THE MARS FRONTIER

Vol. 3

The Settlement

Contents

1.

Commander

Aug. 16, 2039

The sea of protesters—twenty thousand strong—surged across the high-definition video screen in Mars's Habitat 2. It was the largest protest ever seen at the Kennedy Space Center. The reporter summarizing the protesters' battle with the police and National Guardsmen had red eyes; he had been caught in the drifting clouds of tear gas.

The image 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 on San Salvador Island, Christopher Columbus's first landfall, 500 miles southeast of Cape Canaveral. In the lower right corner of the image, in addition to the date—August 16, 2039—was the countdown.

"T-minus 15 minutes. . . mark!" exclaimed Roger Anderson, with a triumphant smile as the clock rolled over. "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.

"That's just media hype; no one actually tried to shoot down that passenger jet last week," replied Roger. "It'd 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, by shooting the shuttle down to make your point!"

"There are people who are that crazy. At least there won't be any more protests of this sort for a while, since they're launching a two-year supply of reactors."

“The protesters are fools. 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 is backed by experience. And 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’s relatively harmless anyway.”

“Roger, I know.”

“Hey, Will, I’m just telling you this because you’re a *liberal*!” Roger tapped Will on the shoulder. After a year and a half, they had gone from geological rivals to friends, in spite of their personality, religious, and cultural differences, but they had not reconciled their opinions.

“Not really; if you want to argue politics, argue with Érico. I’m liberal on some things and conservative on others.”

“You aren’t conservative on that many!”

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

“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.

“Well, let’s not forget solar and wind; they’re expanding vastly and are much safer.”

“And fickle!”

“Let’s be thankful NASA caved in and agreed to use the Swift shuttles to launch the reactors.”

Roger nodded. “NASA actually admitted they’re safer than its expendibles, but the real reason they used the Swift shuttle is because the launch is hundreds of miles from any protesters. I doubt they’ll use the Swift for anything else.”

“The vehicle design is controversial for them, and they say it doesn’t meet the man rating requirements,” replied Will.

“It’s safer for reactors and not safer for people?” snorted Roger. “The second stage is basically a Mars shuttle fueled with hydrogen instead of methane, with larger fuel tanks and a smaller cargo hold. *That’s* NASA’s problem! Dr. Swift avoided thousands of hours of wind tunnel tests as a result. 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 knoooooow,” said Will, exaggerating the word. Roger had been in a didactic mood that sol, or Martian day. “I’m intrigued that the Swift upper stage 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 clipboard-sized computer and communications device—beeped, indicating it had received an incoming message from Earth. He walked over and looked

at its screen, which had flashed alive with the caller id. 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, moved into a position where Roger couldn't see the image, 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 far-sighted. Looking back over the record of Columbus 1 and Columbus 2, now drawing to a close, 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 departure from Martian orbit later tonight, and to continue until the arrival of Columbus 3 some nine months from now. Jerry McCord is the Commander of Columbus 3 during the interplanetary flight phase. Once Columbus 3 arrives in Mars orbit, it is 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! We look forward to good results. Goodbye."

Will watched Lassen's face fade from the screen, shocked. Sebastian Langlais, overall Commander of Columbus 2, had left Roger Anderson in charge just the week before. Mission Control must have approved. He had expected Roger to continue as their leader, especially since Ethel's accidental pregnancy had cast a pall over him.

He clipped his attaché to his belt and headed for the industrial area where Ethel was making iron beams. At the moment she had the metal carbonyl fractionation column—where different metal carbonyl gasses condensed at different levels—open for cleaning. At the bottom of the column, nickel-iron meteor fragments were exposed to heated carbon monoxide, creating a metal gas that rose and condensed into liquids at different levels. The iron, nickel, and cobalt carbonyls could be poured into molds, heated, and converted back to a solid. 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 a message from Lassen. NASA has appointed 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 had the position. You and I are tainted. 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 first."

"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 listserv 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 earlier, during the nine months after Columbus 1's departure and before Columbus 2's arrival. But the Outpost had only had three people at the time; now it had nine, far more than anyone had imagined it would have. He and Ethel had worked steadfastly to create 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 encourage a second. He had 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 more extensive exploration than had been planned. Initially he, Ethel, and Shinji had been practically stripped of any authority and responsibility, since the eight arriving from Earth already had divided all responsibilities for running the place. The first six months had been difficult until the responsibilities were fairly redistributed.

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

From Greenhouse 3 he followed a short, plastic pedestrian tunnel to the Mars Life Sciences Facility. The tunnel had become a greenhouse annex, with pots filled with herbs, trees, and flowers occupying half the floor space. 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. He passed Ethel again, for the Industrial Facility provided the Life Science Facility with its second connection to 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 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 the big screen's speakers. As always, a launch was an awe-inspiring sight. It reminded Will of his flights to orbit from Kennedy and Kourou, riding Ares 1s and Ariane 5s.

Will's attaché beeped; another videomail had arrived from Earth. It was Heather Kimball, an old friend and fellow lunar explorer—the first woman to walk on the moon—who was the new President 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, I recently directed the Mars Exploration Society to answer its phones with 'good sol'; it's a nice touch.

"I was watching the countdown of the Swift shuttle launch when an announcement rolled across the bottom of my screen that you had been selected as 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 exploring the Red Planet. 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 the White House has been pushing to make you interim commander. Any idea why? Their politics don't strike me as yours. I gather, from my sources, that a lot of people in Houston have always favored McCord; he has commanded Shackleton for three six-month tours of duty and he's fifty years old, so this trip is the cap of his career. He's been the Mars capcom on many occasions and works very well with the higher-ups. Many fear you'll never leave Mars, would be its Commander forever, and will become too independent. Some favor you because of your consistently excellent work, of course. It sounds like this arrangement is a compromise. In a sense, it's a defeat for the McCord supporters; he's commander of Columbus 3, after all, and that designation used to refer to the entire thirty-month period.

"I doubt you're 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!

“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 worry Mission Control. It was not a wise move as interim commander. He hit reply and composed a prudent reply.

“Good sol, Heather. Thanks for your congratulations and your frank remarks. I really appreciate both, especially the latter. I have no idea why the White House would favor me; I have never communicated with them. We need to think carefully about ways we can collaborate that will also be welcomed by Mission Control. You and Lassen are good friends; perhaps the two of you should brainstorm first. Based on your comments, this is not a good time for me to rock the boat. 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 main engines had cut off 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, and then he released the news. As of trans-Earth injection tonight, I’m Commander of Mars Operations.”

“Oh?” Roger was startled. “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!”

2

Politics

mid to late August, 2039

The next morning sol, the shuttle *Elysium* descended from orbit, bearing Paul, Érico, and Carmen. They had flown to orbit with several tonnes of rock samples destined for Earth, made a one-week visit to Deimos, and had provided orbital backup to Columbus 2. At supper that night, Érico rose. “We have a presentation to make,” he began. “It’s simple, but was 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. He accepted the rock and looked it over curiously. “Very nice; a good, typical specimen. Thank you.” He sat. “So, tell us about Deimos.”

“What’s there to say?” said Paul. “It looks like Phobos. The highlight for me was lowering myself fifty meters inside one of the moon’s bigger cracks.”

“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 there will be fully fueled.”

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

Paul shrugged. “Of course, as usual.”

“I’ve been thinking about orbital operations. We’ve had at least one ITV 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 have been up to three ITVs there at once, plus a docking unit and a remote-controlled arm. The only thing it doesn’t have is a Lifter, but we can send one there from Phobos or Deimos 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; I’ll ask. HEOSO was supposed to come into existence when ITVs were there permanently. 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. “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. “The place you embark from.”

"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."

"I've been thinking about that, too," replied Will. "Our shuttles are designed to lift themselves, four crew, and a tonne of cargo, plus twenty-four tonnes of extra methane and oxygen fuel, from Mars to Embarcadero. The fuel was needed for trans-Earth injection, but now we get fuel from Phobos and Deimos, so we can replace the twenty-four tonnes of fuel with cargo from the Martian surface. Furthermore, both the Lifters that push the Automated Cargo Vehicles to Mars and the ACVs themselves have to go back to Earth eventually, so they can carry cargo back with them. The Mars shuttles can fly a lot of fuel and cargo back to Earth when they return as well."

"But any major effort to ship things back to Earth is scheduled for Columbus 4 or 5," said Ethel.

"Maybe we can accelerate the plan. Each Columbus mission needs about thirty-six tonnes of argon to push cargo from low Earth orbit to L5 Gateway Station. I don't know how much argon we can extract here in the next ten months—"

"Eight to ten tonnes," interrupted Ethel. "If we don't need to lift argon propellant for the ion engines from the Earth, each launch can carry a third more cargo."

"We could also sell nitrogen to the moon," continued Will. "It's worth several million dollars per tonne, even competing with the Swift shuttle. Each Lifter can haul

twenty to twenty-five tonnes of nitrogen, argon, or methane from Mars orbit to L5 Gateway."

"And the methane from Phobos could be burned with the spare oxygen the moon makes," agreed Paul. "They're venting almost 100 tonnes of oxygen per year at Shackleton. It's a serious pollution problem for the astronomical observatories."

Will nodded. "As long as rocket 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. With our methane, it'll become a commodity. We can haul enough methane back to Earth to fly all of Columbus 4 here if the oxygen's available."

"Shackleton has a serious carbon shortage, too," added Paul. "They might buy our methane just for the carbon."

"We need to pursue this," agreed Carmen.

"It's a shame NASA won't let us do more things to earn them money," added 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 two tonnes have been distributed for analysis. 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 ten times more than gold!"

"It's crazy," agreed Ethel. "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 would dilute 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. That's my concern. I wouldn't go down this road, Will."

"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."

"Like us," noted Ethel, nodding.

"It's too risky," said Roger.

"We can probably export sixty or seventy tonnes of methane from the moons next year," said Paul. "If we export sixteen tonnes of samples for sale and they're worth the same as gold, they'd cover about five percent of Mars's expenses."

"But it would take a lot of our time," said Roger. "That's what worries me; a creeping set of expectations, to raise our 'contribution' from five percent to ten, twenty, then to thirty. . ."

Érico nodded. "We're a scientific effort here and we shouldn't dirty our hands with capitalism." He looked at Roger, who looked back at him, not sure what to say. Roger and he agreed not to export cargo, but for very different reasons.

Will felt the tension in the air. "Well, this isn't the time to resolve the matter," he said. "I'll talk to Mission Control. But we can stockpile argon, nitrogen, fossiliferous samples, and methane over the next nine months. It won't take much time; argon and nitrogen are recovered automatically, methane and oxygen production is automated, and we always have lots of spare samples lying around."

"I have a much simpler request," said Madhu. "Could we ask 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 and African violets for weddings! I want some roses, orchids, carnations, and fuscia."

"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.

The next morning he went to Columbus 3's website. He opened the Mission Goals Section, which had been developing for several years and was filled with technical reports, proposals for potential objectives, and lengthy web-based discussion of them by the Columbus 3 crew and hundreds of terrestrial support staff. Will had not had access to the entire Mission Goals Section, but now he did. He had already proposed several objectives and had commented about many more, but this time he found himself reading Jerry McCord's postings. Jerry advocated clearing "Route 1" as Columbus 3's main goal and said it should start as soon as the new crew arrived. Since it would go all the way around Mars, he called it the "Circumnavigational Trail," a clever term Will wished he had thought of. Will favored Route 1 as well, but Érico and Roger favored completion of "Route 2" to the North Pole first, and they had been planning it for two years.

Will read the latest postings on the forum, then clicked on "post reply" to add his comment. But then he closed the window after writing half a sentence. This was not the time to start an argument with Jerry. He and Jerry would be looking at each other's postings very closely for the next nine months. Should he keep his ideas to himself and risk Jerry stealing them? Should he boldly state them to demonstrate leadership? He wondered how Columbus 3's Mission Plan would ever be finalized without a Commander to break ties, make tough decisions, and sooth egos. If he tried to arbitrate, Jerry could be angered; if Jerry did it, he could be angered; if NASA did it, everyone who would carry out the objectives on Mars could be angered. He'd have to be influential but very tactful.

He turned to the Cargo Manifest Database instead. It was less politically complicated but far more tedious. Massively detailed, and he had maintained only the most cursory familiarity with it in the past. An item like “Truck 3, 2,187.3 kg” was deceptive. A left click on the entry expanded it into ten 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 and the missing parts could be supplied by the Outpost. An 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 hourly—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 Earth side of the moon. A small 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. The Columbus crew would head to Gateway on two different vehicles in early November and were taking 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 moon-bound crew would spend four days at Gateway and launch the three automated cargo vehicles on a minimum-energy trajectory to Mars.

Many of the items already were at Gateway could also be used on the moon. Consequently there was some flexibility in the cargo manifest, even at this late date. The cargo manifest was finalized by Mission Control, but the Commander had a say. And he had ideas how to change it. 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; it's a place of hard work and simple conditions. It now has a new lunar tourist hotel, but Mars Outpost was modeled on the old Shackleton. But we stay a lot 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 think 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."

"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 some of the items on my list for free that way.”

“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 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 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; a

robotic clay molding machine, for example, and I think a knitting machine. But the robotic loom didn't make it. It's capable of making rugs as well as cloth."

"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 lubricating oils. That's separate from graphite, silicone, and other lubricants. 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 mix them in to stretch the supply safely. 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 350 kilograms of copper wire. We can probably make it here, though we haven't been given permission to try. We know we can make the wire from weldalite—we can strip two tonnes of weldalite off of old 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?”

“We would use it to replace the wiring between the Outpost, the solar power units, and the spaceport. That’s high quality wire running on top of the ground that could be collected and used for communications and internal wiring.”

“That’s a week of work to collect and replace. If we eliminated the wire and the lubricant, we could import the stripped down power loom and half 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 make lubricant and 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?”

“Perhaps. The manufacturing schedule is very slow for the next four or five months. It’d help to have some geological exploration personnel transferred over to help.”

“That may be possible because its dust storm season. Let’s take a look at these projects. We’ve found several deposits of low grade copper ore. 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 easy because in an acid solution with nickel-iron meteorite present, copper oxide and copper carbonate will convert to pure copper and the iron will oxidize.”

“Good. I’m going to work on this.”

By the next sol, Will had a plan that Madhu and Ethel were enthusiastic about, Paul supportive of, and Mission Control willing to permit. Madhu got to work right away preparing 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 to remove impurities or replace some of the oils that broke down when the lubricant was used. He had to modify some techniques, but the results were good.

Will and Shinji took a ranger to every rock outcrop in the area where traces of copper had been found, usually above or below ancient lava flows. The first sol they took loose chunks of sandstone and basalt streaked with malachite and azurite. The next sol was frustrating because the loose stuff had been used up. The third sol they took 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 ran it through the rock crusher; she and Paul began to make acid. Will agreed to run the manufacturing equipment.

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. “As you may know, the presidential campaign has several foci, and an important one is strengthening and preserving the family. While NASA has been resistant

to the creation of stable families on Mars, what you have done constitutes an important breakthrough, and we are both fascinated and grateful. The formation of Mars's first multigenerational family is of great symbolic significance to the President's priorities and has the potential to reinforce and highlight important parts of our message. Hence we would be grateful if you could 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 would like you 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 a text file listing some of the talking points that occurred to us. Let us know what you think. Best wishes with all your efforts up there. Goodbye."

Will stared at the screen and felt his anger slowly rising. August 2039: the election was still almost fifteen months away, but the Presidential primaries, which had been pushed earlier and earlier every election cycle, were about to start. Had the White House leaned on Mars Operations to appoint him Commander because Mars was about to gain its first child? Was he expected to reciprocate their favor? He was an American hero, but should the Mars Commander get drawn into terrestrial politics? Furthermore, as a member of the Bahá'í Faith, partisan politics was against his principles.

It was a dangerous situation. Best to think carefully before responding.

By late afternoon he hadn't resolved any dilemma caused by the message. He went to Habitat 3, where Ethel and Roger were helping Madhu with supper.

“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.”

“Maybe you should make the statement instead,” said Will.

“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 this is how the world works. Everything is political. Everyone makes endorsements.”

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

Roger shrugged. “That’s the way it is. It’s an expression of original sin. 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 elections? You are free to hold to your theoretical and private ideas, but I wouldn’t drag them into this situation!”

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

Roger shook his head. “Suit yourself. Of course, your private political leanings are much 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 solid,” said Ethel. “I agree with it. The argument can 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; 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,” replied Roger.

“If I endorsed someone for President, that would make the position of Commander a political appointment as well, and that’s not 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. 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. "So what? It can be sent to Shackleton instead. Every packet is numbered. An astronaut can go find it and pull it out."

"Your plans are increasing our work here. Paul was helping us with processing rock samples, and now he's busy cleaning oil!"

"Paul's a chemist and engineer, not a geology lab assistant. Some tasks will slow down, but I'm hoping we can speed other things up. Most of us could use an Earth-based secretary. If we had assistants on Earth who are crewmembers on a future flight, we'd be training future colleagues."

"We've been pushing for that arrangement for two years," said Ethel.

"Sebastian didn't push it at all. I'll see what I can do."

"Well, that doesn't help me now," complained Roger.

"I'll see what I can do with the time allocations. You're right, geological analysis is important."

Others began to arrive for supper, so the conversation shifted to other matters. Paul and Monika pitched in to help; Madhu and Ethel had been making several weeks' supply of pasta, so it took some time for them to finish.

After supper, Ethel hurried to the industrial area for another hour to work on metal beams; she was preparing the parts to subdivide the basement of Habitat 2. Will helped with cleanup, then did a bit more office work. He had composed a videomail to Carl Reed in his mind and was ready to send it. But when he entered his office—the

former sick bay of Habitat 3—he saw that he had a message from Harold Lassen. It was only 7 a.m. in Houston; Lassen had called from 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 and may strengthen your position here. If you have any questions, let me know. Bye."

That was a surprise, but didn't change his message to Reed at all. Will jotted down a list of talking points and pulled up Reed's videomail, set up a "copy" to Lassen's home internet address, blind copied Jerry McCord, and taped his reply.

"Good morning, 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, in any nation or 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 crewmembers are inappropriate and suspect Dr. Roger Anderson would be in a position to endorse the President, so you might wish to contact him instead.

“There are, however, efforts I can make that will reinforce the President’s policies and general philosophy, and the efforts certainly can be mentioned by the campaign. The first is an effort to make the Outpost more friendly to married couples and families. While the settlement of Mars is not a part of the mandate of the Columbus missions, inevitably it will emerge as a concern. Making Mars a place where strong families thrive is a concern is very close to the priorities of the President and in some ways reinforces them.

“The second effort 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 may have come to work them into Mars operations. Soon I will have some concrete proposals 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 me with your response to Karl. I’m impressed by its clarity, but pleas don’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 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 good for team building. 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. The fourteen of us are having a lot of clumsy interactions. 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 lunar resources. That could help with plans for Mars. Let me know how I can assist. 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. He’d have to be careful about sharing, lest his plans strengthen a rival. But some collaboration would be good. He hit reply. “Good sol, Jerry. We’re about twelve hours behind Houston, right now; we’re the evening of the 24th while they’re the morning of the 25th. 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 share my ideas with you once they gel. 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 appreciate the ethical position you have taken. Please do share your proposals for commercializing Mars with us; we've been gently pushing NASA in that direction for three years. The agency is gradually rethinking its philosophy about married couples in space; for long voyages and tours of duty, it makes 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, we must encourage astronauts to stay as long as is reasonably possible. A certain amount of commerce 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 copied Reed's message to Lassen with a quick cover note that he now needed to share proposals with the White House, but would ask for Lassen's input first.

3

Proposals

early Sept. 2039

In the next two weeks, considerable progress was made on the new projects. Madhu extracted three kilograms of soybean oil from a new harvest. Paul purified six kilograms of discarded lubricant, added a half kilo of light hydrocarbons that he made with the chemical synthesis unit, and added the soybean oil, producing 9.5 kilograms of reconstituted lubricant. Tests on the substance were positive. They loaded some of it into ranger 2 so that the month-long expedition Roger, Érico, Carmen, Monika, and Shinji began could serve as a test.

In the same two weeks, Ethel made a hundred meters of wire using improvised equipment. 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 twenty times as many person hours per kilometer of wire as on Earth, but the result will still be cheaper, as long as I’m willing to do the tedious labor!”

“We’ll rotate the task. Have we freed up the entire 350 kilos?”

“They plan to send us about thirty kilos of parts that I can’t easily make here, so the net gain is 320 kilos. But Paul and I have been reviewing the inventories. Some of the parts that we’ve thrown away could be repaired temporarily if we had to, so we’ve

decreased the allocations for those parts to the predicted replacement level. We can cut another 100 kilos from the spares allocation."

"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 parts while the ideas and issues are fresh in our minds. The rest of the wire 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 fine until the wire making derailed it. Next week I'll need your help 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 areas with a lower ceiling, and 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. The extra work had delayed operation of the telerobotically operated rovers, or Prospectors. Four were still functioning; five were broken and awaiting rescue; four more were on their way from Earth. One had climbed

fifty kilometers up the side of Ascreus Mons, one of the big volcanoes. A terrestrial controller had difficulty moving a Prospector more than about one hundred meters per sol, but when someone on Mars operated it, three hundred meters per sol and ample science were achievable. A single driver could handle at least two Prospectors at once; when a Prospector stopped to perform a task—such as analyzing a rock sample or scanning the area from the new location—one moved the other rover. Running two or three Prospectors, one achieved perhaps a quarter as much geology as one could in a pressure suit, but the Prospectors were located places where humans would not visit for some time.

Before Will could get his 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 one of the times you were here. He's been articulate about his opposition, so you might want to email him.

"We avoided the tackier strategies, like plastering corporate logos on vehicles or the sides of buildings. The 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 twelve-meter inflatable, just like your habitats, but more attractive and comfortable. Some call it luxurious. The system hauls seven tourists and one attendant to the moon per flight. The ultimate goal is twenty-six flights per year—one every two weeks—which would keep the facility full and occupy two vehicles full time. But the ten

million dollar price is too high and it'll take years to grow the infrastructure to produce enough fuel. This year will see four tourist flights, three in the summer and one during Christmas vacation. The guys at Shackleton grumble because they have to cut back on their research to take the tourists around. It takes at least four people to serve them. But the tourists are driving down the cost of moon transportation and have doubled the number of flights to the moon. Shackleton Station's thirty percent larger. The hotel houses professional couples and long-term workers during the off-season; we appreciate that! Lunar fuel output had to double and costs thirty percent less, per kilogram; that benefits Columbus 3 as well.

"I don't see tourism coming to Mars any time soon, so I doubt this is of any help to you. Let me know. Bye."

Will frowned, irritated. Everything Jerry had said was public information; perhaps he was just trying to draw Will out. He immediately hit reply. "Good sol, Jerry. I wasn't interested in tourism; we won't have any for some time. What discussions have been going on about commercializing fuel production? I gather it's controversial. I hear moon rocks are on sale; what's the market? There has been talk about exporting lunar titanium and platinum group metals, and of course there's always the hype over Helium-3 and lunar electricity. Bye."

Rather than turn back to the Prospectors, Will pulled up the Mission Plan website to see what Jerry had contributed lately. While Will plunged into all sorts of discussions and had judiciously tried to reconcile clashing suggestions, Jerry had focused solely on surface exploration. His latest posting criticized plans for an expedition to the North Pole in favor of completion of a route circling Mars near the equator, an effort called "Route

1" on Mars and "the Circumnavigational Trail" by McCord. He was pointed: *We have already visited the polar regions and can drive to the North Pole whenever we have the luxury of time. The great adventure that still remains is a circumnavigation of the Red Planet via ranger and conestoga. Such an endeavor would sample every single remaining geological terrain of significance: former shorelines, vast areas of the highlands, several large impact basis, dozens of important fluvial channels, and the Tharsis Uplift. With the arrival of so many people and a doubling of surface vehicles, plus two nukes, the circumnavigational can be tackled from both directions at once and can be finished in less than eighteen months.*

That seemed unfair to Will. He knew Érico and Roger would both reply, but he couldn't resist adding his two cents: *Route 1 is a worthy endeavor, but clearing 21,000 kilometers of trail may be premature. We may have reached the polar regions, but we have hardly exhausted their science. We've never drilled significantly into the layered terrains, an important priority in the search for life. The North Pole should be visited this coming year.*

Satisfied that he had replied, he turned back to the Hellas Prospector. H moved it twenty meters to a boulder and deployed its science arm against the surface to make measurements. Then McCord replied to his videomail. He projected Jerry's response into the virtual reality helmet, a strange experience because it almost made McCord look like he was sitting nearby.

"Oh, that kind of commercialization. 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. Moon rocks that are pretty sell for more than others. The going rate is about half the value of gold. I suspect Mars rocks with fossils in them would command a better price, and the fossils provide authentication. 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!

“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. I’ll have to suggest that.

“Commercializing fuel production has stalled for various reasons. It isn’t clear it will save money; it may raise costs. Companies doubt they’ll make profits. Because of international treaties, lunar land can’t be sold, but long-term leases appear to be legal. Until that’s resolved, it’s unclear what authority can be devolved to a commercial outfit. Costs are still too high for production of titanium, platinum, or any other lunar metal. 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; 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 27 million year old lava flow. But the questions of expanding Mars exploration

crowded Prospector work out of his mind. Much to his consternation, governmental interest in exploring the Red Planet had again declined. The U.S. was considering cutting its contingent in Columbus 4 in half. Brazil wanted to give up its slot. China wanted to send several astronauts, but the U.S. was vigorously opposing their involvement.

The Swift shuttle was the cause of much of the trouble. Cargo that fit in its small hold could be orbited for one sixth as much money as with an Ares rocket. By siphoning off cargo from the Ares, however, launch costs of large items such as ITVs, Mars shuttles, and surface vehicles would double, because the Kennedy Space Center's staff would not shrink appreciably. NASA was threatening to sue the Swift Company for stealing technology from the Columbus Project. They claimed Swift had cut corners in quality control and that they could not man-rate the vehicle, even if it had been deemed safe enough to launch reactors into orbit.

The discovery of microfossils had hastened the exploration timeline, but perhaps too much; the budget for Columbus 3 had been based on a maximum of twelve Mars personnel, not twenty-three. Further expansion of Mars operations required reduction of transportation costs and possibly another breakthrough in the study of Mars.

His thoughts were interrupted by a notice that Jerry had replied to his web posting about the circumnavigational. It was strange to be exchanging a pleasant, private video on one subject while conducting a public email debate in another medium at the same time. *Extensive drilling of the polar terrain is also premature; we need equipment that can go deep and extract many cores from many areas. The equipment has now matured enough for clearing the Circumnavigational, and eighteen months is the appropriate timeframe for the effort. There is no reason to wait.*

No reason to wait? thought Will. How about the fact that the North Polar expedition was really the completion of an earlier effort and had been in the planning stage for a long time! But he wasn't going to argue; he'd leave that to Roger. He turned to the Elysium Prospector and moved it to a boulder filled with large vesicles. He set it to scan 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 play 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 another source, 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? This is all for background; I won't attribute anything to you without your permission. Bye."

He stared at the screen with a sinking feeling. He had heard the rumor, but no reporters had contacted him about it. Most likely, the White House had leaked the rumor to get back at him. He jotted down the three questions. Then other points occurred to him and he added them to the list. He combed his hair and hit reply.

"Good sol, Liz. Thanks for asking. You can publish this clip: The position of Commander of Mars Operations is not a political position; it is a position of great responsibility focused on exploring Mars and developing the world's resources, all within

the framework of the safety of the people doing the work. Those are and must be the priorities of the Commander. Hence it is not appropriate for the Commander to get involved in domestic politics.

"End of public clip. You ask about my own politics. Like a growing number of my fellow American citizens, I am an independent. I am also a well-wisher of everyone who supports exploring Mars.

"If you want to know what I think about endorsements by other astronauts here on Mars you can publish this clip too: I believe other astronauts here on Mars are free to exercise their freedom of speech.

"You may also ask me about modifications to the Columbus 3 cargo manifest and may make public this video clip: We are currently pursuing some very clever ideas that will make Mars more self-sufficient, 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 and the quality of life at the same time. Our overall goals, long term, are to make Mars exploration cheaper so that it can continue to expand and so that families can be established here that will thrive.

"Hope that helps. Bye."

He sent the message. He was pleased by his phrasing, which allowed reporters to repeat the question in their own words. 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 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 see “Ranger 1 excessive lateral deceleration.”

It was a standard emergency phrase—there were hundreds and they went to the Commander, Aurorae Control Officer, and Houston. The vehicles had accelerometers and when a vehicle got banged or jolted beyond a certain limit, the warning was triggered. But this warning hadn’t occurred more than four times in the last four years. At least the airbags had not deployed and there was no 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 from the ranger, which was clearing the expedition’s trail. “We were advancing along the recommended route at three klicks 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 drop and the radar missed it among the boulders. So we slid to the right about half a meter and banged into the side of the rock.”

“It was a wind erosion trough around the base of the rock,” added Roger. “I can see the rock from ranger 2. I’m right behind you. 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 hear the wheels whining and spinning in the background. Then the alarm went off again: “Ranger 1 excessive rearward deceleration.”

“What happened?”

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

“You’re okay, ranger 1,” reported Roger. “The bumper already had a dent there!”

“Acknowledged; it has a few back there!” laughed Érico.

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

“I think the guys 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 twelve, not twenty-three, 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 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'll make it into Tiu Vallis on schedule. We found the remains of an early Hesperian quiet water pond this morning and the shale layer had great fossils; the macular kind that you can see with the unaided eye. We called the site 'Primavera.' The pond must have existed a hundred thousand years, alternatively freezing solid and getting renewed. Then it was buried under a sand dune and preserved from further erosion, until a crater smashed it and scattered shale all over the area."

"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 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 that the photography missed because of the sun angle. The radar data had ten-centimeter resolution, but if the Sunwing was not straight overhead the boulders cast radar shadows. A more expensive computer program that integrated the radar data from different locations along the flight path would

have eliminated 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 one segment might avoid boulders, rocks, and angled slopes, but might lead into another segment that was quite rough. If one chose a different first segment that was slightly rougher, it might lead to a much better 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, however, required far more personnel.

That was a task, Will suddenly realized, that volunteers could do. If the data were properly integrated and placed on a website, individuals could use their computers to map routes across Mars. Thousands of routes. Each route could be crudely assessed by computer. He popped up a blank page on the attaché and began to scribble talking points, which he could compose into a private videomail to Lassen and Heather Kimball. This was a task the Mars Exploration Society could tackle.

4

Marshall

Feb. 10, 2040

Will, Roger, Paul, Shinji, and Érico headed down the stairs to the basement of Habitat 2. They looked at the corridor and walls that filled what once was a big, cavernous, bowl-shaped void. “Wow, you all did a lot of work while I was away,” said Roger.

“Well, all you’ve been doing for the last six months is exploring,” replied Paul, with a smile. 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 and they stepped into an empty room. “This isn’t bad,” said Roger, admiring the work.

“Most of the room has a two-meter ceiling; a little low, but comfortable,” said Will. “The outer ‘platform’ has a 1.5 meter ceiling; adequate for a bed, a desk, a dresser, etc. Finally, ‘the shelf’ on the edge is 0.8 meters below the ceiling and makes a nice storage area.”

“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. But Columbus 4 is bringing three-dimensional high definition television screens, a meter high and two meters long. You can program the screen to look exactly like a picture window facing a particularly beautiful view on Earth.”

Érico reached out and tapped the outer wall. “Metal. Flame-proof, and it’ll look pretty good with wallpaper. What’s on the other side? A circular crawl-space?”

“Yes, less than a meter high. It’s got life-support machinery, pipes, and storage.”

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

“Do we have enough space, now?” asked Érico.

“Each hab has three enlarged bedrooms on the main floor, an apartment for one couple on the balcony, and four rooms in the basement, for a total of nine, so we can house twenty-seven. We’ll have twenty-three adults, so we have four extra rooms.”

“For offices and work space,” said Érico.

“I gather you’ve added a nursery to your apartment,” said Roger.

“Yes, even though the construction website doesn’t offer a design!” replied Will. “The entire attic 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 and living room to the outer wall to increase storage and added a low-ceilinged third room next to our bedroom for the baby.”

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

“She was due yestersol,” Will replied. “I did most of the work a month ago. The walls are not hard to put together.”

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

“What’s the latest from Columbus 3?” asked Paul as they walked.

“They’re doing fine,” replied Will. “Fourteen people in three ITVs is tight and it’s beginning to wear on them. But they’re now half way to Mars and three light minutes away, so they’re taking over much of the Prospector and Sunwing work on Monsol. That gives them something to do and frees us to finish preparations for their arrival.”

“Do we have a Commander for the nominal mission yet?” asked Érico.

“Thanks for your interventions in the Mission Plan discussions, Will,” said Paul. “We have a consensus on a lot of areas as a result, even without someone to cut Gordian knots.”

“Thanks for the encouragement. I’ve been spending a lot of time proposing compromises, lately. But I see Jerry’s still opposed to the North Pole expedition.”

“He’s offering a South Pole expedition for 2043 instead,” said Roger. “Which is ridiculous because if he gets started on the Route 1 Circumnavigational Trail, he won’t want to stop to head to the south pole.”

“I think it’s a ploy,” agreed Érico.

“And I hear the plans for a Mars Commission have stalled again,” said Paul.

“The partners demanded too much from NASA,” replied Roger.

“How can NASA afford to back out, with all the pressure on them over the Swift shuttle?” scowled Érico.

“It’s a question of national pride,” exclaimed Roger. “Mars has always been primarily an American operation. The Lunar Commission really hasn’t improved 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!”

“The Mars Commission has had similar issues,” added Will. “The French bought one of the ITVs from NASA. They want another one in 2042 and a third one in 2044. In return for purchasing and launching the latter two on Arianes, the French want free berths to fly three astronauts here. They’d lease all three ITVs back to NASA for $1.”

Roger frowned. “What could the French do with three ITVs?”

“It must have angered NASA,” noted Paul.

“NASA may have to agree to the second and third ITVs, though,” replied Will. “The fight in Congress over using Swift Shuttles and phasing out the Ares is really hot.”

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

Will shook his head. “The White House emailed me last month that they were taking the idea very seriously, but now they’re busy with the election campaign. NASA’s opposed, of course. At least NASA approved the establishment of a web-based system allowing amateurs to propose exploration routes across the Martian terrain. I think 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. “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! The plastic outer garment for the diapers is a design achievement I’m proud of.” Ethel had figured 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. “Two squares to go.”

“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 that. Ethel put the new outfit on the cradle that Paul made out of plastic sheets and metal beams. He had even carved a design in the plastic.

“I do have something brief for us to discuss,” exclaimed Will.

“What is it?” asked Roger. “I hate suspense.”

“I was just telling the guys that the French government has purchased the *Amazonis,* one of the ITVs flying here on Columbus 3. But the French have requested that the *Amazonis* be emptied of cargo and passengers and sent back to Earth as quickly as possible. They want it on trajectory that will return it to Earth by November 2041.”

“So soon? Why are they demanding that?” asked Roger.

“So that it can be readied to return here in 2042, instead of 2044. NASA and France have agreed to three conditions: first, Columbus 3 won’t need it to fly some of us to Earth in 2042; second, a Lifter with fuel from Phobos or Deimos will be available to push it back to Earth; and third, that we can refuel its ion engine with half a tonne of argon. With its solar panels making 25 kilowatts of power, the *Amazonis’s* ion engine can shorten its return to Earth by two or three months, thus ensuring plenty of time for refurbishment before the next flight.”

“So, their convenience is our extra work,” complained Roger.

Will nodded. “The first condition is the most important: we need to know who plans to return home in 2042. Of the fourteen arriving on Columbus 3, five have pledged to stay. We have an ITV here now, so if the *Amazonis* leaves, we’ll have the ability to fly

fourteen back to Earth in 2042. That means at least four of the nine of us have to stay for Columbus 4."

Madhu looked at Roger. "We're staying."

"We are?" asked Roger startled.

"If we start a family, we aren't going anywhere for a decade or two."

Everyone smiled. "Great," said Ethel.

"I'll probably go back to Earth in 2042; 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. "Thanks for your frank comments. I have every intention of building a warm social environment that includes everyone, 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 at least four of us plan to stay and that the fuel and argon are available."

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 entered the world, healthy and loud.

It wasn't until the next morning when 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 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. "Six pounds, fourteen ounces. Normal."

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

"He's very healthy," added Shinji. "We did a quick check up this morning. The low gravity 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. He isn’t part Klingon.”

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

“I doubt that’ll stop the rumors,” 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 watching 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 am I,” said Érico. “But I guess I can 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.”

“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 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.”

5

Declaration

mid Feb-mid March, 2040

Sunsol they had a celebration like nothing they had had before, with turkey, chicken, rabbit, *and* tilapia; all four of their meat sources. Will spent much of a sol preparing the bread, brown rice, and pasta. 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 play a musical instrument did so and they 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 it now had a deeper meaning for him.

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 seemingly simple but in reality vexing problem: Marshall's birth certificate.

"I apologize that NASA assigned this task to me; I'm really not sure why," Joyce Hastings explained by videomail. "I consulted several experts and initially they all assured me the matter should be simple. But once they look at the wording of the 'Five Flags' Treaty, their attitude changed. The treaty was never designed to cover matters like issuing birth certificates. 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; by treaty, no one can claim it. Of course, there's no rush for the birth certificate. Marshall won't be applying for school or work for some time."

"But I would like this resolved," said Ethel, raising her voice. "It just makes me depressed, Will. I've felt depressed on and off for the last week. 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 depression?"

She nodded. "This sol. He has some antidepressants, but they're now getting old—over two years—and he has only a one or two week supply of them. He also worries about them ending up in my milk because he can't monitor them in Marshall, though he says that's less of a concern. If we had baby formula I wouldn't worry about

that so much. 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 as good as the simulated milk on Earth."

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."

"I see. Look, I think you should take whatever Shinji has if it'll help. And I'm here for you, don't forget that." He put his arm around her more tightly. She nodded, but it didn't help much.

No one wanted to leave the outpost on an expedition; they preferred to stay and get to know the new resident. In consequence, Will put together a careful plan and patiently persuaded Mission Control to let them try to clear a usable road up Little Colorado Canyon to the top of the escarpment. They needed three vehicles equipped with bulldozer blades, judicious use of explosives, and hard work in pressure suits with pickaxes.

A ranger could tip over and become irreparably damaged; they had to be extremely careful. It took them five sols of careful work to cover the shifting rocks of the talus slope at the base of the escarpment with ramp of small rocks and gravel. They took advantage of Mars's average daily temperature of forty degrees below zero to freeze the roadbed in place; ice was almost as hard as concrete at that temperature. Once into the

canyon mouth, the next three hundred meters were bulldozed in two sols. The first week saw good progress.

But when Will got home after a hard sols' work—one of his first away from the Outpost, for usually he only spent half a sol on the road—he found Ethel's depression, which had been managed by antidepressants for a week, was worse 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 have a better idea. 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. 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 families actually lived on those bodies and had babies," exclaimed Ethel. "I think that's a good idea."

"I'll raise the matter after dinner." It was just about time for dinner, so they picked up Marshall and headed to Habitat 3. Madhu had whipped up a pasta dish using

leftovers from the big meal. Afterward they had a big pot of mint tea, since the coffee and regular tea had run out a month earlier. As the cups were emptied, 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 the best way to issue a certificate because of the ambiguous wording of the Five Flags Treaty. The red tape is driving us crazy, so I'm thinking seriously about an alternative that was proposed to me this morning: that all nine of us should assert, as residents of the first settlement on Mars, our collective right to issue birth, marriage, and death certificates, and other certificates as needed by us. The declaration would also have to state how and by whom such certificates would be issued. Probably the easiest statement to make is that 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's true," agreed Will. "But the authority to marry does not include the authority to grant a certificate of marriage. So our marriages, also, have a funny legal status. 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, 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. 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."

"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 grant such 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. He looked at Érico. "Maybe we need some patience. Eventually a solution can be found, I'm sure."

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 cleared a trail three quarters of the way up the canyon.

The situation with his birth certificate, however, had not moved forward, so Will called various friends for advice, including Heather Kimball. “Can you get some insider information about what’s going on?” he asked her. “Everyone seems to agree that the United States government can issue a certificate, but the European Space Agency objects on the grounds that the child has a parent who is a citizen of the European Union, and therefore a European institution should also have the authority to issue a birth certificate. Mars isn’t fully under the jurisdiction of a particular national government. The idea of establishing a Mars Commission has been resurrected by France, Brazil, and some other nations, which delays things further. Mars Exploration Society members have suggested that a United Nations agency—perhaps the High Commission for Refugees—should issue a birth certificate. They’ve also advocated dozens of impractical and utopian proposals which the media has sensationalized. Ethel is at wits end about all this and the rest of us are beginning to feel ignored or even abused. If you’re talking to anyone in Houston, ask about it, okay? Bye.”

Heather’s reply came less than half an hour later. “I’ll make a few inquiries, but I think you’ve analyzed the situation correctly. The birth certificate has gotten tangled up with some longstanding controversies and they’ve taken over. Congress is making it worse. A Washington lobbyist friend told me Congress wants to lop two billion from NASA’s fiscal 2041 launch budget to force it to lease space on the Swift shuttle, then buy one in ’42. NASA has threatened 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, so it’s possible Columbus 4 will fly without Americans. NASA also is threatening to mothball Shackleton. Under these circumstances, how much can NASA do about a birth certificate? Bye.”

Will hit reply. “Thanks, Heather, you’ve clarified a few things. I’ll keep trying, but our patience is wearing thin! Let me know what you find out, please. Bye.” He sent the message and, restless, walked out of his office in Hab 3. Érico and Roger were sitting at a table in the Great Room with a map of Chryse in front of them. “So, ten more sols of work to extend the route to the rim,” said Will.

“That’s about right,” said Roger. He pointed to the map. “I tried your suggested argument that ‘Route 1’ east of here should follow the old ocean shoreline for at least a hundred kilometers. Jerry made a posting today and accepted it.”

Will smiled. “Great, so we’ve agreed to something on the Mission Plan.”

“I think so,” said Roger, nodding.

“What’s new with the birth certificate?” asked Érico.

Will shook his head sadly. “It’s tied up in politics.”

“Disgusting. We should ignore them and issue one ourselves!”

“The lawyers assure us it will be considered valid on Mars.”

That prompted Roger to laugh. “That’s the problem. But this is getting to be ridiculous. We may have to do something.”

It was March 11—ten sols later—when the road broke through to the top of the escarpment. The ramp up the last cliff was narrow and precarious, but five or six sols of bulldozing heaps of reg down the ramp from the top finished it. They also perfected a way to make “instant Martian concrete,” as they jokingly called it, hot water and dust mixed in a hose and sprayed on a slope to freeze it hard.

“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 be part of some other route, I don’t think we should give it a number.”

“I’m not sure we should use numbers at all,” furthered Roger. “I like Jerry’s term ‘Circumnavigational Trail.’ 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 like it, too,” commented Érico.

“I’ll stick to ‘Route 1’ for now,” replied Will. “But never mind about the name. Now that we have the road up the Little Colorado, let’s 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 the bottom of Noctis Labyrinthus up to the Tharsis Plateau,” said Roger. “I was looking at possible routes last week. The Mars Exploration Society’s volunteers have done a good job of laying out possibilities, but all of them are risky and require a lot of explosives. I’d push a route up Noctis Labyrinthus to the end. 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.”

“Little Colorado 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 along two tonnes of water and reinforce some section. I don’t see a need to continue full-time work on 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.

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

“I’ll stay. 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; when five greenhouses arrive we’ll be in the position to set them up right away.”

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

“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. One lawyer actually advised Ethel and I to 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, and if we ever have any deaths or divorces, we'll have a mechanism to handle them."

"The lawyers, however, have identified disadvantages," said Will. "A civil authority would have implied responsibilities 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 local jurisdiction, *not* the entire planet."

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

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

"One advantage of a boundary like 500 kilometers is that there could not be a second 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 only one station at Shackleton."

"Rather than using 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's better," agreed Will. "But be aware that we will make enemies if we do this, and a lot of them will be in our space agencies and national governments."

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

Roger stared back at Érico. “I have no objection,” Roger finally said, quietly. “And 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. 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 two decades. 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 doing geological research at various locations on the Earth. But that will be difficult if we have a family, and we’ve always wanted to have one. I’ve already visited all seven continents 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 receive 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.

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

“I do have one caveat, though,” said Roger. “It’s about Will. NASA won’t like this. They may not continue Will as Commander.”

Will looked at Roger while everyone else fell silent. Will nodded. “They have not commented to me about this matter at all, but we know they will not be pleased. Nevertheless, I think we need to do what we think is right, regardless of consequences.”

Roger nodded. “I suppose I agree; that’s the principled response.”

“Then 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.

Will slept little that night. What had started as a silly idea was now deadly serious and historic. But at the same time, Will reminded himself that this was not the Continental Congress and the document he was drawing up was not 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 close to opposition, items downloaded in a mere eight minutes—and looked at various examples. He emailed lawyers in Scotland and the US. 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 same.

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 eighteenth sol of March, 2040.

"That's it?" asked Érico, after a moment of silence when everyone contemplated the language.

Will nodded. "It's short and simple. We can add to it as needed later. It doesn't even name a mayor. 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 property," said Roger, suspiciously. "Why do we need those?"

"That list was suggested by a Scottish lawyer," said Ethel. "They're things municipalities usually 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 me. 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. I could see people doing that very soon, so the civic authority has to be able 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 property 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. "Or ownership of housing."

"I had housing deeds in mind," said Will. "I wasn't thinking that the civic authority could grant ownership of land to individuals. No one here owns the land, so no one can give it to someone. 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, it's *very* controversial."

Will shook his head. "No, I don't think so. Let's keep separate what the document means from what it might mean in the future. 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 it doesn't own."

"If we acquire that right, we could sell land to Mars enthusiasts," said Érico. "There are thousands of enthusiasts who 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 is.”

“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 were 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 families will live 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 world will have several nations. But I agree that we can and should take this step."

"I think we should take this step for the sake of the moon, too," said Will. "Shackleton can now accommodate thirty-six. 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. LeMonnier Station in Mare Serenitatis has been authorized for next year, and the Aristarchus Highway will 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. "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 to certify events going back to the beginning of the human presence on Mars,” 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 civic government!”

6

Landings

25 May 2040

The flashing icon on Will's attaché indicated he had received a message. But he was too busy to read. With all the tasks to complete before Columbus 3 arrived, it was not possible to handle routine messages promptly. He reloaded the various machines with rock samples: the x-ray crystallography unit, to determine crystal types; the mass spectrometer, to determine the potassium-argon ratio and obtain a formation date; the microscopic camera, to count microfossils automatically using shape recognition software; the alpha-scattering unit, to provide an elemental analysis. There was never enough time to run thousands of samples through the machines, generating data for doctoral dissertations or articles.

Once everything was loaded, he walked over to his attaché and played the message. Jerry McCord had called.

"Good afternoon, Will. I'm sure you're getting as excited as we about aerobraking. Eight hours to go! We're looking forward to our week-long visit to Deimos and Phobos, then landing at the Outpost!

"I'm going to need your help once we land. There's been some friction up here. The French eat most of their meals on board the *Amazonis*, since it's owned by the French government. They speak French all the time and interact with everyone else relatively little. It's been a huge problem, and we've retaliated a bit by giving the cold shoulder to them.

“But your social skills are legendary. Everyone says if anyone can resolve the ‘French problem,’ you can. So as soon as we land, I hope you can make it 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. McCord was assuming that he, and not Will, would be Commander of Mars Operations. Did he know something? Jerry certainly had better contacts; Will hadn’t had a face-to-face conversation with a NASA official, or drunk coffee with one, for over four years. 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 insider information, it was he.

Upset, he walked to his apartment in Hab 1 to find Ethel. At the moment she and Marshall were asleep on the couch. In the last month Shinji’s antidepressants had run out and Ethel had been so seriously depressed she had not been able to do any work. At least she was still able to watch Marshall, though at times even that had proved difficult.

She sat up when he entered their living room. “I just got a call from McCord,” he said. “He explained 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. “But that’s not what you’re referring to. Do you think he has inside information about the selection?”

“Maybe. He has much better contacts than I.”

“This has been a rough six weeks.”

“The Aurorae Declaration really angered the space agencies. It’s amazing how much some people jump to conclusions.”

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

“True. But we couldn’t have anticipated that the responsibility of the civic authority to ensure oxygen, food, water and other necessities would sound like a complaint about NASA services!”

“It was a slow news month on Earth. That worked to our disadvantage. In the long run it’ll work out alright.”

“At least it has gotten discussion of the space treaties and the Mars Commission going again,” said Will. “And the public likes the idea they might be able to buy Martian real estate. But I think NASA sees me as some kind of unpredictable wild card.”

“They can’t blame you; it was unanimous. It reflected a set of common views and attitudes that developed here over the last nine months.”

“Everyone here’s upset about the reaction, too.”

“Even Roger!” said Ethel “He shocked his friends in Mission Control more than you did. But the furor will die down after the landing. And once everyone sees that we don’t actually do anything—other than issue birth and marriage certificates—they’ll calm down.”

“I hope so.”

It was midnight when the five vehicles making up Columbus 3 separately hit Mars's atmosphere at 26,000 kilometers per hour. In three minutes they burned off their excess speed and went into an elliptical 24.6 hour orbit around Mars. The vehicles closed on Embarcadero Station to dock.

Everyone but Ethel was awake at the Outpost. Will 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 Will by default was the boss, a position that surprised him and no doubt irritated 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 will be frank with you about the delay in finalizing the appointment because if we can't communicate frankly, this appointment won't work. 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 part of the North Escarpment Trail, the pressurization of the Geology Storage Facility with an oxygen atmosphere, the preparation of enough soil to fill the five new greenhouses, the manufacture of construction materials to complete Habitat 4, and the construction of new rooms in the other habitats. After four years, we're eight years into our master plan in some areas and way beyond it in others.

"But we are not pleased by the establishment of a so-called 'civic authority.' You were out of line to encourage it. It has thrown a shadow over all your accomplishments

and it is not clear that the result is a legal birth certificate for your son. The only thing tempering our anger is the puzzling fact that the decision was unanimous and included Roger Anderson as well. As he has explained, the decision was part of the outpost's evolving culture.

"We debated long and hard about whom to appoint Commander. You barely won out. I think you deserve to know that. Strong support from the Europeans, led by your friend David Alaoui, was one factor. The White House saw diplomatic advantage to undermining the existing space treaties, so they were less upset with the Aurorae Declaration than we were in Houston. Finally, your brilliant efforts to persuade people to accept compromises in the Mission Plan has brought us closer to a final plan than otherwise would have been possible. No one else was nearly as successful at reconciling the powerful egos of highly experienced and confident professionals scattered among a dozen localities across the inner solar system. We look forward to your final version of the Mission Plan and working with you over the next two years. Bye."

He looked at the screen and said "Huh." He had given up on receiving the appointment, and some of Lassen's comments stung. But he was grateful for the frankness; he knew where he stood. 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—but not to the personnel in orbit, in case McCord had not yet been informed—letting them know of the appointment. Then he started to think about the final version of the Mission Plan; he now had the clout to resolve the remaining disputes.

The next week saw a whirlwind of activities. The three ITVs and two shuttles of Columbus 3 docked to Embarcadero. The *Amazonis* was emptied and docked to the Lifter *Stickney*, which propelled it onto a trajectory back to Earth. The *Stickney* returned to Phobos and the *Amazonis* activated its ion engines to shorten its flight by two months.

Meanwhile, the *Elysium* blasted off from Aurorae, unstaffed, and docked to Embarcadero. Columbus 3's two shuttles—the *Pavonis* and the *Alba*—refueled and headed to Deimos and Phobos respectively, each with a crew of three. For five sols they carried out maintenance on the fuel-making facilities, moved the drills to make new shafts, explored new parts of the moons, and set up scientific instrument stations.

Work done, the *Pavonis* and *Alba* returned to Embarcadero, where the crew remaining there had installed a new docking module, a second remotely controlled arm, and an ion engine, and had loaded the *Elysium* with cargo destined for the surface. The fourteen members of Columbus 3 dispersed among the three Mars shuttles and headed to the Outpost.

The *Pavonis* was the first to land. On board were Jerry McCord; Rick Page, an American pilot and vehicle engineer; Lisa Kok, a Dutch horticulturalist; Linda Dubois, a Canadian exobiologist; and Lal Shankaraman, an Indian geologist. Will drove a portahab to the landing pad to bring them back to the Outpost, where a crowd greeted them and helped haul the luggage to everyone's new room. The new arrivals explored the habitats, poked around the greenhouses, and chatted with the others. Four hours later the *Alba* landed, followed four hours later by the *Elysium.*

Before dinner Jerry McCord came to Will's office. "Is this a good time to talk?"

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

“Thanks, Will. We’re 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 excited. Lal’s thrilled; he said after brief visits to the moon and Deimos, he’s ready for the kind of geology he’s used to: glaciology.”

“He’s brilliant; he’s made major contributions to reconstruction of the glacial history of the Himalayas. But until the Columbus 3 training flight to Shackleton, he had never left Earth orbit.”

“He’ll have to be on the north polar expedition; the layered terrains will fascinate him.”

“I agree. One reason I stopped by is to ask what has been happening here in the last nine months. All of us on the flight were baffled. We also felt ignored when you all passed the ‘Aurorae Declaration’ and never asked for our input.”

“I’m sorry; I apologize for that. That never crossed our minds; you were still tens of millions of kilometers away. If we had waited, it would have taken a year for you to get up to speed about this place.”

“So, what’s the rush? A baby doesn’t need a birth certificate that urgently. The IRS would have allowed you to count him as a deduction on your taxes. It looked to us like you all were about to launch a land-sales scheme or something else flaky.”

“No, no, nothing like that. Ethel’s post-partum depression did give the effort some urgency. Marshall’s arrival made Ethel and I look at the Outpost—at Mars—differently. We see a home for twenty years of our lives, not eighteen months. That’s rubbed off on the others. Marshall won’t be the only child here for much longer.”

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

“No. No one is pregnant yet, but Ethel and I aren’t the only couple looking at this place long term. And remember that except for Shinji, the residents were four couples.”

“Oh? Paul and Monika?”

Will nodded.

“Four couples would give the place a long-term perspective.”

“Exactly, and having a baby around has made everyone happier. The exception is Ethel. But now that you’ve brought antidepressants, she should start to feel better.”

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

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

“Interesting. That helps. It’s a shame you haven’t blogged about this. Mission Control has kept me in the dark because of confidentiality issues, so none of us knew.”

“And communications have been limited by the distance and the fact that we don’t know each other well.”

“The other reason I stopped by is to talk about my role here over the next eighteen months. As you know, I’m 51, and when I return to Earth I’ll be 53. I doubt I’ll to get to the moon much more because of my cumulative radiation exposure. So this is my big

mission; probably the culmination of my career. I was going to be the fourth Commander of Mars operations. That didn't happen, but I hope I can have a fairly large assignment."

"I can understand and appreciate that, Jerry. We'll be running a lot of expeditions in the next eighteen months and I'm sure you'll head some of them."

"What about a big job relating to the entire mission?"

"You're familiar with the organizational chart. Mars doesn't have an Assistant Commander. We have twenty-three adults and all of them are experts with a lot of experience, so they all have at least one primary responsibility and one or more secondary responsibilities where they assist someone else. We'll have the same structure as on ISS-2: most people will report to me about a particular sphere of activity, and we'll have inter-team meetings to coordinate everything. The exception is expeditions; each one will involve three vehicles and five or six people and there will be a boss. But even then the boss will change every few months."

"I suppose you're planning to send out the North Pole expedition?"

"Yes. A group of people who have already cleared most of the road, have been discussing objectives for years, and therefore have priority. Either Érico or Roger has to be in charge of it. But I know you were advocating a trip to the South Pole a year from now. If you want that expedition, it's yours. There probably will be an expedition to the top of one of the Tharsis volcanoes, too."

"So, I can be the second to visit a pole and the first to climb a volcano," Jerry said, sarcasm in his voice. "Come on, Will, you know what I really want: the Circumnavigational Trail project."

"We don't have clearance for it."

“But we’ll get it.”

“Then you know something I don’t.”

“Come on Will, make some kind of commitment. Is it a question of seniority of the people here, or are you mad at me because I was almost made commander?”

“Seniority. I harbor no resentments against you. You know how Ethel, Shinji, and I suffered. The people who are here need seniority over those who are arriving. It’s an incentive for the latter to work and stay.”

“But I’m not planning to stay. I can’t, my family’s on Earth. Not everyone can become a ‘settler.’ Does my lunar experience count at all towards ‘seniority’? Three six-month stints at Shackleton as Commander? Chief architect and excavator of the Aristarchus Highway? Not to mention your commander at Shackleton on two occasions, and capcom for Columbus 1 and 2 for many months.”

“I know, Jerry. You know this operation inside out and backwards. So I’m in favor of you taking on big responsibilities.”

“I haven’t heard a commitment to a ‘big’ responsibility yet.”

“Let me review the possibilities tonight, okay? I can’t be giving things away to anyone who comes to my door.”

“Is that what I am?” There was an awkward silence as the two men stared at each other a moment. “Okay, have it your way, Will. We can talk more another time.” He rose, waved goodbye, and stepped out of Will’s office.

7

Plans

late May 2040

The sol was frenetic with activity. The dozen new species of fruit and nut trees and five new animal species—honeybees, catfish, trout, miniature pigs, and two small, immature dairy cows—required immediate unloading from the three shuttles. The mammals had been partially sedated throughout the last week of weightlessness and completely sedated for the landing, so they had to be revived.

Shortly after sunset everyone gathered in the Great Room of Habitat 3 for the welcoming dinner. Twenty-four people crowded the room; it made them realize how small the space really was. Will and Ethel sat with Gaston and Eve Gilmartin, two of the three French astronauts on Columbus 3

"Vous êtes tres bienvenue ici (You are very welcome here)," said Will to them.

"Ah, vous parlez français!" exclaimed Gaston, surprised, in French.

"Pas beaucoup, not much," replied Will, continuing in French. "My Russian is better, but Ethel's French is pretty good."

"Marvelous," 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. Some of that expertise may prove useful."

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

The two women laughed. “I’ve also been studying allergic reactions to Martian dust.”

“We need that; it has been a problem,” said Will. He turned to Gaston and switched back to English. “So, your expertise is ‘animal husbandry.’ I’m not sure how to say that in French!”

“Yes; the cows and pigs.” He smiled slightly. “I’m looking forward to the work.”

“How are the calves doing on the moon?”

“They have weak legs, thin bones, and weak hearts. Bad news about the health effects of gravity, though lunar cows make more tender beef! But drugs and various countermeasures like weights have reversed some of the effects of feeble gravity.”

“It’s fascinating research.”

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

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

“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.”

“Yes indeed. 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. 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. 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.”

“I know. Now your last name, Domkowski; is it of Polish origin?”

“Yes indeed. My grandparents settled in Paris after the Second World War. France absorbed many emigrants then. David’s father’s family arrived a bit later from Morocco.”

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

“I’m particularly interested in Mars’s early climate. There’s a new 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 hope to recover ancient gas samples, perhaps 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 work we’ve done 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 that would go into a 24-hour elliptical orbit. They'd dock and spin, just like on our flight out. An automated cargo vehicle would bring atmospheric probes and telerovers for surface exploration. 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 over. "Commander, I have to tell you how impressed I am by the Outpost."

"Thank you. We've put quite a few hours into developing it!"

"Indeed you have! I had done three-dimensional virtual walk-throughs several times and felt familiar with the place, but nothing compares to 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, five new greenhouses, and a pressurized 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 walked over a bit before sunset and saw the stakes marking the future sites of the sandbag corrals. The plan will work well."

"Excellent. We can't wait to get those nukes. They'll revolutionize exploration."

"Not to mention the power available to the Outpost. I'm delighted to be a part."

"You and Neal are committed to stay at least two cycles, right?"

"Yes. You can't leave the nukes without an expert, and that means the experts can't rotate back to Earth in less than two cycles. Neal's thrilled to be staying."

"He's an excellent geologist. We're delighted to have both of you."

"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's like night and day!"

"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. That’s the earliest the safety rules will allow someone drinking two or more glasses of wine to make an EVA.”

“But Commander, we never followed the EVA rules strictly at Shackleton,” replied Karol. His speech sounded slightly slurred as well.

“Here we do follow them closely. I want to be sure everyone is safe. It’s a long way to a professionally equipped hospital. 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 grabbed an extra bottle of wine and are drunk. I grounded them for tomorrow morning’s EVAs.”

“That’s a problem.”

Madhu came over. “Shall we get started?” she asked.

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, 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: culture. It’s amazing how many of you have artistic talents. Let’s 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 enough to listen, but not to don a pressure suit. Besides, I had a conversation with Jerry earlier and I need to consider how to accommodate him.”

After breakfast the next morning everyone drank a second cup of coffee while Will reviewed their plans for the next eighteen months. “We are beginning what someone—I think Jerry—has called the ‘third columbiad,’ the period from the arrival of Columbus 3 and to the arrival of Columbus 4 in 2042,” he began. “The twenty-six month cycle that drives our efforts deserves a name, and a good name at that, so I welcome this new term. The mission objectives have been evolving over the last year as a result of face to face meetings in three places—here, on the Columbus 3 spacecraft, and in Houston—followed up by emails, forum postings, and blogs. We’ve all participated in the discussion and in

many cases consensus emerged. The process has lacked a Commander to resolve differences and finalize some details. This morning I want to review everything—because most people know their part well, but everyone else's little—and give my preliminary vision for what the third columbiad will accomplish. Your inputs will enable Mission Control and I to finalize the plan next week.

"First, I have two announcements. Madhu Gupta Anderson has been doing art in her spare time for two years, now, and her contribution to the Outpost makes it more pleasant and livable. It needs some recognition. Therefore I am appointing her Head of the Mars Art Team. I am not sure yet how many hours per month the team will be allocated, but it will have its quota. Congratulations, Madhu."

She smiled, surprised and thrilled, while everyone applauded.

"I have a second, more important announcement. Jerry McCord deserves recognition for his decades of service to the Astronaut Corps, his leadership experience, and his solid geology credentials. Therefore I am appointing him Director of Surface Exploration, in charge of planning expeditions and assigning personnel, subject to my input as well. We all look forward to working with you, Jerry, in refining the Mission Plan's exploration aspects.

"There's a third organizational detail to mention: I am appointing a Martian Exports Team, which will be responsible for exporting liquefied gasses and surface materials to Earth, and appointing myself the team head. I am not sure who else will be a part of the team, but I am sure it will grow over time. The export team represents our long-term commitment to make Mars a player in the human economy. 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 Team is a very small, token start."

"Interesting," grumbled Roger, disapprovingly.

"Next, we'll review our Mission Plans for the next eighteen to twenty-six months. In many cases we already had formed a consensus online, but in some cases I have modified proposed objectives or postponed them We can't do everything, as much as we wish we could.

"Food Production and Services: The big goal is to raise the number of greenhouses from four to nine, which should be able to feed up to eighteen people. We have new animal and plant species to accommodate and new ecologies to establish. To these objectives, I would add two longer term goals, in this order of priority: moving toward self sufficiency in food by Columbus 4 or 5; and obtaining a large pressurized open space for our own recreational use and for agriculture.

"Construction and Fabrication: The main goal, 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 project requiring four full-time staff. It will strain our existing equipment to make the steel, plastics, and chemicals. If this goal is achieved, we may never need to import another habitat, so it is immensely important. Secondarily, probably during the mission extension, we will aim to construct greenhouses of native Martian materials instead of importing them.

"Maintenance: The main goal is to set up the two nuclear reactors coming on the automated cargo vehicles. Because each one can power an expedition, they are vital to

our exploration plans and maintaining our power supply in dust storms. Secondarily, we will be developing our spaceport and shuttle maintenance.

“Science and Exploration: If all the automated cargo vehicles arrive safely, we will soon have two more rangers and a second conestoga and the ability to mount two simultaneous independent expeditions. The first priority will be reaching the North Pole. The nukes will be essential for the effort. The South Pole may be possible as well; we’ll see. Second priority will build as much of the Route 1 ‘Circumnavigational Trail’ as we can. If approved, we will send expeditions in both directions at once and they will meet on the other side of Mars, thereby constructing a dirt track all the way around. It will open up much of Mars to exploration. Roads to the tops of one or more volcanoes may be possible.

“I know Lal wants to start drilling in 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 northern seabed to search for fossils. It’s not clear we can do both and explore. If we can use the Prospectors to maintain the drillers robotically or if we can fly a small maintenance crew down by sunwing periodically, we will. Our geologists want to sample all the remaining terrain units by Prospector or in person. In a few weeks we’re going to try relocating a Prospector by air; if that works, we’ll need to rethink our telerobotic exploration goals.

“Services: The sick bay will be upgraded and a major study is planned on the health of young mammals, including one young human. Child care and the arts are new service areas with their own objectives.

"We won't visit 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'll be ready to fill them with twenty-four tonnes each of Martian argon, nitrogen, and fossiliferous rocks. The Lifters accompanying them can carry twenty-four tonnes of methane back to Earth, enough to supply all the fuel for Columbus 4, saving about eight percent of its total cost. Surplus methane can be sold to the moon or to low Earth orbit. These exports are easy to accomplish, we are ready, and we anticipate getting approval.

"That's the plan for the next eighteen months. No doubt we will add new objectives as we go. There's one other dimension of this columbiad that's important to mention, though; the social. I hope the twenty-three of us can get to know each other well and become friends. The crews of Columbus 1 and 2 gradually melded together into close-knit groups. The social dimension of this place has proved to be 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 someone commented that the original six Columbus missions were not going to settle Mars, just establish a beachhead. Well, we have settled Mars; that's the reality. We are residents of Mars and of Aurorae Outpost. We have started to create a common Martian society and culture, and we will carry it forward in the next twenty-six months. I'm confident the results will be remarkable."

Will looked around the room. People were chewing on the priorities. 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 Madhu.

"With a nuke, an expedition can cover a thousand kilometers per month. Mars is 21,000 kilometers around and we already have 2,500 kilometers 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 avoid obstacles, and assuming two expeditions are working on the route, it'll take twelve months of continual work."

Érico whistled. "We may circumnavigate the equator and reach both poles during this columbiad!"

"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. The data confirm that there are some remarkable intrusive igneous complexes exposed in the escarpments. I think we should make a detour to Candor."

Will nodded. "Take the proposal to Jerry. Next week we'll hold a big meeting with the terrestrial experts involved in expeditions to finalize priorities."

Lal nodded. Lisa raised her hand, which no one else had done. "Striving for food self-sufficiency sounds good, but the term is vague. If we cut back on plant diversity and focused on a few, high productivity crops, we could raise all the food we need, but the diet would 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 for some time. We also need to set aside at least part of one greenhouse as a park, because all of us miss the chance to be immersed in greenery."

"Here, here!" agreed Paul.

"You're right about self-sufficiency," agreed Will. "I didn't mean we should decrease plant diversity. We need increased diversity *and* self-sufficiency, which requires

more greenhouse space per capita. We're using a bit more than half the consumables per person as Columbus 1, which saves a lot of money."

Lisa nodded. Will added, "Regarding a recreational area, please design one. If we have an orchard where all the trees are in pots on wheels, we could move the trees together for a few hours at lunchtime and at night."

"Yes, we can create dual use areas," agreed Lisa.

"It's important," commented Shinji. "I've been here over four years and I crave a green space. We have a psychological need for it."

"Anything else?" asked Will. No one replied, so he added, "Then let's get to work!"

Everyone rose from their seats, chatting to each other, and began to drift out of the room. Will looked at Lisa, Patrice and Pavel, who seemed uncertain what to do; he nodded to them and they understood that meant they could suit up, so they headed for the airlocks. Will tapped Roger on the shoulder. "Will this work for you?"

Roger nodded. "I think so. Jerry has more experience than I, so it's reasonable."

"You may be dealing with a baby, anyway."

Roger nodded and headed out of the Great Room. Jerry walked over. "Thanks."

"Sure," Will replied. Will this work for you?"

"I doubt we can get to the North Pole and complete the Circumnavigational in 18 months."

"We'll see. We'll do our best."

8.

Exports

early June 2040

Half the Outpost suited up to unload the three shuttles, each of which had brought fifteen tonnes of cargo. Will went outside with Pavel Rudenkov, their new civil engineer, to review where they'd put Habitat 4 and Greenhouses 5 and 6. They stood near the base of Face Rock to view the facilities. Extending north of them were three round habitats in a row, followed by the Quonset-shaped Mars Life Science Facility, looking like big igloos under their radiation shielding of Martian regolith, ice, and white parachute material. To the right and left of the habitats and connecting them together were Greenhouses 1, 2, 3, and 4, their brilliantly green vegetation a sharp contrast to the cinnamon wastes outside. To the left of Hab 1 and Greenhouse 1 was a long mound of dirt burying the Geology Facility, their first pressurized building. It marked the start of another line of construction.

"According to the plan, Habitat 4 will go immediately north of the Geology Facility and west of Habitat 2, and the new building will go north of Hab 4 and west of Hab 3," said Pavel.

"That's the plan, but I'd like to reserve the site west of Hab 3 for a recreational dome."

Pavel was surprised. "But there are no plans for such a facility."

"I know, but yestersol I submitted a request for one. If we put the building there, the dome will be relegated to the side of the Outpost, and I suspect it will prove centrally important to it."

“Where would we put the new building?”

“West of the Geology Building; we’ll start a third line of construction. The northern end would connect to the Geology Building. The southern end would connect to Habitat 4.”

“But the building’s too long; the far end can’t connect to Hab 4.”

“Between pressure tunnels and greenhouses, we can connect the far end to the rest of the Outpost.”

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

“ ‘A bit far’ will still be only thirty meters; less than a minute’s walk. Once the dome is installed they would be a convenient walk from it.”

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

“Sometimes, unexpected change is good, don’t you think?”

“Not always, Commander!”

“That’s true.” Will turned to him so they could see each other’s faces through their helmets. “Pavel, I respect your professional advice very much, and I look forward to the truly excellent, sophisticated building you’ll construct. But let us leave room for a dome or some other large exterior space. It isn’t part of the plans yet, but it needs to be and I think it will be.”

The Russian looked at him, hesitantly, then nodded. “Very well, Commander. We can change the plans. What you are suggesting is not a huge change and won’t cause any significant problems. 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.”

“When do you think we can get started?”

“The next four weeks will be devoted to setup of Habitat 4 and the two greenhouses. I can use that time to move the building plan to the location you propose and resolve potential safety problems. We can start basic work like excavating the foundation in 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 Habitat 4.”

“And I have no plans to move it! I have to go inside for a video appointment. Thanks, Pavel.”

Will walked back to the suit donning facility attached to Habitat 1. In twenty minutes he was at his office. He sent an email to Heather Kimball, his old friend who was President of the Mars Exploration Society, summarizing his various ideas and plans; she had proved a valuable informal advisor and brainstorming partner. Then a message arrived from Harold Lassen, head of Mars Mission Operations, for which he had been waiting with some trepidation. Lassen looked more stressed than usual.

“Good morning, Will. Thanks for the Mission Plan summary you sent last night. It’s impressive and ambitious, which is to be expected of anything that comes from you. It clashes badly with our reality here in Houston. The staff cutbacks we’ve had to implement have caused some chaos, and yesterday I was asked to make a plan to lay off ‘nonessential’ staff. This year’s budget was drawn up three years ago to support a Mars operation of twelve astronauts, not twenty-three, and is now held captive by the Swift shuttle controversy.

"Consequently, Mission Control is able to support a minimal Mission Plan for Columbus 3, but little else. Regarding your wish to conduct two simultaneous expeditions, our request to hire more ground support personnel has been repeatedly denied. Our current team has been able to support one expedition, but I don't know how it'd support two. An emergency on one expedition 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.

"Regarding the Dome Project, I agree that Mars needs a large space for agriculture and recreation, but it is impossible to justify the expense right now. The dome will cost several hundred million to design, build, and launch. The expansion of ISS-2 is costing ten 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, there's the congressional fight over the Swift Shuttles. Upper management is convinced they represent a false economy, that the Swift's safety is unproven, and using it will jeopardize NASA's future. Congress may force the issue by slashing NASA's budget, in which case Mars could suffer badly; there might even be a decision to cancel Columbus 4. So there can't be a dome.

"Regarding your proposal to use the automated cargo vehicles to fly methane back to Earth, it dejustifies Shackleton's fuel manufacturing facilities, demands more ground support for the ACVs, and more work at Gateway to recover and store the methane. We can't afford it.

"Regarding the sale of Mars rocks, the resistance in the scientific community is unbelievable. I suspect you have received hate e-mail. That proposal is dead.

“Regarding the export argon and nitrogen, it is premature; the equipment you have wasn’t designed for the extra demands.

“But I do have some good news! You requested additional reactors for Columbus 4. The President favors further development of nuclear power, in spite of or perhaps because of the launch vehicle controversies. Columbus 4 will carry two more nukes to Mars, even if passengers are cut from it. The moon will get three more. Their new design is optimized for outer solar system use; the Lewis and Clarke Project recently approved uses a nuclear-powered ion engine to push sixteen tonnes of satellites and probes to the Saturnian system. The White House has also given a green light to develop a bimodal solid-core nuclear engine.

“So energy will be on the way. I’m trying to get next year’s budget re-configured to provide better 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 pulled the plug on half of Columbus 3 and possibly ninety percent of Columbus 4. It was a common historic pattern: Apollo had put scientific stations on the moon, but NASA turned them off because of lack of funds; it had even turned off deep space vehicles that were functioning normally. Funding wasteful projects was another pattern: in this case, a nuclear engine that would be more expensive than the solar-powered ion tugs they were already using for cargo transportation. Eliminating a perfectly good vehicle for another, more problematic one was a third NASA pattern. But it made absolutely no sense to put people on Mars and refuse to employ them all. That infuriated him.

Furthermore, the “good” news was not that good. Will had not requested two more reactors; he had just mentioned them in passing in a memo. He knew he didn’t need to request them because the White House was pushing nuclear power in space strongly for strategic and defense reasons, which guaranteed that Mars would get them, whether it needed them or not.

Will calmed himself and began to scribble talking points on his attaché; he had to be clear but exceedingly polite. He hit reply.

“Thank you, Dr. Lassen, for your message. I sympathize deeply with your dilemma, one which the agency has faced again and again. It is easier to justify the expense of mounting a program than maintaining it, once the excitement has worn off. But idling people who have put their lives on the line is a far more serious matter than turning off an automated probe once it has completed its nominal mission. We’re talking about essentially laying off Mars personnel. If we can’t send out two expeditions, what will the folks who were scheduled to go on the second expedition do? Lab work gets tiring pretty fast. What do you advise that I tell them? How will I maintain morale?

“Would it be better if, in addition to an expedition, we use three vehicles to explore Aurorae? Trips of two sols or less aren’t official expeditions and we can authorize them ourselves. But surely they are as risky as a second expedition. On the other hand, if we put those staff to work on expanding Aurorae, that strains the industrial and construction facilities further. How would that be better?

“So I’m not sure how we can resolve this dilemma, especially if boosting Martian exports is precluded. If you use Martian argon in the solar-ion tugs to lift Mars-bound cargo from low earth orbit to the L5 Gateway and use Martian methane to launch it to

Mars, you'll save at least a third of the flight costs. We're not 'dejustifying' Shackleton as a principal source of propellant because we need Shackleton's waste oxygen. The methane extraction equipment on Phobos and Deimos requires very little monitoring and will be maintained twice per columbiad anyway, whether it makes a little methane or a lot. The methane is flown to earth on lifters and automated cargo vehicles that must fly back anyway. Methane exports add insignificant costs compare to the benefits.

"The same applies to export of fossiliferous rocks. We collect tonnes of samples anyway and it is easy to collect tonnes more. We can launch them to Mars orbit when the shuttles fly up to pick up cargo from Earth and can fly them back to Earth orbit when the automated cargo vehicles fly back anyway. They can be deorbited to the Earth's surface in any empty shuttle. Based on the black market for moon rocks, we can sell small samples for five dollars a gram or five million dollars per tonne. Won't we make millions?

We already have ten tonnes of argon and nitrogen in storage. Our machinery can separate a tonne a month with a little extra maintenance on our part. Why shouldn't we fly the gasses to Earth orbit on empty returning vehicles? When vehicles are used to transport in both directions, operating costs are amortized over twice as much cargo and the prices of *receiving* cargo decrease. What do the economists conclude when you calculate the sales of Martian methane, argon, nitrogen, and fossiliferous rocks, and use Martian methane and argon to propel cargo and people here? You save or make hundreds of millions of dollars! That surplus could cover the cost of a dome, don't you think? Or it could provide adequate expedition support, wouldn't it?

“I understand the argument that if Mars starts to export, its scientific mission will be diluted and expectations could rise to the point where we will be expected to cover our entire expenses or be shut down. But surely a middle ground can be found. Why not aim for partial coverage of transportation costs? 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. 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 a month’s time.

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

Will reviewed his message, then sent it. He sat and stared at the screen, wondering what else to do. Possibly a series of calm messages would wear them down; he was good at that. There also was one viable threat: If the Mars residents passed a resolution allowing their 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 would pay the landowner a royalty. It was an excellent bargaining chip. But he didn’t want to use it yet.

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

“Jerry, if Mars exported 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?”

“You mean methane without oxygen?”

“Yes.”

“You’re doing them a favor because every tonne of Martian methane used as propellant requires 3.5 tonnes of lunar oxygen. With the growth in lunar tourism, they’ll soon have trouble meeting demand. They may want to buy some of it.”

“Can you call your buddies about this matter? Because I’m trying to persuade mission control to let us export methane from the moons, fossiliferous rocks, argon, and nitrogen to cover some of our shipping costs. I’d rather not encounter opposition from the moon lobby.”

“Oh, Will, please don’t ask me to do something like that. You may be a *settler* here, but I’m a *scientist*. And I’m not a salesman. You’re rocking the boat with these ideas, Will. I can’t represent them fairly, let alone advocate them.”

Will considered that. “Thank you, then, for your honesty. But consider, Jerry, that the alternative may be to turn the ‘scientists’ here into ‘couch potatoes,’ which may be more like a ‘settler’ than you like, because there isn’t enough money to send out two expeditions at once. There may not be enough to fly any people here on Columbus 4.”

“That’s what they always say. They always go to the brink and solve their financial problems at the last moment. Let’s not rock the boat. Let’s be *scientists,* which is what we are, and let them solve the financial problems.”

“Jerry, if the moon exports propellant, why shouldn’t we? These aren’t changes as big as having married people on Mars, or children on Mars. But 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, angry that Jerry refused to help. He found it hard to believe; Jerry lobbied vigorously for Shackleton when he had been its commander. But Neal Stroger had many friends on the moon—he was a gregarious fellow and made friends easily—and a good reputation. He called Neal, who was outside unloading shuttles. Neal stopped work and stepped aside to listen. “Sure, I can make a call or two. I agree, this is important. If Shackleton can sell propellant, why can’t we? The extra ground support costs are insignificant. The delta vee from Phobos to Earth orbit is less than from the lunar surface! There’s plenty of demand to go around.”

“I agree. The price of propellant in low earth orbit is set by the cost of shipping it there. If we match the Swift shuttle’s price, people will buy from us.”

“Our methane definitely would be cheaper than the stuff NASA launches with its old expendable rockets. I don’t know what they’re thinking! I can’t make any calls until tonight, though.”

“That’s fine. It’ll give me time to brief you 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. I can't change anything until we have a half-day conference of administrators and experts. Everyone is saying we can only support one expedition at a time and that this is not the time to export Mars rocks, methane, or anything else. Kennedy's ground crew doesn't shrink much if we launch fewer Ares, so your exports don't save as much money as you think.

"More importantly, though, experts are raising the question of personal risk. No one has died on Mars yet. The recent accident on the moon generated huge negative publicity. Your proposals risk people and machines. We have to think about their safety extra carefully right now.

"What can I say? I'll try to 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 and felt anger building in him. Caution was always the 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 pressure suit on the moon or Mars. He searched the computer for Lassen's first videomail and attached it to a message to Heather Kimball. "Good sol, Heather. I'm attaching a highly confidential exchange between myself and our friend Dr. Harold. 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 facile or extreme. I'm tempted to tell everyone here that they're now forbidden to do the work they want to do—which I may have to do eventually—and while they're angry, to suggest that the Mars residents authorize the sale of land to anyone who wants to buy it. We could provide services to land owners; we could even collect samples for private export if we

could obtain a vehicle for returning them to Earth. But of course I won't do that to Harold. His hands are mostly tied and it'd make matters worse. Maybe the Mars Exploration Society can act in ways we can't, though. Bye."

Then, if that weren't enough insubordination, he attached the same video exchange to a message to Dr. Armando Cruz, Columbus 2's physician, who was 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. Mission Control wants to idle half of us and won't let us employ ourselves with exports and other potentially useful tasks. You can see him face to face; I can't. I suspect some of this is pure politics—retaliation against us—and you can talk to the people responsible for it face to face. I need help communicating. 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 any work was drained away. 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 ridiculous. Safety is important right now, after the moon accident, but not so important that astronauts are idled. I'll make a few calls to friends to 'discover' this information. If I learn anything else, I'll let you know. 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 journalists. I think we

can be confident there will be embarrassing publicity. They may even want it leaked. Once the news is out, you guys will be able to complain on the social media; they can't stop that, they have to tolerate it, and it'll add further pressure.

"We conducted a survey recently. The 10,000 members of the MES are willing to spend several hundred bucks per year, on average, on Martian land, rocks, and services. About a million people worldwide are willing to spend one hundred dollars. 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. Then another videomail arrived, from Armando. He activated it. "Hi, Will. The Swift shuttle matter has everyone digging in their heals and is screwing up the funding. Some of this is a reaction against too many innovations at once. But Lassen's also getting pressure from the White House to make sure there are no other accidents. If I were you, I'd focus on the safety of people and the reliability of machines. But as you noted, idling people doesn't increase their safety if they can make short excursions instead. I'd emphasize that. Bye."

Will hit reply. "Thanks, Armando; that's very helpful. You may hear from Heather, too. Bye." He sent the message, then sat and looked out the window. He watched the sun drop to the horizon and considered his options. Some safety workshops and drills were already scheduled, but he could add more. That was a legitimate response to the situation and bought time.

9.

Conference

early June 2040

Will continued to exchange emails with Armando, Kimball, and Lassen until midnight. Kimball and Armando called Lassen as well. He said nothing to the other Mars personnel, however. The next morning 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. A month of finishing work could begin.

The next morning, as Ethel and Will, carrying Marshall, approached Habitat 3's great room, 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 is your hometown. It's 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. It's much more isolated and in an incredibly hostile, dangerous environment."

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

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

"I disagree," replied Paul. "I've wintered in Antarctica. It's a wretched place to live. This place may be colder, but that's a technical objection; the atmosphere's too thin to cause a wind chill. In a pressure suit Mars is too warm! It's much safer to be outside here than in Antarctica in winter. And we don't have six months of darkness."

“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.”

“They’re not bombarded with as much radiation.”

“But the radiation level 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 them.”

“I’d worry more about other things,” added Carmen. “Like a safe pregnancy or birth defects.”

“Those would worry me, too!” agreed Jerry, seizing on the point.

“Look, Jerry, this is not the moon, where we can rotate the crew back to Earth every few months,” said Érico. “We know lunar gravity is too low for good health, long term, unless one really works at it. But that’s not true of Martian g. 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. We don’t ask nuclear physicists, chemists, or surgeons to be celibate on Earth. We don’t assume that their professional skills suffer as a result.”

“That’s right,” 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 things going on,” added Rick. “One is a couple versus non-couple dynamic. You all from Columbus 2 were almost completely couples; those of us just arrived were not, except for the Strogers and Gilmartins. Furthermore, we’re used to serving in space in teams that have no couples at all. The other thing is the length of time the couples have been here. Naturally they regard this as home. No one ever stayed at ISS-2, Pax, Gateway, or Shackleton long enough to see them as home.”

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

“Well, I count at least two clicks among the Columbus 3 crew,” replied Gaston. “So I think we have 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 see,” replied Ethel. “He’s just three months old; he couldn’t walk right now in one percent gravity! 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 breakfast and sat at the table closest to the Columbus 3 arrivals; Will was still concerned about integrating the crews. They chatted about the latest soccer and tennis games on Earth, the growing worry about the behavior of Turanistan—Earth’s latest 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. “The Mars Exploration Society has said NASA considers it impossible for us to mount two missions at once because they can’t support them! MES criticized the agency for shortsighted planning and for refusing to let us ship methane and argon back to Earth. They called for the sale of Martian land and rocks to those who wanted them.”

“Can’t mount two expeditions?” said Jerry. “That’s what they always say.”

People turned to Will. “This is different,” he said. “I’ve been in discussions with Lassen for the last two sols. The fatal accident on the moon has triggered a wave of concern about safety, the support staff on Earth is considered insufficient to support two expeditions, and there’s no money to hire more.”

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

“What’s being done?” asked Paul.

“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, and all of us are free to comment on the social media. NASA’s going to get some bad publicity.”

“Serves them right!” replied Érico.

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

“Geological support is abundant anyway,” added Roger. “There are hundreds of professional geologists anxious to serve as ground support advisors. There are talented amateurs. If a fuel cell malfunctions, it can wait until we fix it, and it isn’t hard to get 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 six billion dollars to put Columbus 3 here, yet can’t find fifty million to provide adequate ground support. The White House is pressuring the agency to avoid other accidents and Congress is pressuring them to switch to the Swift shuttle. I told Lassen that we can 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, but greater safety because all the vehicles are in one place."

"We could do something like that even at the equator," said Roger. "An expedition could move forward thirteen hours a sol instead of nine or ten, using three vehicles to clear the route instead of two. We could probably average sixty kilometers a sol instead of thirty."

"We can be creative and solve the problem," agreed Will. Meanwhile, I'm scheduling an extra week of safety training. We don't want a casualty here."

"By the way, Will," said Stroger. "The moon people will support the export of Martian methane. They need the carbon and we can provide it more cheaply than Earth can. They'd buy nitrogen for their greenhouses and argon for their ion tugs."

"They told me. Now we need a meeting, where these issues can be resolved," exclaimed Will.

It was another week before the meeting Lassen had promised. At lunch, Will approached Roger. "Say, can you join me this afternoon? I could use some emotional support, and they respect you."

Roger was surprised. "Sure! I hate slow-motion teleconferences, but I'll endure."

"Round trips communications time is twenty-three minutes today. It starts in. . . twelve minutes."

"Okay."

“So, the Commander and Assistant Commander can handle the matter,” quipped Jerry at the next table. He looked at Will jealously.

“You said it, not me, Sir,” replied Will, irritated. He turned back to Roger, who drained the rest of his coffee. They headed out of the great room.

“What’s his problem?” complained Roger as they headed into Greenhouse 6.

“He wants to be Commander, and failing that, Assistant Commander. Maybe I should designate an Assistant Commander and run it past Mission Control. He’s the obvious choice based on experience, but I need someone who’s a bit more loyal.”

“I’m still upset you made him head of Science and Exploration instead of me.”

“You concentrate on starting a family. Jerry leaves in fifteen months and you’ll be head of Science and Exploration then.”

They headed to Hab 1 and went up stairs to Will and Ethel’s living room, a comfortable and private spot to participate in a long meeting. When they connected the wall screen to the conference call they saw eight NASA officials in the Houston conference room, including Lassen and Armando Cruz. Laura Stillwell, Commander of Columbus 1, was present, as was Carl Reed, the balding, overweight representative of the White House.

“They started without us!” said Roger. There was a powerpoint slide on screen and twelve minutes of transmission had already come in.

“But this is my powerpoint slide,” replied Will. “This is the presentation I taped and sent before lunch. You’ll get up to speed pretty fast.” Will advanced the transmission in ten second chunks. The slides summarized the technical aspects of the export plan.

“There, I’ve saved us twelve minutes,” Will said, advancing the transmission up to the present. He sat back to listen to himself.

“I’ve heard that the effort’s expensive,” he said in his recorded presentation. “Martian argon will save five times as much money as it costs to transport it to Earth orbit. Martian methane will provide all the fuel we need to launch Columbus 4 to Mars and the surplus will pay for the oxidizer. Shackleton wants to purchase ten tonnes of nitrogen. Thirty tonnes of Mars rocks are worth between seventy-five and one hundred fifty million dollars, depending on demand.

“This plan provides the revenue needed to support a robust exploration effort. Mars is set up so that half the personnel can go on expeditions while the other half maintains the Outpost and carries out horticultural and industrial work. Leaving more than half of the crew at the Outpost idles them or will cause them to go out on day trips that need just as much emergency support as a formal expedition. I cannot ask my people to sit back and watch television in the Outpost. It would be an insult to their professionalism and courage.

“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 most of the cost of flying cargo here. 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, and a project to build us a pressurized space twenty to thirty meters across. They are reasonable requests. We’re

ready to launch the exports next month. Many experts and professional organizations say our plans are sound. At least two Congressmen have said they will sponsor bills to authorize the additional spending. So we respectfully ask that our plans be given permission to proceed."

The camera turned to Harold Lassen. He looked at the others. "Comments?"

The director of exploration services spoke up. "The rules governing support are clear. We can't do two expeditions with our current staffing levels."

Will was tempted to respond, but he knew they wouldn't hear him for almost twelve minutes. He scribbled a note so he could send a long response to many issues at once. Lassen nodded. "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 Reed.

"How much are we talking about?" Reed 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 expected twelve people on Mars. We've been denied requests to raise the amount since."

"Okay," said Reed. "The nuclear power initiative is soaking up a lot more money than expected. ISS-2 remains a huge expense, even with twenty-five participating countries. NASA's in serious financial trouble and is 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.”

“We’re not the idiots who refused to authorize the support!”

“That’s water under the bridge now.”

“So what do you suggest?”

“Elliott has saved your ass by telling you where you can get the money to provide more support! Let Mars export!”

Lassen’s face sank. “Mr. Reed, let’s not mix science and exploration with efforts that might not make much money and will distract our people from their primary tasks.”

“Some of the savings are on paper only,” added someone else. “We’ve already paid for the launch vehicles and ground crew to lift the argon to orbit.”

“Use the rocket to launch something else! Harold, your people on Mars want to do this, they’ve offered reliable estimates of the financial benefits, it won’t strain their equipment, and *we’re stuck*.”

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

“They’ll complain and go to the mall to buy a Mars rock for their office,” Reed replied. “This country was built on business, not on pure science! That’s a value we can export to Mars. We can’t fund a dome for them, but we have to provide enough ground support for their expeditions. It’s that or change the safety rules.” Reed shrugged. There was nothing more for anyone to say.

10

Keys to Settlement

late June/early July 2040

The shuttle *Alba* blazed through Mars's upper atmosphere, rubbed off its orbital velocity, and fell like a conical rock toward the surface. In Habitat 2's bridge, Carmen Segovia monitoring it closely. She watched 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 of Pad 5 with the slightest bounce.

"Great landing!" said Will. He was watching; Jerry was there as copilot.

Carmen smiled. "We didn't do practically anything; the software's good."

"You guys were great backups. When do we have a clearance to approach?"

Both of them turned back to their consoles. The propulsion system was shutting down systematically. In a few minutes, Carmen nodded. "Clearance granted."

Will called the rangers and authorized them to head in. He hurried to the airlock, suited up, and followed in a buggy, a small, four-wheeled, one-person vehicle about the size of an all-terrain vehicle. By the time he arrived, the cargo bay was open and airtight containers were being pulled out, one by one, and stacked on a trailer attached to one of the rangers. They were filled with scientific equipment, food, medicines, computers, spare parts, and personal items. Buried in the middle of the cargo was a truck—their first—with a one-tonne nuclear reactor, the RL-75, on an attached trailer.

It took five of them two hours to remove the containers. Then Dr. Rosa Stroger, their nuclear engineer and an expert about all aspects of the reactor, took over. They disconnected all of the truck's restraining cables except two rear wires, which ran through

pulleys. They connected a tow line to one of the rangers and slowly pulled the truck and reactor down the ramp, while playing out the rear wires.

Rosa Stroger and Rick Page, her assistant for nuclear matters, connected a power pack to the truck and Rosa drove it to an enclosure of sandbags east of the Outpost: a radiation-shielded spot to park the reactor, which would become very radioactive once it was activated. Rick and Will disconnected the trailer and connected the reactor to a power line while Rosa drove the truck away. Then they headed to the reactor controls in Habitat 2's former repair room

"So, we'll have power next week?" asked Will, once they were seated at the controls.

"If the check-outs go as planned," agreed Rosa. Then the *Apollonaris* brings reactor 2 down from orbit and we'll set it up as well. Both reactors will be on partial power for a month while we check them out."

"Any updates from the moon?"

"Shackleton's RL-75 has been putting out 800 kilowatts of heat rather than 750 and the Stirling engine is producing 140 kilowatts of electricity. Since we have a frigid atmosphere to provide more efficient cooling, we'll get 150 kilowatts."

"We had quite a tense time at Embarcadero in the last few sols," noted Rick.

Will nodded. "Twenty-four hours of anxiety, but Carmen and Jerry recaptured the Earth-bound cargo pallet before it floated too far and installed it on the ACV. Those new robotic arms at Embarcadero are fantastic."

"Do you think the expedition restrictions will be lifted soon?" asked Rick.

“Yes. The export plan was approved by the White House over the heads of NASA, but they won’t weaken safety regulations. They’re borrowing funds to hire the additional ground support.”

“But no dome.”

“Not through NASA, but I haven’t given up.”

Rick smiled, wondering about the twinkle in Will’s eye.

Will watched the reactor activation procedure a few minutes, then headed to his apartment. His step had an extra spring in it; the nuke was a key to long-term settlement.

Eve was watching Marshall that morning. The boy saw his daddy, lifted his head, and smiled.

“Hey, my little one.” Will picked up the boy, hugged him, and kissed him.

“He’s doing fine. He’s really moving a lot, now.”

“Four months old; it’s normal, right?”

Eve nodded. “Yes, and lots of fun to see.”

“True.” Will held Marshall for a few minutes, then gave 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 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 just had an encouraging 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; probably a fifth the price NASA would pay, but that's the way government work is! The French have a new ultraviolet protective coating developed for space use that will help maintain the plastic's integrity, though the coating has not been tested to one hundred below zero Centigrade. We've begun calling potential donors. I think MES can contribute the dome if we can figure out how to get it to Mars. So good news is rolling in. Congratulations on docking the Earth-bound pallet to the ACV and landing your first cargo shipment with an unmanned shuttle. It's a historic moment at Aurorae. Bye."

Will quickly recorded an acknowledgement and thank you, then a new message from Lassen arrived, which he listened to.

"Good sol, Will. Please congratulate your 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 ISS-2 are still trying to duplicate the problem with their arm. They've promised a report and recommendations within twenty-four hours. We can avoid the mess next time, but that won't mean a different problem won't crop up. Bye."

He listened to the message again to savor the positive tone. The Mars team had made a few compromises; the ACVs would be controlled by Mars until they were half way to Earth to reduce Houston's work load. That tied up one person on Mars a few hours a week. If the experiment worked Mars might eventually bid for deep space service contracts. They had already relayed communications to the advanced robotic probes 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 ISS-2 and Shackleton, an informal email from David Alaoui in Paris, two new reports to read—one of them the report Rosa had mentioned about the RL-75 reactor in use at Shackleton—and several news clippings about Mars that a volunteer sent. The volunteer very reliably sent just the important articles and often provided a summary about lesser publicity. It gave Will a source of information independent of the Public Information Department. He went up and fetched Marshall so Eve could do other things. He held his son and read. Once Marshall began his late morning nap, Will recorded messages.

That afternoon he helped unpack the supplies and verify inventories. As the sun was setting, Will carried a last load of items to the basement storage area of Habitat 4 and detoured into Greenhouse 5 where Lisa and Gaston were setting up plant trays. The eastern side of the greenhouse was enclosed with a silvered insulating blanket, its 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 young plants.

"Wow, you've made a lot of progress in the last few sols," he said.

"It's looking good, doesn't it?" said Lisa, pleased. "The plants are really pretty. This greenhouse was set up much faster than Greenhouse 1."

"The six of us had less spare manpower, we had to make plant trays out of rock walls covered by parachute material, and 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 staff; they already have experience and training.”

“I’m really thrilled with this opportunity,” said Lisa.

“When will we have the water purification plant functioning?”

Lisa glanced at the large tank occupying one end of the greenhouse. “It’ll take another month for the bacterial ecosystem to mature. We still don’t have the rice paddy set up; we’re starting on that tomorrow. It’ll take two or three months for its ecosystem to function optimally.”

“That’s what I thought. When the expedition leaves next month, our drain on the outside water supply will decline substantially.”

“Before that, we’ll use the reactor heat to vapor-purify the bath water,” noted Gaston.

“We already have enough heat for that, we just don’t have the plastic piping to bring 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 walked to the connection to Habitat 4; except for a bit of sunset glow and the pale luminescence 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.

It was seven o'clock; time for supper. They all walked to Habitat 3 where everyone had gathered. Madhu had cooked tilapa, bread, a turkey vegetable soup, several vegetable dishes, and a vanilla cake.

"Very good, as usual," Érico said to Madhu as he finished his first helping.

"Thanks, Érico."

"Say, Érico," said Roger puckishly. "You must be pleased we now have a nuke."

Érico glared at him; his anti-nuclear feelings were well known. "We can be thankful there was no accident to get it here and let's hope it doesn't have an accident."

"Accident? The most highly reliable source of energy ever developed, impervious to meltdowns? The nukes have revolutionized exploration of the moon; it's now possible for an expedition to keep going during the two-week nightspan, thanks to nuclear powered floodlights! Shackleton can produce more hydrogen and oxygen fuel than ever before, and outposts on the equator don't need to store power for nightspan. Incredible!"

"We've traveled thousands of kilometers here without them and could continue to do so. The convenience comes at a big price: *one billion dollars each.*"

"We couldn't explore the polar regions without them; winds and dust make solar energy problematic even when the sun's up. They're essential during dust storms, too. This is the greatest gift to Martian exploration ever."

Érico said nothing.

"Oh come on, admit it!" said Roger with a smile.

Jerry, alarmed by the sharpening tone, shook his head. "Don't push him."

"Jerry, what do you think? Could we go to the poles or clear the circumnavigational without nukes?"

Jerry hesitated, then shook his head. “They’re a key to success.”

“The poles would require a mad dash,” said Érico in a small concession. “But the circumnavigational just requires more time without them.”

Jerry didn’t want to argue with Érico. He stared at Roger briefly, as if to say “Cool it.”

Conversations resumed. Roger got a second cup of coffee—with a bit of swagger in his walk—and Érico got a second helping of supper. Once Ethel was finished eating, she was ready to leave; Marshall was asleep in her arms. Will nodded to the others and left with her. Jerry hurried to catch up. “Will, you should have intervened in that argument!” he said urgently once they were out of earshot.

“Jerry, there’s something you need to understand about Roger and Érico’s friendship. Sometimes they have to argue. Roger usually starts it. It’s like arm wrestling; it isn’t harmful. They respect each other immensely and are baffled by each other’s ideological positions; the tension between those two facts produces the verbal arm wrestling. They’ll be sitting together pouring over maps later tonight or tomorrow and there’ll be no bad feelings.”

“Really?” Jerry was baffled by that.

“Really.”

Will and Ethel headed to their apartment, tucked their baby into his bed, and set up the living room. At 8 p.m. Gaston and Eve Gilmartin knocked on the 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.”

“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.”

“We don’t yet,” Eve corrected him “But it’ll be finished in a few weeks in Habitat 4’s top floor.”

“And you’ll even have windows!” added Ethel. “We don’t have that. Here, sit down.” She pointed to the homemade couch. She and Will sat in metal 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’ve held up,” said Ethel. “They’re wrapped in parachute and covered by a tablecloth we imported from Earth. The frame’s welded iron. 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.”

Will opened a plastic cooler near his chair. “Let me serve everyone. This is real ice cream.”

“Real ice cream? Where’s it from?” asked Gaston.

Will smiled. “The Commander has a special mass allocation. In Columbus 1, it was split between Laura and Sergei, and Sergei used his half to bring vodka and wine. 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, 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 opened the pint of Cherry Garcia and began to scoop it into bowls.

They ate the ice cream silently; it was too rare of a luxury to speak. When they finished Ethel said “mint tea? It’s local.”

“We’re getting used to it,” replied Gaston.

“Regular tea ran out 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 do you plan to stay here?” asked Gaston. “It’s a hardship assignment, don’t you think?”

“So far, we’ve managed fine,” replied Will. “You adjust to the lack of tea, ice cream, and worse. Shopping is a slow affair, between speed of light ordering and interplanetary delivery. Marshall can’t fly back to Earth for at least five years, maybe ten, maybe fifteen.”

“They’re talking about the new SCN-25 nuclear thermal engine being in use in five years,” said Gaston. “That could cut the transport time from six months to three.”

“We’ll see,” said Will. “I’m skeptical. Nuclear will be expensive and we can cut travel times in half with chemical propellants, now that they’re getting cheaper. May be a child can be flown safely back to Earth in a special room surrounded by supplies to reduce radiation.”

“What will you do when he starts to walk?” asked Eve.

“The stairs are very steep, but we’ll install a fence,” said Ethel. “I doubt we’ll want children opening and closing pressure doors until they’re at least seven or eight. But maybe that will change. Our outpost is sixty meters long and sixty wide; there’s a lot for a small child to explore.”

“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 ecology.”

“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. But Seville seems like a vocational retrenchment after being here.”

“I know what you mean; but it’s a beautiful place. I love 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,” said Will. “I’m hoping Pavel will 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.”

“Don’t you worry about Marshall’s health?” asked Gaston.

“All the time,” replied Ethel. “I worry too much! I worry about anything that seems out of normal, even though all children deviate from the norm from time to time. We’re going sol by sol and trusting it’ll work out.”

“That’s all you can do,” said Eve. “The animal studies have been positive and the problems that have been identified are solvable.”

“Especially if we can habituate him to wearing clothes with weighted pockets, once he starts to walk,” agreed Ethel. “But that means all the clothes 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 sewing pockets into the longer hems and wider girths.”

“I’ll help; I’m good at sewing,” said Eve. “My mother taught me well.”

“Thank you. My grandmother tried, but I didn’t learn very well,” said Ethel.

Will sipped his tea. “I’m glad to be getting to know you both. So maybe you can help 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 looked surprised. His voice was calm but strained. “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 living together. All three of them speak French together, rather than English; Patrice is not completely comfortable in English, and even if he were, there is no regulation 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’s not cosmopolitan or sensitive,” added Eve. “He would not have been a good commander for Mars operations 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.

“Not much, but I had a Mexican 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 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.”

“The Bahá'ís stress the family as well,” added Ethel. “That’s emerging as a central aspect of this place also.”

“Yes, it is,” said Will, startled by her insight. “That hadn’t occurred to me.”

“Sure it has,” replied Ethel. “We’ve been pursuing an informal emphasis on marriage and family for some time.”

“True, but I didn’t think of it as a central priority.”

“Stressing marriage and family is a surprising priority,” said Gaston, uncertain what he thought of the idea.

"I think it's important," 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.

Will did not sleep well that night; Ethel's comment and Eve's supportive remarks had triggered a brainstorm. Mars needs to be *settled*, not just *visited.* That meant long-term commitments to stay, which implied marriages and children. Genetics and upbringing fitted human beings to live that way. All the keys for settlement were now in place: their food, water, and power supplies were stable; they had safe housing; they could export to cover some costs; they had a civic authority; and they had started to construct their own buildings. 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 possibly coming soon.

Before the sun exploded above the eastern horizon Will was up. He threw on clothes and headed downstairs to his office. 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 day's work. Will activated the videomail software and recorded a message.

"Good morning, Harold." He intentionally avoided "good sol," which Lassen didn't use. "I want to bounce some ideas off of you. They are of the sort that you may consider crazy. A year ago they definitely would have been crazy. Three years ago they would have been unthinkable. But I want to try to formulate them for discussion.

"Mars needs 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 originated 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. When we establish temporary bases in the polar regions, we'll be laying the foundations for human exploration of the outer solar system. Phobos and Deimos are testing grounds for technologies for exploring the asteroid belt and near-earth asteroids. The interplanetary transit vehicles are helping us learn 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 and making the Outpost a long-term human community. Exploration of Jupiter and Saturn by human beings, even with advanced rocket technology, will involve missions of at least four years. We have to learn how to create stable, diverse, international communities of professionals able to work together for very long periods of time. 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 has five people out of fourteen committed to stay two columbiads. My proposal is that we also request three-columbiad commitments and aim to increase the percentage of the crew pledging to stay either two or three columbiads to fifty percent

of each arriving crew. I see no reason to raise it higher than fifty percent. People like Jerry McCord, Sebastian Langlais, or David Alaoui have made very important contributions to this place and have earned the right to come here through their long and distinguished careers.

"Second, the long-term people who come here should first gain experience as ground support personnel. We're delighted to have Lisa and Gaston here, who both worked in Seville. Jerry was capcom. They arrive ready to work; not much training is necessary.

"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 at least one divorce because of a spouse remaining behind. When people who have just divorced come here it produces difficult social situations in our tight quarters. Tight quarters produce all sorts of difficult situations among the single people, too. Couples generally bring stability. I admit, a bloody divorce could be immensely complicated; but we now have enough habitats for people to live separately, 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. He held Marshall and played with him while Ethel got ready. When they headed for breakfast, Will saw he'd received a message.

"I bet that's Lassen."

"We'll see you in a few minutes, then," replied Ethel. "I hope it's positive."

"All I did was articulate the informal policy you and I have tried to pursue." Will entered his office and played the message.

Lassen's 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 trace the trajectory Mars is following, it implies that the idea will be acceptable in a year or two and natural a few years after that.

"And I suspect that will be the trajectory of this idea. Perhaps the timeframe will be longer; decades. I see no reason why you shouldn't hasten its acceptance via your blog. You've been a pretty cautious blogger heretofore, but I think if you continue to avoid comments about current situations, you can and should comment about long-term trends.

"My role is not to oppose the idea, but to make it practical. It encounters one serious obstacle: every person on Mars requires housing, consumables, waste recycling, pressure suits, equipment, vehicles, electrical power, and much more. Right now it totals 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. Columbus 1's crew was small and it needed one duplicate copy of everything, so we flew double the required mass there. That has allowed rapid expansion of the crew. But the

percentage of equipment that is surplus is now down to twenty percent and can't drop much more.

"Consequently, the only way your proposed policy can be pursued is if Mars becomes much more self sufficient. Your facilities are designed to accommodate a total of twenty-seven adults and you have twenty-three. The greenhouses will be able to feed twenty. If most of the Columbus 3 crew decides to stay, it will be impossible to fly eighteen people to Mars on Columbus 4; we can't afford to fly three twelve-tonne habitats, nine greenhouses, three surface vehicles, plus the tonnes of equipment and consumables they need. It's now looking like use of the Swift shuttle is inevitable and it will cut shipping costs, but the costs will still be staggering. 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 on manufacture of pressurized housing to make them possible."

11

Construction

early August 2040

A week after the *Alba* descended from orbit with the first cargo pallet, the *Apollonaris* roared aloft to chase the second automated cargo vehicle. The shuttle transferred its Earth-bound cargo to the ACV, picked up the second Mars-bound cargo pallet, and landed, all under remote control from Habitat 2. Shortly thereafter the Lifter *Stickney* rendezvoused with the ACV, fired its engines, and sent both vehicles on a trajectory to Earth.

The second cargo pallet included their second nuclear reactor, third ranger, eighth greenhouse, and supplies. Within two weeks the second reactor was putting out 75 kilowatts of power. The first was boosted to 150 kilowatts of electricity. The Outpost needed every watt of power it could get: one shuttle needed to be refueled to retrieve the last ACV and production of iron and plastic was increased to provide materials for constructing their building.

Three weeks after the *Apollonaris* returned, the *Elysium* blasted off to obtain the last cargo pallet and load the last ACV with fifteen tonnes of rocks. When it returned five sols later, it brought their second conestoga, ninth greenhouse, and the last of their supplies. The third ACV rendezvoused with the Deimos-based Lifter *Voltaire*—named for that moon's largest crater—and headed on a twenty-two month journey to Earth.

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 to the construction site to

inaugurate work on the new building. After a brief ceremony, three rangers with steel-reinforced bulldozer blades began to excavate the foundation.

Will watched the rangers do their work. The building was an ambitious project, 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 of floor space would provide housing and work space for eight. It would take at least a year to complete; they would need two of them to provide quarters for Columbus 4, which arrived in less than two years.

Will turned to Pavel, who stood nearby. “How big are the windows?”

“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 modifications.”

“No, I’m thinking about another project. They’re forty centimeters across, right?”

“Correct. Bigger than portholes, and now oriented to let in morning and evening sunshine, thanks to your request.”

“Good. And we can make them completely ourselves.”

“Not exactly. The three automated landers we’re dismantling have plenty of weldalite alloy; it’s higher quality than the nickel steel alloy we can make, and that’s important for the window frames. But this building will use up most of it. 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 trench greenhouses; they’re on the website. Could we excavate a trench, line the bottom and sides with duricrete, and enclose it with an airtight polyethylene cap?”

Pavel nodded. “I’ve seen the trench greenhouse design. The Space Construction Institute in Moscow can make polyethylene strips identical to ours and determine how to overlap them—our equipment can make them up to a meter wide and eight meters long—stretch them, and glue them together to make an airtight structure. Straight-chain polyethylene is almost as strong as Kevlar. But it’s translucent, not transparent.”

“Plants don’t care about that. We don’t have the equipment to assemble the strips into wide sheets, though.”

“We can jury-rig something; there’s a technical report about that. It’d be simpler importing the plastic from Earth, and take a lot less of our time.”

Will shook his head. “I want to keep down our import mass as much as possible; otherwise, we can’t keep expanding the population here.”

“You’re not saving 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. We can reduce the mass of the equipment also. How wide can a home-made greenhouse be?”

“Three to six meters.”

“I’ll talk to Houston about it.”

“The construction consultants are still helping us with the building!”

“They can turn to this problem when they have time. Or maybe the Mars Exploration Society can help.”

“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 call me about anything.”

“Okay. Bye.”

Will 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 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.”

“You’ve got time?”

She glanced at her watched and nodded. “Cooking lunch takes ninety minutes. This sol I need to prepare frozen vegetables for the expedition, and I’m baking them a week of bread.” 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, but his heart is in staying here anyway. Once he gets used to the situation, he'll love having a baby. I know Roge."

"You're right; under that crusty exterior is a heart of gold. When's the baby due?"

"About seven and a half months."

"Wow!"

"It's still early in the pregnancy. Marshall needs someone to play with!"

"We've got to think about releasing the information. You and Roge have to decide when to let everyone know."

"Give us a few more sols."

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 being set up at once, 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 site, and we've called in Karol as well. We can't get the Lifter *Gulliver* to dock properly. That means we can't reconnect it to the fuel making unit to refuel it."

Will was surprised. "That's a real problem. Is it a problem on the *Gulliver* or the docking platform?"

"We 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. The lack of disposable diapers was a real pain; they had to be cleaned 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 commander of Shackleton Station on the moon, and checked the Outpost’s inventories.

At noon he brought Marshall to Habitat 3’s Great Room while everyone ate lunch. Marshall loved the hubbub of people at mealtimes. Ethel nursed him and 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 fancier than usual, so people lingered. Afterward a group played cards in the Great Room while others visited friends or watched television in Habitat 2. Everyone looked forward to the weekend, even though they worked five hours on Satursol. Weekdays they worked ten hours a sol, for a total of fifty-five hours per week, but they had separate no kitchen and cleaning chores.

Will and Ethel entertained the Strogers that Frisol; 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 playing poker with two empty bottles of brandy on the table.

“Did you all drink these bottles tonight?” he asked.

They 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. You won't be sober enough to go outside in the morning."

"Commander, you can't impose your personal views about alcohol on the rest of us!" objected Pavel.

"This has nothing to do with me. 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. All of you are grounded until at least 11 a.m. tomorrow. I suggest you relax in the morning and work one to six."

I *have* to go outside tomorrow; I'm in charge of the work," protested Pavel.

"I've got plans tomorrow afternoon!" exclaimed Patrice.

"The time to drink is Satursol night, when you're free the entire next sol," 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 was your choice. A single serious accident can cost us a life, damaged equipment, and several hundred million dollars in political and financial support. It's nothing to shrug off. Safety must be of paramount importance. 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 sobriety that the safety regs set. So this shouldn't surprise you."

Pavel and Patrice stared at him, angry, not daring to reply. Will shrugged. "Those are the rules. Good night." He headed back to his apartment.

The next morning the three rangers were busy excavating while two astronauts did routine repairs on the drilling equipment and two others did 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 are exposed in 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 the tectonic continuation of Candor, even if they aren't connected."

"I'd favor Noctis Labyrinthus," exclaimed Neal. "The tectonics and volcanism in the area are fascinating. It's essentially a dissected 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. And its midsummer right now."

"It's an ideal time, I agree," said Jerry. "But the first expedition is scheduled to shake down the new rangers, the new conestoga, and a nuke, and I don't think they should travel that far 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 has four months yet. In six weeks the seasonal cap will be further sublimated from the north pole, which is better for the vehicles and the geology, and the temperatures will be higher and more optimal." He looked at Will.

"I agree," said Will, not wanting to undermine Jerry, as Director 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, cleaning up Route 1 as we go. If Candor is uninteresting, we head to Noctis earlier; if it’s interesting we extend our stay.”

“I can lay out a four-week sojourn,” replied Lal.

Jerry shook his head. “Lay out a two-week plan plus a two-week extension.” He looked at Neal. “Same for Noctis.”

“Okay,” said Neal. Neither he nor Lal looked satisfied.

Just then Shinji came up to Will. “Can I talk to you privately?”

“Sure.” Will followed Shinji out of the Great Room, to 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 passed through the airlock, greenhouse, and docking unit into the pressurized tunnel to Habitat 4. The tunnel was unheated and frigidly cold, but it was only a few meters long. They entered Habitat 4 and turned left into a semi-circle with four private rooms. Karol’s name was on his door; they knocked. A moment later he opened it, saw Will and Shinji, and frowned.

“Can we talk?” Will asked.

“I guess.”

They entered his room and closed the door. “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 are much tougher. That’s true on the moon and earth orbit as well.”

“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 habs done this sol.”

“Commander, you’re humiliating me! I have a doctorate in mechanical engineering!”

“And I have a doctorate in geology, have published more papers than you, and I’m Commander. I clean all the time. Everyone has to clean, and if people are going to drink excessively they’re going to do a lot of it. There are no blood-alcohol limits for using brooms and floor cleaners. 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'll lose half your evening free time, two nights a week."

"Okay, okay," said Karol.

12

Gold

late Aug. 2040

Jerry McCord headed straight to the ranger's cab as soon as he rose from his bunk bed in the portahab. The four new vehicles—two rangers, a portahab, and a conestoga—had set out on their first expedition and had stopped for the night near the point where Candor Chasma opened into Melas Chasma. The vehicle was facing north, so the windshield was oriented perfectly to see the towering escarpment illumined by the dawn's first rays.

Jerry was awestruck by the sight. He opened the hatch to the portahab. "Take a look at the escarpment while the sunlight's still pinkish!" he shouted 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 into the cab. "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. It reminds me of the front range of the Himalayas. The peaks rise about 7,000 to 8,000 meters above the Ganges plain. Of course, the Himalayas are separate mountain peaks, like the Tetons, and they're hundreds of kilometers back from the plain. This is a solid, unbroken wall."

“You’d have to drain the Red Sea and look up from the abyssal bottom to find a view comparable to this.”

“Even the Red Sea usually isn’t 5,000 meters deep!”

“There’s really nothing in the inner solar system you can compare it to.”

“Nothing. I’ll remember this all my life.”

“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, laughing. He planned to stay at least another columbiad, but Jerry had repeatedly said he wouldn’t.

The colors began to fade. “Let’s get washed and have our breakfast so we can get into Candor this sol,” said Jerry. “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. Will Elliott was calling from 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 and north into Candor.”

“I remember the route. I was 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!"

"We stopped at one of those spots yestersol. I'd like to clear a 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. An hour ago we got clearance from Houston to send out two three-vehicle expeditions when you get back, or one five-vehicle expedition. They'll have more ground support 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 it. 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 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 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. ESA plans to purchase a Swift shuttle early next year to supplement the Ariane launch system at Kourou. The decision is straining their relationship with NASA, so watch out; NASA wants to keep the Ares and the French want to keep Ariane, but there aren't enough oversized cargos to support both systems.

"This means we can get the dome into low earth orbit for $25 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 ion 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 a lease of 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 our 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 $75 million plus $100 million in launching costs—using their expensive expendable launch vehicle, of course—but we want to avoid that.

"So it's beginning to look like we can develop the dome for about $75 million, plus there will be transfer costs of $5 million, the leased tug will be $15 million, the launch to LEO will be $25 million, the argon will be $2 million, and the lunar fuel for trans-Mars injection will be $8 million, for a total of $145 million when you include insurance and administrative costs. We have a few corporate backers lined up. 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. We want an agreement with 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 them for about $75 million, depending on demand, so it'll cover half of our costs. I need your help to 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. I'm 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, private launch capacity, and lunar propellant. It says something about space agency bureaucracy as well, doesn't it? This would have cost them a billion bucks!

"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. We can't launch to orbit without permission. So far, all launches have occurred at the beginning or end of a Columbus flight. That may change in eight months; we may launch a crew to Deimos 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 need a big pressurized open space. Our production of oxygen, nitrogen, and argon is now so large that, if we can't purify our air, 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 to make sure the dome will work. We can do the testing here.

"How big is this dome, anyway? 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, which 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. All of the greenhouses were now green; in a few months the residents of Mars would have near-complete self-sufficiency in grains, vegetables, fruits, and some meats. They were still importing coffee, tea, sugar, many spices, beef, alcoholic beverages, exotic foods such as mangos, and processed foods such as corn flakes. Columbus 4 and 5 would tackle production of some of them, plus fiber for making paper and cotton.

While he was in the greenhouses Pavel called and asked some construction questions, so Will called him over to Greenhouse 9 where they could see each other's faces through the plastic. 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 the manufacturing cost is equal to one! That's the advantage of private industry. 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."

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 drove over a lithified sand dune and down into a large area where eolian deposits had eroded away, exposing the underlying channel deposits. Several catastrophic floods had issued forth from Candor and for a few million years a stream flowed from the canyon intermittently, producing one of Mars's more mature fluvial features. They had good reason to stop and explore.

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 well documented. He noted the crude stratification and imbrication of the cobbles with an expert eye. The materials had a different physical appearance on Mars because weathering proceeded in mostly

subfreezing conditions in the absence of oxygen; the rocks were not 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 everyone could hear.

"Gold? Really?" asked Jerry, who was nearby.

"Yes, a very nice nugget. Pure gold. 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.

“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; it was worth more on Earth 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 conestoga,” 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 rear 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 two rangers and portahab arrived and they waited while the vehicles docked together. 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. “Please, bury it in the daily report! He’ll want us to become gold prospectors.”

“Jerry, this can help pay for Mars exploration,” said Lal. “I spotted four nuggets in fifteen minutes; maybe 250 grams of gold. If we look closely, we’ll find lots of gold flakes.”

“We should find out,” agreed Érico. “This is not the time to collect a lot of gold, but we can study the deposit.”

“You guys are behaving like colonists, not scientists,” complained Jerry.

“We’d need equipment to collect it anyway,” assured Lal. “Specialized equipment needs to be imported from Earth. 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. You can ‘pan’ for gold in liquid CO_2 just as well as in water.”

“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 and 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, 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? A lot or a little?”

“In fifteen minutes I found four nuggets and picked up three. I’ve weighed them; 233 grams. 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 looks 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 was awake in bed, listening and 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 Mars and have stumbled onto gold.”

“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 size as the Martian surface and it had hundreds of rich deposits of gold. We’ll only go after the richest ones.”

“Which might make them 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.”

13

North Pole

October, 2040

The three vehicles of the Marineris Expedition approached the Outpost. Six weeks of exploration had taken them through parts of Candor Chasma and 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, Roger Anderson greeted Jerry McCord with a big smile and a slap on the back.

"Welcome home!"

"It's good to see you again! Where's Will?"

"He and Paul drove to a sand deposit to get a load for the building. You had quite an expedition!"

"It was incredible! But I was disappointed we didn't get onto the Tharsis Plateau. Maybe next time. We need twenty tonnes of water to freeze the ramp together."

"The Sunwings can drop ice blocks and when you go back the water will be there. But you did get up to Tharsis by foot, at least."

"Yes, that was better than nothing. As you said, next time. It'll take a month to finish the ramp. The building looks mostly finished."

"No, not at all! We have the first floor walls completed, but there's no floor or walls yet for the second story. We're almost back to the original schedule. For a while it was looking impossible. The rangers were constantly breaking."

"Why did that stop?"

“They finished excavating the foundation! We had to weld the bulldozer blades almost every sol. But we got the hole dug.”

“Good. We excavated a hundred kilos of gold in Candor Chasma. We broke a blade, too, and welded it. They aren’t strong enough.”

“How much gold is there?”

“The three-sol survey of the placer deposit suggested there were scores of tonnes of gold, but it will take a lot of work to extract it. The hundred kilos was exhausting!”

“Will’s been talking to folks in Berlin about a centrifugal separator.”

“Yes, I’ve heard.” 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 on Mars.”

“I bet. What’s that doing to your research?”

“I’m grounded for the next year. I’ll be doing a lot of local geology and support work and some writing.”

“You’ll be able to make up for it later.”

“Yes, I’m here long term.”

“That’s a valuable opportunity, though this place would get on my nerves after a few years. I guess that means Érico gets to do more, for a while.”

“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. But I miss them.”

“I can imagine. I don’t know how I could stay here a columbiad without Madhu. I’ve come to agree with Will; we need to make Mars marriage and family friendly. It’s the only way this place will become more than a transitory little hamlet.”

“True; but is the technology mature enough for families?”

“It seems to be. The medical technology’s the big question,” replied Roger.

They unpacked the conestoga. Then Jerry suited up and, out of curiosity, walked around the construction site. The hole in the ground had been filled with a flat slab of duricrete, a mixture of eolian dust and crushed, roasted duricrust that had been formed by natural cementation processes over the ages. When the two substances were mixed with the right amount of water and poured into a heated, airtight mold, in a few hours they made a substance like concrete. Reinforced with iron wire and rebar and coated with plastic to make it water and air tight, the result was an excellent building material.

Ninety percent of the first floor walls had been poured. Window openings, encased in metal frames, poked through the meter-thick duricrete. The last section had iron reinforcements installed and was encased in a sheet metal mold, ready to receive the duricrete mix. Jerry did a quick calculation based on a density of two tonnes per cubic meter and figured the first floor alone required 400 tonnes of duricrete. No wonder the construction had taken so long!

He looked through a window hole. Installation of the ironwork for the interior walls had begun; they would be much thinner because they were not designed to hold 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 hiked 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 Commander Elliott.

Two weeks later a second expedition set out, with two rangers, a portahab, two conestogas, a nuke on a trailer pulled by the robotic truck, and eight people, bound for the northern polar region. They moved down the “Polar Trail” as Route 2 was being called—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 two hour every sol they stopped to do 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 the Polar Trail as constructed the previous annum (Martian year) in nine sols.

The last expedition had had huge difficulties surmounting the cliff edges of the layers in the layered terrains. But now they could use the nuclear reactor to construct ramps. While two rangers bulldozed debris in place against the slope, the reactor was moved as close as was safe—because of its radiation—and a one hundred meter hot air hose was uncoiled robotically to connect to a melter. The conestoga used a scoop on its robotic arm to feed ice chunks into the melter, which expelled a steady stream of water 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 to the next cliff. 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.

Three and a half weeks after the expedition set out from Aurorae, Will got a telephone call from Érico. “Commander, we’ve just arrived at 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 tune 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. 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 near-cryogenic conditions. You’ve helped pave the way for human exploration of the Galilean satellites.”

“By our children’s generation.”

“Probably. This is a great connection.”

“The polar satellite has given great communications and GPS. But we’ve got only three hours before it drops below the horizon again.”

“I’m in the control room, waiting for the television transmission. 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. Just then Jerry McCord called.

“Are you ready to go out yet?” he asked from the portahab. “We’re ready here! Maybe the Director of Exploration should trump the expedition commander.”

“Not on your life, Jerry! I’m stepping into the airlock right now.”

Érico grabbed the United Nations and Brazilian flags, then he and Carmen squeezed into the airlock. A few minutes later he opened the outer door and stepped down onto the ground. The view from the top of Mars was fascinating and breathtaking. The ground was white to the horizon, but the trained eye could easily tell water ice apart from 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 and crater ejecta from distant impacts.

Érico looked up at the dark blue sky. 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 gave no heat.

The others came out of their vehicles. There was a slight mound a dozen meters away; Érico headed there to give the ceremony a better setting.

His communicator beeped; it was a private call from Jerry. “Are you going to erect the U.N. flag? Where’s the American flag?”

“Jerry, I’m not American and this isn’t an American expedition.”

“Érico, the United States paid for the bulk of this expedition! The U.N. hasn’t paid a penny!”

“Thirty percent is not the ‘bulk.’ I can erect the Brazilian flag first; this is a multinational expedition. I have chosen to erect the United Nations flag first instead.”

“Well, then I’ll raise the American flag!”

“Suit yourself, Jerry. You’re free to do so once I raise *my* flag.” Érico punched the connected closed.

The other seven gathered in a semicircle around Érico. Carmen stood opposite him so that her camera could capture his facial expressions and movements.

Érico raised the U.N. flag. “We gather here to mark a significant milestone in human exploration of this solar system. It is an achievement that is possible only because all our governments 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 in peace for all mankind.”

The others applauded; the sound of gloves beating together came faintly over the microphones. 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. Almost immediately Jerry installed an American flag next to the U.N. flag on a pole of equal length. The other expedition members deployed their national flags on shorter poles. Jerry returned to the conestoga to get a twenty-liter canister of ice water and poured it onto the pile, freezing it into a permanent anchor for the flags. A gust of wind caused the array of flags to billow and flutter, much to their pleasure.

Érico hailed Jerry on a private line. “Did you have to use a long pole?”

“It’s my country,” replied Jerry forcefully.

They got to work deploying the ice drill; they planned to remain several weeks to bore a substantial distance into the polar terrain. Finally, while the satellite connection lasted, they began a systematic exploration of the area.

Will Elliott lingered in the control room after the polar satellite set, ending television and data transmission. Short-wave radio transmissions continued to carry the banter among the geologists as they explored the remnants of a carbon dioxide geyser. Will offered occasional suggestions until he noticed a flashing icon on his attaché. He had received a videomail from Harold Lassen, the director of Mars Mission Operations.

“Good day, Will,” Lassen began. “Congratulations on a very successful ceremony at the North Pole. Who would have thought that, five and a half years after the arrival of humans on Mars, we’d achieve such a milestone! The tv audience was several tens of millions, too; not bad, considering all the competition nowadays.

“I’ve recommended that you be added to the team negotiating the Mars Commission treaty. Yours will be a token presence; the meetings cannot be redesigned to

accommodate the communications time delay. Your track record as an innovator and your role as Commander make your input imperative.

"Since the negotiations resumed two months ago, the treaty signators have agreed to renounce any territorial claims over Mars, Phobos, and Deimos. The Mars Commission will have territorial jurisdiction and will be responsible for exploration, exploitation of resources, and settlement. It will have the authority to define units of civil administration, which will make the Borough of Aurorae and its governing declaration fully legal. The Commission will probably 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; it'll probably share space with the Lunar Commission in the new building being erected for the latter. As a result of the Mars Commission negotiations, the powers of the Lunar Commission are under review. The lunar treaty needs to accommodate private mining operations, additional national stations, and construction of tourist hotels.

"We look forward to your participation. If you have any questions, let me know."

Will smiled excitedly. He hit reply. "Thank you, Dr. Lassen, for this opportunity. I'll be honored to participate. Mars has become my life. 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 forward. 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. You can count on me to do my best. Bye."

14

Conjunction

early Feb. 2041

The sunwing circled the Outpost, giving both Jerry and Lal a good view of the habs, solar power units, wind turbines, and shuttle pads. Jerry brought it in slowly and carefully, touching down gently at the beginning of the landing strip and braking gently to stop at the hangar at the end. He and Lal suited up and stepped out, to be greeted by Roger.

"Welcome back to the Outpost!" Roger said, hugging them both.

"Thanks," replied Jerry. "I see the building's enclosed! When we left on December 1, the second story walls were half finished!"

"We've accomplished a lot in three months. And you got out of Noctis Labyrinthus and all the way across Tharsis to Arsia Mons! Congratulations!"

"Thanks. We're making good progress. Érico's team is moving the eastward extension forward even faster; the Central Highlands are easier than uncratered volcanic terrain. The Circumnavigational now stretches a third of the way around Mars."

"Let's get on the buggies and ride to the Outpost. We have a late lunch saved for you, before the meeting starts."

"Late breakfast for us," corrected Jerry. "I hate big two-planet meetings."

"We all do, but it's conjunction; time to reassess plans."

"At least we have good communications with Earth this time, thanks to the Venus satellite constellation," noted Lal.

They climbed onto buggies and rode to the Outpost. Érico and Carmen greeted them; they had landed just an hour earlier. They all went to Hab 4's great room to eat.

“I want to see the new building,” Jerry said to Will, as they finished

“You’re demonstrating more interest in the project than I expected!”

“It’s an ambitious effort. I was proud to work on it, during the three weeks after we returned from the North Pole and before we left on the circumnavigational.”

“Last week we pressurized the building with oxygen. Do you want a tour now?”

“Sure!” Jerry and Will rose. Lal and Érico joined them; Pavel, proud of his achievement, came along. Will led them through the airlock and into a plastic tunnel that ran southward to the building’s nearest airlock. They entered the lower level.

Daylight streamed into the great room, which was ten meters square, through three windows. It was a mess; electrical lines were being laid across the ceiling and pipes along the wall; electrical fixtures had dangling wires; the floor had piles of debris. But Jerry was impressed anyway. He felt the wall. “It feels like plaster. You did a great job of smoothing it, too.”

“The hard part was inside the wall,” replied Pavel. “It has two sets of reinforcing rods, two curtains of wire mesh, and under the plastic finish you’re admiring is a spray-on coating to improve pressure retention.”

“There are still leaks around the windows,” added Will. He pointed to caulking around the edge of the metal sheathing. “They’re pretty slow now. This place can hold air within 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 in the back; the kitchen?”

“And food storage,” replied Will. He led them through a doorway to another empty ten by ten meter space.

They climbed the stairs to the top story. A central corridor ran down the middle of the floor, with five doors on each side opening into unfinished rooms four and a half meters square. Each had a window. “One of these will be a bathroom,” explained Pavel. “The other nine will be bedrooms or work areas. The building can accommodate six people for their sleeping and work comfortably.”

“So, when this is finished, the Outpost’s official capacity is raised to thirty-three,” said Jerry.

Will nodded. “Correct. We can 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 Columbus 4 would have to bring. But they could be installed in 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. Eleven chairs were set in a semicircle with two cameras facing them to send their images back to Earth. Several microphones transmitted their audio to Houston,

where a dozen officials would sit in a similar semicircle. Madhu stretched out on her chair; now eight months pregnant, she was 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 watch the discussion on tape once they were ready. “A minute ago Jerry asked how many humans will be here when Columbus 4 arrives,” Will began. “That’s a good place to begin. Yestersol Lassen confirmed that NASA is launching Columbus 4’s cargo on Europe’s new Swift shuttle. They’ll purchase a Swift in the next two years. Larger items like ITVs and surface vehicles will be launched on Arianes, which the French have committed to maintain. The Ares series will be phased out after it launches a few large items the Arianes can’t transport, like Mars shuttles. Columbus 4’s anemic budget will cover the original plan: two shuttles, four interplanetary transit vehicles, and sixteen people. If the Chinese are invited they’ll add one or two more. The sixteen will include five couples.”

“Five couples?” Jerry’s eyebrows went up. “Congratulations, Will. You won.”

“This represents a commitment to long-term settlement of Mars for the purpose of scientific research.”

“How much cheaper will launching Columbus 4 be?” asked Ethel.

“The whole mission will cost two thirds as much as Columbus 1.”

Several laughed; it was an embarrassing difference. “So how many will we have here?” asked Carmen.

“Good question,” replied Will. “Ethel, Marshall, and I; Roger, Madhu, and child; Érico and Carmen; Eve and Gaston; Neal and Rosa; Lal—”

“Shinji’s leaving,” said Roger.

“No, I talked to him yestersol and he told me he wanted to stay for a fourth columbiad,” replied Will. “Jerry, you’re planning to leave?”

Jerry nodded. “I feel torn, 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 some good examples of happy marriages around us, so 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 adults staying and six leaving. That means if sixteen arrive on Columbus 4, we’ll have thirty-three, and if eighteen arrive we’ll have thirty-five.”

“We’ll need the second building,” exclaimed Pavel. “No problem. We can get started on it right away. I can supervise on the flight home.”

“But the heavy construction 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.

“Even with thirty-three to thirty-five people on Mars, the agency won’t have to fly out a habitat,” said Pavel. “That saves twelve tonnes. Our greenhouse experiment needs to proceed, 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. Heather Kimball told me negotiations with NASA to send their ‘Mars dome’ are moving forward well. It’s thirty meters across and has a floor area of 700 square meters, enough to feed seven to 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 consumables will have to be able to feed everyone if one vehicle is lost; and the new risk assessment suggests the danger of losing a Mars shuttle is one in one hundred fifty, not one in five hundred as it had been thought.”

“Really?” Jerry was surprised. “That’s a serious reappraisal!”

“The committee made many 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. We're out at the end of a long supply line with equipment of uncertain reliability." Will looked at his agenda. "We know how many will be here. We need to complete the first building, build a greenhouse prototype, and almost complete a second building. Turning to the expeditions: We're moving into dust storm season. Storm winds can prevent sunwings from landing and eliminate emergency rescue capacity."

"We're already too far away for the sunwings to provide effective rescue anyway," said Jerry. "It took Lal and me twenty hours to get here."

"From the far side, a return flight will take sixty hours," added Érico.

"We'd have to send a shuttle with an emergency medical team and refuel it there using the nuke's power," said Roger.

"But sometimes duststorm winds are too high for a shuttle landing," replied Will. "What do you say, commanders?"

"My people want to explore," replied Jerry.

"Same here," agreed Érico. "We have Shinji, so our medical care is covered. Jerry's expedition doesn't have a doctor."

"Could we get Eve for a few months?" asked Jerry, looking at her.

She 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. But we can send a medical robot; either physician can perform basic surgery remotely with it."

"Everyone has basic medical training," added Will. He looked around. The others who often went on expeditions were nodding. They wanted to take the risk. "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 September 5. Seven months. If each expedition advances nine hundred kilometers per month, they can clear 12,600 kilometers of trail 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. “Forty’s possible.”

“But should we try this simply for the sake of doing it?” asked Roger. “If we don’t complete it before blastoff, we can complete it later. Right now there are sols the expedition manages fifty kilometers, but other sols they travel less, and they don’t travel at all on Sunsols.”

“And there’s the South Pole,” reminded Érico.

“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.”

“But is that a reason to risk life and limb?” asked Roger. “Let’s think safety, not career achievements.”

Jerry scowled at Roger. Roger frowned back at him. Everyone knew where Jerry’s heart was. “We have to remember that the return trip from half way around—11,500 kilometers from the Outpost—will take at least eleven sols,” said Will. “It’s not a drive around the corner. It’ll strain equipment. And we can’t postpone blastoff very much. We need two rangers here before blastoff based on safety rules.”

“And remember our roads aren’t arrow straight; they twist and turn, which adds fifteen percent,” noted Roger. “The Circumnavigational still needs about 16,000 klicks.”

“So, we clear forty-five kilometers a sol, six sols a week,” replied Jerry. “That’s over twelve hundred per month. In seven months that’s 8,400 kilometers per expedition, 16,800 total. It’s possible.”

“Assuming no breakdowns,” noted Roger. “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. “The Circumnavigational Trail should be made for speed and efficiency in mind anyway; it shouldn’t snake after every good bit of geology. Side routes can be made later to the geologically interesting sites, and they don’t have to meet the quality standards that the main route is built to.”

“That’s one approach,” said Roger. “Or the temporary Circumnavigational can snake around to hit the geological highpoints and we can straighten it later.”

“They’re both legitimate plans,” intervened Will. He looked at Jerry. “You’re pushing the limits of what we can achieve. That isn’t necessarily 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 push it forward continuously until late August, with none of the rangers returning to the Outpost before September?”

“I say, yes,” replied Érico. “And I’m in favor of a straight, short, high quality Circumnavigational Trail now with side routes added later.”

"The sunwings are working fine," added Lal. "They can survey any route we choose, drop supplies in advance, and rotate two crew members per month between each expedition and the Outpost."

"We have four or five people who can't leave the Outpost at all, But we have eighteen who can go out," observed Neal.

"Radiation exposure won't be a problem," said Eve. "If twelve out of eighteen are away from the Outpost for seven months, rotations would average almost five months."

"We could run each expedition with five crew instead of six," suggested Érico. "If we did that, rotations would last closer to four months."

"That's doable," said Will. "Pavel, that means the Outpost has a total of eleven or twelve here at any time, including one physician and two mothers. It needs at least four full-time maintenance positions. Assuming the mothers complete the equivalent of one maintenance position, that leaves us four or five people for construction. Can we finish the first building, one experimental greenhouse, and some work on a second building before Columbus 3 blasts off?"

"Yes, though we may not get much done on the second building."

"Alright, then 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, keeping an average of eleven people out at any time; and complete the building, one greenhouse, and start some work on a second building. There's one twist I have to add. We have never been able to get the Lifter *Gulliver* to achieve a proper hard dock on Phobos, after seven months of trying. We need to fly an expedition to Phobos next month to fix its docking mechanism 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.

"There's one thing we haven't tried," noted Ethel. "The *Limtoc* is now fully fueled. If the *Gulliver* can dock with it, fuel can be transferred to the *Gulliver* and the *Limtoc* can fuel up again."

"It might work, but the docking problem is probably on the *Gulliver*." Will nodded. "I'll ask Mission Control about that. With a one percent chance of shuttle failure, I'd rather not fly anyone to Phobos if it can be avoided."

"What will our plans be for the nine months between Columbus flights?" asked Roger.

"I'd favor improving the Circumnavigational and doing geological work along it," suggested Jerry. "The road will open up a lot of territory. One sixth of the planet's surface is within five hundred kilometers of it. The Circumnavigational and Polar Trails will open every major geological terrain on the planet to us. So I favor completing it fast, then taking our time and exploring its territory in detail. If we don't build it to such high standards, we could finish the Circumnavigational even faster."

There was a silence, while they contemplated their options. Finally, Will said, "We'll be developing and improving the Circumnavigational for years. Let's make it as straight as possible, but let's maintain quality standards. I think our priorities for the nine months after Columbus 3 leaves will look like our priorities now: building buildings, clearing routes, and exploring."

“What we can say about the previous nine months is that the surface vehicles worked well and the reactors proved vital,” exclaimed Jerry. “There’s no reason we can’t finish the Circumnavigational.”

Will nodded. “And on that note, let’s take a break. Most of this 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 a cup of coffee, or brainstorm privately.”

Will rose and stretched, followed by the others. They had been deliberating nearly an hour. Marshall had understood that his daddy was busy and had been pretty good at staying away, but now he was delighted to see Will was free. 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 the eleven month old. 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; everyone had watched. “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!”

"That was something to see, then!" exclaimed Monika, smiling.

"Better ask mission control to save the tape for you," suggested Érico. He pointed to the Habitat's ceiling cameras. Their images were stored a week and destroyed unless an emergency developed.

"It looks like walking develops roughly normal here," commented Jerry.

"He's following the terrestrial growth charts in most indicators," agreed Ethel. She added, with 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 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 more steps unaided, then fell into his father's embrace.

They returned from their break 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 worked adequately to brainstorm about 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 coordinated support by thousands of professionals and held the purse strings, so their resources and concerns had to be engaged.

The Houston panel was hardly surprised by the ideas from Mars; Will had engaged in extensive email discussions over the last week 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 hoped and a south pole drilling effort was desired. Plans to revisit known fossil sites could not be accommodated if the vehicles were all tied up. A Phobos mission might still be necessary because the docking problem was almost certainly on the *Gulliver*. Having all the vehicles out on expeditions limited work around the Outpost; buggies could do little. 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 a year earlier. Reducing the quality of the road raised safety concerns if an emergency required higher speed. The second building couldn't be finished before Columbus 4 arrived, raising issues of crowding and redundancy, although the portahabs, conestogas, and shuttles provided plenty of emergency accommodation. Sending consumables, equipment, and ground support for thirty-three people would be expensive.

Different ground support people expressed various concerns or proposed various solutions. Then Will and his team had a chance to respond to the panel in Houston. The most innovative suggestion came from Érico.

"Currently our expeditions have a conestoga, two rangers, a portahab, and a truck with a nuke," said Érico. "But we can replace one ranger with two buggies. We'd clear

the trail with the conestoga. The ranger would follow and clean it up. That's the reverse of their roles currently. The ranger would pull the portahab until it reaches an exploration site. It would leave the portahab and buggies there and come back to pick them up later. The daily exploration team would use the portahab as their base and get around with the buggies. The ranger would be available to either the exploration crew or the conestoga in an emergency."

"Brilliant!" exclaimed Will. "That'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 third portahab here," added Ethel. "So we would be in the position to send out a complete third expedition if need be."

"Don't get too ambitious!" cautioned Pavel. "We can only do so much."

"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. The road clearing crews never get more than fifteen 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 twenty minutes. That's pretty quick."

"This idea addresses almost all the issues raised in Houston, so let's give them a chance to respond," suggested Will. "That'll take forty-five minutes."

"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."

“Good point,” agreed Will.

They took a second break. Madhu rose painfully. She had been very uncomfortable and did not pay close attention to the discussion. Occasionally she had been in pain. Roger rose with her and quietly they left the room. They returned as the panel in Houston began to comment, but rose again, spoke to Eva, and the three of them left after a few minutes. Will watched them go, worried.

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 of or opposed to the plan.

Others expressed more general concerns. Columbus 2 had explored with two rangers, but there were safety risks that only a third ranger or conestoga solved. Using buggies helped, but they had limited abilities. Others focused on the severe labor shortage that a third expedition would cause. The safety of sending a Phobos mission was also sharply questioned; there was already enough fuel for Columbus 3’s departure and the *Gulliver* could be repaired then.

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 to make a quick trip. There

were times the Outpost crew would have less construction to do. Will was not sure the proposals were that convincing.

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. There’s enough data for both sides to go away, put together a proposal based on the exchange, and report them. Lassen and his lieutenants will make the final decision.”

“We could propose that,” agreed Jerry. He looked around. “Where are Roger and Madhu?”

“They left during Houston’s last 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 false labor before. Eve thinks it’s best to let the birth happen.”

“And the baby?”

“He’ll be premature by a month, but Eve thinks we can handle it.”

“Is there anything we can do?”

“Pray.” Roger sounded worried.

“I’ll do that right away. Give us a call when there’s news.”

“I will. Bye.”

“Bye.”

15

The Commission

early March, 2040

Late afternoon sunlight streamed in through the windows 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 Renfrew 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 that was 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.

Then the audience turned to the television screens on the stage and a video began to play. An image appeared of Will Elliott with Marshall sitting on his lap; Madhu sat next to him with Sam in her arms.

"Greetings from Aurorae Outpost, Mars," he began. "On behalf of the twenty-five human beings resident here, congratulations to the governments and space agencies 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 develop the permanent human presence on Mars. And as you can see, that permanent presence has begun. We can no longer ignore the term ‘resident of Mars.’ We have to allow ‘settlement’ to enter our vocabulary. At some point the term ‘colonization’ may become current; perhaps ‘terraform’ 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 controversial. It conjures up images of vulgar capitalists buying thousands of square kilometers of the Red Planet or starry-eyed Mars enthusiasts spending thousands of dollars to own a few rocks. But Mars will never be a utopia and its future in inextricably linked to Earth’s. It has families already and it will have more. It has an outpost that, in a few decades, will become a village with an associated group of outposts. It cannot remain totally dependent on terrestrial financing; it must make a contribution, even if it can’t pay for itself for centuries.

“We have children to educate and it’ll cost several hundred million dollars to import a teacher for them. Would we save money by not having children on Mars, thereby forcing some people to leave after a sojourn of a few years? 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 Earth orbit or the moon. 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 Borough. It will set up a Property Owners’ Association once land is sold, so that the owners have a voice in running 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 terrestrial citizens 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 sell land?"

Will nodded. "Next year."

"But is the land really worth anything?" Roger persisted.

"The Mars Colonization Society has commissioned surveys and hired economists. They think Martian land has a base value of $1,000 per square kilometer.

Roger snorted. "It's a lot more than I'd pay!"

"But the value goes up near the Outpost and the trails," added Eve. "The proposed formula is that within 150 kilometers of the Outpost, the value of land increases 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; who'd pay $100,000 for a square kilometer of land fifteen kilometers from here?" noted Paul.

"That's $1,000 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."

"The trails will open up land all the way around the world," said Roger. "If they sold it all, it'd depress the value."

"They'll make land available for sale in stages," replied Will. "Land adjoining the trails is estimated to be worth four times as much as the base value, decreasing to double the base value five kilometers away and to the base value ten kilometers from the road."

"And we can tax the property?" asked Paul.

Will nodded. "Within Aurorae borough, probably one mil per year, due in five-year installments. We'll have to develop a suite of services with a range of fees."

"What?" said Roger. "What's the scientific value of that? What a waste!"

"We'll sell land at or near scientifically valuable sites, then charge for detailed aerial photography and three-dimensional video," replied Will. "Scientific value is one of the few criteria available for judging the value of land. If we want samples, we can sell some to the owner and that helps cover our costs. If we extract gravel for construction or meteoritic nickel-iron, we'll pay the owner a royalty."

"That's clever," said Paul. "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."

"And 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," added Will. "It could 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 magnetic and gravity data and have

a meteorology station. Basically, we will be paid to do detailed, automated reconnaissance of the Martian surface."

"That is clever," said Eve. "I assume we'll be importing someone to provide service to the property owners?"

Will nodded. "That's the plan. What we don't know is whether most of the land will be bought by individuals a hectare or square kilometer at a time, or whether a few companies will review the orbital data—which is incredibly detailed—and request 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's worth investing one hundred million to purchase 100,000 square kilometers of the planet and get a stake in the place."

"What's the latest about sending a teacher and child care provider?" asked Ethel.

"They're still negotiating with the wife of one of the astronauts already scheduled to fly here. She has a Master's in Early Childhood Education. But they don't want to stay more than eighteen months."

"What about the Chinese?" asked Roger, worried.

"They'll probably send someone on Columbus 4 and purchase an ITV so that they can fly four here on Columbus 5."

"Really?" exclaimed Monika. "So, there soon may be more Chinese here than Russians?"

Will shrugged. "They have the world's second largest economy, and in a few decades it'll be the largest."

“Their presence on the moon is surging,” noted Paul. “Of the forty personnel at Shackleton, twelve are Chinese! There are only ten Americans there! They’re doing good research and are planning a major probe to the Uranus system.”

“Not to mention the nuclear thermal engine they’ve developing,” added Roger. “It may be flight tested before the American engine.”

“Columbus 6 might use a nuclear engine,” agreed Will. “It’d stay a month and fly straight back to Earth. We won’t keep ITVs at Embarcadero any more, except for emergency shelter.”

“So, will our population grow faster?” asked Eve. “The Commission has pledged to fly four ITVs for the next three oppositions.”

“If the Chinese buy an ITV it’ll be five, and if the nuclear engine comes on line more may be possible,” said Will. “They say the engine will decrease the cost of flying cargo here, but I’m skeptical. We could have forty people arriving every columbiad, in five or seven years. That would probably push our resident population to about two hundred, plus fifty children. We’ll see some pretty amazing changes if the commitment remains strong.”

“That is amazing,” ageed Ethel. “But the technology has been developed step by step, we now have cheap access to low earth orbit, and the political and cultural support for Mars has solidified.”

“We’re here to stay,” agreed Madhu. She rubbed her sleeping son.

“He’s a sweet little boy,” said Paul, leaning over.

“Thanks. 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 conceded that much. “It sounds like there has been some change of approach,” he said carefully.

Monika smiled. “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.”

“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.”

“I think we will all be mothers, fathers, allomothers, or allofathers pretty soon,” agreed Eve. “The Outpost is destined to become 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 obstetrician and pediatrian; but I suspect I will become personally involved pretty soon,” Eve replied.

“And the Strogers 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.

"Mars now belongs to an international commission," Paul said.

Will reviewed the memo one last time. There had been a total of twenty attempts to hard dock the *Gulliver* on Phobos. None had succeeded. The *Limtoc*, once it was full of methane and oxygen propellant, had taken off and the *Gulliver* had been directed to the *Limtoc's* docking pad. After ten attempts, a hard dock had not been achieved. Finally, the *Gulliver* had tried to dock to the *Limtoc* six times, all unsuccessfully. The *Limtoc's* cameras had revealed damage to the docking clamps linking the methane lines together. Only an astronaut could fix them.

The *Alba* could fly to Phobos with two people, execute the repairs in two sols, then return. 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 almost a one 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 pondered the pros and cons. Then 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're slowly pulling down our surplus."

"The sunwing is making another delivery on Wednesol. Did you review the final memorandum about the proposed flight to Phobos to fix the *Gulliver*?"

There was a pause. "Yes, before breakfast. Do you want my frank opinion?"

"Yes, of course." Will's heart sank.

"The lifters *Limtoc* and *Roche* have enough fuel to send to Earth most of our exports. The limitation is the heat shields of the shuttles to aerobake cargo into Earth orbit, not fuel. So I would advise that we not send a mission to Phobos. The *Gulliver* can be fixed when Columbus 4 arrives."

“You’re right, we can achieve enough without the *Gulliver*. 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 once every two years in an extremely cold, dusty environment. I know Rick is very concerned about 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 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 nuke provides a lot more power than the old solar power units. 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 *Gulliver*; 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.

16

Circumnavigation

July 15, 2040

Érico scanned the eastern horizon ahead of them for any sign of Jerry's expedition. The area they were passing through was full of boulders; the zone where the outer rim of Isidis and its rough 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." Érico looked very closely. "Ah, I just saw sunlight reflecting off your windshield! Yes, I see you!"

"We're 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." 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 the blade to bury the rough rock. Rarely, he had to stop, back up, and scrape material to form a smooth surface. He avoided that because it was hard to back up with the portahab hitched behind.

Three hundred meters behind—far enough for the dust to settle—their conestoga followed, but driving two meters to the right, its bulldozer blade set to create a similar ridge of excavated material on the right edge of the road. This made automated driving simple because robotic vehicles had two clear, parallel ridges four meters apart to steer between.

Finally, one kilometer behind both vehicles was a robotic truck pulling their one-tonne nuclear reactor and its stirling cycle engine, turning out a continuous 150 kilowatts of power. The power was fed to a hydrolysis and sabatier unit in the back of the truck, which made methane and oxygen from water and Martian air and stored them in tanks in the front of the robotic vehicle. Every morning the truck would separate from the reactor trailer and drive to the vehicles to refill their oxygen and methane tanks. Then it would return to the reactor and hitch to its trailer again. The expedition would push forward again, sometimes progressing as much as seventy-five kilometers per sol.

The new arrangement had worked remarkably well. The completion of the Circumnavigational Trail was now at hand.

Érico felt his excitement rising as his expedition got closer and closer to Jerry's two vehicles. He could now see the ranger, conestoga, truck, and reactor. He glanced at the computer screen in front of Patrice, sitting 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 where the route they were clearing would link up with the route Jerry was clearing. The two expeditions were just a hundred meters apart.

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 a 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.

“We lost a few sols to maintenance,” noted 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, so fierce they had to travel half as fast and stay inside the vehicles for six sols.

“The bottle of champagne’s ready, 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,” 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 rangers maneuvered their portahab’s rear airlock to dock to the conestogas’ drivers side doors. 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,” 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 everyone ate. The champagne had gone to their heads quickly on empty stomachs, but no one had to go outside.

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 only five months, far sooner than anyone thought possible.”

“God bless the nukes,” replied Shinji.

“We also ignored a lot of geology,” said Érico.

“You’re right,” agreed Jerry. “We’ll head back to the Outpost after a morning expedition to the volcanic field ten klicks south of here. We’ll head 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 the

Circumnavigational, especially the Tharsis Plateau and its volcanoes, some other time. “We should also consider some crew exchange,” 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.

“It’s up to us,” said Jerry. “It’s a nine thousand kilometer drive. If each ranger and conestoga 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 twenty kilometers per hour of automated driving for ten hours every night; that’s 700 kilometers per sol, total. We’ll also lose one time zone almost every sol. The trip will take thirteen sols if we drive on Sunsols.”

“Which we can do. That means by August 7, 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.

“There’ll be three vehicles at the Outpost for the blastoff, which is plenty.”

“You’ll have to run the plan past Will and Mission Control,” cautioned Jerry. “I think people and vehicles need to rest.”

“Well, some people want to finish the Polar Trail before the southern autumn arrives,” replied Érico.

“Suit yourself,” said Jerry dismissively. He and Érico had grown jealous of each other. Érico was happy about Jerry’s success with the Circumnavigational only because he could count on personal success with the Polar Trail shortly thereafter.

“We can all be very happy about this achievement,” replied Paul, trying to calm the tension everyone could feel. “It’s unique and we’ve all contributed to it. The years 2040 and 2041 will go down in history as great milestones in Mars exploration.”

“Let’s drink another toast to that,” agreed Karol, with a smile.

The next morning, the combined expedition drove to the volcanic complex 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 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 terrain 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 want to head to the South Pole. Aren’t you tired of exploring?”

Érico sighed. “I suppose I am, but I want to accomplish something big. My expedition did just 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. So I’m willing to give him a break.”

“Well, I’m not.” Érico 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 going to have families, we might as well, also. The Strogers plan to work on it.”

“Good for them. Monika and I want a child, too.”

“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’s 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, but we’d like to have it 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,” 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 trail from Argyre across Hellas to Hadriaca and Tyrrhena Patera. A trail that drives along the northern crustal discontinuity would be really useful, too. And we haven’t gotten close to the Elysium volcanic field yet; Jerry saved himself a month of road clearing by avoiding it! So there are a lot of projects to tackle. This is a big planet and there are a lot of places to see.”

“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. It isn’t safe.”

“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.”

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 resolve that, 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 can cause silicosis, 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, 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.

The air in the new “greenhouse” had the tang of ozone in it; duricrete 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 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, 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. It does admit 80% of the light falling on it, and the translucent character diffuses the light."

"That's probably better for the plants. It's pretty warm in here." Will 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's experimental. 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_2 as needed. If we start accumulating nitrogen oxides, ammonia, methane, and other trace gasses, 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'll have to spray anti-leak compounds 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. Any news from the architects?”

“They’re just about finished. The details of the garage doors are tricky.”

“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’ll 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 a commitment 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. 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 take a cruise.”

“Those all sound nice.”

“But I will be providing support. I know how persuasive you’ve been in convincing people to stay! You’ve almost convinced me.”

“I think I almost convinced Jerry, too.” Will turned and walked back to the airlock. Pavel followed. They entered Building 1. 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. 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 surveyed 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. And maintain your blog; it’s very popular. Bye.”

Will had to chuckle at Kimball’s comments. Intrepid explorers coming home to their families: it was indeed an appealing image. He had hit on it gradually—accidentally—but it was now obvious even to NASA that it was the way to go.

He 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 and found a spot on my left lung.”

“Spot? What sort of spot?”

“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 usually slow growing. Eve and Shinji could try to operate, but with the facilities here that would be risky, even using laparascopic 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."

"There's only one other," replied Madhu. "Prayer and a miracle."

"And that's an option we take seriously," added Roger.

17

Accident

July 19, 2041 and the week after

The circumnavigational expedition left the Isidis Basin and crossed the wide, rough, and ancient volcanic pile of Syrtis Major. They skirted the edge of Schroeter Crater and 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 in a ranger pulling a portahab. Carmen was riding with Linda, as she often did in the mornings. The four staffed vehicles and their two robotic trucks with reactors were stretched out over several kilometers so the dust kicked up by one had cleared before the next one came along.

“Kilometers and kilometers of kilometers and kilometers,” said Paul, as he drove. “A vast wasteland.”

“I wonder whether millions of people will ever live here,” replied Érico.

“Who knows. If you sink a well you’ll hit water everywhere; and with electricity, the water is oxygen.”

“The problem is getting here, and that will be expensive for a century.” Érico scanned 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 resolve the nature of the spot is small, but the tissue can be frozen and shipped back to Earth if Madhu stays.”

“If it’s cancerous, shouldn’t she go back to Earth?”

“She doesn’t want to. It’ll take her several weeks to recover from even a minor operation enough to be able to fly. If she decides to go, blastoff may have to be delayed.”

“It can’t be delayed much. 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, and it 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 postponing 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 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.

“Ranger 1, come in! Ranger 1, come in!” It was Jerry’s voice. The ranger had put itself into an emergency mode, which meant that all communications were routed over the intercoms. Érico felt for his earpiece; it was intact, which meant his heat rate and the oxygen level of his blood was being broadcast to the Outpost’s central computer. So was Paul’s, if his earpiece hadn’t been knocked out.

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!”

“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 has shot way up and the oxygen level in his blood is dropping,” warned Will. Alarms had rung in the Outpost; the Commander was involved 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 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 connecting tunnel was inflating. Shinji crawled into it, in his suit, and closed the hatch behind him, then Lal conducted an emergency deflation of the tunnel.

Érico could see the rest through the window 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. Shinji had his suit on, but no backpack; the suit could keep him alive long 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 was puffy from vaporization of internal fluids, though that was shrinking fast. Shinji put him down and Lal began to give him mouth-to-mouth resuscitation while Shinji pulled off his helmet. 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 loudspeakers in all the vehicles. Lal walked to a microphone on the dashboard.

"Shinji's now 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, but a small one. I headed for the cab to escape the air leak, 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; six were monitoring Outpost functions, one carried the functions of the damaged ranger, and the last showed Paul Renfrew's vital functions, which were flat. The physical damage to the ranger was confined to a small area near the front passenger corner where it 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 pressure seals around the passenger side hatch. The front right wheel and motor were 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.”

“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. Shinji went into the cab to get Paul, but he’s not breathing.”

“Oh my God,” she gasped.

Will pointed her to a chair next to him. Ethel arrived just in time to hear the last part of Will’s explanation. She sat next to Monika and put her hand on Monika’s shoulder.

Roger hurried in. The tiny bridge had three seats; they were full. Ethel got up, grabbed a seat from the room outside, and sat 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. The defibrulator. No heartbeat.

“Please, Paul,” cried Monika.

Shinji tried three 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. He began to cry as well. Everyone began to cry.

“We had better secure the vehicle,” exclaimed Jerry, a minute later. “Get out everything we need to replace the smashed wheel.”

Will pulled himself together. “Photograph everything thoroughly for the investigation, then resume the drive back here. We can’t leave Paul in the middle of nowhere.”

“Will, we have to inspect the ranger,” insisted Rick Page, who was in the other conestoga.

“You’re right. Take a look at the disabled ranger thoroughly. But they have 90,000 kilometers of driving experience here and twice that on the moon. What are the chances of a design flaw?”

“Pretty small, but we had better look,” said Rick.

The expedition spent most of the rest of the sol investigating. No one was sure why Paul had lost control over the ranger enough to strike a boulder 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; 3.98 meters, two centimeters or 0.8 inches narrower that 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 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 in 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, 2041, many were relieved.

"It's good to be home," said Carmen to Érico, almost in a whisper. They embraced in the suit-donning area and she began to sob. He kissed her, then held her fiercely tight.

Will wasn't sure how to welcome them. He turned to the next one to step into the Outpost. "Welcome Shinji," exclaimed Will. The two men hugged; old friends, they now had yet another common experience.

"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. "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.”

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 circumnavigation of Mars.”

“Thank you, but I’m afraid this accident will overshadow everything,” 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.

“Twenty-three thousand, eight hundred eighty point six; I just checked the odometer. 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.”

“Our first construction priority has to be a garage. Ranger 2 will require extensive repairs and they’re 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. 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, 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. 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 a week later. 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, fresh bread, mint tea, and strawberry pie. They all sat at a long table together, but once everyone had expressed their support for Monika, 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 defibrulator 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 the situation. When you went into the cab his heart was still beating a bit. Who knows why the machinery of his body failed at that point.”

“And an autopsy doesn’t seem called for.”

“No. You need to help 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.”

“So does the video. He was rested, he’d had coffee two hours earlier, the driving conditions were fine, and the ranger did not fail mechanically. Their speed was not unreasonable, either.”

“He had the speed set at 40 kmph. There was that rock in the road.”

“Yes, but it shouldn’t have pushed the ranger fifteen centimeters to the right. If he had been driving in the middle of the trail, he would have been fine and we’d all be celebrating a successful trip right now. There was no reason to drive on the right; there was no oncoming traffic for six thousand kilometers. 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.”

“But there are lessons to learn from this for the future. The airbags didn’t need to deploy. His shoulder belt was sufficient to protect him and they made it impossible for

him to get out of the belt for the first few seconds, when he had to. They made it hard for me to pull him out as well."

"They also displaced air and pushed up the cabin pressure twenty percent, which may have been a factor in the failure of the hatch seals. NASA's looking at ways to reprogram the airbags. They're supposed to get sucked up against leaks and block them; that didn't happen either."

"If he had been able to get into the tunnel to the portahab, he would have been alright. We need better training so people know what to do in these situations."

Will nodded. Then his attaché, which was dangling from his belt, began to beep. Will raised it; an urgent video message from Harold Lassen. He excused himself and walked into the empty kitchen, then pressed "view."

"Good evening, Will. I have some surprising and possibly disturbing news for you and the crew. 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 you of the closure that you badly need. But we have to respect the family's wishes. I'm sure you understand. 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 brought tears 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 actions. 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. 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 to name this building, our first major construction on Mars, the Renfrew Memorial Building. What greater tribute can we offer him? The facility on Phobos that we are gradually building up will 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 tomorrow 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 to 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 comfort him.

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, and carried him to the Mars life facility. There, Monika put her hand on the casket. "I. . . want to look at his face one more time."

"Are you sure?" asked Will. "It may be better to remember him as he was in life. He won't look the same."

"I know. Give me a minute."

They all retreated out of the room for a moment while Monika raised the lid to look at the face of her love, now white with death. Tears stung her eyes and dripped down her cheeks. She touched his frozen face, recoiled from the cold, and felt his hair instead. He hadn't had a haircut for four months; it was quite long. "Will!" she called.

He stuck his head into the room. "What is it?"

"I. . . want to give him a haircut. It may seem silly or morbid, but I want to do something for him, even if it's little. I always used to cut his hair." She began to cry.

Will came over and put a hand on her shoulder. "Are you sure? It won't be easy. He's frozen, remember."

"But his hair isn't." She nodded. "I'm sorry if it seems strange, but please. . ."

"Yes, sure. Maybe Shinji can help you? It won't be easy."

She nodded. “Yes.”

“We’ll get Madhu’s barber scissors.”

“Okay. I want to keep a lock of his hair, too. If Paul and I were married, I would have made the decisions about burial, but instead his mother and sister get to decide.”

“Of course, I understand. Keep a lock of his hair. And set the rest aside; we’ll bury it in his tomb. Even if his body goes back to Earth, we can keep some of the hair.”

“Alright.”

Will went to get the scissors and Shinji. Monika and Shinji gave Paul a very careful haircut and the result was quite attractive, even though the casket would be closed. They put the hair in two plastic bags and gave one to Monika. Then they carried Paul to the Great Room in Renfrew Hall, put him in the place of honor, and draped a Canadian flag—one of their two—over the casket.

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 played. They rose to sing Amazing Grace together, and everyone seemed to join in even if the words were unfamiliar. 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 passing 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 to his faith, and through his tireless and uncomplaining work here on Mars. He was central to the effort to build our first building, 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 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 he wanted 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 about 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.

One by one, 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 except Madhu and the babies headed for the two pressure suit donning facilities and suited up. Four of them—Will, Jerry, Érico, and Shinji—returned to the room to bear Paul to the tomb. Everyone 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 kinder. But I can't bring a child into this world. Not yet. 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 at the same time. Marshall was still with Madhu. “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 wants. 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 or both of us.”

“Yes. . .but that’s life, sometimes. Mars isn’t as safe a place to live as the United States or Europe, but it’s safer 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 it is for the children when the future’s uncertain.”

“Really?” Will considered. “I see your point. But remember, my dear: we’re 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."

"If we need to. My mind is made up."

"Then it's agreed," he replied.

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 I can."

"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 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. “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.

18

Departure

Sept. 15, 2041

The *Elysium's* engines flared alive and five orange-tinged bluish flames 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; 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 imaging 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. Almost six minutes had passed. MECO—main engine cutoff—was scheduled to occur after 5 minutes, 50 seconds.

“You’re looking good, *Elysium,”* exclaimed Roger.

“We copy. Delta vee is nominal,” replied Pavel, who was captain. Jerry had already taken the *Apollonaris* to orbit the sol before and was closing on Embarcadero Station, which included the ITVs *Syrtis, Noachis*, and *Cimmerium.* They 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. The long term ones generated tonnes of samples to analyze. 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.

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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, 2039

2. Politics 13
Érico's team that visited Deimos presents 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, 2039

3. Proposals 34
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. 2039

4. Marshall 47
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 want 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, 2040 (birth)

5. Declaration 57
Will and Ethel begin to purse 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, 2042. They elect Érico the borough clerk.
Date: mid Feb-mid March, 2040

6. Landings 76
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 2040

7. Plans 86
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 reviews the plans for the columbiad. The exports plan raises eyebrows. He outlines the exploration plan as well. Lal wants to explore Candor; Will works out a compromise.
Date: late May 2040

8. Exports 99
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.
Date: early June 2040

9. Conference 113
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.
Date: early June 2040

10. Keys to Settlement 122
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 2040

11. Construction 140
After they start work on their new pressurized building, Will asked Pavel about building "trench greenhouses." Madhu is pregnant. The Lifter *Gulliver* won't dock properly to its refueling pad on Phobos. On Frisol evening Will sees Carol, Lisa, Pavel, and Patrice drinking and grounds them. Satursol 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 2040

12. Gold 151
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. 2040

13. North Pole 164
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, 2040 (arrival at pole)

14. Conjunction 183
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. 2041

15. The Commission 190
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 the *Gulliver*.
Date: early March, 2041

16. Circumnavigation 200
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, 2041

17. Accident 217

Paul hits a bump in the road, the ranger depressurizes, and he dies. The expedition returns to the Outpost and lays 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, 2041 and two weeks after.

18. Departure 238-40
The *Elysium* blasts off into orbit.
Date: Sept. 15, 2041