

*THE MARS FRONTIER*

*Vol. 3*

*The Settlement*

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1.

Commander

Aug. 16, 2024

The high-definition video screen in Habitat 2 was a meter and a half square and gave a vivid color picture of the scene at Cape Canaveral, Florida. Surging across the image was a sea of protesters twenty thousand strong—the largest protest ever seen at the Kennedy Space Center. The reporter was summarizing the battle with police and National Guardsmen, which had included generous use of tear gas.

In the lower right corner of the image, in addition to the date—August 16, 2024, which happened to be the date according to the Aerogregorian calendar as well as the standard terrestrial calendar—was the countdown. The television network abruptly switched away from the angry crowd to the Swift Shuttle—a cone-shaped reusable rocket thirty meters tall—sitting on a simple launch pad. It was not at Kennedy Space Center, however, but on little San Salvador Island, Christopher Columbus’s first landfall in the Bahamas, 500 miles southeast of Kennedy. It was the Swift Shuttle’s base of operations, and beyond the reach of the frustrated protestors.

The countdown clock rolled over to t-minus 15 minutes. “Another quarter hour to launch,” said Roger Anderson, with a smile. “One Swift shuttle with five nuclear reactors on board. Too bad, protesters.”

“Let’s hope none of their friends have purchased stinger missiles,” noted Will Elliott. There had been a terrorist incident recently with a Stinger surface to air missile and a passenger jet, and the media had focused a lot of attention on the possibility one could bring down a shuttle full of reactors.

“That would be pretty crazy, wouldn’t it; protesting the launch of a shuttle with nuclear reactors because you fear the shuttle might crash and dump uranium in the ocean, and then shooting the shuttle down to make your point. I suppose there are people crazy enough to do that.”

“I fear there are. At least there won’t be any more protests of this sort for twenty-six months, since they’re launching a two-year supply of reactors.”

“The protesters are idiots,” said Roger, who had no sympathy at all. “The Swift Shuttle’s safety is estimated at one crash per 2,000 flights, and now that it’s being used as a hypersonic cargo delivery vehicle, the safety claim has some history to back it up. And they estimate that the reactors are practically indestructible. No one can even propose a scenario where uranium would be released into the environment, and if it was, it is relatively harmless anyway.”

“Roger, I know.”

“Hey, Will, I’m just telling you this because you’re too liberal!” Roger tapped Will on the shoulder, partly out of affection. After a year and a half, they had gone from geological rivals to friends, in spite of their personality, religious, and cultural differences.

Will smiled. “I’m not sympathetic to this. The protest is really a publicity stunt and a way to whip up the emotions of the faithful. Those reactors don’t pose any reasonable or significant risk to anyone or anything. We need our two, and the moon needs its three; and rather badly.”

“Reactors are being built all over the earth again to make electrical power; the new generation is cheaper and much safer. The alternative is to remain at the mercy of

the petroleum exporters and their declining output, while melting the polar caps. It's crazy." Roger shook his head.

"Let's be thankful NASA caved in and was willing to use the Swift shuttles to launch the reactors," noted Will.

Roger nodded. "NASA had to admit they're safer; even better, the launch is hundreds of miles from any protesters. I doubt they'll use the Swift for anything else any time soon."

"It's a controversial vehicle design for them, and they say it doesn't meet the man rating requirements" replied Will, trying to justify the decision.

"They should get over it," replied Roger. "The second stage is basically a Mars shuttle fueled with hydrogen instead of methane, with larger fuel tanks and a smaller cargo hold. Dr. Swift avoided several thousand hours of wind tunnel tests as a result, and the resulting vehicle should be man-ratable. The first stage may be harder to man rate because it's an original piece of technology and because it goes straight up, in order to return to the launching site. I admit, the launch profile is strange, but it's not inherently dangerous. The second stage lands using a parawing, which should be safe enough for man-rating."

"I knooooow," said Will, exaggerating the word. Roger had been in a didactic mood this sol. "I'm intrigued that the Swift could refuel in low earth orbit and fly to the moon or even here, where it could serve us as a Mars shuttle. All the experience flying it to low Earth orbit will no doubt result in improvements, which will make our shuttle more reliable as well."

“And cheaper, since the Swift will get a lot more hours of flight time and dollars of investment,” agreed Roger. “Maybe some day.”

Will’s attaché—a computer about the size of a clipboard, but a bit thicker—beeped nearby. That meant it had received an incoming message from Earth. He walked over and looked at its screen, which had flashed alive with a display. Dr. Harold Lassen, Director of Mars Mission Operations, had sent a videomail. Will pushed a few buttons on the screen to transfer the audio to his earpiece, and pushed play.

“Good afternoon, Will. I hope all is well with you and Ethel and the pregnancy is continuing smoothly. You have now been on Mars a respectable three and a half years. Your leadership in exploration and development of the Outpost has been consistently excellent in quality and usually quite far-sighted. Looking back over the record of Columbus 1 and Columbus 2, now drawing to a close, we can see that you have been a key player in many of the most important milestones in Mars exploration.

“Therefore, after considerable discussion and deliberation, we are making you Commander of Mars Operations, to commence with Columbus 2’s trans-Earth injection later tonight, and to continue until the arrival of Columbus 3 some nine months from now. I should add that Jerry McCord is the Commander of Columbus 3, as you already know, but we have decided to use the ‘Columbus’ designation henceforth only to refer to the flight phase. Once the Columbus vehicles arrive in Mars orbit, they are subject to the Commander of Mars Operations. We have not yet decided who will be that Commander, starting next May. It could be you, Jerry, or someone else.

“Congratulations on this appointment. We look forward to see the results. Good bye.”

Will watched Lassen's face fade from the screen, surprised. Perhaps 'shocked' was not too strong of a description of his feelings. Roger Anderson had been designated Commander of Mars Surface Operations by Sebastian Langlais, overall Commander of Columbus 2, with Mission Control's blessing. He had expected Roger to continue as their leader, especially since Ethel's unexpected and accidental pregnancy had cast a pall over him.

He rose and left the habitat quietly, attaché dangling from his belt. He headed for the industrial area, where Ethel was hard at work making iron beams. At the moment she had the metal separating and fabricating unit open and was cleaning the fractionation column, where different metal carbonyls condensed at different levels. At the bottom of the column, nickel-iron meteor fragments were exposed to heated carbon monoxide, creating a metal-carbonyl gas that could be converted back to a solid inside a mold. Several iron beams cast from liquid iron carbonyl, periodically punctuated by holes for rivets or bolts, lay on the floor, the product of yestersol's labor.

"Ethel," he said. "I just got this message from Lassen."

"What is it?"

"He's appointing me Commander until Columbus 3 arrives, and maybe after that date as well. Here, watch." He put down his attaché and played the video message again, with the sound coming out the speakers. Ethel listened, surprised.

"I thought Roger would get the position. You and I are tainted, after all. Well, congratulations, dear!" she kissed him.

"Thank you."

"You should tell everyone; send a quick email to the list."

“I will. Usually Lassen waits about two hours, then releases the information to the public. I need to thank him, as well. The Public Information Office may want to schedule a press conference, too.”

“I suppose I’m prejudiced, but it’s about time you were made Commander.” She kissed him again. “Now I had better get back to work.”

“Okay.” He kissed her in return and headed back to Habitat 2. He glanced at the television screen; the Swift Shuttle was still counting down. He continued to his apartment, where he emailed Dr. Lassen a thank you and sent a brief notice to the listserver of all crewmembers on Mars.

*Commander!* He was excited and more than a little gratified by the promotion. He had been de facto commander two years ago, during the interval after Columbus 1’s departure and before Columbus 2’s arrival. But the Outpost had only had three people in it at the time; now it had nine, far more than anyone would have imagined it would have. He and Ethel had worked steadfastly on creating an atmosphere of friendship and collegiality, bringing the eleven people of the Columbus 2 mission together, and they had served as role models that prompted one marriage and might yet prompt a second. He had also led the effort to build their first pressurized building from Martian materials and had suggested a new approach to exploration that had resulted in far longer expeditions than had been planned. And in return, initially he, Ethel, and Shinji had been practically stripped of any authority and responsibility, since the eight arriving from Earth already had been given all responsibilities for running the place. It had been a difficult eighteen months, especially the first six.

But now he was in charge. He left the apartment and walked through Greenhouse 1, past the entrance to Habitat 2, through Greenhouse 3, enjoying the luxuriant growth of vegetables, wheat, rice, corn, and fruit trees, with a fuzzy view through the plastic of the Aurorae Valley and its steep 1.5-kilometer escarpment to the north. After three and a half years, their greenhouses were now well established and able to grow almost all the food they needed, though the resulting diet was monotonous.

From Greenhouse 3 he followed a short, plastic pedestrian tunnel to the Mars Life Sciences Facility. The tunnel had become a greenhouse annex, with a series of pots half-occupying the floor space and growing herbs, trees, and flowers. He crossed the life science facility, which was designed to study any Martian life they ever found, but currently was being used to study Martian microfossils instead. Then he walked past Ethel again, for she was in the industrial facility that provided the Life Science Facility with its second connection with the rest of the Outpost; everything had two exits for safety. Finally, Will walked through Greenhouse 4 and then 2, returning to Habitat 1. The far southern end of Greenhouse 4 connected to a suit donning facility, and out its windows Will could look southward across a rolling stony plain, interrupted only by cleared circular launch and landing areas for the Mars shuttles. He also could look to the right—west—and see a tall sandstone butte nearby with a craggy outline at top that vaguely resembled a face in profile; aptly enough, it was called Face Rock.

Having made a quick tour of his realm, he returned to Habitat 2. The Swift Shuttle had reached the end of its countdown. Its powerful methane and oxygen first stage engines flamed alive and the vehicle rose rapidly into the sky on an orange-tinged blue flame, accompanied by smoke and a mighty belly-shaking roar that was captured by their

big screen's speakers. As always, a launch was an awe-inspiring sight and it reminded Will of his dozen flights to low Earth orbit from Kennedy and Kourou, riding Ares 1s and Ariane 5s.

Will turned back to his attaché because it had beeped; another videomail had arrived from Earth. It was from Heather Kimball, an old friend of his and fellow lunar explorer—the first woman to walk on the moon—who was the new head of the Mars Exploration Society.

“Good sol, Will. ‘Good sol’ is so much easier than good morning or good afternoon; I don’t have to look up the time at the Outpost to use it. By the way, the Mars Exploration Society is now answering its phones with ‘good sol’; it’s a nice touch.

“I was watching the countdown of the Swift shuttle launch when across the bottom of my screen rolled the announcement that you had been selected to be interim Commander of Mars Operations, with Jerome McCord as Commander of Columbus 3 until it reaches Mars orbit. I thought I should videomail you right away and be the first to congratulate you. I can’t tell you how happy I am; I hope it becomes permanent. The only way the MES will be effective is if it can establish strong relations with the space agencies around the world responsible for exploring the Red Planet, and I think a good relationship with the explorers themselves is important as well. We have a long friendship and I hope we’ll be able to collaborate in many ways to foster common goals.

“I’ve heard rumors for weeks that you might be interim commander. I gather, from my sources, that some people have favored McCord all along; he has commanded Shackleton for several six-month tours of duty, he’s fifty years old, and this trip is the cap of his career. He’s been the Mars capcom on many occasions and works very well with

people, too. Others have favored you. So it sounds like this arrangement is a compromise between the two parties. In a sense, it's also a defeat for the McCord supporters; he was commander of Columbus 3, after all, and that designation had referred to the entire thirty-month period.

“Anyway, I doubt you're very familiar with the internal discussions. Anything anyone says to you has to be in written or recorded form, and people don't want to be frank under those circumstances. You need a confidential set of ears in Mission Control, I think.

“Best wishes with your new responsibilities. Let's find ways to collaborate. Bye.”

Will thought about the message and wondered what would happen if he collaborated with the MES. It was the sort of action that would greatly concern and worry Mission Control. Certainly, it was not a wise move as commander for the next nine months. He hit reply and spoke his reply softly.

“Good sol, Heather. Thanks for your call and congratulations. I really appreciate both. We need to think carefully about ways we can collaborate that will be appreciated and supported by Mission Control. You and Lassen are good friends; perhaps the two of you should brainstorm about things the two of us could do. This is not a good time for me to rock the boat, if your comments are any guide. Let me know if you have some specific ideas. Bye.”

He sent the message and turned to the television screen. The Swift shuttle's first stage's main engines had gone out and only verniers were thrusting, to help gain altitude. Then at sixty kilometers altitude they went out and the stages separated. The second stage

fired its thrusters slightly, pulled ahead of the first stage, turned ninety degrees, and fired its main engines horizontally.

“Perfect firing,” said Roger. Then he added, “was that Heather Kimball you were talking to? How’s she doing?”

“Pretty well, I guess.”

“What was she calling you about?”

“She was congratulating me. I got a call from Lassen, too, and since then he has released the news. As of trans-Mars injection tonight, I’m Commander of Mars Operations.”

“Oh?” Roger was startled; he was currently commander, after all. “It would have been nice if they had told me, too!”

“Maybe they did; check your attaché. I got the message a few minutes before blastoff.”

“Oh; that recently. Well, congratulations.” He offered his hand. “It’ll be an interesting nine months; eight full time personnel, a pregnant lady, and a baby before the end!”

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That evening, the Columbus 2 complex in orbit around Mars separated into its separate vehicles. There were two Interplanetary Transit Vehicles or ITVs, the *Ausonia* and *Solis*, each shaped like a long capsule, six meters across on the bottom and thirteen meters long; each could hold four crewmembers comfortably, recycling their wastes for up to a year. Since only two members of Columbus 2 were flying back to Earth, they were both in one

ITV; the other was empty. A third ITV was also present, the *Syrtis*, but it was staying in orbit around Mars.

There were also three shuttles present; the *Olympus*, docked to the ITV *Ausonia*; the *Hadriaca*, docked to the *Solis*; and the *Elysium*, which had Paul Renfrew, Carmen Segovia, and Érico Lopes in it. They had arrived from Deimos just a sol earlier and had transferred a hundred kilos of samples to the *Olympus*.

At just the right moment, when the vehicles were skimming the top of the Martian atmosphere, the two shuttles with ITVs attached lit up their engines for two and a half minutes. When their engines shut down, the shuttles and ITVs were on their way to Earth.

The entire crew exchanged goodbyes by video.

“See you all on Earth at some time in the future,” exclaimed Sebastian. “I’ll follow the development of Mars closely and hope to collaborate with all of you. And congratulations to Commander Elliott for his new position.”

“Thank you, Commander Langlais,” replied Will. “We’ll miss you here. Have a safe journey back to Earth.”

## Politics

mid to late August, 2024

By midmorning the next sol, the *Elysium* was back at Aurorae, bearing Paul, Érico, and Carmen. The Mars shuttle had made its third flight, the last one scheduled before it flew back to Earth in another two years; it had performed flawlessly. Since its parachutes had been deployed on the first landing and were not reusable, the engines had to cancel out all the shuttle's velocity after it completed atmospheric entry; some 5,000 kilometers per hour.

At supper that night, Érico rose. "We have a presentation to make," he began. "It's simple, but the best the three of us could do when we heard that Will would be our new commander." He reached into his pocket and pulled out a grayish rock. "One piece of Deimosian chondrite, for your rock collection."

Will laughed. The others chuckled and applauded; everyone knew that Will had a small rock collection that he had planned to leave on the Earth, but because of an explosion in the engine of a lunar Lifter, it had come to Mars with him instead. He accepted the rock and looked it over curiously. "Very nice; a good, typical specimen. Thank you." He sat. "So, tell us about the visit to Deimos."

"What's there to say?" said Paul. "You were listening in. The place looks like Phobos; meteor-smashed bedrock covered with fluffy regolith. But we found some outcrops, and there were some pretty spectacular cracks to explore. I got fifty meters down inside one of them."

“The new location for the driller is much better for fuel making,” said Carmen. “I wish we had had better seismic and radar data two years ago when we landed it.”

“Well, it made enough fuel for your visit and return here, so it served its purpose,” replied Will. “And I gather this new location should allow full production?”

Carmen nodded. “One hundred tonnes per year. When Columbus 3 arrives, the Lifter will be refueled and then some.”

“Good,” said Will. “And the ITV *Ausonia* is mothballed with the docking unit and the manipulator arm.”

Paul shrugged. “Of course, as usual.”

“I’ve been thinking about orbital operations a lot in the last few sols,” said Will, to explain his stray comment. “We’ve had one or two ITVs in the same orbit for four years, now, the ‘High-Elliptical One-Sol Orbit’ where we’re supposed to have a station eventually.”

“You mean the so-called HEOSO Station?” asked Ethel. “That’s scheduled for Columbus 4 or 5.”

Will nodded. “We’ve actually had HEOSO Station for four years; there’s always been at least one ITV there, plus a docking unit and above all, the remote-controlled arm. The only thing it doesn’t have that HEOSO will is a Lifter, and we can station one there any time we want. I think it’s time to give the place a permanent name and start developing it as our interplanetary transportation nexus.”

“What will mission control say?”

“I don’t know. Fact is, HEOSO was supposed to come into existence when some Columbus crew stayed an extra columbiad, which meant an ITV had to stay. That happened with Columbus 1! That’s why I said it really has existed for a while.”

“What would you call it?” asked Ethel, curious.

“A name is very important. In this case, it’s the difference between a collection of ITVs and a designated station.” Will paused. “I’d call it Embarcadero Station. It’s the best I’ve been able to come up with. It will be our equivalent of Gateway Station, the jump-off point for transportation beyond Mars. The ‘embarcadero’ is the old wharf district of San Francisco’s waterfront.”

“A good name,” agreed Érico.

“Spanish,” added Carmen, pleased.

“You’re always innovating,” said Ethel, admiringly.

“Embarcadero Station it is, then,” replied Will.

“It’s easy to pronounce in various languages, too,” pointed out Paul. “Mission Control shouldn’t mind, since it’s just a name change.”

Carmen looked at him. “True, but it’s a shame we can’t actually *use* the place as an embarcadero, a place for loading and unloading passengers and cargo from ships.”

“Well, I’ve been thinking about that, too,” replied Will. “As you know, our shuttles are designed to lift themselves, four crew, and a tonne or two of cargo plus twenty-four tonnes of methane and oxygen fuel to Embarcadero. But now that we have fuel from Phobos, we can replace the twenty-four tonnes of fuel from the Martian surface with other things. Furthermore, the Lifters that push the automated cargo vehicles to Mars have to go back to Earth, as do the ACVs, since they’re reusable. The plans for

shipping cargo back to Earth are already pretty well developed; it's just that they're supposed to be implemented by Columbus 4 or 5."

"Are you thinking we should implement them instead?" asked Ethel, surprised.

"We should consider it. Each mission needs about thirty-six tonnes of xenon for the ion tugs, which has to be put into Earth orbit at six million bucks per tonne. Next year the new tugs will use argon instead to save money. I don't know how much argon we can make here in the next ten months—"

"About . . . eight to ten tonnes," interrupted Ethel.

"Okay. Then there's nitrogen we could sell to the moon; they have to import it from Earth. The current cost is thirteen million per tonne; after they switch to the Swift shuttle to low earth orbit and the ion tugs switch to argon, the cost will be two and a half million per tonne. And each Lifter can haul twenty to twenty-five tonnes of methane back to Earth."

"Where would the argon and nitrogen be put?" asked Roger, skeptical.

"The shuttle has enough tank capacity to lift it to Embarcadero, and there we would transfer it to empty tanks on the Lifters," replied Will.

"But it's scheduled for Columbus 4 or 5," groused Roger.

"Yes, but we have everything we need to inaugurate it now."

"And the methane would be burned with spare oxygen in Earth orbit?" asked Paul, trying to remember the plan.

Will nodded. "As long as the engines burn a hydrogen-rich mixture, the conversion of water to hydrogen and oxygen fuel generates 18 tonnes of waste oxygen per hundred tonnes of water. Most of the waste is vented into space. Methane will

convert it into a saleable product. Three Lifters could haul enough methane back to Earth orbit to fly all of Columbus 4 here if the oxygen's available."

"And it will!" said Érico, making a mental calculation. "Right now I think they're venting almost 100 tonnes per year, between low Earth orbit, Gateway, and Shackleton."

"Even Shackleton will buy our methane," added Paul. "They've got a serious carbon shortage on the moon."

"Exactly," said Will. "Each tonne of methane will be worth ten million bucks at Gateway or the moon, until the Swift shuttle reduces its cost. Or we can burn it on Columbus 5 and reduce its launch costs twenty percent."

"And if we supply our own argon there would no longer be a need to lift argon from the Earth," added Ethel. "That would increase our cargo by a third."

"It's a shame NASA won't let us do more things to earn them money," said Paul. "Columbus 1 hauled eight tonnes of samples to Earth. Columbus 2 is hauling twelve tonnes. That's twenty tonnes of rocks and dust, and only about four tonnes have been distributed and analyzed. Meanwhile, because of sloppy security at campus labs, three kilograms of the samples have disappeared. And much of that is for sale on the black market for two hundred dollars per gram; that's twenty times the price of gold!"

"It's crazy," agreed Ethel. "Especially if they sold Martian samples, there would be no security problem for the scientific labs."

"But their point of view makes sense," objected Roger. "First, commercial priorities could take away from our scientific purposes here; second, once some income comes in, there will be pressure to cover as much of our expenses as possible, and inevitably people will complain we are failing to cover them."

“I wonder if we can find a happy balance, though,” said Will. “Some day, Mars will have to be partially scientific and partially commercial. There will be a transition from outpost to settlement, with people living here decades and raising their children here.”

“Like us,” noted Ethel, nodding.

“Some day, commercial considerations have to begin,” agreed Paul. “We can export maybe sixty or seventy tonnes of methane from the moons next year. If we export sixteen tonnes of samples and they’re worth the same as gold—ten million per tonne—that would be another 160 million. That’s a lot of money; maybe five percent of the annual cost of running this place.”

“But the next five percent would take a lot of our time,” said Roger. “That’s what would worry me; a creeping set of expectations, to raise our ‘contribution’ from ten percent to twenty, then to thirty. . .”

Érico nodded. “It’s a risky strategy, politically.” He looked at Roger, who looked back at him, a bit surprised; the two of them usually disagreed.

“Well, this isn’t the time to resolve the matter,” said Will. “I’ll ask Mission Control. Meanwhile, one task I want us to carry out for the next nine months is stockpiling argon, nitrogen, fossiliferous samples, and methane. It won’t take much time; the gasses are recovered automatically, and we always have lots of spare samples lying around.”

“I have a much simpler request,” said Madhu. “Could we make a request to Mission Control for a wedding package. It has to include a proper wedding gown and a three piece suit or tuxedo. I’d also like to make some changes to the ecological mix we’re

importing to include more flower species; we need more than daisies for weddings! I want some roses, maybe orchids, carnations, fuchsia.”

“And we drank all the booze,” added Roger. “Now we’ll be dry for nine months. We need to import more wine and champagne.”

“I’d import more spices; we used most of them up, too,” complained Madhu.

“Speaking of ecology: I want cotton,” said Ethel. “We can’t make anything as absorbent from plastics, and we need diapers!”

“Cotton is coming,” replied Madhu. “Meanwhile, Mission Control is doing research on cotton substitutes from waste plant matter, at least for absorbing liquids. I think they’ll work fine.”

“If there’s anything I’d like, it’s real paper,” exclaimed Will. “Electronic paper is just not the same. Can you make paper from the plant matter we have here?”

Madhu shook her head. “We lack the equipment. The plant matter could be used for that with the right equipment, though.”

“Good to know,” said Will. He looked at everyone. “We have nine months together before Columbus 3 arrives. We have a plan from our meeting in late December. We’re in the dust storm season for three more months, so we have to stay pretty close to the Outpost. Then we have three or four months before we can head for the northern lowlands again; a good time to explore the western end of Marineris and see whether we can get up onto the Tharsis Plateau. And we have a lot of preparations to complete for Columbus 3’s arrival. Do we have any changes?”

No one spoke. Then Roger said “We’ll get back to you.”

“Okay,” said Will.

-----

Part of that night, Will thought about the dinner conversation. The next morning he called up the website with Columbus 3's latest cargo manifest. It was a massively detailed, tedious, exhausting database to review, and he had maintained only the most cursory familiarity with it in the past. Just an item like "Truck 3, 2,187.3 kg" was deceptive. A left click on the entry expanded it into eight subsystems, each of which could also be left-clicked on to reveal sub-subsystems. Eventually one got down to the smallest individual part and its mass. A right click on any entry pulled up reports about that item, its components, their properties, the tests performed on the item, its history, the previous versions of the item, even the future improved versions being considered. As a result, as Mars made more and more items, vehicles could be sent partially assembled with missing parts described and reported on, but having to be supplied by the Outpost on arrival. A small army of webmasters and inventory specialists maintained the database on Earth. As the items were used up and as they aged, reports about each item's condition and fate would be added.

As Will explored the database—which was updated on the Outpost's computers four times per sol—he noted that most of the items had already arrived at Gateway Station, the departure point for Mars hovering some 60,000 kilometers above the moon on its Earth side. A cargo pallet was in the final stages of preparation for launch into low earth orbit next week, where an ion engine would slowly but efficiently spiral it up to Gateway over six weeks time. The crew would head to Gateway on two different vehicles in early November and were taking about four tonnes of consumables each. There was also a flight to Shackleton in early October that could take a tonne or two of supplies; the

astronauts would spend four days at Gateway and launch the three automated cargo vehicles on a minimum-energy trajectory to Mars.

Furthermore, many of the items for Columbus that already were at Gateway could also be used on the moon. Consequently, Will realized, there was some flexibility in the cargo manifest, even at this late date. The cargo manifest was largely determined by Mission Control, but the Commander could play a role. And he had ideas about how it could be changed. The next morning after breakfast he started by talking to Madhu.

“We need to make this place more comfortable,” he said. “Shackleton is set up for four to six month tours of duty because of its proximity to the Earth; it’s a place of hard work and simple conditions. Then there’s the new lunar tourist hotel, which is quite different. The Mars Outpost was modeled on Shackleton, but we stay at least eighteen months, and it is now clear that many people will stay forty-four months, and others, like Ethel and myself, will stay even longer. If we want to make Aurorae Outpost a place where people can stay for one or two decades and raise a family—where people will want to stay that long—what do we have to do?”

“Greenery,” she replied. “I’d say that’s the big need. I can’t tell you how often, when I walk into a Greenhouse to do some work, I find someone sitting under trees or amidst the vegetables with their attaché, working. We need bigger green spaces, and green spaces where we can socialize together.”

“I didn’t think of that.”

“What have you thought of?”

“Better food. If we have a wider range of species and more places to raise them, and we import a wider range of spices, you’d be empowered to cook a wider range of things. There would be less monotony in our diet.”

Madhu nodded. “I argued with Sebastian about that, but he overruled me.”

“Well, maybe I can change it back. What did you want?”

“I’ll find the email and forward it to you. It was a lot; 466 kilograms, but even some of it would help. Spices, cooking chocolate, pomegranates, Coca-Cola extract, a wider range of wines. . .you get the idea.”

“You mean, we’d have Coca-Cola here?”

She nodded. “We’d have to supply the carbonated water, sugar, and a few other items, and the company would pay for the shipment in return for the right to advertise our use of the product. We can get many of the items on my list for free.”

“Interesting. What do you think of the idea of doing more with dinner; singing, movies, etc.?”

She shrugged. “You organize it! I have to handle the food and cleanup.”

“Maybe we can talk about the idea more. I want to make life here more pleasant and knit together. I’d love to see much of Columbus 3 want to stay here. If we could keep ten people every two years, the Outpost’s population would reach fifty in a decade. Imagine what we could do with fifty.”

“I get the idea, so I’ll keep thinking.”

“Thanks.” Will headed over to the industrial area, where Ethel was already hard at work.

“My dear, I was just talking to Madhu about items she wishes we had gotten onto Columbus 3. She actually has quite a list; about half a tonne of spices and other items that could greatly improve the quality of the food.”

“I know of a few items we needed to get on the flight as well. Lisa Kok is on her way to serve as a horticulturist and mechanic here. She’s also very capable as a craftsperson. Some of the manufacturing equipment she needs is in the cargo manifest; there’s a robotic clay molding machine, for example, and I think the knitting machine was included. But the robotic loom didn’t make it, and it’s capable of making rugs as well.”

“How much mass?”

“Four hundred kilograms. But last week there was a study by the manufacturing unit in Houston that it can be reduced to two hundred kilos; we can make the other parts here. Of course, making the parts and assembling them will take about three person months of work.”

“How can we include it?”

“There’s only one way: making more daring assumptions about what we can make here. For example, we’re importing one hundred kilos of lubricant for the vehicles for the next two years. But we’ve managed to save fifteen kilos over the last year and a half, and we’ve kept forty kilos of dirty lubricant. There are ways to filter it better so that some of it can be reused. And there’s a study that we can take soybean oil, animal grease, and a few other locally available ingredients and make a half decent lubricant, especially if it’s mixed with imported lubricant. I think we can import forty kilos instead of one hundred.”

“How many savings of this sort can you identify?”

Ethel shrugged. “I don’t know. Most of them are controversial or risky; if the lubricants don’t work, we can’t drive the rangers! The biggest savings I can think of is the 350 kilograms of copper wire we’re importing. We can make copper wire here, though we haven’t tried. We know we can make the wire from weldalite—we’ve got two tonnes of weldalite we can strip off of unusable cargo landers—and if that didn’t work, we could always make wire from iron! It conducts electricity fine over short distances.”

“Would the quality be high enough?”

“That’s less certain. But we could always use it to replace the wiring between the Outpost, the solar power units, and the spaceport. That’s high quality wire and it’s running on top of the ground.”

“That would take a week or so of work. If we eliminated the wire and the lubricant, we could import the stripped down power loom and most of the food supplements. A few hundred kilos can be flown to Gateway in November with the crew.”

“But there’s already wire and lubricant at Gateway, waiting to fly here.”

“Both can be used on the moon. Let’s say we embarked on programs to simulate lubricant and make copper wire. Could we demonstrate both in the next two months?”

Ethel nodded. “That should be plenty of time.”

“Can we accommodate them in the work schedule?”

“I suspect we can. The manufacturing schedule is very slow for the next four or five months; we’re scheduled to do a lot the last few months before Columbus 3 arrives.”

“Okay, I’ll take a look at these projects right away. We’ve found low grade copper ore at several localities nearby. I suspect a ranger and two astronauts could dig up enough ore in a week to make a few hundred kilos of wire.”

“Refining the copper is extremely easy, also, because in an acid solution with pure iron present, copper oxide and carbonate will convert to copper and the iron will oxidize. We have tonnes of meteoritic iron lying around.”

“Good. I’m going to work on this.”

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By the next sol, Will had a plan; one that Madhu and Ethel were enthusiastic about, Paul supportive of, and Mission Control willing to permit. Madhu got to work right away collecting the soybean oil and other natural oils that Paul would need to supplement the lubricant. Meanwhile, Paul started refiltering the old lubricant repeatedly and synthesizing several chemicals needed either to bind with and remove impurities or replace some of the oils that broke down when the lubricant was used. He immediately found that he had to modify the techniques that had been developed, but the results were good.

Will persuaded Shinji to go out with him in a ranger and they stopped at every rock outcrop in the area where traces of copper had been found. The first sol they found the easiest pieces, sandstone and basalt streaked with malachite and azurite right below or above ancient lava flows. The next sol was frustrating, as there was little else that was loose, so the third sol they went out with pickaxes and chipped away at an outcrop that proved to have a respectable supply of copper. By the end of the sol they had sore muscles, but an adequate supply. Ethel promised to run it through the rock crusher;

meanwhile, she and Paul had to make the acid. Will promised to run the manufacturing equipment so that she would have the time.

The next morning, Will was resting his muscles and sitting at his desk in the bridge considering other minor modifications he could propose to the cargo manifest when he received a videomail.

“Dr. Elliott, you don’t know me, so allow me to introduce myself; I am Carl Reed of the Committee to Reelect the President.” The man was tall, with very closely cropped blond hair, fastidiously dressed, with a picture on the wall behind him of the President shaking his hand. “It was suggested that I give you a call. As you may know, the presidential campaign this year has several focuses, and an important one is strengthening and preserving the family. While NASA has been resistant to the creation of stable families on Mars, it occurred to the campaign the other day that what you have done on Mars is of great symbolic significance to the President’s priorities, and has the potential to reinforce and highlight some of the platform’s planks. Furthermore, if you were willing to speak out in favor of strengthening and preserving traditional family values, it would strengthen our hand in helping the space agency appreciate the approach that you have taken.

“Therefore, we were wondering whether you were willing to make a taped statement that could be used in the campaign, endorsing the President and his policies in favor of a strong family. It strikes us as a mutually beneficial effort. I’m attaching to this video mail a text file listing some of the talking points that occurred to us. Let us know what you think, please. And best wishes with all your efforts up there. Goodbye.”

Will stared at the screen and felt his anger slowly rising. Was there the implication that the White House would lean on Mars Operations in a reciprocal arrangement? He was a celebrity, but should the Mars Commander get drawn into terrestrial politics? Furthermore, he was a member of the Bahá'í Faith and thus had not joined any political party, nor could he endorse a candidate for anything.

But this was a dangerous situation; the reelection campaign was run out of the White House. The people asking him for a favor were powerful. Best to ignore the request for now and think about what to say in return.

By late afternoon he hadn't progressed much on a response. He went to Habitat 3, where Ethel and Roger were helping Madhu with food preparation.

"I don't see any connection at all between two coincidental marriages, an accidental pregnancy, and the current administration's so-called family-centered policy, which amounts to restricting abortions as much as possible, driving people off welfare, and refusing to pay for child care," complained Ethel.

"I think it's brilliant," replied Roger. "The link is psychological, and that's the way politics works."

"Well, maybe you should make the statement instead," said Will.

"So you won't do it?"

"I don't think the Commander of the Mars Operations should endorse politicians. Otherwise, he has to endorse French candidates, British candidates, etc. That is not the Commander's role."

"Theoretically, yes. But Will, this is how it works in practice. Everything is political. Everyone makes endorsements."

“I know, Roger. But what we are talking about, in practice, is two gigantic machines that wring money from special interests, get their own people in power, and lie to the voters in order to get elected.”

Roger shrugged. “That’s the way it is. As Churchill said, democracy is the worst form of government in the world until you consider the alternatives.”

“Well, there is a better alternative.” Will’s voice trailed off.

Roger frowned. “Oh Will, are you talking about Bahá’í stuff? You are free to hold to your theoretical and private ideas, but I wouldn’t drag them into this situation.”

“Roger, Bahá’ís are not allowed to get involved in partisan politics. So I can’t—I won’t—endorse anyone.”

He shook his head. “Suit yourself. Of course, I know your own private political leanings are more liberal than those of our President.”

“I don’t think I should endorse any candidate, regardless of his or my political position.”

“I think your argument that the Commander shouldn’t endorse candidates is strong,” said Ethel. “I quite agree with it. The argument can even be made that we’re too busy to keep track, and that we are not part of a local political jurisdiction, so we really don’t have a role in national politics.”

“I agree; I think the Commander should stay out of politics,” said Madhu. “I’ve never heard of the NASA Administrator or the head of Lunar Operations endorsing a candidate.”

“One, they’re not famous; and two, they’re political appointments anyway,” replied Roger.

“If I endorsed someone for President, that would make the position of Commander a political appointment as well, and I don’t think that’s wise,” said Will. “I’ll decline tomorrow.”

Roger shook his head, but didn’t offer further comments.

There was a lull in the conversation. Then Madhu said “Say, Will, I’ve been reexamining the food allocation. I can save a few kilos here and there, I think. For example, rather than import breakfast cereals, we can now make half-decent substitutes. I may need to import a few ingredients, but they’ll weigh less.”

“Figure it out,” agreed Will.

“But a lot of that stuff is already at Gateway,” complained Roger.

Will shrugged. “Some isn’t; but so what if some is? It can be credited to Shackleton instead. An astronaut can go find it and pull it out of the packaging; every packet is numbered.”

“Your plans are increasing our work here, though.”

“I’m hoping we can increase our efficiencies as well. For example, most of us could use an Earth-based secretary. I have some ideas for keeping Outpost records using a terrestrial secretary. Furthermore, if we had assistants on Earth who are potential crewmembers on the next flight, we’ll be training future colleagues.”

“We’ve been pushing for that arrangement for two years,” said Ethel.

“Sebastian didn’t push much. I’ll see what I can do.”

“Changes,” said Roger. “I hope they work out.”

Others began to arrive for supper, so the conversation shifted to other things. Paul and Monika pitched in to help; Madhu and Ethel had been making pasta, and rather than

making enough just for that meal, they were making several weeks' worth at once, so it took some time for them to finish.

After supper, Will lingered to help with cleanup. Since Ethel then hurried to the industrial area for another hour to wrap up her work on metal beams—she was preparing the parts to subdivide the basement of Habitat 2—he had time to do a bit more office work. He had composed a videomail to Carl Reed in his mind and wanted to send it. But when he entered his office—the sick bay of Habitat 3—he saw that he had a message from Harold Lassen. It was new, too, even though it was 7 a.m. in Houston. Lassen had called from his home.

“Good sol, Will. I understand you received a call from the White House yesterday. Anything you can do to help out would be much appreciated. If you have any questions, let me know. Bye.”

So, NASA was subtly pressuring him as well; that was a surprise. Will jotted down a list of points he wanted to cover. Then he pulled up Reed's videomail, set up a “copy” to Lassen's home internet address, blind copied Jerry McCord, and taped his reply.

“Good sol, Mr. Reed. Thank you very much for your call yesterday asking whether, as Commander of Mars operations, I would be willing to tape an endorsement of the President and his policies. I am immensely appreciative of everything the President has done for Mars exploration and am very grateful for his support of space exploration. I have thought long and carefully about the request so as to do it justice. After careful deliberation I have decided that it is not appropriate for the Commander of Mars operations to endorse political candidates of any sort, for any office, on any planet. The

position exists to coordinate and foster exploration and development of Mars, and tasks greatly at variance with that mandate strike me as a potential distraction or a misuse of the office. Nevertheless, I appreciate that you contacted me about the matter.

“I do not think that endorsements from individuals are inappropriate, though, and I suspect Dr. Roger Anderson would be willing to endorse the President, so you might wish to contact him instead.

“There are some efforts I can make that will further reinforce the President’s policies and general philosophy, and I hope to be able to implement them in the next month or so. The first is an approach to the Outpost to make it more friendly to married couples, and perhaps eventually to families. While the settlement of Mars is not a part of the mandate of the Columbus missions, inevitably it will emerge as a concern. This concern is very close to the concern of the President and in some ways reinforces it.

“The second is a reexamination of the role of private industry and private citizenry in the exploration of this world. Private enterprise and individual initiative are important concerns of the President, and the time has come to consider ways to work them into Mars operations. Again, within a month or so I will have some concrete ideas that may be of use to the President in his continued support of Mars exploration.

“Allow me to convey my thanks to the President for his leadership and extend my warm greetings and best wishes to him in his efforts to serve the American people.

Goodbye.”

Will reviewed the message, then sent it. He was pleased by the result. He was still sitting at his desk a half hour later when three responses arrived almost simultaneously.

Lassen’s was first.

“Will, thank you for copying your response to Reed to me. I’m impressed by its clarity, but I wish you wouldn’t express policy ideas to the White House directly. Send them to me first, and they’ll work their way through the chain of the command as appropriate. I look forward to your ideas. Bye.”

That was predictable. Will hit reply. “Thanks, Harold, for your message, and I apologize if I have made your job more difficult, but I wanted to offer the White House the sort of support that struck me as fruitful, helpful, and fully ethical. Where better to exhibit the highest ideals of our nation than in the efforts to found a new world? I’ll have some ideas for you in a few weeks. Have a good day; bye.”

The second message was from McCord. Jerome McCord was eleven years older than Will, but his face still looked reasonably young and his hair had barely a trace of gray. “Good morning, Will, or at least it’s ‘morning’ here at Shackleton, where we’re wrapping up our training. Thanks for copying me. The nerve of them, to ask for an endorsement! I agree with you, it isn’t the role of Commander to do that.

“We’re doing pretty well, here. The moon’s been a good experience binding us together. Lal has never been here before, so it’s quite an eye opener for him. The space available to us is tight; two Habitats that usually hold twelve. Naturally, we’re having a lot of clumsy interactions among the fourteen of us. It’s pretty crowded and our experience together is relatively limited. But we should have those problems ironed out before long.

“I look forward to hearing your ideas. I have quite a lot of experience, as commander of Shackleton, with commercialization of the moon, and that could help a lot with plans for Mars. Let me know how I can help. Bye.”

Will scratched his head about that reply. He hadn't meant to involve McCord in his plans; he wanted them to be his effort. But perhaps the collaboration would be better. He hit reply. "Good sol, Jerry. We're about twelve hours behind Houston, right now; we're the evening of the 24<sup>th</sup> while they're the morning of the 25<sup>th</sup>. Thanks for the report about Columbus 3. Maybe we should start sending reports to each other every day or two. I'd love to hear about your experience at Shackleton, some time, and I'll plan to share my ideas with you as they develop. Yes, I was surprised about the request for an endorsement, too; I'm glad you agree with me! Have a good day. Bye."

Then Will turned to Reed's message. "Thank you, Dr. Elliott, for your reply. While we are disappointed with the result, we can appreciate your feelings and respect the ethical position you have taken. Please do share your proposals for commercializing Mars with us; we've been gently pushing NASA that way for the last few years. The agency is also gradually rethinking its philosophy about married couples in space; for long voyages and tours of duty, it seems to make sense to send stable married couples, rather than tearing marriages and families apart for years at a time. Considering the expense and risk of getting people to Mars, it makes sense to encourage many of the astronauts to stay there as long as is reasonably possible. A certain amount of commerce then seems to follow logically from the need to develop families there. So we would appreciate hearing your ideas. Goodbye."

That pleased Will; it was exactly what he wanted to achieve. He doubted the White House was really that interested, but nevertheless, it was a lever against NASA. Will copied Reed's message to Lassen, with a quick cover note that he needed to share

proposals with the White House at some point, but would take into account Lassen's input first.

## Proposals

early Sept. 2024

In the next two weeks, and in spite of the fact that Roger, Érico, Carmen, Monika, and Shinji headed out on a month-long expedition to the northeastern chaoslands of Aurorae, considerable progress was made on the new projects. Madhu harvested a new crop of soybeans and extracted three kilograms of soybean oil from them. Paul managed to purify six kilograms of discarded lubricant, added a half kilo of light hydrocarbons to it that he made with the chemical synthesis unit, and added the soybean oil, producing 9.5 kilograms of reconstituted lubricant. The various chemical tests on the substance all came out positive. They loaded some of it into ranger 2 so that the month-long expedition could serve as a test.

Perhaps more important was Ethel's work with the copper. The tonne of copper ore was crushed into small grains and soaked in an acid bath with iron present, precipitating out the copper. Then the latter was collected, rinsed, dried, and melted using a methane-oxygen heater; the softened copper was drawn through a wire maker—they did have that—the separate strands were braided together, the bundle was wrapped in plastic tape (which Ethel was able to make), then dipped into a plastic sealant bath. Since they had few pieces of equipment directly related to the work, a lot of it required improvisation and work by hand. Nevertheless, in two weeks Ethel managed to make five hundred meters of copper wire. Electrical tests showed that it was fine for use in their electrical system, though it did not meet the quality standards for communications systems.

“The guys in the machine shop in Houston are hard at work, figuring out how I can make some simple machines to speed up the process,” Ethel told Will one morning. “We’ve got plenty of small motors here that can be used for spooling the wire as it’s made and for braiding it or wrapping plastic insulation around it. It’ll still take maybe ten times as many person hours per kilometer of wire as on Earth, but the result will still be cheaper.”

“Great. So we’ve freed up the entire 350 kilos?”

She nodded. “Except they will send us about thirty kilos of parts that I can’t easily make here, so the net gain is 320 kilos. Paul and I have been talking, though, and we can cut another 100 kilos from the spares allocation. Some of the parts that we’ve essentially thrown away could be repaired temporarily if we had to, so we’ve decreased the allocations for those parts to the predicted replacement level. If the actual replacement rate is higher, we’ll have to scramble using the old parts.”

“If the two of you are sure, send me an email and I’ll pass it on to Houston. Copy the relevant experts in Houston, too, so they know and can weigh in.”

“Alright.” She leaned over and gave him a kiss. “I’m heading back to the shop now. We want to make some of the wire-making machine right now, while the ideas and issues are fresh in our minds. The rest has to wait until Columbus 3 arrives, not only for the parts, but because we have too many other things to do to prepare for their arrival.”

“How is the manufacture of construction parts coming?”

“It was going fine until the wire making derailed it. I’ll need your help in another week to put up the partitions in the basement of Habitat 2. The design utilizes the curved floor pretty well; areas where people normally stand are in the middle of the design

where the ceiling is the highest, desks and beds are in an area with a lower ceiling, storage is located where the floor meets the ceiling. But it will be a lot of work to implement. We're using sheet metal for almost everything, which involves a lot of cutting and welding. We'll be lucky to get one basement complete before they arrive."

"That'll be sufficient to house people temporarily until Habitat 4 arrives. That's the main priority." Will stood. "If you need me, I'll be in the Prospector control area, then I'll be doing maintenance in Habitat 1."

They both headed their various ways. Keeping the telerobotically operated rovers, or Prospectors, operating was a problem when they were all occupied with other tasks. Three were still functioning; six were broken and scattered across Mars awaiting rescue; four more were on their way from Earth. One had climbed ten kilometers up the side of Ascreus Mons, one of the big volcanoes. When controlled from Earth, it was difficult to move a Prospector more than about one hundred meters per sol. Most of the movement was performed by the Prospector itself, utilizing image recognition and self-steering away from obstacles. But when someone on Mars "drove" the Prospector remotely, three hundred meters per sol and ample science were achievable. The pattern of movement was such that a single driver could handle at least two and as many as four Prospectors at once; one drove it, then set it about to doing something—such as analyzing a rock sample or scanning the area from the new location—while one drove a different Prospector. Even running two or three Prospectors, one achieved perhaps a quarter as much geology as one could in a pressure suit, but the Prospectors were scattered about in areas that humans would not visit for some time.

But before Will could get the virtual reality helmet on, his attaché beeped. It was Jerry McCord.

“Good sol, Will. A few weeks ago I promised you a report about commercialization on the moon. I think we did a pretty good job at Shackleton, but there are critics. Do you remember Theo Brown? He’s an electrical engineer and was on the moon putting together the solar arrays when you were there. He’s been articulate about his concerns, so you might want to email him if you want another opinion.

“We’ve avoided some of the tackier strategies, like plastering corporate logos all over vehicles or the sides of buildings. Our big step was into lunar tourism. It has taken time from other tasks. The hotel module was installed last year and can accommodate eight tourists; it’s a standard habitat, just like your habitats, but more attractive and comfortable inside. Some would call it luxurious. The transportation system can haul up to seven people to the moon at once and the ultimate goal is twenty-six flights per year, or one every two weeks; that would keep the facility full and would occupy two vehicles full time. But the four million dollar price per ticket is pretty restrictive and each trip requires fifty tonnes of lunar oxygen and hydrogen fuel, some of which has to be electrolyzed and refrigerated in low earth orbit. It’ll take years to grow the infrastructure to support the fuel production. This year I think they project four tourist flights; three are in the summer, one during Christmas vacation. The guys at Shackleton grumble a lot because they have to drop all their research to take the tourists around. It takes at least four people to occupy and otherwise serve them. But the projection is that tourists will drive down the cost of moon transportation, and that’s the exciting prospect. The number of flights to the moon per year have been doubled already. Shackleton Station’s thirty

percent larger. The hotel has been used to house professional couples and long-term workers during the off-season. Lunar fuel output had to double and the resulting cost is thirty percent less, per kilogram; that will benefit Columbus 3 as well. It will take a hundred tonnes of lunar fuel to get us on our way in six weeks.

“I don’t see tourism coming to Mars any time soon, of course, so I don’t know whether this is of any help to you. Let me know. Bye.”

Will immediately hit reply. “Good sol, Jerry. I wasn’t interested in tourism. What sort of discussions have been going on over commercializing fuel production? I gather there were some. And I’ve heard that moon rocks are available for sale; what was the result? There has been some talk about exporting lunar iron, copper, titanium, and of course there’s always the hype over Helium-3. I can’t see tourists coming here any time soon, either. Bye.”

Will turned back to the work at hand; Prospectors. He put on his virtual reality equipment and switched to the Prospector in southern Hellas, which was examining both the basin’s rim and associated volcanic features. He scanned the exploration itinerary quickly—it was put together by two geologists at Cornell—moved the Prospector twenty meters over very rough and bumpy terrain to a particular boulder, probably ejecta from deep inside Mars, and placed the sensor package against it. He set the cameras to scan the ground for possible fragments they could pick up.

Then he turned to Sunwing 2, flying high over the northeastern chaos of Aurorae. It was being controlled from Earth, but periodically someone at the Outpost checked in to make sure everything was alright. Finished, he was about to turn back to the Hellas Prospector when he saw that McCord had replied. He projected the videomail into the

virtual reality helmet, a strange experience because it almost made McCord look like he was sitting nearby.

“Oh, that kind of commercialization. We have never officially made moon rocks available for sale, but the twenty-five or so tourists per year bring back a few kilos of rocks in their personal baggage, and some of that gets on the market. Some astronauts have done the same. I think we should haul a few tonnes of rocks back to Earth every year for sale. It appears that moon rocks that are pretty sell for more than ordinary ones. The going rate is about five dollars per gram, which is half the value of gold. I suspect Mars rocks with fossils in them would command a better price. The fossils provide authentication, too. There was a scam a few years ago when some of the ‘moon rocks’ on sale through a reputable science company proved to be anorthosite from the Adirondacks. The microfossils in Mars rocks will guarantee their authenticity.

“Another thing occurs to me; you guys usually collected samples the size of a fist, but analysis requires only a few grams. Half a typical sample could be sold and the other half retained for future scientific study.

“As for commercializing fuel production, this has stalled for various reasons. It isn’t clear it will save money and may raise costs instead. Companies worry about the financial risk. And no one is sure that land on the moon can be sold, because of international treaties, though long-term leases should be possible. Until that’s resolved, it’s unclear what authority can be devolved to a commercial outfit. The problems with titanium and such are similar; we just don’t have the developed technology and the developed market yet. That reminds me, a small number of individuals persistently express an interest in buying plots of lunar real estate. Most of the tourists wish they had

a piece of land of their own that they could visit. If the ownership issue can be cleared up, lunar land sales could be small but significant. Bye.”

That was interesting. Will hit reply. He barely remembered to take off the virtual reality helmet, which would have made for an interesting video image. “Thanks; that’s the information I was looking for. I’ve been wondering about sales of Mars rocks and land. Bye.”

He turned back to the Hellas Prospector, which was still analyzing, so he switched to the Prospector on the western slopes of the Elysium uplift, where it was skirting the edge of a fairly recent lava flow; a sample flown back to the Outpost by the Sunwing last year had been potassium-argon dated at 25.7 million years. But in spite of his interest in the geology, the questions of expanding Mars exploration persisted.

Will was so concerned because governmental interest in exploring the Red Planet had apparently peaked. The U.S. wanted to cut its contingent in Columbus 4 in half; Brazil wanted to give up its slot. Of course, China wanted to join the partnership of nations and send several astronauts, but the U.S. was vigorously opposing their involvement. Columbus 4, tentatively, was scheduled to fly no additional habitats, greenhouses, or vehicles. No automated cargo vehicles were scheduled for use.

American support was soft because of the Swift shuttle. It promised major cost savings; it could put eight tonnes into orbit for eight million dollars. But NASA and its contractors had tens of thousands of workers dependent on the use of the Ares class rockets that cost at least six million dollars for every tonne of cargo placed in low earth orbit. They were refusing to switch to the Swift, claiming the Swift Corporation had pirated technology from the Columbus Project and refused to compensate them, and had

cut corners in quality control that made the vehicle impossible to man-rate for NASA personnel.

The discovery of microfossils had hastened the exploration timeline; Mars had not been scheduled ever to have more than sixteen personnel. Will and Ethel's marriage had helped, also, in terms of the popularity and permanence of the mission. But further expansion of Mars operations required at least a change in NASA's launch vehicles, and possibly another breakthrough in the study of Mars as well. Will was searching for one or the other, even though he knew that one person rarely could set such powerful forces in motion.

He moved the Elysium Prospector to a boulder filled with large vesicles and set it to scanning the surface closely while measuring the rock's chemical composition. He started to switch back to Hellas when his attaché beeped again. It was a video message from Liz Gordon, a very capable space journalist who had always impressed Will as fair and trustworthy. He pulled off the virtual reality helmet to take a rest and played her message.

“Good sol, Will. You've probably heard that there have been rumors over the last two weeks that you were asked to endorse the President of the United States and that you declined because you dislike his politics. I suspect no one has contacted you about the story. It doesn't seem to have any legs. But today I heard it again from a source—a Washington source, let us say—so I thought I would ask you a few questions, if that's alright with you. First: were you asked to endorse the President? Second, did you decline, and if so, why? Third, what can you say about your politics? Bye.”

He stared at the screen with a sinking feeling. He had been warned about the rumor, but no reporters had contacted him about it. Most likely, the White House had released the rumor itself as a way to make a point with him. He jotted down the three questions. Then a few other points occurred to him and he added them to the list. Finally, he combed his hair and hit reply, knowing the video clip could appear on television.

“Good sol, Liz. Thanks for asking. About two weeks ago I considered the matter of issuing an endorsement of the President and concluded that it was not appropriate for the Commander of Mars operations to get involved in domestic politics. The position of Commander is not a political position; it is a position entrusted with great responsibility toward the exploration of Mars and the development of its resources, all within the framework of the safety of the people doing the work. Those are and must be the Commander’s priorities.

“You ask about my own politics. Like a growing number of my fellow American citizens, I am an independent. I am neither a Democrat nor a Republican. I am also a well-wisher of everyone who supports exploring Mars.

“You may ask me, if you want, whether my concern extends to endorsements by other astronauts here on Mars. It does not. The other crew are free to exercise their freedom of speech.

“You may also ask me about modifications to the Columbus 3 cargo manifest. We are currently pursuing some very clever ideas that will make Mars more self-sufficient in several important supplies, allowing us to import more machines and some spices and other foods that will decrease the monotony of our diets. We’re quite excited about ways

to improve our efficiency here. Our overall goals, long term, are to make maintenance of the Outpost cheaper, so that it can continue to expand.

“Hope that helps. Bye.”

He sent the message. He was pleased by the “you may ask me about” phrasing he had hit on. It allowed reporters to repeat the question in their own words and add it to the interview. It saved a lot of time, since every question and response took half an hour. And it gave him greater potential control over the interview; reporters often were lazy, after all, and would follow the interviewee’s lead.

He turned back to the Prospectors. He moved the Prospector in Hellas twenty meters toward its next destination—a small crater one hundred meters away—when the emergency bell on his attaché beeped urgently. He pulled off the virtual reality helmet to look.

It was a standard emergency phrase—there were hundreds, and they all went to the Commander or someone he designated—and it said “Ranger 1 excessive lateral deceleration.” The vehicles all had accelerometers and when a vehicle got banged or jolted beyond a certain limit, the warning was triggered. Still, the warning hadn’t occurred more than four times in the last four years. At least there was no indication that airbags had deployed or that there was depressurization. Will popped up a communications directory by touching an icon in the upper left corner of his screen, then touched the buttons for “Ranger 1 general” and “Roger Anderson,” for Roger was in charge of the expedition. “Will here. I’ve got an excessive lateral acceleration warning on ranger 1. Anything to report?”

A pause. “We slid into a big rock,” replied Érico, apparently from the ranger, which was clearing the trail for the expedition. “We were advancing along the recommended route at three clicks, in and around some pretty big rocks. The ground dropped away about half a meter on the right side of the ranger; the aerial photos didn’t show the ditch and the radar somehow missed it, here among the boulders. So we slid to the right about half a meter and banged into the side of the rock.”

“It was a fluvial erosion feature around the base of the rock,” added Roger. “I can see the rock now, from ranger 2. I’m right behind. Are you stuck?”

“I haven’t tried backing up,” replied Erico. “I was assessing the situation. We have a dent on the right side above the wheel but in front of the passenger door. Cabin integrity is not compromised. Here goes.” A long pause. “Negative, but I did move us a bit before sliding back down.”

“Be careful that rocking back and forth doesn’t bash you into the rock more,” warned Roger.

“Put on your helmets and gloves,” reminded Will. It was a safety requirement.

“Negative. Unnecessary,” replied Érico. “I’m applying more power early, this time.” A long pause. Will could even hear the wheels whining and spinning in the background. Then the alarm went off again: “Truck 1 excessive rearward deceleration.”

“What happened this time?”

“I pulled out of the ditch and backed up so fast, I ran into a boulder behind me!”

Roger laughed. “You’re okay, ranger 1. There was already a dent in the bumper there!”

“Acknowledged!” laughed Érico. The ranger had acquired many bangs in four years.

“This has been a really bad route, Will,” said Roger. “The data have been really poor in the boulder fields. Earlier this sol we backed up thirty meters and set out on our own, and found a much better route right away! A camera on top of a fifteen meter boom often gives us better information than a sunwing.”

“I think the guys in Mission Control in charge of mapping routes were on vacation when this one was planned,” replied Will. “Seriously; I mean it. The top two people were both out. This is a bad time in Houston. People want to rest before plunging into the work for Columbus 3. Our support teams were budgeted when Columbus 3 was supposed to be a crew of eight, not eleven, doing half the exploring that we’ve done, with no more than three people staying over for the nine months during the crew change. We’ve really pushed them hard.”

“Well, we need more support than this. Can you talk to Lassen?”

“We had a long budgetary talk yestersol. Don’t hold your breath. We’ve cost them more than they expected. Lassen’s been told to hold the line on expenses until Columbus 3 arrives. I suggest you slow down in boulder fields, use the boom camera more, and be careful.”

“Thanks a lot,” growled Roger.

How’s it going this sol?”

“We’ve only been out a few hours. We’ll make it into Tiu Vallis as scheduled, I think. We found the remains of a little early Hesperian quiet water pond this morning and the shale layer had really great fossils; the macular kind that you can just see with the

unaided eye. We've called the site 'Primavera.' The pond must have existed a hundred thousand years, alternatively freezing solid and getting renewed, until a flood broke open its spillway and drained it. Then it was buried under a sand dune and preserved from further erosion, until a crater smashed it and scattered the shale layer all over the area."

"But you found the stratum in the crater wall?"

"Affirmative; it's almost a meter thick. We've got some excellent specimens.

We'll be flying some back to you from Tiu."

"Thanks for the update. Be careful, guys."

"We will. Bye," replied Roger.

"Bye." Will closed the line. He wondered about the problem of poor quality data and occasionally poor quality routing advice. The ground crew assembled the best map they could by computer, but the data was sometimes sketchy. The ground could have a dip in it that the photography missed because of the sun angle. Even when the radar data had ten-centimeter resolution, if the Sunwing was not straight overhead the data had radar shadows behind boulders. A more expensive computer program that integrated the radar data from different locations along the flight path would have eliminated much of the shadowing, but had been cut from the budget. And the twenty-member team that planned thousands of kilometers of routes often made bad guesses about the best route; the best route over a half kilometer might avoid boulders, rocks, and angled slopes, but might lead into another half kilometer that was quite rough. If one chose a different route over the first half kilometer that was slightly rougher, it might lead to a much smoother second segment. Fancy software helped avoid such problems, but what was really needed was

more teams planning parallel routes that could be compared and mixed together. That approach, though, required far more personnel.

Of course, Will suddenly realized, that was a task volunteers might be able to do. If all the data were properly integrated and placed on a website, individuals could use their personal computers at home to map routes across Mars. Perhaps thousands of routes. And since each route ran through existing data squares, they could be crudely assessed by computer. He popped up a blank “page” in his “pad” on the attaché and began to scribble talking points, which he could compose into a videomail to Lassen and Heather Kimball. This was a task the Mars Exploration Society could tackle.

Marshall

Feb. 10, 2025

Will, Roger, Paul, Shinji, and Érico headed down the stairs to the basement of Habitat 2. At the bottom of the stairs, they had to bend over a bit to fit into the low-ceilinged hallway, which stretched half way across the habitat. Roger looked at the space around them, once a big, cavernous, bowl-shaped void. “Wow, you all did a lot of work when I was away.”

“Well, all you’ve been doing for the last six months is exploring,” replied Paul, with a smile. Of course, he and Érico had been away about half that time as well.

“You guys make me jealous,” replied Will. “Men with pregnant wives do not gallivant across Mars.”

“Thanks for the warning,” replied Roger. “Because Ethel’s pregnancy has Madhu thinking about babies.”

“You may be next,” laughed Érico.

“Watch out; you have a wife, too,” said Roger.

“Carmen’s not interested in children; not yet, anyway, and not here.”

“Paul, what progress can you report?” asked Will.

The Canadian was startled. “Well, the divorce has come through, but Monika’s not interested in marriage. We’re planning to head home in two years.”

“What, and leave us?” replied Érico, with a laugh.

“Let’s take a look at this miracle of construction,” replied Paul, wryly.

Will nodded. He opened the door on the right that led into a room that represented a quarter of a pie slice. The pie was eight meters across, so the room's length and width were both up to four meters, where the hallway and spiral staircase didn't intrude.

"Oh, this isn't bad at all," said Roger.

Will pointed to the floor around them. "This first, lower part of the room has a two-meter ceiling, where one can stand comfortably. Most of the rest of the room has a 1.5 meter ceiling; plenty for a bed, chairs, desks, a dresser, etc. The shelf on the edge is 0.8 meters below the ceiling and makes a nice shelf and storage area."

"And the floor area is about the same as the bedrooms on the main floor," said Érico.

Will nodded. "Exactly the same; these rooms are 8.5 square meters, which is reasonably comfortable"

"But no windows," observed Roger.

"Unfortunately not, unlike Habitat 3 and 4. But Columbus 4 is bringing three-dimensional high definition television screens, a meter high and two meters long. You can set the screen to broadcast any one of several dozen scenes, programmed to vary their brightness during the course of the sol, so it partially makes up for the lack of a window."

Érico reached out and tapped the outer wall. "Metal. At least it's flame-proof. What's on the other side of the wall?"

"All the dividers down here are metal, so that they are fire proof," agreed Will. "The circular outer wall separates an outer crawl-space two meters wide and less than a meter high. It's got life-support machinery in some places, pipes, and there are a few storage areas."

“Pretty inaccessible,” added Paul.

“That’s the design. At least we’ve captured about thirty-four square meters of usable space,” noted Érico.

“These rooms wouldn’t be too bad,” agreed Roger. “Especially for new arrivals, who can look forward to graduating to better space later.”

“They’ll make reasonably good offices or labs,” agreed Will. “And we can use them for meeting rooms. Right now we don’t have private meeting space.”

“Is this space enough, or do we need more?” asked Érico. “I can’t remember how many we’ll have here when Columbus 3 arrives.”

“Twenty three,” replied Will. “We have space for fifteen right now: three enlarged bedrooms in each habitat and an apartment for one couple on each balcony. Add four basement bedrooms in two habitats and we have the accommodation we need. Four more rooms in the third habitat will be good for offices and work space.”

“Or we can tough it out until Habitat 4 arrives,” added Paul. “Four people can sleep in the shuttles, conestoga, or portahabs, for example. Habitat 4 is the same diameter as the other Habitats, but the balcony and basement levels, rather than tapering from 2.3 meters high to zero, taper from 2.3 meters high to 1 meter high. This makes the entire upper level and the entire lower level usable, so it has 339 square meters of space.”

“It’ll have windows, too!” added Will. “There are a lot of ways we can use its basement area. We could leave it as one big open space for meetings, for example; it could seat thirty or forty easily, with the central floor as a theatre-in-the-round, for example.”

“And once we add rugs to the floors, wallpaper, and furniture, these places will be pretty comfortable,” added Shinji.

“There are some interesting new designs for the upper levels of the habitats as well,” exclaimed Paul.

“I gather you’ve added a nursery while we were away,” said Roger.

“Yes, though that isn’t one of the designs on the website!” replied Will. “I’ll have to show you; we added quite a bit. The entire upper terrace is now closed off from the great room by a double wall of plastic sheets, to reduce the sound of the baby crying. We’ve extended the bedroom back to the outer wall to increase storage and extended the living room back as well, to provide play space. We’ve added a third room next to our bedroom for the baby.”

“How did Ethel do it?” asked Roger. “She looks like she’s ready to pop!”

“Well, she was due yestersol,” Will replied. “The upstairs work was done about a month ago, and I did most of it in the mornings when no one was in the habitat. The walls are not hard to put together, actually.”

Will turned and headed out of the room. The others followed. They all paraded up the stairs and headed back through Greenhouse 4 to Habitat 3, where the women were gathered.

“Any news from Columbus 3?” asked Paul.

“They’re doing fine,” replied Will. “Fourteen people in three ITVs is pretty confining, and it’s beginning to wear on them. But they’re now three light minutes away, in terms of the communications round trip, so they’re taking over much of the Prospector and Sunwing work as of this Monsol. That frees up our time to finish construction and

other tasks to prepare for their arrival, and gives them something to do. The more interesting news, by the way, is that the plans for a Mars Commission have stalled again. The partners have demanded too much of NASA, so it seems to be backing out.”

“How can they afford to do that, with all the pressure on them over the Swift shuttle?” asked Érico.

“It’s a question of pride,” said Roger. “This has always been primarily an American operation. The Lunar Commission really hasn’t speeded up exploration of the moon.”

“Just made the planning more representative,” replied Érico.

“I wouldn’t call it ‘representative.’ The French have insisted they have to have a representative in everything even though they won’t pay for it, and the Chinese are constantly trying to steal technology.”

“That’s been the problem with the Mars Commission idea,” added Will. “The French have insisted on more than just three berths for the 1.5 billion they paid to send three French astronauts here; they want title to one of the ITVs. They want another one next cycle, too, and one the third cycle after that. They’d lease the ITVs back to a Mars Commission for \$1 and are willing to lease back to NASA if necessary.”

“Sounds like a bargaining position to me,” said Roger. “If they didn’t lease them back to NASA, they’d have no other use for them, so of course they’ll have to lease them to NASA.”

“It’s the sort of thing that would anger NASA, though,” noted Paul.

“I think NASA will agree anyway,” replied Will. “Because it means the French are paying for equipment that NASA can’t pay for.”

“Any progress on the idea of selling Mars rocks?” asked Érico.

Will shook his head. “It’s just two weeks after the President’s inauguration, though. The White House said to me last month that they were taking the idea very seriously. But as you probably know, NASA approved establishment of a web-based system allowing amateurs to propose routes across the Martian terrain. I think within six months we’ll see an improvement in the routes we’re given.”

“Good; it’s needed,” replied Roger.

They all entered Habitat 3. Madhu was holding up a tiny boy’s outfit; the ultrasound had shown that the baby would be a boy. “How’s this?”

“Very good!” exclaimed Carmen.

“Especially considering it’s made from an old towel, with the elastic band from an old pair of underpants,” said Ethel, taking the outfit. She felt the soft cloth. “At least the baby will be warm and comfortable.”

“I’m not sure you’ll need the clothes arriving from Earth,” noted Carmen.

“Not as much as I thought, that’s for sure. The plastic outer garment for the diapers is a design achievement I’m proud of.” Ethel had spent nearly a week figuring out how to combine elastics from old underwear with watertight plastic sheeting to make a diaper holder. They had thirty diapers made from old towels and washcloths. At first, they’d have to be washed almost daily. Everyone had sacrificed something for the baby, even Sebastian and Armando, who had left about half their clothing on Mars.

“By the way, the quilt I’m working on will be finished tomorrow,” said Monika. “I’ve just got to complete two squares.”

“Thank you. The baby may be born, by then.”

“Do you feel that close?” asked Shinji, startled.

Ethel nodded. “Yes, I think he’s ready.”

There was a silence in the room as everyone considered her statement. Ethel put the new outfit on the cradle; Paul had managed to make one out of plastic sheets and beams, some of which proved carvable almost like wood.

“I do have an announcement to make,” exclaimed Will. “You may recall that I had stood to make an announcement when Roger had distracted all of us by asked about Habitat 2’s basement. But before we leave the Great Room for the evening, there is something brief for us to discuss.”

“What is it?” asked Roger, who disliked suspense.

“I just mentioned a little known fact to the guys while we walked back here: the French government has bargained to purchase the *Amazonis*, one of the ITVs flying here on Columbus 3. They’re paying \$1.5 billion to fly three astronauts here and want more for the money than just berths. NASA agreed to sell it to them as part of the price of the mission if they would lease it back to NASA for \$1. They agreed to that, too. But the French have made one request: that as soon as the *Amazonis* arrives here and is emptied of cargo and passengers, it is sent back to Earth. It would be put back on the free-return trajectory that would have returned it to Earth automatically in November 2026.”

“Why are they doing that?” asked Roger.

“Both Columbus 1 and Columbus 2 needed one less ITV flying back to Earth as flew to Mars in the first place. If the *Amazonis* flies back to Earth it can be readied to return here in 2027, instead of coming back in 2029. But its immediate return is conditioned on three things: first, Columbus 3 won’t need it; second, there will be a Lifter

with fuel from Phobos or Deimos to send it back to Earth; and third, that we can refuel the ion engine with about half a tonne of liquid argon. With its full solar panels making 25 kilowatts of power and plenty of fuel for the ion engine, the return orbit can be reoriented and the *Amazonis* can return to Earth two or three months earlier—fifteen or sixteen months instead of eighteen—thus ensuring plenty of time for refurbishment before the next flight.”

“That’s greedy of them, in a way,” said Roger. “Because it hinges on us.”

Will nodded. “We don’t have to make a decision until mid May, but you need to start thinking about it. Of the fourteen on Columbus 3, five have pledged to stay, though we can’t be sure they will for another year. We have an ITV here already that could be sent back to Earth if necessary; NASA says the four ITVs, accompanied by two shuttles, could hold all twenty-four human beings on Mars. So we still have the capacity for a complete evacuation if necessary. Admittedly, with a baby that can’t fly for at least several years, that capacity is theoretical only! If about seven of the nine of us stay for Columbus 4, and five of the Columbus 3 crew stay as well, the twelve returning could squeeze into two ITVs plus two shuttles.”

Madhu looked at Roger. “I think we’re staying until Columbus 4.”

Roger was startled by his wife’s announcement.

“I’ll probably go back to Earth; but then, I said that this time,” exclaimed Shinji.

“I’d hate to break up the fun!” exclaimed Érico. “The nine of us have had a blast together for the last six months; it’s really been great. I don’t think I’ve ever had such a close, warm, and friendly working relationship with a team of people. But that said, I can’t predict how Carmen and I will feel in a year.”

Carmen nodded at her husband's remark. "Well put. Right now, I'd like to stay. But who knows how I'll feel after the other fourteen arrive. The social dynamic here could change completely."

"I'd like to stay; where else can I study Martian life so closely?" replied Monika. "And Martian life tells us about the origin of life on Earth. But I can't speak for Paul."

"I'm not even sure Paul can speak for Paul," added Paul. "I really don't know what I'll do."

Will nodded. "Okay; thanks, everyone, for your frank comments. I have every intention of building a warm social environment among the twenty-four of us, but the extent of my success cannot be predicted. I think we can learn from some of our past mistakes and make sure everyone feels valued and welcomed. I'll let Mission Control know that we aren't sure about the number of us staying, though the fuel should be available and we already have the argon in storage."

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It was another twenty-four hours before Ethel began to feel labor contractions. About 9 p.m. the next evening they began; she made herself comfortable in bed and soon Shinji and Madhu arrived to assist with the delivery, with Will alternately helping and reporting the progress to the others. It was a long and hard labor; almost twenty-four hours later, Marshall Stephen Elliott was born, healthy and loud.

It wasn't until the next morning that Ethel felt ready to appear in public. After breakfast she and Will brought Marshall downstairs to the Great Room of Habitat 1 so that everyone could see him. The baby made the round from person to person and was kissed and cuddled by everyone.

“Why Marshall Stephen?” asked Roger, as he carefully passed the boy to Carmen.

“Marshall is my father’s father’s name, and I’ve always wanted to keep it in the family,” replied Will. “Besides, it sounds like, and comes from the same root as, ‘Mars.’ So it seems appropriate. Stephen was Ethel’s father’s father’s name.”

“He’s pretty big!” said Madhu, taking him from Carmen.

“Three thousand, one hundred two grams,” replied Ethel. “That’s six pounds, fourteen ounces. Normal.”

“Oh, I want one, Roge,” Madhu said, cuddling the baby. Will smiled; Érico looked a bit alarmed; Paul was amused.

“He’s very healthy,” added Shinji. “We did a quick MRI early this morning, and he seems to be just fine. The low gravity, so far, shows no sign of impairing his development.”

“The proportions, then, really are alright?” asked Ethel.

Shinji nodded patiently; he had already answered the question. “Yes, babies tend to have large heads and small legs, for example.”

“We had better release a picture of him soon, to dispel all the rumors in the taboids of an alien baby,” exclaimed Monika.

“I doubt they’ll stop the rumors, though,” added Paul, taking Marshall from Madhu. He smiled. “What a fine, handsome boy.”

“He has a sweet face,” agreed Ethel. “My nose, Will’s eyes.”

“We need to plan a proper celebration,” said Madhu. “Do you think you’ll feel well enough for a big dinner on Sunsol?”

“I think so,” replied Ethel. “I need to sleep, mostly.”

“If it’s alright with all of you, I’d like to host the dinner myself,” said Will. “And I’d like to add a few prayers for the baby.”

There was a moment of silence as everyone looked around. Religion was largely a private thing at the Outpost. Then the others nodded, one by one. “No problem,” said Roger, the conservative Protestant.

“Sure,” added Érico, the atheist.

“When do you want us to start helping with child care?” asked Madhu. “I promised Ethel I’d take Marshall two mornings a week. I suspect I can do food preparation while I watch him.”

“I’ll take him one afternoon a week, when I’m here,” added Monika.

“And I said a morning a week,” added Paul.

“And I promised an afternoon,” said Carmen. “And I’ve coerced Érico into taking him a morning a week.”

“I can take a morning or afternoon as well,” exclaimed Roger.

“And I want to volunteer, too; and not just because everyone else has,” said Shinji. “I’m just not sure I’d be very good with a baby.”

“Neither will I,” said Érico. “But I guess I’ll learn.”

“That’s four sols,” said Ethel. “I want to enjoy some maternity leave!”

“It lets you stretch it out a bit,” replied Will. “There are some chores you’re really good at around here. But not everyone will be here all the time, anyway.”

“Well, that’s true.”

Will turned to the others. “I really appreciate your willingness to help take care of Marshall. It’s another example of how close we’ve managed to become, in spite of our differences. It’s really touching.” There was a tear in one of his eyes.

“There’s nothing like a child to bring people together,” said Madhu. “In my opinion, this will be a much healthier place with him here.”

“As long as he stays healthy,” said Ethel.

“Don’t worry; he’s fine,” repeated Shinji. “And Columbus 3 is bringing vaccines, toys, and all sorts of things he needs.”

“I agree with you, Madhu,” said Will. “Henceforth, Aurorae has become a settlement; it’s not just an outpost any more.”

## Declaration

mid Feb-mid March, 2025

Sunsol they had a celebration like nothing they had had before, with turkey, chicken, rabbit, *and* tilapia; all four of their meat sources were drawn on. Will spent much of a sol preparing the bread, brown rice, and pasta; since they were out of bread, that meant baking a full two week supply (which Madhu helped him to do). For dessert, in addition to strawberry shortcake, they split nine ways the very first orange to be picked on Mars, a special treat for Will, Ethel, and Shinji, who hadn't had a fresh orange in four and a half years. After supper everyone who could perform with a musical instrument did so and they all sang a few songs, including the Mars version of *This Land is Our Land* that they had invented a year earlier. The song had started as a joke, but looking at his tiny son, Will realized the song had a deeper meaning for him now.

The next morning, Madhu took over child care; the first time someone else had responsibility for Marshall. Will and Ethel sent a series of videomails to lawyers to handle a simple but rather vexing problem: who would issue a birth certificate.

"I apologize that NASA assigned this task to me; I'm really not sure why," Joyce Hastings assured them in response. "I've consulted with several experts and initially they've all assure me the matter should be simple. But once they look at the ambiguous wording of the 'Five Flags' Treaty their attitude changes. The Treaty says Aurorae Outpost is not a United States possession or a U.S. military base, but it doesn't say what Aurorae *is*, nor does it make it absolutely clear who has possession over it. The analogy that the Commander is like a sea captain works for marrying people, but might not for

signing a birth certificate. At that point the lawyers recommend further diplomatic negotiations to clarify some of the treaty's wording. So I'm afraid we need a few more days—or weeks—to resolve the matter. I'll have to get back to you when I have more solid information for you. Bye.”

Ethel turned to Will. “This is a ridiculous situation! National pride is the problem; the U.S. wanted the Mars outpost to be American and everyone else wanted it *not* American, so the Treaty was worded to make it American and not American at the same time! I can get Marshall E.U. citizenship; you can get him American citizenship; but everyone says we need a birth certificate as a starting point!”

“I know.” Will sighed. “The status of Martian land is part of the problem; no one can claim it. Of course, there's no rush for the birth certificate. Marshall won't be applying for work or even for school for some time.”

“But I would like this resolved,” said Ethel, raising her voice. “It just makes me more depressed, Will. I don't know why I've felt depressed on and off for the last week, but I have. I have this beautiful, joyful baby, and I feel depressed about it. I sometimes think I'm a bad mother.” She covered her eyes and began to cry.

Will was surprised by her reaction. He came over and put his arm around her back. “Don't worry, we'll get this resolved. If nothing else, as Commander I can take on the authority to issue a birth certificate, especially if everyone else here agrees to it. Who will dispute that? Have you talked to Shinji about this depression?”

She nodded. “This sol. He has various medications, but they'll all end up in my milk, so I can't take them. If we had baby formula I could, but that won't arrive for three

months. Madhu has whipped up some simulated milk from soybeans and vitamins, but we can only use it as a supplement because it isn't balanced."

"It wouldn't be very sophisticated as simulated milk."

She sniffled. "I'm pulling myself together now."

"What do you think is causing this depression? Do you feel torn from your career?"

"Yes, some, but I worked my way through that months ago. This is post-partum depression, Will. It doesn't need a rational cause."

"Okay. I'm here for you, don't forget that." He put his arm around her more tightly.

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Even though Ethel was in no danger and the excitement was over, no one wanted to leave the outpost on an expedition. Rather, they wanted to stay around and get to know the new resident. Anticipating that possibility, Will scheduled the next month to focus on clearing a usable road up Little Colorado Canyon to the top of the escarpment. It was something that three vehicles, equipped with bulldozer blades, could accomplish, especially with the judicious use of explosives and a lot of hard work in pressure suits with pickaxes.

It was hard and dangerous work, for a ranger could tip over or get damaged in the process. It took them four sols of careful work to bulldoze sand and gravel over the shifting rocks on the talus slope at the base of the escarpment and create a solid road bed that the vehicles could drive on. They took advantage of Mars's average daily temperature of forty degrees below zero to freeze parts of the roadbed in place; ice was almost as hard as concrete at that temperature.

The talus slope was one of the hardest stretches to complete. The rest of the twelve-kilometer route would take at least thirty working sols to build, using all three vehicles and four personnel. After six sols, they had penetrated 300 meters past the talus slope up the mouth of the canyon. The first week had shown good progress.

But when Will got home after a hard sol's work—one of his first away from the Outpost, for usually he only spent half a sol on the road—he found Ethel more depressed than ever. “Joyce Hastings called again. She still has no concrete plan for proceeding. The legal memoranda she’s receiving contradict each other.”

“She should be finding a way to make this work, rather than finding problems,” said Will. “I wonder whether we should pay a lawyer ourselves to pursue this, rather than relying on the agency.”

“I can ask a friend whom he’d recommend, but he’d recommend people in Edinburgh. Will, I think the easiest thing to do is issue a birth certificate yourself. It’ll be a good bargaining chip and may force the issue.”

“I can do one better than that. I was explaining the situation to Érico and Paul this morning and they felt we should sign a piece of paper—all nine of us—declaring ourselves legal residents of Mars by virtue of our plans to stay at least two more years. As legal residents, we can declare our intention to establish a civil authority; not a national government or anything like that, but the equivalent of a village council. It’s not clear it will hold up in court because of international treaties about sovereignty over the moon and other astronomical bodies.”

“The treaties never were designed for a time when people actually lived on those bodies. At least not families with babies,” exclaimed Ethel. “I think that’s a good idea.”

“I’ll raise the matter after dinner.” Will looked at his watch. It was just about time for dinner, so they picked up Marshall and headed to Habitat 3. Madhu had whipped up pasta left over from the big meal; they had been eating leftovers ever since. Afterward there was a big pot of mint tea, since the coffee and regular tea had run out a month earlier. Will rose and asked for everyone’s attention. “I thought I’d give everyone an update about the effort to get Marshall a birth certificate. So far, no one has determined how such a certificate can be issued because of the ambiguous wording of the Five Flags Treaty. The red tape is beginning to drive us crazy, so I’m thinking very seriously about an alternative that was proposed to me this morning: that all of us should declare the existence of a human settlement on Mars and assert, as residents of that settlement, our collective right to issue birth, marriage, and death certificates, and other certificates as needed by us. I suppose the declaration would also have to state how and by whom such certificates would be issued; probably the easiest statement to make is the Commander of the outpost would have that authority.”

He looked at the others, and no one said anything right away. Then Carmen said “My mother has been worried about the legality of my marriage. I remember when Érico and I talked to Sebastian before the ceremony, he said that as far as he knew, he could marry us.”

“Yes, that is true,” agreed Will. “But apparently the authority to marry does not include the authority to grant a certificate of marriage. So our marriages, also, have a funny legal status. But if we made the declaration retrospective, we could solve that problem.”

“But surely, no one on Earth will question your marriages,” said Roger. “After all, videos of some parts were broadcast. It’s an established fact that the ceremonies took place with the consent of both parties. So I wouldn’t worry too much. You could go to any court on Earth and get a court order to issue you certificates.”

“But who wants to go through that hassle?” asked Ethel. “Especially for Marshall. He deserves some respect.”

“What you’re calling for is a pretty big step,” replied Roger. “It’s not a declaration of independence or anything, but it could be taken by NASA or other agencies as a challenge to their authority.”

“Then they should issue Marshall a birth certificate,” replied Ethel.

“I’m not going to sign a declaration to set up some sort of civil government,” asserted Roger. “It’s ridiculous. This isn’t the wild west. It isn’t clear we have the legal authority to do it, either. In the United States an area on the frontier couldn’t declare itself a town; it had to apply to the territorial legislature for recognition as such.”

“We could always make a declaration and apply for such recognition as well,” said Érico. The idea had excited his imagination. “If no one knows who would make such a recognition, maybe it’s time to figure out who would. Because this isn’t just a base on the moon, with the workers changing every six months.”

“I’ll keep asking,” said Will, looking at Roger. “Maybe we need some patience. Eventually a solution can be found, I’m sure.”

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Work on the road up Little Colorado continued every sol. Several ancient landslides blocked the canyon completely with a tangled mass of boulders; bulldozing a route up,

over, and back down the deposits was arduous and slow. But by the end of a month of work, when Marshall was a month old, they had managed to work their way three quarters of the way up the canyon. Ten more sols of effort would extend the route to the rim.

Normally, at that point, Will would have called off the effort so that they could mount another expedition to the eastern side of Aurorae. The route could be finished during the last few weeks before Columbus 2 arrived. But three factors forced a change in plans: everyone involved in building the road wanted to finish it, support for a geological expedition to the rim and the highlands around it was growing in Houston and at the outpost; and the nine of them didn't want to get split up while a hot issue like Marshall's birth certificate was being discussed.

Because the issue got tangled up in governmental relations, it became even more complicated. Everyone agreed that a United States governmental authority could issue a certificate, but the European Space Agency objected on the grounds that the child had a parent who was a citizen of the European Union, and therefore a European institution should also have theoretical authority to issue a birth certificate, since Mars was not under the jurisdiction of a particular national government. Others argued that a United Nations agency—perhaps the High Commission for Refugees—should issue a certificate of some sort. The idea of establishing a Mars Commission was resurrected by France, Brazil, and some other nations. The media got involved and members of the Mars Exploration Society proposed dozens of impractical utopian solutions. Through it all, the nine adults at Aurorae Outpost said nothing to journalists.

“Hold onto your hat, Will,” Heather Kimball said to him one morning, in a videomail. “I just got a call from Armando. Congress is so mad at NASA for dithering with expensive rockets and shuttles while Dr. Swift built a cheap one, they’re set to punish the agency by lopping a billion from its fiscal 2026 allocation. It would come from the launch budget; the idea is to force NASA to lease space on the Swift next year, then buy one in ’27 if it proves reliable enough to man-rate. NASA has responded in private by threatening to send no crew on Columbus 4 at all if the budget is reduced. It’s not clear they could stop the French and others, of course, so it’s possible Columbus 4 will go with a reduced crew and no Americans. NASA also is threatening to mothball Shackleton. Needless to say, we will threaten privately to leak this rumor immediately. It would cause considerable embarrassment. Thought you should know. Bye.”

Will hit reply right away. “Thanks for letting me know; I think. Now I have to worry about something I can’t change. Obviously, we have to stay out of this fight. Or maybe not. Let me know if there are any calls I can make to Senators asking them ‘to maintain America’s commitment to Mars.’ I suppose that would be safe. Bye.”

But Heather never called him back to ask for support, so Will did nothing. He stayed focused on their efforts to clear the Little Colorado Trail. Finally, on March 11, the road broke through to the top of the escarpment. The ramp was narrow and precarious. It would require five or six sols of widening, which was easy to do now that they reached the top because they could bulldoze heaps of reg down the ramp to improve it, then pour water on the material to freeze it hard and bury it to make the ice permanent; they jokingly called the instant result Martian concrete. Every sol the two rangers had

each hauled two tonnes of water up the route and stopped to spread it in areas needing strength, and the few hours of work every sol had improved the route considerably.

“Since Route 1 is to circle Mars around the equator and we’ve already cleared a long stretch of it along the floor of the Mariner Valleys, I guess this will be called Route 3,” said Will after they had finished their celebratory dinner that night.

“I like ‘Little Colorado Trail,’” replied Érico. “It’s descriptive. Since we still don’t know whether it’ll become some other longer route, I don’t think we should give it a number.”

“I’m not sure we should use numbers at all,” furthered Roger. “The term trail reminds me of the ‘Oregon Trail’ and the ‘Santa Fe Trail’ and the other dirt tracks that opened the western United States to settlement. I think we should call our Mars-circling route the ‘Circumnavigational Trail.’”

“I like that,” commented Érico.

“That does have a ring; I like it, too,” replied Will. “If the Circumnavigational runs along the bottom of the Mariner Valleys, the route along the top could be called the North Escarpment Trail. But never mind about the name. The logical thing to do now that we have the road up the Little Colorado is to set out on a six week expedition westward along the escarpment edge; that will take the trail to Gangis and toward Echus Chasma.”

“Actually, we may have to clear the Circumnavigational along the escarpment top, because there’s no guarantee we can build a road from Noctis Labyrinthus up to the Tharsis Plateau,” said Roger. “I was looking at the possible routes last week. The Mars Exploration Society’s volunteers have done a good job of laying out possibilities. But all the possibilities are risky and require a lot of explosives. I’d push a route up Noctis

Labyrinthus to the end, some time. But it may be easiest completing the road from the top of the cliffs downward in a few years when we have more specialized equipment.”

“This was a pretty dangerous project,” agreed Paul. “I’m glad we did it, but in retrospect, knowing how hard it was, I’m not sure we should have done it.”

“I agree,” said Will. “Fortunately, improvements will now be easy. Every time a vehicle goes up the road, it can haul up water and reinforce some section. I don’t see a need to continue full-time work on the Little Colorado Trail, and I agree with that name. What does everyone think about a new expedition? Based on our rotation, Carmen would be in charge.”

“Let’s do it,” agreed Érico, looking at Carmen.

“I’d like to go,” said Paul.

Roger nodded his support as well.

“Of course, Ethel and I will be staying here,” noted Will. “This would be a five-person expedition. Madhu, would you stay or go?”

“Oh, I’ll stay here. With only four people to feed every sol, I’ll have a lot of time to work on the greenhouses. We’ve doubled the amount of soil in the last year; once the next five greenhouses arrive, we’ll be in the position to set them up right away. I’m looking forward to that task.”

“Don’t consign us to eating just dehydrated rations,” Roger protested gently.

“Oh, the Sunwing will drop you fresh food periodically,” replied Madhu. “I’ll have time to prepare it, don’t worry.”

“Where does the birth certificate mess stand?” asked Érico.

Will shook his head. “Messier than ever. It’s become a political football. I actually got advice from one lawyer that Ethel and I should sue.”

“But he wanted the job, of course, and proposed a hefty fee,” added Ethel.

“I think it’s time to reconsider a declaration of civil authority,” exclaimed Érico. He looked at Roger. “Think of the advantages. Marriage and birth certificates will be simple. If we ever have any deaths or divorces, we’ll have a mechanism to handle them also.”

“The lawyers looking at the option, however, noted disadvantages,” said Will. “A civil authority would have implied responsibilities as well, such as education, health, and safety, responsibilities that overlap with the space agency. It would have the implied right to levy taxes, though in practice that won’t be necessary. It would also have to have an official area of jurisdiction, and I doubt we could claim the entire planet.”

“So, we define these matters,” replied Érico. “We could declare the entire adult population the legislature and the officially appointed the Commander as the executive. We could officially turn education, health, and safety over to NASA, or to ESA or another space agency, for that matter.”

“We could declare a boundary, too; say, all land within 500 kilometers of Face Rock,” said Madhu. She looked at Roger as well.

“One advantage of a boundary like 500 kilometers is that there could not be set up a second, national outpost nearby,” noted Shinji. “I am very uncomfortable about the Chinese Station at Shackleton, which is so close to the Lunar Commission’s station that the two are connected together by pressure tunnel. There should be one station at Shackleton, not two.”

“Rather than trying to figure out a five hundred kilometer radius, it’d be easier to use latitude and longitude lines,” suggested Érico. “This outpost’s jurisdiction could extend over everything from the equator to 15 south, and between 30 and 45 degrees longitude.”

“I think that is better,” agreed Will. “But be aware that we will make a lot of enemies on Earth if we do this, and a lot of those enemies will be in our space agencies and national governments.”

Érico looked at Roger. “I gather this decision should be unanimous, also.”

Roger looked back at Érico. “I have no objection,” Roger finally said, quietly. “I withdraw all the objections I raised last month.”

There was surprised silence in the room. Roger looked at his friends and nervousness flickered across his face. Finally he spoke. “You see, Madhu and I have been talking a lot about our future, over the last month. We’ve decided that, if the good Lord favors us, we’ll start a family here as well, just like Will and Ethel. That probably means we’re committing ourselves to stay here about eighteen more years. That’s a long time, and when you think about a residency of that length of time, your perspective changes. I had thought I’d return to Earth and continue to visit the moon periodically while also doing geological research at various locations on the Earth as well. But that will be difficult if we have a family, and we’ve always wanted to have a family. I’ve already visited all seven continents on Earth over almost twenty years, including my university years, and spent parts of five years on the moon. Twenty years on Mars is a nice complement to that. And it occurs to me that we should be able to bargain for Sabbaticals periodically, so we have time to write. Life here does not have to be a constant stream of

ten hour work sols, six sols a week. So, in consideration of all that, and how cute Marshall is, Madhu and I have reoriented our priorities.”

“How marvelous,” replied Ethel. She leaned over and kissed Madhu on the cheek. “Congratulations, dear. It’ll be fun to raise our children together.”

“I agree.” Will extended his hand to Roger, who smiled and shook it.

“Well, is it unanimous that we will declare a civil authority here?” asked Érico.

Will looked around. No one objected. “I think it’s a great idea,” said Monika, who had said very little about the matter. “All of this is making me think more long term as well. There’s a lot for me to do here for decades as well.”

“Maybe I should plan to stay for a long time, after all,” added Shinji. “All of you have become very good friends.”

Will felt growing excitement as he looked around the room. “Shall I draw up a document for us to discuss, then? I can have something ready by tomorrow night.”

“Yes,” agreed Érico, and the others nodded as well.

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Will slept little that night. What had started as a silly idea was now deadly serious and historic. But at the same time, Will had to remind himself that this was not the Continental Congress and the document he had to draw up was not the equivalent of the Declaration of Independence or the Constitution. It was much simpler and shorter, for a much more limited purpose. It was not even clear it was laying the foundation of the United States of Mars, or anything like it. Rather, it was solving a simple legal problem: who had the right to write birth certificates for children born on Mars.

Nevertheless, it was hard to avoid grand language and ideals when drafting something. Will went on the web—with the Earth still close to opposition, items downloaded in a mere eight minutes—and looked at various examples. He gave everyone the result in paper form after dinner the next evening. Carmen read it aloud:

#### The Aurorae Declaration

We, the residents of Aurorae Outpost,

Recognizing the need for civil authority to handle various matters, such as: certification of marriages, births, deaths, divorces, and other life events of importance; adjudication of disputes; drawing up ordinances to regular behavior for the common good; providing for common needs, such as education, health, safety, and the necessities of life; regulating businesses; and recognizing transfer of ownership of property;

Do hereby agree to establish a civic authority for the Borough of Aurorae, defining the jurisdiction of said authority as covering all residents and territory located between the equator and 15 degrees south latitude and between 30 and 45 degrees west longitude.

Specific actions of said civic authority will be defined and authorized by a majority vote of all residents over eighteen years of age and carried out by such officers as designated by the adult residents.

Modifications to the powers granted in this declaration must be made by a vote of three quarters of all residents.

Signed by all residents of Aurorae this twelfth sol of March, 2025 AG

“That’s it?” asked Érico, after a moment of silence when everyone reviewed and contemplated the language.

Will nodded. “It’s short and simple, for now. We can add to it as needed later. It doesn’t even name a mayor, for example. It occurred to me that birth certificates are not usually signed by a mayor, so we can designate a clerk in a separate resolution to do that. And if someone here dies, God forbid, a death certificate needs to be signed by a medical officer.”

“But you have a lot of other things here, as well; passing ordinances, regulating businesses, recognizing ownership of land,” said Roger, suspiciously. “Why do we need those?”

“That list was given to me by a Scottish lawyer,” said Ethel. “Those are things municipalities often do.”

“And they are things we might do soon, as well,” added Will. “Roger, you and Madhu may be staying here twenty years; until one or more children grow up. Same for Ethel and I. We’ve already stayed here longer than NASA expected. I don’t know why we couldn’t go to half time as members of the astronaut corps and open a business here. I could see people doing that very soon, so the civic authority has to have responsibility to regulate businesses.”

“That’s true; I see.”

“No taxation, though,” said Érico. “Shouldn’t that be in here?”

“I was thinking we could always add that later. It seemed potentially controversial.”

“And recognizing ownership of land isn’t?” asked Roger. “That flies in the face of international treaties!”

“The text says ‘transfer of ownership of property’; I suppose that means someone might buy an old ranger from NASA, and our village government would grant a certificate of title,” said Monika.

“That’s what it does mean, but it could also refer to ownership of land,” said Will. “What I had in mind was not that the civic authority could grant ownership of land to individuals. The authority does not claim to own the land, and since no one owns it, no one can give it to someone else. We would have to declare the right to assign ownership of the land in a separate document, or assert the right to assign ‘user rights’ to land without actually assigning ownership, or we would have to be given the right to assign ownership by another body, such as the United Nations.

“But having said that, I hope we can acquire the right to assign ownership to land. If I’m going to stay here twenty years, I’d like to own a piece of land. Why shouldn’t we have a right to do so? The international space treaties are over fifty years old, are ambiguous, have not been signed by all parties, and are under fire. They will be modified some day.”

Paul whistled. “Even so, Will, that’s playing with fire.”

Will shook his head. “No, I don’t think we are. Let’s keep separate what the document means from what it might mean in the future. As I said, right now the declaration gives the civic authority the right to recognize transfer of ownership of property, but it does not grant the right to assign ownership of something no one owns.”

“But if we acquire that right, we could sell land to Mars enthusiasts,” said Érico. “There are thousands of Mars enthusiasts who probably would be thrilled to buy a piece of Mars. Land is only valuable near a settlement, too; otherwise no one can get to it or exploit its resources. We would never need to tax the residents here; we could raise plenty from land sales!”

“Land with a view is valuable, too,” added Ethel. “And now that we have the Little Colorado Trail finished, the entire top of the escarpment is accessible.”

“I’d say, take out the property transfer provisions or put in the tax provision,” said Roger. “Might as well add the tax provision. It only affects residents or property owners.”

“Okay,” said Will, very surprised. He wasn’t even sure there would be support for the declaration, let alone a desire to strengthen it. He turned to his attaché and added “raising revenue through taxation and other fees” to the text right before “recognizing transfer of ownership of property.”

“Why ‘borough’?” asked Roger.

“We could use township, county, or some other term, but it struck me as useful because of its ambiguity. Some cities, like New York, have boroughs. Alaska has boroughs instead of counties. And it isn’t clear which Aurorae would be.”

“With an area of about 750,000 square kilometers, it’d be a big township,” commented Érico.

“Did you run this by a lawyer?” asked Carmen.

“Yes, a respected lawyer in Edinburgh. I emailed it to him last night, he suggested a few changes, we made the changes and sent it back to him, and he said they worked fine.”

“I’m in favor,” said Shinji. “I don’t know how long I’m going to stay here, but I think Mars needs this. This isn’t the moon; we will always be a lot more isolated, and as we now can see, children can be born here. This is a world that will be settled, not just visited.”

“The moon’s only permanent residents will be the dead,” quipped Madhu. It was a longstanding joke, because a commercial company crashed cremated remains into the moon for a fee.

“Perhaps this outpost is like Jamestown,” added Roger. “Or any of the other tiny European hamlets that dotted the Americas in the 1500s and early 1600s. It was almost two hundred years from the founding of Jamestown to the Declaration of American Independence. Maybe we’re a century or two from the creation of some sort of nation here on Mars. Maybe this place will have several nations. But I agree that we can and probably should take this step.”

“I think we should take this step for the sake of the moon, too,” said Will. “Shackleton now has up to thirty-six people. Who says children won’t be born there, some day, and who says there won’t be permanent residents? I suspect the gravity problem is solvable; weights slipped inside special pockets seem to help a lot. The population there can only grow. LeMonnier Station in Mare Serenitatis has been authorized for next year, and the Aristarchus Highway is slated to be improved as far as the projected Equator Highway, so that automated water trucks can drive to LeMonnier. The moon already has three thousand kilometers of dirt tracks; why shouldn’t they sell land to moon enthusiasts along it? In another decade or two, flights to the moon will be routine enough and cheap enough for prominent scientists to take their families with them

for a few months. I bet there will be kids on the moon in a decade or two. The Lunar Commission should get its act together and plan accordingly.”

“But let’s not do this as a political statement, Will,” replied Shinji. “I would caution against that. It may be counterproductive.”

“This whole thing may prove counterproductive,” replied Monika. “That’s my worry. But I think we should take the chance. It’s strange to say this, but I’m beginning to really like this place! I think it needs a prototype civic authority. The birth certificate mess only highlights the problem.”

“Who are we going to ask to serve as recorder, to sign a birth certificate?” asked Érico.

“Wait!” exclaimed Will. “Are we going to approve this declaration? Is there a motion?”

“I move we approve the Aurorae Declaration,” said Érico eagerly.

“Second,” added Ethel.

“All those in favor?” asked Will. Everyone raised their hands. “Good. No one is opposed. The record should indicate that; but who will serve as recorder?”

“I nominate Érico, because of his enthusiasm,” said Roger.

Érico smiled at the endorsement of his sometime-nemesis. “I second,” added Shinji.

“Discussion? Other names?” asked Will. After a pause, he said, “All those in favor?” Everyone raised their hands. “Okay, Érico, you have to craft some minutes and send them to all of us.”

“And I move we authorize Érico to issue certificates of birth and marriage,” added Ethel.

“I’ll second that,” said Will. “Discussion? All those in favor?” Everyone raised their hands. “Well, my friends, Aurorae Borough now has a fledging government!”

## Landings

25 May 2025

Will saw the flashing icon on his attaché indicating he had received a message, but at first he was too busy to do anything about it. With all the preparations to finish for the impending arrival of Columbus 3, it was not possible to handle messages promptly. He had to reload all the various machines with samples: the x-ray crystallography unit needed a new slide of rock to analyze; the mass spectrometer needed a small sample of solid rock to measure, among other things, the potassium-argon ratio and pin down a formation date; the microscope camera needed another sample of fossiliferous rock because it was counting microfossils automatically using shape recognition software; the alpha-scattering unit was making an elemental analysis on another sample. There was never enough time to run thousands of samples through these machines, generating data for a doctoral dissertation, a geological article, or a website. Alas, they could only analyze to the part per million range; very sensitive equipment on Earth could do a million times better.

Once everything was loaded, he walked over to his attaché and pushed an icon to play messages. Jerry McCord had called.

“Good afternoon, Will. I’m sure you’re getting as excited as we about aerobraking. Eight hours to go! It’s hard to believe. We’re looking forward to visiting with the *Elysium* tomorrow, then heading to Deimos and Phobos for routine maintenance. And then finally landing at the Outpost and getting to work!

“Say, I’m going to need your help once we arrive there. I think you’ve heard that there has been some friction up here, in the tight quarters. The French have been the chief problem. They eat most of their meals on board the *Amazonis*, which as you know is owned by the French government. They speak French all the time and socialize or interact with everyone else relatively little. Frankly, it’s been a huge problem, and we’ve retaliated a bit, I’m afraid, by giving the cold shoulder to them as well.

“But your social skills are legendary. Everyone says that if anyone can resolve the ‘French problem,’ it is you. So as soon as we get down there, I hope you can make this a priority. It’s the only way we can make this a unified community.

“Thanks for listening. Looking forward to working with you. Bye.”

Will stared at the screen, peeved by the message. McCord was assuming that he, and not Will, would be Commander of Mars Operations. Nothing had been announced; did he know something that Will didn’t? Jerry certainly had better contacts; Will hadn’t had a face-to-face conversation with a NASA official, or drunk a cup of coffee with one, for over four years, while Jerry had been the capcom for Mars operations and one of the mission’s chief behind-the-scenes people in Houston. If anyone had access to advance information, it was he.

A bit upset, he walked upstairs to find Ethel. At the moment Marshall was asleep. He found her on the couch napping as well. In the last month she had been so seriously depressed she had not been able to do almost any work at all. At least she was still able to watch Marshall, though at times that had proved difficult as well.

She sat up when he entered their living room. “I just got a call from McCord,” he explained. “He said that after Columbus 3 landed, *he* would need *my* help with the French

delegation to integrate them into the crew better. They're always eating in their own ITV and speaking French together."

Ethel considered. "Well, Jerry shouldn't have let the Columbus 3 crew plan their own breakfasts and lunches and disperse for supper if they wanted. The Great Room can hold fourteen people; that shouldn't be an excuse." She looked at him. "Oh, but that's not what you're referring to. Do you think he has inside information about the selection?"

"Maybe. Who knows. He has much better contacts than me."

"This has been the roughest six weeks of your command."

"The Aurorae Declaration really did not sit well with the space agencies. It's amazing how little people listen and how much they can cast aspersions on your name."

"We should have been wiser. Some agency officials are paranoid about issues like ownership of land, and we knew it."

"True. But we couldn't have anticipated the furor over the statement that the civic authority should be responsible for ensuring availability of oxygen, food, water and other necessities of life. How many times have I had to announce that we were not complaining about the services NASA provides?"

"It was a slow news month on Earth. That worked to our disadvantage; though, in the long run, it many work out alright."

"True, it has gotten discussion of the space treaties going again, and negotiations for a Mars Commission, and the public seems to like the idea that Martian real estate might be on the market soon. But from the point of view of NASA, I look like some kind of unpredictable wild card."

Ethel chuckled. “That’s because you are, Will. What all nine of us did quite spontaneously and naturally reflected a set of common views and attitudes that developed here over the last nine months.”

“Everyone here was upset about the reaction.”

“Even Roger! And he shouldn’t have said anything; he may have shocked his friends in Mission Control more than you did. But the furor will die down, now that fourteen more people are arriving here. And once everyone sees that we don’t actually do anything—other than issue a birth certificate—they’ll calm down anyway.”

“I hope so.”

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It was quite late that night—about midnight—when the five vehicles making up Columbus 3 separately hit Mars’s atmosphere at 26,000 kilometers per hour. In just a few minutes they burned off their excess speed and went into an elliptical orbit around Mars that took twenty-four point six hours to complete one revolution. After emerging from Mars’s upper atmosphere, the vehicles were quite close to Embarcadero Station, which was in the same orbit.

Everyone but Ethel was awake at the Outpost. Will quickly sent congratulations to Columbus 3, expressing their great excitement to have so many people arrive safely. The only awkward problem was who was in charge; no guidance had yet arrived from Mission Control designating a commander of Mars Operations. That meant that Will by default was the boss, a position that surprised him and seemed to irritate McCord.

It wasn’t until the next morning that Will awoke to find a message from Dr. Harold Lassen. “Good sol, Will. We are pleased to appoint you Commander of Mars

Operations until the departure of Columbus 3. I should probably be frank with you, however, about the delay in finalizing the appointment. In the last nine months you have shown strong innovation. We're thrilled about the extension of Route 2 across Argyre and of Route 1 to Noctis Labyrinthus, the clearing of Little Colorado Trail, the construction of a piece of Route 3 along the top of the escarpment, the pressurization of the Geology Storage Facility with an oxygen atmosphere, the creation of enough soil to fill five new greenhouses, the manufacture of construction materials to complete Habitat 4, and the construction of new rooms in the other habitats. We've even come to be happy about the export plan. After four years, we're about eight years into our master plan in some areas and way beyond it in others.

“Needless to say, we are not amused by the establishment of a civic authority and the issues it raises. You were out of line to encourage that. It has thrown a shadow over everything we've done on Mars. And it is not even clear that the result is a legal birth certificate for your son.

“We debated long and hard about who to appoint Commander. You barely won out as our choice. I think you deserve to know that. If it weren't for strong support from the Europeans, you wouldn't be Commander, and as you probably know, we're in a weak position right now. We are looking forward to the innovation and wise guidance you bring to Mars operations over the next year and a half. Goodbye.”

He looked at the screen and said “Huh.” He had given up on receiving the appointment. He sent a quick thank you back to Lassen, pledging to do his best to lead Mars “from success to success.” He sent a quick memo to the Outpost staff—not to the personnel in orbit, though, lest McCord had not yet been informed—letting them know of

the appointment. Then he started to think about changes in the mission plan he would want to consider; Mars had been put in an awkward position in the last nine months, with no one official to bargain with Mission Control over the priorities. Will had wanted to work with McCord to craft a common position so that it would not matter who would be Commander, but slow, impersonal communication had made that impossible.

The first task was to dock the three ITVs and two shuttles together at Embarcadero and transfer all people and movable equipment and furniture from the *Amazonis*. That finished, the *Amazonis* detached and flew to one of the Lifters; three were waiting a hundred kilometers away, each filled with liquid oxygen and methane, one from Deimos and two from Phobos. It docked to a Lifter which, the next sol, fired up its engines and propeled the *Amazonis* onto a trajectory that would return it to Earth in eighteen months. The two vehicles then separated and the Lifter fired its engines to slow itself down, so that it could return to Deimos. The *Amazonis* would fire its small ion engines to advance its return to Earth by two months.

While those maneuvers went on, the *Elysium* blasted off from Aurorae, uncrewed, and docked to Embarcadero. Columbus 3's two shuttles—the *Pavonis*, refurbished from Columbus 1, and the *Alba*—docked with the other two Lifters and refueled. Once the *Elysium* had fueled up as well—so that it could mount a rescue mission to either moon—the *Pavonis* headed for Deimos and the *Alba* for Phobos, each with a team of three. For five sols they carried out routine maintenance on the fuel-making facilities, moved the drills so that they could drill new shafts into the moons, explored new areas on the moons, and set up new scientific instrument stations.

Once the work was done, it was time for everyone to descend to the Outpost. The *Pavonis* and *Alba* both returned to Embarcadero—which now sported a new docking module, a remotely controlled arm, and an ion engine—and took on two additional crew; the other four entered the *Elysium*. All three vehicles fired their engines to dip their orbits into the Martian atmosphere, but they staggered their landings by four hours in order to avoid emergencies.

Jerry McCord was on the *Pavonis*, the first to land, along with Rick Page, an American who was a pilot and vehicle engineer; Lisa Kok, a Dutch horticulturalist; Linda Dubois, a Canadian exobiologist; and Lal Shankaraman, an Indian geologist. Will and Paul drove two portahabs out to the landing pad to pick them up. The portahabs were crowded with pressure suited individuals and their luggage for the ten-minute drive to the Outpost. At the airlock, a crowd greeted them and helped haul the luggage to everyone's new room. For half an hour the new arrivals circulated round and round the Outpost, exploring the different habitats and poking around the greenhouses. Will was in the bridge when Jerry McCord stopped by.

“Shall we talk?” asked Jerry.

“Sure; come in! And welcome again to Mars, Jerry.” Will rose and offered his hand to McCord, who shook it with a bit of hesitation. Will gestured that he should sit, and sat himself. Jerry sat and looked around the bridge, as if wondering how it would feel if it had been his instead.

“Thank you, Will. We all delighted to be here. Did you see the little jig Linda did when she stepped out of the shuttle and onto Mars?”

“Yes! She was delighted. And I talked to Lal in the portahab. He’s thrilled; he said after brief visits to the moon and Deimos, he’s ready for the kind of geology he’s used to: sedimentology, stratigraphy, and glaciology.”

“Yes. He’s brilliant, from what I can see; he’s made major contributions to reconstruction of the glacial history of the Himalayas, you know. Until the Columbus 3 training flight to Shackleton, he had never left the Earth.”

“Our first resident who had never visited the moon before the training exercises. He’ll have to be on the north polar expedition; the layered terrains will fascinate him. What about you, Jerry? How do you want to devote your time here? We’ll be running two expeditions simultaneously much of the time, so there will be plenty of opportunities for exploration and being the boss.”

“Well, that’s what I stopped by to talk to you about. As you probably know, I’m twelve years older than you; 51, and when I return to Earth I’ll be 53. I doubt I’ll be able to get to the moon much more because of my radiation exposure. So this is my big mission; possibly the culmination of my career. I had hoped that would mean I’d be the fourth Commander of Mars operations. That didn’t happen, but I still hope I can be given fairly large assignments.”

“Your experience necessitates it. Frankly, Jerry, I’m uncomfortable being your boss. You were my boss at Shackleton on two occasions! And you know this operation inside out and backwards; you were the chief capcom for about three of the last five years, when you weren’t running Shackleton or clearing the Aristarchus Highway. So I’m in favor of you taking on big expeditions.”

“What about around the Outpost?”

Will hesitated. “I’m not sure there will be big jobs around here. We’ve now got twenty-three adults on Mars, assuming the next two shuttles land safely. All of them are experts in something and all of them have a lot of experience. So I don’t want to set up a structure where a few people give everyone else orders. That doesn’t work here. We have to get to know each other well, trust each other, and want to work closely together. In most cases we’ll be divided into teams of two or sometimes three; and if Dr. A is in charge of Task 1 and Dr. B is the assistant, in Task 2 Dr. B will be in charge and Dr. A will assist. So most people will report to me about one sphere or another, and we’ll have inter-team meetings sometimes when six or eight people get together to plan some tasks together. The exception is expeditions; each one will involve three vehicles and five or six people, and there will be a definite boss. But even then the job of boss will change every month or so.”

“I see. Is there any possibility I can run the expedition to the North Pole?”

“That’s an ongoing effort involving a lot of people who have already cleared most of the road. Either Érico or Roger has to be put in charge of that. But I think we can manage a dash to the South Pole about a year from now; if you want that mission, it’s yours. We will also be extending Route 1 around Mars and someone will probably have the chance to explore the Tharsis volcanoes, possibly to the top of one of them.”

“And I’m a volcanologist, among other things. That intrigues me.”

“Good. Then maybe we’ve found the mission for you.”

“It may have to be sufficient.” Jerry stared at Will closely, then shook his head.

“You know, I really don’t understand what’s happened here in the last nine months.”

“What do you mean?”

“I think you know what I mean. The nine of you have become. . . different. We’re supposed to be scientists here, not settlers.”

“You’re right, we have become settlers; that’s a good way to characterize what has happened. But I’m not sure I’d contrast ‘settler’ with ‘scientist’ because we can be both, and are. This isn’t the moon, Jerry; it’s more isolated and more Earth-like. This place is going to be settled eventually. It just started sooner than anyone anticipated.

“The big shift has been caused by Marshall. Ethel and I now look at this place and we see home for twenty years of our lives; not eighteen months, like most of Columbus 3, but twenty years. You look at a place very differently when you plan to stay that long. You think about it differently. And that’s rubbed off on the others. It may not be long before Marshall won’t be the only child here.”

Jerry’s eyes opened wide, surprised. “And I suppose it won’t be an accident this time, either.”

“No, apparently not. No one is pregnant yet, but let’s just say that Ethel and I aren’t the only couple looking at this place long term. Some of the dynamic here has come from the fact that in addition to Shinji, the residents consisted of four couples.”

“Oh? Paul and Monika?”

Will nodded. “It’s hardly secret. Paul’s divorce decree came through some months back. Last month he and Monika came to me and asked to be assigned a single, large room instead of two smaller rooms, and I granted their request. We combined three small bedrooms together to make one larger room for them.”

“I see. I can imagine that four couples really do give the place a social energy and a long-term perspective. Are they all planning to stay?”

“Almost certainly for Columbus 4.”

And I bet Marshall has changed the social atmosphere.”

“Oh yes, as you will see! Having a baby around has made everyone happier. The exception is Ethel; she has had serious post-partum depression and hasn’t been able to take any medications, because Marshall is dependent on her milk for his nutrition. But now that you’ve arrived with infant formula, not to mention a few dozen other things, she will have a much easier time and will be able to take some medications.”

“I’m sorry to hear about the difficulty.” He sounded genuinely sympathetic.

“Thank you. But it has been manageable because everyone else has pitched in. The birth and her depression have been trials for all nine of us, and they have brought us closer together.”

Jerry nodded. “Well, that helps. But there’s one other thing: it’s a shame you all never consulted with the fourteen of us about the Aurorae Declaration. When we read it, we didn’t know what to think, We felt that something had been usurped from us; a crucial decision was made without our input. Of course, we’re really not sure what was usurped, but that has made us feel even more suspicious and puzzled.”

Will was startled by Jerry’s remark. “I’m sorry, it never occurred to us to ask you for input, because you were still tens of millions of kilometers away. You hadn’t arrived yet and you hadn’t gotten accustomed to this place yet. And if we had waited, it would have been for a year; that’s how long it takes to get up to speed about this place.”

“I see. But couldn’t the matter have waited a year? Does Marshall need a birth certificate that badly? Because to us the birth certificate looked like an excuse to rush something through; probably a scheme to claim and sell land.”

“That question has come up again and again. The Declaration gives the civic authority the right to regulate transfer of existing property, but not to declare land eligible to become property. A separate resolution is needed for that. And you’ll be here when the matter comes up, if it comes up.”

“I hope so; we’ll have things to say about the matter, I’m sure. What do all of you think about the situation with NASA?”

“We’re worried about the reduced budget, obviously. NASA says it’ll launch the Mars shuttles and ITVs for Columbus 4 anyway, since the Ares are already at Canaveral. But they have no money for launching cargo. It’s crazy.”

“They’ll have to accept the Swift shuttle. It’s a matter of time. You’ll see,” replied Jerry.

## Plans

late May 2025

The next two shuttles landed safely as well, smack in the middle of the bullseyes painted on their clay landing pads. Everyone got off and moved their property into their rooms, then began to unload the cargo, starting with the dozen new species of fruit and nut trees and several new animal species: honeybees, catfish, trout, miniature pigs, and two small, immature dairy cows. The mammals required considerable care, as they had been partially sedated throughout the last week of weightlessness and completely sedated for the landing.

Shortly after sunset everyone gathered in the Great Room of Habitat 3 for a big dinner. Twenty-four people filled the room; it made them realize how small the space really was. Will received a steady stream of visitors or went to visit other tables. He and Ethel were careful to sit with Gaston and Eve Gilmartin, two of the three French astronauts on Columbus 3

“Vous êtes tres bienvenue ici,” said Will to them.

“Oh, you speak French!” exclaimed Gaston, surprised, in French.

“Not too much,” replied Will, continuing in French. “My Russian is better, and Ethel’s French is pretty good.”

“How delightful,” Gaston.

“I’m delighted that we finally have a female physician here,” Ethel said to Eve in French. “It will be a great help.”

“Thank you.” Eve smiled warmly. “I look forward to the challenges of this place. In particular, I want to watch Marshall’s growth closely. On the flight out I was studying some rare children’s disorders that affect bones, muscles, and the cardio-vascular system in particular. I suspect some of that expertise may find some use.”

“Thank you; but I hope it proves of no relevance, if you know what I mean!”

The two women laughed. “I’m also interested in studying the problem of Martian dust. Several people appear to have developed allergic reactions after prolonged exposure. It’s dangerous stuff.”

“We need that,” said Will. “He turned to Gaston and switched back to English. “So, your expertise is animal husbandry.”

“Yes; the cows and pigs are my responsibility.” He smiled slightly. “I’m looking forward to the work. Maybe there will be other baby mammals here.”

“How are the calves doing on the moon?”

Gaston smiled. “That depends on your perspective. They have weak legs, thin bones, and weak hearts. Bad news about the health effects of gravity, though lunar cows will probably make better veal! The next step is to try some drugs and various countermeasures like weights to see whether the effects of lunar gravity can be reversed.”

“It’s fascinating research.”

“Yes, quite. I didn’t know you were following it.”

“Not closely, but anything that might have implications for us I tend to pay attention to.”

“Especially anything relating to your son, I presume. He’s a cute baby!”

“Thank you. He seems to have inherited our good facial features. Let’s hope he does the same where character is concerned!”

“Ah, but that is so much harder to arrange!” and they laughed.

Will rose and walked to the buffet table to get another cup of coffee. He stopped at a nearby table on his way back, where Patrice Domkowski, the other Frenchman, was sitting with Lisa Kok, Karol Havlicek, and Pavel Rudenkov. As he approached the table, Lisa said “Commander, can we get another bottle of wine?”

Will saw that their bottle was empty. “I’m sorry; that’s all we have for this meal,” he said. He turned to Patrice. “Patrice, I assume you know Dr. David Alaoui.”

“Oh, yes indeed. In fact, he asked me to convey his greetings to you.” Patrice offered a hand; Will shook it. “He asked me specifically to shake your hand on his behalf, and tell you that all is well with him and his family.”

“Thank you. David and I are in touch about twice a month. As you may have heard, we’ve been close friends for a long time.”

“Yes, he told me! There was that incident where you rescued him at Tycho, too. David was a mentor to me, you might say. He encouraged me at several points in my career, including when this mission came along. David’s a central figure in the Mars establishment in Europe, now.”

“So I’ve gathered. Now your last name, Domkowski; is it of Polish origin?”

“Yes indeed. My grandparents settled in Paris after the second world war. As you may know, France absorbed many emigrants then. David’s mother’s family arrived a bit later from Morocco.”

“Yes, I know something about the subject. I hope you enjoy your work here. There’s a lot of climatology to do.”

“I’m particularly interested in Mars’s early climate. As you know, there’s a computer model being built by a group of European scientists. We’re working on models of the climates of Earth and Venus as well. I’m hoping we can recover ancient gas samples from various places, maybe even from the fossiliferous shales, so we can get a better handle on the evolution of the atmosphere. We need to reconstruct the climatic cycles in detail.”

“Yes, the thermals and ice ages caused by orbital eccentricity and axial tilt. The little we’ve figured out here so far has generated several entirely new fields of study, like eobiology. What do you think of the rumors that France intends to send a mission to Venus?”

Patrice smiled. “I hope it’s true! I’ll be one of the first to sign up! The word I hear from my friends in Paris indicates it is likely. Probably France will invite other European nations to participate as well.”

“Do you think that’s why they bought the *Amazonis*?”

“Maybe. The scenarios I’ve heard involve sending two ITVs, one automated cargo vehicle, and either two or three Lifter-As. The ITVs would go into an elliptical orbit where the delta-vee for the return flight is low; maybe one kilometer per second. They’d dock and spin, just like on our flight out. The automated cargo vehicle would be sent ahead and would have atmospheric probes and telerovers for surface exploration. The boosters would use methane and oxygen propellants, and one would be sufficient to push one ITV back to Earth. There would be four crew.”

“That sounds feasible and very safe. Now that we have this transportation system, it would be a shame if it weren’t used to visit Venus. Besides, the more vehicles manufactured, the cheaper they become. Good luck with your ambitions, Dr. Dumkowski.”

“Thank you, Commander.”

Will walked back to his table. As he sat, Dr. Rosa Stroger rose from her table and walked by. “Commander, I just want to stop by and tell you how impressed I am by the Outpost.”

“Thank you! We’ve put a few hours into developing it, you could say.”

“Indeed you have, over the last four and a half years. I had done three-dimensional virtual walk-throughs several times and felt I was familiar with the place, but nothing compares with walking through the actual facility. It’s pretty big. We won’t feel crowded in here.”

“It’ll be even more spacious with Habitat 4, an additional five greenhouses, and a connection to the Geological Storage Facility. It’s not bad, but you get cabin fever if you don’t go outside every few sols; and you need to go outside for the exercise anyway. Have you seen the proposed site for the nukes?”

She nodded. “Neal and I went for a walk a bit before sunset. We walked along the eastern side of Boat Rock and saw the stakes marking the future sites of the sandbag corrals. I like the plan; it should work well.”

“Excellent. We can’t wait to get those nukes. They’ll revolutionize exploration here.”

“Not to mention the level of power available to the Outpost. It’ll be an incredible change. I’m delighted to be a part of it.”

“You and Neal are committed to at least two cycles, right?”

“Yes. You can’t leave the nukes without an expert, and that means the experts can’t rotate through less often than every two cycles. Neal’s thrilled to be here, anyway.”

“He’s an excellent geologist. We’re delighted to have both of you here.”

“Thank you.” She offered her hand. “Looking forward to working with you.”

“The same.” They shook, then she walked over to the dessert table.

Will sat. Marshall was asleep against Ethel; she seemed happy for the first time in a while. He leaned over. “How are you?”

“Oh, fine! Feeling much better. Marshall’s not happy with the formula, though.”

“He’ll adapt. The medication’s already working.”

“It seems!”

“Good.” He leaned over and kissed his wife. Then he looked around the room to see whether it was time to start his talk. Most people were done eating and were getting coffee. The exception, he noted, was the table with Patrice Dumkowski; looking closely, he saw a new bottle of wine sitting on it, already half gone. And he had told them not to get another one. He rose and walked over.

“This is a new bottle, right?” he said to Lisa Kok, who happened to be sitting closest to the bottle.

“Yes, Commander; oh, I apologize. Pavel didn’t hear you, I think.”

“Hear the Commander say what?” replied Pavel. He looked up at Will. His slurred speech and vacant expression spoke volumes.

“I asked all of you not to drink any more wine. Now we have to ground all four of you until 12 noon, at least. That’s the earliest the safety rules will allow someone drinking three or more glasses of wine to make an EVA.”

“Oh, but Commander, the EVA rules are ideals anyway, they don’t have to be followed strictly,” replied Karol. His speech sounded slightly slurred as well.

“Well, here we follow them pretty closely. I want to be sure we’re all safe here. It’s a long way to a professionally equipped hospital. So we don’t cut safety corners on Mars.” He sounded neutral, matter of fact, rather than didactic; he didn’t want to offend. But Pavel was not pleased.

“Okay, suit yourself,” he replied.

Will walked back to his table, feeling the anger rising in him but keeping it under control. Ethel saw the tension on his face. “What is it?”

“Pavel, Karol, and Lisa are all drunk because they grabbed an extra bottle of wine. I grounded them for tomorrow morning’s EVAs.”

“Oh, that’s a problem.”

Madhu came over. Shall we get started?”

Will nodded. “I’m not going to say much, though.”

He rose and walked to the end of the Great Room away from the tables. “Can I have your attention, please,” he exclaimed. “This is my opportunity to welcome all of you officially to Mars. I had planned to announce various administrative arrangements and talk about priorities, but we’ve all had a very enjoyable evening and I think it’s better to turn to the festivities instead. Tomorrow morning after breakfast, rather than going

outside to continue unloading the shuttles, I think we'll start with a staff meeting to talk about our plans. I look forward to discussing things with all of you then.

“Now, we'll turn to something you might not expect at an outpost far from Earth: a little culture. It's amazing how many of you have artistic talents. We'll now see the results.”

Will walked back to his table and Madhu moved forward to introduce the first act. As Will sat, Ethel leaned over and whispered, “that was a Solomonic decision, my dear.”

“Well, they're too drunk to listen to me. Tomorrow morning they'll be sober, but not sober enough to don a pressure suit. It's the best solution I could think of.”

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After breakfast the next morning everyone drank a second cup of coffee while Will described his ideas for the next eighteen months. “Since we're now fresh from our night's rest, I'm giving you a longer version of the material I planned to cover last night, complete with visuals on the screen.” He pointed to the screen, which already had his first slide on it. “Mars currently has twenty-three adults and one child. It is one of the most educated and highly trained groups you can find. This group, to survive and achieve its goals, must be highly productive, so I want to structure this place to maximize work satisfaction, a sense of empowerment, and a feeling of accomplishment. At the same time, coordination is essential, so there has to be a focus on team building and coordination as well. Finally, there has to be a sense of progress and advancement, which means the people who have been here longer generally have more responsibility; this gives people an incentive to stay and advance.

“With that in mind, I propose to create a series of nested spheres of activity, each of which is a team of at least two with a coordinator. The second person of the team may be the assistant in some circumstances, depending on time allocations, and is the backup. The sections—the smaller units of responsibility—are nested inside departments.

“For example, Gaston Gilmartin is the Coordinator of Animal Husbandry, with Lisa Kok as the second; Lisa is the Coordinator of Horticulture, with Gaston as the second and Madhu Gupta-Anderson as the third; Madhu is coordinator of food services, with Lisa as second and Gaston as third. I should add that I am the fourth member of that team. These three sections together are part of the Department of Food Production and Services, coordinated by Madhu.

“Another group of responsibilities is Construction and Fabrication, the overall coordinator of which will be Ethel MacGregor, though while she is on maternity leave the coordinator is Paul Renfrew. Within that department we have chemical and plastic fabrication, coordinated by Ethel, with Paul as second and Lisa Kok as third; small object fabrication, textiles, and crafts, coordinated by Lisa Kok, with Madhu as second and Ethel as third; metal fabrication, coordinated by Paul with Pavel Rudenkov as second and Ethel as third; construction, with Pavel as coordinator, Paul as second, and Karol Havlicek, and myself as fourth.

“A third department is Maintenance, coordinated overall by Rick Page. Within it is the nuclear equipment section, coordinated by Rosa Stroger, with Rick as the second; the space vehicles section, with Rick as coordinator, Karol Havlicek as second and Rosa as third; the general mechanical section, with Karol as coordinator, Rick as second, Ethel,

myself, and Rosa as thirds; and cleaning, coordinated by Karol, with Lisa and myself as seconds.

“Fourth, we have Science and Exploration, coordinated by Jerry McCord, which is divided into seven groups. Surface exploration will be coordinated by Roger Anderson, with Jerry and Érico Lopes as seconds. Geology will be coordinated by Érico, with Neal Stroger as second and Roger, Jerry, Érico, and myself as seconds. The Geology Laboratory will be coordinated by Lal Shankaraman, with Neal as second. Meteorology and climatology will be coordinated by Patrice Dumkowski, with Érico as the second. Exobiology will be coordinated by Monika Yevtuchenko, with Linda Dubois as second. Prospector maintenance will be coordinated by Koyo Takenaka, with Carmen Segovia as second; Prospector utilization will be coordinated by Carmen, with Koyo as second and myself, Ethel, and Monika as thirds.

I am inaugurating a Department of Human Services, with three sections: Medicine, co-coordinated by Shinji Nagatani and Eve Gilmartin; child care and education, coordinated by Ethel, with Madhu as second; and the arts, coordinated by Madhu.

There are two miscellaneous sections: Phobos, Deimos, and Embarcadero, coordinated by Érico, with Paul as second. It is both a maintenance and an exploration matter, so it fits into neither department. The other is Exports, coordinated by me. The Exports Section will have as its purpose to find things we can sell to Earth and near-Earth space.

Altogether we have five departments and twenty-three sections. I'll meet with the departmental heads monthly to assign how many hours each person devotes to each

department, and the department heads will meet with the section heads or the staff to divide up the hours. People will not, by any means, be limited to their own departments or sections. Anyone who wants to explore, for example, should come to Jerry or me, and we'll schedule them; the second will then take over the section temporarily, or if the second is seeking a temporary assignment his or her responsibilities will devolve upon the first or the third, or someone else. I hope by the end of our time here, every section will have a third member able to perform the duties. We need considerable flexibility in case we have a crisis.

"I hope this system will produce balance, but we may need to replace it with something simpler if it doesn't work. Any questions?"

Will looked around at the audience. Some seemed puzzled or concerned; some seemed flattered. In reality, the division of work was meant to soothe egos as much as anything. But it could also give people power bases instead and force department heads to bargain with section heads about everything. He'd have to be vigilant to make sure the plan worked.

"In practice, how will anything get done?" asked Roger.

"Someone with an idea that affects the section only will run it past the section; if it involves resources across the department, the department head; if it involves resources from several departments, the person will talk to the relevant heads of the departments or to me. I'm not talking about long meetings, necessarily. The principle is for everyone to have an idea what's going on and what ideas will fit in with others. We all have dozens of ideas, but we can't implement them at once."

“How will we all know what ideas are being considered by everyone?” asked Rick.

“Sometimes when I hear about something, I’ll ask for a quick report by email to be shared with everyone via the listservers or the outpost forums. Once a month we’ll all sit down for two hours and share quick reports. I’ll be making rounds two mornings a week to visit and see how everything is going.”

“Just like on Pax Station,” commented Jerry. The principal space station in low earth orbit now had a staff of thirty-six, and a similar system had been implemented there a year earlier.

“Other comments?” asked Will.

“This is a common enough system for organization; it’s worth a try,” replied Pavel.

“I want to know more about exports,” replied Jerry, frowning. “There’s nothing like that at Pax or Shackleton.”

“True. The Exports Section represents our commitment to Mars as a contributor to the economy of humanity. Its purpose is not to cover the costs of Mars exploration and settlement; that’s impossible and will probably remain so for a century. Nor is its purpose to take significant resources away from exploration of this world; exploration remains our focus. Rather, it represents our long-term commitment to make Mars an economic player, which it will inevitably become some day. Who knows, three hundred years from now it may be a huge contributor to a solar-system economy and a major proof that humanity has achieved a stage-two civilization, one that has grown beyond its home world. But those are very long term goals; right now the Exports Section is a very small, token start.”

“Interesting,” grumbled Roger, disapprovingly.

“Other comments and questions?” asked Will. There were none. “Alright. I thought I’d offer what I understand to be our common goals for the next eighteen months. This does not represent a mandate to the departments and sections, but a summary of existing goals. In a few cases I might highlight some possibilities for further consideration.

“Food Production and Services: The big goal is to raise the number of greenhouses from four to nine, which should be able to feed nine to fifteen people, depending on their configuration. We already have most of the soil made and the greenhouses are on their way; two are in the *Alba* waiting to be unloaded. We have quite a few new animal and plant species to get established and new ecologies to differentiate from the existing ones and establish. To these goals, it seems to me, we need to add a few longer term goals: we need to become self-sufficient in food, even theoretically, possibly during Columbus 4 or 5; we need a very large pressurized open space for our own recreational use and for agriculture; and eventually we need to be able to make greenhouses of native Martian materials instead of importing them. To what extent we can pursue these during Columbus 3, remains to be determined.

“Construction and Fabrication: The big goal for Columbus 3, after we set up the new habitat and greenhouses, is construction of a pressurized facility capable of housing people safely and comfortably. This is a very demanding goal for us and will require about four full time staff. It will also strain our existing equipment to make the steel, plastics, and chemicals the facility will need. If this goal is achieved, we may never need to import another habitat, so it is immensely important.

“Maintenance: The big goal for Columbus 3 is to set up the two nuclear reactors coming on the automated cargo vehicles. Because each one is mobile and able to power an entire expedition, they are vital to expanding our exploration plans and maintaining our power output in dust storms. Secondly, we will be developing our spaceport and our ability to maintain the shuttles.

“Science and exploration: if all the automated cargo vehicles arrive safely, we will soon have two more rangers and a second conestoga, able to mount a second independent expedition. A priority will be the North Pole, which we should be able to reach; the nuke will be essential for the effort, as it will allow the melting of large quantities of ice to build ramps up the cliffs of the layered terrain. The South Pole may be possible as well; we’ll need about three months to reach it. Beyond that, it is possible for us to build Route 1 in both directions at once and have the two expeditions meet on the other side of Mars, thereby constructing a dirt track all the way around the planet. Hence the unofficial name of the route: the Circumnavigational Trail. This will open up much of Mars to exploration. Roads to the tops of one or more volcanoes may be possible as well. We may be able to build a road out of the other end of the Mariner Canyons, making the canyon into a transportation conduit.

“Scientifically, I know Lal wants to start drilling one of the layered terrains; this is a very important goal if our equipment can handle the cold. Linda and Monika want a deeper drill hole in the former northern seabed to search for fossils. It’s not clear we can do both and explore, unless we can use Prospectors or the Sunwings to maintain the drillers. Our geologists want to sample all the remaining terrain units by Prospector or in

person. In a few weeks we're going to try hooking and moving a Prospector; if that works, it means we can move them around more effectively.

“Services: The sick bay is being upgraded and a major study will be made on the health of young mammals, including one unexpected young human. We have been studying Martian rabbits for eight generations; we'll be studying calves as well. Child care and art are new areas of endeavor and it will be interesting to see what results with them.

“I don't anticipate we'll be visiting Phobos or Deimos until Columbus 3 is ready for departure. Finally, exports: when the three automated cargo vehicles fly back to Earth in two months, we are prepared to fill them with twenty-four tonnes each of Martian argon, nitrogen, and fossiliferous rocks that we've been saving up for the last ten months. The Lifters accompanying them can each carry twenty-four tonnes of methane. Thus we can supply all the fuel for Columbus 4. This represents a savings of about one hundred fifty million dollars, about eight percent of our total cost. The surplus methane—about thirty tonnes—can be sold to the moon for seventy million dollars or to people in low Earth orbit for about thirty million. It is a very simple, easy task for us to accomplish, though we still don't have a green light to do it. If we get permission, we'll start accumulating exports for two years from now as well.

“That's the plan for the next eighteen months. No doubt there will be many specific objectives to add to it as we go. There's one other dimension of this columbiad that's important to mention, though; the social. I hope that all twenty-three of us can get to know each other well and become friends. Columbus 1 and 2 gradually melded together into close-knit groups. The social dimension of this place has emerged as far

more important than anyone would have imagined. We are all the company we will have for a year and a half, and for those of us who stay, a close working relationship is extremely important. Yestersol I was commenting with someone about that and the statement was made that the original plan for the six Columbus missions was not to settle Mars, but to establish a beachhead. Well, we have settled Mars; that's the reality of the situation. We are residents of a planet as well as of Aurorae Outpost. Like it or not, we have started to create a common Martian society and culture, and we will carry it forward in the next eighteen months. I'm confident the results will be remarkable."

Will looked around the room. People were chewing on the review of the plans. It was on the outpost website, but when reviewed in this way, it seemed incredible that they were trying so much. "Questions and comments?" he asked.

"How long will it take us to go all the way around Mars?" asked Jerry. The idea obviously fascinated him.

"With the nukes, we'll be able to cover a thousand kilometers per expedition per month. Mars is 21,000 kilometers around and we already have 2,500 clicks of route cleared along Marineris. Assuming it takes a month to get out of Noctis Labyrinthus, and assuming we travel an extra twenty percent to visit geological sites and such, and assuming both expeditions are working on the route, we're talking about twelve months of continual work. So it is possible to complete it in the next eighteen months."

Érico whistled. "We may circumnavigate the equator and reach both poles during this columbiad." They had started using "columbiad" to refer to the roughly twenty-six months separating the arrivals of the Columbus missions from Earth.

“And we could do the drilling as well, if we ship a solar power unit to the drill site to power it,” added Roger. “The big problem will be maintaining the drill. That may require regular trips to the drill by people. Prospectors generally are not adequate for work of that sort.”

“We have new Prospectors and new software,” replied Koyo. “The P-250 model is supposed to have the strength of a human. So we should give them a try.”

“I’m not sure whether this is the place to raise this matter,” said Lal. “But I’ve been examining the latest Sunwing reconnaissance of Candor Chasma. In addition to the layered sedimentary deposits and the eolian deposits, there appear to be some pretty remarkable intrusive igneous complexes accessible in the escarpments. I think we have to make a detour to Candor. It’ll take a month.”

Will nodded. “I think a case can be made. I’d take the proposal to Roger; he’s coordinator of surface exploration. My guess is that in about a week we’ll be holding a big meeting of the folks involved in expeditions and we’ll be setting priorities. Houston’s priority list is ready, but it’s up to us to decide whether to stick to it or propose modifications.”

Lal nodded. Lisa raised her hand, which no one else had done. Will nodded.

“Striving for self-sufficiency is a good idea,” she began. “But the term has different meanings. We can cut back on our plant diversity, focus on a few, higher productivity crops, and raise all the food we need, but the diet will be pretty boring. I assume that’s not what you mean; there’s no reason we shouldn’t be importing steak, champagne, caviar, and a few other things we won’t be raising here for the next few

decades. On the other hand, we probably need to set aside at least part of one greenhouse as a kind of park, because I sense all of us miss the chance to be immersed in greenery.”

“Here, here!” agreed Paul.

“Yes, you are right about self-sufficiency,” agreed Will. “I didn’t mean we should decrease plant diversity. If anything, we need to increase the variety in our diet. I’d like us to move toward increased diversity *and* self-sufficiency; that’s what I mean. Columbus 1 arrived here with 5.1 tonnes of food and other consumables for the flight back to Earth and 5.4 tonnes for consumption here on the surface; 10.5 tonnes for the six of us, or 1.75 tonnes per person. For Columbus 2, the greenhouses allowed us to cut the total to 1.25 tonnes each. With Columbus 3, we’re down to one tonne per person, a savings of eighteen tonnes. I don’t mind importing half a tonne per person of steaks, champagne, computers, clothes, or whatever. But if this place is to grow, we have to acquire greater capacity.”

Lisa nodded; she understood his point. “Regarding a recreational area, I’d say yes, design one,” added Will. “If you create an orchard area and all the trees are in pots on wheels, we could move the trees together for a few hours a sol at lunchtime and at night. I suspect there are ways to create dual-use areas.”

“Oh, definitely,” agreed Lisa.

“Then do it,” commented Shinji. “I’ve been here over four years, and I crave a green space. As a physician, I know it’s important.”

“Definitely, let’s add that to the plans,” agreed Will.

8.

## Exports

early June 2025

After the staff meeting ended, work began immediately. Each shuttle had brought fifteen tonnes of supplies and equipment to unload, store, set up, and test; almost as much as Columbus 1 and its three automated landers. Among the items in the cargo were Habitat 4 and Greenhouses 5 and 6. The former was needed because the three habitats were filled to capacity with the twenty-four people in them, and the greenhouses were needed to accommodate the new plants and animals that Columbus 3 had brought.

Will was outside with Pavel Rudenkov, their new civil engineer, that afternoon to plan the location of everything. They stood near the eastern base of Face Rock—an outcrop separated from Boat Rock by a massive crack, its eastern side etched by millions of years of weather so that, if one stood at exactly the right spot, the profile of a human face could arguably be seen—and surveyed the existing facilities stretching out downhill, and north, of them. There were three round habitats in a row, each twelve meters in diameter and six meters high, though with their radiation shields of Martian regolith, ice, and parachute material they looked to be more like sixteen meters across and eight meters high. Sandbags or dry stone walls protected the airlock doors on the east and west sides, and the frequent windows, from sliding and slumping dirt; the parachute material stretched over the tops made the habitats a bright white in the sun. The airlocks connected to greenhouses, which ran north-south on each side of the habitats, providing green corridors through which people could move from habitat to habitat.

At the bottom of the slope was the Mars Life Science Facility, connected to the east side of Habitat 3 via the industrial facility, and to the west side of the habitat via a pressurized tunnel, which was stuffed with aromatic herbs. At the top of the slope west of Habitat 1 was a long mound of dirt which buried the Geology Facility, their first pressurized building, made of welded Martian iron and plastic.

Beyond the habitats and other modules, at the base of the northward slope, were three cylindrical solar power units, each thirty-two meters long and thirty meters in diameter; the cylinders rolled on a plastic skirt to keep their silvered hemispheres pointed toward the sun, which in turn reflected nine hundred sixty square meters of sunlight onto about one hundred meters of solar panels. The high efficiency panels generated about 150 kilowatts of power and, once the sun had heated them to 150 degrees Centigrade, powerful fans circulating Martian air across their backs recovered another 150 kilowatts of heat energy for heating the habitats and greenhouses.

Beyond the solar power units were three sets of wells, drilled up to half a kilometer into the rock and sediment of Aurorae Chaos. Surplus hot air from the solar power units was pumped into the wells, where it evaporated ice from the permafrost, extracting hundreds of tonnes of water per year for the Outpost's use; the emptied pore space could then be used to store compressed oxygen and methane gas, and the heated underground rock stored enough heat to maintain the outpost's warmth for months through the thickest of dust storms. The wells were distinctive because each was surrounded by white parachute material, which in turn covered an ice-dirt mixture that capped the wells against pressure leaks.

Pavel gazed at the very impressive facility, then turned and looked southward past the edge of Face Rock at the rolling, stony plain of Aurorae. The surface was interrupted by a landing strip one kilometer long and one hundred meters wide, with a hanger of stone, plastic, rock, metal, parachute material, and ice-cement at one end. It was for the sunwings, big-winged, flimsy, solar-powered aircraft capable of flying for weeks across the planet, taking extremely high-resolution photographs, serving as high-altitude communications relays, or transporting up to half a tonne of people or cargo from place to place. While the sunwings normally performed vertical takeoffs and landings using small rocket engines, Aurorae outpost had an emergency runway for machines whose rocket systems were exhausted.

Beyond the landing strip were six circular clearings a hundred meters across; landing pads for shuttles. Four pads were occupied. Barely visible were electric cables snaking from vehicle to vehicle; they ran under lines of anchoring rocks to the hanger, then to the Outpost.

“An incredible amount of work,” Pavel finally said.

“You can see why, when I stand here and look around, I feel immensely proud,” replied Will.

“Indeed. And if the work weren’t enough, the view is spectacular as well!” Pavel pointed northward to the escarpment marking the edge of the Aurorae Valley, some twenty kilometers away. Rising 1.5 kilometers, the escarpment was an immense wall of rock blocking part of the sky.

“We’ll have to take you over to the escarpment base; it’s really impressive there,” said Will. “You can see why we moved the Outpost here. The original site was at the

western end of Boat Rock, just on the north side of the notch separating it from Layercake Mesa. The view would have been nice there as well, but here we have Face Rock, we have a better view to the south, and we have better transportation to the air strip and the shuttle pads.”

“And you can get on top of Boat Rock from here.”

“Yes. The path was hard to clear; it would have been a bit easier over by Layercake. We built a narrow road up there a few years ago, and now we have two wind turbines on top of Boat Rock. During the last dust storm season they generated quite a lot of power. When you approach the Outpost they’re the first things you see.”

“I bet. I really have to salute all of you for this achievement.”

“It’s about ten person-years of labor, out of the total of thirty-eight person years of work expended on Mars so far. That doesn’t include the clearing of the pads and the stringing of the cables, which was all done by remote control during the two years before we arrived. And now we have twenty-three adults giving eighteen months of service here; another thirty-five person-years, and another eight to ten will go to expansion of the Outpost.”

“I can hear the pride in your voice,” said Pavel. “It truly is exciting to be involved in this work.” He pointed. “Now, I assume we are expanding parallel to the existing facility, but west of the three habitats and downhill of the Geology Facility? That’s the official plan. Habitat 4 will go immediately downhill from the Geology Facility and west of Habitat 2; then the new building will go downhill from that.”

Will nodded. “That’s the plan, but I’d like to propose a different arrangement. I’d like to reserve the place where the building is scheduled to be built for a dome of some

sort; a large pressurized facility with a transparent top, filled with plants, with open space, etc.” He pointed down slope to the rocky terrain to the left—west—of Habitat 3.

Pavel was surprised. “But no plans for such a facility exist.”

“I know, but I’m hoping we can get such plans approved in the next year. If we build the building on that site, then the dome will be relegated to the side of the Outpost, but I suspect it will prove centrally important to it.”

“Where would we put the building we’re scheduled to erect?”

“West and maybe a bit north of the Geology Building. Its eastern end could have a connection to the Geology Building and a connection to Habitat 4 via separate pressure tunnels, so it would have two exits.”

“But both would be on its eastern end; the western end wouldn’t have an exit at all.”

“True, but the building, right now, is probably going to be two stories high. So if a leak sprang on the top floor, one could run to the western end and down the stairs to the lower level, or the other way around. Alternately, we could build a pressure tunnel into the southern wall of the building, which would be buried and thus would be the most enclosed part of the building.”

“People using that building will be a bit far from the rest of the Outpost.”

“Yes, but ‘a bit far’ will still be only thirty meters or so. It would be thirty seconds walk; not much. Once the dome is installed they would be a convenient walk from it. And the dome, I suspect, will emerge as the new center of the Outpost.”

Pavel looked unconvinced. “This is an unexpected change in the plans.”

“Sometimes, unexpected change is good, don’t you think? Consider that the new site of the building will put it farther up slope, closer to Boat Rock. That means it’ll have a better view of the escarpment. Any building built down slope from it would have to be low enough so that its roof won’t block the view.”

“Of course, as the Outpost expands, there will be many buildings built, and some will have better views than others.”

“Yes, that’s true.” Will was frustrated by Pavel’s resistance. He turned to him so they could see each other’s faces through their helmets. “Pavel, I appreciate your professional advice very much, and I look forward to seeing what you can do to organize us to build a truly excellent, sophisticated building. But let us leave room for a dome or some other large exterior space as well. It isn’t part of the plans, but I think it needs to be, and I think it can be.”

The Russian looked at him, hesitantly, then nodded. “Very well, Commander. We can change the plans. What you are suggesting is not a major change, and it is not a major problem. I’ll see what I can do to refine the idea.”

“Thanks. And call me Will. There are only twenty-three of us here; we can be informal most of the time.”

Pavel smiled. “Okay, Will, I will.”

“When do you think we can get started?”

“With construction? The next four weeks will be filled with setup of Habitat 4 and the two greenhouses. I can use that time to move the building plan to the location you propose and consider the safety implications; as you say, we’ll have to plan a two-story building and maybe incorporate an evacuation tunnel. Such a tunnel would be a good

idea anyway; it would allow for pedestrian traffic through the building without disrupting the interior space, and if the Outpost grows in size quite a bit in the future, a lot of people will be walking through buildings to get to work or to the cafeteria. I suspect we can start with a lot of the basic work in two weeks. We'll have to do all the excavation with the rangers before they're taken out on expeditions."

"Two weeks. Good. I'm glad we were able to come out here and talk about the site."

"So am I. Now I need to supervise the placement of the habitat."

"You go do that, and I have to go inside to complete a video appointment.

Thanks, Pavel."

Will walked back to the airlocks and the suit donning facility attached to Habitat 1. In twenty minutes he was back inside at the bridge in Habitat 1. There he sent an email to Heather Kimball, his old friend who was the new President of the Mars Exploration Society. He summarized his various ideas and plans; she had proved a valuable informal advisor and brainstorming partner. Then he received the message from Harold Lassen, head of Mars Mission Operations, for which he had been waiting with some trepidation, because he had no idea why Lassen wanted to speak to him. Lassen looked older and more stressed than usual.

"Will, I'm glad we can have this exchange of videomails about Aurorae Outpost. For months I've been looking at your various emails and thinking that we need to hold a big half-day meeting with the various experts so we can go through your suggestions and either get them moving or put them to rest. So far, that hasn't happened; the unexpected staff cutbacks we've had to implement have been very difficult. We're in the position,

down here, to hold on and make sure nominal plans are carried out, but we have few resources left over for new ideas. Frankly, Mars has just grown too fast for the budget. Three years ago we drew up this year's budget to support a Mars operation with twelve crew, not twenty-three. This means your hopes and our reality are clashing rather badly, and I apologize for that. I really appreciate your approach to developing the Mars project and wish we could provide more ground support.

“Regarding your conducting two simultaneous expeditions: our ground team will be barely adequate to provide support for normal conditions, but an emergency for one expedition probably would require the other one to hold tight, and an emergency with both would be impossible to deal with. So I don't see how we can do it, right now.

“Regarding the so-called Dome Project: I agree that you all need some sort of large space for agriculture and recreation, but it is impossible to justify the expense right now. The dome will cost between one and two hundred million to design and build. The expansion of Pax is costing two billion more than planned, and the Drake Radio Telescope slated for Earth/solar Lagrange 2 has become a monetary black hole. If that weren't bad enough, as you know Congress is breathing down our necks right now to slash our launch budget and use the Swift Shuttle instead. Upper management is convinced this is a false economy, that the Swift's safety is unproven, and using it puts all our eggs in one basket and jeopardizes NASA's future. I fear Congress may force the issue by slashing NASA's budget, in which case Columbus could suffer badly; there might even be a decision to cancel or cut back Columbus 4. Under those circumstances, there can't be a dome.

“Regarding your proposal to use the automated cargo vehicles to fly methane back to Earth: besides the problem that it partially dejustifies Shackleton’s fuel manufacturing facilities, it will also demand more precise flying of the ACVs, extra computational work, and more work at Gateway to recover and store the methane. Right now we just can’t afford it.

“As for selling Mars rocks, the resistance that idea has generated in the scientific community is unbelievable. I suspect you have received hate e-mail as a result. That proposal will be dead in the water for some time.

“As for the idea of exporting argon and nitrogen, it is premature; the equipment you have wasn’t designed for it.

“But I am not just the bearer of bad news, as sad as I am to have that duty. We have looked at your proposal for additional reactors for Columbus 4. With the President safely reelected, momentum in favor of further developing nuclear power has increased, in spite of the launch vehicle controversies. It appears that you’ll have two more nukes on the way in two years even if passenger flight is cut from Columbus 4. The moon will get three more, minimum. The new design is optimized for outer solar system use as well; the Lewis and Clarke Project was recently approved, as you know, and it involves an ion engine to push sixteen tonnes of satellites and probes to the Saturnian system, where the mother ship will go into orbit around Titan and serve as a powerful communications relay between the entire Saturnian system and Earth. It’ll use a 250-kilowatt nuke. We also have a green light to develop a small bimodal solid-core nuclear engine.

“So energy, at least, will be on the way. I’m hoping that we can get next year’s budget re-configured to provide better ground support for your initiatives. Meanwhile,

let's think of creative ways to use your people efficiently within budgetary constraints. Looking forward to your response. Bye.”

Will stared at the screen, stunned. Lassen was pulling the plug on half of Columbus 3 and possibly ninety percent of Columbus 4. It was a common historic pattern: NASA had put scientific stations on the moon with the Apollo vehicles, and then had turned them off because of lack of funds; it had even turned off deep space vehicles because of no funds, even though they were functioning normally. And they were funding a nuclear engine that would probably be more expensive to operate than the solar-powered ion tugs they were already using for cargo transportation; eliminating a perfectly good vehicle for another, more problematic one was another common NASA pattern. But it made absolutely no sense to put people on Mars and be unable to employ them all. That infuriated him.

Furthermore, the “good” news had nothing to do with him. He had mentioned the potential use of two more reactors in a memo, but had not requested them. He had known that requesting them was unnecessary because the White House was pushing nuclear power in space strongly for various strategic and defense reasons, which guaranteed support for sending them to Mars whether they were needed or not.

Will began to scribble talking points on his attaché; he had to be clear but exceedingly polite because Lassen was known as one who did not like having people disagree with him. He hit reply.

“Thank you, Dr. Lassen, for your message. I sympathize deeply with your dilemma, which is one the agency has faced again and again. It has always been easier to justify the expense of mounting a program than in maintaining it. But it occurs to me that

there is an important principle to remember in this case: idling people who have put their lives on the line to explore is a far more serious matter than turning off an automated probe because of lack of funds once it has completed its nominal mission. And presumably we are talking about essentially laying off people here. If we can't send out two expeditions, what will we do with the folks who were scheduled to go on expedition 2? I don't think it's fair to expect them to sit around watching television for eighteen months. Would it be better if, in addition to an expedition, we have three vehicles exploring Aurorae? Since the trips are a sol or two at most, they aren't official expeditions and we can authorize them ourselves. But surely that is as risky as a second expedition? On the other hand, if we put those people to work on expanding Aurorae, that strains the industrial, construction, and greenhouse support staff more; how would that be better?

So I'm not sure what we can do to resolve this dilemma. Of course, one possibility is to do more work to boost Martian 'exports.' We can intentionally export fossiliferous rock for sale, rock that has not been selected for its scientific value and therefore is not being taken from scientists. Based on the market for moon rocks, we can sell Mars rocks in small quantities for about two million dollars a tonne; and the costs of sending twenty-five tonnes of rocks back to Earth is maybe half a million dollars per tonne at most, so NASA can make a good profit. And we have the rocks sitting here, ready to go.

"We can also devote human resources to methane exports. I was interested in your comment about dejustifying the facilities on the moon; but we are not talking about eliminating Shackleton as a principal source of propellant in low earth orbit, just

supplementing it with a fuel that can use the waste oxygen it currently creates and can't sell. Surely demand is so high, and rising, that shipping seventy-five tonnes of methane every two years hardly undercuts Shackleton? I understand the shipping creates some extra costs, but again the extra costs are less than the potential sales price. Even with the Swift Shuttle as competition, methane is worth a thousand dollars per kilo or a million dollars a tonne in low earth orbit, about fifty percent more than that at Gateway and twice as much on the moon.

“As for argon and nitrogen, we have ten tonnes of each in the extra tank capacity of the shuttles, and we can make a tonne a month.

Every tonne of supplies that is shipped here costs thirteen million bucks in transportation costs, using the Ares, ion tugs with xenon propellant, and lunar fuel. Martian argon will cut that to eight and a half million. The shuttles, automated cargo vehicles, and lifters that bring us supplies are designed to be flown back to Earth and reused, so they are able to fly back to Earth exactly the same mass of Martian resources they ship here. This opposition, we are receiving seventy-five tonnes of supplies and equipment. If we could ship the same amount back, you could amortize the equipment cost over twice the tonnage; that would lower shipping cost to here to about seven million. Perhaps the money saved would cover the cost of greater ground support? I suspect the surplus could cover the cost of a dome, over two years, don't you think? We're talking about a total income of about one hundred million dollars, which can make quite a dent in the shortfall. It could even save important parts of Columbus 4.

“So it occurs to me that one problem we have—the lack of ground support for exploration—is partially solved by another problem, that of exporting and selling Martian materials. Why not create the natural synergy the two offer?”

“I understand the argument that if Mars starts to export, its scientific mission will be diluted and expectations will rise to the point where the outpost will have to cover its entire expenses or be shut down. But surely a middle ground can be found. Why not aim for a partial coverage of transportation costs only? Mars will have to start contributing to its expenses eventually. Why not make the contribution an organic aspect of the expansion of the human presence here?”

“Thank you for the news about the nuclear reactors. That is an excellent development. Not only will our expeditions be strengthened further, but the Outpost will be in a much better position to ride out dust storms. We look forward to the arrival of our first two reactors in about a month’s time.

“What do you think of my concerns? Let’s talk more. Bye.”

Will reviewed his message, then sent it. He sat and stared at the screen, wondering whether he could do anything at all.; If the Mars residents passed a resolution allowing the civic authority to sell land, they could raise millions of dollars from Mars enthusiasts and sell services to them such as photographing their property thoroughly, retrieving samples from it, and combing it for meteoritic iron they could use for manufacture, for which privilege they could pay the landowner a royalty. That would be immensely controversial, and thus was an excellent bargaining chip. But he didn’t want to try something like that yet.

While waiting for a reply, Will called Jerry McCord, who was outside. “Hi Will,” he replied right away.

“Jerry, if Mars exports seventy-five tonnes of methane when it sends the automated cargo vehicles back to Earth, half for Columbus 4 and half for sale, how upset would the folks on the moon be?”

“Hum.” Jerry thought. “You mean methane without oxygen?”

“Yes.”

“Then you can only capture about twenty percent of the market anyway, because they’re still supplying the oxygen. And you’re doing them a favor, in a sense, because it allows the sale of a resource they mostly have to waste now. And with the growth in lunar tourism, they’ll probably have trouble meeting demand. They’ll probably want to buy some of the methane themselves.”

“Can you call any of your buddies about this matter? Because I’m trying to persuade mission control to let us export methane from the moons, fossiliferous rocks, argon, nitrogen, and other items of value, to cover shipping costs at least. I’m sure this is something that will cause some opposition from the moon lobby, at least at first.”

“Oh, please don’t ask me to do something like that. I’m not comfortable serving as salesman. And Will, as you know, you’re really rocking the boat with these ideas. I’m not sure I can represent your ideas fairly, let alone advocate them.”

Will considered that. “Thank you, then, for your honesty. I much appreciate it. Yes, I am rocking the boat and calling for some rather large and important changes. But if the moon exports, why shouldn’t we? These aren’t as major as having married people on

Mars, or children on Mars. At any rate, I can ask someone else for help, if you aren't comfortable with the request. Have a good sol, Jerry."

"Thanks, Will." He sounded relieved.

"Bye."

"Bye."

Will closed the circuit and paused barely a few seconds. Neal Stroger had many friends on the moon—he was a gregarious fellow and made friends easily—and had a good reputation. He called Neal, catching him outside unloading a shuttle as well. Neal stopped work and stepped aside to listen. "Sure, I can make a call or two, if you want. I agree with you, this is an important matter. We need to be able to ship methane. If Shackleton can export, why can't we? The communication and navigational burdens aren't significantly greater than shipping water from the moon; the delta vee is actually much less from Phobos. There should be plenty of demand to go around. I don't see this depressing demand."

"Neither do I. The price of propellant in LEO is set by the cost of shipping it up from the Earth; if we beat that price, people will buy from us. We can beat that price and make quite a profit because even from Mars, shipping to LEO theoretically is cheaper than from Earth."

"Especially for NASA, which is insisting on hauling everything up with its rockets. I probably can't make any calls until tonight, though."

"That's fine. It'll give me time to brief you a bit more."

"Great; after dinner, then?"

"Yes. Thanks."

“No problem. Bye.”

“Bye.”

A few minutes later, Lassen’s reply popped onto Will’s attaché. He opened it immediately.

“Will, thanks for raising these matters further. Look, unless we have that gathering of administrators and experts, I’m afraid I can’t change my positions. Everyone is saying we can only support one expedition at a time and that this is not the time to send us Mars rocks, methane, or anything else. Remember that even if we don’t launch Ares, we have to pay the launch crew anyway.

“More importantly, though, people are beginning to balk at the question of personal risks. No one has died on Mars yet. The recent incident on the moon has generated huge negative publicity. We have to be careful; or maybe I should say we have to be more cautious. These proposals you offer risk either people, or machines, or both. We have to think about them extra carefully right now.

“What can I say? Maybe I can set a date for the meeting for next week. Let’s touch base about this in a few days, okay? Bye.”

Will stared at the screen, anger building in him. Caution was always the recommended reply to innovation. It depressed him to think that far more people do and can have scuba diving accidents in the oceans on Earth than in a spacesuit on the moon or Mars. He searched the computer for the first videomail and attached it to a video message to Heather Kimball. “Good sol, Heather. I’m attaching a highly confidential exchange between myself and our friend Dr. Harold to this message. What can be done? He’s essentially saying that NASA can fly twenty-three people to Mars, but can’t afford to

employ them all, and won't let them moonlight on the side! The arguments strike me as extreme, too. I'm tempted to tell everyone here—which I'll have to do eventually—and while they're angry, suggest that the Mars residents authorize the sale of land to anyone who wants to buy it. Then when we're idle, we can be providing land owners services here; we might even be able to collect items for private export, if we could ever obtain a vehicle for returning them to Earth. But of course I won't do that to Harold. It'd infuriate him and make matters worse. Maybe the Mars Exploration Society can act in ways we can't, though. It sounds like the Swift shuttle is becoming a hot issue. Bye.”

Then, if that weren't enough, he attached the same video exchange to a message to Dr. Armando Cruz, Columbus 2's physician, who had settled back in Houston and was again one of the Capcoms for Mars. “Armando, good sol. I need your help to talk to Dr. Lassen; or maybe he needs your help to talk to me. As you can see, Mission Control wants to idle half of us, up here, and won't let us employ ourselves with exports and other potentially useful tasks. You can see him face to face; I can't. Furthermore, it appears that various people oppose us, and you can talk to them face to face as well. I need help communicating; above all, I want logical reasons, as opposed to political reasons, why we should accept Lassen's arguments! Bye.”

He sent the videomail, then stared out the porthole window. A late afternoon dust devil swirled a few kilometers away. His desire to do anything was drained from him, so he sat and looked. The window faced part of the future construction area that he and Pavel had just examined and he wondered what would rise there, and on the stony plain beyond.

He was startled when his attaché beeped with an incoming message. Ten minutes had passed.

“Good sol, Will,” said Kimball. “I’m blown away by Lassen’s message. This is just ridiculous. Safety is important right now, but not that important. I’ll make a few private calls to friends to ‘discover’ this information. If I learn anything else, I’ll let you know. Then the Mars Exploration Society will act. I may start by talking to Lassen and a few of his associates, letting them know what the MES can do, and I’ll talk to some journalists. I think we can be confident there will be embarrassing publicity.

“I know the 10,000 members of the MES will spend money on Mars; our survey indicates they’ll spend several hundred bucks per year. The survey suggests that there is about a million people around the world willing to spend an average of one hundred dollars per year on land, rocks, and services. Money is out there, it can be tapped. And the quantity can grow. A friend of mine who just retired from the astronaut corps has ‘his own’ little piece of the moon bordering the Aristarchus Trail south of Tycho; he doesn’t own it, but he’s explored it, has a chunk of it at home, he drove a few stakes into the reg to mark boundaries, and he considers it ‘his.’ Why shouldn’t he be able to buy it? The situation is ridiculous. Anyway, I’ll get started. Bye.”

That gave Will some hope. Just then another videomail arrived, from Armando. He activated it. “Hi, Will. I know something about this. Lassen’s getting pressure from the White House to make sure there are no other accidents. So if I were you, I’d focus on safety for people and reliability for machines. Some of this is an excuse to avoid innovation, too. The Swift shuttle matter has everyone scared. Regardless, I can’t see

how idling people increases their safety; as you noted, they can make short excursions instead. I'd focus on that. Bye."

Will hit reply. "Thanks, Armando; that's very helpful. You may hear from Heather, too. Bye." He sent the message, then just sat and looked out the window. The sun was getting low. He watched it set and considered his options. Now that Columbus 3 had arrived and the entire team was assembled in one place, it was time for safety practices and briefings. Some were already scheduled, but he could easily stretch out the schedule of other tasks and increase the safety drills. Then he rose to head to supper and talk to his staff about the new plans.

9.

## Conference

early June 2025

Will continued to exchange emails with Armando, Kimball, and Lassen the rest of the sol. Kimball and Armando called Lassen, as well. He decided to say nothing to the other Mars personnel, however. The next morning everything was quiet, so Will went outside to help place Habitat 4. By the end of the sol it had been inflated, Greenhouses 5 and 6 had been attached to it, and they had been inflated as well. They were ready for the interior work to begin: In the case of the habitat, reinforcing floors and walls with hard plastic sheeting, installing support columns, running pipes, placing stoves and other heavy equipment, laying wallpaper over everything to beautify the interior, installing plastic hoods around the skylights and windows, and covering the structure with a mix of water and reg; in the case of the greenhouses, setting up electricity and heating lines, hauling regolith-soil mixture from other greenhouses, placing the mix in locally made plastic trays and sowing seeds. A month of work faced them.

The next morning, everyone rose at the usual time—6 a.m., with dawn at 7—to eat breakfast, wash, and get ready to go outside. Ethel was to be among the workers, so Will planned to stay inside with Marshall. He carried Marshall into the great room of Habitat 3 with him, Ethel walking at his side. As they approached the habitat from their apartment in Habitat 1, quite a discussion was raging over breakfast.

“This is what I can’t understand about all of you,” Jerry said to Paul. “You’re treating Mars like it was. . . your home world. The Outpost seems to be your hometown. It’s just. . . crazy. As much work as you’ve done—and I salute you for your dedication—

this is a little hamlet out in the middle of nowhere. This isn't a sheep station in the Australian outback or something. It's much worse than that, it's isolated, primitive, in an incredibly hostile environment, dangerous, and constantly on the verge of getting wiped out."

"Jerry, you make us sound like a little European camp in a jungle surrounded by savages somewhere," objected Monika.

"Well, if you want to play colony, I can recommend a lot of places in Antarctica that are more hospitable to settlement."

"Oh, I disagree," replied Paul. "Antarctica is a wretched place to live in the winter. This place may be colder, but that's a technical objection. In a pressure suit it's too warm. It's much safer to be outside here than in Antarctica in winter. And we have sunlight all the time, too."

"But surely you would agree that this is no place to raise a family," said Patrice. "Who will the child play with? How will they get an education?"

"Now the Australian sheep stations are a good analogy," replied Paul. "They manage fine, there."

"They're not bombarded with as much radiation."

"But the radiation levels in the Habitats has been determined to be safe, long term," replied Érico, who was also listening. "A few months ago we doubled the mix of reg and ice covering them. They're the safest environments off Earth. And with all that reg and ice, nothing can puncture the habitats, either."

"I'd worry more about other things," added Carmen. "Like a safe pregnancy or all sorts of birth defects that could crop up independently of Mars."

“Those would worry me, too,” agreed Jerry, seizing on a point of agreement.

“Look, Jerry, this is not the moon, where we can rotate the crew back to Earth every six months,” said Érico. “It’s not the moon in terms of gravity, either; lunar gravity is too low for good health, long term, unless one really works at it. This place will become a successful center of science and exploration only if some people decide to stay, acquire far more experience than they can get in eighteen months, really get to know the place, and maintain their health carefully. If people plan to stay many years, you can’t expect them to be celibate monks or emotional automatons. They have to have partners. I don’t see how science suffers. We don’t ask nuclear physicists, or chemists, or surgeons, to be celibate on Earth. We don’t assume that their professional skills suffer as a result.”

“I can see that,” agreed Eve, who was listening from another table.

“Just don’t pressure me to marry,” replied Lisa, grumpily. She glanced at Karol, with whom she was sleeping most nights, and he nodded.

“I think there are two different concerns that are being mixed,” added Rick. “One is the couple versus non-couple dynamic. Of the twenty-three adults here, about half are couples and about half aren’t. You all from Columbus 2 were almost completely couples; those of us just arrived were not, except for the Stogers and Gilmartins. Furthermore, we’re used to serving in space in teams that have no couples at all. And the couples that have been here a while naturally regard this as home; no one has ever viewed ISS, Pax, Gateway, or Shackleton that way.”

“Definitely,” agreed Jerry.

“And the people leaving their spouses on Earth suffer a pretty high divorce rate,” added Paul. “I speak from painful, personal experience.”

“I suppose I’ll get used to this place eventually,” said Jerry. “It’s still culture shock every morning, though. And sometimes you all are a bit clickish.”

“Well, I count at least two clicks among the Columbus 3 crew,” replied Gaston. “So I think we have at least three clicks, here.”

At that point, Will came in with his family. He had heard only a bit of the conversation; it immediately ceased with the Commander present. “Good sol,” he said to everyone.

“Morning,” replied Jerry, as if he were correcting Will, but others replied with “good sols” and “good mornings” of their own.

“Here, let me take the baby while you get your breakfast,” offered Eve, so Will handed Marshall to her. She cuddled the little boy, who had become used to being passed around in the Great Room. Gaston took the boy next and kissed him; then he handed him to Jerry. “Here; it’ll do you good. Holding a baby releases serotonin; you can always justify it that way.”

“I don’t need to justify holding a baby!” replied Jerry, and he took Marshall quite gently and cooed at him. “My son’s now twenty-one; it’s been a while.”

“I wonder whether he’ll start walking early, in the lower gravity,” commented Gaston.

“Unlikely,” replied Eve. “Animal studies don’t reveal any changes of that sort.”

“We’ll wait and see,” replied Ethel. “He’s just three months old, remember. He couldn’t walk right now if the gravity were one percent. And the normal range is nine to fifteen months, so one data point won’t tell us anything.”

“Furthermore, I walked early and Ethel walked late,” added Will.

The two of them got their food and sat, choosing a table closest to the Columbus 3 arrivals; Will had been very concerned about the crews integrating. They chatted about the latest soccer and tennis games on Earth, the growing worry about the behavior of Turanistan—Earth’s current rogue state—the continued global recession, the continued successes of the Swift shuttle, and a few other topics.

Breakfast was beginning to break up when Roger and Madhu arrived, later than usual. “Have you heard the news?” Roger asked. He glanced at the television screen on the wall; it was off, which was unusual. He looked at Will first, then the others. Everyone shook their heads. “I was very surprised and concerned. The Mars Exploration Society has said NASA considers it impossible for us to mount two missions at once, like we plan, because they can’t support them. MES criticized the agency for shortsighted planning and for refusing to let us ship methane back to Earth. They called for the sale of Martian land and rock samples to those who wanted them.”

“Can’t mount two expeditions?” asked Jerry. “What will we do?”

People turned to Will. “It’s true,” he said. “I’ve been in discussions with Lassen on and off for the last two sols. Apparently the freak accident on the moon has triggered a safety crackdown, and the support staff on Earth is considered sufficient to support a Mars operation of only twelve.”

“That’s crazy!” exclaimed Érico. “It’s idiocy!”

“What’s being done?” asked Paul.

“I think this is something all of us have to work on,” replied Will. “Since the MES has made the problem public, those of you who don’t work for NASA are free to comment on it to the press. They’re going to get some bad publicity.”

“Serves them right!” replied Érico.

“There’s not a lot of support they can provide us with, anyway,” said Jerry. “That was true on the moon as well, but with the time delay, it’s even more true here.”

“Geological support is abundant anyway,” added Roger. “There are hundreds of professional geologists anxious to serve as ground support advisors. There are even talented amateurs. If a fuel cell malfunctions, it can wait until we try to fix it, and it isn’t hard to get stand-by support when the repair’s scheduled.”

“I’ve spent the last two sols reminding them of this,” said Will. “And of the fact that they’ve spent four billion dollars to put Columbus 3 here, yet can’t find about thirty million to provide adequate ground support. Apparently the White House is putting the agency under a lot of pressure to avoid other accidents. The MES publicity was really aimed at getting the White House to move, I think. I told Lassen that if they don’t change their policy, we’ll send out a five-vehicle expedition with twelve people on board to the north polar region, and with the midnight sun there this time of year, we’d run the expedition in shifts twenty-four point six hours a sol; the result would be as much exploration as a two-expedition plan anyway, but greater safety because the vehicles are all in one place.”

“We could do something like that even at the equator,” said Roger. “We could keep the expedition moving forward thirteen hours a sol instead of nine or ten, and use three vehicles to clear the route instead of two. We could probably average fifty kilometers a sol instead of thirty.”

“Exactly,” said Will. “We can be creative and solve the problem. Meanwhile, I’m scheduling an entire extra week of safety training before the first expedition departs. We have to focus on safety more; we don’t want a casualty here.”

“By the way, Will,” said Stroger. “I think the moon people will support our shipping of methane back to Earth orbit. The ones I talked to said they would consider buying it from us because they need carbon, and we can provide it more cheaply than Earth can. They’d buy ten tonnes of nitrogen, if we can get it to them. They’d even consider buying Martian argon for their ion tugs.”

“I already have a pledge from them for the nitrogen. Now we need a meeting, where these issues can be discussed and resolved,” exclaimed Will.

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It was another week before the meeting Lassen had promised could be held. Eight top brass attended, included Lassen and Armando Cruz; in addition, Laura Stillwell, Commander of Columbus 1, attended, as did a balding, slightly overweight representative of the White House, John White. Will Elliot invited Roger to “attend” with him as well.

“We’ve already laid out our arguments in detail,” Will began in a video he taped an hour before the meeting. “You have the twenty-page proposal and Powerpoint summary we emailed to you, so all I’ll offer is a compressed summary. Mars is set up so that half the personnel can go on expeditions while the other half maintains the Outpost and does horticultural and industrial experiments. Leaving more than half of the crew at the Outpost simply idles them, or will cause them to go out on day trips that need just as much emergency support as a formal expedition. Our recommendation is to send out an expedition of five vehicles and ten to twelve people; it will require about as much support

as a three-vehicle, six-person expedition, but will accomplish about thirty percent more. Frankly, I cannot ask my people to sit back and watch television in the Outpost. It would be an insult to their professionalism and their courage.

“One alternate activity for my people would be exporting a payload of argon, nitrogen, and fossiliferous rocks. We have to fly three Mars shuttles to orbit anyway to bring back the cargo of the three automated cargo vehicles or ACVs. We have ten tonnes of argon, ten tonnes of nitrogen, and thirty tonnes of samples ready. Our three shuttles can easily lift them to Embarcadero; the argon and nitrogen will go in empty fuel tanks. The mechanical arm at Embarcadero can be used to exchange the ACV’s Mars-bound cargo with our Earth-based cargo, and the nitrogen and argon can be transferred into empty tanks in the Lifters. Then the shuttles refuel from methane and oxygen stored in a Lifter at Embarcadero, and three other Lifters with twenty tonnes of extra methane head to Earth with the ACVs. Finally, the shuttles return to Mars with the cargo.

“The ACVs and Lifters will aerobrake separately into Earth orbit. The argon will save us sixty million dollars lifting ion tug propellant. The methane will provide all the fuel we need to launch Columbus 4 to Mars and the surplus will pay for the oxygen the methane needs and make a small profit as well. The ten tonnes of nitrogen will be purchased by Shackleton for two point five million per tonne. The thirty tonnes of samples are worth between sixty and one hundred twenty million dollars, depending on demand.

“I’ve heard the objection that the effort’s expensive. It’ll cost less than ten million, so the result is a profit. The Mars shuttles have to fly to orbit anyway; the ACVs and Lifters are flying back to Earth anyway. The profit will buy all the extra ground

support we need. Mars will not pay for itself any time soon, but in a few years it can export as much mass as it imports and thereby cover the cost of flying the supplies here, and that's a statement of symbolic importance. Or, the increase in available funds can be put into the dome project that we are requesting; we need a large pressurized open space for agriculture and recreation.

“So, in summary, we are asking for three things: full expedition rights, exportation of methane and Mars surface resources with the ACVs, and a project to build us a pressurized space some twenty to thirty meters across. We see them as reasonable requests. We're prepared to launch everything next month. Based on articles in several newspapers yesterday and today, some other influential people and organizations think our plans are sound. In fact, at least two Congressmen have said they will sponsor bills to authorize the additional spending.”

Will could hear the last words playing back in the meeting room in Houston. Lassen looked at the others. “Comments?”

There was a pause, then the director of exploration services spoke up. “The rules governing support are clear. We can't do two expeditions with our current staffing levels here.”

Will was tempted to respond, but he knew they wouldn't hear him for twelve minutes. He had to scribble notes and send long responses to many issues at once. Lassen nodded. “What you say is true, and cutting corners with the rules is not possible in the wake of the accident on the moon. But idling ten people on Mars because we can't support them is insane.” He looked at White.

“How much are we talking about?” White asked.

“Thirty to forty million per year if we are to support the expeditions and the activities at the Outpost adequately.”

“How did you underestimate this so badly?”

“We turned in the estimate two years ago when we projected twelve people on Mars. We’ve been pressured not to raise the amount since.”

“Okay,” said White. “The nuclear power initiative is soaking up a lot more money than expected. ISS II remains a huge expense, even with twenty-five participating countries, even with the lower inclination orbit. NASA’s in serious financial trouble, and it’s refusing to authorize a Swift Shuttle to replace its launch vehicles which are six times as expensive—”

“Mr. White, this matter has nothing to do with the Swift,” objected Lassen.

“Oh, is that what you think? Tell that to Congress. You’ve already botched this affair, Harold. You look like idiots by planning to idle half your Mars staff. And if those Congressmen act, you can be sure their bills will specify that money budgeted for launch vehicles be transferred to Project Columbus.”

“So what do you suggest?”

“Well, Elliott has saved your ass by telling you where you can get your money to hire support staff! Let Mars export!”

Lassen’s face sank. “Mr. White, we’re talking about mixing pure science and exploration with very low level profit-making efforts that might not make much money and will distract our people from their real tasks up there.”

“I understand, Harold. But your people want to do this, they have offered reasonable estimates of the profit, it won’t strain the equipment, and we’re stuck. We can’t look like idiots and we don’t want Congress involved in this matter.”

“But Mr. White, the scientific community is strongly against trivializing Mars exploration this way,” objected the science advisor.

“They’ll complain, then spend two hundred bucks to buy a Mars rock for their office,” White replied. “I can’t see how we’ll fund a dome for them, but you have no choice but rearrange spending to provide enough ground support or change the safety rules.” And White shrugged. There was nothing more for him to say.

## Nuke

late June/early July 2025

The shuttle *Alba* blazed through its reentry into the upper atmosphere of Mars, then fell like a rock toward the surface. In Habitat 2's bridge, Carmen Segovia sat at the controls, monitoring everything, watching the engines flame alive to burn off the last 1,500 kilometers per hour of velocity. The shuttle slowed to a stop a few meters above the surface, then settled in the middle of the bull's eye with the slightest bounce.

“Great landing,” said Will. He was watching; Jerry was there as copilot. Carmen smiled. “We didn't do anything; the computers are good.”

“Well, you guys were the backups. When do we have a clearance to approach?”

Both of them turned back to the consoles. The engines were shutting down; the pumps were off, the fuel valves closed. In a few minutes Carmen nodded. “Clearance granted.”

Will picked up his phone, called the rangers, and authorized them to head in. He hurried down to the airlocks as well and suited up to follow in a buggy, a small, four-wheeled, one-person vehicle about the size of an all-terrain vehicle. It was a half hour before he arrived; by then the cargo bay was open and airtight plastic containers were being pulled out, one by one, and being stacked on a trailer pulled by one of the rangers. He helped remove the containers filled with scientific equipment, food, medicines, computers, spare parts, and personal items. In the middle of the cargo was a truck—their first—with a one-tonne nuclear reactor, the RL-75, on an attached trailer.

Once the cargo containers were removed, Dr. Rosa Stroger immediately took over. She was their nuclear engineer and was an expert about all aspects of the reactor, including removing it from the cargo pallet. They disconnected all of the guy wires except two rear wires, which were on pulleys. Then they connected a tow cable to one of the rangers and slowly pulled the truck with its reactor down the ramp, while playing out the rear wires. Soon the truck stood on the Martian surface.

Rosa Stroger and Rick Page, her assistant for nuclear matters, moved in with a power pack; since the reactor had never been activated, it was unable to power the truck's wheels. The power pack dropped into place and was quickly connected to the truck's power systems. Then from Habitat 2, Carmen drove the truck remotely to a crescent-shaped enclosure built of sandbags: a radiation-shielded parking spot.

Rosa, Rick, and Will followed in ranger 2 at two kilometers per hour as the truck rolled down the road from the spaceport to the reactor pad east of the Outpost. Once it arrived, Carmen disconnected the trailer from the truck and drove the latter away. Rosa and Rick left the ranger and connected the reactor's power cable to a power line that ran to the three reactor pads from the Outpost. Then they headed to the Outpost; the reactor controls were set up in Habitat 2's former repair room, next to the bridge that was used to control space vehicles.

“So, we'll have power next week?” asked Will.

“If all goes as planned,” agreed Rosa. “And then the *Apollonaris* arrives with reactor 2, and we'll set it up as well. Both reactors will be on partial power for a month, until we have everything fully checked out.”

“When will we be able to install the Stirling cycle engine?”

“We can give it a try in four weeks or so. The latest report from the reactor at Shackleton suggests a bit more output than originally projected.”

“Oh? I didn’t hear about that.”

“Sorry; I got it from the nuclear engineer there by email yestersol. He says the RL-75 there has been able to put out 800 kilowatts of heat rather than 750, and the Stirling there is putting out 140 kilowatts of electricity. Since we have a frigid atmosphere to provide more efficient cooling, I think we’ll get 150 kilowatts of power from each. The thermal-electric system, though, can put out only 75 kilowatts, and that’s what the reactor will put out on the road.”

“Can we attach the Stirling to the reactor and move it with a truck?” asked Will.

Rosa hesitated. “Eventually, I think so. We’ll have to see how bumpy the ride is and how robust the Stirling is. The expedition can always bring it along; it only weighs 200 kilos.”

“We have to see how well the truck’s robotic arms can install it, too,” said Rick. He smiled. “I was going to add that you’d never get the agency’s permission for that, but I won’t make any predictions any more!”

Will chuckled. “Neither will I. But ACV-106 is at Embarcadero with ten tonnes of rocks and seven tonnes of argon, and it’s ready to head for Earth.”

“I had my doubts Carmen and Jerry would get it all transferred,” said Rosa. “It wasn’t looking good for a while.”

“We had some tense moments,” agreed Will. The ACV’s cargo container had drifted free from one of Embarcadero’s docking ports while the arm was transferring the

cargo of rocks; it had taken twenty-four hours to recapture the cargo and get it in the shuttle's cargo bay.

“You must be pretty excited, Will,” exclaimed Rick. “Do you think you'll get the expedition guidelines changed, also?”

“Probably. The export plan was approved by the White House over the heads of NASA, but they won't approve safety changes. However, they're working on borrowing the additional funding to hire the additional ground support. That should come through next week.”

“But no dome.”

“Not through NASA, but I haven't given up, yet.”

Rick smiled, wondering about the twinkle in Will's eye.

They backed the ranger slowly against an airlock, manipulated the mechanism remotely, and achieved a hard dock. They stooped to pass through and entered the Outpost, and Will's step did have an extra spring in it. They had their first of two nukes; reliable, continuous power in a compact, mobile source that could power expeditions anywhere or run the Outpost. The nukes on the moon had revolutionized exploration, which was now possible during the two-week nightspan. They had also permitted more reliable production of water and hydrogen-oxygen fuel. The disadvantage was their cost: some four hundred million dollars each.

Will stopped at their apartment in Habitat 1 to check on Marshall. Eve was watching him that morning. Marshall saw his daddy, lifted his head, and smiled.

“Hey, my little one.” Will picked up the boy and hugged him, then kissed him.

“He's doing fine. He's really moving a lot, now.”

“Four months old; it’s normal, right?”

Eve nodded. “Yes, but it’s still a lot of fun to see.”

“True.” Will held Marshall for a few minutes, then handed him back to Eve. “You and Gaston can still make it?”

“It’s not like we have a lot of other invitations!”

“True. Eight o’clock.” Will headed out the door, down the steep stairs, and to his office, Habitat 1’s former repair area next to the stairs. He checked the status of the unloading, checked with Carmen about deactivation of the shuttle, then checked his videomail. Heather Kimball had called, as he hoped.

“Good sol, Will,” she began. “I had an excellent discussion with Sun Daiyu about the latest techniques for manufacturing very large structures of Kevlar, straight-chain polyethelene, and nomex. He thinks we can get a very reasonable estimate for a multilayer transparent dome. The French have a new anti-ultraviolet coating developed for space use, also, that will help protect the plastic’s integrity, though the coating has not been tested to one hundred below zero Centigrade. We’ve also begun calling potential donors. I think MES can contribute the dome, assuming we can get someone to fly it to Mars. Our European chapter also reports that they’ve made contact with the Director of Manned Spaceflight about reestablishing talks about setting up a Mars Commission. So good news is rolling in, right now. Enjoy it while you can. And congratulations on docking the rock container with the ACV, then deorbiting your first cargo shipment using an unmanned shuttle. It’s a historic moment at Aurorae this sol. Bye.”

Will quickly recorded an acknowledgement and thank you, then noticed that a message from Lassen had come in, which he listened to:

“Good sol, Will. I just wanted to send a message of congratulations to your entire crew for their successful landing of cargo pallet number 1. One down, two to go, eh? And congratulations on getting the cargo onto the ACV. The guys at Pax are trying to duplicate the problem now, but they’ve already promised a report and recommendations within twenty-four hours. I think we can avoid the mess next time; but that won’t mean another problem won’t crop up. Looking forward to the arrival of the cargo. Bye.”

He listened to the message again to savor the positive tone. The Mars team had made a few small compromises; the ACVs would be controlled by Mars until they were half way to Earth, at which point Houston would take over. That tied up one person on Mars a few hours a week. But Mars’s communications satellites were plenty adequate to communicate with the ACVs, and were cheaper to operate than Earth’s deep space network; furthermore, when the switchover occurred, the ACVs would be close enough to Earth for a cheaper, lower-power communications system to be used. If the experiment worked well enough, Mars might eventually contract for control services. They had already served as a relay for communications to the advanced satellite systems in the Jupiter, Venus, and Mercury systems when the sun blocked direct transmission from Earth.

Will had half a morning of work to do; he had messages from the International Space Station and Shackleton, an email from David Alaoui in Paris, two new reports to read—one of them the report Rosa had mentioned about the RL-75 reactors in use on the moon—and several news clippings about Mars that a volunteer sent him. The volunteer had proved very competent at sending him just the important articles and often sent a report about lesser publicity as well; it gave him a source of information independent of

the Public Information Department. He went up and got Marshall so that Eve could do other things, holding his son and reading at the same time, recording messages once Marshall took his late morning nap.

That afternoon he helped with the unpacking; most plastic containers had to be opened in the suit donning area, then the items dispersed to storage areas in the basements of all four habitats. In spite of careful planning, there were always items in the wrong containers. No matter how well the inventory was set up and maintained—and they had several full time staff on Earth who just kept track of the inventory, looking at video to see who took what—they were always losing things temporarily.

As the sun was setting, Will dropped off his last load of items in the basement storage area of Habitat 4 and detoured into Greenhouse 5. Lisa and Gaston were hard at work setting up plant trays. The entire eastern side of the hemispherical greenhouse was enclosed with a silvered insulating blanket, the inner surface reflecting the dying rays of sunlight onto the plants. It was quite a scene: a blazing red sun, a pink sky, a silvered reflector, and a greenhouse floor carpeted in the soft light green of baby plants.

“Wow, you’ve made a lot of progress in the last few sols.”

“It’s looking good, isn’t it?” said Lisa, pleased. She stopped to look around. “The plants are really pretty. I guess this greenhouse was set up much faster than Greenhouse 1.”

“Oh, of course. The six of us had less spare manpower, we didn’t have enough plant trays and had to make most of them from rocks and parachute material, and of course we had to make the soil. Columbus 3 arrived to plenty of readymade soil and plant trays.”

“We’ve benefited from your experience as well. I really enjoyed my three years providing ground support for the greenhouses.”

“And we’re grateful you came. I want our new people recruited as much as possible from the ground support people; they already have experience and training. People get up to speed faster.”

“I’m really thrilled with this opportunity,” said Lisa.

“When will we have the water purification plant up to speed?”

Lisa glanced at the large tank occupying one end of the greenhouse. “It’ll take another month. The bacterial ecosystem isn’t mature enough. And as you can see, we still don’t have the rice paddy set up. We’re starting on that tomorrow. It’ll take two or three months to get its ecosystem functioning well.”

“That’s what I thought. Well, when the expedition leaves next month, our drain on the outside water supply will decline substantially.”

“Before that, once the reactors are fired up, they’ll generate the heat to vapor-purify the bath water,” noted Gaston.

“Actually, we have that already, we just don’t have the plastic piping to take the water to the heat or the heat to the water,” said Will. He looked west. The sun had just dropped before the horizon. The sky was glowing red, orange, pink, and a bit yellow in places. They all paused to enjoy the sunset; it only lasted a minute, then faded into a deep violet. Stars began to appear.

“We’d better close this place up,” said Lisa. They carefully walked to the connection to Habitat 4; except for a bit of sunset glow and the pale light of a one third full Phobos—too faint even to throw shadows—there wasn’t much light to navigate by.

There, Lisa flipped a switch. The silvered insulation blanket covering the western side of the greenhouse rose along the wall until it reached the peak and stopped.

It was seven o'clock; time for supper. They all walked to Habitat 3 where almost everyone had gathered. Madhu had cooked tilapia, bread, a turkey vegetable soup, several vegetable dishes, and a vanilla cake. They all feasted.

"Pretty good, as usual," Roger said to Will as they were putting their dirty dishes in the sink.

"Madhu's a good cook."

"Yes, and now that she doesn't have to worry about the greenhouses as much, she's much more content to focus on diet." Roger rolled his eyes. "And babies," he whispered.

"Is she pregnant?" replied Will, quietly.

"Not yet."

Will walked back to his table. Ethel was ready to leave; Marshall was asleep in her arms. They headed to their apartment and tucked their baby into his bed, then set up the living room for their guests. At 8 p.m. Gaston and Eve Gilmartin knocked on their door.

"Come in! Bienvenue!" exclaimed Ethel.

"Thank you," replied Eve. She entered; Gaston was right behind. They spoke to Ethel in French, then Will entered from the bedroom.

"Sorry; I was just checking Marshall. Good evening to both of you."

"Thank you for inviting us," replied Gaston. "Though I'm surprised you're inviting people to your apartment."

“Yes, this is not a big place,” agreed Will. “But we want to be able to get to know people more directly than just sitting around the same table with them in the Great Room. All the couples have their own living rooms, after all.”

“We don’t yet,” Eve corrected him “But it’ll be finished in a few weeks, of course, upstairs in Habitat 4.”

“And you even have windows!” added Ethel. “We don’t have that. Here, sit down.” She pointed to the “couch”; it was a homemade thing. She and Will sat in standard-issue plastic chairs.

The Gilmartins sat on the couch. “This is pretty comfortable,” said Eve.

“The cushions are foamed plastic—more like Styrofoam than foam rubber—but they have held up,” said Ethel. “They’re wrapped in parachute and covered by a tablecloth we imported from Earth. And the frame is welded iron. It was an experiment. Would you like one?”

“I think so!” said Eve.

“I’ll try to schedule it,” replied Ethel. “Now that I’m feeling better, I’m back to a reasonable work schedule.”

“And the prescription calls for a lower dose every two weeks,” added Eve. “I’m glad the medication has worked out. You should be able to resume breast feeding Marshall in a month or so, if you can.”

“I want to,” replied Ethel.

Will opened a plastic cooler near his chair. “Well, let me serve everyone. This is real ice cream.”

“Real ice cream? Where does it come from?” asked Gaston.

Will smiled. “As you may know, the Commander has always had a special mass allocation. In Columbus 1, it was split between Laura and Sergei, and Sergei used his half to bring vodka. In Columbus 2, Sebastian imported various wines and liquors and some other special things for the crew. Well, as you may know, I am a Bahá’í, so I didn’t want to haul booze here; in fact, I wish we could eliminate the stuff entirely, here for safety reasons. So I had the liquor allocation transferred to the food budget, and Madhu made decisions to import a little wine in the context of what she thought would be needed for cooking, special meals, etc. My mass allocation was reduced, and I used it for various special items that I won’t reveal at this time, but ice cream was one of them.” He lifted a pint that was half chocolate and half vanilla, and began to scoop it into bowls.

They were silent when they ate the ice cream. It was too rare of a luxury to speak. When they finished Ethel said “mint tea? It’s local and not imported.”

“I guess we should get used to it,” replied Gaston. “I gather we often run out of regular tea.”

“It ran out early, last year,” replied Ethel. “But mint tea really isn’t bad.” She poured them cups of the light green liquid.

“Will, Ethel, I am curious how long you plan to stay here?” asked Gaston. “It’s a hardship assignment, I think.”

“We’ll see,” replied Will. “So far, we’ve managed fine here. You adjust to the lack of tea, ice cream, and worse. There are no malls here, and mail order shopping is a slow affair, between speed of light ordering and interplanetary delivery. Marshall certainly can’t fly back to Earth for five years, and it isn’t clear he’ll be able to then, either.”

“They’re talking about the new SCN-25 nuclear thermal engine being in use by then,” said Gaston. “That’ll cut the transport time from six months to three, they say.”

“We’ll see,” said Will. “I’m skeptical that nuclear will help very much because of the cost. It may be that a special room wrapped in supplies and plastic can be built to reduce the radiation levels enough, and a child can be flown safely back to Earth. Space vehicles are still no place for children. I think we’ve shown that habitats are okay for them, but I’m not so sure about space vehicles.”

“What will you do when he starts to walk?” asked Eve.

“We’ll see,” replied Ethel. “The stairs are very steep, but we’ll install a low railing, and in the low gravity a child could lower himself by hand if he had to. I doubt we’ll want children to be opening and closing pressure doors until they’re at least seven or eight. But maybe that will change, too. We now have an outpost sixty meters long and forty wide; there’s a lot to explore here, for a small child.”

“It should work out, as long as Marshall doesn’t stick his finger in an electrical outlet,” agreed Gaston.

“What are your long-term plans?” asked Will. “We’d love to have you stay.”

“Maybe we will; who knows,” replied Eve. “We’ve signed up for two columbiads, just like the Strogers. We don’t have plans after that. Gaston can’t do much animal husbandry on the moon; they haven’t developed that side of their recycling as much as Mars has.”

“We could always go back to work at the Mars Environmental Support Facility in Seville,” he added. “Eve can do her space medicine from there as well. But Seville seems a bit of a vocational retrenchment after being here.”

“I know what you mean; but it’s a beautiful place. I loved Seville,” said Ethel.

“In four years, you’ll be able to see how well this place has been for Marshall and decide whether it’s a good place for a family, at least,” said Will. “I’m hoping to convince Pavel to stay two cycles instead of one, because he’s a genius where construction is concerned. He’d be hard to replace. With his leadership, we should be able to increase our pressurized space significantly, and that will make quite a difference where raising children is concerned.”

“But don’t you worry about Marshall’s health?” asked Gaston.

“All the time,” replied Ethel. “I suppose I’ve worried way too much! I worry about anything that seems out of normal, even though all children deviate from the norm from time to time. But we are just giving it a try and trusting it’ll work out, and we hope it will.”

“That’s all you can do,” said Eve. “At least the animal studies have been positive, and the problems that have been identified are solvable.”

“Especially if we can train him to wear clothes with weighted pockets, once he starts to walk,” agreed Ethel. “The weights seem to guarantee reasonably strong bones. But that means all the clothes imported from earth have to be modified, and we didn’t think of that when we ordered clothes for the next few years!”

“We’ll be putting him in clothes for older children,” said Will. “And sew pockets into the longer hems and wider girths.”

“I’ll be delighted to help; I’m good at sewing,” said Eve. “My mother taught me well.”

“Thank you. My grandmother tried, but I didn’t learn very much.”

Will sipped his tea. “I’ve enjoyed so much getting to know both of you. So maybe you can help me solve a puzzle. I heard complaints from someone on the flight out that the French weren’t socializing much with the rest of the crew. But I haven’t seen that here.”

Gaston was a bit surprised. His calm voice betrayed a bit of strain. “Perhaps that was Jerry’s opinion. You see, Patrice is a good friend of Karol because they’re both Slavic; Patrice is a Frenchman of Polish background, while Karol is Czech. Lisa and Karol are very close as well. All three of them would speak French together, rather than English; Patrice is not completely comfortable in English, and even if he were, there is no code saying he should speak English in his off-duty hours. And naturally Eve and I gravitated to the three of them, even though we are rather different in personality and . . . approach to life. So five of us were often speaking French. Pavel would join us as well, sometimes.”

“Ah,” said Will, nodding. “Now I see the picture. Jerry is a good man, but perhaps he could still learn how to accommodate different cultures and languages. I can imagine that would disturb him.”

“He’s not cosmopolitan,” agreed Eve, rather bluntly. “He would not have been a good commander for the entire Mars operation because he doesn’t understand diversity.”

“I’ll try not to disappoint you,” replied Will. “We also have a Spanish-speaking group here, and I often sit at their table.”

“I was surprised to see you speak Spanish,” said Gaston.

“Well, I had an Hispanic grandmother. I have the privilege of reflecting much of America’s ethnic diversity. My father was partly African American, partly American

Indian—Cherokee—and partly European American. My mother’s mother was from Veracruz, Mexico and her father was part German and part Polish.”

“And you are a Bahá’í, which is a religion of diversity as well.”

“Yes, it stresses the oneness of humanity and consultation with everyone. I’ve tried to make those two values central to my coordination of this place.”

“And the Bahá’ís seem to stress the family as well,” added Ethel. “That’s emerging as a central aspect of this place as well.”

“Yes, it is,” said Will, startled by her insight. “Actually, that hadn’t really occurred to me.”

“Sure it has,” replied Ethel. “We’ve been pursuing an informal emphasis on marriage for some time, and now on family as well.”

“True, but maybe it hadn’t quite percolated to the top of my brain.”

“Stressing marriage and family is a surprising priority,” said Gaston, uncertain what he thought of the idea.

“I think it’s potentially valuable,” replied Eve. “The vast majority of people on earth are married and have families. If Mars is the same, it makes the place more human. Humanness may play as well in public relations as heroism.”

“Family, humanity, *and* heroism,” replied Will. “That’s a pretty powerful combination.” He rubbed his chin and thought about the idea.

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Will did not sleep well that night; Ethel’s comment, and Eve’s supportive remarks, had triggered a brainstorm. Mars needed to be *settled*, not just *visited*. That meant long-term commitments to stay, which implied marriages—of whatever sort—and children. The

vast majority of human beings were geared to live that way by genetics and upbringing. And now all the keys for that process were in place: their food, water, and power supplies were stable; they had functioning housing; they had the ability to export to cover some costs; and they had started building their own enclosures, as the Geology Storage Facility—now renamed and serving as the Geology Facility—demonstrated; they had a critical mass of people, and especially of couples; and by accident or divine fiat, Mars had its first child, with a second one intentionally soon to be on the way.

Before the sun exploded above the eastern horizon Will was up. He threw on clothes and headed down the stairs to his office below. Deimos, full but so small to look star-like, blazed above the western horizon outside his window as he turned on his attaché. Houston was now two hours ahead of the Outpost, so Lassen would be in his office, starting his sol's work. Will activated the videomail software and recorded a message.

“Good morning, Harold.” He intentionally avoided “good sol,” which Lassen usually didn't use, and decided to try the director's first name. “I want to bounce some ideas off of you. They are the sort of ideas that you probably will consider crazy. A year ago they definitely would have been crazy; two or three years ago they would have been unthinkable. But I want to try to formulate them for discussion.

“Mars needs more people if it is to become a successful and significant scientific project and exploration effort. This world has already told us a lot about the solar system from 4.5 to 3.8 billion years ago, including what the early Earth was like, what some of the prebiotic precursors of life were, and how life evolved there. It's also teaching us significant lessons about climatic and atmospheric evolution, not to mention

geochemistry, geophysics, volcanology, glaciology, meteoritics, asteroids, and how to live in new environments. Once we explore the polar areas and establish a temporary base there, we'll be laying the foundations for human exploration of the outer solar system; Phobos and Deimos are opening up technologies for exploring the asteroid belt and near-earth asteroids; the interplanetary hubs are teaching us how to establish a viable station in Venus orbit; and all of this, and the experience on the moon with polar ice, is teaching us how to send humans to Mercury.

“All this underlines the importance of expanding the Mars facilities as much as is practical, and the importance of making it a long-term human community. Exploration of Jupiter and Saturn, even with advanced rocket technology, will involve three or four year missions, maybe longer. We have to learn how to create stable, diverse, international communities of professionals able to work together for years. Otherwise people will not be able to take advantage of the new technologies to explore.

“My question to you is, what are the implications of this insight? I think there are several. First, we should aim to increase the percentage of people coming here who plan to stay. Columbus 3 had five people out of fourteen who had committed to stay two cycles. My proposal is that we also request three-cycle commitments, and aim to increase the percentage of the crew pledging to stay either two or three cycles to fifty percent of the arriving crew. I see no reason to raise it to one hundred percent. People like Jerry McCord, or Sebastian Langlais, or David Alaoui, all have made very important contributions to this place, have earned the right to come here through their long and distinguished careers, and should come. But as I understand it, Columbus 4 will involve four ITVs and about eighteen personnel. If we flew nine long-term people and nine short-

term people, we'd still be flying more short term folks here than Columbus 4 was ever planned to fly. After all, through Columbus 6, the original plan was to fly two ITVs each opposition, not three or four.

“Second, the long-term people who come here should have experience in the ground support facilities. We're delighted to have Lisa and Gaston here, who both worked in Seville. Jerry was capcom. They arrive with their feet on the ground and ready to run; not much training is necessary. This is immensely valuable.

“Third, and in some ways more important, the long-term people should be married to someone else who is coming here as well. You know how high the divorce rate is among the astronauts. Columbus 1, 2, and 3 each produced one divorce because of a spouse remaining behind. When people who have just divorced come here it produces difficult social situations in the tight quarters we have. For that matter, the tight quarters produce all sorts of difficult situations among the single people here. Couples generally bring stability. I admit, a bloody divorce could be immensely complicated; but we now have enough habitats for people to stay apart and one former spouse or the other can be away on an expedition. So, in the balance, I would like to see us tailor selection policies that encourage long-term sojourns by couples. Think how capable this outpost will be if it had dozens of people with a decade of experience working here.

“Let me know what you think. Bye.”

He sent the message and looked out the window. The sun had popped up and Deimos had set. Early morning sunlight streamed across the stonescape.

He went back upstairs to brush his teeth, shave, and shower. Then he held Marshall and played with him while Ethel got ready. When they all headed downstairs for breakfast, Will looked in and saw that he'd received a message.

"I bet that's Lassen."

"We'll see you in a few minutes at breakfast, then," replied Ethel. "I hope it's positive."

"So do I." Will entered his office and played the message.

Lassen's face appeared on the screen. He looked pensive. "Good morning, and oh, good sol. As you said, your idea was unthinkable two or three years ago, and it is difficult now. But if you follow the usual trajectory, that implies the idea is acceptable in a year and natural a few years after that.

"And I suspect that will be the trajectory of this idea, at least eventually. Perhaps the timeframe will be closer to decades. I regard my role not as opposing the idea, but making sure it is practical. And it encounters one serious obstacle: every person on Mars requires housing, consumables, waste recycling, pressure suits, equipment, vehicles, electrical power, etc. Right now, each person living on Mars needs about a tonne and a half of housing, a tonne and a half of greenhouses and waste recycling, a tonne of consumables, and two tonnes of equipment; six tonnes, total. The initial crew was small and it needed one duplicate copy of everything, so we had to fly a lot extras there; subsequently the percentage of extras has been dropping and has allowed rapid expansion of the crew. But the percentage of Martian equipment that is surplus won't drop much more.

“Consequently, the only way your proposed policy can be pursued is if Mars becomes much more self sufficient. If most of the Columbus 3 crew decides to stay, it will be impossible to fly eighteen people to Mars on Columbus 4. Your facilities are designed to accommodate a total of twenty-four adults, and you have twenty-three. The greenhouses will be able to feed fifteen once they are set up. If you don’t build pressurized space, we’ll have to fly nine-tonne habitat shells there for every six new residents. I think use of the Swift shuttle is inevitable, and it will cause shipping costs to tumble. But the costs will still be staggering if the Outpost expands beyond thirty residents in two years. So we can start discussing policies like this and floating them to the public to see what the reaction is. But your team will have to work pretty hard to make it possible.”

## Construction

mid August 2025

A week after the *Alba* returned from orbit with the first cargo pallet, the *Apollonaris* roared aloft to chase the second automated cargo vehicle. It rendezvoused, transferred the cargo to the ACV, picked up the second cargo pallet, and landed, all under remote control from Habitat 2. Shortly thereafter a Lifter, holding fifty-five tonnes of methane and oxygen from Phobos, rendezvoused with it, fired its engines, and they headed outward from the sun into the asteroid belt on an orbit that would take it and the ACV back to Earth in about twenty months.

The second cargo pallet included another nuclear reactor, another ranger, another greenhouse, and supplies of all sorts. The crew redoubled their efforts to set up everything and to test the vehicles and reactors. Within two weeks, the second reactor was putting out 75 kilowatts of power, while the first, which had proved as reliable as hoped, was hitched up to the Stirling engine early to generate 150 kilowatts of power. The Outpost badly needed every bit of power it could get; the shuttles were all empty and one needed to be refueled to retrieve the last ACV; production of iron and plastic increased to prepare for construction of their building; and there were now eight greenhouses and four habitats to heat and power. Consequently, all three solar power units were putting out 150 kilowatts of power and the solar panels—including two of the Sunwings—were deployed to generate 100 more, on top of the output of the reactors.

A month after the *Apollonaris* returned, the *Elysium*, fully refueled, blasted off to obtain the last cargo pallet and load the last ACV with fifteen tonnes of rocks. When it

returned five sols later, the conestoga and greenhouse had been deorbited and the rest of their supplies had arrived. The third ACV rendezvoused with a Phobos-based Lifter and headed for a rendezvous with Earth twenty-two months later. Excitement rose at the Outpost because shortly after the ground was broken for their building, the first expedition would depart.

Four sols later—after the bulk of the unpacking was done and Greenhouse 9 was set up—Will, Pavel, and the first contingent of workers headed for the construction site to get started. After a brief ceremony—very brief, since pressure suits were not conducive to them—three rangers with steel-reinforced bulldozer blades got started excavating the foundation hole.

Will watched the rangers do their laborious work. The building they would be working on for the next year—for it was quite an ambitious long-term project, considering their human and manufacturing resources—would be twenty meters long, ten wide, and two stories high, with walls of nickel-iron reinforced duricrete a meter thick, punctuated by small windows every five meters. Its four hundred square meters would be equivalent to two habitats. While the habitats were designed to accommodate six people, the building was being designed with larger rooms and would be able to accommodate eight rather than twelve. They would probably need to complete two of them in order to provide quarters for Columbus 4.

Will turned to Pavel. “How big are the windows in this building going to be?”

“Don’t think of making them any bigger! You’ve already suggested a dozen changes, small and large. Reorienting the building’s axis to run north-south required a lot of redesign.”

“No, I’m thinking about another project. They’re forty centimeters across, right?”

“Correct. Bigger than portholes, and oriented to let in morning and evening sunshine.” These were the issues Will had raised a few weeks earlier, which had been accommodated.

“Good. And we could make them completely ourselves.”

Pavel nodded. “We’ve got plenty of weldalite alloy from the three automated landers we’re dismantling; it’s of a more uniform, reliable quality than the nickel steel alloy we can make here, and that’s important for the window frames. But don’t think we can make a lot of windows, because the weldalite will be mostly used up by this building. The panes are glass imported from earth, but we could make slightly translucent polyethylene panes using the new plastic making unit, which can turn out high quality, straight-chain polyethylene.”

“I ask because I’m thinking about greenhouses. Trench greenhouses; they’re on the website. Could we excavate a trench in the reg, line the bottom and sides with duricrete—which is pretty air tight all by itself—and glue together the meter-wide sheets of polyethylene we can make here to form a continuous transparent roof strong enough to hold in significant air pressure?”

Pavel began to think. “I’ve seen the trench greenhouse design on the website; that part is not a problem. They could do experiments on the polyethylene made by the duplicate plastics unit in Houston to determine whether it’s strong enough. But straight-chain polyethylene is incredibly strong; almost as good as Kevlar. I suppose the question really is whether we can make the polyethylene thick enough, and I suspect we can. We

can extrude polyethylene that is up to half a centimeter thick, in addition to a meter in width. Of course, it's translucent, not transparent."

"Plants don't care about that. We'd have to overlap sheets, stretch them a bit to make sure they're tight, and glue them together to hold an airtight seal," added Will. "We don't have equipment for that step."

"We could jury-rig something. It'd be simpler importing the plastic from Earth, and would have better transmissivity."

"But I want to keep down our import mass as much as possible; otherwise, we can't keep expanding the population here."

"You're probably not saving that much mass. Greenhouses have two tonnes of machinery and two tonnes of plastic structure; you're saving maybe 1.2 tonnes of the latter."

But every bit helps, Pavel. I suspect we can cut down on the mass of the equipment as well; we can probably make some of the outsides of the equipment here. How wide could be the home-made greenhouse be, I wonder?"

"An experiment will tell us. But the greenhouse sides could also lean toward each other, with metal braces between them to keep them from falling over. You could have a three-meter width at top and maybe a six-meter width at the bottom, and use silvered plastic mirrors to reflect additional light in."

"Then the design should be possible, especially if we used a lower air pressure. I'll talk to the Cap Com about it."

"The designers are still busy helping us with the building!"

“They can turn to this problem when they have time. Or maybe the Mars Exploration Society can help.”

“Perhaps. . . but I’d be careful using them. Their dome proposal is getting a lot of criticism.”

“And they’re fixing it. They’ve got a year to get NASA approval for it.”

“We’ll see.” Pavel was skeptical.

“I’m taking a wait and see attitude. I’ve got to go inside now, but you can reach me easily enough.”

“Bye.”

Will turned and walked to the airlock. In twenty minutes he had peeled off his pressure suit, hung it in his locker, and walked to the apartment to check on Marshall, now almost six months old. The baby smiled when he saw his daddy, and said “da.” Will gave him a big kiss.

“He’s been a good boy?”

Madhu nodded. “He ate up all his apple sauce and rice. He’ll be taking a nap pretty soon, so you should be able to get some work done.”

“Good. The laundry?”

“There are some diapers that need hand-washing, but I have a load in the drier right now. I’ll go get it right now.”

“You’ve got time?”

She glanced at her watched and nodded. “Sure. Cooking lunch takes ninety minutes. But this sol I need to prepare a lot of frozen vegetables for the expedition, and

this afternoon I'm baking an extra batch of bread to freeze it for the expedition as well.”  
She rose slowly and stretched. “Wow, I'm getting stiff.”

“Maybe you need more exercise.”

Madhu laughed. “No, nothing simple like that.” She looked at him. “I told Ethel this yestersol. I think I'm pregnant.”

“Really? How exciting and marvelous! Congratulations! What does Roger think?”

“He grumbles about it, as you can imagine, but I think his heart is in staying here anyway. Once he gets used to the situation, he'll love having a baby as part of our family. I know Roge.”

“You're right; under that crusty exterior is a heart of gold. When's the baby due?”

“I think in about seven and a half months.”

“Wow!”

“It's still early in the pregnancy. Marshall needs someone to play with, after all!”

“We've got to think about releasing the information. You and Roge have to decide when we'll let everyone know.”

“Give us a few more sols before doing anything.”

Will nodded. Madhu headed out of the apartment; he put Marshall in a baby carrier and walked around the outpost to see how various tasks were going, especially manufacture of nickel-iron parts for the new building. The five additional greenhouses were all being set up at once, also, which was an impressive effort. When he stopped at the spacecraft control room in Habitat 2, he noticed that the atmosphere was tense.

“What's happening?” he asked.

“Damned if I know,” replied Rick. “Érico just called me in from the construction work outside, and we’ve called in Karol as well. We can’t get Lifter number 2 to dock properly. That means we can’t reconnect it to the fuel making unit or refuel it.”

Will was surprised. “That’s a real problem. Is it a problem on the vehicle or the docking platform?”

“We still don’t know. We’ve alerted Houston. This should be fixable in a sol or so.”

“Keep me apprised, okay?”

“Of course,” replied Rick.

Will headed back to his apartment. By then Marshall was falling asleep, so he put the baby in his crib, pulled it to the door of the bathroom, and washed diapers by hand for half an hour. One regret of having a child on Mars was the lack of disposable diapers, and the need to clean them as much as possible before putting them in the washing machine. Finished with that chore, he sent an update to Harold Lassen, exchanged emails with the current commander of Shackleton Station on the moon, and checked the Outpost’s inventories.

At noon he brought Marshall to Habitat 3’s Great Room, where everyone ate lunch. Marshall seemed to love the hub-bub of people at mealtimes. Ethel nursed him, then fed him some baby food Madhu had made. After lunch she watched him while Will drove a ranger to bulldoze the foundation hole for the building.

Supper that Frisol evening was a bit fancier than usual, so people lingered. Saturisol was a work sol until 1 p.m. only; they worked ten hours a sol, five sols a week, and five hours on Saturisol, a total of fifty-five hours, but in turn had no domestic chores

like preparing meals and washing dishes, so the schedule was not as difficult as it sounded. A group of people sat down afterward to play cards as others went to visit friends or watch television in Habitat 2.

Will and Ethel entertained the Stogers that evening; they were systematically inviting everyone, two or three at a time. When Rosa and Neal left, Will went to the Great Room to grab a snack. He was startled to see Lisa, Pavel, Patrice, and Karol sitting around playing poker, with two empty bottles of brandy on the table.

“Did you all drink those bottles tonight?” he asked.

They immediately looked embarrassed. “Don’t worry Commander; we’ll be fine tomorrow,” replied Karol, but the slight slurring of his speech belied his defense.

“I don’t think so. That stuff’s high in alcohol. You won’t be sober enough to go outside in the morning.”

“Commander, I *have* to go outside tomorrow; I’m in charge of the work,” protested Pavel.

Will shook his head. “The safety rules are clear. No consumption of alcohol within twelve hours of suiting up. I’m not going to change those rules; we have to be very careful here. All of you are grounded until at least 11 a.m. tomorrow. I suggest you relax in the morning and work one to six tomorrow afternoon.”

“But I’ve got plans tomorrow afternoon!” exclaimed Patrice.

“The time to drink is Saturdaysol night, not Frisol. You don’t have to work on Sunsol at all, after all,” replied Will, raising his voice. “I want all of you to take a breathalyzer test tomorrow morning. As soon as you pass it, you can go outside. Maybe you’ll be lucky and the alcohol will clear out by 10 a.m., so that you can finish by 3 p.m. This

situation's your choice. A single serious accident can cost us a hundred million dollars in political and financial support. It's nothing to shrug off. Safety is of paramount importance here and has to be. I have said that on several occasions already. And I've already warned some of you that you can't go outside until you pass the rigorous standards of absolute sobriety that the space agency has set. So this shouldn't be surprising to you."

Pavel and Patrice stared at him, angry, but not daring to say anything. Will shrugged. "Sorry, but those are the rules. Good night." And he headed back to his apartment.

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The next morning the three rangers were busy excavating again while two other astronauts did routine repairs on the drilling equipment and two others completed interior work on the new conestoga. Toward the end of lunch, Will overheard a table nearby debating the first major expedition's destination, so he joined them.

"I suppose I sound like a broken record, but I want us to head for Candor Chasma," said Lal. "It has more extensive sedimentary deposits than you'll find anywhere else, igneous layered complexes appear to be exposed in some of its walls, and the fact that it is a parallel chasm is tectonically intriguing."

"I doubt it's that different from what we've already seen," replied Roger. "Especially Gangis, which is a tectonic continuation of Candor, even if they aren't directly connected."

"I'd favor Noctis Labyrinthus," exclaimed Neal. "The tectonics and volcanism in the area are fascinating. It's essentially a piece of the Tharsis Plateau."

“And I favor the North Pole,” replied Érico. “If anyone will sound like a broken record, it is I! A three-month expedition there in the height of midsummer would be an incredible opportunity. It’s just about the first sol of summer right now.”

“It’s an ideal time, I agree,” said Jerry. “But the first expedition is scheduled to take the new rangers, the new conestoga, and a nuke, and I don’t think they should travel that far away for three months yet.”

“But we’ll lose our chance to head north if we wait too long,” replied Érico.

Jerry shook his head. “Not if we made a six-week expedition to the west. Summer will last six months and it just started. In six weeks the water-ice will be further sublimated from the north pole anyway, which is better for the vehicles, and the temperatures will be higher and more optimal.” He looked at Will.

“Oh, I agree,” said Will, not wanting to undermine Jerry, since he was in charge of exploration.

Jerry looked at Lal. “My suggestion is that we head west, plan a two-week visit to Candor, then continue on to Noctis, extending Route 1 to the end of the canyon. If Candor is uninteresting, we head to Noctis earlier; if it’s interesting we extend our stay.”

“I can easily lay out a four-week sojourn, though,” replied Lal.

Jerry hesitated. “Let’s lay out a two-week plan plus a two-week extension.” He looked at Neal. “Same for Noctis.”

“Okay,” said Neal, satisfied. But Lal did not look so happy.

Just then Shinji came up to Will. “Can I talk to you privately?”

“Sure.” Will followed Shinji out of the Great Room, toward the airlock leading toward Habitat 2.

“I just tested Karol again. He still doesn’t pass a breathalyzer test.”

“Still? It’s after 1!”

“After you argued with them, he must have had more to drink. He still has too much alcohol in his bloodstream to go outside.”

Will shook his head. “Can you come with me to talk to him?”

“Sure. I think he went to his room.”

Will nodded and they turned toward the airlock. Beyond it was a “docking unit,” a metal cube with doors in all four sides. Straight ahead was the greenhouse to Habitat 2, but to the right was the new pressurized tunnel to Habitat 4. The tunnel was unheated and frigidly cold, but it was only a few meters long. They entered the docking unit of Habitat 4 from it, then the habitat itself. On the left was a semi-circle with four private rooms; on the right, the area that would be the Great Room was subdivided into two halves, used to control the various Prospectors on the Martian surface and for construction coordination respectively. Upstairs was the Stogers’ two-room apartment; downstairs was a mechanics workshop and storage for spare parts. Connecting the bedrooms, the work areas, and the stairs was a small lounge with a television screen on one wall.

The bedrooms on the left all had names on their doors, so they walked straight to Karol’s and knocked. A moment later he opened it, saw Will and Shinji, and frowned.

“Can we talk a moment?” Will asked. The tone of his voice indicated it was more than a request.

“Ah, I guess.”

They entered his room and closed the door. “I guess Shinji explained to you that you failed the breathalyzer test. The only way that is possible, unless you have an unusual metabolism, is that you drank more after we talked last night. Is that the case?”

Karol looked at Will. “Commander, is this really necessary? My bloodstream still has traces of alcohol in it, but my reflexes are not impaired at all. I can go out and work and I want to.”

“These levels are not traces,” replied Shinji. “Yes, you are not legally drunk based on the vehicle driving laws on Earth. But our standards to work in a pressure suit, as you know, are much tougher. That’s true everywhere.”

“Did you drink more after we talked?”

Karol shook his head. “No Commander, I didn’t.”

Will stared at him; the evidence was against Karol and Will did not believe him. “Well, it’s too late to go outside this sol, and no one will be going out tomorrow. You can’t go out by yourself, even if you’re excavating. But there’s plenty of work to do inside. You’re now in charge of cleaning all four habitats for the next month. If you spend the next five hours on the task, you can get at least two of them done this sol.”

“Commander, are you trying to humiliate me? I have a doctorate in mechanical engineering!”

“And I have a doctorate in geology and have published more papers than you, and I’m Commander. You’ve already seen me cleaning around here. Everyone has to clean some time, and if people are going to drink excessively they’re going to do a lot of cleaning. Most of it, in fact. Have you got anything else to say?”

Karol shook his head.

“If you don’t know where the vacuum cleaners are, I’ll be glad to show you. Don’t forget to clean the bathrooms twice a week. I suspect you will lose half your evening free time, two nights a week.”

“Okay, okay,” said Karol.

## Gold

late Aug./early Sept. 2025

Jerry McCord headed straight to the ranger's cab as soon as he rose from his bunk bed in the portahab. Four new vehicles—two rangers, a portahab, and a conestoga—had set out on their first lengthy expedition and had stopped for the night near the point where Candor Chasma opened into Melas Chasma. The vehicle was facing west, so the windshield was oriented perfectly to see the towering escarpment illuminated by the first dawning rays.

Jerry was awestruck by the sight. He opened the hatch to the portahab. "Come take a look at the escarpment while the sunlight's still pinkish!" he exclaimed to Lal Shankaraman, with whom he was sharing the portahab. Dawns and dusks at the bottom of the Valles Marineris were among the planet's most colorful, because of the thick air and dusty conditions.

Lal jumped off the upper bunk and hurried forward. "Wow!" he said, peering out the windshield. He had to lean forward in order to look all the way up to the top, towering so high it blocked a noticeable section of the sky. They were a mere two kilometers from the base of the cliffs.

"Have you ever seen anything like it?" Then Jerry answered his own question. "It reminds me of the Grand Tetons. They just rise straight into the air like a wall!"

"I've seen them. Actually, this reminds me more of the front range of the Himalayas. The peaks rise about 4,000 or 5,000 meters above the Ganges plain. Of

course, the Himalayas are separate mountain peaks, like the Tetons. This really is a solid, unbroken wall.”

“And 5,000 meters high. You’d have to drain the Red Sea and look up from the abyssal bottom to find a comparable view.”

“Even the Red Sea usually isn’t 5,000 meters deep!”

“You’re right. There’s just nothing in the inner solar system you can compare it to.”

“Nothing. I will remember this all my life, I’m sure.”

“It’s almost enough to make me want to stay on this isolated world.”

“No, Jerry, nothing would make you want to do that!” replied Lal, joking. He planned to stay at least another cycle, but Jerry had repeatedly said he never would.

“Well, let’s get washed and have our breakfast so we can get into Candor this sol. I hope your detour proves worth while.”

“I’m sure it will.” Lal headed back into the portahab to use the bathroom. Jerry lingered another minute in the ranger to scan the rock spurs and building-sized boulders that dotted the escarpment, then headed back to the portahab to pull out breakfast items; they had been gone from the Outpost only a week, so there was plenty of fresh food.

Then his attaché rang. A call from Will Elliott, back at the Outpost.

Will looked happy. “Morning. How’s everything at Melas?”

“Fine; we just woke up. We’re now three time zones to the west, remember.”

“Oh, I’m sorry. I thought you were two. You’re going into Candor this sol, right?”

“Yes. That’s why we aren’t at the Melas Cache. Route 1 turns south at this point and heads into the middle of Melas, where the landing pad and the supplies are located. From here we head west a few kilometers, then north into Candor.”

“I remember the route; I was just making sure everything is on schedule. Isn’t the escarpment incredible there? I like it the best a bit farther east in Coprates; the escarpment is 6,000 meters high, and there are spots where the cliff is intact all the way up and you can stand so close you hurt your neck to see the top!”

“Yes, we stopped at one of those spots yestersol. I’d like to clear the route along the top, some day; the views would be incredible.”

“But so different. At the bottom the horizon is in your face because of the wall of rock; from the top, it seems you can see all the way around the world. Anyway, I was just checking in. An hour ago we got clearance from Houston to send out two three-vehicle expeditions when you get back, or send out one five-vehicle expedition. They will have more ground support people by then.”

“Excellent; congratulations on winning that battle! How’s the construction?”

Will sighed. “More delays. The excavating work is just too much for the rangers; they aren’t designed for the strain. So we’re constantly breaking parts and replacing them, then repairing the parts for later use. But we’ll have the foundation excavated in another week. Meanwhile, we’re welding various metal sheets and beams together so that they’re ready for installation when we start to pour the walls.”

“It’s amazing that we can do so much construction in pressure suits; though not very conveniently. I’m glad I’m out here.”

“Well, enjoy, and call me if there are any questions or problems. Bye.”

“Will do. Bye.”

Will closed the circuit and watched Jerry’s face disappear from the screen. He had received a call from Earth during the conversation. He opened the videomail; it was from Heather Kimball.

“Will, I just got a call from our Mars Exploration Society chapter in Germany. They’ve been negotiating with the German government and it looks like a cooperative arrangement might be possible whereby Germany will sponsor the launch of our Mars dome on Europe’s Swift shuttle. As you probably have heard, ESA plans to purchase a Swift shuttle early next year to ‘supplement’ the Ariane launch system at Kourou. Basically, Europe has caved in and is switching to the Swifts. The decision is becoming politicized in their relationship with NASA, so watch out.

“This means we can get the dome into low earth orbit for \$16 million; one launch with the dome and one with the life support equipment and ion engine propellant. There, the German government will oversee transfer of the propellant and cargo to a used interorbital tug they will help us lease, which will push the payload to Gateway. It’ll take ten months because the tug has been modified to use argon propellant; we can’t afford \$70 million for four tonnes of xenon. If we can get it to Gateway, we hope NASA will agree to lease one of their automated cargo vehicles for the Mars flight, since they aren’t planning to use them all next opposition. Of course, all of this compounds NASA’s embarrassment over the Swift, but that isn’t my problem. I’m hoping the embarrassment will push them to lease an ACV to us. If they refuse, we may be able to purchase a vehicle from the Japanese for \$50 million plus \$20 million in launching costs—using their expensive EELV, of course—but we want to avoid that.

“So it’s beginning to look like we can develop the dome for about \$50 million, plus there will be transfer costs of \$5 million, the leased tug will be \$10 million, the launch to LEO will be \$16 million, the argon will be \$1 million, and the lunar fuel for trans-Mars injection will be \$5 million, for a total of \$100 million when you include insurance and administrative costs. We have a few corporate backers lined up, too. Of course, at your end there will be costs for the flight up to orbit to retrieve the dome, but that won’t be the MES’s concern. What we would like to do is acquire an agreement from NASA that the shuttle you send up to retrieve the dome will lift fifteen tonnes of fossiliferous rocks to the cargo vehicle and send it on a trajectory back to Earth. We can sell the fossiliferous samples for about \$75 million, depending on demand, so it’ll cover most of our costs. I suspect you can help talk Lassen into this. I have contacts at the White House, which is more receptive than NASA, ironically enough, but we need comments coming from many directions, if you know what I mean. Bye.”

Will savored the videomail for a moment before replying. “Good sol, Kimball. My goodness, I am impressed by your ingenuity! It speaks of the maturity of space flight technology that a private society can cobble together an interplanetary mission from ion propulsion vehicles flying around Earth orbit, a heat shield, private launch capacity, and lunar propellant. It says something about space agency bureaucracy as well, doesn’t it?”

“We’ll be glad to help in any way we are allowed to. If NASA leases you an ACV, they’ll permit a Mars shuttle launch. Alas, we can’t launch to orbit without permission. So far all launches have been to retrieve cargo or people or to take cargo and people up. That may change in eight months; we may launch a crew to Phobos because one of the two Lifters based there has still not managed a suitable hard docking with the

fuel-making plant. That means it can't be refueled. Meanwhile, the other Lifter is taking all the fuel produced by both plants and will soon be full. This is good news because we will have a launch with unused cargo capacity and bad news because we can't promise to push anything back to Earth if one of the Lifters can't be refueled.

"I have to talk to Lassen tomorrow about various matters, so I'll raise this one as well. We really could use a big pressurized open space. Our production of oxygen, nitrogen, and argon is now so large that, if the air inside can't be kept purified, we can replace it entirely every month or so. Hence I'm not convinced by arguments that a hundred million dollars of basic research is needed first to make sure the systems work. We can do the testing here.

"Oh, and let me know how big the dome is now, will you? They keep changing the specifications. Bye."

Will went back to his work. One of the agency's lawyers sent him an email about the negotiations toward establishing a Mars Commission; the formation of the Mars civic government had created legal complications, ones Will welcomed because it meant he had to be consulted about the plans. He stored the questions so that he could think about them and ask the opinions of others.

He left his desk to wander the outpost and make sure all was well. The greenhouses were now all green; they promised near-complete self-sufficiency in vegetables, fruits, and some meats in a few more months. This did not equate with complete self-sufficiency because they were still importing coffee, tea, sugar, many spices, beef, alcoholic beverages, exotic foods (such as mangos), some grains, and processed foods (such as corn flakes), but they were meeting about 70% of their needs

and could meet 85% with some emergency rearrangements. They were not yet beginning to meet their needs for cotton or for fiber (for making paper, for example). These were matters to tackle in the future.

While he was in the greenhouses Pavel called and asked about construction details, so Will called him over to Greenhouse 9 where they could see each other's faces and converse by cellular communicator. Pavel pointed to the places he had to ask about and Will agreed with his plans. He was about to return to his office when his cellular videophone flashed with a notice that Kimball had replied. Will turned away from the sun to shadow the tiny video screen and pressed play.

“Hi again. Thanks for promising to talk to Lassen. As for the specs, they've just been updated on the website. The dome will be thirty meters in diameter and have a maximum center height of ten meters. That'll give you 700 square meters of enclosed space; equivalent of six greenhouses, and we're manufacturing it for the cost of about one! That's the advantage of private industry, as opposed to the space agency doing the work. I don't know why NASA should fly you greenhouses any more; these are more energy efficient and have a mass less than half of the greenhouses per square meter. Take a look when you get the chance. Bye.”

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After breakfast, Lal drove the conestoga due west, leading the expedition's three vehicles around boulders, craters, and landslide piles. After six kilometers they came to the opening to Candor Chama and turned northward. The connection was a chaotic area of channel deposits buried by landslide debris and blanketed by thick deposits of windblown dust. Geologically, it was one of the planet's most complex pieces of real estate. Half the

crew, riding in a conestoga, stopped frequently to explore while the two rangers pushed forward, clearing a 4-meter wide dirt track across the stone fields.

Close to sunset, they came over a lithified sand dune and down into a large area where eolian deposits were eroded away and underlying channel deposits beautifully exposed. Several catastrophic floods had issued forth from Candor and it appeared that for a few million years a stream flowed from the canyon most of the time, producing one of Mars's more mature fluvial features. Consequently they had good reason to conduct a thorough examination of the exposed deposits.

Lal Shankaraman was in his element as he strode across the slightly lithified deposit of gravel, pebbles, and sand. It reminded him of hundreds of alluvial fans and boulder bars he had prowled, from the base of the Himalayas to Nevada. There were differences caused by the lower gravity that were already documented and he was familiar with them; he noted the crude stratification and imbrication of the cobbles with an expert eye. The materials had a different physical appearance on Mars as well because weathering proceeded in mostly subfreezing conditions in the absence of oxygen; the rocks were not as deeply rusted and oxidized. But otherwise they were a familiar mix. Upstream had been high-silica intrusions, nearly granitic rocks such as were found in thousands of regions across the Earth, the stuff of the Earth's continents though fairly rare on Mars. Consequently the deposits were filled with quartz and feldspars, though the feldspars were richer in calcium than typical on Earth.

As Lal scanned the outcrops under his feet, a shiny yellow reflection caught his eye. The sun had not yet dropped beneath the escarpment; sunlight was glinting off of something shiny. Curious, he reached down and tried to pick it up. It was cemented in

place—the deposit was three billion years old, unlike the alluvium he usually studied on Earth—but a single tap with his rock hammer was enough to break it free. He picked it up and brought it to his helmet. Uncertain what it was, he pushed a button and flipped a magnifying lens down in front of his left eye, to take a close look.

“Say, this is gold,” he exclaimed aloud. His radio was set on a public channel so that everyone could hear.

“Gold? Really?” asked Jerry, who was nearby.

“Yes, a very nice nugget. Pure gold, probably; I’d say it weighs 100 or 150 grams.”

“This deposit is eroded from the right kind of host rock,” observed Jerry. “I’ve never seen gold on the moon before; let me see.” McCord walked over and took the nugget from Lal. He looked closely through his magnifier, then nodded. “Fascinating. I’ve never seen native gold before.”

“Never?” Lal was surprised.

“The igneous processes on the moon don’t segregate it, and my geology has focused on the moon or terrestrial analogs.” Jerry sounded a bit defensive.

“Goodness, I’ve even panned for gold once! It was fun. Do you realize this nugget is worth over a thousand bucks on Earth?”

“I’d say you should keep it, but it belongs to the agency. Does it tell us anything about the depositional environment?”

“Nothing we don’t already know.”

“Interesting.” Jerry handed it back to Lal, who put it in his collection pouch. But as he walked around, he found the gold distracting him. Lal was planning to stay on Mars

four years and he was sensitive to the need to find ways to support the mission. Gold, obviously, was a valuable resource; at ten million dollars per tonne on Earth, it was worth far more than the costs of shipping it there.

He continued to scan the deposit, but his eye was now sensitized to gold. He spotted another glint and ignored it, trying to return his thoughts to professional concerns. A few minutes later he spotted a third nugget; that time he bent down and picked it up. It was much smaller and he decided he'd keep it for himself, since they were free to keep samples. Then he spotted a fourth one, which he also collected.

The light began to fail around him. Lal looked up; the sun had dropped below the escarpment and only the topmost cliffs were still reflecting light downward. He looked around; he had walked a hundred meters or more from Jerry. The others were exploring another alluvial deposit about 400 meters away. He turned and headed back to the vehicles; it was time.

“Everyone back to the vehicle,” exclaimed Jerry just then. He had realized it was time as well.

By the time they reached the conestoga, they were stumbling in semi-darkness. The four of them entered it through the back door; rangers 1 and 2 were on their way back to them, having pushed the dirt track forward another five kilometers. They closed the door, pressurized the cabin, then pulled off their helmets and gloves. Érico and Patrice had found a quiet water deposit and excitedly described it; it was unexpected. Lal listened and wondered what to say about the nuggets.

The other two vehicles arrived and they waited cautiously while they all docked together, including the portahab. Once the docking was complete the others entered the

conestoga. Linda Dubois—who had been driving the second ranger—entered and they all exchanged stories. Lal told everyone about the gold.

“We should let Will know,” said Érico. “This is significant.”

Jerry rolled his eyes. “He’ll want us to become gold prospectors. I’d be careful.”

“This does have the potential to help pay for Mars exploration,” agreed Lal. “I spotted four nuggets in fifteen minutes; maybe 250 grams of gold. If we look closely, we’ll find lots of gold flakes as well, I’m sure.”

“We should find out,” agreed Érico. “This is not the time to collect a lot of gold, but we can study the deposit.”

“We’d need equipment to collect it anyway,” said Lal. “Specialized equipment could be imported from Earth and liquid carbon dioxide could be used to concentrate it. An astronaut would just feed gravel into the hopper with a power shovel.”

“Liquid carbon dioxide?” asked Patrice, skeptically.

Lal nodded. “There are studies about the problem of separating gold from rock under Martian conditions.”

“There are studies about everything,” said Maria. “Making it work is another thing.”

There was a lull in the conversation. Then Jerry said, “Well, let’s get supper cooking.” They all turned to supper duties.

But after supper Lal headed to his bunk in the portahab, then pulled out his attaché. He dialed Will’s number.

“Hello; Lal?” he said, answering the live video call. He was surprised to receive a call from the geologist.

“Good evening, Commander. I hope it’s not too late to call you; goodness, it’s 9 p.m. here, so I guess it’s now midnight there! I’m sorry it’s so late; I forgot about the additional time zone. I thought I should let you know that I found four gold nuggets this sol just before sunset.”

“Gold?” Will’s voice went from sleepy to wide awake. “How much? Is there a lot, or a little?”

“In fifteen minutes I found four nuggets and picked up three. I’ve weighed them; 233 grams, a bit less than I thought. It’s a placer deposit and we’d have to tear it apart to get a real sense of the quantity, but I’d say it’s looking promising.”

“It sounds like it! I’ll call Jerry. We need to survey the deposit. If we can extract a few tonnes of gold, we can make a substantial amount of money for the mission. What was his reaction?”

“Scientific curiosity about the samples.”

“That’s what I would expect. Okay, I’ll talk to Jerry in general terms. He and I always talk every morning before your breakfast anyway. Thanks for letting me know.”

“Delighted, Commander. I agree that this is immensely important for our future here. We’ll need equipment to extract gold easily and in quantity, but at least the option may now be available to us.”

“Exactly. We need to be able to justify the settlement of this place. Settlement means families and children, and they are not needed for scientific work here so they can’t be directly justified financially. But if a small amount of our time can generate large financial returns we can justify settlement of this place, which is the only way to do good long-term science here anyway! So I am very grateful for your sharp eye.”

“Delighted. Good night.”

“Good night.” Will and Lal both closed the phone line.

Ethel had been awake in bed, nursing Marshall. “Gold, huh?”

“Yes, isn’t that fantastic! It sounds like a lot of it, too.”

“Amazing, that we’ve explored a tiny fraction of this world and have stumbled onto gold.”

“Yes. But I suppose it isn’t too surprising; we’re looking at the most interesting geological provinces first. The dry land area of the Earth is about the same as Mars and it had hundreds of rich deposits of gold. We won’t exploit any poor quality deposits because we can go after the richest ones instead.”

“Which would make them more profitable, compared to the remaining deposits on Earth. But we haven’t decided to harvest it.”

“I have every intention to pursue this matter. We will harvest gold. When Jerry calls tomorrow, I suspect he’ll tell me he plans to stay and survey the deposit. He knows my priorities.”

The three vehicles of the Marineris Expedition approached the Outpost. Six weeks of exploration had taken them through several sections of Candor Chasma, then to the end of Noctis Labyrinthus, where they built a partial ramp to the Tharsis Plateau at the west end of the canyon. Once they had docked to the Outpost's airlocks, Jerry McCord greeted Roger Anderson with a big smile and a slap on the back.

"It's good to see you again! Where's Will?"

"He and Paul will be back in a few hours; they drove to a sand deposit to get a load for the building. Wow, you had quite an expedition!"

"I'm a bit disappointed; I really was hoping we'd get up to the Tharsis Plateau. Maybe next time. We need about twenty tonnes of water to freeze the ramp together."

"The Sunwings can drop ice blocks, so that when you go back the water's already there. But you did get up to Tharsis by foot, at least."

"Yes, that was better than nothing, but we need to be able to clear a route all the way up. As you said, next time. It'll take maybe a month. I'm surprised to see the building mostly finished."

"No, not at all. We do have the first floor walls completed, but there's no floor or walls yet for the second story. But we're almost back to the original schedule. For a while it was looking impossible. The rangers were constantly breaking."

"Why did that stop?"

“Because they finished excavating the foundation! We had to weld the bulldozer blades almost every sol and we snapped several power shafts. But we got the hole dug.”

“Good. Well, we excavated about a hundred kilos of gold in Candor Chasma. We broke a blade, too, and welded it. They aren’t very strong.”

“How much gold is there?”

“Hard to be sure, but we conducted a three-sol survey of the placer deposit. There’s probably scores of tonnes of gold there, but it will take a lot of work to extract it. The hundred kilos was hard work!”

“I gather Will’s already been talking to folks in Berlin who are designing a centrifugal separator.”

“Yes, I’ve heard about that as well.” Jerry slapped Roger on the back again. “So, Madhu’s pregnant. Congratulations.”

“Thank you. We’re delighted; or maybe I should say she’s delighted and in a few months I suppose I will be, also. I’m still adjusting to the idea of fatherhood, and on Mars.”

“I bet. What’s that doing to your research?”

“Madhu’s basically grounded me for the next year. So I’ll be doing a lot of local geology and support work.”

“On the other hand, you’ll be able to make up for it later.”

“Yes, we’ll probably be here for a decade or more.”

“That’s a valuable opportunity for research, though I suspect this place would get on my nerves after a few years. I guess that means Érico gets to do more, for a while.”

Roger nodded. “Yes, but Madhu’s working on Carmen, so his freedom may not last.”

Jerry laughed. “My wife is not interested in space flight at all, lets me go, and my kids are in college. We had our kids early, and I’m glad we did! But I miss them.”

“I can imagine. I don’t know how I could stay here without Madhu. I’ve come to agree with Will on this matter; we need to make Mars a marriage-friendly and family-friendly place. It’s the only way this place will become more than a transitory, small hamlet.”

“That’s true; but is the technology mature enough for families?”

“It should be. Madhu and I will find out,” replied Roger, with a shrug.

They all plunged into the work of unpacking. Then Jerry suited up and, out of curiosity, made a walking tour of the new building. The hole in the ground had been filled with a flat slab of duricrete, a mixture of eolian dust and crushed, roasted duricrust. The latter had been formed by natural wetting and drying of the regolith over the ages, causing an accumulation of sulfates and salts in the surface layer that cemented it together. The wind-borne dust, also, tended to bond together. When the two substances were mixed in the right ratio with the right amount of water and poured into a heated, airtight mold, in a few hours they set to make a substance with less strength than concrete but more strength than plaster. Reinforced with iron wire and bars, and coated with plastic to make it water and airtight, the resulting duricrete was an excellent building material.

The foundation was over a meter thick and at Mars’s arctic temperatures was rock-hard. The iron reinforcements had been completely installed for the first floor and

ninety percent of the walls had been poured; the last section was still encased in sheet metal molding, ready to receive the duricrete mix. Window holes, still encased in heavy sheet metal, poked through the meter-thick walls. Jerry did a quick calculation based on a density of two tonnes of mass per cubic meter; the first floor alone involved almost 400 tonnes of duricrete. No wonder the construction had taken so long.

He looked inside through a window hole. Installation of the ironwork for the interior walls had begun; they would be much thinner, since they were not designed to hold in pressure. In a week or two the floor for the second story would be poured, then the ironwork for its interior walls would go up. It was a long process, especially when much of the work had to be done in pressure suits.

He walked around the Outpost, then climbed to the top of Boat Rock to admire the view. It was a fascinating place in a beautiful natural setting. It had a lot going for it; he did feel a certain desire to stay.

Then he saw two rangers returning with trailers full of high-quality sand. He headed down to greet the Commander.

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Two weeks later a second expedition set out, with two rangers, a portahab, two conestogas, a nuke on a trailer pulled by a truck, and eight people bound for the northern polar region. It was midsummer, with constant sunlight and relatively mild conditions. They moved down the Polar Trail—a route that eventually would run from pole to pole via Aurorae Outpost—fairly quickly, forty kilometers per hour when a human could drive during the day and half that at night when the vehicles drove themselves automatically. For ninety minutes every sol they stopped to do additional geological exploration; every

evening the vehicles docked together for ninety minutes so that everyone could eat dinner together. Moving at 600 kilometers per sol, they reached the northern layered terrains and the end of Route 2 as constructed the previous annum (Martian year) in nine sols.

A major problem in driving across the layered terrains was crossing the frequent layer edges, which were either steep slopes or low cliffs. But the portable nuclear reactor, with its 800 kilowatts of thermal output, provided the power for quick construction of ramps. While two rangers bulldozed debris in place against the slope, the reactor was brought forward by its truck and a conestoga with a scoop fed ice chunks into a melter, heated by reactor heat. A steady stream of liquid water was ejected from a hose at the growing ramp, filling the gaps between the chunks with instant ice and freezing the ramp together. Liquid water could also be directed at the top of the cliff to melt it down, the resulting water refreezing into ice almost instantly. Once a ramp was completed the expedition proceeded forward to the next cliff, and the reactor and its melter stopped to fill in cracks and crevasses in the route as it went. The expedition moved forward about twenty kilometers per sol, half their usual speed when one considered that they utilized the midnight sun to carry out their road clearing effort sixteen or eighteen hours per sol.

Three and a half weeks after the expedition set out from Aurorae on the Martian equator, Will got a telephone call from Érico. “Commander, we’ve just stopped at what we believe to be the North Pole,” he exclaimed.

“Congratulations! This is an historic sol. You’ll go down in history as the conqueror of the Martian North Pole.”

“Thanks, Will. It’s really exciting. Most of Brazil will be tuning in when we step outside.”

“They should be proud of you. Let’s please fly the United Nations flag first, then the Brazilian flag.”

“I wanted to make sure that arrangement was agreeable to you. I’m uncomfortable about planting the American flag here.”

“We’ll let Jerry do that, if he leads the expedition to the South Pole or to the top of one of the volcanoes. No, plant the U.N. flag. We do this for all of humanity. We may still be under NASA, but we’re an international team.”

“Thanks, Commander.”

“You’ve also demonstrated that our equipment can handle pretty extreme conditions. You may have paved the way for human exploration of the Galilean satellites.”

“By our children’s generation.”

“Probably. This is an incredible connection; I guess the satellite is up.”

“Yes, we timed our arrival so that the communications and navigational satellite is above the horizon. We’ve got about five hours of coverage before it drops below the horizon again. It is our source of geopositioning signals, which is how we know where we are.”

“I’ll watch on television. Good luck.”

“Thanks. Good bye.” Érico closed the connection and looked at Carmen, who had accompanied him on the expedition. “Let’s suit up.”

She nodded and helped him with his suit, then he helped her with hers. They put on their helmets, checked out all the suits’ systems, then headed for the conestoga’s

airlock. The other three were suiting up as well, but no one dared to depressurize their vehicles before the expedition commander. Érico was the first one out.

He opened the door and stepped down onto the frozen ground. The view from the top of Mars was fascinating and breathtaking. The ground was white for as far as they could see. The terrain had whitish materials that a trained eye could tell apart easily by consistency: water ice and dry ice. The latter formed a scattered summer layer on top of the former, sublimated completely away on slopes that exposed it to greater sunlight, and was thick and semi-permanent in shadows. The only objects interrupting the unbroken expanse of bluish-white were occasional meteorites that had fallen from space and crater ejecta that landed on the ice from distant impacts. They had collected hundred of samples and, when possible, photographed the impact features to determine the direction of arrival; in some cases they would be able to match the ejecta with specific craters.

Érico also looked up at the sky. It was unique because of its close resemblance with Earth's: a blackish-purple blue, it had no dust in it and therefore no pink or orange hues, as was common closer to the equator. Wispy white clouds made the scene almost resemble Antarctica. The sun shone fiercely close to the horizon, but seemed to give no heat.

The others came out of their vehicles. There was a slight mound a dozen meters away; Érico grabbed the flag and moved over there to give the ceremony a bit better setting. The eight of them gathered round in a circle. Carmen stood opposite Érico so that her camera, which was carrying the image of their gathering back to Earth, could capture his facial expressions and movements well.

Érico raised the U.N. flag up slightly. “We gather here to mark another significant milestone in human exploration of this solar system. It is an achievement that is possible only because the governments of all of us have worked together to send us to this world and to develop the equipment to make our journey here possible. We express our gratitude to humanity for this adventure of the human spirit and this scientific development. Human beings now stand at the North Pole of Mars.” He pushed the butt of the pole into a crack in the ice. “We come here in peace for all mankind.”

The others applauded; the sound of gloves beating together came faintly over the microphones. Then Érico held the pole steady while the others brought over ice chunks and meteorites, building a pile around the flagpole to hold it in place. Érico returned to the conestoga, brought over a pressurized twenty-liter canister of water, and squirted it onto the pile, freezing it hard into a permanent anchor for the flag. A breeze rose and caused the flag to billow and flutter, much to their pleasure.

The expedition members deployed their own national flags as well, an array of miniature flags around the base of the big one. Then they got to work deploying the ice drill; they planned to remain in the vicinity of the North Pole several weeks, so there was plenty of time to bore a substantial distance into the layers. Finally, while the satellite connection lasted, they began a systematic exploration of the area. There was much to do.

The event grabbed headlines across Earth and was watched eagerly by tens of millions on television. Its newsworthiness was assisted by the fact that no crisis had occurred on that sol that diverted the attention of the media. But other developments related to the exploration of Mars were going on. Three sols after the conquest of the top

of the Red Planet, Will Elliott received a surprising videomail from Harold Lassen, the director of Mars Mission Operations.

“Will, I’ve recommended that you be added to the negotiating team that is working on the establishment of the Mars Commission. Because of your absence from Earth and the likelihood the meetings will not be redesigned to accommodate the time delay to include you, your presence will be something of a token; however, I have said that your track record as an innovator and your experience as Commander makes input from you imperative.

“As you know, the negotiations broke down last year and were resumed two months ago. Currently the parties include the United States, Russia, Japan, France, Britain, the European Space Agency, Canada, Brazil, and India. Australia has applied to join, South Africa and Mexico may apply, and China may apply as well. The White House is set to make a decision whether to invite China in the next few months. There is also the possibility Iran, Pakistan, Korea, Germany, and Italy may join eventually.

“The Commission will involve an international treaty whereby the signators renounce any territorial claims over Mars, Phobos, and Deimos, and agree to turn such jurisdiction over to a Mars Commission, which will be responsible for exploration, exploitation of resources, and settlement. The Commission will have authority over such matters as defining units of civil administration; hence the need to include you, since the residents of Aurorae Outpost have already taken steps to set up a legal civic authority. The Commission will make such a body fully established in a legal sense. The Commission will also be authorized to grant title to land on Mars and utilize the proceeds from sale of such for the further development of Mars. The Commission’s headquarters

tentatively is set for Houston, Texas; it'll probably share space with the Lunar Commission in the new building being erected for the latter. By the way, the powers of the Lunar Commission are under review as a result of the Mars Commission negotiations. Several companies have approached the Lunar Commission and requested the right to purchase or lease plots of lunar land, or at least the mineral rights to the same, to extract water, other volatiles, and nickel-iron. The need to privatize mining operations on the moon, accommodate additional national stations, and build such assets as tourist hotels are forcing a reevaluation of the lunar treaty. An Asteroid Commission is under consideration as well, since the ITVs are now a proven technology and can be flown to other destinations in the inner solar system.

“We look forward to your participation in the work. If you have any questions, let me know.”

Will smiled in excitement as he contemplated the offer. He couldn't help but think that the White House and NASA were agreeing to participate only because they had a weak hand; Congress has cut NASA's budget and was considering a huge cut for the next year to force NASA to use the Swift shuttle. He hit reply. “Thank you, Dr. Lassen, for this opportunity. I'll be delighted to participate. Mars has become my life, as you know. I have a long-term commitment to this place by virtue of the fact that I have a child here. The Commission sounds exactly like the structure needed to move the work here forward into the future. Mars also needs privatization, the chance to sell resources, and above all, it needs settlers. Our work here is deliberately laying the foundation for all of those achievements. So you can count on me to do my best. Bye.”

## Conjunction

early Feb. 2026

The North Polar Expedition reached the pole on October 18, 2025. After five weeks of exploring the layered terrain it returned to the Outpost. Then in early December two expeditions, each with two rangers, a portahab, and a conestoga, set out to the east and west respectively to cross Mars. The western expedition, led by Jerry McCord, completed the ramp and escaped Noctis Labyrinthus, then drove across the Tharsis Plateau toward Arsia Mons, then Amazonis Planitia. The eastern expedition, led by Érico Lopes, broke out of the chaotic terrain at the opposite extremity of the Mariner canyon system and began to cross the ancient cratered highlands of Mars, making for Isidis Planitia. After two months, each expedition had added 1,600 kilometers to the Circumnavigational Trail or Route 1, which had already been 4,000 kilometers long. The 7,200 kilometers of dirt track now stretched one third of the way around Mars.

It was almost conjunction, a traditional time to pause and reflect on their efforts, and almost the onset of the duststorm season. Because of reliable communications relays via communications satellites in orbit around Venus, the conjunction would see less disruption of contact with Earth than the previous two. Even so, it was time to re-evaluate their plans. Will called Érico, Carmen, Jerry, and Lal back to the Outpost for a few sols of discussions with him, Pavel, Madhu, Roger, Monika, and Ethel.

A sunwing bearing Érico and Carmen rode westward with the sun and touched down in the early afternoon. The sunwing with Jerry and Lal left their expedition the afternoon of the previous sol and rode eastward five time zones, landing an hour later.

“I want to see the new building,” Jerry said to Will, as they all sat in Habitat 4 to eat a late lunch, which was a late breakfast for Jerry and Lal.

“Oh? You’re demonstrating more interest in the project than I expected!”

“It’s an ambitious effort. As we were landing, I saw that the windows are in.”

“Yes, in fact we pressurized the building last week with oxygen. Do you want a tour right now?”

“Sure!” Jerry and Will rose. Lal and Érico, curious, rose to join them; Pavel, proud of his achievement, went along as well. Will led them through the airlock and into a tunnel that ran southward alongside a greenhouse to the building’s closer airlock. They passed through and entered the lower level.

Daylight streamed into the great room, which was ten meters square, through three windows. It was still untidy; electrical lines were being laid across the ceiling and pipes along the wall. Electrical fixtures had dangling wires. Materials lay on the floor and debris was in piles. But Jerry was impressed anyway. He felt the wall. “It has the feeling of plaster. You all did a great job of smoothing it, too.”

“The hard part was inside the wall,” replied Pavel. “There are two sets of reinforcing rods in it, two curtains of wire mesh, and under the plastic finish you’re admiring is a stray-on plastic coating to improve pressure retention.”

“There are still leaks around the windows, too,” added Will. Each window was forty centimeters square and was encased in metal sheathing. He pointed to caulking around the edge of the sheathing. “The leaks are pretty slow now, though. This place can hold air within the pressure specifications for three sols. That’s good enough to continue the installation work without pressure suits.”

“But it’ll have to improve before we can rate it for standard use,” added Pavel.  
“We’ll fix the leaks gradually.”

“This will be a fantastic great room; so much bigger than anything we have now,” said Lal. “What’s back here; the kitchen?”

“Among other things,” replied Will. He led them across the space to a five by ten meter kitchen, then a work room of the same size.

They climbed the stairs to the top story. It was much less finished. A central corridor ran down the middle of the floor, with five doors on each side opening into unfinished rooms about four and a half meters square. Each had a window. “One of these will be a bathroom,” explained Pavel. “The other nine can be bedrooms or work areas for one person. With the work space downstairs, we figure the building can accommodate six people for their sleeping and work pretty well.”

“Comfortably, too,” noted Jerry. “So, when this is finished, the Outpost’s total capacity is raised to thirty.”

Will nodded. “Correct. Furthermore, we could build another building of this size more quickly, so if we need more capacity before Columbus 4 arrives, we could have it ready.”

“Ready for habitation?” asked Lal, surprised.

“Almost,” replied Will. “There would be a few tonnes of necessities that Columbus 4 would have to bring. But they could be installed in less than a month.”

“We could manage that,” agreed Jerry, nodding. “But how many people will Mars have at that point?”

“That’s a matter on the agenda, so let’s get back to Habitat 4 and start our meeting.”

They all headed back to Habitat 4, where the Great Room had been set up for their conference. Ten chairs were set in a semicircle with two cameras facing them to send their images back to Earth. Several microphones guaranteed that their audio would be received in a similar conference room in Houston, where a dozen officials would sit in another semicircle ready to listen and reply. Madhu stretched out on her chair; now eight months pregnant, she was beginning to get quite uncomfortable. Ethel sat near Will with Marshall, now eleven months old, who was crawling around on the floor or cruising along the wall, pacifier in his mouth.

There was no reason to wait; the audience in Houston could always watch the Mars team on videotape. “Jerry asked how many humans will be here when Columbus 4 arrives,” Will began. “Yestersol I got advance notification from NASA. They have decided to lease space on Europe’s new Swift shuttle to launch Columbus 4’s cargo and will purchase a shuttle of their own in the next two years. This means Columbus 4’s anemic budget will stretch to cover the full original plan. Columbus 4 will include two shuttles, four ITVs, and sixteen people. If the Chinese join they’ll be able to add one or two more people. The sixteen include five couples.”

“Five?” Jerry’s eyebrows went up. “Congratulations, Will. You won.”

“I wouldn’t put it that way, Jerry. It is true, however, that this represents a commitment to long-term settlement of Mars for the purpose of scientific research. It’s important to add that; we’re not talking about colonizing Mars. That’s not justified

economically or by any other criterion. Maybe it will be in a few decades, but it isn't yet."

"How much cheaper will launching Columbus 4 be?" asked Ethel.

"They already have the Mars shuttles in orbit, undergoing testing, and the ITVs can't be redesigned to fit into the Swift cargo bay. Those items will cost \$6,000 per kilogram to put in orbit, using the Ares and Ariane launch vehicles. But the other half of the mass to be launched can fit in the Swift, and it'll cost—" Will paused so that he wouldn't laugh "\$1,000 per kilogram."

Several others laughed instead; it was an embarrassing difference. "So how many will we have here?" asked Carmen, getting them back to the subject at hand.

"Good question," replied Will. "Ethel, Marshall, and I are staying; Roger, Madhu, and child are staying; Érico and Carmen are staying; Eve and Gaston signed up to stay and plan to adhere to their commitment; same for the Strogers; Lal committed to stay—"

"Shinji's leaving," said Roger.

"No, I talked to him yestersol and he told me he wanted to stay for a fourth cycle," replied Will. "Jerry, you're still planning to leave?"

Jerry nodded. "I feel torn sometimes, but I have a family on Earth."

"We're staying," exclaimed Monika. "Paul and I, that is. This may come as a shock to some of you, but we've decided to get married."

"Congratulations!" said Ethel, delighted.

"I'm so surprised, you could knock me over!" proclaimed Roger, startled.

“We have so many good examples of happy marriages around us, we figured we’d give it a try,” commented Monika. “The one-child family seems attractive, too, especially if the support network remains as good as it seems to be.”

“It does take a village,” agreed Ethel.

“So, that’s six couples, Lal, and Shinji; 14 so far,” said Jerry, getting them back on the topic. “And two leaving. Sixteen out of twenty-three adults accounted for.”

“I’m heading back,” said Pavel. “The building will be done, a second one will be started, and the skills will be conveyed. It was fun.”

“Rick’s going back also,” added Will. “Lisa and Karol sound interested in staying. Koyo seems to want to stay; Patrice definitely plans to leave because he has his eye on the probable French mission to Venus; Maria and Linda are planning to go back as well. So that’s seventeen staying and six leaving. That means when sixteen arrive on Columbus 4, we’ll have thirty-three, and if eighteen arrive we’ll have thirty-five.”

“We’ll need another building,” exclaimed Pavel. “No problem. We can get started on it right away, in and around other tasks, and do the heavy construction work later.”

“The heavy construction work requires rangers, and they’re all out exploring,” noted Will. “So unless they have to come back because of a dust storm, the bulk of the work will have to wait until Columbus 3 blasts off, which gives us only nine months to complete the building. Furthermore, we’ll have a crew of eleven at the Outpost to do the work if six are exploring in three vehicles. But it’s possible.”

“Definitely,” agreed Pavel.

“So, even with thirty-three to thirty-five people on Mars, the agency won’t have to fly out a habitat,” said Pavel. “That saves a lot of mass. Our greenhouse experiment

needs to proceed next, before we even complete the building, because it will determine whether they have to fly out five to seven more greenhouses.”

“Yes, that has to be a priority,” agreed Will. “If we can build a greenhouse entirely out of local materials, or even if we can reduce imports by half, we save a lot of money. By the way, Heather Kimball, head of the Mars Exploration Society, told me that she has been having a lot of private conversations with Harold Lassen lately, and she’s pretty sure he’ll be able to secure permission for the MES to send their Mars dome, as they’re calling it. The decision to accept the Swift has helped. It’ll be thirty meters across and have a floor area of 700 square meters, enough to feed nine people if it were all agricultural. So our existing greenhouses plus the Mars dome will meet basic food needs. But the rules require redundancy, so we can’t plan on using the Mars dome except as an emergency supplement. The arriving equipment and consumables will have to be able to feed everyone if one cargo vehicle is lost; and the new risk assessment suggests the danger of losing a vehicle is one in one hundred fifty, not one in five hundred as it had been thought.”

“Really?” Jerry was surprised. “That’s quite a serious reappraisal!”

“The committee made a large number of recommendations for improving reliability, and NASA is setting a goal of tripling reliability in the next few years,” replied Will. “But it’s a wake-up call to us. We’re out at the end of a long supply line with equipment of uncertain reliability.” Will looked at his agenda. “So we know how many will be here, more or less. We need to complete the first building, build a greenhouse prototype, and start on a second building. Regarding expeditions, we’re moving into dust storm season in a few weeks. Storms can eliminate emergency rescue

capacity because the high winds will prevent sunwings from landing. They can even prevent use of a shuttle. Our expeditions can proceed on nuclear power; visibility is never so low that people would have to stay inside the vehicles. But there's the risk that rescue capacity is diminished. What's your fancy, commanders?"

"My people want to explore," replied Jerry.

"Same here," agreed Érico. "But we have Shinji, so medical care is covered. Jerry's expedition doesn't have a doctor."

"Could we get Eve for a few months?" asked Jerry.

Will shook his head. "Negative. The outpost is a more dangerous environment because of the construction and it has a baby, with another one on the way. We have to keep one physician here all the time."

"But we can send a medical robot; either physician can perform basic surgery remotely with it," noted Madhu. "And many people have basic first aid training. I don't think emergency care is a serious issue."

Will looked around. The others who often went on expeditions were nodding. "Okay, we'll stay out during the dust storm season and hope no one has an accident or gets appendicitis. Mission control will let us do this; I asked."

"That's new," observed Jerry.

"It is. They're letting us set the balance of safety and exploration."

"Can we get all the way around the Mars in the time left?" asked Lal.

"This sol is February 3," replied Will. "Blastoff is set for September 12, with trans-Earth injection on September 19. That means the expeditions need to be back here no later than about August 31. That's seven months. If each expedition advances nine

hundred kilometers per month, they can clear 12,600 kilometers of road in seven months. Mars is 21,000 klicks in diameter, and we've already cleared 7,200, leaving 13,800."

"But we can do better than thirty klicks per sol," replied Jerry. "I think we can average forty."

"But should we try to do this simply for the sake of doing it?" asked Roger. "If we don't complete it before blastoff, we can complete it a month or two later. Right now there are sols we manage even fifty kilometers, but other sols we travel less, and we don't travel at all on Sunsols."

"And there's the South Pole," reminded Érico. "The best time to go there is August of this year, after the dust storm season has ended but before winter has set in."

"How many poles can we reach?" asked Jerry. "The South Pole can always wait. No one has circumnavigated the moon yet! We can beat them."

Will looked at Jerry. It was obvious that he wanted to try for it. "We have to remember that the return trip from half way around—about 11,000 kilometers from the Outpost—will take at least eleven sols of driving, or almost three sols flight in a sunwing. It's not a drive around the corner. It'll strain equipment. And we can't postpone blastoff very much. We'll need at least two rangers back here before blastoff based on safety rules."

"And remember our roads aren't arrow straight; they twist and turn a bit, which adds fifteen percent," noted Roger. "Route 1 needs about 16,000 klicks of clearing."

"So, we clear forty-five kilometers a sol, six sols a week," replied Jerry. "That's 270 kilometers per week and over a eleven hundred per month. In seven months that's

7,700 kilometers per expedition, 15,400 total. That's just about what we need if we straighten the routes. It's possible."

"Assuming no breakdowns," noted Érico. "And making generous assumptions about what can be done every sol."

"The route will have to be selected to pass over smooth terrain and avoid the most geologically interesting sites," added Neal. "That would be unfortunate."

"We'll have to look into it," replied Jerry, his voice rising a bit. "A circumnavigational trail should be made for speed and efficiency in mind, anyway; it shouldn't snake after every good bit of geology. But side routes can be made to the geologically interesting sites, and they don't have to meet the quality standards that the main route is built to."

"You're really pushing the limits of what we can achieve," said Will, looking at Jerry. "But I don't mean that as a criticism. It leads to innovation, as long as we don't compromise safety." He looked at the others. "Whether we can complete the route before blastoff or not, should we try to push it forward continuously that long, with none of the rangers returning to the Outpost before September? The sunwings are working fine. They can survey the route, drop supplies in advance, and rotate two crew members per month between each expedition and the Outpost. We have only four or five people who can't leave at all, so we have eighteen people who can go out."

"Radiation exposure would not be excessive in that time," added Roger. "But that means the eighteen people would be away from the Outpost about five months out of the next seven."

“We could run the expeditions with five crew instead of six, if necessary,” suggested Érico. “If we did that, people would be away about four months out of seven.”

“That’s doable,” said Will. “Pavel, that means the Outpost has a total of eleven or twelve here at any time, including one physician, two mothers, and at least four full-time maintenance positions. Assuming the mothers complete the equivalent of one of the maintenance positions, that leaves us four, sometimes five people for construction. Can we finish the first building, one experimental greenhouse, and do some work on a second building in that time?”

“Yes, though we may not get much done on the second building.”

“Alright. So I think we have a plan for the next eight months: build as much of the Circumnavigational Trail as we can, all of it if possible; keep an average of eleven people out at any time; complete the building, one greenhouse, and start some work on a second building. There is one twist I have to add. We have never been able to get one of the Lifters to achieve a proper hard dock on Phobos, after seven months of trying. We probably need to fly an expedition up to Phobos next month to fiddle with it and get it properly docked, so that it can fuel up. But that means Érico’s group will have to come back here for a week to ten sols to provide ground support for the shuttle launch and landing.”

Jerry groaned. “There’s no other way?”

Will shook his head.

“Actually, there’s one thing mission control hasn’t let us try,” noted Ethel. “Lifter 2 is fully fueled, now. It could take off and Lifter 1 could dock where Lifter 2 was docked. Maybe Lifter 1 can achieve a hard dock on the other docking collar. Or failing

that, maybe Lifter 1 can achieve a hard dock to Lifter 2, in which case the fuel can be transferred to Lifter 1, and Lifter 2 can dock again and fuel up again.”

“And once Lifter 1 is fueled, it doesn’t need to achieve a hard dock to anything. It could just land on Phobos and wait.” Will smiled. “I’ll ask Mission Control about that. It’ll save a lot of hassle. With a two percent chance of mission failure, I’d rather not fly two crew to Phobos if it can be avoided!”

“What about the nine months between Columbus flights?” asked Roger.

“One possibility is refining and improving Route 1, and doing further geological work along it,” suggested Jerry. “It occurs to me that we could finish Route 1 more quickly if we don’t build it to such high standards. We could also postpone a lot of the geological work until later. The road will open up a lot of territory, after all; a strip one hundred kilometers from the route will embrace over four million square kilometers of Mars. A five hundred kilometer wide strip would embrace a sixth of the planet’s entire surface area. Routes 1 and 2 together will open every major geological terrain on the planet to us. So I’d favor completing Route 1 fast, then taking our time and exploring its territory in detail.”

There was a silence, while at least some of those present thought about Jerry’s burning ambition to be the man to complete the first phase. Finally, Will said “We will be developing and improving the route for some time, and we will be exploring the area around it for some time, before and after Columbus 3 leaves. What you say makes sense in outline. I think our priorities for the nine months after Columbus 3 leaves will look like our priorities now: build buildings, clear routes, and explore. They will change if we find an incredible fossil location or a lode of gold, so we have to be flexible.”

“What we can say about the previous nine months is that the rangers are all working well and the reactors have proved a vital success,” exclaimed Jerry. “They have opened the door for all of this work. There is no reason why we can’t finish Route 1.”

Will nodded. “And on that note, let’s take a break. This entire discussion is still winging its way to Earth via Venus. Mission control’s panel at the other end needs half an hour to listen, digest our ideas, and offer their response. So let’s stretch, get another cup of coffee, or brainstorm privately.”

Will rose and stretched. They had been deliberating nearly an hour. Marshall had sensed that his daddy was busy and had been pretty good at staying away, but now he was delighted to see that Will was done. Everyone else was standing as well. So Marshall smiled and walked toward his father along Ethel’s chair. When he reached the edge of her chair and had nothing to hold onto, he kept going in wobbly, tentative steps.

“Marshall my boy, come on! Come to daddy!” Surprised by his son’s first independent steps, Will squatted down and opened his arms toward his eleven month old son. Marshall smiled and, encouraged by his father’s love, kept on coming. He wobbled forward about ten steps, then began to fall just as he reached his father’s outstretched arms. Will caught him. “Good boy!” he said, kissing Marshall. The boy—now a toddler instead of a baby—giggled.

Ethel was right behind Marshall most of the way. She embraced Marshall next.

“Were those his first steps?” exclaimed Jerry.

Will looked up; most had been watching. “Yes, they were! He’s been cruising along furniture for two weeks or walking with someone holding his hand, but this was his first unaided solo trip!”

“Wow, that was something to see, then!” exclaimed Monika, smiling.

“Better contact mission control and ask them to save the tape for you,” suggested Érico. He pointed to the Habitat’s ceiling cameras as well as to the camera they had set up to tape the conference. The ceiling camera’s images were stored twenty-four hours, then destroyed, and not looked at unless an emergency developed.

“It looks like the development of walking is roughly normal here,” commented Jerry.

“He’s following the terrestrial growth charts in most indicators,” agreed Ethel, though there was a note of worry in her voice. “Except his bones are a bit thin, so we plan to start putting weights in his clothes once he can walk, so they experience more normal stresses.”

Madhu rose and walked over. She carefully got down on the floor so that she could embrace Marshall. He turned to her happily and embraced her as well; she often provided child care and so he was close to her.

Then Madhu rose stiffly and uncomfortably. She turned to Roger. “I need to stretch; let’s go for a little walk.”

He nodded, and they headed out the door. Marshall turned back to his daddy and walked three steps unaided, then fell into his father’s embrace.

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They returned from their break a half an hour later when the panel in Houston was ready to critique their brainstorming session. The long time delay made rapid exchange impossible, but two sequential panel discussions seemed to be a fairly good forum for discussing mission plans. With twenty-three professionals and extensive equipment on

Mars, much of the decision making had to come from the people carrying out the work. But ground control provided hundreds of support personnel of all sorts, most of whom provided support for the lunar and orbital facilities as well, so their priorities and abilities had to be engaged as well.

The Houston panel was hardly surprised by the ideas from Mars; Will had been engaged in extensive email discussions over the previous few sols and the agenda he offered had been shaped by that exchange. Consequently the comments coming from Houston were cautionary or supplemental, not critical. Drilling priorities hadn't been mentioned; the driller at the North Pole hadn't penetrated as far as desired and a south pole drilling effort had been desired. Plans to revisit known fossil sites could not be accommodated if the vehicles were all tied up. The Phobos mission might require a shuttle flight anyway if the docking problem was caused by the Lifter's mechanism, as was increasingly suspected. Having all the vehicles out on expeditions somewhat limited work around the Outpost, where buggies provided only limited capacity. There was no time in the proposed schedule to obtain more gold; Will was surprised that was mentioned, as gold harvesting would have been considered a dangerous waste of time six months earlier. Reducing the quality of the road raised safety concerns if an emergency required driving vehicles at a high speed. The second building couldn't be finished before Columbus 4 arrived, raising issues of crowding and redundancy in case of emergency, although the portahabs and conestogas had ample backup space. Providing consumables, equipment, and ground support for thirty-three people would be difficult and expensive.

Different ground support people expressed different concerns, and some responded with solutions. Then Will and his team had a chance to respond to the panel in Houston. Perhaps the most innovative suggestion came from Érico.

“We’ve already talked about reducing each expedition to five people,” he said. “We explored the north polar terrains with five during Columbus 2 and it was fine. We used a conestoga, two rangers, a portahab, and a truck with a nuke. I think we can replace one ranger with two buggies with considerable safety and flexibility, though. The two buggies would pull the portahab robotically. We’d clear the trail with one ranger, with the conestoga following slowly behind to clean it up. The daily exploration team would use the buggies and the portahab. They could leave the portahab on the trail and head off to places of interest with the buggies. The conestoga would be available to either the exploration crew or the lead ranger in an emergency.”

“Brilliant!” exclaimed Will. “That would solve some of our other problems. It’d free up two rangers to be at the Outpost some of the time, to run drilling equipment in various places, and to get gold. Of course, that would place further strains on our human resources.”

“We have a spare portahab here,” added Ethel. “So we would be in the position to set up a complete third expedition if need be.”

“Don’t get too ambitious,” cautioned Pavel. “We can only do so much.”

“We’d have to reconfigure the buggies,” noted Érico. “They aren’t designed to pull heavy loads. Hitching two of them together will be complicated.”

“But it’s possible,” said Will.

“I have a comment about the issue of road quality,” said Jerry. “As I recall from the time I was capcom for Columbus 2, we have never needed the ability to drive sixty kilometers per hour on our dirt trails. The road clearing crews never get more than about twelve kilometers ahead of the exploration team. So if there’s an emergency, even at forty kilometers per hour—which would be a manageable speed—the conestoga could get to the ranger or the exploration team in seven or eight minutes, as opposed to five minutes. It’s not a huge difference.”

“This idea addresses almost all the issues raised in Houston, so let’s give them a chance to respond,” suggested Will. “That’ll take half an hour or so.”

“If I can comment about the concern that thirty-three people will strain the supply capacity of Columbus 4,” added Ethel. “I think that’s not so true, once the mass savings of not needing a habitat or as many greenhouses are concerned. Furthermore, this change might allow reduction in the number of rangers flown here.”

“Good point,” agreed Will.

They all took a second break. Madhu rose painfully. She had not been paying close attention to the discussion and had occasionally appeared to be in pain. Roger rose with her, and quietly they left the room together. They returned as the panel in Houston began to comment, but rose again and left after a few minutes. Will watched them go, momentarily surprised.

But he had to focus on the discussion. The head of surface vehicle operations spoke at length about the qualities of the buggies and their limitations and the problems of clearing a trail with only one ranger. By the time he finished, it was unclear whether he was in favor or opposed to the plan.

Others expressed more general concerns. Columbus 2 had explored with two rangers, but there were risks in that mode and only a third ranger or conestoga solved them all. Using buggies was a stopgap, but not a wise final solution. Others disagreed. Above all, if a third team were sent out using the extra ranger, portahab, and buggies, it would cause severe labor shortages for other tasks.

The safety of sending a Phobos mission was also questioned; there was already enough fuel for Columbus 3's departure and the Lifter could be taken care of then. It was not clear that the extra fuel could be used.

Additional comments were made about the need to drill the northern layered terrain, even though it was now too late in the season and would have to wait for the next northern summer. Will shifted in his chair; panel exchanges got tedious after a while.

The Outpost folks responded. There were ways to rearrange the crew to send out an occasional third expedition; when a crew rotation occurred the other two expeditions would have only four people, sparing four people temporarily who could go out in the other vehicles. There were times the Outpost crew would have less construction to do. Will was not sure the proposals were that convincing, so he suggested another approach that might work.

They ended their response and took yet another break. Jerry turned to Will. "Now the tedious part begins. I hate a day of give and take like this."

"Let's propose something better, then, if we can think of an alternative. I suppose there's enough data for both sides to go away, put together a proposal based on the exchange, and exchange them. Lassen and his lieutenants will make the final decision afterward."

“We could propose that,” agreed Jerry. He looked around. “Where are Roger and Madhu?”

“They left during the Houston presentation.” Will pulled out his portable phone and dialed Roger’s number. He held it at arm’s length to see Roger’s face; he could hear the audio in his earplug.

“Hello? Oh, Will. Sorry we didn’t tell you. Madhu’s here in sick bay.”

“What’s happening?”

“She’s started labor! She’s a month early and has had trouble preventing this from happening. Eve thinks it’s best to let the birth happen.”

“And the baby?”

“He’ll be premature by a month; not a great situation, but Eve says we should be able to handle it.”

“Is there anything we can do?”

“Ah; say a prayer.” Roger sounded worried.

“I’ll do that right away. Give us a call when there’s news.”

“I will. Bye.”

“Bye.”

## The Commission

early March, 2026

Late afternoon sunlight streamed in through the portholes of Habitat 2. Ethel sat on a chair; Will stood next to Marshall, who liked to run across the room, then back to his father. It had taken the boy only a month to go from a few halting steps to rapid running. Near Ethel were Roger, Madhu, and their four-week old baby, Sam, asleep on his mother's lap. Paul had just come back from the central highlands two sols earlier for a month; Monika sat with him, holding his hand. Eve, Rosa, and Koyo rounded out the group watching the signing ceremony for the Mars Commission treaty.

The administrator of the National Aeronautics and Space Administration completed his welcoming remarks about the importance of space flight for the future of humanity, then sat to warm applause. Dr. David Alaoui, head of France's Manned Spaceflight program, spoke about what it was like to explore Mars. He was followed by representatives of the European, Russian, and Japanese Space Agencies, who spoke about the importance of international collaboration in space and its contribution to world peace.

Then the audience turned to the television screens on the podium and a videotape began to play. Marshall sat on Will's lap; Madhu sat next to him, holding Sam. Will sat up in his chair to see how well the tape had come out.

"Greetings from Aurorae Outpost, Mars," he began. "On behalf of the twenty-five human beings resident here, congratulations to the governments and space agencies of the nations of the world for putting together a long-term organization to oversee and coordinate the exploration and development of the Red Planet. The Mars Commission

represents a great conceptual leap forward in our thinking about spaceflight. The Commission will focus not just on pure science and the abstract idea of 'exploration.' It will consider the question of the long-term human presence on Mars. And as you can see by these two children, the long-term presence of humanity has begun. We can no longer ignore the term 'resident of Mars.' We have to allow the word 'settlement' to enter our vocabulary. At some point the term 'colonization' will become current; perhaps 'terraform' will eventually. Certainly, the time for 'commercialization' has come; that's one reason the Commission has been established. The sale of Mars will begin.

"The idea of selling Mars is highly controversial. It conjures up images of vulgar capitalists buying thousands of square kilometers of Mars or starry-eyed Mars enthusiasts spending thousands of dollars to own a few rocks. But Mars will never be a perfect utopian world, and its future is inextricably linked to Earth's. It has families already, and it will have more. It has an outpost and in a few decades that outpost will become a village with an associated group of outposts. It cannot remain totally dependent on terrestrial financing; it must start to make a contribution of its own, even if it will not be able to pay for itself for decades, if not centuries.

"We have children to educate here, and it'll cost two hundred million dollars to import a teacher for them. Would we save money by not having children on Mars, thereby forcing people wishing to have children to leave after a few years of work here? What will humanity learn from raising children in a Martian outpost? Perhaps it'll speed the day when space flight for children will become possible.

"Mars, out of necessity, already represents a different approach to space exploration compared to the moon or Earth orbit. The Mars Commission has been set up

in recognition of these facts. It is structured to allow creation of civic authorities on Mars such as Aurorae Outpost's. It will set up a Property Owners' Association once land is sold, so that the owners have a voice in the running of Mars. It will establish an agency for the sale of Martian resources, such as water, fossils, and gold, and for commercial contracts for the same. The result will not be an Oklahoma land rush; it will not be the corruption of Mars by the Earth's commercial powers; it will not be the beginning of the United States of Mars. But it will be a step toward a larger population here, the development of this world's resources, and the broader involvement of interested civilians on Earth in this world's evolution. As such, it will be very important in shaping the lives of these two children."

Will's comments were received with loud applause. Ethel turned to him and squeezed his hand. "It was good."

"You hit the nail on the head," agreed Paul.

Roger shifted uncomfortably in his chair. "Will the Commission really set up a system for land sales?"

Will nodded. "Next year."

"But is the land really worth anything?" Roger persisted.

"We'll see. The Mars Colonization Society has commissioned surveys and hired economists, who think right now Martian land has a base value of \$400 per square kilometer. That's fifty billion for the whole planet."

"That's not much," said Paul. "Less than the cost of getting us here."

Roger snorted. "It's a lot more than I'd pay!"

“The value’s higher near the Outpost, too,” added Eve. “The proposed formula is that inside 150 kilometers, the value of land increased by the inverse square of the distance, so land 75 kilometers away is worth four times as much and fifteen kilometers away is worth a hundred times as much.”

“That assumes a lot of growth; who’d pay \$40,000 for a square kilometer of land fifteen kilometers from here?” noted Paul.

“That’s \$400 per hectare,” replied Ethel. “That’s a lot less than rural land in the western United States. If we provide services the land will be worth more.”

“Route 1 will open up land all the way around the world, too,” said Roger. “If they sold it all, it’d depress the value.”

“They’ll make land available for sale in stages,” replied Will. “Land along Route 1 is estimated to be worth four times as much as the base value if it adjoins the road, decreasing to double the base value five kilometers away and to just the base value ten kilometers from the road.

“Aurorae could charge a property tax of, say, one mil per year, due in five-year installments. We’ll have to develop a whole suite of services with a range of fees, including detailed aerial photography, three-dimensional video, even transport of surface samples back to the owner. And if we extract resources from the property, such as gravel for construction or meteoritic nickel-iron, we’ll pay the owner a small royalty.”

Roger frowned. “And who will do the work?”

“The sunwings have already been photographing the surface at a ten-centimeter resolution for years. Someone can be hired on Earth to write software to sell the data to a landowner in an attractive format. As for the three-d video, Columbus 3 will bring two

Prospector-500s able to harrow the reg to extract magnetic particles for our iron making, and it'll have a stereo camera pair. We can let it drive automatically across a line of property owners' lots extracting the iron and making a three dimensional video. That won't take much of our attention. It could even stop and sample each lot if we want. Maybe it'll take a minute or two of someone's time to direct the sample arm. The Prospector will collect all sorts of magnetic and gravity data and will have a meteorology station. Basically, we will be paid to do detailed, automated reconnaissance of the Martian surface. Wherever there are areas we want to study with the Prospector, we'll sell some or all of the land."

"That's clever," said Eve. "I assume we'll be importing someone to provide service to the property owners, then?"

Will nodded. "That's the plan for Columbus 4. What we don't know is whether most of the land will be bought by individuals a square kilometer at a time, or whether a few companies will review the orbital data—which is incredibly detailed—and request to purchase specific blocks of a thousand or ten thousand square kilometers. They may not be able to exploit the resources for a few decades, but they may feel it is worth it to invest thirty or forty million and purchase 100,000 square kilometers of the planet."

"Is there any update on the question of sending a teacher and child care provider?" asked Ethel.

"I'll ask again. They were in negotiations with the wife of one of the astronauts already scheduled to fly here. She has a Master's in Early Childhood Education. The problem is that the two of them didn't want to stay on Mars more than eighteen months. We'll see."

“What about the Chinese?” asked Roger. He sounded worried.

“They’ll probably send someone on Columbus 4. They may purchase two ITVs so that they can fly four here each opposition.”

“Really?” exclaimed Monika. “So, there may be more Chinese here than Russians, pretty soon?”

Will shrugged. “They have the world’s second largest economy, and by the end of the century it may be the largest.”

“Their presence on the moon is surging,” noted Paul. “What did I hear the other sol? Shackleton now has forty personnel, and twelve are Chinese! There are only ten Americans there! They’re doing a lot of good research and are considering a major probe to the Uranus system.”

“Not to mention the nuclear thermal engine they’ve almost developed,” added Roger. “It may be flight tested before the American engine.”

“Columbus 6 might fly here using a nuclear engine,” agreed Will. “It may be able to stay a month and fly straight back. We won’t need to keep ITVs here any more, except to provide emergency shelter. Times are changing.”

“So, will our population be growing a lot?” asked Eve. “I thought the Commission has pledged to fly four ITVs for the next three oppositions.”

“They have,” agreed Will. “But if the Chinese buy ITVs it’ll be five per opposition instead, and if the nuclear engine comes on line ten will be possible. They say the engine will decrease the cost of flying cargo here as well, though I’m skeptical. We could have forty people arriving every two years, in five or seven years. That would

probably push our resident population to about two hundred, plus fifty children. I think we'll be here to see some pretty amazing changes, if the commitment remains strong."

"That's amazing," said Ethel. "But then, this isn't Apollo. The technology has been developed step by step, we now have cheap access to low earth orbit, and the political and cultural support for the mission was developed as well."

"We're here to stay," agreed Madhu. She rubbed her sleeping son.

"He's a sweet looking little boy," said Paul, leaning over.

"Thanks. He's coming along quite well. He's even beginning to let us sleep at night."

Paul chuckled. "Yes, my sister has been complaining to me about her baby." He looked at Monika. "They can be quite cute and precious, you see."

"Yes, dear. But just one."

Will was surprised Monika had even conceded that much. "It sounds like there has been some change of approach, here," he said carefully.

Monika smiled. "Perhaps. You all are really having a lot of fun, so I suppose Paul and I should join in. Especially since Érico and Carmen plan to start a family here, now."

That was not news to Ethel and Will, though it was to the others. "I guess I can expect more business, then," commented Eve.

"It really has been rewarding to have children the same time as a close friend," agreed Madhu, looking at Ethel. "I'm having fun being an 'allomother' to Marshall, also."

"I think we will all be mothers, fathers, allomothers, or allofathers pretty soon," agreed Eve. "The Outpost seems destined to become very family oriented."

“Come and join us, Eve,” said Will, with a smile. “The more people involved in the great experiment, the better.”

“I’m already involved professionally, as the physician to the mothers and children; but I suspect I will become personally involved pretty soon as well,” Eve replied.

“And the Stogers may join the movement as well,” commented Rosa. “If we have to import a teacher, might as well keep her properly busy.”

“And that’s the last signature; the signature of the United States!” exclaimed Roger, pointing at the television. Everyone had forgotten about the news event they had assembled to watch. They turned toward the screen in time to see the NASA administrator signing the treaty on behalf of the U.S. He turned toward the audience and it applauded.

“The treaty’s signed,” said Paul. “Mars now belongs to an international commission.”

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Will reviewed the memo one last time. There had been a total of twenty attempts to hard dock Lifter 1 on Phobos. None had succeeded. Lifter 2, once it was full of methane and oxygen propellant, had taken off and Lifter 1 had been directed to Lifter 2’s docking pad. After ten attempts, a hard dock had not been achieved. Finally, Lifter 1 had tried to dock to Lifter 2 six times, all unsuccessfully. Lifter 2’s cameras had revealed damage to the docking clamps linking the methane lines together that required a person to make repairs.

The *Alba* could easily fly to Phobos with two people, execute the repairs in probably two sols, then fly back down. It was fueled and in excellent shape. Of course,

the work afterward to prepare it for another flight would take two people a month; the shuttles were not aircraft that just needed fuel and a little routine maintenance. With all the advancement of technology, space flight was hardly routine.

And the latest critical analysis indicated the shuttles had a two percent chance of failure per flight. Rick Page hotly disputed the claim on the grounds that the Mars shuttle had more reliable engines than the old space shuttle, and none of that vehicle's other flaws. Yet others argued the calculations could be optimistic. The two shuttles being prepared for flight to Mars with Columbus 4 had several crucial redesigns. The safety of the shuttles using ethylene fuel in particular had been criticized and they had no plans to try it.

Will wondered how to weigh the pros and cons. Lifters 2 and 3 did have enough fuel for Columbus 3's departure, but it would reduce their exports somewhat, and they had no redundancy if there was trouble with either vehicle. They could solve the problem in September by flying up a third shuttle with fuel or cargo; but they could also fly up one shuttle now and two later.

Finally he pulled his attaché forward and punched Érico's number. The expedition was almost three thousand kilometers and three time zones east of the Outpost, so Érico certainly was awake.

"Good morning, Commander," Érico replied a moment later. There was no video feed, just audio.

"Are you driving right now?"

"Yes, so I can't be looking at a picture. This is a rough stretch, too."

"How's the progress this sol?"

“We’ve been managing six kilometers per hour and the road quality isn’t bad. Setting the blade lower guarantees a clean path and leaves enough displaced reg to fill most low spots; but boy, does it consume fuel!”

“The conestoga will use less, though.”

“True, but overall, we use fifty percent more fuel per hour. We have to conserve energy to do it. Even so, we’re slowly pulling down our total surplus.”

“The sunwing is making another delivery on Wednesol.”

“We’re going to have to slow down pretty soon; we won’t be able to sustain this rate of advance. Do we have clearance to install the Stirling cycle engine on the nuke yet?”

“I’m still working on it. The engineers are being very conservative, naturally. Say, did you review the final memorandum about the proposed flight to Phobos to fix Lifter 1?”

There was a pause. “Yes, before breakfast. Do you want my frank opinion?”

“Yes, of course.” Will’s heart sank.

“Refueling the shuttles with the two Lifters, we can push to Earth most of the cargo we want to send. The limitation is the heat shield of the shuttle to aerobake cargo into Earth orbit, not fuel. So I would advise that we not send a mission to Phobos. When Columbus 4 arrives, Lifters 2 and 3 will be refueled and will have plenty of fuel for a visit to Phobos and the landing at Aurorae. Lifter 1 can be fixed then.”

“You’re right, we can achieve enough without Lifter 1. And the safety issue is more serious than expected.”

“Even though Rick disagrees, I concur with you. We can’t ignore the study. The Mars Shuttles are remarkable pieces of equipment, but every two years we get better ones. It isn’t easy to design something to work about once a year for four years in an extremely cold, dusty environment. I know Rick is very concerned about the dust getting into the pumps. This isn’t the time for a flight, Will.”

“I agree. Okay, thanks, Érico. We won’t be flying to Phobos. We’ll just accumulate more cargo for later exportation. Good luck on the work this sol.”

“Thanks. Jerry’s pleased; lately we’ve moved forward sixty-five kilometers per sol.”

“It’s amazing. The extra power from the nuke really helps. I’ve got to run, Érico. Thanks for the advice. Bye.”

“Bye.”

Will closed the connection and stared out the window of his office, frustrated. A flight to Phobos could have done more than fix the Lifter; it could have flown up equipment to enhance their ability to export more methane to Earth. But it was a risk, and this wasn’t the time to take risks. The opportunity would be missed.

## Circumnavigation

July 15, 2026

Érico scanned the eastern horizon ahead of them for any sign of Jerry's expedition. The area they were passing through was pretty bouldery, though; it was the Isidis/Syrtis border, a zone where an impact crater rim and its bouldery ejecta blanket yielded to lava plains. Still, the expedition should be visible by now.

He glanced at the GPS coordinates, then called Jerry. "I still don't see you guys."

"I just spotted your conestoga; a bit north of west."

"So you should be a bit south of east, then." Érico looked very closely. "Ah, I just saw sunlight reflecting off your windshield! Yes, I see you!"

"We're just a bit over a klick away!" exclaimed Jerry.

"I copy." Érico pushed another button, to call Will. "Will, we're just about to meet up! I'm starting transmission from our cameras!"

"Great!" replied Will. "I'm glad I won't have to stay up too much longer!"

"I thought Marshall wouldn't go back to sleep."

"He wouldn't; but now he's sleeping anyway." It was 3 p.m. at Isidis, but 5 a.m. at Aurorae.

"Go to the right of that boulder; it's smoother," said Patrice to Érico, pointing to a boulder about thirty meters ahead. Érico was heading toward its left side.

"Okay." Érico turned the steering wheel slightly. He was in the lead and kept the ranger moving forward steadily at six kilometers per hour, with the bulldozer blade set to excavate about five centimeters into the regolith. The result was a smooth road surface

cleared of all rocks, with a low ridge of excavated material on the left side about sixty centimeters high, forming a very clear road edge. Sometimes bedrock was visible and Érico raised the blade slightly, allowing the pile of material in front of it to bury the rough rock. Rarely, he had to stop, back up, and scrape material to form a smooth surface.

About one hundred meters behind the ranger, the conestoga followed, but driving two meters to the right; its bulldozer blade was set to create a similar ridge of excavated material on the right hand edge of the road. This made automated driving very simple because the automated buggies had two clear, parallel ridges four meters apart to steer between. Following the conestoga by one hundred meters were two buggies pulling a portahab. Finally, hanging one kilometer behind them was a truck pulling a supply trailer and their one-tonne nuclear reactor and its attached stirling cycle engine, which turned out a continuous 150 kilowatts of power. The power was fed through a cord to a hydrolysis and sabatier unit, which made methane and oxygen from water and Martian air. Every morning before they set out, the ranger would bulldoze a big loop through the terrain around the reactor, pull up to the back of the reactor trailer, and refill its oxygen and methane tanks. The conestoga and the buggies would follow, and then the expedition would push forward again, sometimes progressing as much as seventy-five kilometers in a long sol's work.

The new arrangement had worked remarkably well. Now the end of construction of "Route One" or the Mars Circumnavigational Trail was at hand.

Érico felt his excitement rising as his expedition got closer and closer to Jerry's two vehicles and two buggies. He could see the ranger and conestoga now. A few

minutes later he could see the buggies and the truck as well. He glanced at the computer screen in front of Patrice, who sat in the middle seat next to him. The road surface was projected onto the image of the terrain—the Mars Exploration Society amateurs had gotten extremely good at selecting optimal routes across the surface—and Érico could even see the route they were clearing linking up with the route Jerry was clearing. The two expeditions were just a hundred meters apart, now.

One minute later, the lead rangers were nose to nose and Érico stopped, smiling broadly at Jerry, whom he could see behind the steering wheel of the other vehicle just two meters away. “We did it!” he exclaimed over the radio.

“We did!” agreed Jerry. “Incredible! All the way around! We’ve linked up a road that goes all the way around!”

“Congratulations, gentlemen!” said Will from the other side of Mars. “This is a truly historic moment.”

“The credit goes to Jerry,” said Érico. He was disappointed to say that; he had contributed just about as much as McCord had.

“Yes, we managed to clear 165 degrees of the 300 degrees that had to be completed,” said Jerry. He looked at Érico through the windshield. “Of course, it helped that we got the stirling first, so we had the extra kilowatts.”

“We also lost a few sols when the ranger’s bulldozer blade had to be welded back together,” added Érico.

“Not to mention the great fossil locality we found last month,” added Karol, who was listening from the conestoga.

“We hit some pretty rough territory, though,” commented Jerry. “There were a lot of lava flows to go around and the degraded ones we went over in Amazonis were torturously slow. The fumerole was a fascinating delay. And then there was the dust storm.” That had been quite an experience, forcing them to travel half as fast and stay inside the vehicles for six sols.

“I’ve got a bottle of champagne, so let’s dock together and celebrate,” suggested Patrice.

“Watch the quantity if you want to go outside,” warned Will, ever vigilant.

“It’s late in the sol; we won’t drive any farther this sol,” replied Jerry. “We can have an early supper and explore a bit tomorrow. Let’s dock.”

“Acknowledged,” said Érico. He turned his steering wheel sharply to the left, then drove forward, passing Jerry’s ranger on its north side and widening the road even more. Jerry plowed forward to connect the two halves of the Circumnavigational Trail together, officially completing it, then turned around and began to plow the roadway wider to the south in order to create a very wide space for docking. Meanwhile, the two conestogas reached each other, turned around, and backed up, docking rear to rear. Then the buggies, which had been pulling the portahabs, maneuvered the portahab’s rear airlock to dock to the conestogas’ drivers side doors. The buggies were then detached from the portahabs and driven away, and the rangers docked to the fronts of the portahabs. In a few minutes all six pressurized vehicles—rangers, portahabs, and conestogas--were docked together securely.

Érico, Karol, Shinji, Carmen, and Patrice opened the hatch to the other expedition's conestoga. Jerry was waiting to hug everyone and shake hands.

"Congratulations, we did it!" he repeated over and over.

The atmosphere was heady, joyful. They opened the champagne bottle; it sprayed all over the rear cabin of the conestoga and they laughed. They brought folding chairs into the main cabin so that all ten of them could squeeze in, ever wary of the two escape routes if there was a pressurization problem. Millions tuned in to catch a glimpse of their celebration.

"We've conquered Mars!" exclaimed Jerry, with a laugh, raising his glass. Everyone toasted and drank.

"To dozens of more trails and dozens of vehicles cruising them!" replied Érico.

"Here, here!" someone replied, and they all drank again.

"We've got to get some supper, too," said Patrice.

"Well, my team traveled farther, so your team has to feed us," replied Jerry.

"It's only fair," agreed Paul, who had been riding with Jerry.

Shinji and Carmen retreated into their conestoga to heat up a meal. In half an hour they brought it over, and they all ate. The champagne had gone to their heads quickly on empty stomachs, but no one had to go outside, so there was no problem.

The sun set about the time they finished eating. Coffee came out and they felt a bit more sober. Érico began to smile at Carmen and she smiled back; they were anticipating a quiet evening together in their portahab. Jerry rose. "Okay folks, let's review the plan. It's July 15; two months before blastoff. We completed the Circumnavigational in record time, far sooner than anyone thought possible."

“God bless the nukes,” replied Shinji. It was true; they had been able to travel twice as fast as any expedition on Mars before because they had robust, mobile energy sources that made power-hungry road-clearing techniques feasible.

“You’re right,” agreed Jerry. “We’ll be heading back to the Outpost after a morning expedition to the volcanic field ten klicks south of here. We’re heading back westward, since that’s the shorter route.”

It was also the route that took Jerry and his team all the way around; Érico and his people would be backtracking. That way, Jerry would get the credit for the effort. But Érico didn’t mind. Jerry was leaving; he was staying. He’d see the other half of Route 1, especially the Tharsis Plateau and its volcanoes, some other time. “We should also consider some exchange of crew,” he suggested.

“I want to switch with Paul and ride with Lisa for a while,” exclaimed Karol.

There was a moment of silence. Riding was not all he had in mind; everyone knew Karol and Lisa were close. “Fine with me, if Paul doesn’t mind,” said Jerry.

“Oh, it’s fine with me,” replied Paul.

“We’ll get back to the Outpost in about two weeks, right?” asked Érico.

Jerry nodded. “It’s a nine thousand kilometer drive. If each vehicle makes a two-hour geology stop every sol we’ll do four geology excursions and will manage ten hours of driving at fifty kilometers per hour. Add thirty kilometers per hour of automated driving for nine hours every night; that’s 770 kilometers per sol, total. We’ll also lose one time zone almost every sol. The trip will take twelve sols.”

“Good. That means by August 1, an expedition can head southward from the Outpost. With these new driving techniques and the long summer days, we should be able to reach the South Pole by mid September.”

“That’s the time of blastoff,” noted Jerry.

“I know, but there will still be three vehicles at the Outpost for the blastoff, which is plenty.”

“You’ll have to run the plan past Will and Mission Control,” reminded Jerry.

“Of course. It’d be nice, with the Circumnavigational Trail finished, that we finish the Polar Trail as well before the southern autumn arrives,” replied Érico.

“Yes, that would be good,” agreed Jerry, though his tone had a growl to it. He and Érico had grown jealous of each other lately, and Érico was happy about Jerry’s success with Route 1 only because he could count on personal success with Route 2 shortly thereafter.

“We can all be very satisfied personally by this achievement,” replied Paul, trying to heal the tension everyone could feel. “This is a unique achievement we have all contributed to. The years 2025 and 2026 will go down in history as great milestones in Mars exploration.”

“Let’s drink another toast to that,” agreed Karol, with a smile.

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The next morning, the combined expedition drove over to the lava flows and all ten of them got out to explore together. It was quite an experience, tackling the geology site en masse. They actually outnumbered the geology ground support personnel, most of whom

were on summer vacation at the time. A few samples were taken, though not too many; after six years on Mars, there wasn't much unusual or interesting about the site.

Finished, they all climbed back into their vehicles and headed westward on the Circumnavigational, up a long, gradual slope that would take them across Syrtis Major's ancient volcano and onto the ancient cratered highlands of Mars on their way back to the Outpost. Paul and Érico got into the same ranger and drove together; it gave them a chance to catch up.

"I'm surprised you're heading for the South Pole. Aren't you tired of exploring?"

Érico sighed. "Yes, I suppose I am. But I want to accomplish something big this year. My expedition did just about as much work on the Circumnavigational as McCord's, but he gets the credit. It isn't fair."

"No, it isn't. But he's heading home next month, this is his big accomplishment, it's the culmination of his career, really. So I'm willing to give him a break."

"Well, I'm not." He paused to think. "I'll be back to the Outpost in early October, and at that point I'll want to rest and move on to other tasks for a while. Carmen feels it's time to start a family."

"Really? It's amazing how much her views have changed over the last two years."

"Me, too. I never thought I'd be a father on Earth, let alone on Mars. But if we're going to stay, and if our friends are all going to have families, we might as well, also. The Strogers plan to work on it as well."

"Good for them. Monika and I want a child as well."

"Are you getting excited about the wedding?"

“Yes! It feels right. She’s been doing all the planning, and now that Mars has wedding gowns and can make lots of kinds of food, there’s some planning to do! She emails me almost every evening about something. She wants to make the first wedding invitations issued for a joint Earth-Mars wedding.”

Érico smiled. “That is surprising. Well, don’t rush the plans for children too much. Carmen and I have really enjoyed the last eighteen months of marriage without children.”

“I’m sure, but the clock is ticking for Monika and I a bit more.”

“That’s true; you’re 37 now, right?”

Paul nodded. “And so is Monika. We both feel ready to settle down. When we get back to Aurorae we want to look around for a piece of land somewhere on Little Colorado Trail that we can claim as our own. We won’t be able to build there, or anything like that, but we’d like to have a piece of land anyway.”

“Really? I guess we’ll have a town meeting at some point soon to talk about sale of land. I suppose Carmen and I will buy something, too.”

“It’ll give us a sense of roots here,” said Paul. “What exploration do you want to do, after the South Pole?”

Érico considered. “I’m not sure. We need a Tharsis Trail connecting the volcanoes together; the road should go to at least one of the peaks as well. We need a road from Argyre across Hellas to Hadriaca and Tyrrhena Patera. A road that drives along the northern crustal discontinuity would be really useful, too. And we haven’t gotten close to the Elysium volcanic field yet, either; Jerry saved himself a month of road

clearing by avoiding it! So there are a lot of projects to tackle, yet. This is a big planet and there are a lot of places to see.”

“I understand Columbus 4 will bring two more nukes and three more vehicles, so we’ll have a lot of options.”

“Including three-vehicle expeditions again. This two-vehicle arrangement is okay, but it isn’t ideal.”

“No. Thank God the rangers and conestogas have proved really reliable.”

“Ten years of operating them on the moon worked a lot of the bugs out of the design.” Érico sighed. “As much as I enjoy exploration, though, I think I’d rather slow down a bit and enjoy family life. Once we have a kid, I want to stay around the Outpost for a while. It’s a different phase of life.”

“You sound like you’re ready to retire!”

“In a way, I am. Six years of exploring this world has just about burned me out. I’d like to take my time for a while and see Aurorae build up.”

“I can understand that,” agreed Paul. “A happy, stable marriage and family is very satisfying.”

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Eve Gilmartin pulled the magnetic resonance image from the printer. It was unusual to print something out; they didn’t have a lot of paper. But this was an unusual situation.

“There it is,” she said to Madhu, pointing. “That’s your left lung. The spot is only 1.5 millimeter across.”

Madhu looked, simultaneously fascinated and horrified. “And you can’t tell what it is?”

Eve shook her head. “Only a biopsy can determine what it is, and we don’t have the capability to do that here. It could be completely harmless. It could go away in a few months, or it could persist and be benign. Or it could be early stage lung cancer. We’ve been breathing a lot of dust, and the particles are extremely fine. They cause silicosis in enough quantity and silicosis can lead to cancer.”

“Could this be silicosis, then?”

“I don’t know, but I don’t think so.”

Madhu stared, horrified at the choices she faced. “So you’d recommend I’d return to Earth?”

“Well, if you didn’t have a baby I would. I don’t know what I’d do if I were in your shoes. I am very sorry to give you this news. Roger could raise Sam for a while and you could probably fly back here in two years, or maybe four.”

Madhu shook her head. “I could also die far from Roger, or be too sick to ever fly back. There’s no way Sam can fly back to Earth?”

Eve shook her head. “If he vomited in weightlessness, he could choke to death. He doesn’t know what to do. And the radiation exposure would be very dangerous for him at such a tender age.”

Madhu closed her eyes, shocked and horrified by the choice. “And can I wait until Columbus 4 arrives with medications?”

“Probably. If it’s lung cancer, it’s probably fairly slow growing. We can import chemotherapy drugs and I can rig up something to give you radiation treatments if you want to try that. If it comes to it, we could operate. Shinji is pretty good, and of course

we'd have the advice of the absolute best experts on Earth. There are options if you decide to stay."

"Eve, what choice do I have, really? My baby's five and a half months old. I can't leave him with Roger and I can't take him back to Earth. I'm not even sure it would be that safe for me to fly back to Earth. I'd spend six months between the planets with no physician."

"If this is cancerous, it shouldn't be serious in six months, but we can get other opinions if you want."

"No. I can't leave, Eve."

"I understand." Eve looked at her and tears welled up in her eyes. Tears welled up in Madhu's eyes as well. Eve embraced her patient and they both began to cry.

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The air in the new "greenhouse" had the tang of ozone in it; it was the smell of new duricrete construction, because the material gave off a whiff of ozone for a few weeks after it hardened. Will looked down the ten-meter trench they had excavated in the regolith and lined with ordinary duricrete. Overhead were sheets of plastic, meticulously glued together to form an airtight barrier, duricreted into place, and stretched taught by the air pressure beneath.

"It's too bad the plastic isn't more transparent," he said. His voice echoed in the empty, but pressurized space. "I gather from the presence of two light sources that there's a mirror above the dome, reflecting light in?"

“Yes,” replied Pavel. “This plastic is the best we can make, right now. I admit it isn’t very good, but it does admit 80% of the light falling on it, and the translucent character diffuses the light.”

“That probably is better for the plants. It’s pretty warm in here.” Will reached and felt the walls. The duricrete still needed to be sprayed with a plastic lining. The material was warm to the touch.

“We imported a lot of heat from the solar power units to warm it up, and now the sunlight is adequate.”

“So, once we spray plastic over the duricrete to protect it from moisture, we can haul in the plants?”

Pavel nodded. “It’ll be a bit experimental because we don’t have filters, but we have sensors in here to monitor the carbon dioxide, oxygen, and nitrogen levels, and we can add CO<sub>2</sub> as needed. If we start accumulating nitrogen oxides, ammonia, methane, and other trace gasses, right now we’ll have to vent the atmosphere to the outside, but we can afford to do that.”

“How long before the plastic and duricrete starts to leak?”

“A few years, we think. We’ll have to refurbish this space periodically. Lisa’s ready to move in pots and trays of soil and get it set up. If it works as well as we think, the Mars Commission will be importing clear plastic for the roof only.”

“Then let’s get it started.” Will pointed toward the far end. “Does the next building go there, or another ten meters farther north?”

“Right there. The duricrete wall is a meter and a half thick; on the other side is the beginning of the foundation hole for the building.”

“Good. How’s the progress on the design?”

“They’re just about finished. The details of the garage doors are tricky.”

“Well, we need a garage, and it’s surprising we’ve never gotten one all this time. Some vehicle maintenance is almost impossible in a pressure suit.”

“You all will have a very good facility, and pretty large; it’ll be usable for assembly of large objects as well. Have you seen the proposal to install an airtight Kevlar barrier around the building?”

“Yes. Will the Kevlar be able to retain enough pressure so that the area around the building can support plant life? The report didn’t say.”

“I asked about that. They didn’t want to make the commitment in writing yet, but privately they think it can. The pressure would not be high enough for humans.”

“I figured.” Will looked around at the future greenhouse again. “Thanks, Pavel, for this and all the construction you’ve supervised here over the last year and a half. You’ve moved us forward enormously. We’ll be able to live much more comfortably as a result.”

“It’s been a pleasure, Commander, and I’ll be providing ground support, so I’ll still be involved. This has been the experience of a lifetime.”

“It’s a shame you can’t stay.”

Pavel shrugged. “I have a family. Besides, this place isn’t for me; I can’t cope with the tight living spaces and the constant need for pressure suits. I want to go swimming again, fly a glider, and maybe take a Mediterranean cruise.”

“Those all sound nice.”

“But I will be providing support, like I said. I know how persuasive you’ve been in convincing people to stay! You’ve almost convinced me.”

“I think I almost convinced Jerry, too, but he is heading back to Earth next month.” Will turned and walked back to the airlock. Pavel followed. They entered the building. It was finished now, the rooms ready for occupancy, the kitchen and great room ready to take over from Habitat 3’s. For six months they had been installing pipes, wiring, and doors, painting walls, and moving in new furniture. Meanwhile, the pressure had held quite well, and minor leaks had been easily fixed. Duricrete buildings were more porous than the Kevlar and nomex habitats; they constantly leaked at a very slow rate. But the greenhouses produced oxygen at a high enough rate to replace the losses.

From the new building Will walked back to his office in Habitat 1. He walked slowly through the pedestrian tunnel in spite of its icy temperatures; he loved the view of the Outpost. It was becoming quite impressive.

Once at his office, he saw he had a message from Heather Kimball.

“Good sol, Will. We got the results of the poll we commissioned. They show that your strategy of portraying Mars as a family friendly place has been very appealing. The polling company asked the questions of six thousand people in the Mars Commission countries. Seventy-five percent think the personnel on Mars should be able to stay long term and start families there ‘if medical and educational issues can be resolved.’ Seventy percent say they can identify with the Mars mission more than the lunar exploration efforts. Sixty-six percent say Mars will eventually be ‘colonized’ and ‘will become a great nation.’ Sixty-one percent favored exporting Martian resources such as fossils and gold. A whopping eighty-two percent favored buying and selling Martian land. Asked

whether the funding level for Mars exploration should be increased, left the same, or decreased, only twenty-seven percent favored a cutback; forty-one percent thought it should be left the same and thirty-two percent thought it should be increased.

“We were also surprised by how many people were willing to contribute privately and personally to the exploration effort, and how many people said they’d consider joining the Mars Exploration Society. MES is planning a major membership campaign based on the results. It’s clear that a segment of the middle class—usually aged 18 to 39—is fascinated by space exploration in general and Mars exploration specifically and is willing to support it if the services are designed carefully. Just keep sending visuals of babies and craggy cliffs coming! The moon and low earth orbit can’t compete with either one. Bye.”

Will had to chuckle at Kimball’s last comment. Intrepid explorers coming home to their families: it was indeed an appealing image. He had hit on it gradually—accidentally—but it was obvious to even NASA that it was the way to go.

He hit reply and acknowledged Kimball’s message. Then he headed to Habitat 3. On the way he passed Habitat 2; Ethel sat in the great room with Marshall and Sam while Roger and Madhu sat on a couch together nearby.

Everyone looked so serious, Will stopped. Madhu looked up and her face immediately told him that something was very seriously wrong. He stopped in his tracks. “What happened?”

She looked at him a moment. “Eve gave me a body scan this sol and found a spot on my left lung.”

”Spot? What sort of spot?”

Madhu shrugged. “Maybe cancerous. Maybe not. I’ve been exposed to a lot of sub-micron dust; it could be caused by silicosis. The spot isn’t very large. It might just go away.”

“So. . . what will you do?”

“Will, she recommends that I go back to Earth.”

“Oh. . . I see. I’m sorry, Madhu.”

“But surely chemotherapy will work here,” said Ethel.

“There’s a new chemotherapy drug for lung cancer. It can be here in about ten months, and that probably will not be too late, since lung cancers are often slow growing. Eve and Shinji could try to operate, but with the facilities here that would be risky, even using laparoscopic techniques.”

Will shook his head. “Madhu, what a terrible dilemma. I’m really, really sorry.”

“Thanks, Will. This is just one of those things life can put in your path. I have to stay here for Sam.”

“But you could go, be cured, and fly back in two years,” said Roger.

Madhu shook her head firmly. “No, I have to stay for Sam. I’m not leaving.”

“Honey, maybe it would be better—”

“No, I’m, staying!”

Roger looked down at the floor and said nothing. No one else spoke.

“Let’s talk to Eve and Shinji together,” suggested Will. “And figure out what other options exist.”

“It doesn’t sound like there are others,” replied Madhu.

## Accident

July 19, 2026 and the week after

The Isidis Basin had been followed by the wide, rough, and ancient volcanic pile of Syrtis Major. The Circumnavigational—as Route 1 was called, now that it represented an actual circumnavigation of Mars—skirted the edge of Schroeter Crater, then rolled past dozens of ancient, battered rings as it headed toward Tikhonravov and Arabia, the half-way point back to the Outpost.

On the fourth morning of the return ride, Érico and Paul were in the lead again in a ranger pulling a portahab with a buggy in tow. Carmen was riding with Linda, as she often did in the mornings. The four staffed vehicles and their two robotic trucks with reactors and supply trailers were stretched out over quite a long section of the road, each at least one hundred meters from the other—so that the dust kicked up by one had cleared before the next one came along—the trucks falling gradually farther behind (they would catch up when the vehicles stopped for the night).

“Kilometers and kilometers of kilometers and kilometers,” said Paul, as he drove. “A vast wasteland.”

“And I wonder whether millions people will ever live here,” replied Érico.

“Who knows. It’s land, and if you sink a well you’ll hit water eventually everywhere; and with electricity, the water is oxygen.”

“The problem is getting here, and that will be expensive for a century.” Érico was scanning his email. “There’s a new message from Will. As soon as we get back, Shinji and Eve will examine Madhu again. They may try to biopsy the spot in her lungs. The

chance they can determine what the spot is is small, but the tissue can always be frozen and shipped back to Earth if Madhu stays.”

“And if it’s cancerous, she can go back?”

“She doesn’t want to. It’ll take her at least four weeks to recover from even a minor operation enough to be able to fly. If she agrees to go back, blastoff may have to be delayed.”

“It can’t be delayed much, though. The ITVs can’t fly more than nine months.”

“I feel terrible for Madhu. I can’t imagine a more difficult situation to be in.”

Paul nodded. “This is not an easy place to live in, and the problem isn’t just the lack of malls.”

“That’s for sure. The only reason to stay, really, is the people and the friendship.”

“I agree. Monika and I have been talking about whether we should postpone the wedding.”

Érico frowned. “Why? I wouldn’t. All of us will need a happy occasion. Besides, you should get married before Columbus 3 leaves.”

“Yes, I think everyone would agree on that.”

Érico glanced at the rocky landscape ahead of them. “I’ve got to go to the bathroom.”

“Okay.” Paul stopped the ranger; no one was supposed to travel between the ranger and the portahab while they were moving, though sometimes they did it anyway. Érico upstrapped his safety belt, passed through the plastic tunnel, and walked to the back of the portahab. He entered the bathroom as Paul began to drive them forward again.

He did his business and was about to flush when he was suddenly thrown against the wall. The ranger, moving at forty kilometers per hour, had collided with something. Immediately the depressurization alarm went off in the main cabin.

“What the hell—” Erico stood up, smarting from the bump, and hurried out of the bathroom. His ears weren’t popping, so the air pressure was stable, but he could hear a hiss indicating both a leak and that the life support system was compensating. He hurried forward to the tunnel to the cab; it was a possible escape route, and Paul was already there.

The red light over the hatch was on; the tunnel had at least partially depressurized. He glanced through the windows into the cab and saw that it was full of airbags. Paul was buried in them. He could see a red emergency light flashing in the cab; it was undergoing decompression as well.

“Ranger 1, come in! Ranger 1, come in!” He suddenly became aware of the urgent calls on the radio. The ranger had put itself into an emergency mode, which meant that all communications were routed over the intercom in it and in the attached portahab. Érico felt for his earpiece; it was intact, which meant his heart rate and the oxygen level of his blood was being broadcast to the Outpost’s central computer. So was Paul’s, if his earpiece was in place.

There was a computer console built into the front wall with a folding keyboard. He folded down the keyboard and pushed a few keys to open a general communications line. “Érico here. I’m in the portahab, but Paul’s still in the driver’s seat.”

“What happened!” It was Jerry’s voice.

“I don’t know; I was in the bathroom when the ranger hit something. You guys can see more than me.” He pushed buttons as he talked to pull up the emergency systems.

“Paul’s heartbeat is slow and dropping,” warned Will. Alarms had rung in the Outpost; the Commander was involved by satellite as well.

“We’re backing up against the driver’s airlock right now,” replied Lal. “Shinji’s getting his helmet on.”

“I’d better get mine on, too,” said Érico. His helmet actually was in the cab, but there were others in the cabin. He had not donned a helmet immediately because the pressure in the portahab was stable. He grabbed one and put it on, then put on some pressure gloves.

A moment later Érico heard a faint clank as the conestoga’s docking tunnel contacted the hatch. He looked through the window into the cab. He could hear a series of clanks as the latches fell into place, then the sound of metal under strain; the short tunnel was inflating. Shinji crawled into it, in his suit, and closed the hatch behind him, then Lal ordered an emergency deflation of the tunnel.

Érico could see the rest through the windows into the cabin. Suddenly, the driver’s side hatch opened and Shinji could be seen pushing air bags out of the way and clawing at Paul’s safety harness. Érico could see that Shinji had his suit on, complete with helmet and gloves, but no backpack. He hadn’t had time to put on life support; but the suit would keep him alive for five minutes, enough to effect the rescue.

The safety harness opened and he grabbed Paul, whose face was white. He pulled him into the tunnel. The hatch closed and Lal began an emergency air flood.

In less than a minute Shinji had Paul inside the other portahab. He wasn't breathing and he was puffy and distended from vaporization of internal fluids, though that was shrinking fast. Shinji put him down and Lal began to give him mouth-to-mouth resuscitation immediately. Meanwhile, a conestoga had arrived and was backing up against the rear hatch of Érico's portahab, to get him out of harm's way.

"What's happening?" asked Will. His voice echoed over the loudspeaker in all the vehicles. Lal walked to a microphone on the dashboard.

"Shinji's giving Paul mouth-to-mouth resuscitation and heart massage."

"It doesn't seem to be working, according to the data from his ear piece. Érico, what happened?"

Érico was still in a different vehicle, but it didn't matter; everyone could hear everything. "Commander, I have no idea. I was in the bathroom. I don't even know what we hit. The portahab has an air leak, too, though a small one. I went forward to escape the air leak by entering the cab, but it was already depressurized."

Will said nothing for a second. "Thank God you're alright. Catch your breath." Will turned because someone entered his office. It was Ethel with Marshall. "Go get Monika immediately."

Ethel hesitated, but the tone of his voice communicated urgency. "Okay." She saw a video image of a ranger bashed into a boulder on the edge of the trail. She turned and hurried out.

Will had eight computer screens in the bridge; usually six were monitoring Outpost functions. He had one of the other two on the functions of the damaged ranger and the other on Paul Renfrew's vital functions, which were still flat. The physical

damage was confined to a small area near the front passenger corner where the ranger had struck a boulder on the edge of the trail. It wasn't clear why the cab had depressurized; Will suspected the impact had broken the pressure seals around the passenger side hatch. The front right wheel and motor appeared nonfunctional, but the other five wheels and motors were alright.

He called Roger and asked him to come help immediately. He switched a third screen over to the portahab. It had a very slow air leak, no doubt from around a hatch.

"This is not working," said Shinji.

Will snapped back to the drama in the other vehicle. He looked at Paul's vital functions. The oxygen level in his blood had come up because of the heart massage and mouth-to-mouth resuscitation, but there was no breathing, no heartbeat.

"How long has it been?" asked Eve. She was now tied into the conversation from the sick bay.

Will glanced at his computer screens. "The airbags went off four and a half minutes ago."

"It's still possible," said Eve. "You need to shock his heart."

"The defibrulators are in the conestogas," replied Érico.

"We're docking to the portahab now," exclaimed Carmen, who was driving the lead conestoga. "We've rescued Érico already."

"The chances of it helping are pretty low," Eve added.

The docking began and a minute later Érico was able to cross into the portahab with the defibrulator. Just then Monika rushed into the bridge. "What is it?"

Will looked at her. “Paul was driving the lead ranger and somehow lost control. The ranger hit a rock, the airbags deployed, and the cabin depressurized. Érico’s fine and Shinji went into the cab to get Paul, but he’s not breathing.”

Monika looked shocked. “Oh my God.”

Will pointed her to a chair next to him. Ethel arrived just in time to hear the last part of Will’s explanation. She came in and sat as well, next to Monika, and put her hand on Monika’s shoulder.

Then Roger hurried in. The tiny bridge had three seats; they were full. Ethel had to get up and grab a seat from the room outside and sit behind Monika; Roger sat in front of the consoles and helped monitor everything. “What’s going back to Earth?”

“All the telemetry and audio,” replied Will. “Get the video from all the vehicle interiors on line to Earth as well.”

“Clear!” exclaimed Shinji. There was a buzz over the radio and the screen with vital functions went crazy for a moment. No heartbeat.

“Please, Paul,” cried Monika.

Shinji tried two more times; no heartbeat. “We’re too late,” he said. “I’m sorry. We’re too late.”

“I’m afraid so,” concurred Eve, over the radio. Her voice broke as she said it.

The oxygen level in Paul’s blood began to slide downward; Shinji had stopped his efforts. Monika broke down and cried. Will turned and embraced her, and began to cry as well. Everyone began to cry.

“We had better secure the vehicle,” exclaimed Jerry, a minute later. “Get everything out that we need and replace the smashed wheel. It should be able to limp back to the Outpost.”

Will pulled himself together. “Photograph everything thoroughly for the later investigation, then resume the drive back here. We can’t leave Paul there in the middle of nowhere.”

“Should we stop and inspect everything?” asked Rick Page, who was in the other conestoga.

“Affirmative, Rick. Take a look at the disabled ranger thoroughly. But they have 40,000 kilometers of driving experience here and even more on the moon. What are the chances of a design flaw?”

“Pretty small, but we had better do a little looking,” said Rick.

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The expedition spent most of the rest of the sol at the accident site investigating. No one was sure why Paul had lost control over the ranger enough to strike a boulder which was located five centimeters beyond the road’s edge. It was one of the rare, close boulders that the road usually avoided. The road was a bit narrower than usual at the point of collision; 4.0 meters, which was the official minimum. But no one had ever drifted off the cleared dirt track before, let alone at the very spot where there was a rock. The steering system, tests soon showed, worked fine. Possibly the ranger’s suspension was old enough to bounce the vehicle around when it hit a small rock in the trail—there was one—but no one was sure the bouncing would be enough to lose control.

So they put Paul into his pressure suit, tied him to the roof where he would stay cold, and headed for the Outpost. Everyone there remained in a kind of suspended animation, waiting for the expedition to arrive, somehow hoping the data was unreal, all the while preparing a tomb for their fallen comrade. It was a long, eight-sol wait. When the expedition got home two hours after sunset on July 27, 2026, many were greatly relieved.

“Welcome home,” said Carmen to Érico, almost in a whisper. They embraced and she began to sob. He kissed her, then held her fiercely tight, as if it would make up for the several months of separation and weld them into one.

“Welcome Shinji,” exclaimed Will. The two men hugged as well; old friends, they now had yet another common experience binding them together.

“Thank you; it’s been quite something.” Will nodded, then turned to Lal. Shinji headed into the habitat where Eve greeted him warmly as well. Lal extended a hand to Will. “My, it’s good to be home, Commander.”

“I can imagine. Welcome home, my friend.” Will actually did not know Lal that well; the Indian had spent almost a year of the last seventeen months exploring the planet. He and Jerry had equaled Érico in their hours outside.

“You’re very kind, Will.”

“Kindness and love are the traits that make Mars worth living on, and that hasn’t changed.”

Lal nodded and smiled, then moved into the habitat. Will walked over to another airlock that was opening at that moment. Jerry McCord stepped into the pressure suit donning area. Will extended his hand. “Welcome back, Commander of the first

expedition to circle the planet Mars by wheeled vehicle. Your name will go down in history.”

“Thank you, but I’m afraid so will this incident,” replied Jerry. He and Will shook hands, but Jerry’s warm smile was accompanied by a rock-hard grip.

“Twenty-one thousand kilometers,” said Will.

“No, twenty-three thousand, eight hundred eighty point six; I just checked the odometer. The road wasn’t straight, after all. We’ve got months of repair work on the rangers and conestogas. They all have at least one flaky fuel cell and one bad motor; one has two bad cells and another has two bad motors. The tires have taken an incredible beating, too.”

“Our first construction priority now has to be a garage. Ranger 2 will require extensive repairs and they are best done in a pressurized space.”

“At least we didn’t have to abandon it a quarter of a planet away. It should roll in by dawn tomorrow. Well, I want to get to my room, take a shower, and call my wife.”

“Don’t forget supper in an hour. We made a big meal.”

“I know. If I were you all, I would have hesitated to do it.”

“Why?”

“It feels like a celebration. And there’s always the danger that we’ll have a big, pleasant meal ready and another disaster will strike.”

“That’s the chance we have to take, Jerry. The big meal can always be put in a refrigerator if eating isn’t appropriate. But this won’t be a celebration; it’ll be a chance to reestablish the bonds this disaster has damaged.”

“Some of them, at least.” Jerry glanced at the habitat door, Monika had appeared.

All of the arrivals went to her right away, hugging her, even kissing her, giving their condolences. No one dared to mention the wedding that would have happened three sols later, though it was on everyone's mind. She was gracious and nodded in thanks, though she said very little.

“When can we bring Paul inside?” she asked.

“Where can he rest?” asked Jerry, delicately.

“We've made a place for him in the Mars life facility that's pressurized but unheated,” she replied, her voice hardly quavering at all.

“Tomorrow morning, with some ceremony,” replied Will. She nodded.

Everyone helped haul suitcases and other personal effects into the habitats. Gradually everyone gathered in the great room of the new building for a 10 p.m. supper. Even the two babies were there, though they were asleep against the wall, judiciously close to an airlock.

The meal was very good but intentionally simple; a delicious soup, home made bread just from the oven that afternoon, mint tea, and strawberry pie. They all sat at a long table together, but once everyone had expressed their support for Madhu, conversations were subdued.

“I wish I could have done more,” Shinji said to Will over tea. “If we had only gotten to Paul faster; if we had the defibrillator ready; if we had gotten the adrenaline into his heart faster; things could have been different.”

“My friend, you did your best. You didn't know what the situation was, you didn't know what shape Paul was in. When you went into the cab his heart was still beating a bit. Who know why the machinery of his body failed at that point.”

“And an autopsy doesn’t seem called for.”

“No. Look, you need to help encourage Monika; she’s afraid he was distracted by thinking of her and the wedding.”

“Oh, I’m sorry. The circumstances do suggest some sort of lapse of attention, too.”

“So does the video. He was rested, he’d had some coffee two hours earlier, the driving conditions were not extreme—they weren’t optimal, but within limits—and the ranger did not fail mechanically. Their speed was not unreasonable, either.”

“No, the speed was alright. I was driving right behind them, as you know. We can’t drive too fast because the auto-driving buggies would fall behind, and we’d have to wait for them to catch up and refuel us. There was that rock in the road.”

“Yes, and it was a factor, but it shouldn’t have pushed the ranger fifteen centimeters to the right. If he had been driving more in the middle of the trail, he would have been fine and we’d all be celebrating a successful trip right now. This was a freak accident.”

“I agree. It’s ironic; our machines can fail us in hundreds of ways and we’ll never avoid that danger. Yet a split second of inattention at the wrong time can be fatal.”

“It kills thousands on Earth’s roads every year, too.”

Shinji nodded. Will turned back to his strawberry dessert. Then his attaché, which was dangling from his belt, began to beep. Will raised it; an urgent video message from Harold Lassen. He rose and walked into the empty kitchen, then pressed “view.”

“Good evening, Will. I have some surprising and bad news for you and the crew up there. Paul Renfrew’s mother and sister have changed their minds. They want his body

brought back to Earth so that he can be interred in the family plot outside Toronto. I suspect this will come as a terrible shock to all of you. It'll deprive all of you of the closure that you badly need. But we have to respect the family's wishes, as I am sure you know. I'm sorry to be the bearer of this bad news. Bye."

Will stared at the wall, shocked. This was a major change of plans and would come as quite a shock. Thinking about it, tears came to his eyes. But crying would do little good. He had to come up with a solution, and quick. Thinking about the matter, he could see several things he could do. He headed back into the great room. He walked to the head of the table and began to bang his glass.

"My friends, I need your attention," he said.

There was almost instant silence; people had been speaking in hushed tones, so anything he said was easy to hear. "My friends, I want to say a few words in honor of our fallen comrade, Paul Renfrew. We all knew him, so I won't talk about his life right now. But I want to acknowledge his greatest of all sacrifices for Mars exploration, a sacrifice we had all hoped would never have to be made by anyone. There really is nothing we can do that equals his sacrifice. But we can be sure he will never be forgotten by future generations of Martians." He used a word he had never used before, and it sounded strange, coming from his mouth. What was a Martian, after all? Were Marshall and Sam 'Martians'?

"The first thing we can and must do is that henceforth, this building, our first major construction on Mars, is named the Renfrew Memorial Building. What else can we do, after all, to honor him? The facility on Phobos that we are gradually building up must be named Renfrew Station in his honor. Paul was in charge of it. The irony is that had he

flown to Phobos in the spring—a flight canceled because of the uncertain safety of the shuttle and the uncertain need for the flight—it may very well be that his life course would have been different and this accident wouldn't have happened.

“The third thing we will do is complete a small rock garden around his memorial at the base of Face Rock. Madhu and I have already talked about it, and she will design a park even if someone else has to complete the work.

“I had planned to announce all of these steps yestersol at the funeral. But I just received a call from Dr. Lassen that requires some changes in our plans. Paul's mother and sister have asked that he come home.” Will paused and looked at everyone. There was surprise on many faces; anger on a few; sadness creased his own. “Paul's tomb will be a memorial for him instead. Tomorrow we will take him to the tomb and lay him there, until the time comes to move him on board a shuttle. We will give him a proper sendoff on his journey to his true home.” Will's voice broke as he said that, and tears came to his eyes again. He went back to his seat and Monika herself came to him to comfort him.

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Will, Monika, Érico, Roger, and Jerry went outside at 7:30 a.m. to bring Paul inside. They placed him in a casket of polyethylene, white and shiny, closed it, carried it to the Great Room in Renfrew, put it in its place, and draped a Canadian flag—one of their two—over it.

Soon everyone began to arrive, dressed in their best for the funeral. Three cameras in the back of the room broadcast the scene back to Earth. A video made on Earth of his life was broadcast. They all rose and sang Amazing Grace together, and

everyone seemed to join in even if it was unfamiliar to some of them. Roger read a verse from the New Testament, spoke of his friend's faith—Paul was a quiet but devoted member of the United Church of Canada—and continued briefly about the promise of eternal life. Then Will stepped forward.

“We gather this sol to remember a friend who made the ultimate sacrifice. Paul's death reminds us of several things. First, that exploration is dangerous and no amount of training will make it safe. There will always be risks, risks which all of us here have decided to take. But Mars will be explored; space will be explored; humanity will reach the stars. All of us strive to make a contribution to humanity's ultimate purpose. Paul has made a great contribution through his love of people, his devotion to his country and his faith, and through his tireless and uncomplaining work here on Mars. He was central to the effort to build our first building here, was a force behind the first major expedition to the South Pole, and spent much of the last year on the road, helping to clear the Circumnavigational Trail. Few people—let alone few engineers—have contributed so much to geology and exobiology.

“But beyond his sacrifice for exploration, Paul's passing reminds us that life is fragile. We all have a fixed time in this plane, and we know not when our end will come. It has become easy to become complacent about life; medicine has forced the forces of death into a temporary retreat. But those forces cannot be defeated. Their victory over our bodies is inevitable. The only way to defeat them at all lies in how we live. Paul understood this basic insight and lived life fully. He knew the power of kindness to others, the importance of fairness in his relationships, the need for truthfulness in everything he said, and the supreme value of supporting and helping others. Érico tells

me that one of Paul's last comments before the accident was that the main reason to stay on Mars was the people and the friendships we have been able to make here. We become genuine, happy, fulfilled human beings in relationship to others. All of us have tried to make this outpost a place of fellowship and friendship, a place where the human bonds are deep. For the sake of Paul and his memory, we have the opportunity now to honor him by working even harder to build a true community here. On that work we will build the foundation of the future Mars society, a society closer to the ideals of justice, equal opportunity, an engaged citizenry, universal peace, and universal human rights than ever has been seen."

He walked back to his seat, realizing that he had made yet another speech in favor of settling Mars. It had become the supreme goal of his life, one that could not be deterred by the death of one of his companions.

The time had come for anyone to speak about Paul. Jerry, Érico, Carmen, and Ethel rose to speak about their friend. They were followed by a minute of silence, when everyone contemplated their friend in their own way.

Then everyone headed for the two pressure suit donning facilities and suited up. Four of them—Will, Jerry, Érico, and Shinji—suited up and returned to the room to bear Paul to the tomb. They all formed a procession outside and with great ceremony brought Paul to the tomb, placed him in it, and shut the opening with a slab of sandstone. Then they all learned the difficulties of crying in a pressure suit.

They returned inside. Everyone had the rest of the sol free; Will had declared it a holiday. Carmen and Érico went back to their room, where Carmen sat and looked out the

window for a long time. “I’ve been thinking,” she finally said. “You know, I just don’t feel. . . confident about this place any more.”

“Really?” replied Érico. “I think I know what you mean. The Outpost, Mars in general, no longer feels quite as friendly.”

“Exactly. The people haven’t changed; if anything, Will’s call for us to love each other more will make this place even nicer. But I can’t bring a child into this world. Not yet, anyway. Maybe I’ll feel more confident in a few months. It doesn’t seem fair to the child.”

“I agree.” Érico came over and sat with her, and they comforted each other.

Will and Ethel went back to their apartment as well. Marshall was still with Madhu, the only person not to go outside for the graveside ceremony. “Your words were beautiful; I hope everyone thinks about them,” said Ethel.

“We’ll see,” replied Will. “Life is never as predictable or as controllable as one thinks. Paul’s death has driven that point home for me. It makes me want to make this place even more redundant, with more pressurized spaces, more tunnels, more greenhouses, more supplies in storage.”

“The Outpost is not invulnerable,” she agreed. “Paul’s death makes me think about Marshall. I don’t know what he would do if he lost one of us, or both of us, God forbid.”

“Yes. . .well, that’s life, sometimes. Mars isn’t as safe a place to live as the United States or Europe, but it’s more safe than either of those places was in the nineteenth century.”

“Safer than a lot of places on Earth now.” Ethel looked at Will. “You know, Marshall needs a brother or sister. The bigger the family, the better for children when the future’s possibly uncertain.”

“Really?” Will considered. “I see your point. But remember, my dear: we’re both 39 years old.”

“I know. The biological clocks are ticking, but it isn’t too late. Marshall’s a year and a half old. It’s a good time to plan for another one.”

“Are you sure you’re up to it?”

“What about you?”

He thought. “It’ll be a lot of work.”

“You haven’t left the Outpost for more than two sols in the last two years.”

“Neither have you. There’s plenty to do here for another year or two.”

“Yes, for me, also. We’ll be pretty busy with children for the next four or five years. But it’ll be better, Will, for us as well as for Marshall.”

“I . . . think you’re right.” He nodded. “Alright. We can still think about this some more, though.”

“If we need to. My mind is made up.”

“Then it’s agreed,” he replied.

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They stayed in their apartment until a bit before lunch, when Ethel went to get Marshall. Will went to find Monika. She was in her room. “I just thought I should stop by to express my feelings of grief again,” he said to her. “And my determination to help in any way.”

“Thank you.” Her eyes were red and puffy; she had been crying much of the morning. “The funeral has helped bring closure, even if it isn’t Paul’s final rest. Your comments about him were really beautiful. I’ll cherish them.”

“I’m glad they helped.”

“Will, I’ve been thinking. You know, this place no longer feels the same to me. I . . . I can’t stay here. It isn’t just a matter of moving into another room. This entire place reminds me of Paul and that phase of my life. I’ve got to go back to Earth, Will.”

Will was startled. “Well. . . okay. There’s plenty of room on Columbus 3. That’s not a problem. I understand, Monika. You’ve done some good work here, you’ve made a sterling contribution to this place. But you need closure, too.”

“My life has to move on, and I don’t know that it can here.”

Will nodded. “I understand. I’ll contact Houston this afternoon and make the arrangements.”

“Thank you.” She smiled. “You’ve always been very kind to me. This has been a special place and I’ll always remember it.”

“And we’ll always remember you.” He looked at the door. “Shall we go to lunch?”

She nodded. They both walked into the great room in Renfrew where lunch was spread out and ready.

Ethel and Marshall were already there and she had him in his highchair, where he was happily eating vegetables and fish. Carmen and Érico had entered before Will. Carmen went over to Marshall, looking at the boy in a different way than before.

“He’s getting so big,” Carmen said to Ethel. “It’s really amazing.”

“Children are little miracles,” replied Ethel. “As you’ll see.”

“Oh, I don’t know. I think we’ll wait. I’m feeling too insecure right now.”

Ethel was surprised. “Oh? I feel the same way, so Will and I plan to have another child.”

“Really?” said Carmen, a look of astonishment on her face. She could not comprehend Ethel’s comment; it made no sense. Ethel smiled and shrugged when she saw Carmen’s surprise.

Will got in the buffet line right behind Érico. “You know, we have to look over all the vehicles now,” he said. “They all have failed parts and reduced redundancy.”

Érico was surprised. “They all have at least four of their six fuel cells and motors functioning, and we can take to the South Pole the ones that have five of the six.”

Will shook his head. “There won’t be a South Pole expedition, Érico. I’m sorry. I wish there could be. We have to check out and repair the vehicles, and there are investigations that are still going on in Houston. By the time the repairs are done and the investigations are over, it’ll be too late this year. It has to wait.”

“Will, there’s no danger to this expedition. It’ll take maybe two months, and most of that is exploration on the way back, as the sun retreats northward. We can make it to the pole before the autumnal equinox.”

“I’m sure it’s possible, and I agree the danger hasn’t changed. But Érico, as I said, there’s not going to be an expedition to the South Pole this time. Politics on Earth are the reason. There has to be a suspension of expeditions and a reevaluation.”

“There’s nothing you can do?”

Will shook his head. “I’m sorry.”

“Okay, Commander,” replied Érico, very sadly.

## Departure

Sept. 19, 2026

The *Elysium's* engines flared alive as an orange-tinged bluish flame erupted from the bottom of the shuttle. A cloud of dust shot to the side. The flames steadied for two seconds, then grew in intensity, lifting the shuttle into the air. The flame extended even further until it was just touching the ground as the shuttle rose to the height of one hundred meters. The *Elysium* tilted toward the east and rose rapidly into the sky.

Will sat behind the controls of a ranger, watching the liftoff. Roger was in the bridge serving as mission control; as a geologist, Will was not trained to do that task. Three vehicles stood ready in case the shuttle developed trouble.

He watched it shrink until it was a bright spot against the pinkish sky. He turned to a picture on the ranger's right screen; the Outpost's long-range telescopic camera gave a magnificent close up, and two satellites in orbit were photographing the vehicle continuously as well. He pushed a button to watch one of them, but it was a very small image.

"Vehicles stand down," announced Roger. The shuttle had now gotten so high that an accident would bring it down over a hundred kilometers away and at a speed that nothing would survive. Only a minute had passed. Will deactivated its systems—leaving the key in the ignition—and opened the hatch. He was still docked to the Outpost, so he could reenter it easily.

He walked through Habitat 1 and the tunnel to the Geology Building, and from there to Renfrew. Everyone except Roger and Érico—who was also in the bridge—sat and watched the launch on the video screen hanging on the wall.

“You just missed MECO,” said Ethel. Marshall sat on her lap watching the launch, but he had no idea what it meant.

“Already?” Will glanced at his watch. But almost six minutes had passed. Main engine cutoff was scheduled to occur after 5 minutes, 50 seconds.

“You’re looking good, *Elysium*,” exclaimed Roger.

“We copy. Delta vee was nominal,” replied Pavel, who was captain. Jerry had already taken the *Apollonaris* to orbit the sol before and was closing on Embarcadero Station, which consisted of the ITVs *Syrtis*, *Noachis*, and *Cimmerium*, which had been flying around Mars for the last year and a half.

“So, we’ve got 90 minutes to the elliptical orbit insertion,” said Madhu.

“I feel a sense of loss,” exclaimed Rosa Stroger. She looked at Neal; he took her hand.

“The departure of a Columbus mission to Earth always is sad,” agreed Will.

“Friends are leaving. More than that: the only way for us to go back to Earth is leaving as well, and the window won’t open again for twenty-six months.”

“It’s a bit frightening,” agreed Rosa. “Not that we want to leave. I love running the reactors, now I’m trained to work on shuttles as well, and Neal enjoys the geology.”

Madhu looked around the room. “There are now seventeen people on Mars; fifteen adults and two children. Five couples.”

“Or six, sort of,” replied Lisa, looking at Karol. He smiled back.

“So, is there a wedding in the air?” asked Madhu.

Lisa shrugged. “Who knows.”

“Watch out; the majority of single woman who have come to Mars have gotten married here,” commented Will.

“So; nine months before Columbus 4 arrives,” said Eve. “This used to be a time of rest.”

“It still will be,” replied Will. “There are short-term expeditions planned, but no long-term ones. Without any exobiologists, we won’t be doing much work with fossils. We’ve got to focus on our second building because the increase in Columbus 4 makes up for the loss of Paul and Monika. We’ll have thirty-three adults here next summer.”

“We’ll be pretty busy,” agreed Lal.

Will looked at the tiny image of the *Elysium*, taken from an orbital camera. “Shall we get started?” he suggested.

The others nodded. One by one they rose and headed to their work.

Finished 10:47 a.m. Feb. 10, 2003. Started Dec. 30, 2002

## Columbus 3 Plot Summary

### 1. Commander

3

As the Swift shuttle is launching five nuclear reactors into low Earth orbit, Will hears he is the interim commander of Mars Operations until Columbus 3 arrives. He goes to tell Ethel. He tells Roger, who is disappointed (he had been appointed interim by Sebastian). He receives congratulations from Heather Kimball of the Mars Exploration Society. That evening, Columbus 2 heads for Earth. The next sol the *Elysium* returns to the Outpost, after exploring Deimos.

Date: Aug. 16, 2024

### 2. Politics

14

Érico's team that visited Deimos present Will with a piece of Deimosian rock. Will considers ways to reorient the cargo manifest toward self sufficiency, such as manufacturing lubricants and copper wire on the surface, allowing for the import of a rug making machine. Will is asked to endorse the President for re-election and carefully declines.

Date: mid to late August, 2024

### 3. Proposals

36

Will discusses tourism, sale of moon rocks, and sale of lunar real estate with Jerry McCord, who is with Columbus 2 at Shackleton. Mars exploration appeared set to reach a steady level with fourteen astronauts arriving every two years; he wants a breakthrough to keep the number increasing. He realizes that volunteers could play a major role in developing routes across the Martian surface.

Date: early Sept. 2024

#### 4. Marshall

50

After an expedition returns to the Outpost, the men tour the new basement of Habitat 2, set up with four bedrooms. They talk about how to accommodate Columbus 3 personnel in another month. The women are working on clothes for the baby. Will announces that the French are purchasing the ITV *Amazonis* and what to fly it immediately back to Earth. Marshall Stephen Elliott is born a sol later. He is healthy. Everyone volunteers to help take care of him. Will says the outpost is now a settlement.

Date: Feb. 10, 2025 (birth)

#### 5. Declaration

62

Will and Ethel begin to pursue the vexing problem of getting Marshall a birth certificate. Their marriages are only partially legal, also. The idea of declaring a civil authority was raised, partly to pressure the governments to resolve the problem. No one wants to go out on an expedition, so they clear a road up Little Colorado Canyon to the top of the escarpment. Governments used the issue as a bargaining chip to pressure the US to establish a Mars Commission. NASA may not send any astronauts to Mars; Congress punishes it for ignoring the Swift. Roger holds out and objects, but then he and Madhu decide to stay and start a family as well, so he is concerned about a long-term residency on Mars as well. Will drafts the Aurorae Declaration and they all sign it on March 12, 2025. They elect Érico the borough clerk.

Date: mid Feb-mid March, 2025

#### 6. Landings

82

Will learns he will be Commander, but barely; the Europeans insisted and NASA was too weak to resist. After Columbus 3 lands, Jerry and Will have a long conversation about expeditions, Jerry's desires, the Mars declaration, and NASA's reduced budget.

Date: 25 May 2025

#### 7. Plans

94

The other two shuttles arrive and a big dinner is held. Will meets other crew. The rumor of France's Venus plans is mentioned. One table drinks an extra bottle of wine and Will grounds them the next sol. Will announces the administrative structure with five departments and twenty-three sections the next sol. The exports section raises eyebrows. He outlines the exploration plan as well. Lal wants to explore Candor; Will works out a compromise.

Date: late May 2025

8. Exports 112  
The shuttles land with supplies, Habitat 4, and two greenhouses. Will talks to Pavel Rudenkov about a new site for the building they plan to build. Will and Lassen exchange messages about Mars; Lassen wants one small expedition only because of lack of ground support, rejects a large dome, and refuses to support exports, but can offer more reactors Mars doesn't need. Will mobilizes support for Mars behind the scenes and the Mars Exploration Society launches a media campaign to shame NASA about its lack of support. The MES wants sale of land as well.  
Date: early June 2025
9. Conference 131  
Jerry McCord complains the people of Aurorae Outpost treat the place like their residence and home, not like another NASA outpost. The crew consider ways to create bigger expeditions without changing the safety regulations. A week later Will attended a big meeting of NASA officials and a White House representative, who agrees to find more money for exploration and pressures NASA to allow exports as well.  
Date: early June 2025
10. Nuke 142  
The Automated Cargo Vehicles arrive with the two nuclear reactors. Will oversees their arrival, then talk to Lisa and Gaston about the greenhouses. Roger tells Will that Madhu wants to get pregnant. At 8 p.m. Gaston and Eve arrive in Will and Ethel's apartment for dessert and coffee. They talk about staying and Marshall's health. Will thinks about Mars needing to be settled, not just visited. He calls Lassen about how to change priorities to stress more long-term residency by couples.  
Date: late June/early July 2025
11. Construction 162  
After they start work on their new pressurized building, Will asked Pavel about building "trench greenhouses." Madhu is pregnant. Lunar-based vehicle 2 won't dock properly to its refueling pad on Phobos. On Frisol evening Will sees Carol, Lisa, Pavel, and Patrice drinking and gets mad. Saturdays morning a group debates the destination of the first expedition. Shinji tells Will that Karol is still not sober at about noontime, so Will puts him in charge of all interior cleaning for a month.  
Date: mid August 2025
12. Gold 175  
Will talks to Heather about the Mars Dome, which will fly to orbit in Europe's Swift shuttle. He promises to talk to Lassen about the matter. Lal finds gold in Candor and tells Will about it.  
Date: late Aug./early Sept. 2025
13. North Pole 188  
Érico leads an expedition to the North Pole and raises the U.N. flag there. Lassen adds Will to the negotiating team to set up a Mars Commission.  
Date: Oct. 18, 2025 (arrival at pole)

14. Conjunction 198  
North Pole expedition returns to the Outpost in late November. In early Dec. two expeditions set out to east (Érico) and west (Jerry) to clear the Circumnavigational. As conjunction approaches on Feb. 6, the expedition commanders return to the Outpost for a discussion of the last half of Columbus 3. Jerry gets a tour of the new building [Renfrew], with its Great Room on the bottom floor and ten rooms (4.5 m by 4.5) on the top floor. They have a long meeting to plan the future. NASA agrees to use a Swift shuttle. Sam is born.  
Date: early Feb. 2026
15. The Commission 217  
The Commission treaty is signed. Will's comments talk about the sale of Martian land and the existence of "residents." Will reviews a report and Érico concurs that they should not fly a crew to Phobos to fix Lifter 1.  
Date: early March, 2026
16. Circumnavigation 228  
Érico and Jerry's expeditions meet in Isidis, completing the Circumnavigational Trail. Paul and Érico discuss plans for weddings and families. Madhu learns she has a spot on her left lung. Will and Pavel tour their first trench greenhouse and Pavel discusses his plans after returning to Earth. Heather reports on a poll that shows the middle class likes a family friendly Mars of explorers, and will support it.  
Date: July 15, 2026
17. Accident 245  
Paul hits a bump in the ranger and the decompression kills him. The expedition returns to the Outpost and lay Paul in his memorial, even though his body has to be returned to Earth. Érico and Carmen feel they can't bring a child into existence; Will and Ethel decided the uncertainty means that Marshall needs a sibling; Monika decides she wants to fly back to Earth. Will tells Érico there will be no south pole expedition.  
Date: July 19, 2026 and the week after
18. Departure 266-68  
The *Elysium* blasts off into orbit.  
Date: Sept. 19, 2026