutes. We’ll keep you posted.”

Before anyone could ask a follow-up, Venkat strode out the side door and hurried down the hall to the makeshift *Pathfinder* control center. He pressed through the throng to the communications console.

“Anything, Tim?”

“Totally,” he replied. “But we’re staring at this black screen because it’s way more interesting than pictures from Mars.”

“You’re a smart-ass, Tim,” Venkat said.

“Noted.”

Bruce pushed his way forward. “Still another few seconds on the clock,” he said.

The time passed in silence.

“Getting something,” Tim said. “Yup. It’s the panoramic.”

Sighs of relief and muted conversation replaced tense silence as the image began coming through. It filled out from left to right at a snail's pace due to the bandwidth limitations of the antique probe sending it.

"Martian surface..." Venkat said as the lines slowly filled in. "More surface..."

"Edge of the Hab!" Bruce said, pointing to the screen.

"Hab," Venkat smiled. "More Hab now...more Hab...Is that a message? That's a message!"

As the image grew, it revealed a handwritten note, suspended at the camera's height by a thin metal rod.

"We got a note from Mark!" Venkat announced to the room.

Applause filled the room, then quickly died down. "What's it say?" someone asked.

Venkat leaned closer to the screen. "It says...'I'll write questions here—Are you receiving?'"

"Okay...?" said Bruce.

"That's what it says," Venkat shrugged.

"Another note," said Tim, pointing to the screen as more of the image came through.

Venkat leaned in again. "This one says 'Point here for yes.'"

He folded his arms. "All right. We have communication with Mark. Tim, point the camera at 'Yes.' Then, start taking pictures at ten-minute intervals until he puts another question up."

LOG ENTRY: SOL 97 (2)

"Yes!" They said, "Yes!"

I haven't been this excited about a "yes" since prom night!

Okay, calm down.

I have limited paper to work with. These cards were intended to label batches of samples. I have about fifty cards. I can use both sides, and if it comes down to it, I can re-use them by scratching out the old question.

The Sharpie I'm using will last much longer than the cards, so ink isn't a problem. But I have to do all my writing in the Hab. I don't know what kind of hallucinogenic crap that ink is made of, but I'm pretty sure it would boil off in Mars's atmosphere.

I'm using old parts of the antenna array to hold the cards up. There's a certain irony in that.

We'll need to talk faster than yes/no questions every half hour. The camera can rotate 360 degrees, and I have plenty of antenna parts. Time to make an alphabet. But I can't just use the letters A through Z. Twenty-six letters plus my question card would be twenty-seven cards around the lander. Each one would only get 13 degrees of arc. Even if JPL points the camera perfectly, there's a good chance I won't know which letter they meant.

So I'll have to use ASCII. That's how computers manage characters. Each character has a numerical code between 0 and 255. Values between 0 and 255 can be expressed as 2 hexadecimal digits. By giving me pairs of hex digits, they can send any character they like, including numbers, punctuation, etc.

How do I know which values go with which characters? Because Johanssen's laptop is a wealth of information. I knew she'd have an ASCII table in there somewhere. All computer geeks do.

So I'll make cards for 0 through 9, and A through F. That makes 16 cards to place around the camera, plus the question card. Seventeen cards means over 21 degrees each. Much easier to deal with.

Time to get to work!

*Spell with ASCII. 0–F at 21-degree increments. Will watch camera starting 11:00 my time. When message done, return to this position. Wait 20 minutes after completion to take picture (so I can write and post reply). Repeat process at top of every hour.*

S...T...A...T...U...S

*No physical problems. All Hab components functional. Eating 3/4 rations. Successfully growing crops in Hab with cultivated soil. Note: Situation not Ares 3 crew's fault. Bad luck.*

H...O...W...A...L...I...V...E

*Impaled by antenna fragment. Knocked out by decompression. Landed facedown, blood sealed hole. Woke up after crew left. Bio-monitor computer destroyed by puncture. Crew had reason to think me dead. Not their fault.*

C...R...O...P...S...?

*Long story. Extreme botany. Have 126 m2 farmland growing potatoes. Will extend food supply, but not enough to last until Ares 4 landing. Modified rover for long-distance travel, plan to drive to Ares 4.*

W...E...S...A...W...—...S...A...T...L...I...T...E

*Government watching me with satellites? Need tinfoil hat! Also need faster way to communicate. Speak&Spell taking all damn day. Any ideas?*

B...R...I...N...G...S...J...R...N...R...O...U...T

*Sojourner rover brought out, placed 1 meter due north of lander. If you can contact it, I can draw hex numbers on the wheels and you can send me six bytes at a time.*

S...J...R...N...R...N...O...T...R...S...P...N...D

*Damn. Any other ideas? Need faster communication.*

W...O...R...K...I...N...G...O...N...I...T

*Earth is about to set. Resume 08:00 my time tomorrow morning. Tell family I'm fine. Give crew my best. Tell Commander Lewis disco sucks.*

...

VENKAT BLINKED his bleary eyes several times as he tried to organize the papers on his desk. His temporary desk at JPL was nothing more than a folding table set up in the back of a break room. People were in and out picking up snacks all day, but on the plus side the coffeepot was nearby.

"Excuse me," said a man approaching the table.

"Yes, they're out of Diet Coke," Venkat said without looking up. "I don't know when Site Services refills the fridge."

"I'm actually here to talk to you, Dr. Kapoor."

"Huh?" said Venkat, looking up. He shook his head. "Sorry, I was up all night." He gulped his coffee. "Who are you again?"

"Jack Trevor," said the thin, pale man before Venkat. "I work in software engineering."

"What can I do for you?"

"We have an idea for communication."

"I'm all ears."

"We've been looking through the old *Pathfinder* software. We got duplicate computers up and running for testing. Same computers they used to find a problem that almost killed the original mission. Real interesting story, actually; turns out there was a priority inversion in Sojourner's thread management and—"

"Focus, Jack," interrupted Venkat.

"Right. Well, the thing is, *Pathfinder* has an OS update process. So we can change the software to anything we want."

"How does this help us?"



“*Pathfinder* has two communications systems. One to talk to us, the other to talk to Sojourner. We can change the second system to broadcast on the Ares 3 rover frequency. And we can have it pretend to be the beacon signal from the Hab.”

“You can get *Pathfinder* talking to Mark’s rover?”

“It’s the only option. The Hab’s radio is dead, but the rover has communications equipment made for talking to the Hab and the other rover. Problem is, to implement a new comm system, both ends of it need to have the right software running. We can remotely update *Pathfinder*, but not the rover.”

“So,” Venkat said, “you can get *Pathfinder* to talk to the rover, but you can’t get the rover to listen or talk back.”

“Right. Ideally, we want our text to show up on the rover screen, and whatever Watney types to be sent back to us. That requires a change to the rover’s software.”

Venkat sighed. “What’s the point of this discussion if we can’t update the rover’s software?”

Jack grinned as he continued. “*We* can’t do the patch, but Watney can! We can just send the data, and have him enter the update into the rover himself.”

“How much data are we talking about?”

“I have guys working on the rover software right now. The patch file will be twenty meg, minimum. We can send one byte to Watney every four seconds or so with the ‘Speak&Spell.’ It’d take three years of constant broadcasting to get that patch across. Obviously, that’s no good.”

“But you’re talking to me, so you have a solution, right?” Venkat probed, resisting the urge to scream.

“Of course!” Jack beamed. “Software engineers are sneaky bastards when it comes to data management.”

“Enlighten me,” said Venkat.

“Here’s the clever part,” Jack said, conspiratorially. “The rover currently parses the signal into bytes, then identifies the

specific sequence the Hab sends. That way, natural radio waves won't throw off the homing. If the bytes aren't right, the rover ignores them."

"Okay, so what?"

"It means there's a spot in the code base where it's got the parsed bytes. We can insert a tiny bit of code, just twenty instructions, to write the parsed bytes to a log file before checking their validity."

"This sounds promising..." Venkat said.

"It is!" Jack said excitedly. "First, we update *Pathfinder* so it knows how to talk to the rover. Then, we tell Watney exactly how to hack the rover software to add those twenty instructions. Then we have *Pathfinder* broadcast new software to the rover. The rover logs the bytes to a file. Finally, Watney launches the file as an executable and the rover patches itself!"

Venkat furrowed his brow, taking in far more information than his sleep-deprived mind wanted to accept.

"Um," Jack said. "You're not cheering or dancing."

"So we just need to send Watney those twenty instructions?" Venkat asked.

"That, and how to edit the files. And where to insert the instructions in the files."

"Just like that?"

"Just like that!"

Venkat was silent for a moment. "Jack, I'm going to buy your whole team autographed *Star Trek* memorabilia."

"I prefer *Star Wars*," he said, turning to leave. "The original trilogy only, of course."

"Of course," Venkat said.

As Jack walked away, a woman approached Venkat's table.

"Yes?" Venkat said.

"I can't find any Diet Coke, are we out?"

“Yes,” Venkat said. “I don’t know when Site Services refills the fridge.”

“Thanks,” she said.

Just as he was about to get back to work, his mobile rang. He groaned loudly at the ceiling as he snatched the phone from his desk.

“Hello?” he said as cheerfully as he could.

“I need a picture of Watney.”

“Hi, Annie. Nice to hear from you, too. How are things back in Houston?”

“Cut the shit, Venkat. I need a picture.”

“It’s not that simple,” Venkat explained.

“You’re talking to him with a fucking camera. How hard can it be?”

“We spell out our message, wait twenty minutes, and *then* take a picture. Watney’s back in the Hab by then.”

“So tell him to be around when you take the next picture,” Annie demanded.

“We can only send one message per hour, and only when Acidalia Planitia is facing Earth,” Venkat said. “We’re not going to waste a message just to tell him to pose for a photo. Besides, he’ll be in his EVA suit. You won’t even be able to see his face.”

“I need something, Venkat,” Annie said. “You’ve been in contact for twenty-four hours and the media is going ape shit. They want an image for the story. It’ll be on every news site in the world.”

“You have the pictures of his notes. Make do with that.”

“Not enough,” Annie said. “The press is crawling down my throat for this. And up my ass. Both directions, Venkat! They’re gonna meet in the middle!”

“It’ll have to wait a few days. We’re going to try and link *Pathfinder* to the rover computer—”

“A few days!?” Annie gasped. “This is all anyone cares about right now. In the world. This is the biggest story since Apollo 13. Give me a fucking picture!”

Venkat sighed. “I’ll try to get it tomorrow.”

“Great!” she said. “Looking forward to it.”

#### LOG ENTRY: SOL 98

I have to be watching the camera when it spells things out. It’s half a byte at a time. So I watch a pair of numbers, then look them up on an ASCII cheat sheet I made. That’s one letter.

I don’t want to forget any letters, so I scrape them into the dirt with a rod. The process of looking up a letter and scraping it in the dirt takes a couple of seconds. Sometimes when I look back at the camera, I’ve missed a number. I can usually guess it from context, but other times I just miss out.

Today, I got up hours earlier than I needed to. It was like Christmas morning! I could hardly wait for 08:00 to roll around. I had breakfast, did some unnecessary checks on Hab equipment, and read some Poirot. Finally the time came!

CNHAKRVR2TLK2PTHFDRPRP4LONGMSG

Yeah. Took me a minute. “Can hack rover to talk to *Pathfinder*. Prepare for long message.”

That took some mental gymnastics to work out. But it was great news! If we could get that set up, we’d only be limited by transmission time! I set up a note that said, *Roger*.

Not sure what they meant by “long message,” but I figured I better be ready. I went out fifteen minutes before the top of the hour and smoothed out a big area of dirt. I found the longest antenna rod I had, so I could reach into the smooth area without having to step on it.

Then I stood by. Waiting.

At exactly the top of the hour, the message came.

```
LNCHhexiditONRVRCMP,OPENFILE-/usr/lib/habcomm.s  
o-  
SCROLLTILIDXONLFTIS:2AAE5,OVRWRT141BYTSWT  
HDATAWE'LLSNDNXTMSG,STANDINVIEW4NXTPIC20  
MINFTERTHSDONE
```

Jesus. Okay...

They want me to launch “hexedit” on the rover’s computer, then open the file /usr/lib/habcomm.so, scroll until the index reading on the left of the screen is 2AAE5, then replace the bytes there with a 141-byte sequence NASA will send in the next message. Fair enough.

Also, for some reason, they want me to hang around for the next pic. Not sure why. You can’t see any part of me when I’m in the suit. Even the faceplate would reflect too much light. Still, it’s what they want.

I went back in and copied down the message for future reference. Then I wrote a short note and came back out. Usually I’d pin up the note and go back in. But this time I had to hang around for a photo op.

I gave the camera a thumbs-up to go along with my note, which said, *Ayyyyyy!*

Blame the seventies TV.

...

“I ASK for a picture, and I get the Fonz?” Annie asked, admonishing Venkat.

“You got your picture, quit bitching,” he said, cradling the phone on his shoulder. He paid more attention to the schematics in front of him than the conversation.

“Ayyyyyy!” Annie mocked. “Why would he do that?”

“Have you *met* Mark Watney?”

“Fine, fine,” Annie said. “But I want a pic of his face ASAP.”

“Can’t do that.”

“Why not?”

“Because if he takes off his helmet, he’ll die. Annie, I have to go, one of the JPL programmers is here and it’s urgent. Bye!”

“But—” Annie said as he hung up.

Jack, in the doorway, said, “It’s not urgent.”

“Yeah, I know,” Venkat said. “What can I do for you?”

“We were thinking,” Jack began. “This rover hack might get kind of detailed. We may have to do a bunch of back-and-forth communication with Watney.”

“That’s fine,” Venkat said. “Take your time, do it right.”

“We could get things done faster with a shorter transmission time,” Jack said.

Venkat gave him a puzzled look. “Do you have a plan for moving Earth and Mars closer together?”

“Earth doesn’t have to be involved,” Jack said. “*Hermes* is seventy-three million kilometers from Mars right now. Only four light-minutes away. Beth Johanssen is a great programmer. She could talk Mark through it.”

“Out of the question,” Venkat said.

“She’s the mission sysop.” Jack pressed on. “This is her exact area of expertise.”

“Can’t do it, Jack. The crew still doesn’t know.”

“What is with you? Why won’t you just tell them?”

“Watney’s not my only responsibility,” Venkat said. “I’ve got five other astronauts in deep space who have to concentrate on their return trip. Nobody thinks about it, but statistically they’re in more danger than Watney right now. He’s on a planet. They’re in space.”

Jack shrugged. “Fine, we’ll do it the slow way.”

Ever transcribed 141 random bytes, one-half of a byte at a time?

It's boring. And it's tricky when you don't have a pen.

Earlier, I had just written letters in the sand. But this time, I needed a way to get the numbers onto something portable. My first plan was: Use a laptop!

Each crewman had their own laptop. So I have six at my disposal. Rather, I *had* six. I now have five. I thought a laptop would be fine outside. It's just electronics, right? It'll keep warm enough to operate in the short term, and it doesn't need air for anything.

It died instantly. The screen went black before I was out of the airlock. Turns out the "L" in "LCD" stands for "Liquid." I guess it either froze or boiled off. Maybe I'll post a consumer review. "Brought product to surface of Mars. It stopped working. 0/10."

So I used a camera. I've got lots of them, specially made for working on Mars. I wrote the bytes in the sand as they came in, took a picture, then transcribed them in the Hab.

It's night now, so no more messages. Tomorrow, I'll enter this into the rover and the geeks at JPL can take it from there.

...

A NOTABLE smell hung in the air of the makeshift *Pathfinder* control room. The ventilation system was not designed for so many people, and everyone had been working every waking moment without much time for personal hygiene.

"Come on up here, Jack," said Venkat. "You get to be the most Timward today."

"Thanks," said Jack, taking Venkat's place next to Tim. "Heya, Tim!"

"Jack," said Tim.

"How long will the patch take?" Venkat asked.

“Should be pretty much instant,” Jack answered. “Watney entered the hack earlier today, and we confirmed it worked. We updated *Pathfinder*’s OS without any problems. We sent the rover patch, which *Pathfinder* rebroadcast. Once Watney executes the patch and reboots the rover, we should get a connection.”

“Jesus, what a complicated process,” Venkat said.

“Try updating a Linux server sometime,” Jack said.

After a moment of silence, Tim said, “You know he was telling a joke, right? That was supposed to be funny.”

“Oh,” said Venkat. “I’m a physics guy, not a computer guy.”

“He’s not funny to computer guys, either.”

“You’re a very unpleasant man, Tim,” Jack said.

“System’s online,” said Tim.

“What?”

“It’s online. FYI.”

“Holy crap!” Jack said.

“It worked!” Venkat announced to the room.

...

[11:18] JPL: Mark, this is Venkat Kapoor. We’ve been watching you since Sol 49. The whole world’s been rooting for you. Amazing job, getting Pathfinder. We’re working on rescue plans. JPL is adjusting Ares 4’s MDV to do a short overland flight. They’ll pick you up, then take you with them to Schiaparelli. We’re putting together a supply mission to keep you fed till Ares 4 arrives.

[11:29] WATNEY: Glad to hear it. Really looking forward to not dying. I want to make it clear it wasn’t the crew’s fault. Side question: What did they say when they found out I was alive? Also, “Hi, Mom!”

[11:41] JPL: Tell us about your “crops.” We estimated your food packs would last until Sol 400 at 3/4 ration per meal. Will your crops



affect that number? As to your question: We haven't told the crew you're alive yet. We wanted them to concentrate on their own mission.

[11:52] WATNEY: The crops are potatoes, grown from the ones we were supposed to prepare on Thanksgiving. They're doing great, but the available farmland isn't enough for sustainability. I'll run out of food around Sol 900. Also: Tell the crew I'm alive! What the fuck is wrong with you?

[12:04] JPL: We'll get botanists in to ask detailed questions and double-check your work. Your life is at stake, so we want to be sure. Sol 900 is great news. It'll give us a lot more time to get the supply mission together. Also, please watch your language. Everything you type is being broadcast live all over the world.

[12:15] WATNEY: Look! A pair of boobs! -> (.Y.)

...

"THANK YOU, Mr. President," Teddy said into the phone. "I appreciate the call, and I'll pass your congratulations on to the whole organization."

He terminated the call and put his phone on the corner of his desk, flush with the desktop's edges.

Mitch knocked on the open door to the office.

"This a good time?" Mitch asked.

"Come in, Mitch," Teddy said. "Have a seat."

"Thanks," Mitch said, sitting in a fine leather couch. He reached up to his earpiece and lowered the volume.

"How's Mission Control?" Teddy asked.

"Fantastic," Mitch said. "All's well with *Hermes*. And everyone's in great spirits thanks to what's going on at JPL. Today was a damn good day for a change!"

"Yes, it was," Teddy agreed. "Another step closer to getting Watney back alive."

"Yeah, about that," said Mitch. "You probably know why I'm here."

“I can take a guess,” said Teddy. “You want to tell the crew Watney’s alive.”

“Yes,” Mitch said.

“And you’re bringing this up with me while Venkat is in Pasadena, so he can’t argue the other side.”

“I shouldn’t have to clear this with you or Venkat or anyone else. I’m the flight director. It should have been my call from the beginning, but you two stepped in and overrode me. Ignoring all that, we agreed we’d tell them when there was hope. And now there’s hope. We’ve got communication, we have a plan for rescue in the works, and his farm buys us enough time to get him supplies.”

“Okay, tell them,” Teddy said.

Mitch paused. “Just like that?”

“I knew you’d be here sooner or later, so I already thought it through and decided. Go ahead and tell them.”

Mitch stood up. “All right. Thanks,” he said as he left the office.

Teddy swiveled in his chair and looked out his windows to the night sky. He pondered the faint, red dot among the stars. “Hang in there, Watney,” he said. “We’re coming.”