

MARINERS

Vol. 1

Transitions

Copyright © 2014 Robert H. Stockman

All rights reserved

Contents

1. Chief Minister (Nov. 2073)	2
2. A New Era (Dec. 2073)	24
3. New Missions (Dec. 2073)	45
4. Synergy (Feb. 2074)	83
5. Mother Nature (Mar. 2074)	104
6. Vision (May 2074)	141
7. Making it Work (May 2074)	169
8. Whirlwind (May 2074)	183
9. Launches (late June/early July 2074)	207
10. New Endeavors (Aug. 2074)	237
11. Gold Rush (Sept. 2074)	252
12. Challenges (Oct. 2074)	277
13. Future Plans (Dec. 2074)	303
14. Visitors (Feb. 2075)	338
15. Births and Beginnings (Mar. 2075)	355

1.

Chief Minister

November 2073

It felt like a bad dream.

Jacqueline Collins walked from the platform in the front of the Mars Council chamber to her seat on autopilot, the shock of being elected Chief Minister reverberating through her body. She sat and turned to face the front, but found that she couldn't pay attention to the next item of business: electing the Chair of the Council. Ethel MacGregor Elliott, wife of the outgoing Chief Minister, turned to her and whispered, "you look white as a sheet."

That startled Jacquie; she was light-skinned, half Jamaican, half Scottish, so that was impossible. But then she realized Ethel was speaking metaphorically. "I'm . . . overwhelmed!" she whispered back.

Ethel put her hand on Jacquie's shoulder. "Of course! But you don't have to sit here, this is Council business. Go out and call your husband."

Jacquie nodded; it was a good idea. She rose and headed out of the chamber's side door. The guard, Rashida Hanna, was a friend from Barbados. She offered her hand. "Congratulations! I'm so excited for you!"

"Thank you, but if you pray, pray for me!"

"I think I'll hug you; you need that first!" Jacquie smiled and they hugged.

"Thanks, I needed that!" She walked down the hall ten meters to the end. Two other people came out of the chamber to congratulate her or talk to her; the guard shook her head and kept them back.

One click on her cellular communicator connected to her husband, Mario Esposito, an Italian-Canadian. “Jacquie, my God, I was watching on tv!”

“I know. Can you come down to the Capitol? I’m at the side entrance to the chamber. I’m sure you can come in with me.” She paused. “I need you.”

“I’ll be right there. It must be a terrible shock.”

“It is.”

“I’m on my way. Bye.” He closed the line; she wished he had stayed on while he walked over from their apartment, which was just a few minutes away. She put the communicator back in her pocket and walked to the side entrance.

“Mario’s on the way over; can he come in with me?”

“Of course, you’re Chief Minister!”

“Not yet; inauguration’s a week away.”

“Never mind about that!” Rashida smiled. “I am so excited for you!”

“For us,” said Jacquie, referring to black women in general. “But it is a huge, huge responsibility, Rashida. It’s a life and death responsibility.”

“You can do it! You’re a great choice!”

“Thank you. One problem of our election system: you don’t know you might get chosen! If you can run for office, either you are elected or you aren’t.”

“It’s like adopting a child. My husband and I just adopted a baby and we had two sols warning. We sure could have used nine months of preparation!”

“Exactly. Lord, I don’t know what I’ll do. My life has to be rearranged, then I have to set up a government.”

“You don’t have to make any promises or commitments for a week, so use it to get ready. Come to the mosque Frisol at 6 p.m. During the hour right before the evening prayer we just gather with our friends and pray any prayers people want to pray, then we have our evening prayer and our friends can watch or can learn how to join in if they wish.”

“Thank you, I think I’ll do that. I probably should go to many of the religious communities in the next month or so.”

They heard footsteps in the hall and turned. Mario ran in from the building’s main entrance. He hurried up to Jacquie and they kissed. “Congratulations, my dear.”

“Or commiserations! I’m not sure ‘congratulations’ is the best thing to say.”

“How about ‘I love you?’” He kissed her again.

“Thanks, Mario. I don’t know how I’m going to do it.”

“Your words of thanks were very well done. I was impressed that you managed to be so eloquent in such difficult circumstances. You’ll do fine, honey. You’ll be great.”

“Oh, I hope so, everyone will be depending on me! I’m afraid Mary may not see her mom quite as much!”

“We’ll manage, don’t worry.”

They heard applause coming from the council chamber. “We’d better get back inside before everything is over,” Jacquie said. Mario nodded. Rashida opened the door and they walked back in.

Lal Shakaraman and Lyle Quincy were standing up front, nodding in thanks to everyone. Jacquie and Mario walked to the guest area. “They were just reelected as Speaker and Clerk,” explained Ethel. “Though it took a little while; Lal required two ballots and Lyle, five.”

“Really?” said Jacquie, surprised that they were not reelected immediately. She wondered how much support they had in the Council.

Lal adjourned the gathering and banged the gavel. Everyone rose and half of the hundred people in the chamber turned to congratulate their new Chief Minister. Will Elliott came over as well and a second cluster formed around him, shaking his hand and thanking him for his service to Mars. People went back and forth between the two groups and they gradually shrank until Will and Ethel were able to come over to Jacquie and Mario.

“I can’t imagine a better choice, Jacquie,” said Will. “We need someone young, smart, good with people, able to communicate well, and possessing a vision for Mars. You have those qualities. I really couldn’t be happier.”

“Thanks, Will, I really appreciate your encouragement. I’m going to need a lot of help.”

“And there are plenty of people to help you, don’t worry about that. Take the weekend to talk to Mario about family arrangements; this job can easily take twelve to fifteen hours a sol. You’ll have to figure out how to carve out family time.”

“Make sure she does,” Ethel added to Mario.

“We can meet on Monsol, or any other sol you prefer, to talk about the transition. We have no great secrets to convey to you.”

“No hidden nuclear missile arsenal and a robotic army poised to invade Earth, like the America-firsters claim?” asked Jacquie, and they all laughed.

“No, not yet, and no secret contact with aliens, either. You’ll have to figure out how to accommodate the robotic army to invade Earth in the fiscal 2074-5 budget,” replied Will, with a smile. “But there are a lot of transition issues. No doubt you’ll want to reappoint the Cabinet, and our two chief diplomats on Earth want to retire. You can still appoint and send a replacement

team; opposition's three months away and United Spaceway's caravel will head back in two weeks. I suspect some Supreme Court justices will want to retire, too. There will be a lot to do."

"There are still a hundred or two arrivals on Phobos, waiting to come down," said Jacquie. "And the next six months we'll receive three thousand more arrivals."

"That's not as daunting as it sounds because most of the work is done," said Will. "It could still go wrong, but the arrival plans are in pretty good shape."

"Why don't the two of you come over for dinner morrowsol night?" asked Ethel.

"That would be delightful," said Jacquie.

"We'd really appreciate that," added Mario.

"Come at 6," suggested Ethel. "We can have a nice, relaxing chat about all the challenges."

Charlie Langlais's dorm room was full of people. It wasn't because he had a bigger screen on the wall than anyone else, or that he had popcorn; his friend Sirikit Thanarat had supplied that. There was something about Charlie that made him popular; perhaps it was his warm sense of humor, or his natural friendliness to everyone. The girls in particular flocked to him because he was tall and blond and liked to flirt, and they attracted the other boys.

"Who is she?" asked Wicahpi-Luta Hunter, Charlie's closest friend, whose room was two doors down the hall. He was pointing to Jacquie on the t.v.

"I don't think I've heard of her," said Charlie, disappointed, as they watched Jacquie Collins walk to the front of the Mars Council chamber to accept her election.

"Minister of Space Exploration," replied Sirikit, who always seemed to know everything.

“She’s a good choice,” added Bill Hollingworth. His room was next door; at 23, he was the old man of the group, and a shuttle copilot besides. “She has been very good at coordinating Marsian involvement in solar system plans. She’s been working with Emily Scoville-Rahmani, Minister of Development, on the Phobos expansion plans.”

“The place is doubling,” agreed Sirikit. “Low earth orbit demand for everything is exploding.”

“Maaka’s really excited about the place,” added Wicahpi-Luta, whose brother was a galleon construction specialist there.

“Yeah, dad has talked to her a few times, and I think he likes her,” said Charlie, nodding. He wasn’t sure of what he had said, but was glad to remind everyone that his father was Executive of Ceres Borough and Commissioner of the Asteroid Belt Commission.

“I’m surprised they didn’t elect Lal; he’s been around forever and has served on the Council almost as long,” said Guillermo Del Rio.

“That’s true,” agreed Bill. “But Lal is better known for his work on Martian glaciology and charting Martian ice ages, than for legislation or political leadership.”

“Yes; he’s a solid researcher,” agreed Charlie. “Though he can be hard to understand when he lectures, because of his accent!”

“Half our profs have accents,” noted Esther Harris.

“So, Bill, what will she do differently?” asked Charlie.

Bill thought a moment. “I don’t know, but the current vision of Mars as the center of solar system exploration is as much hers as Will Elliott’s, I think. That policy won’t change, I bet.”

“It shouldn’t, either!” added Wicahpi-Luta. “I think Elliott’s farewell speech was brilliant. This place has direction. Earth doesn’t. That’s why people want to come here; it gives them

something to sacrifice for, to contribute to. The centerpiece of our direction is exploration outward. We can't just be climbing another ancient Martian cinder cone or exploring yet another impact crater. We have to move outward to Uranus, Neptune, the Kuiper Belt, and eventually to Alpha Centauri."

"But can we really afford it?" asked Esther. "And we don't want to become an imperialist power. We aren't setting up colonies to send their profits back here, if anything they're draining off our surplus."

"Not all of them; Ceres will soon be making a big profit off PGMs," said Charlie. "We'll be earning enough to cover all Asteroid Belt exploration."

"But the others will cost us plenty," replied Wicahpi-Luta. "Saturn won't cover its costs for decades, if ever. Jupiter and Venus are supported 100% by governments. Who knows how much Mercury can earn from Platinum-Group Metals and maybe Helium-3. But it doesn't matter. We'll soon have 16,000 people and four years from now it'll be over 20,000. The other worlds together have less than a thousand. Twenty thousand can cover the costs of another thousand, and we should because they're Marsian citizens too, and because we're doing the exploration we're committed to."

"Spoken like someone who plans to apply for the Uranus mission," said Esther.

Wicahpi-Luta shrugged. "These places challenge our civilization, bring us innovations, and give us purpose. That's their purpose. Like Elliott said, we could sit back on Earth, go to malls, and do everything via robot. Boring."

"And it could all get shut down, too, because of budget cuts," said Charlie. "Right now half the people who want to go to the mall are unemployed and angry."

"I'll never understand Earth," said Wicahpi-Luta. "So much chaos."

“You would, if you had taken Terrestrial Culture and Politics with me,” replied Sirikit. “It all makes sense, more or less, if you study it.”

“In other words, the idiocy has a partial explanation,” he replied.

Sirikit scowled at him. “So, none of you have visited Earth?” asked Charlie.

“No,” replied Bill. “You’re the only one who’s been beyond the Martian gravitational sphere of influence.”

“Maybe we should all volunteer for the next galleon to Earth in two years,” said Wicahpi-Luta. “Seriously. We’ve all been on Mars long enough to earn a free trip. It’d be fun.”

“It’d tie us up for almost a year, though,” said Sirikit.

“I think it’d be fun,” replied Charlie. He paused because Lal and Lyle were walking onto the stage to accept the applause of their peers, who had just elected them as speaker and clerk.

“No change there,” said Bill. He turned to the door. “I’ve got studying to do.”

“Propulsion systems? I’ll join you,” said Wicahpi-Luta.

“The more the merrier.”

“And I have economics,” said Sirikit. “Sorry Charlie; the party here’s over.”

“I guess so, for a while anyway,” said Charlie.

The Great Room in Acheron Outpost’s N-5 cavern had just about every adult on Titan in it; 375 of the 400, anyway, the children’s teachers, cooks, and emergency personnel being elsewhere. Yuri Severin, elected Executive, saw that everyone was present who planned to come and stepped forward to the front. Cameras caught his image and projected it onto screens so everyone could see him clearly. “Welcome, everyone, to the Future of Saturn Forum. We had planned to call it ‘Future of Titan Forum’ but it involves plans about objects other than this moon, so we

have broadened the focus. For the last month, since the *Cassini* arrived, we have all been undergoing education and training. The Saturn Science Conference allowed us to share the latest scientific conclusions about the planet and moons with each other and with our colleagues on Earth and Mars. Training briefings have reviewed and updated safety standards. Small group meetings have refined the details of our exploration and ecology plans. The purpose of today's gathering is to review the details together and discuss more intangible issues of building our community. Andries, could you summarize the exploration side?"

Andries Underwood rose. He was an unmarried South African petrologist who had spent almost thirty years on Mars before leaving for Titan, having commanded the *Cassini* until its arrival just a month before. "The plans for exploring the Saturn system over the next two and a half years, before the arrival of the *Ptolemy* with another hundred or so residents, are now pretty well developed. Most importantly, over the last year we have refined and expanded our relationships with scientists located at sixty different universities located in twenty-two countries. These relationships involve scientists located at those universities applying for research grants in partnership with our scientists up here. The government grants cover our research expenses, including salaries and some overhead, and thus contribute substantially to the income of the Saturn settlement; in fact, we anticipate covering one third of our local costs directly this way. When you remember that the salaries of scientists also pay for their food, consumer goods, and housing costs, it ends up amounting to one half our local expenses. This is an impressive and important development."

He paused for everyone to applaud. Science was one service they could sell, if they could find buyers, and currently governments were willing to pay for it. Rahula Peres, Director of Fabrication, raised his hand to indicate a question, then spoke. "But Andries, if governments are

giving us more money via grants to their universities for joint projects, won't they give us smaller subsidies?"

"Yes, they have cut back somewhat," conceded Andries. "But some subsidies will continue, and this is a fairer way to obtain support anyway, because it is tied to specific outputs, rather than being generic. I hope we can get grants for fabrication and construction efforts.

"As a result, our Saturn meteorology, geophysics, and magnetics teams will all be busy with projects," Andries continued. "In the next two months we will deploy six more satellites into Saturn orbits to provide the sensors we need for our work; using Titan gravity assists, several of them will be moved into polar or high-inclination orbits. We also have two more nuclear powered communications hubs to deploy, to maintain communications with Earth and Mars respectively. The current satellites will be used as backups.

"In the last four years, teams have visited ten moons other than Titan. They have left androids or rovers on three of them. The *Cassini* brought three automated bases to deploy. They were developed for the Galilean satellites where radiation levels are too high for humans and have been modified for use here; yet another generation is being developed for the Uranus project. Each one includes a 100-kilowatt nuclear power source, a mobile lab where samples can be analyzed and machines repaired robotically, and a team of androids and rovers, all nuclear powered. An inflatable habitat can be added. They're remarkable facilities, costing a hundred million redbacks each, and will allow telerobotic teams to explore each moon together while remaining here with their families. They were a huge investment in this place. They won't eliminate the need for us to physically visit the various moons—we'll still need to go redeploy them periodically—but they'll greatly reduce it.

“We have something similar for Titan: two mobilhabs of the sort used on Mars modified to function telerobotically, each with a 100-kilowatt reactor and a team of androids and rovers. The Titan exploration team has charted a ‘round the world tour’ that the two will conduct together. They’ll move forward and explore areas during dayspan; during nightspace they’ll analyze samples and repair things. The team will visit the mobilhabs periodically to retrieve samples and explore particularly important sites in person.”

“Can I ask a question?” exclaimed Gwangya Kwok. “I’ve asked Soo several times how often she’ll be going out and she hasn’t told me.”

“Marshall hasn’t told me, either,” exclaimed Amy Elliott.

Marshall rose. “We’re still not sure. I suspect we’ll send one mobilhab ahead of the other to the next good site, then send out a team to spend two or three days at each site, then fly them home. We’ll probably do that every month or two. The surface exploration team and the satellite exploration team overlap in membership extensively, so everyone will go out maybe once every four or five trips.”

“And the satellite exploration team will probably see two missions a year, so the average member will be out once every two years,” said Andries. “This is a big change. The new robotic systems are much better and the communications systems are robust, so we can stay home more.”

“That’ll be safer, too,” added Yuri. “There are no expeditions for the next three months because the satellite exploration team and the mission control team will be training, and because both teams and the surface exploration team will be laying a power cable to Licoma Facula and setting up our first three wind turbines and adjusting their function. We need wind power to be able to expand our caverns. Tomas, can you review the schedule?”

Thomas Racan rose. “Sure, Yuri. In the last six months, the construction team has melted four of the eight caverns we need for bioarchive and has completed metal domes and floors for one. To call the project ‘bioarchive’ is actually a bit misleading, as we have not obtained a grant to reconstruct and study an entire terrestrial ecosystem the way Mars once did. In the last five years, the Marsian bioarchival ecologies have become a pool of additional species to provide rare drugs and other materials and to bulk up their supplies of enclosed space, oxygen, and fresh water. Our bioarchives serve a similar purpose; they give us a much larger enclosure to live in and enjoy, greatly expanded biodiversity, and a wider range of plant and animal resources. We hope to set up three per year, completing the last two just months before the *Ptolemy* arrives, assuming the construction and power production schedules hold. Each bioarchive is 5,000 square meters—half a hectare—and requires an average of 4,000 kilowatts of power for half a day, so completing them on schedule is quite a challenge. We also hope to seek biological research grants from any governments willing to give them and hope Andries can help with that effort.”

“Definitely,” replied Andries. “The potential for grants is there.”

“Sridhar, can you summarize the construction plans?” asked Yuri.

“Sure.” He rose to speak. “Last month we completed the final work on Bubbles N-1 through N-6 and S-1 through S-6; they took the construction team three years. They still contain about 35% unused volume, so we have room for growth in them if we get more population in three years. Work on converting the *Cassini* to Titanian gravity is also complete, so we now have three gravitied spaces, which is mostly useful in case we have to stop the rotation of one of the three and repair the hub unit. The three of them give us nominal gravitied housing for 600, so we have surplus capacity. With the use of the bubbles, we have the capacity to accommodate 750 or 800 comfortably. In the next three years construction will focus on completing the bioarchive

spaces, meaning installation of an arched nickel-steel roof, a nickel-steel floor, insulation, an average of half meter of artificial soil, and artificial sunlight. We also must develop our unused 35% as demand requires. Some of the construction team will transition to fabrication, which has expanded significantly with the arrival of the robotic factory and new metal and plastic production equipment. Once the design of the wind turbines is refined for our low gravity and low wind speeds, we will be putting a lot of resources into manufacturing and installing a wind turbine farm along our 40-kilometer power line to Likoma Facula. We also plan to drill another geothermal well and install a 20-megawatt turbine. Likoma has the potential to produce hundreds of thousands of kilowatts for us; plenty to keep us going without reactors, allowing us to save them for backup power.

“We also have a research grant from the Uranus Project to construct a test bubble on the surface of Enceladus near its south pole. While the location is advantageous for us—it’s near the water geysers that erupt there periodically—because the site is in partial shade it is as cold as the surface of the moons of Uranus. We have a special ‘U-75’ bubble, 75 meters long and 35 meters wide by interior dimensions but containing three separate nested bubbles. Our goal will be to go to Enceladus, inflate the triple-thick bubbles, and fill the compartments with water, which once they freeze will produce an ice cavern with walls three meters thick, sufficient to provide robust cosmic ray shielding inside. Our goal is to refine the construction technique for the Uranus project, because they may find it hard to excavate subsurface caverns; the ice crust has solid and liquid nitrogen disseminated in it that could become explosive when heated. The U-75 project will probably take ten personnel, a caravel, and a 100-kilowatt nuclear reactor six weeks.”

“Is this something we could use elsewhere?” asked Marshall.

“Definitely. It could be used on all the moons and on Titan to produce living and working quarters. Most likely, the nested bubbles can be placed closer together to produce walls only a meter or two thick, and additional insulation and radiation protection can be added in the form of snow blown over it. We’ll explore optimal variants.”

“I think those are all the reports,” said Yuri. “As you can see, we have some pretty ambitious plans over the next three years. Now I want to—”

Marshall raised his hand. “Yuri, don’t you think we should say something about the university?”

“Oh, sure, go ahead.”

Marshall Elliott rose. “As most of you know, the Titan Campus of Mariner Institute of Technology is now official, and the Council has appointed me Chancellor; a fancy title for a paper institution.” He chuckled and so did the others. “But it won’t remain a paper institution forever. Some of that unused 35% of volume is the third floor of N-6, and it is now the official home of Martech-Titan. Of the 375 adults, I figure about 360 of us have the degrees to be faculty, and the other 15 have relevant experience. One-hundred eight of us were already affiliated faculty to Martech on Mars and are now the official faculty of Martech-Titan, but I hope everyone else will request faculty status. This is important because our faculty will be part of the MIT and Caltech online consortia and therefore can teach in those systems, and can earn some of the money we need to stay here! Andries’s effort to set up government research grants will go through Martech-Titan, and we already have a pretty impressive faculty, but more cvs means more possibilities.”

“I’ll give everyone release time to teach one online course per year,” said Yuri. “Unless there’s an urgent need for your full energies up here.”

“Will we be able to take courses through Martech-Titan?” asked Rosa Chen, a fabrication specialist.

“Yes; we’ll be teaching at least a dozen classroom courses per year,” said Marshall. “Of course, we already had an arrangement for people to take online courses through Martech and the MIT and Caltech online consortia to complete Master’s and doctoral degrees.”

“Let’s open the floor to questions; this has gone too long,” said Yuri. “What are the pressing issues for the future of Titan?”

There was a long pause, then Toru Takahashi, one of their systems analysts, raised his hand. “With another fifteen births, we’ll pass the 500 mark,” he noted. “And we have enough people here planning to start or expand their families to reach that number in less than a year. Titan is here to stay; many of us are here to stay forever, or at least a very long time. So my question is, what’s our next population goal? Why should we set it at that number? What are the limits to our growth? Clearly, Titan has vast resources. This place has twice the land area of Asia. Its geothermal and wind energy is sufficient to heat and light thousands of square kilometers of underground tunnels, sufficient for millions of people, if it is our will.”

“That’s not going to happen,” exclaimed Adel Mehmetoglu, one of the geologists. “We have no gold or PGMs to fuel our growth, and scientific grants can do only so much.”

“We also have to balance imports against something; either income from sales of goods and services, or grants,” said Yuri.

“I understand that, but if we grow, we’ll become much more self-sufficient,” replied Toru. “Mars is a case in point; it now has a substantial internal economy. These new robotic manufacturing systems greatly increase our self-sufficiency. Consider that the most sophisticated item we have to import is probably galleons, and we need them because they provided rotating

housing. But galleons are made on Mars by a workforce of about a thousand people. We're already getting close to half of that."

"Actually, the most expensive items we import we can't make; nuclear power sources and electronics," noted Rahula. "There are no sources of uranium here, and electronics require mass production to be cheap. Even Mars imports its electronics."

"Okay, I concede that," responded Toru. "But my major points remain: the larger we are, the less we have to import per person and the more we can make ourselves. What is our next population goal?"

"I'd say another galleon-full; 150 adults in 2077-78," replied Yuri. "If we could add a galleon to the surface every six years, and we import young people who will start families here, we'd grow by about 600 people every six-year period."

"We need to keep in mind that Mars currently has committed to spending ten percent of its GDP on solar system exploration, and that GDP grows every two years," noted Marshall. "We're one of the best places in the solar system for a settlement. Venus has no place to put a station, Mercury's deep in the sun's gravity well, and all of Jupiter's large moons, except Callisto, have radiation problems. I'll concede Ceres may have some advantages over us. Uranus and Neptune are much more remote. We're a logical place for Mars to commit a large fraction of its solar system support."

"Perhaps we should negotiate a link between our population and Mars's," suggested Sridhar. "If Mars's population grows by thirty percent, so should ours."

"I think that may be hard to argue, because a thirty percent increase in the Marsian population does not increase their GDP by thirty percent," replied Yuri. "Their GDP is still

heavily dependent on exports of gold, PGMs, and deuterium, the prices of which are volatile. But I agree we need to negotiate an expansion plan.”

“And I wouldn’t write off the possibility that we can bring in more income,” said Marshall.

“Do you have ideas?” asked Yuri, with a chuckle.

“No; not yet.”

“Well, I appoint you a committee of one to come up with some.”

Everyone laughed, but Marshall nodded. “Alright, I will!”

“What’s the optimal number of scientists here?” asked Ryoko Furukawa, their artist and store manager.

Andries looked at Marshall Elliott, Sydney Kilgore, and Teresa Alvaro, who were in charge of exploration of Titan, Saturn, and the moons respectively. “I’m not sure there is an optimal number,” Marshall replied. “Mars has about 300 scientists dedicated to the study of Mars. The Saturn system could certainly use that many. But right now, no one will fund that number, and if we reached 300, no doubt we’d think of other subspecialties that have to be covered.”

“If we could get to 300, we’d need a total population of about 2,000,” added Yuri.

“Unlike Mars, we aren’t studying one world; we’re studying a giant planet, a giant moon and its atmosphere, a giant ring system, a collection of ice moons, and a collection of captured asteroids from various places in the solar system. We could easily use a thousand scientists for all that.”

“Then let’s consider a different question,” said Ryoko. “To make a civilization here, what should the ‘artists to scientists ratio’ be? Right now it’s about fifty to one! I think we need more artists!”

“In a way, we already have them,” replied Sydney Kilgore. “I have my violin with me. We can form a small orchestra if we want, or a rock band. We’ve had a few plays. We have some painters. I think we need more time to pursue these other aspects of our lives.”

“And someone to coordinate plays and concerts,” added Shiyoko Takashima, Director of Mission Control. “I may be able to do that. I already have to coordinate a lot of different types of tasks.”

“If people did less extra work on the weekends, they’d have time for arts and culture, too,” said Marshall. “I think we should do that.”

“Then let’s give it a try; we have a volunteer!” said Yuri. “I think this meeting has worked out quite well. I’m glad to see everyone is so enthusiastic about our future here; quite a contrast with the angst we felt on arrival! The topics very much remind me of the ‘Future of Mars’ forums we all attended, focusing on expansion and quality of life. Remember, we can continue our discussion on the ‘Titan Today’ web forums.”

“It’s an ongoing discussion,” agreed Marshall.

“Congratulations on your recent reelection as Chief Executive of Ceres Borough, Dr. Langlais,” began the videomail. Helmut shifted in his chair impatiently; he had listened to the message three times now. “I am Arnold Comiskey, President of Fontein Metals. Until recently we operated several platinum mines in South Africa and one in Canada. Currently we operate a nickel mine in Ontario.

“I’m writing you because we are interested in investing in your PGM production. We understand that in four months Ceres will quadruple its PGM production team and receive new equipment that will enable it to produce 100 tonnes of PGMs per year, plus several thousand

tonnes of cobalt and tens of thousands of tonnes of nickel. The equipment you are receiving, we hear, is experimental and if it works as predicted will allow production of PGMs in the micro-gravity environments of asteroids. If you check our website, you will see we are a company of significant size, able to invest a billion or more redbacks in your operation. We are also prepared to invest in Ceres infrastructure; for example, your borough has only two physicians and the number will increase to only three when the *Bode* lands in March. If we sent a crew of twenty, we'd be willing to include a physician and at least one other support staffer. So our operation will not only expand yours, but diversify it.

“Any PGM extraction effort that is large scale and permanent requires considerable support personnel, comfortable living areas, and diverse food sources. We don't want to ship a team of guys to an asteroid for six months so they can live in cramped quarters and be bombarded by cosmic rays while they extract twenty or thirty tonnes of PGMs. Any profitable effort has to be large. That's why Parenago and Uzboi are successful, and why Ceres will be. We'd like to be part of your success. Please get back to me so we can start negotiations.”

Helmut looked at the follow-up email he had received earlier in the sol; Comiskey's first videomail had arrived almost two weeks earlier. It was a short, quick, polite reminder. It was time to respond. Helmut pushed an icon to record a video response and looked straight at the screen in front of him, where a camera was mounted.

“Thank you, Mr. Comiskey, for your detailed and intriguing videomail of November 6, 2073. I apologize for the delay in responding, but I wanted to be sure to talk to my PGM production team first. The big concern we have is that the ataxite body here at Central is estimated to have 25,000 tonnes of PGMs. There is the possibility that there is more farther down, though the magnetic anomaly data is ambiguous. Twenty-five thousand tonnes sounds like

a lot, and at 100 tonnes a year—our first production target—it would last 250 years. But it is unlikely our production will remain at that level. It is easy to imagine production of 500 tonnes per year in a decade or two, and at that rate the body would be totally exhausted in 50 years. What would Central do then? We need to plan for the future of this place; we don't want Ceres to become the site of a ghost town. If this borough is to have a future, we need to be careful in our planning.

“Consequently, we can't pursue your kind interest at this time. We much appreciate your interest though, and wish you all the best with your company's future plans.”

He listened to his message once and, satisfied, he hit send. But then he just sat at his desk, dissatisfied with the approach they had agreed to take. He was the one who had found the ataxite impactor a decade earlier and proposed that a Ceres settlement be set up next to it. But Ceres had tens of thousands of craters that were at least one kilometer in diameter, hundreds that were ten kilometers in diameter. Three percent of them were formed by nickel-iron impactors, and there were various types of them with varying concentrations of platinum, gallium, germanium, palladium, rhodium, and iridium. Ataxite was not the only option. “Shari, can you call up a map of Ceres on my desk screen please.”

“One moment,” replied the voice of his automated assistant, and as soon as she spoke the words, the image of a beautiful, dark mahogany surface was replaced by a Mercator projection. “Can you add known nickel-iron impactors, please.” Two seconds later a series of splotches appeared—a dozen or so—color coded. He touched several and chemical data popped up. They were fairly conventional. “Can you add magnetic anomalies also, please.” A second passed and a series of swirly red lines, often in circular knots, were superimposed on the map. Nickel-iron meteorites of all sorts were magnetic; many of the circles of magnetism were not located at the

sites of known nickel-iron meteorites, though all of the latter were surrounded by circles of magnetic field lines. Ceres had a lot of unknown metallic resources.

“Shari, please connect me to Jack Alberghini,” he asked, and a moment later Jack’s communications line was ringing.

“Morning, Helmut.”

“Morning, Jack. Say, I’m looking at a magnetic anomaly map of Ceres right now, and there are maybe a hundred circular magnetic knots indicating nickel-iron impactors. But it looks like we have characterized only 15 or 20 of them.”

“That sounds about right. It was an early priority, then the war blocked PGM sales and we postponed further investigations in favor of deep drilling and basic field geology.”

“Well, let’s refocus. You heard about Comiskey’s videomail, right? I bet we’ll get other investment offers. We have ataxite here; Mars has ataxite at Uzboi; but there are other types of nickel-iron bodies with other characteristics. Ceres has centuries of resources even at expanded exploitation rates. We need to determine what all our choices are.”

“Okay. We have a dozen prospector teleroovers out in the field that we can move to magnetic anomalies near them, and I suspect we have regolith samples near just about every anomaly that can be checked for small particles. I’ll get started on it. Of course, it wouldn’t be very convenient if we wanted to utilize an impactor hundreds of kilometers from Central.”

“I’m not so sure. A hopper can go to any spot on Ceres with a delta v , round trip, of 1.2 kilometers per second, and can get there in an hour. Nowadays we can run equipment remotely pretty well; we can even repair it remotely. Any mining and refining operation would require a fairly small crew and it could be rotated weekly.”

Jack considered his comment. “That’s true. Alright, I’ll see what I can find right away. There’s the matter of Earth profiting from space resources.”

“Yes, that’s a concern, too, although we won’t attract investment if we don’t generate profits. We’ll have to work on that one.”

2.

A New Era

Dec. 2073

Andalus Square was packed wall to wall, standing room only, for Jacquie Collins's inauguration. After Will Elliott conveyed the ceremonial "ship's bell" to her and the Chief Justice administered the oath of office, the crowd roared with applause. Jacquie, wearing a fashionable dress suit of local manufacture, walked to the podium, feeling nervous but looking confident. She glanced at Mario sitting up front and their daughter Mary sitting on his lap, for comfort in the huge crowd.

"I stand before you at the beginning of a new era," she began. "In three months we will mark the thirty-eighth anniversary of the arrival of human beings on Mars. Six people stepped onto the surface of Dusty Red that momentous sol in February 2036. Three of them sit here before us right now. Let us all acknowledge their sacrifices and dedication." She began to applaud, and the entire crowd stood and joined in. Will and Ethel, and Shinji, who were all seated in the front row, rose and the view screens momentarily focused on them so the entire crowd could see them. "We are particularly grateful to Will Elliott, who has been in the lead or central in the settlement of this world for thirty-four of those thirty-eight years. For over three decades we have turned to him for leadership, advice, and example. I know I plan to continue to seek his advice. In the week since I was elected, he has been unstintingly generous. He cleared out his office for me immediately! I have already occupied that office, but I will find it much harder to fill his shoes.

"Our nearly four decades have seen our population grow from six people to thirteen thousand, with three thousand more arriving in a matter of months. In 2036, the moon had two dozen inhabitants, low Earth orbit just a few more; now both are pushing toward a thousand.

Mercury, Venus orbit, Ceres, Callisto, and Titan, now the sites of small but thriving communities, were empty. In spite of enormous economic uncertainty on Earth, we have not begun to reach the limits of our growth. Mars is on the verge of domestic self sufficiency. One of the priorities of my administration will be to continue the expansion of our production capacities, with electronics being a major focus. If Earth slips into another depression—as it may—we will not have to worry about being cut off.”

She paused and the audience applauded. Most remembered the hardships and uncertainty of three years earlier; none wanted to repeat it. “One way we will increase our production capacity is to expand our engineering and scientific research laboratories. The Mariner Institute of Technology will see a major investment in its facilities, both here and at its Cassini and Phobos campuses. We will continue to seek research and development partnerships with universities and corporations all across Earth, but we will be in the position to pursue more opportunities, and more often to take the lead. Mars aims to be a major center of technological innovation, one that cannot be shut down by the economic and social disruptions that seem to sweep Earth every year, one that will be able to improve our life here and allow human beings to continue their expansion into space.

“Efforts to grow Mars are dependent on a vigorous flow of immigrants. The new Prometheus shuttle and the larger scale of our operation appear to be moving us toward a new, lower base price for immigration: a quarter million redbacks per person, which represents just fifteen months’ salary for many of our lower paid positions. That’s much less, in fact, than the cost of raising children here. We are literally at the point where we can loan money to people to fly here and expect them to pay it back over ten years. I plan to appoint a commission to reexamine costs with an eye to lowering it even more; some think in ten years it may be possible

to fly here for 100,000 redbacks. Either way, we are on the verge of getting beyond another limitation our immigration plans have always faced: the fact that they cost so much, we couldn't afford them. That appears no longer to be true. Our policy will be to aim for a thirty to fifty percent increase in immigration numbers every columbiad. We can do it."

She had to pause for that statement, because it generated applause, though it was not always vigorous; large immigrations tended to be disruptive. "Most of you have seen the projections: with natural increase, our population should grow at about fifty percent per columbiad, and that translates into a doubling about every four years. The year 2100 is 27 years or almost seven doublings away. Could Mars have a population of over a million by then? Yes, it could. Should it? Yes, it definitely should! Imagine what a dynamic, young population of a million could do!

"Clearly, one thing our population will be doing is exploring and supporting exploration. Mercury, Venus, Ceres, Callisto, and Titan together have barely a thousand people, a thirteenth of our population. If we want them to start here, go out, and return here, if we want them to be faculty at Martech, if we want them to turn to Mars, buy from Mars, and partnership with Mars for technological development, we have to support them as well. While all mariners may not be Marsians, all Marsians are mariners. Therefore, we are committed to the solar system exploration plan. Indeed, we will look for ways to expand it further. Two new priorities stand out. First, we will initiate plans to establish a settlement on Triton, the largest moon of Neptune, between 2085 and 2090. The technology to do this is not substantially different from that needed for the Uranus project. The exception may be propulsion technology, which will require considerable development if people are to get to Neptune in less than three years, and if the settlement is to be in regular interchange with the rest of humanity. Second, we will continue the quest to find ways

the solar system exploration plan can pay for itself. There are raw materials throughout this solar system of ours that are potentially useful to humanity. We must lead the way in finding them and determining how they will help us in our quest to improve civilization.

“The improvement of human civilization is the final priority of my administration, and the hardest goal to define. Mars has achieved some remarkable breakthroughs in its four decades. We have developed a governing system that minimizes disruptive dissidence and a social system that gives everyone education, health care, and employment. Our systems are far from perfect and can be improved further. But they are already possible models for nations on Earth to look at. Perhaps they can try implementing some of our innovations on a small scale and see how they work. We stand ready to assist. We seek to be friends with everyone on Earth and pledge our resources to the improvement of human life and its expansion from its terrestrial cradle to the stars. Thank you.”

The crowd rose and applauded. Taking advantage of the noise, Ethel leaned over and said, “Pretty good, but I think you do better. Maybe I’m just biased.”

“Her delivery was pretty good,” replied Will. “I was beginning to think she was going to rehash our existing priorities, but she added some focus to them, and both Neptune and greater revenue from space were important additions. I’m not sure how we’ll do the latter; that’s a huge challenge.”

“Do you really think we can grow to a million by 2100?”

“Who knows? We’d need technology able to support immigrations of one or two hundred thousand per columbiad. That means interplanetary vessels accommodating 10,000 or more and shuttles from the Earth’s surface to orbit able to launch a thousand people at a time. A crash would be absolutely devastating to such an enormous effort. But it should be possible; 100,000 is

25 times more than the 4,000 we're transporting this columbiad, and 4,000 is several hundred times more than the 6 we transported to Mars 38 years ago."

"A ship able to transport 10,000 in three months could accommodate a quarter or a third as many on a twelve-month journey, so two round trips per columbiad might be possible."

"The scale will reduce the cost per passenger, too, but we will need to spend billions to develop the technology."

They stopped talking because the applause waned. The Aurorae Philharmonic Orchestra struck up "Red Mars Our Home," the nearest thing to a national anthem they had, sung to the tune of "God Save the Queen" or "My Country 'Tis of Thee." Everyone rose to sing along. Then Ananda Thanarat closed the gathering with a Bahá'í prayer, for the inauguration was usually closed with words by a faith representative or a humanist. When he finished, everyone rose to leave.

Will's communicator buzzed. He pulled it from his pocket and smiled. He showed the text message from Marshall: *How are you feeling?*

"That was clever timing, since he must have sent it from Titan an hour ago!" said Ethel.

"Clever or lucky." Will was tempted to dictate a text back, but too many people could hear him, so he quickly typed, *I don't know! I guess I am now retired, but I have plenty of things left to say and ideas left to suggest.*

Ethel watched him type the message. "That's for sure," she said.

"So, did you guys finish work on your presentations for Propulsions Systems?" asked Wicahpi-Luta, as he brought his tray of food to their table in Martech's cafeteria.

Bill nodded. “Yeah; I’ve got my presentation ready. When are you on? Next week? You should have joined us.”

“I went to the inauguration.”

“I listened to a bit of Collins’s speech. You must be happy!”

“So, have you applied for the Neptune mission too?” teased Esther.

“No, because I’m going to Uranus instead,” joked Wicahpi-Luta.

“When are applications, anyway?” asked Bill.

“The second round is January 2075 and the third round is early 2076. I’m waiting for the second round; I’ll be at least half way through senior year. I wonder when they’ll start registrations for Neptune; probably 2080 or so.” Wicahpi-Luta looked at Charlie. “Your dad must have been happy about her call for developing revenue from the settlements.”

“He’s been wracking his brain about it for the last week, so this will probably keep him up all night,” replied Charlie.

“The economics are pretty depressing,” replied Sirikit. “Maybe Titan can export paperweights made from tholin? The only export anyone has ever identified is helium 3 from the atmosphere of Saturn, and it’s still not clear the Earth’s electrical industry will embrace helium-3 fusion.”

“We’ll see in the next year. But even then, it won’t help Saturn for a decade,” agreed Bill. “Maybe you should email them the idea about the tholin paperweights.”

Sirikit laughed. Charlie looked at her. “So, what’s the price of platinum today?”

“Eight hundred redbucks per ounce; down again. The post-war investment in infrastructure pushed it up to twice that level, but now governments are cutting back on deficits

to rein in inflation and the terrestrial economy is slowing. The PGM average price is even lower; ₨656 I think. Not good for Mars or Ceres.”

“But gold is trending upward?” asked Bill.

“It probably will, but it isn’t yet. So that’s an early problem for the Collins administration.”

Just then Guillermo came along with a stranger; older than them, in his mid thirties, with jet black hair. “Hey everyone, this is Corey Kubota,” he said. “An electrical engineer who just arrived to work at Phobos, down at Aurorae for a few weeks of training.”

“Corey Kubota, the zero-gee volleyball expert?” asked Charlie, his ears perking up.

“That’s me; and I recognize you as Charlie Langlais. When Guillermo told me you were here and he knew you, I asked him to introduce me.”

“Really? Why?”

“Because you know all the moves!” Corey sat at the table across from Charlie. “I’ve watched videotapes of the games up on Ceres; you’re brilliant! I think the Ceres teams were as good as any in low Earth orbit or on Phobos.”

“Oh, I don’t know,” replied Charlie. “I was on Phobos briefly a few months ago. They weren’t very good up there.”

Sirikit laughed at that, which made him smile slightly. “I see your friends have a keen appreciation of your modesty,” said Corey with a grin.

“Seriously, they are good on Phobos,” replied Charlie. “And it is hard to compare the games because we have point oh-three gees. I may only weigh two kilos there, but that’s something, and I use it.”

“Still, it can’t be that different.”

“I suppose not. I didn’t try it because I was on Phobos only two sols; my family here was anxious for me to come down.”

“Well, do you want to try it? I’m flying back up in two weeks, and when I get there, my half-time job—believe it or not—is to organize a proper intramural league. There are six hundred people up there and a lot of them want to play; it’s a rough and tumble place, full of single people, a great place to live and study.”

“Really?” said Charlie. “That’s very tempting. But I’m settled in here in Aurorae. My classes are here.”

“Take them by video. A lot of folks up there are doing the same.”

“True. Well. . . . no, I can’t do that. I have a field geology course down here next semester. You can’t do it by video.”

“Take a Phobos field geology course instead.”

“Oh, he doesn’t need any of them, believe me,” said Wicahpi-Luta, with a smile. “He’s a sophomore and he has already been asked to give lectures on the geology of Lutetia and Ceres.”

“Oh, I see,” replied Corey. “Sorry; not my field! Then come up for December break! It’s three weeks long. The outpost is full of empty quarters; a thousand immigrants just arrived and were accommodated for a few weeks, and the next wave doesn’t hit until February. They won’t charge you to stay, I bet. The food costs the same there as here.”

“Right now the weekly shuttle has a lot of empty seats, too,” said Bill.

“But how do I get one? How much is a round trip ticket; ten thousand redbacks?”

“Who pays?” replied Bill. “Just write up an email explaining why you need to go and Spacelift will issue you a free ticket, if you have all the certifications.”

“Which I do.” Charlie thought about it. He looked at Sirikit, wondering whether he could encourage her to go as well. “Okay, Corey, I’ll do that.”

“Great. Because like I said, you know the moves. I’m hoping we can organize a zero-gee Olympics in a few years, probably alternating between low Earth orbit and Phobos. Wouldn’t that be cool?”

“That would be very cool!” agreed Charlie.

Jacque Collins was still not sure she was satisfied by the new arrangement of the executive office. Will Elliott had removed all his furniture—the only item he offered to her, she didn’t want—and the replacements weren’t quite as elegant. She had an enormous L-shaped desk against the eastern and northern walls that gave her a good view of Andalus Square out the eastern windows, which also made it easier for her to walk to the southern half of the office where a semicircle of comfortable chairs gave her a place to talk to visitors. Her first visitor that Monsol morning was Ambassador Zhao Tao of China. He was uncharacteristically late, so she reviewed the latest status report from Earth. The galleon *Alcor* was nearly filled with passengers and would depart for Mars in another week. It was a great relief to have almost all of the 4,000 migrants safely launched from Earth. The next challenge would be launching 1,500 tonnes of cargo bound for Mars during late December, January, and February, which would arrive six to twelve months later.

A videomail from Vasili Ivanov popped into her inbox. He was in charge of infrastructure operations at Parenago, the large facility on the back side of the moon that extracted platinum group metals for export to Earth. She opened it with some trepidation.

“Good morning, Chief Minister Jacquie,” he began. “I’m afraid I am the bearer of bad news today. Did you see the precious metals price forecast issued yesterday? I gather you had an inaugural concert last night, in addition to the inaugural ball the night before, so perhaps your weekend was already full. Anyway, it’s quite bad; the price may halve in the next year, depending on how much industrial production drops. Consequently, the team here met this morning and we have decided that we cannot purchase a reactor from Mars in 2074-75. We’re not even sure we will assemble the one arriving early next year. We plan to maintain PGM production—we’ll cover expenses even at the lower price—but we can’t justify an expansion of capacity in the current climate. A new study also suggests that a large solar facility with hydrogen-oxygen fuel cells can be built more cheaply than a reactor, so we plan to investigate that option in more detail as well.

“As always, we value doing business with Mars. Ciao.”

She stared at the screen, stunned. Two hundred million redbacks of export revenue, evaporated in an instant. It was a bad way to start a term as Chief Minister. She hit reply and copied a half dozen others. “Thanks, Vasili, for the bad news. I understand the situation; we’re reexamining expansion plans as well. We’re always glad to do business with you and look forward to other opportunities. Ciao.” She hit send.

The rest of her inbox had congratulatory messages from the other facilities in space, which had come to her inbox because she had been Minister of Space Exploration before her elevation to the position of Chief Minister. Mercury had 140 personnel at Concord Station at that world’s north pole, where there were extensive ice deposits and perpetual sunlight; they had cleared a network of dirt trails across the planet over the previous twenty-five years and had set up a buried gold-mining station at Caloris Basin, a small occasionally manned station at the

South Pole, and a transit station called Portage at the Mercury-Sun Lagrange 2 point, where liquid hydrogen tanks could stay permanently in Mercury's shadow. Their two challenges were well-known: setting up an ataxite mining facility near Concord to extract platinum group metals for export to Earth, and their relationship with the European Union, which was promising further funding.

Magellan Station, in an elliptical 24-hour orbit around Venus, had thirty personnel residing in two caravels, and explored the surface of Venus remotely. They had three perpetual problems: the constant breakdown of equipment on Venus because of the extreme heat, the lack of an "outside" to relieve their cabin fever in orbit, and the fickle support of the Europeans, which was partially ameliorated by increased Indian involvement.

Ceres had seventy personnel and was now a borough of Mars, so its problems were hers: two aging caravels that required maintenance, a huge expansion in PGM production to cover costs, and more personnel to harvest the PGMs and study the asteroid belt.

Callisto also had two caravels and seventy personnel, was even more remote, and suffered from strained relationships between the American and Chinese crews on each; it was hoped the galleon *Galileo* and its 125 Marsian and international personnel, plus 30 more on the Chinese caravel *Gan De* and 30 on the *Barnard*, would change the balance when they arrived in 2075.

Titan had nearly 500 personnel and was the bright spot, in spite of its remoteness; its size and optimism made the situation with Callisto and Mercury worse, because they were envious. So she had to record a series of carefully worded responses to the messages of the commanders and Commissioners.

But before she could start, there was a knock on the door. “I apologize I am late; I was delayed by an important video message from Earth,” exclaimed Ambassador Zhao Tao. “Please allow me to extend my nation’s congratulations to you again. Shall I refer to you as Chief Minister Jacquie?”

“Yes, and I’ll call you Ambassador Zhao, as is the Marsian custom, unless we prefer Madame Chief Minister and Mr. Ambassador. Please come in and sit down.” She pointed to the chairs and headed to the one nearest to her.

“I like your changes to the office; very attractive. I see you have removed the hutch with the coffee and tea.”

“Yes; my automated assistant will provide instead. What would you like?”

“Black marabica.”

“Alright. Miki, did you hear that? And please bring me my usual.”

“Right away,” replied an automated voice. A moment later the main door of the office opened and a cart rolled in, complete with coffee and tea and two mechanical arms to prepare and serve them. It handed them cups—Jacquie had decaf coffee with cream—and then offered them a tray of cookies.

“Very nice hospitality, even with a robot,” said Zhao. “My government has asked me to discuss a matter with you. Now that the *Alcor* is just about filled and ready to depart Earth, and its passenger roster is finalized, my government has reviewed the various rosters and was surprised to discover that of the 4,000 migrants coming to Mars, 650 are Chinese. This is one sixth of the total. We calculate that the cost to China of educating them through their Masters or doctoral degrees was half a billion redbacks; more than twice the cost to the Marsian government to transport them here. We are very distressed and disturbed by this situation.”

“I understand your point, Mr. Ambassador, but how many Chinese leave China to settle in other countries every year? I suspect it is a larger number. Furthermore, the immigration wave has nearly a thousand Indians, a thousand Americans, six hundred Europeans, and three hundred Latin Americans. They have the same issue, I am sure.”

“I don’t know what they think of the matter, but I know we are concerned. Don’t you think that Mars has an ethical obligation to provide some partial compensation?”

“Has your government approached the American or European governments with this same concern? Because they are gaining more migrants from you than we are.”

“Madame Chief Minister, I am addressing the Marsian government right now with the issue. My government doesn’t inform me of its relations with other governments.”

“Perhaps you should ask, then. But to respond to your question, I am not aware of any government that feels it is ethically obligated to repay some other government for the education of its immigrants. Don’t you think this is an unusual question?”

“I am passing on my government’s concern. This issue has reached our national media and we see a backlash building against Mars. It complicates our efforts to cooperate with you in space. As you know, our budget is immensely tight because of the need to rebuild infrastructure destroyed in the war. It appears that we will not be in the position to send a galleon or even a caravel to Titan next summer.”

“Because of a matter like this? I suspect the real situation is that your government can’t justify spending a billion redbacks on a galleon when you’re under pressure to spend Chinese tax money on reconstruction and on old-age pensions, which are a bigger burden in China than just about anywhere, thanks to the old one-child policy. You realize if you don’t purchase the galleon from us, your nuclear team up here will also have one less gaseous core nuclear engine to

produce, which will put a big hole in their budget as well. Furthermore, if you don't allow your people to migrate to Mars, Chinese civilization will have that much less influence here; and without a Chinese galleon, there will be measurably less influence in the Saturn system."

"We have to make our own strategic allocations, Madame Chief Minister. Even a one hundred million redback reduction in the cost of the galleon will allow us to justify the expenditure to our Congress and to the people, who are indeed very concerned about the brain drain."

"I see." Jacquie considered the situation. "If the concern is over Chinese jobs, it may make more sense to look at larger Marsian expenditures on Chinese equipment. The first robotic road paving system has arrived and is being set up. A second unit is on the way. We will probably want to purchase two more, and they're one hundred million redbacks each. I could reasonably see us contracting for three or even four of them instead of two. And if you want to postpone the purchase of the galleon a year, we might want to purchase the gaseous core nuclear engine anyway, because we would use the ship to transport migrants in 2076."

"Interesting." Zhao considered. "We may indeed want to postpone the purchase of the galleon. I'll check with Beijing. We are concerned with the nuclear team's tasks; the engine is crucial for that. And an expanded contract for automated road pavers would be very welcome."

"Then perhaps we have an arrangement that is mutually beneficial for everyone."

"Possibly," replied Zhao skeptically. "I'll take your reply to my government."

"Thank you." Jacquie rose. "It's always good to see you, Ambassador Zhao." She smiled and they shook hands. She escorted him to the door and sat to consider what she had done. The plan had been to purchase up to six road building machines, two per columbiad; now one purchase would be moved up, maybe two if they proved effective. The plans for the 2076

migration required more vehicles than they could easily build, and now they had one of the vehicles they needed. The Chinese working on Mars and Deimos had more money to spend in the Marsian economy. And Chinese influence in deep space was reduced. Not bad for her first sol on the job.

Charlie walked to the front of the classroom as the other students began to walk out. “That was great, Firuz,” he said to Dr. Firuz Moulin, his friend from the flight to Mars from Ceres.

“You made some great points about Baetica’s cratering history. And you must have been happy to see your geological map!”

“Thanks for acknowledging me. Yes, that was nice.”

Firuz detached his tablet from the projector. “As you know, several of us have been planning an entire course on the geology of Lutetia next semester. It’ll be more like an advanced seminar, I think; several of the geology faculty want to participate.”

“I know. I can’t take it, though, because I’ve already done a seminar on Lutetia with you.”

“I know, but that’s not what I was asking. I want you to give two presentations. That’d make you faculty of sorts, and since you are also a student, they’d give you graduate level credit for it.”

“But I’m an undergraduate!”

“Yes, I know. It doesn’t matter; you have expertise to offer and I am confident you can offer it.”

“Really? Thanks, Firuz!”

“You’re welcome. You will have to attend the sessions, of course. They’ll be Monsol evenings.”

“Okay, I can do that.” Firuz headed out of the classroom, so Charlie followed. “How’s your research?”

“Pretty good. Most of my time has been devoted to wrapping up the work we did on Achilles and Agamemnon, a year before we got to Ceres. I’m lead author on Achilles and support author for Agamemnon, and I’ve also written a chapter about cratering on Hektor.”

“Do you think there’ll be another mission to the Trojans soon?”

“I hope so. We visited four at L4 and we’re getting samples back from fifteen others. We need at least to send a mission to the L5 Trojans. I’m thinking of committing to either Ceres or Callisto for five years.”

“Ceres might be the launching point to the Trojans, too.”

“Definitely. There are plans to launch missions from there every year to nearby asteroids, and the asteroids in the outer belt are quite similar, if the expansion plans happen.” Firuz looked at him. “So, is life treating you well?”

Charlie shrugged. “Yes, well enough. There’s this girl I really like, and she won’t let me . . . romance her at all.”

“I see. What does she want?”

“Hum. Love rather than sex, I suppose.”

“And that’s bad?”

“Well, it is now!”

“I see.” Firuz smiled, amused.

They turned the corner and saw Sirikit Thanarat coming toward them. They both smiled at her. “Alláh-u-Abhá,” said Firuz, for they were both Bahá’ís and it was a common Bahá’í greeting. It reminded Charlie that both his favorite mentor and the girl he really liked were of the same faith. It also reminded him that he had almost committed a fatal mistake by talking about his interest in her.

“Alláh-u-Abhá,” she replied to Firuz. She turned to Charlie and smiled. “How are you?”

“Pretty good; I finally have a sol or two between papers and exams, so I can breathe!”

“Yes, I know what you mean. I do, too, but now I have a new project. Professor Hun-jai Park just told our advanced econ course that he’s offering a course on “Solar System Economics” next semester. The idea is to take up the challenge that First Minister Jacquie laid out in her inaugural address that we need to find more ways for the other settlements to pay for themselves.”

“That’s a great idea,” said Firuz. “Martech students are the best group to engage in that challenge. I’ve got to go; I’ll see the two of you later.” Firuz nodded in good bye and headed down the corridor.

“Bye, Firuz,” they both replied.

“So, do you want some lunch?” asked Charlie.

“Sure, I’ve got an hour.” They started walking toward the cafeteria.

“That course sounds really cool. But isn’t it for graduate students?”

“Martech has no economics graduate students, so he makes do with us undergraduates.”

“Oh, of course. We have plenty of geology grad students.”

“Of course, but it’s a desert in the social sciences. We’ve got pretty good faculty, at least.”

“True. Say, I’ve been thinking about the meeting with Corey Kubota the other sol. Why don’t you come to Phobos, too? You don’t have anything else to do over Christmas vacation, do you?”

“No, but how would I explain that to my parents, going to Phobos with you! And I like you, Charlie, but that’s rather . . . bold of you.”

“Sirikit, that’s not what I meant! It’d be an adventure, don’t you think? A fun way to spend the vacation. We could hike outside, float through the agricultural cylinders, explore the gravitied areas—Phobos is getting really big—you could watch my zero-gee games, and you could get some certifications.”

“I don’t need zero-gee certifications, space suit certifications, etc., I’m not planning to leave Mars, or not any time soon.”

“Well, you never know.” Charlie saw he was losing the argument. “But couldn’t you do research for the Solar System Economics course? Get a jump on that? Sure, you can talk to people by videophone, but going to look at the factories, talk to people face to face . . . isn’t that better? Because Phobos is absolutely unique in the solar system, and always will be.”

“Yes, that would be much better.” She was thinking about that idea quite seriously.

“Well, think about it,” added Charlie encouragingly.

They reached the cafeteria. Wicahpi-Luta was seated at their usual table and Esther arrived moments after they did. Charlie and Sirikit stopped to say hello to Wicahpi-Luta and left their bags there. “That was a good geo class; Firuz does a good job,” said Wicahpi-Luta. “But since I’m an engineer and you’ve been there, can we sit down and go over some things?”

“Sure.” Charlie sat to answer his friend’s question about the cratering ages of different units and the problem Firuz had mentioned of reconciling the dates with the date of the late

terminal bombardment. By the time he had finished, Sirikit was back at the table with Esther, having gone through the cafeteria line with her.

“You better get some food; they’re almost out of fish,” said Sirikit. “And by the way, Esther and I will ask our parents about going to Phobos over vacation.”

“Both of you?” said Charlie, surprised.

“I want to learn more about their horticulture; I’m taking a horticulture course next semester,” said Esther.

“Ah.”

Wicahpi-Luta looked at them “You’re going to Phobos?”

“I’m going for the zero-gee volleyball; remember Corey Kubota invited me? And Sirikit is going to do research for her course in Solar System Economics, next semester.”

“Really? I wonder whether I can get some certifications up there? Space suit operation, for example, or low gravity EVAs.”

“Both,” agreed Charlie, confidently.

“Then maybe I’ll go, too,” he said, looking at the others, but especially at Esther.

“Hey Marshall, have you checked the election website yet?” called his neighbor, Toru Takahashi.

Marshall turned toward the line of dachas along the “west” end of H-4. The LED sunlamps were turning down and turning red to simulate sunset; by 8:30, the enclosure would be completely dark, but they still had fifteen minutes of twilight. Toru was standing on his patio at the gate opening onto the park, clearly visible in the twilight.

“No; voting doesn’t end until midnight.”

“It ends early if everyone has voted, and that happened about two hours ago,” replied Toru. “I suggest you take a look when you get the chance.”

“Okay, thanks.” He looked at Guangya Kwok. The two of them had been playing ball with Willie and Kam-yuen, a tricky proposition in Titanian gravity, because the longer distance the four year olds could throw the ball magnified their inaccuracy.

“You go; I’ll keep the ball going,” replied Guangya.

“We have to stop pretty soon, anyway,” said Marshall. He headed toward his dacha, which was between the Takahashis’ and the Kwoks’. He had left his tablet and his communicator downstairs in the bedroom. Amy was there packing up everything; they only spent the weekends in Titan’s low gravity. During the week, they stayed in their condo in the spinning space of the *Von Braun*. “Do you see my communicator?”

“There.” She pointed to the table. He picked it up, pointed it at the wall screen, and pushed an icon so that everything he did appeared there. “Please display Titan election results, Shari,” he said.

“Here they are,” replied a voice from the communicator. The screen suddenly changed from a three-dimensional twilight view of the Cascade mountains outside Vancouver, British Columbia—Amy’s home—to a table of voting results.

She looked. “My goodness. Congratulations, dear!”

“Thank you; I guess.” He looked more closely. “So, of 375 adults, 340 voted for Yuri; clearly they want him as Executive.”

“I think so. Sridhar Prathan, 290, and Andries Underwood, 270; I’m surprised he got more votes than Shiyoko Takashima, at 221. She was already on the Council, after all.”

“And Marshall Elliott, 137.”

“I’m proud of you.”

“Well, Tomas Racan was right below me at 130, and the next three got more than 90. It was hardly a landslide.”

“It never is when there’s a vacant seat and there’s no campaigning. No one knows who will be elected.” She kissed him. “It means people trust you and your character.”

“Now I have to add the Titan Council to my many duties.”

“You do. We’ll accommodate it, don’t worry.”

“Thanks, I’ll need your help.”

“You’ve got it.”

3.

New Missions

Dec. 2073

“Sirikit, come over and see the Spirit of Mars!” exclaimed Esther.

“Go slowly so you don’t barf again!” warned Charlie. “Phobosian gravity is like none at all. It won’t prevent space sickness.”

Wicahpi-Luta unstrapped himself from his seat and pushed himself upward gently. He floated up. “Interesting; I think I can feel the gravity, but I’m not sure,” he said.

“No, you can’t; you’re flying on a trajectory, and while you’re doing that, you’re weightless,” pointed out Charlie.

“You’re right.”

Charlie unstrapped himself and pushed over to another porthole next to Esther’s. The four of them had the entire deck of the passenger shuttle to themselves; during Christmas vacation the traffic was mostly downward to Mars, not upward to Phobos. Wicahpi-Luta reached out to Charlie as he floated by and Charlie gave him a tow so that his half-Lakota friend could look, too.

The four of them looked at the androgene of gold-colored mylar, both hands upraised, a rocket flame extended downward from his/her feet. It was balanced on a high point of the rim of Stickney Crater, several kilometers east of them. Mars loomed huge, right behind it; an amazing sight.

“The symbol of Mars,” said Esther, admiringly.

“It greets all the arrivals,” said Charlie. “I don’t remember seeing it when I was ten. I guess it didn’t register. But when the *Wolf* landed here back in September and I saw it, it brought tears to my eyes.”

“And when we take the low-gravity certification course, we get to fly over to it and take a look,” said Wicahpi-Luta.

“I’m still not sure I want to do that,” said Sirikit. “I’m an economist, not an astronaut!”

“You’re a mariner,” exhorted Charlie, gently. “For mariners, pressure suit and space suit certifications are like getting a driver’s license.”

“Well, that’s your understanding! But I suppose I’ll do it, if my friends are going to do it.”

Esther nodded. “I don’t need it to do biology or nursing or psychology—whichever one I settle on—But I’ll give it a try.”

“That’s the spirit,” said Wicahpi-Luta.

“Level one certification only requires six hours outside,” said Charlie. “And the teacher said he’d give you the low-gee training as well, so you can get that certificate at the same time. That’s a good deal.”

“If there’s time, I’ll get the level 2,” said Wicahpi-Luta. “You never know when it’ll come in handy.”

The intercom crackled and Bill Hollingworth’s voice could be heard. “The egress tunnel is now pressurized and available. You may exit the vehicle.”

“Let’s go,” said Charlie. He reached up and opened an overhead compartment, where he pulled out the bags for all four of them and gave each a gentle shove toward its owner. They floated to them. The four of them turned to the stairwell and Charlie plunged down it head first,

much to Sirikit's surprise. But she followed him to the lower level quite safely. The other six passengers on the flight were located down there and were gradually heading out. Just as they started into the tunnel, Bill Hollingworth came down the stairwell also.

"Are you finished with checkout?" said Wicahpi-Luta, surprised.

"Yes. The pilot is finishing it up, but it's mostly automated anyway. I wanted to give you guys a tour of the outpost."

"That's nice," said Charlie.

"Of course, if one does a virtual reality tour, one already knows where everything is," said Sirikit.

"Well, I'll let you lead us around and I'll add the emotional coloring, how's that?" replied Bill, irritated. She smiled slightly, enjoying his reaction. They all began to walk-float through the pressurized tunnel that had been attached to the shuttle. In a few meters they stopped at a spot where there was a huge plastic window looking out on the rolling, crater-pocked, reddish-gray surface of Phobos. The Spirit of Mars statue crowned the eastern horizon with Mars itself as a backdrop.

"Wow," said Esther.

"If you take a level-1 space suit course, it culminates with a walk around the statue," said Bill. "Level 2 is more ambitious; they usually take you up part of the steep wall of Stickney crater, which is on the other side of the androgyne. The view is really cool: you can see all of Stickney and our water extraction wells on the bottom of Limtoc to the east, the outpost and greenhouses to the west on the Stickney ejecta blanket—you can't see the solar panel farm though because it's farther west where Mars never eclipses the sun—and to the south you can see the Stickney Overlook hotel, a converted caravel on the rim about half a kilometer from the

Spirit of Mars. It's a great place for a honeymoon." He pointed down the passageway and they floated along the ramp down to the surface and through a pressure door to an underground tunnel, which was buried for radiation protection. Tunnels from two other landing pads joined theirs, then after one hundred meters they reached an intersection with three choices. To the left it said, "South: Alpha, Beta, offices, Landing Pads 4-6"; to the right it said, "North: Gamma, Delta, Greenhouses 1-24"; and straight ahead it said, "West: Galleon and Caravel Construction drydocks, Greenhouses 25-42."

"Alpha has the cafeteria and stores," said Bill. "You guys must be really hungry."

"We are, but there's also a snack place on Delta, and that's where our rooms are," said Sirikit. "I suggest we go there. The four galleons all looked pretty much the same to me, other than the stores and the big eating area."

"They're almost identical," agreed Bill. "Delta has smaller rooms; it's overflow housing, especially when a galleon arrives from Earth. You've got to experience the cafeteria, though; big, noisy, full of energy."

"Alpha, Beta, and Gamma accommodate 250 each," noted Sirikit. "And Phobos has a bit less than 700 residents, so Gamma isn't full yet, though it will be within a year."

"This place is growing fast," agreed Bill.

"It has to," replied Sirikit. "Low Earth orbit has the advantages of proximity to terrestrial markets and smaller delta-v. The only way we can compensate is scale and long-term accommodation. Phobos still has twice the population of all the facilities in low Earth orbit combined, and people can live here all their lives; there's no need to rotate to another place, and if they do decide they need shore leave, Aurorae is half the delta v from Phobos as low Earth orbit is from the earth's surface."

“Spoken like an economist,” said Charlie.

“Well, I’ve got a lot of interviews to make up here, for my project.”

“I’m getting a tour of the greenhouses,” said Esther. “One of my biology professors put me in touch with Marci Carnegie, who’s in charge of horticulture and biological research up here.”

“Can we go along, do you think?” asked Wicahpi-Luta. “We’d all like to see them.”

“Probably. Do you think I can get a tour of the geological labs with you?”

Wicahpi-Luta nodded. “Probably. If we all stick together and use our different contacts, we should see most of this place.”

They passed a corridor to Gamma, then one to the greenhouses. The main passageway ended at a left turn to Delta. They turned and headed up to the surface, where they had another view of the moonscape; the Spirit of Mars was much farther away and smaller, and most was over the horizon. After looking for a minute, they headed up into the galleon. They popped up into the center of the spinning hub.

Bill put his feet down on the non-spinning surface and stepped over onto the spinning part. “Just like stepping onto an escalator.”

“Mars doesn’t have any escalators!” replied Sirikit. But she watched Charlie and Wicahpi-Luta step across—Charlie already had practice—so she followed, then Esther. She looked at the three elevators, then pointed. “That one. Esther and I have rooms on the fifth level, Charlie and Wicahpi-Luta on the fourth level, and the cafeteria’s on the third level.”

“Okay, let’s go,” said Charlie. He pushed the down button and the door immediately opened. They all stepped in. “Let’s get something to eat, first.”

“Once I’m in real gravity, I’ll feel better,” agreed Sirikit. She pushed “three.” The elevator descended and gravity immediately built up from almost nothing to almost Mars normal. As the door opened, they saw a sign: “3d floor, 0.2 gee.” Sirikit walked out with a feeling of relief. “Ah, I can feel the up and the down,” she said.

The cafeteria was a few paces away. There were two people sitting and drinking coffee, but otherwise it was empty. The food service was completely automated; they ordered from a simple menu and hot food appeared a minute later. They sat at real chairs with real gravity. “Be careful drinking,” advised Bill. “You have to move open cups rather slowly in 0.2 gees or you’ll spill the contents all over you.”

“There’s a cool competition in Phobos gravity,” said Charlie. “Who can drink from an open cup of water. It’s really hard, but possible.”

“It just takes 2 or 3 minutes to move a cup to your mouth!” added Bill, with a laugh.

They heard the elevator door open and a minute later Maaka Hunter stepped into the lunchroom. The twenty-three year old was the older brother of Wicahpi-Luta; ironically, he looked more like his Lakota father and Wicahpi-Luta more like his Maori mother, the opposite of the origins of their names. He walked straight to his brother and they embraced. “You arrived! Welcome to Phobos!”

“Thanks, bro. It’s good to see you!”

“It’s been a while, and I don’t think I’ll be going to Aurorae before June; the work up here is good and I have a lot of friends.”

“Mom and dad want you to come down for a visit! So, did you get off work early?”

“Yes, four hours; the shift ends at 7. Sorry I couldn’t meet you at the shuttle, but there was a minor problem and it took two of us to fix it. How was the flight?”

“That’s a loaded question, with the copilot present,” joked Charlie.

“Oh, that’s right! But Bill knows I don’t mean any offense. We went to high school together!”

“It was pretty good, except for Sirikit.”

“I threw up twice.”

“Motion sickness; it’s just like going out on the sea. People get seasick for a few days, then they adjust,” said Maaka. “Or so I’ve been told!”

“The new fast trajectory works pretty well,” said Bill. “Three hours from launch to apoapsis just below and a dozen kilometers behind Phobos, circularization burn, then the moon’s gravity pulls you in and one hour later you prepare for landing. The old system took up to one sol.”

“It still wasn’t fast enough for me,” said Sirikit.

“So, how’s work? You’re building galleons, right?” asked Bill.

Maaka nodded. “I’m a mechanical engineer and a metal worker. Right now we’re welding the bulkheads—mostly via robots—and main structural elements for section six, which is the last section of the galleon we’re working on. Once we’re done, the galleon can be moved out of drydock to a parking spot, a big bag can be put on top and filled with three thousand tonnes of water, and the spin can be increased; right now we’re working in a twentieth of a gee, which requires special training. Once it’s parked and has radiation shielding, we’ll weld the remaining bulkheads one section at a time, and once we finish a section, the construction specialists move in to complete the interior. At that point another galleon shell will have been inflated in the drydock and we can move back in there to complete the metal work.”

“So you’re working on two at once?” asked Sirikit.

Maaka nodded. “Currently, and we’re running three shifts, which allows us to complete two galleons a year. There are plans to increase production to three per year if there’s demand. Once the shell is completed and airtight, it could be moved out of the drydock and the metal work added.”

“And when can we get a tour?” asked Wicahpi-Luta.

“We? I had asked to bring you in when the shifts change at 7 p.m. You can’t see section 6, but the welding is done in the other sections, so I can show them to you.”

“We’d all love to come along, though,” said Bill.

“And I have a lot of questions to ask,” added Sirikit. “I’m up here researching a presentation and paper for a course on solar system economics next semester. A tour would be very helpful for me.”

“I bet all of you plan to go to space sometime, too,” said Maaka. He nodded. “Okay, I think I can talk my boss into letting all of you in. But if you were having troubles with nausea on the shuttle, you better take some dramine. You can’t vomit in the drydock!”

“I promise I won’t,” replied Sirikit.

The Oberland Uplift of the Thaumasia Mountains was a rounded, crater-pocked rise peeking over the western horizon. Madhu Anderson looked at it and it reminded her of something her late husband Roger had said: that Thaumasia was a collisional plate boundary that had never been dissected into peaks by erosion like collisional mountain ranges on Earth, rather it was a series of big, rounded crunches. She saw what he meant; other than a few tectonic rips, craters of mostly small size, and gullying by rain a few billion years earlier, it had never been eroded. It was not a “range”; it was an uplift.

As the lead vehicle crossed the intervening terrain, the five-kilometer rise reared higher and higher in front of them, rather like a smoothed version of the Front Range from Denver. The trail turned south a bit and rolled over a low rise that proved to be the battered, ancient rim of Grandi crater. They descended to its flat, smooth floor, and after twenty kilometers the trail widened into a hard, smooth, runway of duricrete: Thaumasia Outpost's air strip. At the far end they passed a water well and a cluster of buried water, methane, and oxygen tanks. A power line now lay along the ground next to the trail.

After crossing Grandi, the trail climbed up a much steeper, taller rim, and wound around foothill ridges and craters on the other side. Soon a fresher rim rose steeply over a hundred meters in front of them: Apgar Crater. Topping the crest, Oberland spread out in magnificent, rolling desolation before them. Looking into the crater below, they could see a clump of tanks for water, oxygen, and methane, a cluster of refining equipment, several piles of ore, an array of solar panels against the north-facing inner rim, and two lines of buried metal quonsets. They had reached Thaumasia Outpost.

The mobilhab descended to the crater floor and crossed it. It slowed and turned in order to tow into place the metal Quonset it had just brought. For several minutes it inched forward, then backward under the direction of a man in a pressure suit. Finally a series of clanks told them the Quonset had been detached. "We're free," said Mindy.

Madhu nodded. "I wonder whether we're going to dock with the outpost, or drive into a garage."

"We'll see."

The Mobilhab moved away from the Quonset and for a second they could see the ten meter long, eight meter wide, 8-tonne unit in place against an earlier unit. The other mobilhab

was busily placing a second addition to the outpost next to it. Thaumasia had just received living and working accommodation for ten more people, between the two Quonsets, which was good, because the Mobilhabs had brought the same number of additions.

The mobilhab drove into a Quonset that served as a garage and waited. The second vehicle followed two minutes later and the airtight garage doors closed. In ten minutes the garage had been pressurized and they could step out: Madhu; Mindy; Mindy's son, Victor; the vehicle driver, Tonya Manyhorses; her son Neal, also four years old like Victor; and Tonya's husband, Ken Manyhorses. Sam Anderson was there to greet them all.

"Hi, mom, thanks for coming to Thaumasia!"

"Delighted," replied Madhu, kissing her son. "You look well."

"Commanding an outpost agrees with me, I guess." Sam said, a bit boastfully. He picked up Vic and hugged him and Mindy at once. "It's so good to have both of you here!"

"Daddy, I missed you!" said Victor.

"So did I," echoed Mindy.

"I missed both of you so much." He kissed them both. Sam turned to the Manyhorses family. "It's so good to have you here. Thanks for coming."

"We're delighted, Commander," replied Ken.

"And having two boys of the same age; that was smart advertising," added Tonya.

"With me to help with child care, we should do pretty well," said Madhu. "The other four of you will have child care responsibilities for only four hours every other sol."

"We're very grateful for that!" said Tonya.

"Let me greet the crew in the other Mobilhab," said Sam. He walked back to the other vehicle and shook hands with the four young men and the two young women who had arrived in

it. Meanwhile, the Manyhorses grabbed their luggage and headed into the outpost. “There’s not a lot to show you,” said Sam, when he came back to his family. “Thaumasia Outpost consists of two lines of five metal Quonsets; no, two lines of six Quonsets, once the two new ones are welded in place and buried. There’s a cross connection between every other pair, which is also where you’ll find the ramp to the second story. The garage here is paired with an equipment storage and repair Quonset, and it has a big airlock as well so we can move big pieces in and out. The egress airlock and locker rooms are there, too.”

“So, there are now forty personnel here?” asked Madhu.

“Yes, with the arrival of ten more adults in these two mobilhabs. We’ll be getting a pair of Quonsets every two weeks through mid March, at which point we’ll have room for fifty more personnel. The new people will start arriving in March and April after the next two galleons arrive and the personnel land on Mars and complete a two-week orientation. This place has the feel of a mining camp; the personnel are all in their twenties, almost all are single, men outnumber women two to one, and people work very long hours. There’s a fair amount of drinking on Saturdays night. They need a grandma, mom.”

“I’ll see what I can do,” said Madhu, amused.

They passed through a pressure door into a cafeteria. “The equipment control room is opposite,” said Sam. “Our apartment is in the back; my original room is now my office and is pretty small.” They crossed the cafeteria and headed down a corridor in the next Quonset, past the kitchen and food storage area. The next Quonset was another equipment control area, where a half dozen personnel monitored automated mining and refining equipment. The fourth Quonset held a machine room for repairing small items and creating spare parts with 3-D printers. They reached a node where they could turn left and cross into the other line of

Quonsets, which were residential; most had a corridor running their length with a small lounge in the middle onto which opened four private rooms and two bathrooms. They walked the length of one Quonset and reached the last one, where their quarters were located.

“We have the front half and the Manyhorses have the back half,” explained Sam. “Mom, this first door is yours; the second door leads into Mindy and my bedroom.” He led them to the second door and opened onto a room that was four meters by five, with a couch as well as a Queen-sized bed. “Vic’s bedroom’s back there and is small, but so is he. That door goes to the bathroom; your room has a door to it as well. That door leads to our closet. We’ll use the couch as our living room.”

“Small, but cozy,” said Madhu, walking in with her luggage. She pointed to a door. “And this leads to my bedroom?”

“Exactly; you can come straight here, or through the bathroom, or through the corridor. The back of your bedroom has a large closet area which is family storage.”

“The ‘attic,’” said Madhu. She opened the door and entered her room; it was three meters by five. She put her suitcase on the bed and walked back to the main room. Mindy and Vic were exploring the little boy’s bedroom.

“I’m really grateful you came, mom,” said Sam. “It makes it possible for Mindy and Vic to come here.”

“I finished my art projects at Aurorae, so it was a good time. I’m sure I can do some art here, too, maybe using minerals from the pegmatites the outpost is mining.”

“How long can you stay? A year?”

Madhu nodded. “Or longer. I’ve made an arrangement to work with the Aurorae preschool and kindergarten, so that Vic and Neal can see what’s happening there and can

participate via live video. We'll do the same sorts of activities. When the boys move up to first grade, they'll be able to participate in Aurorae Elementary School and I'll be able to coordinate the lessons. I'm not sure how long I'll be able to do it beyond that, though."

"There's another family that probably will come; they have two girls, aged 5 and 8. At that point, Thaumasia Outpost will have to hire a professional teacher for the third grader. But if you can stay 2 years and complete kindergarten, that'd be good. I want to put you on salary for the four hours a day you'll provide."

"It really isn't necessary; I have plenty of money."

"No, it's important. Thaumasia is a borough with a civic government and is the seat of Thaumasia Minerals, Inc. The Commonwealth is guaranteeing salaries for two years, which should be plenty for us to set it up. In return, the Commonwealth gets shares in the company in proportion to its financial investment in it. The rest belongs to the residents, who receive stock in the company in proportion to their salary and the number of hours they work. That's one reason everyone's working sixty or seventy hours a week. If we get you on the payroll, you will get stock as well, and that's only fair."

"Well, I really don't need it, but I don't have any objection, either. How does the financial viability of this place look?"

"Oh, it's viable; we were sure of that already. We started mining spodumene two weeks ago and our first lithium shipment is later this month. Demand is only 100 tonnes per year, but it costs 200,000 redbacks per tonne to import from Earth, so spodumene alone will be sufficient to pay off the investment in equipment and infrastructure over ten years. Fifteen kilometers farther from here is a tungsten deposit and we will soon start mining it and extracting the metal, though Marsian demand currently is only a tonne or two per year, mostly for nuclear reactor

production. We also have minor gold deposits, but sufficient to produce perhaps three tonnes per year; that'll cover our expenses as well. The aluminum feldspar deposits are large, but Tithonium is already producing aluminum and we can't compete with them. Beryllium and fluorine will probably be our next priority, followed by niobium, but demand for all of them is fairly small; a few tonnes per year. We'll probably build up an inventory of ten or twenty tonnes and warehouse it until it's needed. There are also gem stones we can mine for the jewelry industry and granitic building stone."

"Basically, we're here to mine resources we're importing from Earth."

"Exactly, and as Mars grows, our role will grow."

Madhu looked up. "And we have three meters of regolith overhead?"

"Yes, on top of a meter of plastic bags full of ice; really good cosmic radiation shielding. We want to keep everyone safe. Not only is Vic sensitive to radiation; the crew is outside about sixteen hours a week, on average."

"I know we have a room for child care, but where will the boys run? The cafeteria?"

"Yes, that's the biggest space available for now, unless the garage is empty and pressurized. We're getting a B-75 greenhouse in January and a second one in March, so you'll have a half hectare of polder to explore at that point."

"But they'll be full of vegetables and a few staples, like corn; they'll provide the basics for fifty people. If we could have a play area, that'd be great."

"I'll look into that, but that would be hard. The March arrivals will include an enclosure construction crew. They'll build us a 70 by 150 meter enclosure by October and a second one by next March. At that point we'll have 2 hectares of polder."

"That's generous, for an outpost of 100 people. Plenty of room for playing then."

“And for adults with cabin fever,” added Mindy. “These tin cans will get boring pretty fast! When can I get up into Oberland and see the mines?”

“I’ll take you and the Manyhorses up morrowsol. We’ll make a little tour of the mines. If we have time, we’ll even head north to Como Fossa, which is a big, deep rip in the uplift; spectacular to look at, and probably full of resources for future use.”

“I’d love to see that.”

“I would, too, but I have another concern,” said Madhu. “Sunsol is three sols away. Is anyone offering any Sunsol worship?”

Sam shifted on his feet nervously. “No, mom, no one has been doing that.”

“Your father was quite a good preacher, for someone whose training was geology, and I miss his sermons. So I think it’s time for me to try my hand.”

“Really?” said Sam, surprised and unhappy. “Do you feel able to do it?”

“I do; I just said so. We can select hymns, broadcast the instrumental accompaniment, select the Bible texts; it isn’t hard.”

“I’ll help,” added Mindy.

“Good. Because I want my grandson getting a Christian education, even if it didn’t take so well with my son. It’s a precondition of my stay here.”

“Okay, mom,” agreed Sam. “Maybe it’ll help with the grandmothering that some of the crew need. But I suggest you hold the service Sunsol afternoon, because this crew plays hard Saturdays night and they aren’t up until noon on Sunsol.”

Charlie had never played zero-gee team handball before. It was a misnomer, really; one could hit the ball with any part of the body, including the feet, one just couldn’t hold onto it more than

three seconds. It was strange to have an audience all around the court, separated from it by a transparent hard plastic barrier that one could bounce oneself or the ball off of. One could kind of dribble the ball, and Charlie noted that the dribbling could also be used to control and direct one's own movements if one was skillful and didn't lose the ball to an opponent. The frequent strips of Velcro on the barrier were immensely useful for stopping and standing. Getting the ball in the meter-wide circular goal was not easy, mostly because one had to be dangling in space in front of it to do so, and it was hard to float. When he managed a goal for the red team, the sparse audience watching the practice cheered. The game ended 1 to 0 and he was the hero of the scrimmage.

"Look, we need some wings," he said to Corey Kubota as the sixteen players stood on Velcro strips to talk at the end of the game. "The air is thick enough to give you some traction even with fairly small wings, once you learn how to use them. They need to be about 75 centimeters wide and extend all the way from your wrist to your shoulder. I suspect all of us have experience with zero-gee flight; I've been flying since I was six or seven."

"We should get flippers, too," agreed another player. "That way our feet can propel us as well, and we can use the flippers to catch and direct the ball to our hands. If we had them, I think the goal could be shrunk down to the size of a basketball hoop, because we'd be much more effective."

"And much less frustrated by our movements," added a third player.

"Okay," said Corey. "We'll try that next time. I think this twenty-five by fifty meter court works pretty well inside the B-75. There's plenty of room for spectators; five thousand, by one calculation! But eventually we'll need to install seats with seat belts and set up float corridors for ingress and egress. That'll cost a lot of money."

“We’ll need to install a court with better access to several passageways; maybe at the main north-south and east-west passageways,” suggested someone.

“And much better lighting; it’s dim in here,” noted Charlie. “If you want to televise it, you’ll need at least a dozen cameras.”

“Oh, we have a plan for that,” replied Corey. “Skip Carson’s planning that aspect. He even wants cameras on tracks that can follow the ball. But more about this later, guys. See you morrowsol.”

“Bye, Corey,” replied several. Men began to pull free from the Velcro strips and soar across the court to the eastern and western doors.

Corey turned to Charlie before he could go. “I really wish you’d consider relocating here. You’re really good; I suppose it’s because you’ve been floating and flying since you were a kid. You could do plenty of jobs up here. They’re expanding the Center for Asteroidal Studies of Martech; it’s supposed to become the most important center for studying them in the solar system.”

“I know, I’ve followed the news. But you’re talking about a professional team.”

“Yes, but studying here while we get the teams established and professionalized would make a good transition. The Phobos Preschool and Elementary School already has almost 100 kids in it who can start learning zero-gee sports now. This place will grow to a thousand people in the next few years, and then who knows where it’ll go? There’s nothing like this in low earth orbit, and there may never be. Phobos has trillions of tonnes of water, carbon, and nickel-iron, not to mention radiation shielding. Any place suitable for raising kids in LEO will require tens of thousands of tonnes of shielding, and no one will haul that much stuff up. The crews in LEO rotate every few months; they won’t stay long-term and get good at zero-gee sports. This is the

place where zero-gee sports will develop. Television contracts will pay for it. I predict a small professional zero-gee sports league here in five years.”

“Really? That is tempting, I must say. It’s not the career direction I considered, though.”

“You’re what; twenty? I doubt you can be a professional player beyond your early thirties anyway, because that’s the way it is. So you’ll need another career after that. You’ll have plenty of time to do asteroidal missions, if that’s what you want.”

“That’s true. Well, I’ll keep it in mind, Corey.”

“Please do. Consider it seriously.”

Charlie nodded at that and waved goodbye. He headed for the east door. When he opened it, he was surprised to see Firuz Moulin waiting for him with a man who looked vaguely familiar. “Firuz, what a surprise! I didn’t know you were coming up here!”

“Yes, I arrived yestersol; I guess you’ve been here a week?”

“Yes, with three friends. We’re all here for different reasons; I’ve come up to participate in zero-gee sports. Corey Kubota’s organizing some teams, and he saw video of me playing zero-gee volleyball on Ceres, so he invited me.”

“We were watching; Jean Paul told me about it and we came to watch, and I was surprised to see you here. This is Jean Paul Poirier, by the way.”

“Oh, the asteroid expert! Pleased to meet you. Charlie Langlais.” He extended his right hand and they shook.

“Pleased to meet you,” replied Jean Paul. “Firuz was telling me that you’ve been asked to help teach the course on the Geology of Lutetia next semester.”

“Yes, thank you. I suppose I won’t be teaching much.”

“Why not?” replied Firuz. “I can think of two classes that you could handle. I’ll show you the outline of subjects some time.”

“You’re still an undergraduate, right?”

“Yes; at the end of this semester I’ll have completed my junior year. Because of study on Ceres and on the way back here I’ve essentially completed my major in planetary geology. Firuz wants me to expand my work on Lutetia into a senior thesis.”

“That’s impressive. Are you up here to get certifications?”

“No, I’ve got the ones I need already. I was invited up to play zero-gee volleyball by Corey Kubota! But now we’re inventing a new game instead. We’re calling it zero-gee team handball, but it really isn’t like anything on Earth. Some people have started calling it ‘striker’ which is a clever name, but it refers to striking the ball, not the members of the other team.”

“Striker, huh?” Jean-Paul looked at the court, a bit unapprovingly. “I suppose he’s trying to establish professional teams and obtain tv contracts.”

“Jean-Paul, this is no longer a little, remote place,” counseled Firuz. “It’s getting pretty cheap for people to immigrate, and we need more people. If we can make money on professional sports, so be it.”

“I suppose.”

“He’s hoping to create professional teams, and in the transition he needs people here who are learning the game and earning a living by other means,” said Charlie. “He’s urging me to move here. You work at the Center for Asteroidal Studies, Dr. Jean Paul, right? What are the possibilities for me to study and work there?”

“I don’t know; I’m heading for Jupiter this summer and taking a quarter of the staff of the Center with me. We have a commitment for a two-year mission based at Callisto to visit all of

the prograde and retrograde satellite families and as many of the individual members as possible. It's a fast and easy way to sample D-class and Hilda-class asteroids and probably at least one comet. We're hoping to find debris from the proto-jovian nebula, too. We'll have one caravel, the *Barnard*, named for the astronomer who discovered the first outer moon, and an advanced SCN-75 nuclear engine. Firuz is coming."

"And we were wondering whether you wanted to join the mission, too."

"Me? Launch is in early July! I thought the crew was finalized!"

"It was, until we were able to add a caravel to the mission last month," replied Jean-Paul. "So we're adding thirty more personnel, fifteen of whom will stay on Callisto while fifteen go out, rotating every six months. We still have three slots."

"But I'll be in school until May."

"So will I," replied Firuz. "That's not a problem. The bulk of the training will be done during the cruise to Jupiter. We'll be docked to the *Galileo* and the *Gan De*, so we'll have quite a community during the voyage. Four other crew from the *Wolf* will be on board, so you'll know some of the others."

"Outer moons of Jupiter," said Charlie. "That's exciting. When do you need to hear from me?"

"Pretty quickly; we want to finalize the crew roster by New Year's."

"Okay." Charlie nodded, but he could feel himself vibrating in excitement. How could he say no? "I'll get back to you in a sol or two. I need to talk to my mom and dad, and my grandfather as well."

"Definitely," agreed Jean-Paul. Then he smiled. "You're following in your father's footsteps."

Charlie smiled. “You mean, how he got suddenly added to the Gradivus mission, Mars’s first major expedition into asteroidal space? I suppose I am.”

“Well, get back to me,” said Jean Paul.

“I will. I had better go back to my room now and take a shower. Ciao.” He turned and pulled himself out of the court. Once he was in the main passageway outside, he began to pull himself along the railing as fast as he could. He practically shot back to Gamma and his room, 4B23. There, he knocked on Wicahpi-Luta’s door first.

“Oh, you’re back.”

“How was the field trip?”

“Pretty good. We went into some of the Phobos impact fractures to study the bedrock. One had some outgassing from volatiles released by drilling, even though its ten kilometers from the nearest well. Not good. I now almost have my level 2 microgravity EVA certification. I need six more hours. How was the scrimmage?”

“Really great. I scored a goal; the only one of the game. We proposed some changes to make it faster and more engaging. But I saw Firuz Moulin and he was with Jean Paul Poirier. They’re part of an expedition to the outer moons of Jupiter that was just added to the *Galileo*’s flight this summer. They asked me to apply!”

“Really? Wow, that’s incredible! Just twenty years old, and going to Jupiter!”

“Dad came to Mars when he was just 26. But if I leave for Jupiter in July, I won’t have finished my Bachelor’s.”

“You can get it on the flight out, taking online courses. But the bigger question is Sirikit.”

“Yes, I know. I really like her.”

“I doubt there’s any way they can use an economist on Jupiter, especially at this late date.”

“I doubt it, too. But we haven’t made any sort of commitment to each other, either. We’re not even boyfriend and girlfriend.”

“Well, no, I’d say you are boyfriend and girlfriend. You guys have liked each other at a distance for years. I remember in high school she wanted to do school projects with you, even though you were just a video presence in class.”

“I wanted to do projects with her, too. Well, I’ll need to talk to her about this. But right now I need to videomail my parents and my grandpa, then I need to take a shower and wash off the sweat so I can go have supper.”

“Okay, go,” replied Wicahpi-Luta.

Helmut was surprised by how shiny the boulder was. The nickel-iron fragment had flown several kilometers from the point of impact and had made a small crater in Ceres’s dusty-ice-filled terrain, where it had shattered into pieces. When he looked at it closely he could see the telltale metal stripes of the mineral taenite.

“What’s the germanium concentration? Two thousand parts per million?” he asked.

“That’s right; that’s two tenths of one percent,” replied Jack Alberghini. “And gallium is 85 parts per million. Nickel is 16 percent, which is high as well.”

“Germanium’s worth only 1.5 million redbacks per tonne. Gallium’s twelve million.”

“This particular octahedrite impactor has other platinum group metals, too. It’s a good complement to our ataxite mine.”

“Too bad Mahuika Crater is four hundred kilometers from Central; but I guess everything can’t be in one place, can it? How big was the impactor?”

“The magnetic and gravity anomalies suggest it was seventy meters in diameter; that’s one million tonnes of octahedrite, roughly. Some of it is buried, though. We’ll be lucky to recover half of it.”

“Half a million tonnes; that’s still about a thousand tonnes of germanium and thirty tonnes of gallium.”

“Altogether, the metals in this impactor are worth about 2.5 billion redbacks at current prices.”

“That’s got to be profitable.” Helmut looked around the site one more time. “Okay, let’s head home.” He reached down and picked up a loose piece of the octahedrite as a souvenir. Then they headed for the hopper for the twenty-minute ballistic flight home.

After the hopper had fired its engines for thirty seconds and they were on a ballistic trajectory, they took off their helmets. Helmut pulled out his tablet and looked at a map of Ceres. “So, we’ve now checked out half the known nickel-iron impactors. So far, our ataxite impactor is by far the best, followed by Mahuika.”

“We may find one or two more with important characteristics,” said Jack. “Actually, every impactor has a different chemistry, so all of them may be useful in the future, assuming we can get the costs to work out.”

“They have to work out. We have the advantage of being an established outpost with resources; a small operation on an asteroid somewhere won’t have the redundancy, safety, or efficiencies of scale we can offer. We have to watch the robotic technology, though. It’s moving very fast.”

“That’s the advantage of being a borough. Martech can watch that for us.”

“That’s true.” Helmut sighed. “We have the potential to grow to at least several hundred, and then we’ll be a very different operation with very different capacities.”

His communicator beeped. He glanced at the screen; it was Charlie. He pushed play. The sound went straight to his ear piece, so he had some privacy. “Hi, dad, mom, and grandpa. I can’t believe this just happened. After a scrimmage Firuz Moulin introduced me to Jean Paul Poirier, the asteroidal geology expert. He’s leading an expedition to the outer moons of Jupiter; the caravel flies to Jupiter with the *Galileo* this summer. And they offered me a position on the mission! They plan to stay about two years, so I suppose the total trip is four. I have all the certifications and I have experience on Ceres and Lutetia, which makes me very qualified. Can you believe it? What do you think? I’d have to finish my bachelor’s en route; this June I’ll still be one semester short of graduation. But . . . how can I say no to this!? Let me know what you think, please. Bye.”

Charlie’s image faded and Helmut smiled in pride for his twenty year old son. That was quite an accomplishment, but it raised complications. The boy would have been on Mars less than a year and wouldn’t have completed his education. As he contemplated these matters, his communicator beeped. It was Clara. “Did you see Charlie’s message? Oh my God, this is complicated. He has to finish his Bachelors degree and pursue graduate work! And he seems to like Sirikit; what happens there? I think we need to talk to him about this very carefully.”

“Hold on.” Helmut unstrapped himself and floated to the far end of the hopper’s cabin so he had some privacy. “I think we all have to consider this carefully. Presumably all the other members of the flight will be Martech faculty, so he’ll have an entire graduate department with him. I bet some of them will be running online courses from Callisto. If he wants a Masters

degree and a doctoral thesis that focus on the subject of the mission, he won't have any problem. Other people have done that before."

"Then we should ask him whether he has approached any of them about that."

"Yes, I agree. We can probably look up the mission roster; it should be on the web. I bet we know some of them."

"But what about Sirikit?"

"That's between the two of them, don't you think?"

Clara considered, then nodded. "Yes, I suppose. What don't you talk to your dad about this? I see Charlie copied him as well. He can talk to him face to face. He'll be able to pursue questions we can't."

"Alright, I'll do that. That's a good idea. We're landing in twelve minutes, so you and I will be able to discuss this more in a little while."

"Good. This really worries me."

"I know. Bye."

"Bye."

Helmut pulled up his father's number on Mars. "Audio only," he commanded. "Hey dad, can you talk to Helmut about his message? It's pretty exciting to be invited to join a mission to the outer moons of Jupiter; no question about that. It's flattering and speaks highly of his capabilities and talents. But we want to be sure he'll continue to pursue his education; he can't go gallivanting out there and not finish his Bachelors. The mission will be full of Martech faculty, I'm sure, so he needs a plan. There are also delicate matters about women that we can't ask him about when there's a sixteen to eighty minute round trip time delay. So see what you can

do, okay? I think it's great, but I'm worried; Clara's worried and probably thinks it's a great chance, too. Thanks. Bye." He hit send.

The message flew to Mars, some twenty light-minutes away. Meanwhile, Sebastian Langlais had walked to Ethel MacGregor Elliott's retirement party, a large affair with a hundred people. After the new Chief Executive Officer of Mars Metals praised her leadership highly, Charlie's videomail arrived. He discretely listened to the audio, leaving the video off, and pondered his grandson's great accomplishment while several people spoke about how marvelous it was to work with Ethel. Just after Madhu Anderson spoke about her longtime friend—her video presence had been continuous on a screen in the corner of the room—Helmut's audio arrived. That gave him something else to ponder while Ethel briefly spoke and thanked everyone. He rose and walked to her and Will as the crowd turned to the reception.

"So; we're all retired now!" he said to them.

"We are," agreed Will. "The only ones still working from Columbus 1 and 2 are Érico and Carmen."

"They're younger. How have you liked your retirement so far?"

Will shrugged. "I haven't been any less busy, but the responsibilities have shifted. I'm still going into the capitol building once a week to brief Jacquie; there are a lot of details to convey. Fortunately, her robotic assistant can process everything I say and spit it back to her when she needs it. But that means I need to spend hours briefing a robot!"

Sebastian laughed. "Times have changed, haven't they? But now that Ethel's retired, I hope the two of you will take more time together."

“Oh, we will,” said Ethel. “I’ve been briefing Milton for months already, and he has been gradually taking over. We want to travel; neither of us have been to Jumla or Elysium, and I want to see Tithonium.”

“And maybe the North Pole station; that would be interesting,” added Will. “We should go to Phobos, too.” He turned to the video screen and said to Madhu, “And maybe we should come to Thaumasia!”

She was momentarily startled that someone was addressing her. “Yes, come! I’d wait six months; right now there are no guest accommodations. But the place is really coming along.”

“Are you all settled in?” asked Sebastian.

“Yes, pretty much; I’ve been here ten sols. The two kids are pretty good together. I’ve been outside, too, and I’ve seen the spodumene mine. The terrain is pretty dramatic.”

“How’s Sam doing?” asked Sebastian.

“He’s working his tail off! He’s made a few minor errors, I’d say, but everyone likes him as a boss and the morale is good. We’re on schedule.”

“He’ll do great,” said Will. “He’s smart and capable. He has lacked confidence in the past, but it sounds like he’s got it now.”

“Yes, I think so. Thanks, Will, for giving this to him. He needed it.”

“And he could do it, Madhu. That was the key,” said Will.

“I have every reason to be proud of my grandson Charlie,” said Sebastian. “He’s up on Phobos right now, helping to set up zero-gee sports and doing some geology. Jean Paul Poirier just approached him and invited him to join the expedition to the outer moons of Jupiter.”

“Really?” said Will, pleased. “And he’s what; nineteen or twenty? Does he have his bachelors yet?”

“He just turned twenty last month. No, he doesn’t have his degree yet.”

“But he’ll get it on the flight out, and go on to write a fascinating thesis,” said Will.

“That’s great. Congratulations, Sebastian. I’m glad I approved that mission! It was one of my last acts as Chief Minister.”

“I’m glad, too! Helmut and Clara are worried.”

“Of course,” said Ethel.

“Just like you worried about Helmut,” added Will.

Sebastian smiled. “That’s for sure.”

Charlie stank after the scrimmage, so he took a shower and changed clothes. He decided to put on something nice to impress Sirikit, though he wasn’t sure what the point was; Jupiter had never been in her plans. As he was about to head for the cafeteria in Alpha Galleon, he got a text from his grandfather: *I’m so proud of you, Charlie. It’s a great opportunity! Let’s talk morrowsol after we’ve both slept on it.*

He looked at the text, wondering whether there was a secret message embedded in it or any sort of hint about his grandfather’s opinion. It seemed supportive and positive and was giving him the time and space to firm up his own position. That was good.

Alpha was several hundred meters away and the main passageway connecting the units was crowded at that hour, so he had to float carefully, even slowly. Alpha’s cafeteria was a gigantic open-air space called the Atrium, eighteen meters in diameter, accessible from the entrance hub at the center of the spinning galleon via three glass elevators. He was getting used to floating into a circular hub surrounded by a rotating carpeted wall, putting his Velcro-soled shoes down onto that “wall,” and suddenly having a tiny bit of gravity. He walked across the

“wall,” which was now a circular floor, to one of the three elevators, and descended to the Atrium level. Most of it was set up with tables and chairs that were crowded by diners at that hour, but some of it was occupied by shops; both Desert and Silvio’s had outlets. One entire wall—which faced “upward” away from Phobos, though one could not feel the moon’s gravity to sense the direction—was covered by three-d screens, some of which broadcast window-like views of the outside, while others carried various web and television programs. His friends were seated near a screen carrying the BBC news—their usual spot, which was also next to a lemon tree—so he grabbed some supper and hurried over.

“There he is!” said Sirikit, as Charlie approached. “The zero-gee team handball champion!”

“So, Wicahpi-Luta told you about the goal?”

“Yes. You guys definitely need a different name for the game, though; it’s too long,” she replied.

“How about ‘striker’ or ‘slamball’?”

Sirikit considered. “The first sounds too violent and the second, a bit silly.”

“I agree,” said Esther.

“How about ‘spiker’?” suggested Bill. “It could only apply to the ball, not other players.”

“I’ll suggest it,” said Charlie, sitting. He looked at Wicahpi-Luta, whose face showed that he hadn’t spoken about other news. “How was your excursion to the Spirit of Mars?”

“It was good,” replied Sirikit. “I was nervous that I’d screw up and float away, somehow. But the suit controls are the same as a pressure suit’s and you adjust to the stiffness pretty quickly. The gravity is the tricky part. An accidental move can propel you off the surface pretty easily.”

“There’s not much to keep you down,” agreed Esther. “I’m still not sure I even felt the gravity!”

“‘Gravity’ doesn’t mean much when you weigh less than a candy bar would on Mars,” agreed Wicahpi-Luta. “You have to use your jets to get around.”

“And the ski poles,” agreed Sirikit.

They all looked up as someone approached the table. Esther smiled, a smile of both pleasure and worry. “Dad, you made it!”

“Yes, I’m finally here,” replied Greg Harris. “How are you, dear?” He leaned over and kissed his daughter.

“So, you did make it on yestersol’s shuttle,” said Wicahpi-Luta. “I was wondering when I didn’t see you last night.”

“There’s a patient in the infirmary with a very serious complication from her pregnancy. I spent last evening and much of this sol there with her. I also had a series of appointments; Catholic priests get here only a few weeks per year. When someone does come up, they’re pretty busy.”

“Of course, Father Javier was scheduled to spend January here,” noted Esther. “And once I decided to come here, surprise, surprise! The schedule changed and ‘Father Dad’ came instead.”

Greg smiled at her pet name for him. “Well, I suppose I am doing a bit of chaperoning, aren’t I? And you could call it ‘multifaith’ chaperoning, since there are two other sets of parents who were happy to hear I was going.”

“Don’t worry, Wicahpi-Luta and I have been perfect gentlemen,” said Charlie.

“We have,” concurred Wicahpi-Luta. He liked Father Greg and they got along well, so his tone conveyed friendliness.

“It’s true, they have been gentlemen, maybe even too much gentlemen,” replied Esther, teasing her father.

“Speak for yourself,” replied Sirikit.

“You all have spent your time up here well,” said Greg. “I’m impressed by all the certifications you’ve arranged.”

“Just Wicahpi-Luta; he’s pursuing four,” replied Sirikit. “I’ll stick to two, level one space suit operation and level one micro-gravity EVAs. But this afternoon I got a long interview with Executive Zhang Bao-zhi and he had a lot to say about the expansion of space vehicle production and associated production of metals, composites, and plastics. Phobos may not have PGMs, but it has a fair amount of nickel-iron fragments, and this place could go into production of nickel steel and other alloys for export to Earth.” She turned to Charlie. “I asked him about importing materials from Ceres, since they have lots of iron, nickel, cobalt, and chromium already and he said they hadn’t considered that possibility.”

Charlie smiled. “Good! Thanks! Dad should follow up on that!”

“Once Ceres can make structures like beams and spheres, they may be a cheaper source than the Martian surface,” said Sirikit.

“Well, I can see you all are doing fine, so I think I’ll move along,” said Greg. He turned to Esther. “Stop by later, okay? But call first, to make sure I don’t have a client.”

“Okay, dad.”

Father Greg nodded and walked to the nearest elevator.

“So, is there a parsonage here?” asked Charlie.

Esther nodded. “It’s a chaplain’s residence and different clergy rotate through, including Zen monks and Siddarth from the Hindu temple. There’s no place for me to stay, though.”

“Ah,” said Charlie. He opened his mouth to tell the others about his offer, but Bill spoke first.

“I’ve had a lot of fun up here with you all this week. My flight back to Aurorae is morrow’s morning,” Bill said. “I’ll probably be copilot the week after when you fly home, so I’ll see you then as well.”

“It’s been good having you around, Bill,” said Wicahpi-Luta. “You really helped me get used to this place and figure out all the opportunities.”

“I’m glad to help. I’m glad I was able to put you in contact with the rocket propulsion team. They’re doing some really interesting testing.”

“It’s a great opportunity; they’ve invited me to watch a test in three sols. That’s experience I can’t get in a propulsion seminar at Aurorae!”

Sirikit saw Firuz Moulin walking across the floor nearby. “Oh, there’s Firuz. Firuz!”

He heard her and walked over. “Alláh-u-Abhá.”

“Abha. Say, I’m facilitating a class morrow’s evening about personal transformation, ‘From Divine Attributes to Personal Attributes.’ Can you come?”

“At the Bahá’í Center?” asked Firuz. “Sure. I’ve heard about that module and I hear it’s good. I’ve heard you’re a good facilitator, too.”

“Oh, thanks.”

Charlie scowled. “Phobos has a Bahá’í Center?”

“It’s just two rooms and the big one can be split if we need three classrooms,” replied Firuz. “It’s in Beta. There are twenty-five Bahá’ís up here, and another twenty or thirty people who come to things occasionally.”

“I doubt dad gets many more when he gives mass,” commented Esther.

Firuz turned to Charlie. “Say, you should come and see Sirikit in action. This is a pretty interesting module; it’s about compassion, truthfulness, fairness, and trustworthiness. Just four qualities, but very important ones for improving society.”

“And personal relations,” added Sirikit.

Charlie frowned briefly, wondering whether she was suggesting he wasn’t good at one of those things. But the topic sounded safely non-theological, and he wanted her good will.

“Morrow’s evening? Sure, I’m free. Sounds interesting; psychological.”

“It’s not psychological as much as it’s spiritual,” she replied.

“So, have you all been congratulating Charlie?” asked Firuz.

That wasn’t how Charlie wanted the news to come out. Sirikit, Bill, and Esther frowned. “Firuz is going to Callisto for the Barnard Mission to the outer satellites of Jupiter. Jean Paul Poirier is in charge. He just invited me to join,” Charlie explained.

“Really?” said Bill, his eyes wide. “Fantastic, man! Congratulations!”

But Charlie was watching Sirikit, who was surprised. “That’s amazing,” she said. “How long will you be going?”

“I’m . . . not sure exactly,” admitted Charlie, turning to Firuz.

“You have to launch to Jupiter when Mars is sixty to ninety degrees behind it in its orbit, and you have to launch from it to Mars when Jupiter is sixty to ninety degrees behind Mars’s position at arrival,” replied Firuz. “So Mars needs to move between a third and a half of its orbit

in between; seven to eleven months. But you can't go from Mars to Jupiter and back in that length of time; the flight takes about a year in each direction. If you're going to spend two years en route, you might as well spend at least as much at the destination. So all Jupiter missions are on a cycle of about four and a half years."

"And Uranus missions are being planned based on two-year flights, each way, and a four and a half year stay," added Wicahpi-Luta.

"Congratulations," said Sirikit, ambiguously.

"That's really great, Charlie," added Esther. "Just twenty years old and going to Jupiter!"

"He has all the certifications and experience," replied Firuz. "Not many do."

"So, what will you be doing?" asked Sirikit.

"Geology. I suppose, since I'll be on the bottom of the pecking order, I'll have some grunt tasks."

"Robots have taken over most of them, but I'm sure you'll be asked to spearhead efforts to investigate certain questions, and they'll often be supportive of bigger questions," said Firuz. "On the other hand, if a big question occurs to you, you'll be able to pursue it."

"A lot of this work is done by teams, and the 'pecking order' emerges through discussion," agreed Wicahpi-Luta.

"That's true of us economists, too," said Sirikit. "I have to think seriously about going to Earth for graduate study because the economics team here is so small and specialized."

That surprised Charlie. "That sounds like a good plan, because you are going to be a great economist, and we need great economists."

"And we need great planetary scientists," she replied.

“Can I walk you home?” asked Charlie to Sirikit. The small crowd in the Bahá’í Center was dispersing as people left for home. A woman had just finished talking to Sirikit while her twin six year olds played, and Charlie had been more interested in contemplating what it was like to grow up on Phobos than to listen to the woman’s questions.

“Yes, sure; I’d appreciate that,” replied Sirikit, with a smile. She hadn’t smiled at him since his announcement, the previous evening, when he had been accepted to go to Jupiter. He took that as a good sign.

“Great.”

She picked up her communicator and stuck it to her belt and they turned to the door. “Do you want some ice cream?” she suggested. “There’s an ice cream shop here in Beta. I’ll buy.”

“Yes, that’d be great, but can’t I buy?”

“Well, either way. You buy next time.”

“Alright,” he agreed.

They headed for the elevator, but Sirikit stopped short of it. “Let’s take the ramp. No one ever does, except me anyway.”

They started up the ramp, which was very steep in the low gravity. Pressure doors opened automatically for them at every floor. The galleon’s atrium—smaller and less magnificent than Alpha’s—was three levels above. “It’s funny to feel the gravity wane as we climb,” he said.

“It is.” They reached the atrium level at the top of the ramp and the door automatically opened. The ice cream place was twenty meter away and had a scattering of patrons, none of whom they knew.

They ordered ice cream, she paid, and they sat. “So, did you enjoy the class?”

“Yes, more than I thought. I thought maybe it’d be like high school ethics class or the ethical reasoning class the Martech Freshman take. But the quotations from the Bahá’í texts give it a more metaphorical, poetic character.”

“That’s true, which is one reason we break into small groups to discuss them. They have to be digested consultatively and reflectively. They aren’t logical syllogisms.”

“No, they’re metaphorical. But what do you do when you disagree about their meaning?”

“First, we consult other texts, because they tend to form the surface of a sphere, as it were; comments that seem poles apart are connected together in between, in many cases, and prove to be complimentary rather than contradictory. But if we’re still not sure, we contact the Universal House of Justice. They have access to everything and often can find the spherical surface connection between poles. Other times, they will tell us not to argue about something; both positions are alright. Rarely, they’ll actually rule and clarify the meaning.”

“How many texts?”

“We have six million words from Baha’u’llah and five million each from `Abdu’l-Baha and Shoghi Effendi, so the corpus of authoritative texts is pretty huge. But then, this is a modern religion; it arose after the printing press and the widespread diffusion of literacy.”

“And people want answers. Especially on Earth right now, with the entire world economy wobbling on the edge of oblivion again.”

“If they want economic stability, they need unity, and conditions there make unity impossible.” Sirikit shrugged. “So, when do you report to Phobos for launch?”

“I don’t know; I haven’t asked. I haven’t actually said yes yet.”

“Why not? It’s a perfect opportunity.”

“I haven’t said yes yet because there are still unresolved matters to resolve. And one of them is us.”

She was surprised. “I’m not sure there’s anything to resolve. We haven’t made any sort of commitment to each other, and we can’t yet; we really don’t know each other very well. “

I think that’s true.”

“And I’m not just going to have sex with you, Charlie. I’m sorry about that. I feel attracted to you and find you very handsome; I really do. But relationships ideally develop in a certain order, and the physical is last, because it’s the hardest to control or direct. “

“What’s wrong with that? It’s a natural part of life.”

“Yes, of course it is. But so are the spiritual and the emotional. They’re all part of life and they have to be in balance. That’s why the place to start is the spiritual and an exploration of the other person’s qualities. If you do it the other way around, a physical attraction grows to someone who can’t control his temper, or who lies, or who can’t get their life together. If you avoid people with those traits, life is simpler and the positive traits you have will be reinforced by the partner you choose.”

“And who will the liars marry; other liars?” he asked.

She smiled. “Maybe, or maybe they’ll realize they have to work on truthfulness.”

“Ah. Hence the importance of tonight’s class on personal transformation.”

“Exactly. We don’t believe in instant enlightenment or salvation. Sometimes it happens, and that’s great, but usually it has to be accompanied by some hard work on one’s character. That’s why we Baha’is have all sorts of voluntary classes and stress habits of daily prayer and meditation on scripture. We hope to chip away at our flaws.”

“I’ve been impressed by the Bahá’ís I’ve met.”

“I’m glad to hear it. Once we get to know each other, we’re often not so impressed by each other!” She laughed, so he chuckled, too.

“So, then, where do we stand?” he said.

“Well, I can tell you where I stand, how’s that? I’m in the ‘getting to know you’ stage. This is made more complicated by the fact that I’m twenty and still in the ‘getting to know me’ stage, if you know what I mean. So I want to get to know your character, and in the process, I want you to help me get to know my character. How’s that for a challenge?”

He smiled. “I like it, but if we get to know each other’s character too much, we might be naturally inclined to slip into the next stage, don’t you think?”

“Yes, I do think so. But if we get there, we’ll have to talk about it. And I have every intention of emphasizing my career. If you can go to Callisto, I can go to Earth. We can always wait five years; we’ll only be twenty-five.”

“Hum. Not sure I like that.”

She shrugged. “Well, that’s where I’m at.”

“Okay.” He ate several spoonfuls of ice cream, thinking about what she said. “Then here’s my next challenge for you. Morrowsol evening, I’m getting a tour of the Barnard; it’s the caravel that’s going to the outer jovian moons. Why don’t you come along? If you fly to Earth, it might be on a caravel, after all.”

“Sure, that sounds great. But let’s invite Wicahpi-Luta and Esther along, too. One of the best ways of getting to know someone else is to watch them interact with others.”

“Alright; that would be fun, actually, and I’d like to hear Wicahpi-Luta’s questions and comments about the mission plan. I suggested he apply for one of the remaining slots, but he reminded me that he had none of the necessary experience.”

“Good. Esther has arranged for the two of us to get a special tour of the horticultural cylinders; do you want to come along? I’d like to hear from your experience, since Ceres is dependent on B-75s.”

“Yes, that was ‘nature’ for me, growing up. Okay. And now that the three of you have stage 1 certifications, let’s make a four-person excursion outside. If we hike just two kilometers, we’ll be able to see all of Mars.”

“That’d be fun. We’re here another week. Let’s make it a foursome for part of every sol. We all have some interesting contacts up here and we all can benefit from them.”

“Good, that’s a plan. But I also want some time just with you every day: breakfast, lunch, supper, or ice cream. Okay?”

Sirikit nodded. “Okay, you’ve got a deal.”

4.

Synergy

February 2074

"I'm so glad we called Executive Zhang," said Hun-jai Park to Sirikit. They entered his office and the lights automatically came on, though the gigantic window overlooking Shikuku Dome and the escarpment beyond provided plenty of light. He sat behind his desk; she sat at a chair by the side of it. "The class asked great questions, too."

"His presentation on the economics of space vehicle manufacture was surprisingly good, for an engineer," replied Sirikit. "When I talked to him in his office, six weeks ago, he seemed much less informed. I think the presentation prompted him to do some reading."

"And pull together the statistics; they were pretty fresh. I hope he sends them to Jacquie."

"You won't forward them?"

Park shook his head. "First of all, it's his data, not mine, so it's his responsibility. Second, I'm no longer in charge of the economy. I did that for four years, shepherded it through some very difficult crises, and now we have other people who can do that. Jacquie has appointed a cabinet of her own. She needs that in order to make a fresh start."

"It's rather controversial, appointing all new people."

"The Mars Council has approved half of the appointees and will approve the other half in the next few weeks. She needs her own team; Mars needs fresh blood anyway." He waved his hand, ending the topic. "So, why do you want to go to Earth? Does it have anything to do with your boyfriend going to Callisto?"

She flushed. "No. I'll have my degree in six months, and there won't be any flights to Earth for over a year once the *Alcor* and *Castor* head back via Mercury in two months, so I need

to plan now. They have plenty of space. I'll reach Earth in early January next year, in time for the spring semester in any school I decide to go to."

"Assuming you get into the school you want to go to. I suspect that's the case, but you'll have to do all the applying en route, with no support system, other than email."

"I've got your recommendation, I'm sure, and Vanessa Smith has promised one; not many people get a recommendation from a Nobel Prize winner. I'll have to finish this semester long distance; the galleons leave for Mercury right after classes end, but before final exams. During the fall semester, which is my last semester of senior year, I can take classes via distance learning. I've been taking one or two via distance learning every semester already."

"That's true. You've thought this through. But you aren't considering the economics of the situation. This is a very bad time to go to Earth." He paused. "The world economy is like Humpty-Dumpty. The war shattered it, tore apart all the transnational or trans-regional connections. Greed and suspicion are preventing their reestablishment. In phase one, patriotism was used to call for sacrifice, which was reinforced by rationing laws and price controls. People sacrificed to some extent and that helped rebuild a lot of essential infrastructure, but the economy was still devastated. In phase two, most economies expanded their money supply vastly and that caused inflation and government debt. The United States and Europe had the least, but inflation was still twenty percent per year. Savings have been cut in half and many investments were wiped out. Some sectors benefitted, but unemployment is staying above twenty percent in most economies, thanks to robotization of many tasks. Now phase three is starting, when the pressure is to cut government spending, rein in inflation, and bring the money supply down closer to normal. What will that do?"

"Recession."

“Good guess. My guess, though, is depression. And what will that do to unemployment?”

Sirikit shuddered. “I hesitate to think about that.”

“Of course! And what will it do to the political process, if unemployment hits thirty percent?”

“Oh my God. But surely there’s a solution.”

“Of course; there are always solutions, in fact there are more than one. The simplest one, though, is the hardest: the Grand Union. It will produce economic winners and losers; when you create a true world economy, you eliminate inefficiencies. That means a lot of businesses will close and economic circumstances will get worse in many areas. But if people pool resources—which is what the Grand Union represents—the economy will recover.”

“But the United States Congress just pulled out of the plans to join the Grand Union.”

“They wanted a better deal and the rest of the world said no. I am guessing that the same thing will happen with the Chinese, but we’ll have to wait and see. Neither of them can afford to stay out; they’ll have to rejoin eventually. Meanwhile, in a way there’s nothing to join anyway, because the Europeans, Latin Americans, and Indians don’t have meaningful economic integration. There are too many ‘temporary measures’ in place. But at least they have a rough framework. The Indian economy is now the world’s largest. Would you consider studying economics at an Indian university?”

“I had Stanford in mind, or MIT.”

Park shook his head. “In January of next year, they may be paralyzed by student strikes. I’m guessing; I don’t have a crystal ball. I wouldn’t go to Earth right now. You might be stuck in an apartment with no heat or power and no classes, wondering where you’ll get your food.”

“I see.” Sirikit thought a moment. “It sounds like my father paid you to discourage me.”

Park laughed. “No, I haven’t talked to him! There’s plenty you can do here. I have friends in several excellent economics departments. Student strikes won’t affect graduate student seminars as much. We can put together an excellent Masters degree program and doctoral program in economics for you up here, where there will always be heat, power, and food. I think Martech will have to do more and more of that sort of thing in future years. The resistance to international integration is fierce, entrenched, irrational, is fed by some economic and political interests, and is sustained by the balkanization of the media. It’ll take at least a generation to achieve, if not a century.”

“And what will that do to Mars?”

“That’s another reason you have to stay; we need a strong team to figure that out. PGM prices have dropped by half and gold prices have gone up by a quarter. If you ask me for a guess, a year from now PGM prices will be down to a quarter of what they were two years ago and gold prices will be double. We’re lucky the Indian economy is so strong; they love gold jewelry. I’m not sure gold investment as a hedge against economic downturn will work so well as a price support, this time. I’m already planning a summer seminar on the history of gold and PGM prices.”

“I’ll plan on taking it.”

“Good. I may want you to do some research for me; I need someone I can count on.”

She smiled. “Thank you, Dr. Park!”

“Sirikit, you are my best economics student ever. Keep that in mind. I’ll do everything I can to get you the best economics education available. Once Charlie heads to Jupiter, you won’t have any distractions. Five years later he’ll come back with his Ph.D., you’ll be here with yours, and then you’ll be old enough to decide whether you want to pursue a relationship or not.”

“Well he’s really not much of a distraction now. And I’m not sure he’ll be able to complete his degree there.”

“Of course he will; as soon as the expedition sets out from Callisto, they’ll organize the Galileo campus of the Mariner Institute of Technology. He’ll be surrounded by people with faculty status in his specialization. They’ll push him, too.”

“I didn’t realize there would be an actual campus en route. I thought they were organizing one after arrival.”

“No. There will be 173 adults on board the three vehicles and 146 have doctorates. Some of the rest will be pursuing degrees. That’s the way it is up here; everyone is educated.”

“You’re educated or you’re a robot. Thanks, Dr. Park. I’ll be ready to present to the class next Monsol.”

“I’m sure you will. Ciao, Sirikit.”

“Ciao.” She rose and walked out of his office and headed down the ramp to the courtyard. She crossed it and entered the opposite building, then passed through to a back entrance that led to Building 10, a long underground facility that housed Martech’s engineering departments. She turned right into Building 12, where artificial intelligence was located. Her father was in his lab on the right. “Dr. Park agreed with you.”

Ananda Thanarat looked up from his computer screen. He was fifty-four, with thinning black hair, and still spoke English with a Thai accent. “I never said you shouldn’t go to Earth, remember, though I was inclined to discourage the idea. What reasons did he offer?”

“By the time I get there next January, there may be severe economic disruption and university strikes.”

“That bad, huh? Interesting. We are getting emails from colleagues on Earth every few sols asking how they can apply to immigrate. I never thought it could get that bad, though.”

“I’d sell PGM stock and buy gold stock, too.”

“Too late; the PGM stock has been sliding in value for six months or more, and gold has been going up. Sami, how much has Mars Mining Stock gone down?”

The android next to him turned its head toward them. “Mars Metals peaked at fifty-six redbacks per share back in May and is now thirty-nine redbacks. Gold stocks started going up in May as well and have gone up forty percent since.”

“Thank you. I’m curious; why did you add the gold stock information?”

“You mentioned both and asked about one. I thought the gold stock information would bolster your argument. Was it an appropriate addition?”

“Yes it was, thank you.” Ananda turned to Sirikit. “He’s one of the new series of Amanu-30 androids, developed for the Uranus project. So smart, it almost makes it unethical to send people, aside for cultural and purely exploratory reasons. If you go out with one of these things on a virtual reality exploration of a moon, it’ll anticipate the rocks you want to examine with seventy percent reliability. You can sit in a comfortable chair here or on Earth and do a geology expedition on Titania or Oberon, complete with close observation via hand lens or alpha scattering or infrared and ultraviolet spectra.”

“Don’t tell Wicahpi-Luta; he has his heart set on going.”

“So do a lot of people. We will plant settlements in the Uranus and Neptune systems; no question about it. And they’ll be able to do so much more with units like this. Sami, would you like to go to the Uranus system?”

“I’ll go anywhere people ask me to go, assuming they can add some Americium heaters to me, so my insides don’t freeze up!”

Ananda chuckled. “You’re right, you aren’t set up for the cold. Alright, dear, see you at supper?”

Sirikit shook her head. “No, I’m meeting Charlie at 6 and we’re going to his grandpa’s for supper, but I’ll stop by the house after that.”

“Good, your mom would like to see you. Why are you visiting with his grandfather?”

“I want to see how he interacts with his family. And I think he should come have dinner with us next week.”

“Alright. But I think you have to be careful. You can’t practice courtship without courting; do you understand what I’m saying?”

“Yes, and you have a good point. But he’s going to Callisto in four and a half months, then he’s gone, so it feels like a good time to get to know him.”

“Well, maybe. You have to be careful to protect your feelings, too. Anyway, stop by tonight.”

“Okay, thanks dad. Ciao. And Ciao, Sami.”

“Ciao,” replied the android.

Sirikit headed out of the lab and to the Martech cafeteria. Now she was late to meet Charlie. He was sitting at a table, recording a quick message to his dad, so she waited for him to finish. “Good sol,” she said.

“Good sol; and I hope it was?”

“Yes and no. I’ll tell you as we walk.” He nodded and they started across Yalta Dome toward Sebastian Langlais’s condo. She told him about Park’s advice.

“I’m surprised he suggested India, after that big terrorist cyberattack last week.”

“Name a region that doesn’t have bombings, cyberattacks, and miscellaneous terrorism. Everyone has their extremists now. It’s as if all of Earth is searching for unity around various extreme ideas.”

“I wouldn’t go there; I’d stay up here.”

“Well, a lot of Mars kids who go to Earth stay, at least for a while, so it can’t be that bad. I can’t meet very many economists up here, and I hesitate pursuing a degree in a field where there’s only one face to face expert. Park is confident he can give me a great education; but of course he’d believe that!”

“He’s a pretty self-confident guy. But with email, audiomail, videomail, 3-D mail, thousands of hours of high-quality lectures on video, and a zillion learning aids, we can do quite well up here. Heck, a Neptune settlement could do well, even with a six-hour round trip time delay!”

“You’d have to tape your questions about something a sol in advance!” said Sirikit.

“Some kids do that, even on Earth. By the way, I don’t think I told you: this is a family dinner. My uncle and his family will be there, and my mom, dad, and brother will join us via screen. We do this every week or so.”

“Really? I feel like I’m crashing!”

“No, no. We sometimes have non-family members,” though Charlie couldn’t think of any.

“We’ve done that a few times with mom’s or dad’s families on Earth; in fact we plan to next week, since Earth and Mars are at opposition. I’ll see whether you can come, too. If we meet with dad’s family, the conversation is partly in Thai, so maybe that won’t be so good, but my mom’s from west Texas.”

“And most people consider their dialect ‘English.’”

Sirikit laughed. “Yes, but sometimes I don’t understand it!”

They crossed Andalus and Cathay Domes and entered the labyrinth of underground passageways leading to Sebastian’s condo. He opened the door before they could knock.

“My communicator was set to beep when your GPS coordinates were inside the building,” he explained to Charlie. “Sirikit, it’s good to see you again. Welcome.”

“Thank you.” They walked into the living room.

“Oh, she is pretty!” exclaimed thirteen year old Nicola, nodding to Charlie.

“Yes, of course she is!” he replied.

“Don’t mind her; I’m Irma,” exclaimed Irma Baeker Langlais. “Welcome. It’s nice to meet you.”

“Thank you.”

“And I’m Charlie’s Uncle Kristoff. Mark and Nicola are our kids,” said Kristoff, pointing to Nicola and her twin brother.

“It’s good to see you again, Kristoff,” replied Sirikit. “I think we’ve met a few times.”

“Yes, we have; I’ve been here almost seventeen years, and it was a much smaller place back then.” He pointed to the screen. “Helmut, Clara, and Oskar have gathered in their living room for dinner as well. Ceres now keeps Mars time and its clocks are synchronized with Aurorae’s.”

“Yes, I know.” She and Charlie walked to the screen.

“Hi mom and dad,” said Charlie. “Hope you’re doing pretty well. This sol I got more paperwork to fill out for the flight, and there are yet more medical tests! It’s crazy, considering they’ll have three physicians with them and entire small hospital of equipment and medicines.

They're pretty routine, though; mostly MRIs and blood tests. I'll take care of them this weekend. The geology of Lutetia course is going well; I give my second lecture, on cratering in the Baetica region, next week. We'll have three courses on the flight out, about Class-D asteroids, Trojans, and a Jupiter outer moons seminar. They'll count toward my Masters because they're graduate level courses. Otherwise, not much new here. Let me introduce Sirikit Thanarat to you."

She stepped before the screen. The people at the other end were chatting obliviously, so she dimmed the picture so it wouldn't distract her. "Good evening to all of you! Thank you so much for inviting me to this dinner, I'm really honored. Clara, your bravery in insisting that kids should be taken on field trips is still widely remembered; indeed, it is mostly taken for granted now. Commander Helmut, I very much admire the way you've been pushing the development of Ceres. This second PGM find is exciting and potentially a great supplement to the asteroid's income. I wish you the best with it and wish I could help in some small way."

She stepped back from the screen. "It'll be half an hour before they reply," said Sebastian. "Ceres is approaching opposition with Mars in six months. When they're on the other side of the sun, it's useless trying to do tandem dinners."

"At least they're on Aurorae time now."

"Yes, that helps. So, you're studying to be an economist? Charlie was telling us about your group visit to Phobos."

"Yes, the four of us had a lot of fun. Everyone pulled some strings and arranged something we all could do. Wicahpi-Luta eve managed to get us a tour of the 50-meter telescope! I'm afraid all I could offer was a meeting with the Executive."

"No, you helped arrange our tour of the galleon manufacturing facility," said Charlie.

"That was really cool."

“I hope you enjoyed the agricultural cylinders, because I was a member of the three person team who set them up,” said Kristoff. “That was right before Irma and I got married. So, you were up there interviewing people for your course on interplanetary economics? Were you looking at any particular aspect of economics?”

“No, the whole thing as it relates to Phobos, through the focus is on vehicle production. That’s the piece I’m writing up for the course. Other people in the seminar—there are only nine learners in it—are looking at gold production, PGM production, technology development and export, interplanetary trade relations, nuclear power and isotope production, interplanetary transportation issues, interplanetary cash flow, and other subjects. We want to produce a report that might be useful for the new administration.”

“Jacquie could use all the help she can get,” said Sebastian. “The cabinet is taking too long to appoint and everyone’s worrying about whether we’ll be ready for three thousand more arrivals over the next five months.”

“We’ve never had so many, and it never works out so well to import the construction workers first and have them finish everything for everyone else,” agreed Kristoff.

“It’s too bad no one in your course is looking at the role of Ceres,” said Charlie. “Because it’s always the orphan. It’s part of Mars, but people here forget it and don’t consider its role very seriously. And since it’s part of Mars, it isn’t part of the interplanetary strategy, either.”

“Neither fish nor fowl,” agreed Sebastian.

“What’s being forgotten?” asked Sirikit.

“Phobos and Ceres can have a symbiotic relationship,” said Sebastian. “Phobos is expanding its manufacturing fast because it’s the cheapest source for almost everything in space, in terms of transportation; its delta v to everywhere, even low Earth orbit, is less than from

anywhere else, including the surface of the Earth or the moon. But Phobos lacks a lot of resources. It has to import all its metals from Mars.”

“How much carbon does Ceres have?” asked Sirikit.

“Ceres is twenty-five percent water ice, and water ice includes a percent or two frozen carbon dioxide,” replied Charlie. “We even have access to nitrogen, because the frozen ocean under the crust has ammonia in it, and some of it has leaked into the crustal materials.”

“If Ceres can make graphite block, it could easily turn out solar thermal engines. The mirror systems are easy to make now. I suppose water is virtually free.”

“Exactly; we have a quarter as much water as in all the Earth’s oceans.”

“I suspect Ceres could make simple solar thermal engines that use steam. The specific impulse isn’t great, but if you have plenty of water, who cares? How are they planning to export cobalt and nickel to earth?”

“Using the new Prometheus launch vehicles,” said Charlie. “They’re more powerful and less expensive than anything else available. But I bet they’d be more expensive than a solar thermal vehicle.”

Sirikit nodded. “Definitely. Our class had a presentation about the latest solar thermal rocket technology the other day. Ceres is the cheapest source of metals to Phobos. In fact, it’s probably the cheapest source of water to low earth orbit, considering Phobos has to reduce carbonaceous chondrite to obtain water and other volatiles.”

“This is the sort of information Ceres needs and doesn’t always get,” said Charlie. “Who should I ask about it?”

Sirikit smiled. “Ask Bill, he was in that class! It was a group of guys in engineering. They’re developing simple manufacturing techniques to build solar thermal rockets.”

“I was talking to some people in engineering the other sol about throwaway rocket engines made by three-d printer,” said Sebastian. “They can’t handle high pressures, but they don’t have to if fuel is cheap enough. But never mind, let’s eat.” He led them to the dinner table. They sat and dished out the lasagna. “So, Charlie, what’s the latest about the *Barnard*?”

“More medical tests; they want to check practically everything.” He shrugged. “The team has meetings on Phobos every week to discuss plans, with a group of us down here connected by video link. I have to give a report about the surface composition of Themisto in three weeks. Most of the presentations are either of that sort, or technical reports about the delta-v necessary to visit several moons in one mission, or reports about how our horticulture will complement the horticulture of the *Galileo* and *Gan De* on the way out.”

“Complement?” asked Kristoff.

“Yeah; who will raise the coffee, who will raise the sugar beets, that sort of thing. We’ll be running complementary horticultural systems. The *Galileo* is also transporting a small bioarchive of live plant and animal species, and seeds and frozen embryos for over two thousand species. Callisto outpost will have some pretty extensive underground biology in a few years.”

“It’s really amazing what we can do now,” said Kristoff. “We can now send out an entire settlement of several hundred people, complete with a complex ecology.”

“It’s a matter of time before we send a settlement to another solar system,” said Sirikit.

“But back to Ceres; here we are sending 175 people to Callisto, we have almost 500 on Titan, we’re looking at sending 300 to 500 initially to Uranus, and Ceres still has only 70,” said Charlie. “It’s ridiculous, because we even have an economic base!”

“You do,” agreed Sirikit. “You should grow to at least the size of Uzboi because you can export nickel and cobalt profitably, and they are thousands of times more abundant. Who’s designing the export system?”

“That’s part of the problem, I think,” said Charlie. “A group on Earth was hired to work on Phase 2 because no one here was available to consider the job.”

“Which is ridiculous,” added Sebastian. “The people here know what we can do, and we want the system made here. Part of the problem, also, is that the Asteroid Belt Commission used to consist of a Commissioner and several staff here, plus support staff on Earth. But Helmut’s now Commissioner, he’s on Ceres, and there is no longer support staff here. Four staff are arriving in May from Earth, but I’m not sure they can provide the liaison that’s needed.”

“Marsians need to do it,” agreed Charlie.

“From what I’ve seen of the PGM export plan, it looks good,” said Sirikit. “It’ll make Ceres and exploration of the asteroid belt financially self-sufficient and it’ll grow Ceres to at least 200 people. Growth beyond that point needs to have a goal. If Ceres grows to 500 and starts exporting several hundred tonnes of PGMs per year, it’ll make a huge profit and the money will go to Mars, not Ceres, because Ceres can’t use that much.”

“It could if it just imported population,” said Charlie.

“But what would they do there? You don’t need several hundred scientists studying and exploring Ceres and the asteroid belt,” said Sirikit.

“I think you do, eventually,” replied Charlie. “But maybe not yet.”

“That’s the problem,” said Sebastian. “Ceres can get to a thousand or so eventually, but not as quickly as we want.”

The screen beeped and “incoming message from Ceres” flashed on it. “Oh, good, they’ve replied,” said Irma. She added to the house computer, “Karli, please play the message.”

The screen glowed, then focused on Helmut and Clara. “Hello, everyone,” said Helmut.

“Hello,” added Clara. “It’s good to see you all. Charlie, I’m glad you’re doing well. Sirikit, it’s so nice to meet you. I remember seeing you when you were 10 or 11, but it’s really like meeting someone entirely new! Thank you for your kind words about my activism when I was young. I think I now have second thoughts about my naïve ideas about taking kids out on the range, but I’m so glad the equipment has been improved and is more shielded, so that expeditions are safer for everyone. I think that’s the big change that resulted.”

“It is good to meet you, Sirikit,” said Helmut. “Charlie has told us so much about you, and now I understand why. I’ve been listening to your conversation about your course on interplanetary economics. It sounds fascinating! I’m glad Park is running it and I hope it’ll produce some significant results. Mars has pretty good economic planning, but a lot of it is still Earth based because we don’t have the Marsians who can do it. So your interest in the subject is immensely important. Even more important is interplanetary economic planning, and I don’t just mean Mars-Earth, or even Mars-Ceres. The latter is badly needed and sadly lacking. But what we really need is a solar system economic plan to complement the exploration plan that we have. A solar system economic plan would make the exploration plan more relevant, easier to achieve, and more well rounded. I think it’s a mistake to think that we’re going to Uranus solely to explore and plant a new human civilization. That civilization will remain tiny and ineffective without an economic basis; it’ll always face the danger of abandonment, too. So that needs to be the goal. And no class held on Mars about the subject should ignore Ceres. We’re a borough, after all, we have a very shallow gravity well and vast resources, and we’re surrounded by the

solar system's largest archipelago of worlds. We are an important key to Mars's future; an important key to the future of the entire solar system. The sooner we figure out what doors we can unlock and open, the better."

Sirikit stared at the screen, struck by Helmut's insight. "I . . . I've never heard it put that way," she replied. "And I think you are probably right. Our class is about a solar system economic plan, I suppose; it's about solar system economics and that implies the possibility of developing a plan. Maybe the idea seemed premature to Park, but we're now five weeks into the course and maybe it isn't feeling so premature to me anymore. I very much agree that Ceres is not being considered adequately; we've been discussing that tonight. My presentation about the role of Phobos is just about finished and I have to deliver it in two weeks. At that point, almost half of the course will be left, so I will try to work on a second report about Ceres. I'm sure if I talk to Dr. Park, he'll agree that I can get some additional university credit toward my degree if I work on a second report. So I'll do it."

"Are you sure you have time?" asked Charlie. "You're taking three other courses!"

"I am, but I can make time. And I bet you can help me. I'll interview the former Commissioner of the ABC, here." She turned to Sebastian, who nodded. "And I'll interview the current Commissioner, if he's willing."

"You won't hear from him for another thirty minutes, but you can be sure he'll be willing!" replied Sebastian.

Marshall Elliott scanned Mimas Central Station one more time. It was buried under three meters of ice blocks which provided excellent radiation shielding; he was standing about thirty meters from the door to the pressurized section, which was next to the garage. Inside the latter, which

was open to the terrain of Herschel Crater, was a six-wheeled truck-like vehicle to which was attached an enclosed trailer. Both had very large, wide wire wheels with enormous spiky treads for handling rough terrain in Mimas's 0.007 gravity. Nearby was a huge inflated mirror 100 meters in diameter that tracked the sun; its fifty percent efficient solar panels provided the station with sixty kilowatts of electrical power when the sun was up. Because of the low gravity and absence of atmosphere, the enormous structure weighed only a hundred kilograms.

"This is an impressive facility, Teresa," he said to Teresa Alvaro, who was in charge of Saturn moon exploration. Her android was standing next to his.

"The enclosure is quite comfortable for a crew of six, should we decide to station a crew on Mimas for a few months."

"I could see it. The six-second time delay is rather irritating. When I commanded my android body forward, it stopped several seconds before I commanded it to stop, I thought it hadn't reached the spot I wanted it to reach, I managed to get it to move forward another half meter, realized it had stopped where I wanted it to, moved it back half a meter, etc."

"You get used to it. The software is incredibly smart. Have you tried to pick up a sample and look at it? The false-color infrared view is amazing! And once you get used to it, you can recognize mineral types immediately by their false color. If you aren't sure, a 30-second wait is enough for the android to complete an analysis for you."

"Yes, we've been using that feature on Titan, too. But on Titan we don't have any time delay."

"That's why we're thinking about stationing crew here occasionally. This place has the surface area of Spain and we already know it holds some important clues about the formation of the moon system."

Marshall turned toward the inner wall of Hershel Crater a kilometer away. The station had been built near a natural route in and out of Mimas's largest impact feature. "It's an impressive looking spot, too." He looked up at Saturn's rings, which were just a few tens of thousands of kilometers away. They were a pencil-thin line but stretched much of the way across the sky, with the enormous, pastel colored swirls of Saturn behind. "I could look at Saturn and its rings all day, too."

"It is so, so beautiful. I think it may be the most beautiful object in the solar system, and Mimas is the most beautiful observation platform for it. We've spent hours staring at it. But we're refueled, now, so tomorrow we're on our way to Enceladus to set up a station there, and I'll enjoy the rings from there as well."

"From everywhere but Titan; it's a shame we can't see the rings from under the clouds. I'll have to come back here in virtual reality some time, when the androids are free."

Teresa laughed. "They're never free. If they aren't being used by someone, they're busy with one task or another. In the next two years they're scheduled to circle this moon. We're filling the truck's hydrogen and oxygen tanks before we take off so they can set out immediately."

"I know; scheduling people to run all these different expeditions, one per moon, is almost impossible! Once we have the power line finished, though, we'll have a lot more personnel. I'm looking forward to my stint 'on' Rhea in June. Anyway, I had better go, Teresa. Talk again later."

"Okay. Bye."

Marshall closed the line. He thought 'virtual reality off' and Rhea faded from the helmet screen surrounding his head; hundreds of electrical receivers pressing against his head picked up the thought. Rather than take off the helmet, though, he thought 'Mauna Ulu geology team' and

received the thought ‘one android available.’ He felt ‘yes’ and suddenly the work site on top of a cryovolcanic ridge thirty-five kilometers from Acheron Outpost appeared around him.

The blackness of Mimas’s sky was replaced by the orange grayness of Titan’s atmosphere, and the crisp gray-whiteness of Mimas’s surface was replaced by the tholin-streaked dirty ice of the Titanian crust. Marshall turned the head of his android body to the west and saw a line of three wind turbines, the nearest one being only half complete. They were an engineering challenge unlike anything else attempted on Titan before. The atmosphere had ten times more mass per cubic meter than the Earth’s atmosphere, but it rarely moved more than a few kilometers per hour, so the turbines had to be designed very differently than on Earth. In Titan’s low gravity, towers could easily be built twice as high as Earth, so they were building 200-meter pylons to loft 150-meters blades high into the air above Mauna Ulu ridge. Most of the work was being done robotically. Connecting the turbines together was a power cable running across the frozen ground.

“Where did you guys go?” asked Marshall. He checked the area map and saw the team of men and androids—some occupied via virtual reality, some not—had walked a kilometer to the southeast.

“We’re over here!” shouted David Omar, who was leading that particular team. Marshall acknowledged and started to jog over, which in Titanian gravity involved a series of long lopes. The android did most of the work automatically and for Marshall it was almost like riding a horse, though the virtual reality helmet transmitted to his brain the feeling of rippling muscles and the clomp of every footfall. David and the other geologists were gathered around a crevice several tens of meters long and almost a meter wide in spots.

Marshall stopped and looked down; there was inadequate light to see the bottom, but an image appeared anyway, apparently via radar, and wherever he focused a little number appeared, revealing the depth in meters. “A long way down. Was this here before last week’s quake?”

“Apparently not,” replied David. “Tholin dust has blown in, but not much; a millimeter or two. The infrared data shows no fusing of the tholin, so there hasn’t been a methane rain since the crack opened up.”

“And there’s methane and nitrogen gas escaping, with a little hydrogen,” added Chad Sutton. “So this connects to the Likoma Diapir, or another subsurface water-ammonia reservoir.”

“Likoma’s the nearest one, but it’s thirty kilometers away,” said Marshall. “How good is the seismic data under Mauna Ulu?”

“It’s good; no diapir,” replied Chad. “The Mauna Ulu ridge hasn’t had an eruption in 3,000 to 6,000 years.”

“I guess we’ll have to watch it, though,” said Marshall. “The crack should freeze up in a few weeks. If it doesn’t we’ll have something to worry about.”

“The quake was centered about twenty-five kilometers west of here and five kilometers down,” said David. “It was on the edge of the Likoma Diapir, and it seems the water body there is pushing upward and maybe eastward a bit. This crack could go that far. We’ll have to look for some others.”

“The escaping gas is at ambient temperature, so it traveled through the crust a long way,” added Chad.

“We may want to site the remaining wind turbines farther east,” said Marshall. “Mauna Ulu is lower, but we can’t have an eruption wipe them out. Every cavern we’re excavating needs two of them to provide heat and light.”

“We can make the pylons taller,” added Toru Takahashi. His comment surprised Marshall; he didn’t realize Toru had possessed one of the androids. “The design can accommodate 250 meters of height. I’m more worried about the geothermal wells. If the diapir is working its way a bit eastward, they’ll be right over it.”

“We should have acquired more expensive drilling equipment and drilled straight down under Acheron Outpost,” said Chad. “Two kilometers would have been enough to tap geothermal power. It doesn’t take much temperature increase to boil liquid methane.”

“But the resulting well would have been low power; we would have had to drill ten of them to get sufficient power,” replied Toru. “Geothermal has worked out pretty well in Likoma, but has been interrupted because of crustal instability. That’s why we’ve drilled four wells; together, they’re providing pretty reliable power. The wind turbines are probably more reliable.”

“Assuming they survive a once-per century windstorm,” replied Marshall. “This place can get some pretty strong winds, in spite of the feeble sunlight. We’ll be in the best shape when we have turbines and geothermal wells sited in many different locations. But that’ll be decades.”

“And we’ll need to be much bigger; I don’t know that will happen,” said Chad. He sighed. “I guess this isn’t the place to debate our growth and diversification of our energy supplies!”

“No, but let’s watch this crevice,” said Marshall. “We had better launch a drone to scan the area for more crevices, too.”

5.

Mother Nature

March 2074

“Are you sure the terminal velocity calculations are right?” asked Sirikit, a big frown on her face.

“Yes,” replied Wicahpi-Luta patiently. “At a beta of 1,000 to 2,000—that’s mass in kilograms per square meter of aerodynamic surface—the terminal velocity at terrestrial sea level will be about the speed of sound. A nickel or cobalt sphere at that speed will be smashed to pieces on impact, but all the pieces will be recoverable.”

“Buried under ten meters of mud?”

Wicahpi-Luta shook his head. “No, but it will make an impressive crater.”

“Better be absolutely sure it comes down in an uninhabited area,” said Charlie.

“Mars Metals is already using reservations in central Australia, Libya, Kazakhstan, western China, southern Argentina, central Nevada . . . plenty of places to drop capsules of metals already,” said Sirikit. “So, what’s the price? Eedie, please calculate.”

Her tablet took only the briefest second and a complex calculation flashed on the screen. “Assuming maximum annual production of metal spheres, the cost is 20,000 redbacks per sphere, exclusive of materials.”

“Wow! That’s basically one redback per kilo of cargo!” Sirikit pushed an icon and popped up a list of alloy prices. “Ceres can export all sorts of things at that price!”

“Of course, the investment is a couple billion redbacks,” said Charlie. “Assuming your calculations are right, of course.”

“Well, we’re not rank amateurs,” replied Sirikit, careful not to get angry at the challenge to her expertise. “I’ll admit, we have to run this past professionals. But the prices for the plants to

make spray-on heat shields, solar concentrators, thin-film solar arrays, and metal carbonyl parts fabrication are well established, as are the transportation and labor costs.”

“So, we’re talking about exporting 100 tonnes per sol, 36,500 tonnes per year,” said Charlie. “If it’s 500 tonnes of PGMs at 1 million redbacks per tonne and 36,000 tonnes of cobalt at 15,000 redbacks per tonne, we’re talking about 1 billion redbacks of income?”

“Basically. But the ataxite refined to extract 500 tonnes of PGMs will have closer to 50,000 tonnes of cobalt and 150,000 tonnes of nickel, worth 12,000 redbacks per tonne, so it makes more sense to produce 36,500 tonnes of cobalt and nickel and just 80 tonnes of PGMs. Ceres will get closer to half a billion redbacks per year, but that’s still more than it needs, and it’ll be exporting all its production.”

“I’m not used to the idea of exporting regular metals to Earth!”

Sirikit smiled. “I hope the folks up there can get used to it!”

“Are the three of you finished, now?” asked Esther, who was sitting in the corner of the room working on her biology homework. “Because we’ve missed the regular cafeteria hours and I’m starved. The sun’s been set half an hour, Sirikit. You can break the fast, now.”

“I agree; I really wasn’t worrying about sunset,” replied Sirikit. “Thanks, Wicahpi-Luta, for your help. We never could have put this together without you. I think we now have a viable plan.”

“Well, it was an unusual project for my advanced propulsion class, but the professor was intrigued and he helped, too,” replied Wicahpi-Luta. “I think we’ve hit on a pretty cool and cheap system.”

“I think so,” agreed Charlie.

“So, here they are!” It was Bill Hollingworth; they all looked up and saw him standing in the door with a young blonde woman. “We were looking for you in the cafeteria, but you weren’t there.”

“We’re on our way now,” replied Sirikit.

“I haven’t seen you for a few days,” added Charlie, whose room was next to Bill’s in the dormitory.

“No, I’ve been with Suzanne. Suzanne Rivers; these are my friends Sirikit Thanarat, Charlie Langlais, Wicahpi-Luta Hunter, and Esther Harris.”

“Pleased to meet you all,” she replied.

“Are you new at Martech? I don’t remember seeing you before,” said Charlie.

“Yes, I arrived last month on the *Alcor*,” she replied. “I started the semester taking just one class online and all the arrival briefings and training has put me a month behind, so I’m struggling to catch up.”

“Thank goodness you took only one class!” said Sirikit. “Where were you from?”

“Canada; British Columbia.”

“As beautiful as she is,” said Bill gallantly, and Suzanne smiled affectionately at him in reply.

“Say Bill, our project may interest you,” said Sirikit. “We’ve just designed what we think is the cheapest way to haul metals from Ceres to Earth or Phobos.”

“Really? How so?”

“Picture a big metal sphere; a bowling ball, if you will,” replied Sirikit. “It’s easy to manufacture hemispheres out of metal carbonyl and robotically weld them together. One hemisphere will be covered with spray-on heat shield. It’ll have a cargo hold and a water tank.

The other half will be partitioned into hydrogen and oxygen tanks and have a simple three-d printed rocket engine with spray-on ablatant in its combustion chamber.”

“No cryogenic recirculation to keep the engine from melting; too complicated and expensive to make,” added Wicahpi-Luta.

“Ceres can make this vehicle quite easily and cheaply; it could probably turn out five per sol. The flight computer, inertial guidance system, and celestial navigation sensors would have to be imported from Earth but could be produced for maybe a thousand redbacks each; they’re pretty cheap.”

“So you fill them with hydrogen and oxygen and launch them from the Ceres surface before the fuel boils off,” said Bill. “That’s clever. What about midcourse corrections?”

“The vehicle would have a small set of cheap solar panels and an electrolyzer unit that would convert the tonne of water on board into gaseous hydrogen and oxygen to store in the tanks,” replied Wicahpi-Luta. “It couldn’t store much at a time, so midcourse corrections would be a series of small engine firings, but that would be better for the rocket engine anyway.”

“We figure Ceres can make a five tonne vehicle for about twenty thousand redbacks, and all the five tonnes of vehicle, plus fifteen tonnes of cargo, could be metal for sale,” said Sirikit. “Nickel and cobalt could be exported to Earth profitably. Ceres could supply Phobos with all its metals more cheaply than could Uzboi, including iron.”

“Five tonnes; that’s a pretty heavy cargo vehicle, much heavier than anything we can make here.”

“It doesn’t have to be light because the vehicle itself is made out of the cargo,” replied Charlie. “Better to make it thicker and heavier than necessary. It’s cheaper.”

“That makes sense. And you’re talking about roughly one redback per kilogram transport costs? If your calculations are right, you’re geniuses!”

“Thank you, we think so,” replied Sirikit.

“But now we have to figure out how to explain the plan,” said Charlie. “Wicahpi-Luta is presenting the vehicle schematics in his advanced propulsion class and Sirikit’s presenting the economics in her solar system economics class.”

“Well, if they don’t listen, maybe my uncle will,” exclaimed Suzanne. “Tree Rivers, the prophet of the Green World Community.”

“He’s your uncle?” said Wicahpi-Luta, surprised.

She nodded. “I’m here this semester, then on my way down to Aram for the summer.”

Sirikit was rather disturbed by her offer. “Well, I’m sure people will listen. The professor of my class is Hun-jai Park, our leading economist, and Charlie’s dad is the Chief Executive of Ceres.”

“Then you have the right ears,” said Suzanne. “But the prophet would be interested also, I’m sure. The Green World community is planning to initiate an asteroid settlement, probably on an Earth-crosser or possibly one placed in Venus orbit, and probably on a nickel-iron body, if we can find the right one. This sounds like the kind of technology we’d need to export metals.”

“It is if you’re planning for a large volume,” agreed Wicahpi-Luta, nodding vigorously.

“Well, let me tell you why we came to find you,” said Bill. “Down in Aram, they’re planning a big timber-cutting project in two weeks, while we’re on spring vacation. We can go down to help and they’ll pay us! It struck me as a perfect adventure for the five of us. We’d get away, see a different outpost, do something we’d never do otherwise, get some exercise . . . I think it’ll be fun.”

“That would be fun!” said Wicahpi-Luta.

“And interesting for me, as a biologist,” said Esther. “Aram’s ecology is fascinating and is very little studied, scientifically speaking.”

“That’s because we’ve been pursuing a best practices approach,” said Suzanne. “We see what works and improve on it; we don’t stop to figure out what the approach is doing to the microorganisms in the soil or atmospheric trace gasses or soil chemistry. But we do need that research too, and we’re not opposed to it.”

“Well, I have a lot to get done over spring vacation,” replied Sirikit.

That surprised Charlie; they had been talking about spring vacation. “No, not really.”

She scowled at him, irritated.

“Well, let us know,” said Bill. “Suzanne and I are going. It’d be fun if all of us go down together.”

“Thanks, we will,” replied Charlie. He looked at the others. “Let’s get some supper before there’s nothing left.”

They nodded and packed up their stuff. Bill and Suzanne waved goodbye and headed down the hall. As the four of them headed for the cafeteria, Sirikit turned to Charlie and said “Please don’t contradict me! Remember, not everything you know needs to be disclosed.”

Charlie recognized her comment as a quotation from the Bahá’í class she had given. “And shouldn’t everything you disclose be the truth?” he replied.

She was startled and angered by that. She said nothing for a moment. “I apologize, that was self-righteous of me.”

“Oh, that’s okay. I shouldn’t have responded, either.”

“Ah, they’re already trying to change each other,” said Wicahpi-Luta, with a smile.

Esther chuckled. “Back to this proposed trip. I’d like to see Aram; their ecology is supposed to be fabulous. But there’s no way my mom and dad will say yes if I go just with Wicahpi-Luta, Bill, and his girlfriend.”

“I think the Green World community’s religion is kind of weird,” said Charlie. “Mother Earth and Father Mars? ‘Living’ planets? Funny rituals wearing green and red and talking about the male and the female?”

“I don’t know about the rituals, but the Mother Earth and Father Mars stuff just strikes me as a set of metaphors for the sacred,” said Sirikit. “They aren’t my metaphors, but I can deal with them that way.”

“Their metaphors resonate with Lakota religion,” said Wicahpi-Luta. “My father often speaks of Father Mars, and I think he did before the Green World community people even arrived. He says he can feel the spirits here.”

“I suppose we’re talking not about *physis* or nature here, but metaphysics,” added Esther. “When you get into the realm of the metaphysical, I tend to listen and be tolerant.”

“That’s how we all are, up here; otherwise we’d kill each other!” said Sirikit, laughing.

Charlie looked at her, then Wicahpi-Luta. “I am curious about the tree cutting. Sounds like a lot of hard physical work, unless we’re sitting back, watching a ritual, then watching robots do the cutting.”

“I don’t think they have many robots down there,” said Wicahpi-Luta. “So, are you game?”

Charlie thought a moment. “Sure. It’d be interesting.”

“Okay, I’ll ask my parents, too,” promised Sirikit.

Two weeks later, Sirikit and Esther stepped onto an interborough vehicle at the Cochabamba Transportation Center. “Is this the right one?” said Esther, wondering aloud.

A face appeared on a screen set in the wall. “Welcome to the interborough to Aram, with continuing service to Thymiamata.” It was an artificial face; they could tell because it was a young woman of intermediate skin tone and black hair with slightly East Asian eyes and a slightly African nose. Sirikit was always amused because with a German-American mother and a Thai father, she looked similar. But the voice was artificial as well. “We leave at 7 p.m., which is in ten minutes. The trip will take 12 hours and 10 minutes and we will arrive at 6:10 a.m. Aram time, which is one time zone ahead of Aurorae. Thymiamata is reached at 10:30 p.m. local time. You may wish to select a sleeping compartment. Number one, over the driver’s cab, is already reserved.”

“Good idea! Thank you.” Sirikit opened the door to the first cubicle. It was rather like some train compartments on Earth; two long, wide seats facing each other, whose backrests folded up to form a second set of beds a meter above. Another level on top provided two more private beds. When the compartment was set up for the night, each person could draw a curtain around their small private space and had a light, blankets, and pillows. “This is good. Maybe we can banish the boys to the next compartment back at bedtime, though.”

“Yes. Mom and Dad asked me specifically about that,” said Esther. She stepped inside and pushed her suitcase into the space under the seat.

“So, did they agree to let you go if I went along?”

“Yes.”

“My mom and dad said the same thing!” They both laughed. “Actually, my dad warned me extensively about not cutting off any of my fingers with the equipment.”

“You aren’t that bad, mechanically.”

“Oh, I don’t know. Sometimes I feel downright un-Marsian. We’re supposed to be able to do a lot of things with some competence up here!”

“Well, your economic talent makes up for it, don’t worry.” There was admiration in her voice. “I wonder where the boys are?”

“They’ll be along. Wicahpi-Luta’s really prompt and he keeps Charlie on time.”

“True. That’s something I wish Charlie were a bit better at.”

“Yep. So—you really like him, don’t you?”

Sirikit smiled. “Yes, he’s handsome. I really like his humor. And I like his friendliness; he gets along with everyone. He’s . . . principled too, in his own way.”

“In his own way.” That made Esther smile. “I think he appreciates your principled approach to the world.”

“Yes. He’s not interested in religion, exactly, but he seems respectful of it, and that’s not as common up here as I’d like.”

“That’s true. I’ve never been quite sure what Wicahpi-Luta believes. It seems to be a sort of private nature mysticism coupled with a strong dose of high school ethics classes. But he’s . . . steady. I guess that’s the word.”

Sirikit nodded. “That’s the word. Do you think he prays?”

“Yes, but I’m not sure to what!” Esther laughed at that and Sirikit joined in.

“I don’t think praying is an idea that has ever occurred to Charlie,” said Sirikit. “Not that he would be against it, but it’s just not in his nature.”

“Not now, anyway. But he’s a good guy.”

“He is. He’s a good man.” Sirikit nodded for a long time at that.

They heard a sound at the door of the interborough and looked up. Bill and Suzanne were entering with someone Sirikit didn't recognize; young, with a thick black beard. "Good sol!" exclaimed Bill. "Where are Charlie and Wicahpi-Luta?"

"Coming," replied Sirikit.

"So, should I have brought a female partner along as well?" said the young man. "Do they believe in free love at Aram?"

"No," replied Sirikit, affronted.

"Cool it, Giovanni," replied Esther, with a smile.

Sirikit looked more closely and recognized Giovanni Diponte under the beard. "Oh, I didn't recognize you. I haven't seen you for a year or two."

"I've been working mining equipment at Thymiamata; big diggers that scoop up a tonne of ore a minute, crush it, and centrifuge it in liquid carbon dioxide to separate the gold. Hard work, but it's a blast and I'm making a ton of money."

"He's a crack mechanic," added Bill. The three of them stowed their luggage and settled onto the seat across from Sirikit and Esther.

"The machines mostly run themselves," added Giovanni. "They steer, dig, etc., autonomously. My main function on board is to repair stuff because they're constantly breaking something. You can't chew through rocks at 60 below zero Celsius, spin them, then kick the waste out without breaking something."

"But is it a career?" asked Sirikit.

Giovanni scowled. "Sure, why not! There are families at Thymiamata now, too; lots of people make a career out of it. But I'm not sure how long I want to stay or what else I want to do."

“There’s always asteroid mining,” said Bill.

Giovanni shook his head. “No, not for me. Too many certifications! Everything you do here requires a dozen certifications, then it requires recertification every year or two and every time the regs change! I hate it.” He shook his head to emphasize the point. Sirikit frowned at him, wondering whether he preferred unsafe ignorance to safety in knowledge.

There was sound at the door. Charlie and Wicahpi-Luta hurried in. “We made it!” said Charlie.

“Sorry; we ran into my parents on the way over and they wanted to lecture me one more time about being careful,” said Wicahpi-Luta.

“I’m glad mine are on Ceres,” added Charlie.

“Can we all squeeze into here?” asked Wicahpi-Luta. He put his luggage under the seat and sat, leaving Charlie in the aisle.

“Yeah, we can. There are some spare chairs.” Charlie disappeared down the hallway for a moment and returned with a chair. There were depressions in the metal floor where he could anchor the legs. Just then the door of the interborough closed and the vehicle began to move toward the airlock. They all sat and watched out the windows as the vehicle drove into an airlock that was almost exactly the same size as the vehicle itself. In just a few seconds the outer airlock door opened and they drove onto the Martian terrain, which was illumined by the slanting rays of dusk. The interborough turned onto the metal roadway and accelerated rapidly and smoothly.

“Wow, we’re going really fast!” said Charlie. “On Ceres, you’d fly into space after hitting the first bump, at this speed!”

“It’s really smooth, too,” added Sirikit.

“It won’t last,” replied Giovanni. “I take this interborough every few months; it’s 27 hours to Thymiamata. On the metal road it can go 130 kilometers per hour, but that lasts for only ten kilometers! After that it goes between 70 and 100 kilometers per hour on the dirt highway, depending on curves and slopes. It’ll get a lot bumpier, too. At least it’s almost silent because the air is too thin to transmit sound very well.”

“So, are you going back to Thymiamata?” asked Sirikit.

“No, Bill invited me to cut timber, and I wanted to try it. Also, I pass by Aram ever time and never stop.”

“How long do we stop in between?” asked Charlie.

“No stops,” replied Giovanni, shaking his head. “There are two oases in between that can provide emergency shelter if necessary. Each one sends out a refueling trailer that catches up to the back of the vehicle, docks, transfers its fuel, then detaches and returns to the oasis, so we don’t need to stop for methane and oxygen.”

“I’m surprised this goes all the way to Thymiamata, rather than Meridiani or Aram,” said Wicahpi-Luta.

“Yes, that’s interesting,” agreed Bill. “People usually think of Thymiamata as part of the ‘Central Highlands’ region but it’s 2,200 kilometers from Aurorae; not much more than Uzboi. It’s eleven hundred kilometers from Meridiani and 3,400 from Dawes. As comfortable as these interboroughs are, most people don’t want to ride in them more than about 24 hours; an overnight ride would be more convenient. We have an overnight interborough to Meridiani twice a week—Frisols and Sunsols—but if we want to go to Dawes, we have to buy a jetwing ticket.”

“And the metal highway won’t help much,” said Sirikit.

“No. They say it’ll make Thymiamata and Uzboi into overnight trips, but Dawes will still be over thirty hours, and jetwings will be the only practical way to go. Unless they upgrade the highway for hyperloop vehicles, which they want to do eventually.”

“Well, the galley is stocked with plenty of food; let’s cook some supper,” suggested Sirikit.

“Yes, let’s eat; I’m starved,” said Bill. “I just returned from Phobos three hours ago! I had no time to eat since, either, so I haven’t had anything since breakfast twelve hours ago. I’ve got the week off, too, in spite of the transportation mess right now.”

“We can watch some movies, too,” suggested Charlie.

“And I brought cards,” added Wicahpi-Luta.

“Good, it’ll be a fun trip,” said Bill.

Almost every square centimeter of Jacquie Collins’s desk glowed white with documents covered with data. In between each sheet was a thin strip of the mahogany desk that was supposedly underneath the glass top, though in fact the whole surface was a giant screen and mahogany was the default setting when no documents covered it. Lately, little mahogany had been visible.

She scrutinized the revised guess for when the thousand arrivals who had come with the *Castor* and its associated caravels could be deorbited. One of the Arion class shuttles had experienced premature engine shutdown earlier that sol, forcing the landing at Dawes into emergency mode; now they were suspending the flights for a week to check out the problem. The delays would ripple through the entire schedule for everything. Sunwing passenger flights to Tithonium, jetwing flights to Dawes and Cassini, and interborough vehicle schedules all had to be rearranged, and with them orientation schedules and work schedules. More people would be

at Phobos longer, so more training could be scheduled there, including more certification classes for low-gee EVAs. Fortunately, she didn't have to do all of that; different people, supervising powerfully intelligent software, would handle much of it. But there were still egos, bruised by the unpopular but necessary decisions, to assuage, and some work delays would cause cascading delays for others.

One new report had arrived an hour ago and stood out: a memo about the road construction delays. She pressed an icon and it popped up on the desk right in front of her. Moses Waigwa, the Minister of Construction, was apologizing that the metal road building equipment had been able to lay only 1.1 kilometers per sol, rather than the projected 1.75 kilometers per sol. "Miki, convert this into an email to Moses," she said to her automated assistant. "Moses, we have to get the road building system going at the 1.75 kilometers per sol that was expected, or even better. The prime site for a wind farm is 227 kilometers north of Aurorae and the construction team is already at work erecting the turbines. Uzboi needs the methane and oxygen power as soon as possible; the lower that PGM prices go, the more PGMs we need to export to make our budget. Do you need an outside assessment and consulting group to take a look at procedures? Get back to me later this sol. Bye. Miki, just send that. What's the estimate when the second metal road building unit will be read for operation?"

"July," replied Miki. "But it starts at Meridiani and builds toward Thymiamata. Your appointment is arriving now: Ramesh Prathan."

"Okay, clear my desk and admit him. And bring us coffee and tea; you know what he likes, right?"

"I've got that in my database."

“Great.” Just then the desk’s top surface turned from papers to mahogany; nothing confidential could be seen by Ramesh. The door opened to admit him just as Jacquie rose. “Good sol, Ramesh. How are the wife and the baby?”

“Oh, thank you, they’re fine. How’s Mario and Mary?”

“They’re doing well; they’ve adjusted to life in Aurorae with a partially absent mother very smoothly. Sit down; Miki will bring us coffee and tea in a moment.” She came out from behind the desk and sat in her comfortable chair; he sat next to her.

“How the situation on Phobos?” asked Ramesh.

“It’s fine. The schedules are in the process of adjustment. We think the Arions will be grounded just a week, but we’ll be sure by this afternoon.”

“And the road metaling operation is behind, I hear.”

“Yes, but I’m confident Moses will fix the situation. It’s new equipment and it’s hard to predict how long it takes to break it in and adjust its functioning. Marcraft is ahead of schedule with the latest galleon, though, and the designs for the corvet are finalized, so we can start manufacturing some of its breakthrough equipment, as well as start building the corvet dry dock. Housing is in good shape, too; your team has done a great job of preparing housing and office space for 4,000 people. There are some furniture shortages, but the companies making them are fixing the problems.”

“We focused personnel on housing and office space, but it has put us behind with the Martech expansion. That’s why I wanted some time this morning.”

Just then Miki rolled in with a tray holding two cups of hot liquid and some little cookies, so they paused to take their refreshments. Ramesh seemed nervous and used the time to plan his next comment “As you know, we’ve been working steadily on Caspian Enclosure for months

now, and we're getting close to the point where we will inflate it. But we're dealing with delays, too. We sacrificed some personnel to get the housing ready, and now the landing delays will affect the schedule further. I'm afraid there's only one way to have the entire interior oxygenated and the ground ready for crops by the end of the year. We need to eliminate the divider half way down the length of the enclosure and make it one large space instead of two smaller spaces."

Jacque frowned. "The safety commission required the addition of the divider so that we wouldn't lose the entire space if we had a depressurization event. Caspian's a kilometer long and 700 meters wide; if we lost it, we'd lose capacity to house and feed 5,000 people. We can't afford such a loss."

"I know what the safety commission said. It was a recommendation, not a requirement. If we eliminate the divider, the entire space can be pressurized on time. Otherwise, there's a three-month delay, and that'll make it difficult to feed the arrivals in 2076."

"Dr. Pradhan, let's not play with words. The safety commission can't order or require anything, but that doesn't make their findings any less urgent. In fact, it's rather self-evident. If something happened to Caspian, we'd lose a quarter of our polder. There would be malnutrition, possibly starvation."

"But it really can't happen! That's what I keep telling people. Caspian is perfectly safe and a divider is unnecessary. The extra time we gain by getting it ready in time is sufficient to grow a three month supply of extra food, and that's plenty of insurance against depressurization."

Jacque frowned at that assertion. "And you want to store three extra months of food for five thousand people forever? The safety recommendations stand. We must complete the divider."

"But it'll delay completion of Caspian."

“Figure it out, Ramesh. Tighten the schedule a bit; there are always ways to speed things up a bit because the timelines are always slightly generous. Why are we three months behind? Do we need an outside audit?”

“Certainly not! We tried some new construction techniques and they delayed us, but they’re working better, now.”

“So, you’ll be able to catch up some? I’m sure you can, Ramesh, you’re a brilliant planner and director. Everyone knows that.”

He scowled briefly at the last comment, which made her statement sound like flattery instead of truth. “I’ll see what I can do, Ms. Chief Minister. Thank you for your time.” He rose, and nodded to her.

“Thank you, Ramesh. Have a good sol.”

“Good sol to you, too.” He turned and headed for the door.

Jacque watched him go. After he stepped out and closed the door behind him, she said “Huma!” Huma Mubarak, her chief of staff, stepped in. She had been Will Elliott’s chief of staff as well and brought experience and continuity to the job. “What do you think?”

“Ramesh is a stubborn man. His real issue here is aesthetics; he doesn’t want the thousand meter long sightline down the enclosure interrupted by a divider. That was the fight he had with Will last year.”

“Ah, so that’s what’s going on. But he’s also testing me, too; pushing me.”

“Yes. That’s Ramesh.”

“How did Will tolerate him? He has such an ego!”

“He kept Ramesh in line. I think it was a combination of inspiration, flattery and gravitas.”

Jacque laughed. “I have to learn how to inspire and flatter, then, and I still don’t have gravitas!”

“I think inspiring people and the passage of time will give you gravitas, so don’t worry too much!”

“Thanks. I feel better.” Jacque chuckled a bit. “So, when Will was ready to launch a legislative initiative, he’d invite everyone to his house for dinner?”

“It only holds two or three dozen, so that limited him when the Mars Council got big. He used the function room on the top floor of the Gallerie, too, once or twice.”

Jacque nodded. “I think I’ll hold a series of one on one meetings right here, including one with Will Elliott.”

“Do you want to postpone the announcement?”

“Yes, not morrowsol morning; I’ll use the press conference then to talk about the Arion and the plans to reschedule the landing of the arrivals. But in two or three sols this crisis will pass enough and we can announce the legislative initiatives then.”

“Tuessol, then?”

“I think so.”

As the interborough rolled silently across the darkened Martian range, its seven inhabitants explored the galley and cooked themselves an adequate dinner. “If you want anything other than standard stuff, you’ve got to bring your own,” explained Giovanni. “Breakfasts are usually particularly thin.”

So they ate quickly and pulled out playing cards. Soon a bridge game was going, then they watched a movie together. Bill and Suzanne retired early to sleeping compartment 1, a large,

horizontal space over the empty driver's cab. The rest of them retired at midnight in compartment 2. Sirikit wasn't sure whether she was unsettled and interested by the fact that Charlie had chosen the sleeping bunk right across the space from hers. Esther and Wicahpi-Luta occupied the two lower bunks, Giovanni one of the top ones.

They rose, tired, at 5:30; just enough time to clean up, change clothes, and eat a sparse breakfast before they arrived on time at 6:10. It was still dark out, but they could see the long enclosures as big shapes against the stars; twenty of them in pairs, an average of 200 meters long each, an outpost of immense size for only 450 people. As the interborough entered the airlock between Genesis Dome and Aram 1, the sky began to brighten with the light of an impending dawn. When the airlock door opened, a lone person greeted them.

"Morning, Tad!" exclaimed Suzanne.

"Morning. So, these are our volunteers! Welcome to Aram!"

"Thank you," replied Bill, who led them off the interborough. As soon as the last one stepped off, the automated voice on the vehicle said, "this vehicle departs for Thymiamata in five minutes. Please be sure you have all your personal property."

"Of course, if you don't, it'll still be on board next weekend when it takes us back to Aurorae," quipped Giovanni.

"Let me take you to your quarters," said Tad. "The ceremony starts right at sunrise; thirty-two minutes from now."

"Thirty minutes?" said Charlie. "I thought we'd have some time for breakfast."

"No; sorry, you should have eaten on board. I can get you some sandwiches later, though. There's just enough time to put down your stuff. This way." Tad set out across the arrival hall, some urgency in his step, and they hurried along behind him. He took them down a long corridor

punctuated periodically by doors to private quarters. At the far end they suddenly emerged into Genesis crater, 150 meters in diameter and 30 meters deep, ablaze with artificial light and filled with trees and other verdure. They stopped momentarily to stare at the sight. "It's pretty," said Tad with some pride. "Since we have no guests right now, you guys get the guest house over there." He pointed to a rustic looking stone building built into the rim on the left. It was the one of only two buildings in the crater, though they could see windows cut into the cliffs, indicating that behind the natural rock walls were other rooms.

They followed Tad down and around the rim to the guest house. Tad opened the heavy wooden door and led them into a large common room dominated by a magnificent stone fireplace. He pointed. "There are four rooms upstairs and four downstairs, all big enough for two. The rooms downstairs all have hot tubs, so you may want to choose them; after a hard day's work, the hot water is very nice. You can also swim in the pond covering half the bottom of Genesis crater or in the salt water covering Enclosure A or the fresh water covering Enclosure B. I can wait here while you settle in."

"Alright," said Sirikit. She looked at Esther. "Let's take Room 1."

"Okay."

They all headed down the hallway and took rooms. In fifteen minutes they had unpacked and were ready to go, so Tad led them back out. The bright lights illuminating the crater had gone out and the sun was almost up. "The lights are on until 11 p.m. and starting at 6 a.m.," Tad explained. "They give the plants a bit more light. That's one reason this place is so lush."

"It's warm and a bit humid, too," said Esther. "That helps."

Tad led them back up the rim and down the long corridor. The far end took them into Enclosure 1, one of their first enclosures, only thirty meters wide and 150 meters long, all

agricultural. Snaking the length of it was the Gihon, one of Aram's two "rivers." When they crossed into Enclosure 3, another agricultural enclosure, they saw that the Gihon flowed into a pool in Enclosure 3 and down through a siphon tube into Enclosure 1, which would allow it to flow even if one of the enclosures lost pressure. Enclosure 3 was 200 meters long by 70; now that the sun was almost up, they could see Enclosure 4 next to it through the plastic walls.

When they passed into Enclosure 5, farmland was replaced by forest, a surprisingly thick forest. As far as they could see, the trees stretched the entire 200-meter length of the enclosure. The small cleared area where they entered already had a small crowd, shivering slightly in the cool morning air. Tad began to introduce the seven of them, for they had introduced themselves to him during the walk. Before he finished, Tree Rivers entered, dressed in red robes. His two assistants, Victor and Victorino, entered with him, dressed in green robes. The crowd parted for them to walk to the edge of the Gihon and fell silent in the presence of the prophet. Sirikit pulled out her communicator and looked at the time; 6:44, or sunrise.

Rivers raised his hands. "We have much to be thankful for this sol; the gift of life, of fecundity, of richness all around us." He reached down and dipped his hand into the Gihon. "Of pure water." He raised his hands again. "And of fresh air." He reached down and grabbed a handful of dirt. "Of the richness of the soil of father Mars." He plunked a blade of grass. "Of the green of Mother Earth, cladding the body of Father Mars." He raised his hands toward the east. "Of the blessed light of the sun, the giver of life to all of us, for we all run on sunshine." He raised his hands straight up. "Father Mars, Mother Earth, bless our work. We thank you for this rich, tall, beautiful forest. We thank you for the gift of wood for building things, creating art, and warming us when we are cold. We thank you for leaves, which feed the animals. We thank you for roots, which sink deep into the ground to find Father Mars's rich nutrients. We thank you for

the gift of oxygen these trees have made for us. We thank you for the sun, the engine that powers it all.” He lowered his hands and turned to the others. “Father Mars and Mother Earth have indeed blessed us. Let us commune with them now.” He beckoned the others forward and they formed a single line. Wicahpi-Luta, Suzanne, and Bill immediately joined the line; Sirikit and Esther hesitated; Charlie watched the whole thing, a smirk on his face; Giovanni stared, incredulous. Rivers looked up briefly to see who was in line and who wasn’t. Then he reached into the Gihon, scooped up a bit of water, and anointed the first person with water on the forehead. “The gift of Mother Earth and Father Mars.”

“Thanks for the blessing of life,” replied the recipient, who then moved out of the way. Seeing the ritual, Sirikit shook her head and stood her ground. Charlie just watched, as if it didn’t even occur to him that he could participate.

There were only twenty in the line; it moved fast. When he finished, Rivers turned to everyone and said, “The forest is ready for us, and we are ready for the forest! Let me thank our guests, who have come all this way to help us.” He walked over briskly and extended his hand straight at Sirikit. “Tree Rivers.”

“Oh. Ah, Sirikit Thanarat.”

They shook hands; Rivers had a gentle grip. “Surprised to shake hands with a prophet?”

“I suppose!”

He laughed and moved on to Charlie, who gave him a strong grip in return. “Oh, a strong guy.”

“I suppose.”

“We need strong guys for this task; a lot of trees to cut!”

“If we hadn’t come, what would you have done?”

Rivers shrugged. “Hire some robots; we do use them. But it is better to do this work by hand, and we’re grateful you came to help.” He moved on to Wicahpi-Luta, then the others, shaking hands and chatting with each one. Then he waved goodbye and headed out of the enclosure.

“They would have hired robots?” asked Charlie.

Giovanni looked around at the others and whacked him. “Let’s get to work.”

“Do you know how to use one of these?” asked Tad, holding up a compact gasoline-powered chain saw. “We import them from Earth and make the gasoline ourselves. I’ll show you. Come on, gather around.” He picked up chain saws and handed one to each of them. Sirikit, startled, took it with some surprise. “Don’t worry, you won’t cut off any fingers,” said Tad, amused.

“I hope not,” she replied.

The control room of Acheron Outpost, Titan, was crowded with electrical engineers and observers. Marshall Elliott was one of the latter; as a geologist, he knew little about electrical work, but as a member of the Saturn Council and one of the supervisors of the 40-kilometer power line from the Likoma Facula cryovolcanic complex to Acheron, he had a special reason to be present.

“Everything is go,” said Sridhar, their chief engineer. He pushed another button on his screen and another electrical connection turned green. There were ten circuits; one more to test. He pushed the last button and it turned green as well. “It’s good work.”

“Well, let’s push some power through,” exclaimed Yuri, excited. Sridhar nodded and pulled up the commands for geothermal well number one. He opened valves and heated methane

gas began to flow up and through a turbine. The power needles moved to the right. Yuri smiled; they were getting power.

“Let’s try the wind turbines,” suggested Marshall. Sridhar nodded and turned to another screen, where he popped up the controls for ten turbines. He clicked on the odd-numbered ones in a series of five button pushes and they watched needles on five power lines rise to about a thousand kilowatts each.

“Not too much wind today,” noted Marshall.

“Every little bit helps,” replied Sridhar. He turned on the even-numbered turbines next and the power coming in on the five lines doubled to about two thousand kilowatts each. Sridhar pushed some controls and shifted the turbines to just two lines, freeing up the others. He turned to geothermal well number two and got it running as well.

“Look at that,” said Yuri, with a smile. The power coming in kept going up until, after two minutes, each geothermal system was putting out twenty thousand kilowatts.

“Look at the reactors,” said Sridhar, pointing to another screen. They were automatically cutting back.

“Will they go off completely?” asked Marshall.

“Eventually. It’ll take a few days,” replied Sridhar. “The cores are hot. Meanwhile, the surplus power is being routed to the Sabatier system and is being converted into methane and oxygen.”

“Essential backup,” added Yuri. “Because we can be sure the power line will go down, sometimes.”

“We need to drill geothermal wells right here,” said Marshall. “They’ll have to be deep, but they’ll be more reliable.” He looked at the controls in the various caverns. “Let’s flick on all

the lights in the new caverns. B-1 and B-2 have plants, but they're growing under minimal illumination."

"That can change now," agreed Yuri. He leaned over and pushed some icons. The power demand bars moved up by 10,000 kilowatts in a matter of a few seconds. "I bet that'll surprise the horticultural specialists!"

"Amy's working in B-1 right now," said Marshall. "I think I'll go look."

"We're done here," agreed Yuri. "Congratulations everyone. The inside team, the outside team, and the android control team: you all did superb jobs. Acheron can actually turn off its reactors and run on Titanian power now. And Titan has enough power, it is estimated, to allow us to fill ten percent of the subsurface with tunnels! This place could support hundreds of millions of people."

"Not that it ever will," said Sridhar.

"You never know," replied Marshall. He waved goodbye and headed for the door. Many of the other observers were right behind him; the historical event was over. Marshall headed for B-1 to see what it looked like in full illumination. He had to pass through N-7 first; it was their enlarged cavern and their oldest park. Like the bioarchive caverns, they had upgraded it considerably after the arrival of cargo on the *Cassini*. One of the items it had brought was several thousand LED "sheets" able to put out intense light in a variety of colors and they had covered the ceiling of N-7 with them. Looking up, he could see cumulus clouds that literally glowed; they drifted slowly across the "sky" that otherwise was a bright blue. But most of the sky was "cloud" covered, because the "clouds" were the main sources of illumination. A bright yellow circle representing the sun wasn't bright enough to hurt one's eyes or cast shadows; a white penumbra of "cirrus cloud" followed it to brighten its output.

It was hard to see the “sky” in N-7 because the trees had grown up so much; most were two or three meters high. Secondary illumination sources underneath their leafy canopies fed light to crops beneath them. But when Marshall entered B-1, the entire “sky,” one hundred meters long and fifty wide, was easy to see; the ground was covered by shade-grown plants that could handle the low light levels that previously had been available to them. B-1 was so bright it hurt his eyes. Amy saw him. “So, we have the Acheron connection?”

“Yes. It looks bright enough to get a suntan in here!”

“Or we’ll go blind; I can’t believe how bright it is! It’s getting noticeably warmer in here, too.”

“They’re turning down the lights,” said Gwangya, who had his communicator to his ear. “The cooling system is already compensating, too.”

“We’re now independent of the reactors, theoretically,” said Marshall. “It’s hard to believe! Of course, by the time we get all the bioarchive caverns set up, we’ll be dependent on them again, but we’re planning a third geothermal well at Likoma and we’ll set up more wind turbines.”

“We won’t need the reactors in the long run,” agreed Amy. “That’ll save a lot of money. Geothermal, wind, artificial soil, artificial air, bubbles of heat in a cryogenic world . . . so much for Mother Earth and Father Sun.”

Marshall nodded. “Yes. We’re freer from the natural environment more than any community in history.”

“So, how sore are you this morning?” Sirikit asked Charlie over breakfast.

“It’s not bad, this sol,” he replied. “Three sols of exercise; I think I’m adjusting.”

“I think I am, too,” she replied. “The hot tub really helps at the end of the day!”

“And how!” Charlie picked up his bagel and stuffed the last bit in his mouth. “I don’t know where the others are. You want to go for a walk around their enclosures? Three days of cutting trees in enclosure 5, and I still haven’t walked the length of the outpost.”

“Good idea,” agreed Sirikit. She picked up her coffee cup and downed the last bit, then picked up her two slices of toast. “Let’s go explore.”

“Alright!” They walked from the table—just then Bill, Suzanne, and Esther entered the cafeteria, so they waved goodbye and headed out the door. They knew their way down the corridor into Enclosure A, Aram’s shallow “sea,” and along its strip of beach into Enclosure 1, and from there to Enclosure 3. Beyond it was Enclosure 5. “Looks like we’ve cut down two thirds of the trees in here,” said Charlie. “Two more sols at most and we’ll be done.”

Sirikit looked at the big pile of lumber. “I guess this all goes to Aurorae for construction and furniture. Then they’ll warm up this enclosure and plant tropical vegetation instead. Esther is really impressed by their ecology.”

“When you spend time here, you understand why the standard for our enclosures has gone from one hundred square meters per person to one hundred fifty,” said Charlie. “And why Titan is aiming for two hundred square meters per person in the next few years, and eight different ecologies.”

“What’s the plan for Callisto?”

“Right now, they have a single buried B-75 with 2,500 square meters and 75 people! Our expedition will add about 185 personnel and about 30 or 40 are leaving, so Callisto should have about 220 personnel afterward. The plan is to inflate two 50 by 100 meter C-100 bubbles on the surface of Callisto over three years. After that, who knows?”

“You’ll be on your way back here by then.”

“I suppose; that’s the plan.” Sirikit nodded and the two of them fell silent over the thought that he was going away and she was staying on Mars. They had been walking on a winding trail along the Gehon and came to the northern end of Enclosure 5. The door to Enclosure 7 automatically opened and they entered.

“Wow; open parkland with groves of trees and brush. Pretty,” said Charlie.

“Yes, it feels much more open; Enclosure 5 is like a green tunnel. I guess it’s drier in here.”

“Look!” Charlie pointed as two deer leaped across the enclosure to the far end and disappeared through the automated door into Enclosure 9.

“They seem to understand the doors!” said Sirikit, impressed.

“Or the doors understand the deer,” quipped Charlie.

She pointed to a flock of birds. “Wild turkeys.”

“I wonder what else they have here!” added Charlie. “It’s pretty amazing.”

“It is. You won’t have anything like this on Callisto.”

“No, not for decades anyway. We really don’t have anything quite like this at Aurorae! Aram has a quarter the area of Aurorae and a twentieth the population. They love their nature, here.”

“They do; they worship it.” She said that with an incredulous tone.

They entered Enclosure 11; just four years old, it was prairie with scattered low trees. Enclosure 13 had chest-high grass and their progress became a sort of wade across the space, which lacked a trail. Ahead of them, next to Enclosure 15, was the construction area for another enclosure, and when they entered Enclosure 15 they saw construction ahead of it as well.

“End of the line,” said Charlie. “It’s all swamp!”

“As I understand it, when they first complete an enclosure, they flood it and leave it flooded for a year or two. The swamp vegetation and fish produce an inch or so of black soil. Then they complete another enclosure, flood that one, drain the swamp, and convert it to prairie, which becomes forest over a decade or so.”

Charlie pointed to the construction to the right. “And now they’re completing two enclosures?”

“I read their website; they’re switching from two lines of enclosures that are 300 meters long and 100 meters wide to four lines of enclosures that are 500 meters long and 150 meters wide. The two new lines of enclosures will hold the Hiddekel and Phrath Rivers. The Hiddekel will flow into the Gihon here, and this will have a permanent lake.”

“Where do they get the names?”

“The four rivers mentioned in Genesis.”

He nodded and they walked along the narrow strip of dry land extending to the left, where they crossed into the parallel line of enclosures. It also had a swamp, the source of the Pishon River, with two future enclosures under construction to the north and west. They skirted its edge and entered enclosure 14, which had chest-high grass and no trail, just like 13 to its east. They passed through 12 and 10, where there was young forest and meadows of grass. “So, do you think you’ll stay on Callisto?” said Sirikit.

“What? No, I’m coming back after this two-year expedition; why?”

“You sounded uncertain about your plans, that’s all.”

“Well, I suppose I am. I have no commitments here, after all. We haven’t talked about whether we have any kind of future together.”

“No, we haven’t, that’s true.” She wondered whether she should say anything more, but then Charlie suddenly pointed.

“Hey, what’s that little thing?”

She turned and was surprised. “A puppy of some sort; I think a coyote. He’s cute.”

Just then another pup appeared from behind a bush. They were about twenty meters away and oblivious to the humans, so Charlie walked, slowly, toward them. A third puppy popped out and jumped on one of the others and they wrestled, so Charlie and Sirikit stopped to watch.

“Why do they have coyotes here?” he asked.

She shrugged. “To eat the rabbits and mice.”

“Why would they have mice here?”

“Maybe they don’t, but I wouldn’t be surprised if they did; they believe in nature, after all. I think Aurorae has a biome with coyotes.”

They had been talking quietly, but the coyote pups noticed them and stopped playing. They sniffed at the humans, curious, then began to wander closer. Charlie and Sirikit smiled, amused to watch them. The pups came forward slowly, sniffing, sometimes pausing to play with each other, then advancing a bit closer. It was not a quick advance; after five minutes, the pups finally stopped just five meters away, decided to ignore the people, and went back to playing.

“This is really special,” Charlie said.

“It is. Look at the grass around us; it’s all been knocked down. This is their playground.”

“Oh, yeah. I wonder whether they have any natural enemies?”

“Probably just humans. The deer are too big for them, and they’re hunted for their meat and hide.”

Just then, the pups looked up and turned to the right. Charlie and Sirikit turned as well and heard a loud growl. The mother coyote had showed up. Charlie froze, uncertain what to do, but Sirikit immediately straightened her back, stared at the mother, moved closer to Charlie, and growled loudly right back, surprising Charlie. The pups dashed toward their mother; Charlie turned to Sirikit.

“What the—?”

“Just stare at her, look fierce, and slowly back up.”

“Okay.” He took a big step backward.

“Slower.” She stepped back, too, and bared her teeth at the coyote, who stood her ground, but did not charge them.

Step. Step. Step. They retreated slowly, and in a minute they were fifteen or twenty meters farther away. Sirikit relaxed and began to walk backward more gently. She pointed to the door to the next enclosure and he nodded. They began to walk sideways; the mother turned away from them.

“Where did you learn that?” he asked.

“That was a high school class you couldn’t attend from Ceres. Every Frisol afternoon we went to a different biome and the person in charge would show us around, point out various plants and animals, and give us general advice. There was one time when we encountered a mother fox and her babies. They were smaller and cuter, and we stayed farther away, but the teacher said some very interesting things about what to do when you encounter some species of wild animals: look confident, stare back, and slowly retreat. If you run, some will chase you, like buffalo and moose, and they’re faster. Others will just run away anyway. Some require some bluffing. I took a chance and decided to bluff with this one!”

“Well, it worked!”

“I guess so!” And she tipped her head back and emitted one of the loudest laughs Charlie had ever heard. He laughed, too.

“I’m sorry I was on Ceres for that class. I’ve noticed that Esther, Wicahpi-Luta, Bill, even Giovanni seemed much more comfortable in the woods than I was.”

“Yes, I think we’re more familiar with nature than a lot of suburban kids on Earth, because we have so many biomes and spent so much time learning in them. My dad once told me that whenever he went into Ceylon Dome, he felt at home with the plants; they were so familiar, so much like Thailand. But I can go into almost any biome and feel at home. They’re all familiar.”

“Another reason for Callisto to build a bunch of bioarchives; it isn’t just a matter of being able to obtain natural plant products.”

“Exactly. I think it’d be hard to be confined to the inside of a ship or a bubble, and I’m not sure walking around the outside on Callisto would be much of an antidote to cabin fever.”

“Yes, I know what you mean; though we did fine on Ceres with two caravels and a bunch of B-75s. But this does get us back to the subject of us; do we have a future together?”

Sirikit turned to him. “I don’t know. I really like you, Charlie. You’re . . . confident and determined, and you attract people to you.”

“And you’re beautiful, smart, and creative; and now I can add, brave!” Charlie chuckled and she chuckled too.

“Oh, I don’t know about that. Sometimes I’m pretty uncertain about myself.”

“We all are, sometimes.”

“Well, let me ask you this: what do you want out of life?”

“Out of life?” He paused to think about that. “That’s a big question. Can anyone who’s twenty be sure of the answer of that? I want to be a crack geologist, I want to explore worlds, I want to have a wife and family, I want to be respected, maybe to be a leader . . . how’s that for a list?”

She laughed. “A good one. I want to be a crack economist, I want to serve—we Bahá’ís always want to serve—I want to love God, I want a husband and a family, and I want to help move Mars forward.”

“How about, move the Mariners forward?”

“Okay, the Mariners, but I still feel more Marsian than Mariner, I suppose because Mars is the only world I know. Do you feel Marsian, Cererian, or what?”

“I think ‘Mariner’ works very well for me. I was raised on Mars until I was ten, then on Ceres, which is now part of Mars, but wasn’t when I was there, and I’m going to Jupiter, and then . . . who knows. Back to Mars for a while, for sure.”

She smiled. “I hope you come back to Mars, Charlie.”

“Okay, I will.” He smiled at that.

They had passed through Enclosure 8. The door to 6 had a tunnel that led to 5 as well, so they crossed to Enclosure 5 and entered the familiar green tunnel of its forest. They could hear talking and laughter; everyone was there to start work. “They must be waiting for us,” said Sirikit, hurrying forward.

But when they arrived at the work area, they found everyone was clustered around the prophet, Tree Rivers. “We definitely could use your skills,” he was saying to Bill. “And I’m not talking just about serving as crew on our caravel that runs between Mars and Earth. We’re going to be doing asteroid missions very soon. Somewhere out there we’ll find Themis, the daughter of

Gaia, a mother world among asteroids, and when we do, we'll need skilled pilots like you to get us there and help us terraform her."

"Themis?" said Bill, puzzled.

"Yes, Themis, the embodiment of divine order. She is a mother force and a mother world, and she will be our next home. Don't worry; you'll understand." Rivers turned to the new arrivals. "Ah, our economist has arrived from her walk in nature!"

"Yes, we saw three coyote puppies," she said. "And the mother, who growled at us."

"The coyotes are usually pretty harmless; she didn't attack you?"

"No."

"Sirikit growled right back, and it worked!" exclaimed Charlie.

"Very resourceful," said Rivers. "So, I hear you have developed a way to get cobalt and nickel from Ceres to Earth for just a few redbacks per kilo. Very resourceful; indeed, a breakthrough."

"Well, I didn't develop it," replied Sirikit. "A group of us taking a course in solar system economics developed a plan, and it is still in draft form. We have a few weeks to refine the plan, then we'll present it to Dr. Park, and if he likes it, we'll publish it, so the whole world will see it. I'm also not sure it will apply to other situations, because the plan requires a large scale and the investment of several billion redbacks."

"Ah; that's how you'd do it," said Rivers, nodding. "If the scale is large enough, the price will come down."

"Yes, that plus some key robotic factories and probably some technological breakthroughs," she replied. "But you'll have to wait for the published version. It's not ready yet, anyway."

“Well, we will read it with great interest when it’s ready, then,” replied the Prophet. He looked at the seven of them. “So, what do you all think of the proposal for a new way to apportion representatives in the Mars Council? Chief Minister Collins just announced it.”

Sirikit frowned. “Really? We haven’t heard.”

“Oh?” Rivers was surprised. “Right now, as you know, boroughs elect one representative to the Council per hundred representatives until the borough reaches a population of a thousand, then one per five hundred thereafter. With the arrivals in April, potentially the Mars Council grows to 101 representatives, which is getting pretty large for the existing chamber. If we continue the current arrangement, our small nation will end up with a very large legislature. So Collins is proposing a Mars Council consisting of two automatic representatives per borough, plus representatives totaling 51 more, apportioned strictly by population. For the current population of 16,000, that’d be one additional representative per 300 people. Aram has five now and would have four instead. Aurorae would go from 28 to 33. We have thirteen boroughs, so the Council would have 77 members.”

“It sounds like it would keep representation close to what it is now,” said Sirikit.

“Yes, close,” agreed Rivers. “It would increase Aurorae’s representation on the Council, though.”

“But that’s fair,” noted Charlie. “It would still have a lot less than half the members of the Council, but it has two thirds the population.”

“And Ceres would go from one rep to three,” noted Sirikit.

“Another thing the legislation does: boroughs off Mars could elect as representatives people permanently living on Mars,” added Rivers. “I suppose that’s essential for Ceres. I’m not very happy that our representation would drop, though. She also proposed legislation this sol to

extend the hours when alcohol can be sold to the entire weekend; very few people are going outside regularly now, and restrictions on alcohol consumption would remain in place for certain occupations, like pilots. Collins also proposed legalizing marijuana.”

“I didn’t know we had any on Mars!” said Sirikit.

Rivers looked at her, surprised. “Oh, yes. In fact, we probably grow the finest weed in the solar system, right here.”

“It sounds like Jacquie Collins is moving fast to make an impact,” said Bill.

“Yes, I think so,” agreed Rivers. “Anyway, I came down here to thank all of you for your assistance. It looks like you’ll finish morrowsol afternoon, after only five sols of work, so we will provide you with a very relaxing vacation for the remaining two sols here. There are some rather nice geological field trips, if that interests you, there’s an excursion down Aram Canyon and a bit of Ares Vallis and up to Aram’s rim, and of course we have some excellent swimming and snorkeling; our salt water body has baby coral reefs which are quite interesting to look at. Suzanne can give you other suggestions, too, I’m sure.”

“There’s some good hiking inside here,” she noted.

“Anyway, thank you again,” said Rivers. “Have a blessed sol.” He turned and walked away.

They all looked at each other. Sirikit looked particularly at Suzanne; she wished the prophet hadn’t been told of the metal-mining proposal, but it was too late for that. “Well, let’s get to work,” said Bill, picking up a chain saw.

Charlie picked up one, also, and looked at Sirikit. “Shall we work together?”

She smiled and picked up a chain saw as well. “Sure.”

6.

Vision

May 2074

The basement of the Bahá'í House of Worship in Aurorae was filled to capacity. All the sliding partitions had been pulled back, creating a single large space; nearly every one of the 164 Bahá'ís who had arrived from Earth over the last six months were present, as were an equal number of Aurorae Bahá'ís. Sirikit headed for the refreshment tables as soon as she came downstairs from the devotional space, but she had lingered to talk to a friend after the prayers had ended, and now she found that the cookies and little sandwiches were almost gone. She took one of each and looked around for Will Elliott, hoping to talk to him before he addressed the crowd.

“Siri!” she heard her father’s voice and turned. Ananda Thanarat was walking over. “How are you, dear?”

“Pretty good, dad. Are you speaking, too?”

“No, just Will this time. You didn’t bring Charlie, did you? Because this really wouldn’t be an appropriate gathering, I think.”

“No, I didn’t. He did seem a little curious, but in the end he didn’t ask any questions.”

“Is he interested in the Faith?”

Sirikit shook her head. “No, not really. He isn’t against it either; his reaction is the same as yours would be if someone was talking about medieval European clothing.”

“No interest or relevance.”

“Exactly. But he has a good heart, and he’s a man of honesty and integrity. I really like his instincts.”

“That’s good. I’m glad you’re thinking about the relationship very carefully. Remember, you’re both pretty young; you have a lot of time ahead of you to think about relationships. And every relationship teaches something.”

“I know, dad, I know.” She didn’t like her father interfering, however gently. And she didn’t want to admit that she really liked Charlie. Really liked him. “We’re just friends.”

“Well, yes, I can see that you’re just friends,” he replied ambiguously. “How’s the project?”

“Park really liked it and had some suggestions for improving it, but he’s not sure we should offer it to Jacquie Collins. First, she’s really busy right now. Second, while the proposal is theoretically practical, it’ll cost too much money; no one will invest two billion redbacks to do it.”

“Not now, anyway. That’s too bad. I want to see it, some time. I bet it can be improved and streamlined, or maybe a series of phases or steps can be proposed that will make it practical.”

“That’s possible.” She saw Will Elliott move to the platform in front of the room. “Oh darn, I was hoping to talk to him.”

“Maybe afterward; let’s sit down.” Ananda pointed to some seats nearby; Kim Irion, Sirikit’s mother, was already sitting there, so they walked over and joined her.

The crowd fell silent as Will Elliott stood straight and scanned the gathering. “Several people were wishing me Happy Birthday, a few sols early,” he began. “And I told them that the best birthday present I could get was 164 new Marsian Bahá’ís! I should add that the three waves of vehicles that left Earth carried only 151 Bahá’ís from Earth orbit; 13 people declared their belief in Bahá’u’lláh during the trip. So we welcome them in particular.” He began to applaud, so

everyone joined in. “I’ll be 73 years old in a few sols, and someone pointed out to me that in terms of annums, it’s 38.8, so I think I will think of myself as being in my thirties, still.

“When the National Spiritual Assembly of the Bahá’ís of Mars decided to invite all of you to a special welcoming reception, I asked them for the privilege of speaking to you about the uniqueness of the nation you have now joined. There is really no nation on Earth that resembles Mars in terms of its culture. I refer not simply to its diversity, which is in itself very unusual and nearly unique. There are neighborhoods or communities on Earth that are just about as racially and ethnically diverse, but in every case there was a preexisting substrate culture on which the diversity was overlain. Not so here; the diversity was the substratum, and our culture was built on both the diversity of backgrounds and the diversity of cultures and customs we all brought here. That is our first form of uniqueness.

“Our second has to do with science and education. Seventy percent of the adults on Mars have a doctorate and twenty percent more a Masters degree, and the vast majority of those degrees are in the sciences, engineering, research and development, horticulture, and medicine. The result is a remarkably well informed, intellectual, and skeptical public unlike anything that any nation on Earth has ever had. You will struggle to find anyone here who rejects evolution; there have been a few, but generally they have come around after a few years. No one here will question human-induced climate change; we hope to use the same principles to manipulate the climate here eventually, after all! It’s very hard to lie and obfuscate to the public here because they are too smart. That’s one reason *Mars This Sol* is getting a bigger and bigger audience on Earth; it speaks the truth, because no one here expects anything less. But there’s a flip side to the Marsian public’s skepticism; they ask very sophisticated questions, where religion is concerned. If you want to persuade people, you need to have equally sophisticated answers for them.

“And that brings me to our third form of uniqueness here: our religiousness. In Europe, religion remained allied with the aristocracy in the nineteenth century and was discredited when they lost political power. Many churches remained dependent on state support and never needed to reach out to their members. As a result, church membership plummeted. In the United States, churches competed against each other for members and often used marketing techniques and arguments that turned off the more sophisticated; they also remained bound up in particularistic cultural and ethnic concerns. Consequently, their membership has also dropped a lot.

“On Mars we have had a new start. Only about half our citizenship consider themselves believers in a religion, but theirs is often of the thoughtful type. It is diverse; if you go to mosque on Frisol or church on Sunsol, the congregations are multiracial and multi-ethnic. Even the church of Jesus Christ and the Creator, which arrived with an all-Nigerian membership, now has a significant number of white congregants. The Buddhist monastery up on the escarpment has non-Japanese monks. As a result, no group is unwilling to pray with anyone else. Interfaith work is stronger here than just about any place on Earth, partly because the believers, together, barely equal the nonbelievers. Service is emphasized over polemics.

“Among the believers, the Bahá'ís hold a strong position. On Earth we are still less than one percent of the population, but on Mars we are closer to four percent and growing. People do convert to religions up here, and we have done reasonably well; I should add, so have the Mormons, the Church of Jesus Christ and the Creator, and the Buddhists. We have also been able to be influential in several key areas. Interfaith dialogue is an obvious one, where our approach to consort with the followers of all religions with fellowship has become the dominant ethos. But more important, our approach to elections has become the standard cultural value on Mars. This is so true that Marsian Christians have been writing articles widely read on Earth about how

politics must conform to the ninth commandment, which forbids bearing false witness against another. Buddhists have been making the same case, citing the third precept of the Eightfold Path, which commands ‘right speech.’ The entire collective decision making approach we are following on Mars echoes with Bahá’í principles of consultation! And the virtues that the public school system has adopted are also similar to our code, because virtues are inevitably humanistic and therefore are fairly universal.

“So, what is your role in all this? You have come here because you want to contribute to building a new society, a society that we hope will be an example to old, squabbling Earth. But Marsian society has a long way to go before it is the example to Earth it can and should be. And what direction does it go in, to arrive at that point? Its science, its ecology, all have a role to play, but the ‘Marsian middle way’ as we are calling it, because it is neither eastern nor western, neither religious nor atheistic, but it is inclusive, pluralistic, and peaceful: it is what will really give Earth something to think about. That middle way will be shaped by all the people up here, but we Bahá’ís have an outsized role to play. Your personal example, your family life, your marriages, your children, your positive contributions to Marsian society, and the values you share with your neighbors, that you debate about with your neighbors, these are what will build up the middle way. The middle way must be kind, generous, open to discussion, fair, inclusive, just, and above all it must be unific, it must bring the people together. And who should understand unity better than the Bahá’ís?

“The Bahá’í community needs your contributions, too. It is easy to get immersed in all sorts of work projects, then come home exhausted and crash. We are one of the most workaholic societies that humans have ever created. In contrast, the Bahá’í community relies on volunteers for everything, and it needs you. Indeed, how can we be an example of unity if we’re too busy to

get together or to serve the greater community together? We especially need all sorts of teachers and trainers, because people up here will get together for brief, focused study classes in people's houses; unlike on Earth, everyone up here feels safe, so they like to come to each other's houses. So plan classes, give prayer meetings at home and invite friends, give people hospitality, and be dynamic examples of unity. If we can all do that, we will imbue Mars with Bahá'í principles and values and the culture will move in our direction. And because so many people on Earth look to Mars now, we will change human society as well. Allow me to thank you ahead of time for your signal contributions to this endeavor."

Will Elliott stepped down off the stage to thunderous applause. Quite a crowd gathered around him and Sirikit moved in as well, because she still wanted to talk to him briefly. She had to be patient, as many people swirled around to shake his hand and introduce themselves to him. One young man asked him, "How can we move the Marsian middle way in our direction if there is current legislation to legalize marijuana and extend the public drinking hours?"

Elliott smiled and replied, "You can't expect everything to move our way all at once. There will be progress and retreat. The public laws represent the consensus of the public. In the past, when almost everyone went outside several times per week, it made sense to limit alcohol consumption to Saturdays; by Monsol it had cleared out of the system. But now, the average person goes out less than once per month. So that reason no longer makes sense. I am on the Mars Council and need to vote based on what I think is best for Mars. In the long term, we believe people shouldn't drink alcohol at all, but short term, that is not the case. So perhaps I will vote for the law. I don't know; I haven't yet decided how to balance the long-term goal with the short-term situation."

"But wouldn't that be hypocritical, to vote against our principles?"

“It would be if it were my long-term position. But if everyone wanted to impose their long-term goals on Marsian society morrowsol, the Mars Council wouldn’t get anything done, would it? If we want to see alcohol banned up here, we need to start by persuading the vast, vast majority of the public, and that will take a long time.” Will Elliott smiled.

“That’s true,” the young man conceded.

Several others got his attention, then he turned to Sirikit. “This is primarily for new arrivals, Sirikit! But that’s alright, there’s plenty of time. I’ve heard some good words about your proposal to export nickel and cobalt from Ceres.”

“Oh, have you! I’m surprised. That’s what I wanted to ask you about.”

“I think Charlie was boasting to his dad, who was boasting to *his* dad, and Sebastian was telling me. Isn’t it amazing that we are now at the point where refining and transportation have gotten cheap enough to export cobalt and nickel to Earth, and iron to Phobos. It’s a very impressive development.”

“It is, but it’ll require the investment of about 2 billion redbacks. A lot of robotic factories have to be developed, built, and hauled to Ceres, which will need to grow to at least 300 or 400 people. Settling them will take another billion or so.”

Will’s face grew grave. “Ah, that’s the rub, then. That’s a big investment, assuming the numbers are right of course; bad management or a few misjudgments and they might be twice that.”

“We think we have taken all that into account pretty well.”

“Good. So, this was for a course in solar system economics?”

“Yes. Our goal was to figure out ways the other worlds could cover their expenses better. We came up with great ideas for Ceres, some for Phobos, and maybe a few for Mercury, but none for Venus or Jupiter. Saturn has the long-term possibility of helium-3.”

“No, there’s nothing Jupiter can export right now that makes an economic contribution to the solar system economy. Perhaps there’s a moon of Jupiter that is nickel-iron; there are a lot of tiny ones that are captured asteroids. But even that wouldn’t be economic, because the scale of the operation would be too small and transportation costs too high.”

“Yes, we thought of that. We even checked for any stray nickel-iron asteroids between Jupiter and Saturn. The data’s pretty limited, but the other economic factors are serious limitations.”

“And they will remain as limitations for several decades, most likely. Ceres expansion should be the priority, and there are a lot of private companies that could invest. If the expansion focused on PGMs, then turned to cobalt and nickel, it might work, economically.”

“That’s where we’re going with the ideas now. It’s a shame we can’t use the profits from Ceres to fund the other outposts.”

Will shrugged. “Why not? Those are not purely economic arrangements, though. That would be a matter of government policy; either Mars decided to fund the expansion and devote the profits to the outer solar system, or it arranged for grants from other governments, or it used some combination of government grants and bank loans.”

Sirikit looked at Will. “That could be done?”

“Of course. It would require support from the Chief Minister and the Mars Council. That’s not a simple thing, but it’s done all the time. In fact, I think a strong argument could be made, because it’s potentially a long term solution to the economic problem of perpetual

subsidies. Of course, no one knows where the prices of PGMs, cobalt, and nickel are going; probably down, as the technology for space mining improves. But even that's not an argument against the idea, because if Ceres wants to stay competitive, it has to have economies of scale."

"That's true." Sirikit smiled. "I think you may have solved a problem!"

"No, you solved the problem; I just gave advice. And we still don't know whether this plan will work."

"That's true, but we'll do our best to make sure it does!" replied Sirikit. "Thank you!"

She backed away; she had tied him up a long time and Will had already turned to someone else. She headed for the door; she'd explain to her mom and dad later. She had to go talk to Charlie, Esther, Bill, and Wicahpi-Luta.

Ceres was gray, dusty, uniformly pocked with craters, and had a surprisingly reddish tinge. The caravel *Bode* approached the dwarf planet with its nuclear engines blazing, then they fell silent and separated from the vehicle itself once they were in orbit. Several hours later the *Bode* fired its small chemical engines briefly, burning off 250 meters per second—a mere five hundred miles per hour. The *Bode* was heading to the surface, just a few kilometers below. The engines fired periodically as it descended to keep the speed low, then burned off the last vertical component when it was just ten meters above the surface. It hovered and slowly moved horizontally one hundred meters, then settled precisely on its landing pad. A surface crew in space suits came out to attach a pressure tunnel with a spiral ramp inside to the *Bode's* ventral hatch, and once it was tested, it was pressurized. The sixty-five personnel inside the vehicle disembarked and Helmut Langlais, commander and Chief Executive, welcomed each one with the shake of a hand and sometimes with a hug.

Carter Levine, their expert at PGM refining, was one of the recipients of the latter. “I can’t tell you how thrilled we are to have you on Ceres, Carter,” said Helmut. “Your talents and experience will be one of the keys to our growth.”

“I can’t tell you how excited I am to be here, Helmut. I never thought I’d be focusing on space mining! I had always prepared to work on Mars. But here I am!”

“Well, this is Mars. And more generally, we’re all Mariners. I rather like that term and that identity, even though it’ll be up to us to figure out what it means!”

“That’s true.” Carter looked at the short line of people still awaiting the commander’s welcome. “Greet them; I’ll wait. I want to talk.”

“I may know why; I want to talk to you as well.” Helmut turned to the last six men and women in line. They were young; the average age of the arriving crew was 29. Of the sixty-five, forty-two were married, and they had only five children among them, including Levine’s two. Once they were all settled and shielded from radiation by several meters of regolith, Ceres could anticipate a baby boom.

“Welcome to Ceres,” Helmut said to the last one, the captain of the *Bode*. “After five years of seeing the same faces sol after sol, you can’t imagine how exciting it is to have our population double instantly!”

“Thank you, Commander,” replied the captain.

Helmut turned to Carter at last. “Be careful walking in this gravity; it’s tricky. I wonder how your crew will do, eating the welcoming dinner in Cererian gee! All drinks have to be in closed containers, and we never serve soup out here.”

“How often do you eat in the new hall?”

“Only once a week, usually Sunsol lunchtimes. Neither caravel has a lunchroom large enough to hold all 76 of us comfortably, though we used to squeeze in together once a month. Now with the Bode and a population of 146, it’s impossible. But we’re delighted to have the new faces.”

“We’re delighted to get off a crowded caravel, after a year of floating through the asteroid belt. The two brief stops weren’t much of a relief from cabin fever. Central will be so much larger!”

“Yes, we’ve been expanding in anticipation of your arrival, with a big low-gee gym and a new dining and meeting hall that can accommodate 300.”

“We won’t outgrow that very soon.”

“I wonder. Have you talked to Sirikit and Charlie about the new proposal?”

“The group videomailed me yesterday, asking how Uzboi had gotten its funding for expansion in the past, and they explained the new idea then.”

“What do you think? I’m quite excited about it.”

“Yes, it has a lot of potential. You know the diplomatic side much better than I do. Whenever Uzboi has expanded, it’s a three-way negotiation between Mars Metals, the Commonwealth government, and one or more banks, with funding split more or less equally among the three.”

“The diplomatic side worries me. Should the Asteroid Commission get involved? Some might say a plan to fund outer solar system exploration is none of their business, even if it involves Ceres. Should it be the Marsian Commonwealth? That will generate rivalries with China and possibly the US. But I think it has to be both. I’m planning to propose exactly that to

Jackie, who unfortunately has her hands full right now rounding up votes for the new legislation.”

“You’re better off waiting, then, because half the mining companies on Earth will look at this as a move that could eventually drive them out of the nickel and cobalt mining business, so they will oppose or want a piece of the pie, which means they’ll want to make a small financial investment and in return for options to license the technology and compete with us. Governments will want to provide investment if we license the technology to their companies, too. This is a huge thing; we’ll have a tiger by the tail.”

“And we have to protect Uzboi.”

“And we have to protect Mars! PGM prices go up and down with the terrestrial economy, but gold demand is countercyclical. We need the buffering that Martian gold provides.”

“Yes, that’s true. I’ve already been thinking about whether we should open a second and eventually a third mining operation on Ceres to utilize different nickel-iron resources and the balance of metals they’ll offer. That’s another partial buffer. It’ll be decades before we can replace all of the Earth’s nickel production, so that should provide a reasonably stable price, also. We could also sell shares in the three operations; so many for Venus, so many for Saturn, so many for Jupiter, so many for mining companies, so many for Mars itself, so many for asteroid belt exploration, etc. But let me ask you this: have you actually read their proposal? Based on your expertise, what do you think?”

“I can only tell you about the metals refining part, which is the least innovative section. They got most of that from me; it’s boilerplate stuff. My take on the overall report is that it is a brilliant, synthetic piece of work by a bunch of early-twenties, but they are in their early twenties. It will take some refining.”

“Fair enough. Overall, I am extremely impressed. But we need input from Alexandra Lescov and the automation experts about the robotic factory to mass produce cheap little rockets from cobalt. Jackie has to authorize that.”

“Did you ask her?”

“We’re having a rolling meeting tomorrow afternoon; can you join me? She has seen the proposal, was impressed, decided it cost too much, and shelved it. I’m in the position to push it forward as a priority of the Asteroid Belt Commission on the grounds that it will grow Ceres significantly, whether any revenues go to the outer solar system or not. But this could become a cause of mistrust quickly and could complicate our relations with Mars, and we need Mars. You know Jackie right? I’ve never actually met her.”

“Yes, and I’ve worked with her. She’s a good choice for Chief Minister; a good listener, a good bridge builder. I’ll be glad to join the meeting.”

“Good, because three billion redbacks—even over a course of a half dozen years—will take a lot of persuading.”

Anne Hollingworth looked at her husband, Kurt, then at her son, Bill, then back to Kurt. He looked as incredulous as she felt. “So, you want to become a pilot for the Green World Community, move to Aram, and marry Suzanne,” she said, repeating the information Bill had tried to break to his parents gradually and gently. “I . . . don’t know what to say.”

“Mom, I’m 24 years old. I thought I should tell you what’s happening with me, especially with the two of you about to head to Phobos, then Titan in two months. This is a big change, I know, but it feels right. It’s an exciting change.”

“Are you joining that prophet’s religion?” asked Kurt.

Bill shook his head. “No, not really. You can go to his ceremonies whether you believe or not; in fact, I wonder whether most of them believe. He says he receives inspiration from Mother Earth and Father Mars, but if you ask anyone what it means, they say it’s just a metaphor for his ‘genius.’”

“Genius or craziness? He speaks such utter nonsense. It’s hard to believe this is Mars and the late twenty-first century. Mother Earth and Father Mars! Belief in God; that’s illogical enough, but really, Mother Earth and Father Mars? Two gods rather than one is twice as crazy. Bill, really, why don’t you . . . just come to Titan with us. We plan to stay two years, we’ll help set up Saturn Commission facilities there and strengthen the liaison between Titan and Mars, then we’ll be back here. Your piloting skills will be immensely useful; we can still add you to the control room crew.”

“Dad, it’s not my path. I’m sorry you’re disappointed in me, but I have to do this.”

“This woman, Suzanne . . . Bill, you’ve only known her for three months,” pleaded Anne. “Take your time, don’t make any commitments yet, get to know her better. We’re still around for a few weeks and I’m no longer Executive of Aurorae, as of yestersol, so we have time, too. Let your dad and I get to know her better.”

“I’d love that, but mom, I love her and I’m not changing my mind.”

“Why would the Green World Community need a pilot, anyway? Will you be flying from Mars to Earth and back? How many more people are they going to bring to Mars?”

“They can bring 150 every columbiad and yes, they want me to help fly their caravel back and forth; they have to hire a crew. They plan to bring at least two more loads of people to Aram; they might even buy a galleon. But in about four to six years they want to start an asteroid colony, possibly on an Earth-crossing orbit or maybe even in orbit around Venus if they can

figure out how to reduce the insolation. By then I'll be in line to be captain of the vehicle leading the expedition, if it happens."

"But why, Bill, would they want to do this?" asked Kurt. "There's no rational, reasonable, argument for such a plan. It doesn't make money, it doesn't achieve certain scientific goals, it isn't a step in the settlement of Venus orbit for humanity, it isn't even a project to do asteroid mining. It's just . . . a crazy idea, a whim, something to amuse Mother Earth and Father Mars. Why do it? Why respond to a metaphor?"

"Dad, it's part of a bigger vision. That's all I can say in explanation. The Green World community wants to turn worlds green. They're spreading a web of life over the Aram plateau; you should see it, it's really beautiful. That's one reason our green space has been getting bigger; the ecological management people are looking at it aesthetically and psychologically as well as ecologically. For their next project, they want to turn an asteroid green. Ramesh Prathan has even been designing the system; for a price, of course. It's really impressive already and it'll get even better. Not everything has to be scientific or economic, you know. Nature and beauty are a motivation as well."

Anne and Kurt looked at their son, startled. "Well, now you're talking religion, Bill, whether it's god or something else," replied Kurt. "And I'm sorry that you have gone down that road, because it simply makes no sense. I'm not saying that nature and beauty are useless, but they are not practical or sufficient."

"Well, that's what you say, but I disagree," replied Bill. "I'm sorry this is dividing us, especially in the last two months before you leave for Titan. I ask you to accept Suzanne into the family, though. We probably can't arrange to get married in the two weeks before you leave for

Phobos, but maybe we can get married before you leave for Titan, if you'll come to the wedding."

"Let's get together with her for dinner tomorrow night," said Anne.

"And then we'll see," added Kurt.

The conference room's table was covered by eleven glowing pieces of electronic paper, all of which carried copies of the final report about PGM mining. Sirikit was the only member of the solar system economics class involved in the presentation, but her 'team' of close friends who had helped were all there: Charlie, Esther, Wicahpi-Luta, and Bill. Dr. Hun-jai Park was there to add an occasional economic clarification and watch how his star pupil was doing. Jacquie Collins looked fascinated by the entire presentation, even though she had heard a shortened form of it before. Alexandra Lescov, Mars's expert at spacecraft construction, sat listening and flipping back and forth through the pages, scribbling notes on her copy. Yevgeny Lescov, head of interplanetary transport, pondered the implications of the new cargo transportation system it proposed. Rodrigo Moreno, Executive of Uzboi, had flown in especially for the occasion and scribbled his own set of notes, in Spanish for privacy. Xiaopeng Cai, the former Minister of Solar System Exploration but now head of the soon-departing expedition to Callisto, listened with fascination. Helmut Langlais watched the entire procedure from Ceres.

"It should work," concluded Alexandra, in a short, curt evaluation of the plan. Silence followed as everyone waited for her to say more, so she finally added, "there are a lot of technical details to work out."

"What about the financial estimate?" asked Jacquie.

Alexandra shrugged. "It's probably within twenty percent. We can refine that."

“How much can it earn?” asked Xiaopeng.

“That depends on the price of the exports,” replied Yevgeny. “And that’s hard to predict. It’ll make Ceres potentially as big as Uzboi.”

“And together we’ll be as big as Parenago,” added Moreno. “For every billion you want to earn per year, eventually you’ll probably have to invest two or three billion, especially once volume goes up and prices drop. Jupiter, Saturn, the asteroid belt, and Venus each could use a billion redbacks per year.”

“Something like that,” nodded Yevgeny. “Initially the investment is closer to one to one.”

“What about the sources of financing?” asked Alexandra.

“That’s the weakest part of the proposal,” said Hun-jai. “I haven’t had the time to think about it much and this presentation is still a class presentation.”

“I hope she gets an A!” quipped Jacquie.

“This is most of the way to a strong Masters thesis,” replied Hun-jai. “Clean up the financing and it’s there. But by the time that gets done, the financing effort may be underway.”

Jacquie nodded. “The four-way equal split among the Commonwealth, Mars Metals and other corporations, terrestrial governments, and the various Commissions is a fascinating suggestion, but that’s not an economics question anyway, Hun-jai; that’s politics. You can’t expect her to get that part right in an economics class!”

“So, what will we try for?” asked Rodrigo.

“I’d try to keep the corporate partnership restricted to Mars Metals, if we can, so we retain patent control, and I’d restrict terrestrial government investment as much as possible to maintain as much freedom as possible,” said Jacquie.

“Keep in mind the Commissions want as much freedom as possible, too, and that’s legitimate; the Saturn Commission should be in charge of Saturn exploration,” responded Cai.

“Sure; I concede that,” said Jacquie. “But I don’t want us developing technology that someone else gets a license to use on some near-earth object where they can undercut our sales. Perhaps that’s not a serious possibility, though, if you have to invest several billion redbacks in automated factories in order to export the metals cheaply.”

“Right now, this will only work with a big investment,” said Sirikit, happy she could get a word in. “But the experts on factory automation told us that there was a good chance, in twenty years or so, that a completely automated factory could be sent to an asteroid with a maintenance crew of just three or four and it could export hundreds of tonnes of nickel and cobalt per year. Longer term, an automated factory able to turn out thousands of tonnes a year, possibly with no crew at all, is probably possible.”

“That’s still a generation away,” said Alexandra. “The real advantage of this system is that it will build Ceres up to a population of several hundred adults, and that’s a critical mass for a community. Four people won’t stay permanently on an asteroid; they’ll have no adequate medical care and they’ll be starved for society. Ceres has a variety of nickel-iron bodies with different combinations of rare metals, so it has diverse resources, and if we can get it up to several hundred people, it’ll have a scale of operation that no one can afford to match. I guess the question, then, is what will it do to Uzboi.”

“That’s our question, too,” said Rodrigo.

“The Commonwealth has to be committed to both,” replied Jacquie. “That means we have to see them as complimentary natural resources and have to develop them accordingly. Uzboi probably can’t export nickel and cobalt to Earth, but we need their production here.”

“So, where will we get the resources to do this?” repeated Rodrigo.

“We’ll start by reexamining our budgets for the next five years and see what we can rearrange,” replied Jacquie. “The galleon *Herschel* is already budgeted and scheduled to fly to Ceres in three years, but we hadn’t finalized what the personnel would be doing or what equipment they would need. That’s a billion redbacks right there. I’m sure we can find another half billion in the budgets through 2078, maybe a billion through 2079. We can borrow; our credit right now is excellent. And we can approach several governments for support, especially the ones that will be receiving the cobalt and nickel capsules.”

“Argentina and Kazakhstan don’t have any space mining companies, so they’d be best,” said Yevgeny.

“I’m sure we’ll need to approach the United States and China, but if we keep their investments small, we’ll retain a lot of freedom,” continued Jacquie. “We were already committed to expanding Ceres and its PGM output, so this actually isn’t a huge change of policy; adding the system to export nickel and cobalt is the big change. If we can, we should give shares in the export to the various Commissions, rather than having terrestrial governments paying for and giving them the shares; the latter adds strings to the deal.” She turned to Sirikit. “Mars owes you—all five of you—an immense debt of gratitude. What you have accomplished demonstrates what our educational system should aim to do: raise up a new generation of bright and innovative citizens. I want to establish an annual innovation prize and award it to the five of you, and I’ll plan to get that done in the next week. Meanwhile, go to any restaurant in Aurorae tonight and have them call me; I’ll pick up the tab.”

“So, you’re going to adopt the plan?” asked Sirikit.

“Absolutely! And refine it, of course; no plan ever moves forward without modification. We are not just grateful, but proud.” Jacquie rose and walked to the five of them, hand out. She shook hands with each of them. Park, Cai, Moreno, and the Lescovs rose and did the same. Sirikit had tears streaming from both eyes.

“You deserve it, Sirikit,” said Park, giving his special pupil a hug.

Everyone turned off the epaper in front of them and picked up their communicators and any other personal possessions they had. The fivesome headed out of the Capitol building into the dusk of Andalus Square. “Where will we eat?” asked Charlie. “Sirikit, you decide. You were our fearless leader this sol.”

“Where?” She thought. “American steakhouse. Let’s get the biggest steaks they have.”

“Yes, yes!” agreed Wicahpi-Luta.

“What a relief to have this over,” said Bill. “I was so nervous!”

“You and Wicahpi-Luta provided some of the most important data, and it was right,” said Sirikit. “I still can’t believe it! They accepted the plan!”

“I can’t believe it, too!” said Charlie. “Not only does this grow Ceres to maybe 500 people; it helps to support Venus and the outer solar system!”

“Well, this is probably a temporary solution,” said Sirikit. “Or maybe it’s just a step. If Saturn gets a billion redbacks of profits per year, it’ll grow until the billion redbacks are used every year, but it’ll still want to grow more, so it’ll need more. Whether Ceres can export more is not so clear. If the cost of exporting metals drops and it can export iron, theoretically it could supply the earth with hundreds of millions of tonnes every year.”

“Or alloys; they wouldn’t just refine the metals, but mix them,” said Charlie. “But if the technology develops that far there would be competition from near earth asteroids, because their transportation costs would be lower.”

“Ceres will have to count on economies of scale at that point,” said Sirikit.

“I wish they’d consider adding Uranus and even Neptune to the system now,” said Wicahpi-Luta. “Both projects are underway and costing money; a lot of money, in fact, because there are new propulsion systems being developed for them.”

“I disagree,” said Sirikit. “Both projects are monetary black holes. Money is being spent on a lot of things that will benefit space exploration in general and some things that may never produce anything. The Ceres profits need to go to supporting existing settlements; if they go to future projects, the profits will be gone and have little to show.”

“That’s true,” agreed Charlie. “And governments already have lots of reasons to invest in technology.”

“Don’t worry, you’ll get to Uranus!” added Esther, patting Wicahi-Luta on the back.

They continued in silence through Cathay, Punjab, and Zanzibar, past some very good restaurants, to Liberty Enclosure, with its miniature Statue of Liberty, its Marriott Hotel, and its Mormon Temple. The American Steakhouse was built into the Marriott and was one of the finest and most expensive restaurants on Mars. As they were about to enter, Charlie’s communicator beeped. The tone indicated a message from his dad on Ceres. “Wait, let me see this,” he said, pushing the play button.

Helmut’s face appeared on the screen. “Hi Charlie. I can’t begin to tell you how grateful all of us here are to the five of you and the proposal you put together. It’s a bit of a miracle. It takes us to a whole new plateau, and mind you, we just reached a new plateau with the arrival of

the *Bode*. As we expand our PGM production, we'll store the nickel and cobalt and we'll convert as much of it into capsules as we can, because we will have limited capacity to do that. We'll also start planning for new system. The crew of the *Herschel* can now be hired with a clear set of goals in mind and they can already get started with training. So this speeds up and reorients the entire borough. But we won't start tonight; we'll celebrate! The five you have a second dinner, morrow's evening, on me! Please thank everyone for me. Bye."

Charlie smiled at that. "Come on, crowd around," he said. "There's plenty of light right here for us to record a reply." He waved the others to step behind him. He reached over to Sirikit and pulled her close to him, shoulder to shoulder, and kept his left arm around her while he set up the communicator in his right. He checked the image; all five of them were visible in it, with him and Sirikit in front. He pushed record. "Hi, dad! Here all of us are! We're on our way to the American Steakhouse right now to celebrate. We are so, so happy that we put this proposal together, and even more happy it was accepted! In fact, we can't believe it yet! So we are delighted. Thanks for the second dinner. And thanks for persisting with Ceres! This would be impossible without your vision for the place!"

"Thank you, Dr. Langlais!" added Sirikit. "We're very honored to be able to make a contribution to Ceres and the outer solar system this way. And Charlie is right; your vision was essential, too. Not everything is determined by cold, hard, rational facts; sometimes you need to go with possibilities. You loved Ceres and now this is possible. I think you can count on Central growing to be at least 500 in six years. After that, who knows."

"Maybe we can come up with another breakthrough at that point," said Charlie. "I'll be back from Callisto by then. Anyway, we'll talk more later. Bye."

“Bye,” the others repeated. Then Charlie closed the recording and send it winging its way to Ceres.

They all trooped inside the steak house. Charlie headed for a booth and sat; Sirikit sat next to him, Wicahpi-Luta and Esther sitting opposite. Bill hesitated. “There’s room,” said Sirikit and she moved close enough to Charlie so that their hips were touching.

“Oh, okay.” Bill sat on their side. Sirikit looked at Esther, smiling; usually the two of them sat on one side of a booth with the boys on the other side.

“You know, you’re right about vision and possibility,” said Wicahpi-Luta. “Mars itself is an example, isn’t it? We wouldn’t be sitting here now if it weren’t for the love that our parents felt for Mars.”

“That’s true,” agreed Esther. “They stayed, they persisted, it was a small, isolated settlement, and they built it.”

“Love of Mars,” agreed Bill. “Father Mars and Mother Earth,” he added quietly.

They had a grand dinner with the most expensive steaks in the house, and huge ice cream sundaes for desert. They walked out slowly two hours later, stomachs full. “I need to walk this off,” said Sirikit, looking at Charlie.

“I’ll walk with you,” he said.

“I have to go find Suzanne,” said Bill. “She was wondering what would happen and will be mad I didn’t invite her to dinner, but Jacquie didn’t say she’d pay for hers, too!”

“Good night,” said Wicahpi-Luta. He looked at Esther. “I’ll walk you home.”

“Okay. Come inside and have some coffee. Mom and dad would enjoy that.”

“Alright,” he said, smiling.

Sirikit turned the opposite direction: west, toward the far end of Aurorae outpost. Charlie nodded a goodbye to the others and stepped off, next to her. “How far do you want to walk?”

“All the way to the end and back; I won’t sleep very well if I don’t work some of this off.”

“Okay. Mediterranean’s getting pretty.”

“It’s really coming along. I’m not sure Caspian will be inflated before you leave; when do you fly to Phobos?”

“May 15th; two sols after final exams are finished.”

“Three weeks from now. But trans-jovian injection is still two months away.”

“Nine weeks, but they want me up there to complete training.”

“And I’m sure there’s a lot of it.”

“Some certifications they want me to get or update before launch. Not too many, fortunately, since I get a lot of them to fly here on the *Wolf*. But they want the crew to bond, also.”

“You’ll be flying to Jupiter for a year; plenty of time to bond, then.”

“Yes, that’s true. They were pretty flexible, since I had to finish the semester.”

“I wish you could stay longer,” she said.

“I wish I could stay longer, too,” he replied. “But I’m going to Jupiter and you still may go to Earth, and we’ll both be back here in four or five years.”

“I’m not sure I’m ever going to Earth, actually. Dr. Park wants me to make the Ceres proposal into a Masters thesis and wants me to take graduate courses in economics next fall; I can take them online. By the time I can actually get to a graduate program on Earth, I’ll be half way through a doctorate, and I don’t need to be present to write a doctoral dissertation. Dr. Park

says I can get a doctorate in economics here through him and through a committee he can put together out of colleagues at Stanford and MIT.”

“Really? That’s good for you. No flying a hundred million kilometers, no relocation, no cultural adjustments.”

“Yes, it’ll be simpler. And there appear to be a lot of economics jobs here. Ours is the most computerized economy ever, and it’s small enough to collect statistics continuously in automated fashion. We don’t need to estimate unemployment or GDP via surveys; we can know it in considerable detail continuously. There are all sorts of research projects that can be done. Then there’s the emerging field of ‘mariner economics’; how to fund the settlement not just of Mars, but the entire solar system. And there’s solar system economics, models of a human economy spread among a dozen worlds. That’s a lot of possible work to do!”

“There is. I can’t see you modeling the Marsian economy by computer, though.”

“No, that’s not my thing, but mariner and solar economics are fascinating.”

“I’m interested in mariner and solar science, too. The Center for Asteroidal Research at Martech-Phobos is already planning a 2077 mission to a series of asteroids, and it’ll stop at Ceres as well. And in 2079, a year after the *Barnard* returns to Mars, it’ll set out on another asteroidal mission; we’re not sure where it’ll go yet. The Center plans to send out two caravels almost continually. It may even open a secondary center at Ceres; Ceres-Martech, I suppose, though there is no such branch yet. It has the advantage that asteroids are constantly passing by, so one can make a lot of short trips and visit a wide variety of places.”

“That’s true of Mars, too,” she noted. “But these long trips are very hard on families. Most of the personnel of the Center for Asteroidal Studies are young and unmarried, perpetual

bachelors and bachelorettes, or childless career couples. Don't you want to settle down and have a family?"

"Yes, I think I would. So I suppose I should get these long trips over now, then do short three to six month trips later."

"Three to six months," pondered Sirikit. "I think part of the problem Bill has with his parents is that they were so busy throughout his childhood. And Giovanni, the recluse . . . his father was running the store and the bank 24.6 hours per sol."

"He's the sole reason they say 95% of the first generation goes to college," said Charlie, chuckling.

She laughed. "He is the only one. But I don't know how people balance family and career. My mom and dad did a pretty good job. I guess your parents did, too."

"But you know how they did it? Mom insisted that Oskar and I go out in the field with them, and whenever dad went out, mom was there too, running the systems and watching us at the same time. And we're fine."

"Well, you guys got pretty heavy cosmic radiation dosages, I'm sure, and who knows what that'll do in the future. This is not Earth."

"No, and thank God it isn't. How many of us would have been robbed or murdered? How many of us kids would have had drug and alcohol problems? I'll stick to our problems, thank you."

"You have a good point."

Just then they entered Mediterranean. Unlike other enclosures, it did not have night curtains to keep in heat and block the view of the stars; it was so big, it retained plenty of heat. Phobos and Deimos were both up. The constellation Cygnus rode high in the northern sky,

pointing toward the north polar axis just below the northern horizon. The ground-facing lights illuminated the path, but left the sky dark enough so they could see it, so they stopped to look.

“It’s so beautiful,” said Sirikit.

“Are we destined to travel up there?”

“Well, you already have and you will again in two months. Me? I don’t know.”

“Why not? Callisto sounds really interesting and we’re going to more than double its size. Ceres is hot now and is growing. Titan would be interesting; in many ways, the Saturn system’s more interesting than Jupiter’s. In another decade, Venus will have an artificial moon and lots of radiation shielding. And Mars is fascinating, too.”

“Charlie, I’m an economist, remember? None of those places need economists, and certainly the ships don’t! Wicahpi-Luta and Esther may get married and apply for the Uranus mission together, and they’re perfect because he’s in geology and she’s in horticulture. I’m afraid I’m not destined to gallivant around the solar system.”

He sighed and turned to face her. “I suppose not. But . . . Sirikit, I love you.”

“I love you, too, Charlie.” She looked at him, a mix of love and frustration on her face. He leaned over and kissed her on the lips, startling her. Then she leaned toward him and kissed him back. He smiled, put his arms around her, slowly pulled her close, and kissed her on the lips, and she relaxed in his arms as he did so.

They separated. “Oh, Charlie, what are we going to do?” she said, almost pleading with him.

“I don’t know. We’re stuck.”

“I think so. It’s a cruel twist of fate.”

“We can wait for four years.”

“Maybe we should. I don’t know. We’re both just 20 years old. Pretty young for big decisions like marriage.”

“I suppose.” She looked across Mediterranean, a half kilometer wide before them, but she no longer wanted to cross it. “Let’s go back.”

“Okay.” He turned and put his arm around her shoulder; she put hers across his back and looped a finger in his belt loop. They walked back toward her room at her parent’s house and his dorm at Martech in silence.

7.

Making it Work

May 2074

Kim had never seen her daughter so glum. “You haven’t had practically any breakfast,” she said. “What’s wrong, Siri? You should be on top of the world, after your presentation yestersol afternoon!”

“I was; we all had a great time at the steak house. But . . . well, Charlie’s leaving for Phobos in three weeks and for Callisto in nine. And I can’t stand the thought of not being with him.” She looked down as tears came to her eyes.

“Oh, honey, I’m sorry.” Kim sat next to her and put an arm around her.

“Mom, he said he loved me, and I said I loved him, too. And . . . then we kissed.”

“That’s marvelous, dear. I’m so happy for you. To be in love is a great and glorious thing, and Charlie’s a good man. I feel your pain.”

“Mom, what do I do? It’s just so unfair. So unfair.” She put her head down and began to cry.

“Well, four years may seem like forever, but it really isn’t. It can pass quite quickly. And it’s a good chance to get to know each other better. Videomail isn’t as good as being together, but sometimes it’s safer on the feelings and allows you to explore your relationship in a more clear-headed way.”

“That’s true,” Sirikit said. “But relationships are not supposed to be clear-headed, it seems to me.”

“Sometimes, it’s useful, though.”

“Yes, I’m sure that’s true.” She smiled.

“Finish your tea and toast, at least. Don’t you have a class at 9?”

“Yes, I do. I have to get going. I have a lot of catching up to do because I put so much time into the project.”

“And the semester ends in two weeks. Just hang in there and concentrate on your remaining work. You can see Charlie in the evenings and talk more. Maybe he’ll stay; who knows.”

“Maybe.”

Charlie shoveled the omelet into his mouth. When he was upset, he ate. “So, what do I do?”

Wicahpi-Luta shook his head. “I don’t know. You could cancel. There will be other expeditions to asteroids. There will be a flight to Jupiter every other year.”

“But I don’t want to do that. This is such a ridiculous situation. But I love her, Wicahpi-Luta. I *love* her.”

“Esther and I love each other too, I think. We’ll probably get married after graduation.”

“Have you talked about it?”

“A little bit.”

“But you haven’t slept with her?”

“No; she’s quite proper. She feels she has to be. What about you and Sirikit?”

“No, not yet, and I doubt she’d be willing in the next three weeks. Four years . . . that’ll be torture.”

“I think you have to pull out of the expedition, then. What’s the Bible passage? It’s better to marry than to burn.”

“How do you know the Bible?”

“Esther quoted it to me.”

Charlie laughed. “Okay, I see.” He swallowed the last bit of egg. “I’ll call Firuz. He should be in the office pretty soon, since Phobos keeps the same time as Aurorae. Maybe he has some ideas.”

“Good idea. There’s always the 2076 expedition to the central and outer belt that the Center is planning, and there are expeditions to Mars-crossers almost every year. A three-month expedition departs for Gradivus in late July.”

“I know, but I’ll never get added to it at this late date.”

“You never know. Your dad got added to the first Gradivus expedition twenty-five years ago.”

“That’s true.” Charlie sighed. “Okay, I guess that’s the best thing to do.” He stood up and picked up his tray. “I’ll go call now.”

He put his tray on the belt leading into the kitchen and walked back to his room, where he had privacy. He closed the door and commanded his communicator to connect with Firuz Moulin. A few seconds later, Firuz’s face appeared on the screen. “Good morning, Charlie! How are you this sol?”

“I’m okay; I guess you could say I have good news and bad news. The good news is that Sirikit and I are in love and I want to marry her.”

“Wow, that’s great news! Congratulations!” said Firuz, surprised. “But it does put you in a difficult position. I suppose that’s the bad news.”

“Exactly. Firuz, what should I do? I guess I should drop out of the mission. There will be others, after all.”

“So, have you asked her to marry you?”

“Actually, no; not yet.”

“I’d start there! You don’t know for sure she’ll say yes, after all!”

“That’s true, but after our conversation last night, I’m pretty sure. But what do I do? Should I talk to Dr. Poirier? Can I still drop out?”

“You can drop out any time; we had someone cancel last week. We have a backup list. But maybe you should approach Jean Paul about adding Sirikit instead. The galleon was theoretically staffed at 86% max capacity; 125 instead of 150. That was done because there could be some births during the flight, even though people have been told not to start a family on the way to Jupiter, and because the mission is to last four years, which is a long time for the ships to remain at full capacity. She has space suit and zero gee certifications.”

“And microgravity; they’re all second class certifications, too. But she doesn’t have the safety certs, nor does she have certifications in any onboard tasks, like horticultural or systems engineering.”

“I think she can get the safety certifications before or right after launch, and she can get the others later. These vehicles are so highly automated, there’s actually very little that has to be done. Food is planted, raised, picked, and cooked robotically, except when people choose to do those tasks out of enjoyment or to prevent boredom.”

“But . . . what would she do on the mission?”

“I don’t know. Maybe she could do economics! The situation has changed a lot in the last decade, with automation of systems. You’d have to talk to Jean Paul, and maybe to Commander Cai; he may have final say, especially if the two of you wanted to live on the *Galileo* on the way out, rather than on the *Barnard*. Have you asked her about the possibility of going?”

“No, it never occurred to me she could go!”

“I’d pursue that. The door should be open.”

“Okay, thanks, Firuz! I’ll call Jean Paul. I really appreciate your advice!”

“Glad to help two friends. Let me know what happens.”

“Okay. Bye for now.” Charlie closed the line. He was vibrating with excitement. She could go along! But would she agree to it? He glanced at the chronometer; 8:45. They both had classes in 15 minutes. She would be coming from home, so he headed to her classroom, then followed her usual route to her parent’s place. He caught up to her just twenty meters from class.

She smiled at him as he approached. “Good morning.”

“Good morning, my love.” He said the last rather dramatically, or maybe it was romantically; he wasn’t sure. “I know you have class now, but I need to talk to you, really quick. Or maybe not so quick.” He took a deep breath. “I’m not sure where to start. I called Firuz Moulin and told him I wanted to marry you and drop out of the *Barnard’s* crew. He said he thought you could come along instead, and maybe even do economics. He’s right about crew duties; they’re light on the trip out and focus on geological training, with lots of seminars and other preparations.”

“Wait a minute; you said what?”

“Sirikit, will you marry me? I love you very much. I’ll stay here and skip this mission, if that’s what it takes. I don’t want to wait four years.”

“Oh, that’s so sweet; so romantic! But you’d drop the trip?”

“Yes, a four year trip is too long to be apart. There will be shorter three to six month trips. I think we could handle that.”

“Yes . . . but Firuz thought I could probably go to Callisto? Really? I don’t have the certifications and don’t have any certifications that would let me do anything on board.”

“He said he thought you could get them en route, but I think you could devote most of your time to economics anyway. Robots do most of the work nowadays. That’s even true of geological exploration; the main advantage of going is to reduce the delay caused by the slowness of the speed of light.”

“Well, we’d have to look into that. I wouldn’t want to be stuck washing dishes for four years. But I know that’s something that’s automated, too. This is . . . unbelievable.”

“You were planning to take a bunch of economics courses on Earth via distance learning, right?”

“Yes, and I could do that on board just as easily. I was planning to assist Dr. Park and I may not be able to do that so easily, nor could I participate in his face to face seminars so easily. But it might be possible.” She smiled at him. “And yes, I will marry you!”

“Thank you!” He hugged her and planted the biggest kiss on her lips he had ever tried.

She giggled. “I love you, Charlie. I’m still not sure what that word means, rationally at least, but I feel it. I love you.”

“And I love you too, Sirikit.” He kissed her again.

They remained in each other’s arms a long moment. She looked around, suddenly aware that they were in a very public space and friends would be walking by on their way to class.

“What are we going to do?” she asked.

“Let’s call Jean Paul Poirier and see whether we can get you on the flight. Then maybe we should tell our parents.”

“And I should talk to Dr. Park.”

“Okay. Come on.” He took her hand and they headed for his dorm room together, forgetting about their 9 a.m. classes. Sirikit set her pace so they put their right and left legs

forward at the same time, as if they were marching together. They nodded to a few acquaintances as they went. After they entered his room, he closed the door and kissed her again.

“Wait, wait a minute,” she replied, after kissing him back. “Let’s take a hold of ourselves for a minute. If we call Poirier now, we’ll come off as a pair of immature, love-crazed kids.”

Charlie hadn’t thought of that; he was love-crazed. “What do you suggest?”

“Let’s email him and ask for a time to talk to him in, say, two sols. I’m sure you don’t want to wait that long, but it’s probably better because we can figure out what certifications I don’t have, I can talk to Park and have a plan ready to propose, etc.”

“Good idea. I already talked to Firuz and he suggested I talk to Poirier. Maybe he’ll have some suggestions.”

“Exactly. We want to talk to Poirier prepared to convince him to say yes, not to give him reasons to say no. I certainly need to clear my head about all this. This is about more than hormones; this is a lifetime we’re talking about.”

“You’re right,” he said, trying not to sound disappointed.

“I don’t want to become a nag from the start, but we do need to think about this and plan. Departure for Jupiter is when; June 27? We have to finish the semester, write a few final papers and exams, squeeze a wedding in, and get to Phobos in time for me to complete some certifications, all in a bit over eight weeks! You were planning to fly up on May 15. If we push that back to about June 1, we’ll have a month to plan and hold a wedding.”

“No time for a honeymoon, though.”

“We have to squeeze that in, too. I have to take some extra medical tests, also. At some point soon, we have to make a list of tasks.”

“You’re right. I’m not trying to be impractical, I’m just excited.”

“I can see that.” She leaned over and they kissed again. “So am I. Let’s forget about classes; neither one of us would be able to pay attention anyway! Let’s see whether we can have lunch with my mom and dad, and maybe we can have dinner with your grandfather and Kristoff and family. As you know, for Bahá’ís, this is a union of families as well as of individuals.”

“Yes, I know.” He was aware that Bahá’ís had to have permission from their parents to get married.

“Then let’s go walk and talk. And kiss. We need to make some plans.”

It was, Charlie reflected afterward, an “interesting” lunch. Ananda and Kim both had busy days at their respective work places and had little time, nor were they sure what to say. Liking Charlie and being willing to give permission for their daughter to marry him, after knowing him only six months—with the possibility she’d leave for Jupiter in two months—were different things. It was a pleasant enough lunch, but they said they needed a sol to talk about it in more depth together, and with Sirikit.

In contrast, supper with Sebastian, Kristoff, Irma, and the kids, was joyous. They had no permission to give; Charlie was already going to Jupiter and maybe this meant he’d be back; they liked Sirikit; they wanted to be supportive. Slightly more ominous was the fact that after taping a videomail to Helmut and Clara, they heard nothing that night.

The next morning, however, all four parents signified their permission. After lunch—they went to class that morning, unlike the sol before—they videomailed Xiaopeng Cai and Jean Paul Poirier formally asking for permission for Sirikit to join the mission. Both commanders were on Phobos and sat next to each other in Xiaoping’s office the next afternoon for the video interview.

“It’s good to see both of you,” Xiaopeng began. “I hesitate to mention this, but I arrived on the same flight as your father, Sirikit. That was one flight after your mother arrived and one flight before Charlie’s dad arrived. It’s strange interviewing someone for a mission who grew up before my eyes, and makes it difficult for me to feel that I’m being impartial and fair. This is made even more complicated by your certifications and other credentials. The latter are very impressive for the field they represent; the former, rather meager for a four year mission to Jupiter and back. I understand this is not an ordinary application to join a mission; you aren’t arguing you have something unique to the mission that compels us to accept you, like most of the others, but that you want to accompany your husband on his inaugural flight. By the way, have you set a wedding date? I assume you have all the permissions you need?”

“Yes, all four parents have given permission, and we have set the wedding date, tentatively, as Saturisol, May 26,” replied Sirikit. “That means we will be flying to Phobos on Frisol, June 3.”

“That cuts it close,” said Xiaopeng, looking at Jean Paul, who nodded in agreement. “But it would work, considering the circumstances. As you know, the *Galileo*, the *Gan De*, and the *Barnard* will have 185 adults and 6 children on board. The flight from Mars through the asteroid belt to Jupiter will take a year, as will the return flight, with no possibility of rescue or help en route. Our stay in the jovian system will last two years and seven months and the situation there will be better in that Callisto will provide us shelter and resources, plus it has a caravel already and will probably receive a Chinese galleon a year before we depart. But the *Barnard* will be making a series of trips to the jovian moons that will last as much as four to six months, and during that period of time, the two of you often will be separated, since presumably you’ll stay on Callisto. There’s the potential that either or both of you could get killed in an accident; there

are so many possible accidents that could occur, I can't begin to list them all. You understand that?"

Sirikit nodded. "Yes, I understand it."

"Good. I'm sure you knew that, but I have to mention it anyway. The chance of a serious accident is rated at 'one percent or less' by the safety board, but that statistic must be remembered at all times. All of us have an obligation to each other to reduce that chance as much as possible, and that means constant training and vigilance. You are willing to undergo constant training and increase the number of certifications you have throughout the flight?"

"Yes, certainly. I understand that that is the culture of the mission."

"Exactly right. We are already a community—I can't say *will be* because most of us are on Phobos already, and have been since January, living in our quarters, familiarizing ourselves with the vehicles, upgrading and repairing them, and working together in teams to solve problems or test each other's readiness. Are you prepared to become an active part of our community?"

"Yes, I understand that missions work exactly the way you describe, as entire communities of people setting out together to accomplish something as a group. It's a very exciting, unifying, rewarding community to serve in."

"It is indeed, but until you experience it, you can only understand it in abstract. I mean no offense. Charlie can agree with me about this, I suspect."

"Yes, I know what you mean. I grew up on Ceres in exactly such a community."

"Good. All this is the setting for my question: what will you bring to our community, Sirikit, other than being Charlie's wife?"

That surprised her; she wasn't prepared to answer that question. "There are things I can contribute to the Galileo mission and things I can contribute to space exploration in general," she replied. "Regarding the latter, I want to become an economist specializing in solar system economics; mariner economics, shall we say. I can't become a mariner economist without understanding what it means to be a mariner, and Mars only tells part of the story. The rest of the story involves the communities on Callisto, Ceres, Titan, Venus, Mercury, and soon in the Uranus system. By participating in this mission, being part of this community, my ability to become a mariner economist is greatly enhanced. As for contributing specifically to this community, I am not deeply aware of the community's needs and resources. But I know how to build unity, how to bring people together, and that's something I can focus on."

"How would you do that?"

"You bring people together through common activities. Food, classes, and cultural activities are all ways to do this. I'm not a great cook, but I want to bring people together through hospitality when I can. I play the violin and could organize musical events."

"We could use a director of arts and culture," said Xiaopeng. "We had someone who had agreed to do it, but then he pulled out. We were going to try forming a committee instead. Could you do that?"

"How much time will it leave me to pursue graduate seminars and research in economics?"

"All of us will be in school and all of us will have duties on board, so you won't be any different from the rest of us."

"Then yes, definitely, that's something I could do."

“Another possibility is running our store. It won’t take much time because these things are automated nowadays.”

Sirikit nodded. “That’s a possibility, too.”

Xiaopeng smiled. “Good. I suggest you spend a sol or two with Liz Elliott Tobin before you fly to Phobos and find out what the Aurorae Center for the Arts does. As you may know, when this mission arrives at Callisto, it will more than triple the outpost’s population, which now stands at 81. We are bringing a branch of Martech with us as well as a public school, a store, and a center for arts and culture. In short, we are already functioning like an outpost, even though we are still sitting on Phobos. We’ll also bring elections with us; after we arrive we will hold an election for Executive and an outpost Council of 4 others, and we will invite the current Callisto crew to join us in the election. In short, our goal is to normalize the situation on Callisto, so that it functions just like the mariner communities on Mercury, Ceres, and Titan. As you said, there is an emerging mariner culture, and Callisto is joining it. So if you want to experience it, this is the mission for you!”

“Thank you,” said Sirikit. “I do want to join it, and it sounds like I will have some interesting contributions to make.”

“I’m sure you will. So, assuming you pass the psychological tests, which I suppose you will, we’ll see both of you up here on June 3. After the launch and everyone gets to know you, we’ll plan a little wedding reception, too. It may be the only social event of the trip you won’t plan.”

“Alright, we’ll look forward to it,” said Sirikit.

“Excellent,” said Xiaopeng. “By the way, the pay grade for someone with a Bachelor’s degree only on a flight is Commonwealth Service Grade 4, step 1.”

“Thanks,” she replied.

“You’ll both be quartered on the *Galileo*,” added Jean Paul. “We’re putting just about everyone there for the duration of the voyage because the radiation shielding’s the best; the other two vehicles will provide work space and hydroponics. We’re looking forward to seeing you in five weeks.”

“Thank you,” said Charlie. “We’re looking forward to being part of this historic mission.”

“Until then,” said Xiaopeng. “Bye.”

“Bye,” replied Sirikit and Charlie. Then the screen went blank.

“There; it’s done. You’re a member of the crew. Congratulations.” Charlie leaned over and kissed her.

“Thanks. Director of Arts and Culture and store manager: I never expected that!”

“No free ride. We should have expected something like that.”

“I suppose. But it sounds like I’ll have time to pursue graduate school, maybe slowly. Dr. Park and I talked this morning after class for fifteen minutes. He thinks we can manage the distance fine. He may even have me serve as teaching assistant for a few courses.”

“Really? Great. So: we’re getting married in five weeks and heading to Phobos in six, then to Callisto in eight!”

“It’s unbelievable. It’ll be a whirlwind.”

He leaned close. “Let’s celebrate.” He reached to hug her and kiss her. They were in his bedroom and she saw where he was going.

“Charlie, just a second.” She let him kiss her, then pulled back. “Look, let’s get something straight. I want to wait for sex until we’re married. That’s the Bahá’í standard. It’s not like something terrible will happen if we have sex now; no lightning bolts will strike. It’s what

we are called on to do by Bahá'u'lláh. It's part of our behavioral standard; part of the restraint and self-control we're called on to exercise as adults. That restraint and self-control has other benefits; it makes us better people, gives us better judgment, makes us more mature. We don't condemn others for violating our standards, not even other Bahá'ís. But I ask you to respect the standard and wait. It's just a few weeks."

He was surprised by the tone of calm in her voice. "I . . . I see." He leaned back, away from her. "Alright, I see what you're saying. I can't say I'm happy about it, but I can respect it, because I love you."

"Thank you. And you can always kiss me." She leaned over and kissed him. "I love you, too. I think we'll have a great marriage together, we'll be great partners for each other, and in about five years we'll start a family together here on Mars. That'll be quite an adventure."

"It will. Going to Callisto together; that'll be quite an adventure, too."

"Yes, it will, and I'm looking forward to it."

8.

Whirlwind

May 2074

“I really appreciate you taking some time out of what must be a crazy schedule to come meet with me,” Will Elliott said to Sirikit, as she entered his office at Martech. “Let me pour you some marjeeling tea.”

“Oh, there’s no need to bother yourself, I can pour it.”

“No bother! It’s hospitality, is it not? I hear Jacquie has one of those fancy new robotic systems hooked into her personal assistant that remembers every cup you’ve had with her and makes exactly the same thing for you again. But I can remember that and do it myself. Milk? Sugar?”

“Just milk, please.”

“Milk; alright. Now I have to remember that for five years, because it’ll be that long before you return from Jupiter!” He pointed to a chair; she sat, and he sat opposite her in a comfortable section of his large office. “So, graduation, marriage, a flight to Callisto: and two of those are new decisions. Surprises.”

“Not just for me! My parents were shocked!”

“I bet they were. But you are continuing in economics, right?”

“Oh, definitely, in fact I’m trying to convert this into a useful experience for my future service. We need to think about ‘mariner economics’ and this will make me a ‘mariner.’”

“Indeed it will. I like that idea. We need to start thinking solar-system wide, not just Mars-wide. Your proposal for the other settlements to invest in Cererian mining was brilliant in

that respect. It won't solve the problem, but will lay a financial foundation under them, and that helps. Otherwise Mars would have to pay for almost everything." He sighed at that thought.

"Yes; Earth appears to be retreating back into a major recession, and the infighting over the shrinking pie is particularly fierce."

"Exactly. I received a videomail from my friend, President Bart Mennea, yestersol. We really are friends from Earth; he was an undergraduate at Brown University while I was in graduate school there, and we served on an interfaith committee together. While I was Chief Minister we didn't write much, but now that I'm retired he seems to feel freer to write, and I feel freer as well. I wanted to ask you about the concept of 'Commonwealth.' The economists don't talk about it much; it's an old word that has been emptied of any real meaning, nowadays. "

"Commonwealth: No, Dr. Park has never talked about it in economic terms. But I suppose it fits Mars pretty well. We haven't paid the term mere lip service."

"Yes, that's right. I'm sorry Hun-jai doesn't embrace or discuss the word. I'm planning to write a series of essays about it; I'm hoping to get the Center for Values here at Martech to hold conferences, sponsor lectures, and publish papers about it. I think it's a key ethical notion, where economics is concerned, because the term underlines the common prosperity we must strive to achieve. I was the one pushing for Mars to be a 'Commonwealth.' It had political uses, too, because it was ambiguous where sovereignty was concerned; Massachusetts, Virginia, Kentucky, and Pennsylvania are states within a nation that call themselves commonwealths. Then there's the old British commonwealth, which is just a loose association of states. When we adopted the term Commonwealth of Mars, no one was sure what it meant, so they couldn't oppose it! But what it *really* means to me is the creation of an authority that looks out for the common good.

The term, by the way, is often used in the authoritative Bahá'í texts to refer to the future state of humanity; they often use the phrase 'world commonwealth.'"

"Really? It has utopian connotations, one might say."

"Absolutely. But what are some of the characteristics of a 'commonwealth' from an economic point of view?"

Sirikit frowned and began to think. "I suppose, one aspect is the reduction of the extremes of wealth and poverty. And I suppose we have achieved that up here; the salary range from richest to poorest is maybe ten or fifteen to one, rather than a thousand to one. It's quite interesting to note that the 'Commonwealth Service Schedule' is used by almost everyone to determine salaries, even private companies."

"Yes, that is fascinating, isn't it! Martech uses it, Mariner Hospital uses it, all the semi-public companies like Marfab and Margen and Marcraft use it, but so do the gold and PGM mining companies; they just advance everyone three grades to 'flight pay' status because of the stress and danger."

"Even Deseret and Maryam Salih Fashions use it. But with very small companies it also provides an excuse for relatively high executive salaries, since the CEO awards himself a Grade 15, Step 10 salary! And that reduces the company's profit, which also affects workers, since most companies offer profit sharing. But overall, we have a fairly flat income scale."

"That's partly historic; highly trained professionals sacrificed to come here, the costs of living are very high, and once they were paid there wasn't much left over! It partly reflects our small size, too. When there are tens of millions here, we'll have billionaires. Actually, we're not far from that already, because the people who stay decades and invest in land and mining

company stocks end up pretty wealthy. And we need that, too; we need people willing to endow educational and cultural institutions.”

“That’s true, but if there’s one complaint everyone has, it’s that it is hard to start and grow small businesses. The percent of our GDP that comes from small businesses is much smaller than most terrestrial nations.”

Will nodded. “We’ve tried a lot of different incentives, too. Robotization is helping; a couple can easily open and run a restaurant without hiring any help, for example. Until recently, the business environment was too uncertain. But as we grow, that will stabilize.”

“What are you planning to focus on, in your essays on commonwealth?”

“I want to question the idea that selfishness is good for an economy. The key idea behind the term ‘commonwealth’ is a community established for the common good. Theoretically, all democracies are founded for that reason. Several countries, notably Australia, still include the term in their official names. This idea of the common good resonates with a number of Bahá’í principles, including justice and unity in diversity. Now that I am retired, I can make some useful contributions to public discourse.”

“And you have been. I follow everything you write.”

“Thank you. Now that I’m no longer in charge of anything, it’s the only thing I can do. I think my emails to President Mennea may have influenced a few of his policies, or maybe I’m just fooling myself. I’m also concerned about things up here. There’s now some talk of revising the Commonwealth Service Schedule to make the pay of grades 12-15 higher, or adding five more grades. I don’t see the need; if anything, we want companies to feel public pressure to use the system, not for them to exceed the pay grades and the Commonwealth government to feel pressure to compete. I’m also fascinated by this idea of ‘mariners’; I was glad to hear you use the

term. I want to see mariner identity to develop, and Mars to be at the center of it. The alternative is to have all sorts of notions of greed, self-advancement, and competition spread across the solar system and strengthened here on Mars. We can't eliminate those attitudes—I don't think we should—but the culture here on Mars has successfully balanced them with communal attitudes. The smaller settlements scattered across the solar system are natural homes for communal approaches to problems, homes of self-sacrifice and serving others."

"And there are millions of people who yearn for those ideals," added Sirikit.

"Absolutely. Look who's emigrating to Mars! They want to be part of a project bigger than themselves; they want to make a contribution. It's rather like a revolution. But maintaining that revolutionary attitude; that's the hard part. Anyway, I'm rambling."

"No, not at all. If I may ask, how are you going to vote in the next few sols?"

Will smiled. "Yes, the Mars Council's last session is coming up. I think the legislation modifying the representation of the various boroughs has undergone some excellent revisions and I will support it. Everyone has agreed that Ceres needs to be able to be represented remotely and for its representatives to vote remotely, so that legislation will pass, and I'll support it. The alcohol and marijuana laws are much tougher to decide, ethically. I don't think we need more votes or more time to use them, but very few people go outside now, the culture here is changing, and the people seem to be in favor of both changes. I don't know what I'll do yet. Pray about it, I guess."

"That's a tough one. At least the politicking here isn't too bad."

"Yes, no political parties, and most legislators want to do what is right; they don't want to cut back room deals so much. So, how are you going to run the cultural center on the *Galileo*?"

“I don’t know. I just finished final exams last week and then took all the medical and psychological tests; that’s been a long and rather unpleasant ordeal! I did talk to Liz the other sol and she had some ideas.”

“Good, but my suggestion would be for you to call Madhu Anderson, because she ran the cultural and artistic activities here at Aurorae when it was about the same size as the mission. She’ll have ideas from that time, and they may be more practical.”

“Oh, that’s a good suggestion! She’s in Thaumasia; I’ll videocall her.”

“Definitely, I’d do that.”

“When’s daddy coming home, nana?” asked little Victor Anderson, who was 4.

“Very soon, dear,” replied Madhu. “Let’s walk through the B-75 a little farther. Maybe we’ll see him.”

“Okay,” agreed Vic. They had walked part way down its 75-meter length, past the wheat and into the corn, which wrapped them in a green blanket and hid the Martian landscape outside the bubble’s transparent plastic walls. When they exited from the corn they entered a section of tomatoes, some plants of which were three meters tall; the eolian dust and crushed rock they were growing in was particularly rich.

They stopped at the end of the bubble and Vic put his hands on the cold plastic that separated him from a quick death in the cold, suffocating air of Mars. He looked at the other B-75 next to them, then at the humps of the buried Quonsets. “Which way will they come from?”

“The road from Aurorae is over there.” Madhu pointed straight out in front of them, due east, where the ground was disturbed by frequent traffic. “They should be along any minute, based on the call your daddy made.”

“Is that them?” said Vic suddenly, pointing to a cloud of dust on the eastern horizon.

“Yes, I think it is!” Madhu drew close to Vic and they watched a gap in the jagged crater rim. A minute later a truck topped the rise and slowly descended into the crater pulling a new Quonset behind it. A second Quonset followed the first, then another truck with two more Quonsets attached to it. Altogether, four trucks and eight Quonsets entered Apgar crater, raising quite a cloud of dust.

Vic began to jump up and down in excitement. “Wow! It’s like a parade!”

“Your dad is coming with the dome builders; 80 of them altogether. Thaumasia is doubling in population.”

“And they’re bringing more bubbles?”

“No, they’re going to enclose ground; don’t worry, we’ll come out here every day and watch. We’re going to have big, big places to walk around in, with trees and grass and flowers. It’ll be beautiful.”

“Nana, why can’t trees grow outside?”

“It’s too cold outside, and there isn’t enough air.”

They watched the first truck back a Quonset up against one of the outpost’s two chains of Quonsets; Thaumasia now consisted of four rows of five or six Quonsets each. The arrivals were in the Quonsets waiting for the airlocks to be docked against the outpost, but some, wearing pressure suits, were coming out and walking to the outpost’s main airlock complex. Vic was getting bored, so Madhu led him back inside. When they reached the dining hall, it was already filled with people greeting and talking. Sam had come in through the first docked Quonset and was there. “Daddy!” exclaimed Vic, dashing to his father, whom he had missed quite badly over the last two weeks.

“Hey, Vickie!” Sam replied, catching the little boy up into the air, something nearly effortless in Martian gravity. “How are you?”

“I missed you!”

“I missed you, too.” He kissed his son and hugged him close, then put him down. “Have you been playing in the B-75s? Aren’t they fun?”

“It’s so nice to go outside!”

Sam laughed at that. “Wait until these guys build us a really big outside.” He pointed to the newly arrived crew gradually accumulating in the dining hall. “Then we’ll add even more miners and start trucking all sorts of good stuff back to Aurorae.” Sam turned to his mother. “Has he been good?”

“Oh, yes. He and Neal have been having a lot of fun running around the outpost and especially the corn patch in B-75A.”

“We can play hide and seek there!” added Vic.

“That would be fun,” agreed Sam.

“So, how was the closing of the Mars Council?” asked Madhu.

“It went well. Did you hear that the legislation about attendance at the Council meetings was modified to say that anyone representing a surface borough that lacked air connections could vote by video link? That should help me.”

“Yes, I heard. It strikes me as a bit absurd, though, that Thaumasia will have two representatives, even though it has less than 150 people!”

Sam shrugged. “That’s the legislative formula. We won’t get a third representative until our population hits 493, based on Mars’s current population.”

“So, Will voted against legalizing marijuana.”

Sam chuckled. “Yes, as did a dozen other representatives, all of whom were fairly religious. It was one of the few times there was a noticeable divide between the religious and the nonreligious on the Council. I have to admit, the argument that we have enough vices is probably true, but I’m told the marijuana being grown up here is *really* good. I’ll have to try it some Saturdays.”

“Not here; you’re Commander, you can’t afford to be stoned! I was surprised about the last minute modification of the legislation about alcohol consumption.”

Sam laughed at that. “That was classic Will Elliott! The wise compromise that got him off the hook: let each outpost set its own hours when alcohol is allowed. That makes a lot of sense here, because almost everyone here goes outside several times per week, so we have to restrict the hours of alcohol use a lot more than Aurorae does.”

“I’m surprised no one thought of that earlier in the debate. I’m impressed that Jacquie Collins managed this legislative session so well. She proposed some bold moves, explained them, built support for them, and got them passed.”

“She was the central organizer of the Mars Council before being elected Chief Minister, so she knows how to do it. I very much agree. The plan to spend a billion redbucks over the next four years to expand Martech to a world-class research university is very exciting and timely; we can do it now, but couldn’t have earlier. The plans to expand the human presence across the solar system are also very innovative. And the Commonwealth is joining the United Nations! I think that’s exciting.”

“Yes, it’s about time,” agreed Madhu. “How did your meeting with her go?”

Sam nodded. “Reasonably well. Thaumasia’s level of support is continuing; once the construction workers leave, it appears we’ll be able to maintain employment at about 140. The

Overland Uplift has so many possible mineral resources, we should be profitable long term. It also looks like we'll get priority for metalling the road, because we're not that far off the Uzboi Highway, and because we export a lot of bulk ores, it'll be cheaper to move them on the lower friction metal roads." He looked around. "I had better find Mindy and talk to her, then I need to plan my remarks at the welcoming dinner tonight. Say, mom, let me introduce you to someone." Sam looked around, then called, "Hey, Giovanni!" He beckoned the man over.

A young, bearded man approached. Madhu looked at him and frowned; he looked familiar. Then she smiled. "Giovanni DePonte! How are you! What brings you here?"

"You recognized me! I'm surprised. I'm here to do construction; I had a job in Thymiamata mining gold, but the contract ran out and I thought I'd try something new."

"Fantastic! Well, welcome. I don't think I've seen you for several years!"

"Probably not. My path, shall we say, has been different from anyone else's in my generation. I didn't go to Martech and become a geek. I've been doing mining, surface geology, and construction ever since I graduated from high school five years ago. I love to do stuff with my hands and I like independence. Surface geology has been the most fun, though it earned the least."

"And where do you lay your hat? Do you have an apartment somewhere?"

"No, I haven't bought anything because I've been moving around. This is my fourth borough since high school. Sometimes I stay with mom and dad in Aurorae, but I haven't even seen much of them, lately."

"Well, next time you talk to them, say hello for me. I miss Aurorae and my friends there. I've been here now four months and I love it, but it is rather slow and quiet."

"I saw your artwork on the side of the crater rim, while driving in!"

She smiled. “A simple multicolored stone mosaic. It was fun to make. Everyone and every place need the arts.”

“Oh, I agree; I love to look at things like that.”

“So, what do these arrivals think of you? You’re experienced; a real native.”

Giovanni smiled. “Sometimes I’m exotic; other times they treat me like an old man, even though I’m several years younger than most of them! It’s fun. I’ve been tempted to make up all sorts of stories about ghosts out on the range!”

She laughed. “Yes, I’ve heard a few of those. It’s funny hearing someone repeat one of those stories as if it were a real event!”

“This bunch is hard to fool; construction engineers are tough. Rather like miners!”

“Well, we have a few of them here, too. Sometimes I think I’m the grandma of an entire nineteenth century American wild west town! But they’re good, sweet men and women.”

He nodded. “Yes, they are.”

Madhu felt her communicator vibrate in her pocket. She pulled it out; it was another message from Sirikit. “It’s good to see you, Giovanni, and I look forward to talking more and meeting your friends,” she said. “I should respond to this right now, though. I’m helping a friend with an artistic and cultural project.”

“Good luck with that, then,” replied Giovanni.

Madhu walked out of the cafeteria and into the hallway for privacy. Sirikit had sent a list of items she was ordering for the flight. Madhu scanned it, then dictated a text message in reply. “This is a great start, but I would think in terms of five years, not one; the whole mission and not just the flight to Callisto. I doubt Callisto has some of these supplies or the ability to make them. Maybe the synthesizer guys can make paint at Callisto, maybe even on the flight; you should

check, because the painting of murals is one of the simplest art projects to organize. I see you want to include 25 kilograms of clay for pottery and other projects; I'd make it 100 kilograms, even 200 kilograms. They are popular projects, especially for kids, and might have other uses as well. Don't let the commander talk you out of ordering at least a hundred kilos of clay. They are bringing about a tonne of water, carbon dioxide, nitrogen, and supplies per person on the flight; a hundred kilos of clay reduces the volatile inventory by less than one part in a thousand. You can probably get colored pieces of plastic made during the flight, and it sounds like the flight will include plant matter that can be used to make a variety of types of paper, so those are easy art projects to do. But I would concentrate on organizing concerts, talent shows, and plays, because those can involve just about all the adults. We have never done enough cultural events here on Mars. If you check the cvs of the people on the flight, I think you will see that quite a few of them play musical instruments or have participated in theater. Good luck and let me know what else I can do. Bye."

Madhu sent the text. It flew to areosynchronous satellite 2, hovering in space between the orbits of Phobos and Deimos, then back down to Aurorae, where Sirikit's communicator beeped a tenth of a second later. She pulled it out of her pocket, read the message, and dictated a response. "Thanks, Madhu," she replied. "This is very helpful. I'll ask Commander Cai about increasing the amount of clay. He's been pretty cooperative, so far, probably because of the generous volatile allowances, and because Phobos has plenty of liquid hydrogen propellant to sell. I'll ask about the possibilities for making art supplies en route; I already have a call into the fabrication department, but we haven't actually talked yet. I have the database of artistic and cultural skills, and you're right, the crew has a lot of talent. I'll call you again if I have other questions. Bye." She checked the transcription and sent the message.

“You’re really getting into the cultural director job,” said Charlie. He was sitting next to her on the couch in the Thanarat’s living room. They were hanging out there most of the time, now that the semester was over and Charlie had given up his dorm room for a bedroom in his grandfather’s house.

“Yes, I’m going to enjoy it. At first I thought the store would be interesting, because it relates to economics, and it will be good experience. But it actually won’t take too much time because it has very powerful inventory software. I will have to learn accounting, though, and I guess that’s practical and useful. The cultural director job gets to something that’s dear to the heart of any Bahá’í: unity. It’s a really important opportunity to build unity on the mission. We need concerts, plays, lectures, debates, cultural evenings, art contests, all sorts of art classes . . . the possibilities are endless.”

“The flight will be boring, too. On the *Wolf* we spent nearly all our spare time—maintenance took us only two hours per sol each, on average—in seminars. We rotated the task of presenting and ninety percent of the seminars were on geological subjects, but we did have seminars on how to invest in stocks and one in how to scale a cliff—we actually built a six-meter cliff inside the ship! Firuz occasionally gave classes on the world’s religions, too. He was our spiritual director, you might say.”

“Really? I’ll have to ask him whether he wants to do something like that on our flight.”

“The cultural director could also plan interfaith services and such.”

“Yes, that’s true. Good idea. I’ll have to ask everyone who else wants to be involved in that effort.”

“I . . . I could help a little,” said Charlie. “I can’t say that I have a particular affiliation. I’m not even sure if I have an interest. But I guess I have a curiosity.”

Sirikit beamed at that. “That’d be great. I think you’re a very . . . spiritual person, Charlie.”

“Spiritual?” He laughed.

“Yes, spiritual. Spiritual values, ultimately, are human values; things that bring people together and make them better and more human. And you seem to have a deep interest or affinity for that.”

He smiled. “I suppose I do. I’ve never thought of it that way before.”

“It’s one of the reasons I love you.” She leaned over and kissed him.

“What are those geese doing now?” asked Yuri Severin, interrupting his own sentence. He leaned forward to look out the big windows facing “Titanus Lacus,” as the big fresh water pond at Acheron Outpost was called. Two ganders were honking loudly at each other in a confrontation over a female.

The entire Saturn Council stopped their deliberations to watch. “This would be a bad time to go outside and walk along the shores of the lacus,” noted Sridhar Prathan. “Those guys will go after you, and in this low gravity and thick air, their wings give them quite an advantage!”

“They haven’t bothered the swimmers, though,” said Shiyoko Takashima. “Even the kids. They seem to have learned to stay away from the swimming beach.”

“They have,” agreed Yuri. “But we need to be careful; we wouldn’t want them to put out a kid’s eye. I think we should move them to bioarchive-3.”

“I suppose,” said Sridhar. “It’s a shame, really. We’re meeting here in the pavilion so we can enjoy nature while we deliberate. We’re enjoying an artificial nature, and I guess it isn’t artificial enough; the geese have to go!”

“That’s a valid point,” agreed Yuri. “But what if one of the beasties attacked a child?”

“Can we possibly program a robot to keep the geese away from the swimming area?” asked Marshall.

“Probably,” replied Andries Underwood. “I can see two funny looking headlines: ‘Child on Titan Safe from Cryogenic Cold, but not from Geese’ and ‘Titan Astronauts Reprogram Robots to Keep the Geese Away.’”

The five of them laughed at that. “I prefer the second headline,” said Yuri. “Sridhar, can you look into it?”

“Sure.” Sridhar made a note on his tablet; he was in charge of infrastructure.

Yuri looked out over the S-3 enclosure one more time. One gander had chased the other to the far end, some seventy meters away, so their honking was fainter. The lacus itself glowed from the lights set underwater to maximize biological productivity; they harvested 500 kilograms of fish from the water body every month. The shore was lined by productive marshes, except where there was the swimming beach, and behind the marshes was a thin screen of tropical trees, with vines climbing high up the enclosure’s stainless nickel-steel sides. It was indeed a lush, beautiful place.

“So, Ceres,” said Andries, reminding Yuri of the subject at hand.

“Yes; sorry, I was admiring about our bubble of Earth here. I know it’s late; this is the last topic I was hoping we could discuss. Of course, the proposal to invest in PGM production on Ceres is a matter for the Commissioner, not the Executive, and the Commissioner does not have to bring his business to the Council. But I’d like your thoughts informally. This is a much more complicated idea than it looks. The technology is probably straightforward and the probability of success is very high. But the politics are not so simple. I’ll try to describe the basic problem

quickly. Mars wants the Saturn Commission to invest in Ceres PGM, nickel, and cobalt production and in return receive a proportional share of the profits. But the Saturn Commission has no money itself, so where can it get money to invest in Ceres? Its largest donor is the Commonwealth of Mars, and they don't want to give anything for the Commission's investment! So then we turn to the other nations, and what do they say? 'Why should we contribute if Mars doesn't?'! They view this partly as a way for Mars to acquire investment capital from them to expand its own influence in the solar system, so they're hesitant."

"But Mercury has committed," noted Marshall.

"Yes," agreed Yuri. "Because they want access to the technology. The Europeans have agreed to invest an extra 224 million redbacks per year for five years in Ceres in the hopes that they will be able to reduce their Mercury commitment permanently once Ceres starts to produce. That's another danger: we could invest in Ceres and end up with a smaller annual subsidy from governments."

"It's very hard to predict the profitability," agreed Sridhar. "I've looked at the proposal. Technologically, it's very clever, but it's unpredictable how much shipping costs will be reduced by it."

"And you never know what the sales price of the exports will be," added Andries. "So you have two unknowns: the cost of the production and transportation, and the income from the sale. That's pretty worrisome."

"Too worrisome to get bank loans?" asked Marshall.

"Yuri nodded. "Almost certainly, except maybe from Marsian banks."

"So, which Commissions are investing?" asked Marshall. "What about Venus? They need a steady income pretty badly!"

Yuri shook his head. “They also have Project Aeneas. The Europeans, Russians, and Indians have committed several billion redbacks over the next decade to round up small Venus-crossers and move them to an orbit around Venus to build a permanent moon for the Magellan station there. No one will invest in a second project for the Venus Commission right now.”

“What about the Asteroid Commission?” asked Andries.

“They’re enthusiastic, of course, and see Ceres as the source of income for exploring the entire Belt. Mars is putting its investment in through them at the moment and they have gotten Australia to commit several hundred million redbacks over the next decade. But that’s sucking up the oxygen for the rest of us.”

“And I’m sure the Jupiter Commission isn’t investing,” said Andries. “They’re torn by national rivalries.”

“If anything, Mars may put into Ceres on the Jupiter Commission’s behalf to dilute the influence of the Americans and Chinese and dampen down their fights,” said Yuri. “The Saturn Commission doesn’t have fights of that sort, so we won’t draw Marsian support; not for a while, anyway.”

“And Uranus isn’t investing,” noted Marshall. “Because they’re focusing on getting people to Uranus.”

“Exactly.”

“They’re looking for investment in Helium 3 harvesting instead,” said Sridhar.

“Commercialization of Helium 3 fusion has just started and lunar Helium 3 is very expensive, but theoretically Uranus is the cheapest source in the solar system.”

“Of course, we can produce it, too!” said Sridhar. “So we need to get involved in that effort as well.”

“Money,” replied Yuri. “We don’t have it. Ironically, one of the problems is that we are the largest outpost off Mars. We’ve had our growth spurt and now we can’t get the money to continue it.”

“But you have repeatedly suggested that Mars hasn’t closed the door to investing in Ceres on our behalf,” exclaimed Marshall. “I think we need to push them to make at least a small annual investment commitment on our behalf, and work to get matching contributions from terrestrial governments. Earth has a *lot* of money.”

Yuri nodded. “It does, but it is also pursued by thousands of lobbyists. I agree with you; that’s the way forward.”

“I can call my contacts in the Indian space agency,” promised Sridhar. “India has more disposable income than just about anyone now, since it came through the war intact and it has a relatively small elderly population.”

“Good. Andries, Shiyoko, how are your contacts in South Africa and Japan?”

“I’ll see what I can do,” said Andries.

“Japan isn’t likely to do much, but I’ll try,” added Shiyoko.

Yuri turned to Marshall. “Should we get your dad involved?”

Marshall nodded. “Yes, I think we should approach him. I’ll call him.”

“Good. Let’s put together some talking points. I think our approach should be that we need to diversify our income sources and Ceres is an important part of that strategy. We aren’t seeking to replace terrestrial and Marsian support, but supplement them.”

“That makes sense,” said Marshall. “We need to pursue government guarantees of bank loans, too. That will cost governments much less and get us the cash to invest. The report talks about that source, too.”

“Good point; I’ll remind our representatives on Earth and Mars. If the Marsian ambassadors got involved, they could help a lot.”

“I’ll mention that to dad, too,” said Marshall.

It was a beautiful wedding.

The stereotypical phrase was repeated over and over. After a brief devotional program in the Bahá’í House of Worship, Sirikit and Charlie led the wedding party out into the gardens of the temple, where they repeated their vows and heard a closing song, a biblical psalm sung mellifluously to violin. Then they followed the violinist in procession from the temple grounds, across Andalus Square to the Gallerie. Passers by paused to applaud, as was the custom; Martian outposts were small and vehicles few, so processions were a common part of weddings and funerals. They shared the function space on the top of the Gallerie with another wedding involving two recent arrivals from Earth, a wedding exclusively of twenty-somethings; Charlie and Sirikit’s wedding, in contrast, included all ages, including some of Mars’s oldest residents.

“In a way, Charlie’s the first third generation Bahá’í to come of age,” Will Elliott said to Sebastian Langlais. “It’s quite something to see, eh?”

“Yes, though Helmut wasn’t born here, so in a sense he and Charlie are both second generation.” Sebastian looked at his old friend and occasional nemesis. “We’ve seen some remarkable developments here, Will.”

“Imagine, we walked on this very spot at various times thirty-eight years ago and it was all desert; just wasteland. We didn’t even call it ‘range’ then. And now it’s a thriving small city. What an incredible privilege to witness it all.”

“Indeed. A privilege these young ones barely appreciate. And now Charlie’s going to Jupiter with a wife, after a teenage stint on Ceres! It boggles the mind. And what are they? Mariners? Marsians? German-Americans? Germans?” He shrugged.

“Well, you were German and I was American, then you became German-American, I suppose, and Helmut was German-American, but then all three of us became Marsians, and Charlie was born Marsian, but I think you are right that he is now or will be a Mariner. It sounds better than ‘Solarian’ or some such. We all might be Mariners in a decade, Sebastian.”

“If I live that long!”

“Yes, we’ll see how quickly the identity forms and becomes real. ‘Marsian’ definitely is an identity now.”

“We’ll need some sort of political structure, for ‘Mariner’ to emerge.”

“Yes, some sort of ‘post-Commission’ structure too, I suspect. The idea of Commissions for these different parts, I think, won’t last much longer, or it will change drastically. But I’m not sure what will replace it; maybe a confederacy or league or something. We’ll see.”

“Earth won’t like it.”

“Earth governments will resist it and prevent it if they can, but meanwhile their citizens will continue to lobby for more health care and senior pensions and complain about investments in space exploration. If they spend more on those two things, they’ll spend less on space, and we’ll be more independent, de facto. Their policies are in tension.”

“And their economies are doing badly.”

“Exactly. How’s Helmut doing, lining up terrestrial support for PGM mining?”

“I gather it’s been very slow lately. Governments hesitate to commit; they assume Mars will pay, or they want private firms in their jurisdiction involved so that some of the profits come home.”

“But they don’t seem to be supporting private efforts to mine PGMs elsewhere, either.”

“No, everyone assumes that it’ll be hard to compete against Ceres. Even Parenago is worried. I think they’re waiting a year or two to see what we do and what the slowing economy does to the price of PGMs.”

“That makes sense.”

Will noticed Jacquie Collins had entered and was talking to the bride and groom. “And speaking of the economy, there’s the Chief Minister. Maybe this is my chance to have an informal conversation with her.”

“Oh? About what?”

“I’ll tell you later.” Will headed toward the head table. It was not unusual for the Chief Minister to drop in briefly at a wedding reception; he had done it occasionally if he knew either the groom or bride even slightly. Jacquie had gotten to know Sirikit in particular over the last few months.

“I really wish both of you a lifetime of happiness,” Jacquie was saying to Sirikit and Charlie. “Mario and I have been very happy together, and Mary is the joy of our lives. So I hope the two of you come back here and build your lives here.”

“That’s our plan,” replied Sirikit. “The mission will last almost five years, and by then we’ll want to start a family.”

“There’s plenty of research to do here,” said Charlie. “We’re reconstructing the first few million years of the formation of the solar system! All the pieces land on Mars eventually, or get stuck in orbit around Jupiter, or end up as a Jupiter trojan.”

“You’re in a good position to do the research, then,” agreed Jacquie. “And five years from now, Martech will be the major research center for that work.” She turned back to Sirikit. “I can’t tell you how grateful we are for your creative economic ideas.”

“Thank you. This mission should be good for them, too; no one has tried to work on economic theories while embedded in an outpost off Mars before. It’ll be interesting to see how it helps me develop perspective.”

“We need that, too, if Mars is to become the center of solar system exploration. We’re probably just one or two generations from the launch of the first interstellar probes. This place has a great future, and we need everyone’s help to build it.”

“That’s what we want to do,” said Sirikit, enthusiasm in her voice. Will had to smile; Jacquie had gotten good at inspiring others.

She reached out with her hand. “One more hug, and I’ve got to go.”

“Feel free to stay if you want; there’s plenty of cake and refreshments!” said Charlie.

“No, this sol is your sol.” She gave both of them a hug. “Have many safe journeys.”

“Thanks,” they both replied.

She turned away from the newlyweds and toward Will, whom she had noticed. She walked over and they shook hands.

“Good sol,” he said.

“Good sol. And it is a very good sol. Two beautiful weddings.” She leaned close. “And so different. The other one is all young arrivals, full of energy and enthusiasm and planning to party hard all night. And this one is full of families, celebrating the continuation of generations.”

“Yes; Sebastian and I have been waxing nostalgic about the settling and peopling of this place.”

“I heard you gave a very nice speech to the couple, during the dinner.”

“I hope it encouraged everyone. I like your ‘have many safe journeys.’ I think you inspired them, too. How have you been doing?”

Jacquie shrugged. “I have pretty much recovered from the legislative push; that was draining. Thank you so much for your support for the various bills. And before that, there were several dozen major positions to fill and get passed through the Council, and the transition in administrations, and the chaos caused by the arrival of four thousand people and a thirty-three percent increase in population.”

“I didn’t mean to set that up, then leave the mess for you to handle!”

“No, that’s alright. It was a baptism by fire, but it’s over. All those tasks are over. Now things should settle into relative peace. I can’t wait to establish a routine!”

“I suppose the question now is what will happen to the terrestrial economy, which has been wobbling for months.”

“They say it should pull out soon, and I hope it does; it has made balancing the budget an exercise in guesswork.”

“I feel your pain; I felt it many times myself. I was talking to Marshall the other sol and he said that they’re going crazy up there because terrestrial support is unpredictable and they

can't get any terrestrial governments to provide them investment monies for the Ceres project, and Marsian support for their investment is uncertain as well."

Jacquie nodded. "Confidentially: we've spent our time thinking about the proposal and endorsing it in principle, while the various Commissions have either jumped in or held back. Their efforts were unanticipated. We need to bring some coherence to the process."

"I was thinking about that. There are some friends of Mars on Earth with deep pockets; people like Hans Muller of Muller Mining, who donated half the money for the Cassini campus of Martech, and Jimmy Leong, the roboticist who helped start Mars Metals and is a major investor up here. We need to approach them and see what investments we can get from them. I know you are hesitant to encourage terrestrial investment because the profits go elsewhere. But with them and a few other friends, we can be sure some of the profits will come back here eventually. Ceres and Callisto will need Martech campuses; Phobos needs an expanded facility. We'll get donations from them eventually."

Jacquie's eyes lit up. "Ah, I see what you mean! And then we can open up some stock sales to other terrestrial investors, and they won't feel like we're anti-corporation."

"Exactly. And with the bigger investment pool, and government-guaranteed loans, we can balance out the investments in the different outposts."

"Can you come to my office on Monsol? Let's getting together a group at 10 a.m. and develop a strategy."

Will nodded. "Sure."

9.

Launches

Late June/July 2074

The three nuclear engines had been thrusting for over six hours. In spite of the vacuum of space and the thirty-meter columns they rested atop, their deep-seated growl echoed through the *Galileo* and shook one's gut, rather like the sensation one had when a marching band's big drum paraded by. Sirikit did not like the feeling. She had spent endless hours in briefings and classes over the last three weeks, but none of them had prepared her for the vibration.

She glanced around the room shared by a dozen others, most of whom were watching the big tv screens or ignoring them in favor of a personal feed on their communicator or tablet.

Charlie looked at her, puzzled; he had a bored look on his face.

"One minute to engine shut off sequence," announced Commander Cai over the intercom.

"Oh what a relief," said Sirikit.

"It is; I'm tired of this."

"It's not just tired; the vibration is driving me crazy!" Then she calmed herself and added "Sorry."

"That's okay." Charlie reached over and took her hand. "We're on our first big adventure together."

"Yes, we are," she replied, ambiguously.

Charlie frowned at that and decided to change the subject. "What do you think about Hurricane Catherine?" He pointed to the CNN news feed, which showed a massive category 5 bearing down on North Carolina, with clouds extending as far north as New England.

“It’s very serious. American emergency infrastructure still hasn’t recovered from the three nuclear bombs dropped on the country four years ago. I don’t know how they’ll cope.”

“At least Catherine missed Houston and the Gulf Coast.”

“Yes, but the detour took out Miami and may take out everything from Washington to Boston!”

He nodded in grim agreement. Just then they felt the deep-throated shake fade, then suddenly stop; the higher pitched sound of two other engines continued. “The gaseous core has been expelled successfully,” Cai added. “That engine is shut down.”

At that point, the sound of the two solid-core nuclear engines began to fade; Jupiter-4 was equipped with a gaseous core engine for speed and two solid core engines for reliability, either one of which could propel the *Barnard* to Jupiter’s outer moons. They continued to fire to move the vehicle complex out of the path of the deadly uranium gas the gaseous core had expelled, then they shut down, except for a slight hiss that continued for a few minutes. Finally, Commander Cai came onto the intercom again. “Ladies and gentlemen, trans-jovian injection is complete. Our delta-v, according to the deep space gps system, was just one centimeter per second slow, But a course correction is scheduled next week anyway. You are now free to move about the complex.”

Charlie disconnected his safety belt. It wasn’t clear how necessary the belt had been; the complex had been accelerating at less than half meter per second—0.04 gee, to be exact—enough to tilt the floors somewhat, but one could still move around and use the bathroom. Still it was nice to have “up” and “down” back to where they belonged. “Shall we go to the observation deck?”

She nodded. “Sure.”

They headed out of the room. Half the mission was heading there; the six elevators leading to the Atrium were crowded, and the three leading to the hub were even busier. They had to exit the elevator into the hub slowly and hop off the rotating floor onto the non-rotating floor with dozens of other people. From there, it was a quick float up to the egress level and exit through any one of three airlocks.

When they stepped out of the airlock, they entered a pressurized, transparent bubble thirty-two meters in diameter and fifteen meters high. The top or dorsal side of the *Galileo* was a flat metal surface separated from them by plastic; above them was the flat dorsal top of the *Gan De*, which was upside down relative to the *Galileo*. If they crossed into the *Gan De*, they could exit that vehicle through an egress area in its heat shield covered ventral bottom and enter another bubble separating it from the heat shield of the *Barnard* and pass into that vehicle. In addition to the air-filled bubbles, a ring of metal beams outside the bubbles locked the vehicles in place relative to each other, so they could neither move closer nor farther apart.

At the moment, the heat radiators for the *Gan De* and the *Galileo* were swiveled out of the way, providing an unimpaired view of interplanetary space. Normally they were arrayed around the bubble to protect it from micrometeoroids. The lights in the bubble were turned down so their eyes could adjust to the darkness and see the stars. Charlie's eyes were drawn to Mars and he instinctively floated to that side of the bubble. "Wow, isn't she magnificent, Siri!"

"Mars is truly magnificent," Sirikit agreed. But she felt more than an aesthetic thrill; she felt home sickness, as everything she had known and loved was flying away from her at fifty thousand kilometers per hour. "How far are we?" she added.

“We’re already over 150,000 kilometers away,” said Charlie. “Half the distance from the Earth to the moon. Add the velocity of Mars around the sun to our velocity, and we’ll travel over two million kilometers per day toward Jupiter.”

“Oh, I miss everyone already!” said Sirikit. It burst out of her in a way that even surprised her.

Charlie realized what she was thinking and pulled closer to her. She snuggled against him, against the body she had become intimately familiar with over the last few weeks. “You still have me, and I love you very much. And we both have 189 other members of this community we are now in, as we fly through the solar system together.”

“You’re right.” She kissed him.

“So, are you alright?”

“Yes, I’m fine; just a little home sick, but it’ll pass.” She turned to him. “We’re starting our first big adventure together.”

“I wish more people had come,” Will said, as he came back into his house with Ethel, Liz, Mike, and their twins, Jason and Shayda.

“I was disappointed, too,” said Mike. “What fraction of the Bahá’ís came to their own House of Worship? A quarter?”

“Something like that,” agreed Will.

“Even on Sunsols, people are busy, and there was nothing obligatory about this event,” replied Ethel. “If all the Bahá’ís had come, there wouldn’t have been room for visitors! And they were half the audience.”

“The House of Worship is getting too small,” said Liz.

“But it was still barely half full,” said Will. “And there was video feed. I wrote President Mennea and told him about the chain of worship services this weekend dedicated to the victims of Hurricane Catherine.”

“For better or worse, I don’t think the other services were very full,” said Mike. “I heard the Jewish service yestersol was its usual size. I went to the Catholic mass last night so I could tell my parents I did, and other than a few prayers and a reference to the storm in the homily, it was an ordinary mass.”

“Most people up here aren’t Americans and most aren’t religious; praying doesn’t seem very useful,” agreed Ethel.

“It isn’t, unless it changes us,” said Will. He pulled out his communicator; it had vibrated in his pocket. “How do you like that! Mennea never got my video mail; it just bounced!”

“A videomail to the President of the United States bounced?” exclaimed Mike, shocked.

Will held up the screen so his son in law could see. “It sure did! That storm surge must have done a lot of damage to Washington infrastructure.”

“A thousand killed, no power for one hundred million people, no communications, extensive flooding in most East Coast cities, and the stock market is still closed after four days,” said Mike. “It is unprecedented.”

“All the more reason for people to have come to the service,” grouched Will. “It’s quite frustrating.”

“Every religious community that has ever coming into existence has more active and less active members,” replied Mike.

“Stop worrying about it, dear,” Ethel said, a bit exasperated with her husband. “Where is our Sunsol dinner?” She pulled out her communicator and pushed an icon. “Almost outside the door!”

“I’ll get it!” Mike jumped up and walked to the front door just as the doorbell rang. He opened it and the robotic cart displayed a smiling face on its screen and said, “thank you!”

“Please bring the food to the dining table,” he said.

“Certainly.” The cart rolled across the living room to the dining area where the family gathered. They began to remove the lasagna with vegetables and vegetarian turkey, garlic bread, and soup from the cart. “Have a good sol,” said the cart, and it headed back to the door. Mike sat; the cart could open and close the door itself.

“This looks great!” said Mike. Jason and Shayda were vibrating in their seats, so he said to them, “Just wait! We’ll serve you first!”

“It’s our birthday!” said Jason.

“Not for two more sols, but today we’re celebrating it,” replied Liz.

“It didn’t bring us a birthday cake?” asked Shayda.

“Don’t worry, I might have something in the kitchen,” replied Ethel cryptically.

Mike dished out lasagna for the twins and his parents in law, then for Liz and himself.

“I’ll be missing all of you very soon,” he said as he began to eat.

“Daddy, please, please don’t go!” said Jason. He almost wailed it; he was not looking forward to blastoff in two sols’ time.

“I’m sorry, honey, but I’m committed, and this is part of my work. Don’t worry, I’ll be back.”

“And daddy will call us every day. He won’t be so far away that we can’t talk to him,” added Liz.

“Even when we get to Gradivus, the delay will be less than a minute, so we’ll be able to talk,” said Mike.

“We’ll help, too,” added Will. “It’s our chance to be with the two of you.”

“I know,” said Jason, but he was disappointed that daddy was going away for three months, and at his age, he couldn’t fathom three months.

“I’ll bring you back a piece of Gradivus,” added Mike. “It’ll be an ordinary piece of shiny rock, but you’ll be able to look at it and remember it came from another world.”

“And maybe you’ll visit another world someday,” added Will. “This is what we do. We explore, visit new places, discover what they have.”

“In a few years, the two of you can even go out with me to explore some bits of Mars no one has ever visited before,” offered Mike. “Won’t that be fun?”

“It would be,” agreed Shayda, but Jason wasn’t so sure.

“How will we know that no one has been there before?” he asked.

Mike smiled. “You’re so smart! That’s a good question. We’ll see that there are no footprints. The Martian wind doesn’t cover them up or fill them for a very long time, and people haven’t been on Mars a very long time.”

Jason nodded, satisfied. Ethel turned to Mike. “So, you’re pretty much ready to go?”

“Yes; the preparation is more psychological than anything,” replied Mike. “I’m glad the pre-departure training was cut way back to just a week on Phobos.”

“You’ll have plenty of time on the flight to train,” said Will. “First we launch the *Galileo* to Callisto, then two weeks later the *Courageous* to Gradivus, then two weeks later the *Ptolemy*

to Saturn. It's amazing we have the capacity to send out so many vehicles and people in such a short span of time!"

"Almost four hundred people," agreed Mike. "Phobos will have supplied nine thousand tonnes of liquid hydrogen! Apparently the tanks are just about drained dry."

"Yes; they've vented over sixty thousand tonnes of 'waste' oxygen and carbon. It's a shame, but there's no way we can use that much. At least they expelled it from Phobos so that its orbit is raised a bit and the gas will mostly crash into the Martian atmosphere, so it isn't a complete waste."

"I'm impressed by our Center for Asteroidal Studies," exclaimed Ethel. "As soon as they get established, they plan flights to the outer moons of Jupiter and to Gradivus, and they're making all sorts of new plans to visit extinct comets, earth crossers, and the main belt."

"And we're negotiating with the Asteroid Commission to establish a branch center on Ceres," said Mike. "Jean Paul is a real go-getter."

"He's what we needed," agreed Will. "Rather than let politics decide what exploration to do, let the scientists decide. They can allocate resources better. The institutions were getting in the way and competing for targets."

"There's a role for those of us who can't go to Jupiter or Ceres, too," said Mike. "I think the Center will really speed up research."

"And that's a relief for us, because I can't go to Ceres!" said Liz.

"The kids really can't go anywhere for about fourteen years," agreed Mike. "But after that, maybe you'll be tired of running the Arts Complex, and who knows? Mercury again?"

Liz shrugged. "Who knows? It's got the same gravity, at least."

Will felt his communicator vibrate, and from the frequency he could tell it was a videomail from Earth. He looked at his plate; three more bites of lasagna to go. He finished them, then pulled out his communicator. "I'll be right back," he said, rising from the table and walking to the back of the house where he had privacy.

It was a message from Arnold Comiskey of Fontein Metals, a multinational mining operation based in South Africa. They had been negotiating for several weeks. The videomail was copied to Helmut, who had also been involved, and to several lawyers. "Good morning, Dr. Elliott," began Comiskey. "I think this new offer from you moves us much closer to a contract. We grant your point that for every miner and metal processor on Ceres, there has to be about one additional person there running the ecology, providing medical services, educating the children, etc. Our offer to provide some support service personnel was never meant to imply we would provide the salary for one support staff for every mining staff person we send to Ceres. But we will pay for the transport of the support staff to Ceres and the transportation of any equipment or infrastructure needed for them, within reason. You will have to purchase their supplies and equipment and cover their salaries and other costs, presumably from the profits that the operation will eventually generate for you.

"Any proportional profit sharing arrangement with you can only begin after we have recouped our expenses and have seen a twenty-five percent return on investment. This is a rather uncertain investment, not because of the technology or the location, but because of the unpredictable market price of the export. Who knows what will be happening on Earth over the next decade or two. We have to cover our costs and make a profit; our investors and shareholders are counting on it. Once we have generated a twenty-five percent profit, we are willing to share

profits based on the proportional sizes of our investments. That's a conventional arrangement. So get back to me about this. Bye."

Will considered the offer. It was better; the back and forth was producing results. They had played hardball with the company about the support personnel, but now he wondered whether that had been such a good idea, since the cost of transporting personnel and equipment increased the company's investment and therefore their share of the profits. If an entire galleon full of people flew to Ceres and landed there to serve as part of Central Outpost, and half were support personnel, then legitimately half the cost of making the galleon could be considered the company's; that was half a billion redbacks. It was a big investment for the company, but would help spread out Mars's limited resources. Furthermore, Mars presumably could consider the salaries of the support personnel as part of their investment, until profit began to flow to them; that added up to at least fifty million redbacks per year. They had wanted a lower guaranteed profit for the company, but it was worth paying out less now. He hit reply to all. "Thank you, Mr. Komiskey. I understand you to agree to cover the cost of transporting the support personnel and their equipment; that is fine with us provided that cost includes the manufacturing cost of the vehicle that transports them, which also becomes their housing on Ceres. If that is the case, and if our investment includes the cost of their salaries up to the point when profit sharing begins, we will agree to the twenty-five percent profit margin. Let me know. Bye." He hit send. He was sure that Comiskey would object and refuse to cover the manufacturing cost of the galleon, or would insist on title over the vehicle and the option to sell it back to Mars later. But that was how bargaining worked. At least it was inching them closer.

Xiaopeng Cai was not one to appreciate, as he would put it, “metaphysics.” He prided himself in his rigorous, rational thought and was skeptical of anything for which a verifiable, repeatable experiment was not possible. In consequence, he was uncomfortable throughout the *Galileo’s* interfaith service for the hurricane victims. He wouldn’t have been caught dead in such a program if it hadn’t been in honor of sufferers.

Besides, the mission’s media team was there. As soon as the program ended, the cameraman closed in on him while the journalist asked him a few simple questions about the purpose of the program and the role of services on board. He had rehearsed his answers ahead of time and they went well. It was a good opportunity to support the victims of the hurricane while looking like good middle class citizens of Earth’s many counties.

When the interview was over, almost everyone had left, except for Sirikit, Charlie, and Firuz. They were three of the seven members of the interfaith committee Sirikit had put together. “Could we do an interfaith service focusing on virtues?” asked Charlie. “Can we find scriptural passages that focus on acquiring virtues, developing them, etc.?”

“Certainly,” replied Firuz. “That’s not too hard. I have a collection somewhere.”

“I think people would enjoy that subject,” added Charlie.

“I guess we’ll be doing more of them, then, even if the other committee members don’t want to participate,” said Sirikit.

Commander Cai sensed a lull in the conversation. “Thank you for organizing this program,” he said. “I think it was a valuable contribution to the community here, even if most didn’t come. But Leroy’s ‘we pray this in the name of Jesus’ was offensive. Dave Cohen was startled and Abdullah didn’t look happy about it, either. If these interfaith gatherings are

supposed to bring people together, it did not fully succeed. And as Commander, I may not be willing to assign the space for the service if it becomes divisive.”

Charlie was startled by that and was about to respond with raised voice when Firuz put his hand on Charlie’s shoulder. “I talked to Leroy before the service,” said Firuz. “I told him it was appropriate to say ‘I pray this in the name of Jesus’ but not to use ‘we.’ Leroy is an evangelical and believes that if he doesn’t include Jesus’s name, it isn’t a valid prayer and God won’t listen.”

“Then why is he participating in an interfaith worship service? I suppose he doesn’t think God is listening to any of the others; just to him!”

“I’m not sure he’d go that far; I suppose his position is that he doesn’t know what God will do with the other prayers, or that God has a different expectation of him than of the others,” replied Firuz, patiently. “Commander, our goal is to be as inclusive as possible. The Jupiter-4 flight is just as diverse as Mars. About a third of us have no religious affiliation at all. Catholics and Protestants are about a sixth each. The remaining third is divided among Hindus, Muslims, Buddhists, Bahá’ís, Mormons, and Jews, in that order. All of those groups were represented here today. And some of the people here profess no affiliation at all.”

“Perhaps you should have had someone unaffiliated involved in the planning, then.”

“I’m unaffiliated,” replied Charlie. “And we included that poem.”

“I see.” Xiaopeng looked at them. “Well, work on Leroy. And we have a concert tonight, right?”

“Yes,” said Sirikit. “Piano and violin, in the Atrium, right after dinner.”

Good, I’m looking forward to it. See you then.” He waved and headed out of the function room. The stair down one level to the bridge was just a few meters away. He pulled the heavy pressure

door open and entered, descended a level, then opened the pressure door there and exited. When he entered his office, he saw he had received a reply from Commander Chen Wei, who was in charge of the international Callisto Outpost. The outpost consisted of two caravels, the *Tienan* and the *Pacifica*; Commander Charles Vickers of the latter alternated with Commander Chen annually for overall command responsibility. The caravels were often referred to as Chinese and American-Marsian respectively based on their funding and command, but the Chinese caravel also had Brazilian and Vietnamese personnel and the American-Marsian vehicle had crew from twelve countries.

Cai Xiaopeng pushed play with a bit of hesitation. He had asked Chen Wei to start accumulating meteorites, which were scattered throughout the icy crust of the moon; they needed the nickel-iron ones for construction and the chondritic and stony meteorites for artificial soil. That day, round trip communications required an hour and a half.

“Good day, Commander Cai,” Chen began. They spoke to each other in Mandarin; the Marsians had insisted on the appointment of a Chinese-Marsian commander of their mission to smooth out relations and improve communications. “I hear your first course correction has been canceled because of the precision of your launch. Congratulations. We look forward to all the company you are bringing and the great increase in exploring capacity that will be actualized in less than twelve months.

“I was just reviewing your phase one plans for outpost expansion. They are ambitious and very impressive. As I am sure you heard, we began excavation of our first cavern last week. We don’t have much spare power up here, our plastic manufacturing capacities are limited, and our personnel are fully occupied with their tasks, but we anticipate completing two caverns over the next year. This is both good and bad news. It means that your plans need extensive revision

because our second cavern will extend into an area between two of your enclosures, into an area that needs to remain intact to support the overburden. It also means that all meteoritic materials we excavate need to be reserved for our own use; you will have to accumulate your own materials for agriculture and manufacturing. We hope to finalize the length of our second cavern in a few months and will let you know, so you can accommodate it in your revised plans.

“We’re sorry we can’t be of more assistance to you, but are confident that you will greatly expand Callisto Outpost even without our help. The result will be incredible. Bye.”

Chen’s face faded and Cai scowled. Behind the friendly rhetoric was a complete block of their plans; they couldn’t bury their enclosures or obtain an advance supply of the meteoritic materials they needed. Humans had lived on Callisto eleven years and had never excavated anything more than two short, small tunnels; suddenly they were excavating caverns using small hand-held equipment that was slower and less safe than the high-powered robotic equipment they were bringing. It was hardly a coincidence.

Xiaopeng Cai clicked forward and sent Chen’s message to Wang Chenguang, Commander of the *Gan De*. He had access to a Chinese Commander, too, and one that was forty meters away, rather than 800 million kilometers. “Wang Chenguang, I’m on my way over; let’s discuss this,” he said, by way of cover note. He hit send and headed out of his office.

It was a two minute walk and float. He hurried up the stairs to the Atrium, then took an elevator to the hub of the *Galileo*, where he crossed from the rotating, gravitied section to the non-rotating zero-gravity section. From there he floated up to the egress area and into the bubble separating the *Galileo* from the *Gan De*. He was surprised to see Charlie was already organizing a game of Striker in the space, which served as their zero-gee gymnasium. He floated across into

the egress tunnel of the *Gan De*, into the hub area, and crossed to the rotating, gravitied area. From there it was a quick elevator ride to the bridge.

The *Gan De* was bustling with activity. While the 30 personnel of the *Barnard* had moved into the *Galileo* to benefit from the radiation protection its hydrogen tanks offered, most of the *Gan De*'s crew had not; they were employees of the Chinese government or other governments that had contracted for transport with China and had stayed on their vehicle. At least they had arranged its water and volatile supplies to shield the opposite side of the vehicle from the *Galileo*, so that each vehicle was located in the radiation shadow of the other. The bridge had one day officer only; Sundays were always quiet. Wang Chenguang was in her office next to it.

"I looked at the videomail. I don't know what to say," she said, as he entered the office.

He sat in a chair in front of her desk unhappy by her less than cooperative start. "Do you think this comes from him, or from the Chinese government?"

She considered. "Or from a consensus on the Callistan surface."

"I can call Charles Vickers and ask him about that. I doubt he and his crew are in favor of this. What is the logic of this decision? It certainly appears, on the surface of things, to be purely obstructionist. We can't use our year of flight time to plan our tunnels and ice structures because they don't know where they're going to put a single cavern? Or how long it will be? Maybe we should move five hundred meters away and build our outpost there. If they want to connect their system to ours, they can excavate the needed half kilometer tunnel themselves!"

"No, that doesn't make sense, either."

"I agree. We should all be together, to support each other in case of accident. So, how can we determine what is going on?"

She considered. "I can call Mission Control in Beijing, if you call Chen Wei."

"You can't call Chen Wei? Because if I call him, I'm calling Vickers as well. I think we can agree that he'll find some time among his crew to collect meteorites for us. There are heaps of them available in the talus piles at the base of crater rims."

"That will undermine Chen Wei's command, which means he'll undermine your command after we arrive."

"Perhaps he will. But I'll command three or four times the human resources that he'll command. I don't need him; but when the command returns to China's vehicles, he'll need me."

"I'm sure the plan to hold an election after we arrive is part of the issue."

"I'm sure of it. The fact that Mars decided to fund an entire galleon and triple the population on Callisto is part of it, too. China is free to send a galleon and reinforce their contribution, too."

"There's one scheduled in two years."

"There is indeed, if the funding comes through. It may not; China's struggling right now to repair the war damage, rebuild its military, and take care of its elderly."

Wang Chenguang nodded. "Alright, I'll call Chen Wei as well. I'll let you know what I learn."

"Good. In twenty-four hours."

"Alright, I can do that."

Giovanni DePonte loved the color of the pegmatites that Thaumasia's miners drilled and blasted through. Because of his mining experience, he got to substitute for the miners when they got sick or injured; it was a nice change from construction. Pegmatites were slow cooling, large-crystal

bodies that had formed deep underground. Later, they had been exposed as a result of cratering events. Spodumene crystals—lithium aluminum inosilicate, Mars’s principal source of lithium—could be a meter across and might be yellow, emerald green, even lilac in color. Small pieces were purchased by Aurorae’s jewelry makers. The green crystals had chromium impurities, the lilac ones manganese, and all of them had aluminum; valuable elements in themselves. Associated beryl—also a very pretty gemstone—provided beryllium. Lepidolite crystals yielded lithium and fluorine. Topaz provided fluorine as well. Quartz provided silica. Safe inside a pressurized, armored cab and armed with several drills, jack hammers, and mechanical arms, Giovanni made quick work of the rock face, sometimes loosening two cubic meters of minerals an hour.

That sol the work went very fast because the pegmatite was heavy cracked. Periodically he sprayed water onto the roof of the cavern to freeze any loose chunks in place. The cavern he was carving was only a dozen meters wide and in Martian gravity the compressive force was not too great, but he had to be careful; after lunch he backed out and used the cab’s powerful mechanical arms to install several steel roof supports.

It was an hour before sunset when he finished filling the trailer that would be hauled back to Thaumasia Outpost that evening. He texted the outpost that he was finished a bit early in the hopes they could get him more quickly—a truck delivered four miners and empty trailers every morning and picked them up every evening—but he quickly got a response “running late because of mechanical problems. Will get you by 7 p.m.” which was actually a half hour after sunset and almost two hours away. So he pulled on his pressure suit and depressurized the cab so he could poke around the area a bit. Safety regulations said he couldn’t explore by himself, but

he decided to ignore that; the chance of accident was very small, as he had spent hundreds of hours in pressure suits.

First he walked around the power center to look it over. It had two thirty by thirty meter power cylinders, each of which had a thousand square meters of curved, aluminized reflector surface that rolled across the ground to focus sunlight on a line of fifty percent efficient solar panels, able to provide the mining machine up to 500 kilowatts of continuous power during the day. A deep well provided the power center with a source of water to electrolyze; the hydrogen was combined with atmospheric carbon dioxide to make methane, and the oxygen was stored in liquid form. A tiny emergency shelter provided him with extra accommodation if something happened to the mining machine. Methane and oxygen storage tanks and a series of fuel cells provided power; the first task to accomplish every morning was to switch out the mining machine's spent tanks and waste water tank for freshly charged tanks. The entire site was a small, self-sufficient outpost; a sort of daily staffed homestead.

After poking around what was a standard setup—he had worked on them before—he hiked up the steep slope above the mine to see what he could see. There were rock outcrops everywhere and he had a rock hammer, so he often took a swing at the exposures and brought fresh pieces up to his helmet. He could see where the geologists had walked around; their footprints, from several years earlier, were still clearly visible. He quickly discerned that they were going outcrop to outcrop—no doubt ones that had been characterized by satellite data—so he chose a different route to see different, unvisited outcrops, and after half an hour was rewarded by discovering an exposure that included minor galena, an important ore of lead. Mars had some lead production as a byproduct of gold and PGM mining, but no separate source.

Unfortunately, the outcrop was too small to be economic, but he made a note to come back and look more later. It was the sort of work he really enjoyed.

Fading sunlight made him realize that dusk was falling. He could always get back to the mine via GPS and his headlamp, but there was no reason to take a chance. He jogged the two kilometers back and arrived five minutes after sunset, but there was still plenty of light because the Martian atmosphere was quite dusty that day. A few minutes later the truck arrived with its large passenger cabin, rear airlock, and a string of cargo trailers. He hitched his trailer to the end and climbed into the airlock. The truck started forward, slowly, as soon as he closed the outer door.

It took ten minutes to blow the dust off his pressure suit, purge the dusty air from the lock, and remove his helmet and gloves. He entered the cabin and nodded to the three other guys, all of whom he knew slightly. They started to exchange greetings when the driver—a woman—shouted back to him, “so, you went out exploring!”

He looked up. A blond head turned around to look at him, with a smile. She gave him a good looking over—the truck was mostly driving itself—which intrigued him. “Yes, I had some time on my hands and was tired of sitting all day. I found minor galena, too.”

“Really? We could use some of that.”

He walked forward to see who she was. A caravan had arrived two sols earlier and he thought he had noticed her among the dozen newbees; certainly, she hadn’t been at Thaumasia previously. “How did you know? GPS?”

“Yes; I happened to check. Don’t worry, I won’t report you.”

“Who are you? I’m Giovanni DePonte.”

“Holly Swan. You’re Italian?”

“Marsian, born and raised.”

“Really?” She was surprised to hear that. She was pretty young, he thought; most arrivals were in their late twenties, but like him, she appeared to be in her early to mid twenties. “I’m from Western Australia; born and raised.”

“I’ve heard of it. Much bigger than Aurorae.”

She laughed. “Definitely! But Aurorae’s much bigger than Paraburdoo, the iron mining town where I grew up.”

“Really? You mean there are smaller places on Earth than Aurorae?” He said it sarcastically.

“Oh, yes, and much less *sophisticated*.” She said the last word with a sarcastic mock.

Giovanni laughed. He moved forward and sat in the bucket seat opposite her. “So, what’s it like to grow up in a little mining town in the outback?”

“Probably not too different from growing up in Cassini Outpost, except the outback has bushes and grass and the range doesn’t. Well, Cassini also has a university campus, and Paraburdoo barely has a high school; most college bound kids go to boarding school.”

“So, is that what you did?”

She shook her head and said nothing more.

He held up his hands. “If you know how to use these right, and you don’t need a university degree. They say 99% of the Marsian kids go to Martech. I’m the one percent. The *entire* one percent.” He chuckled at that.

“And proud of it?”

He shrugged and didn’t say anything.

“So, what have you been doing, since high school?”

“Odd jobs at Aurorae, then mining at Meridiani and Thymiamata, and now construction here.”

“But you were mining this sol.”

“I’m a substitute. I like the change.”

“I agree. I can do repair and horticulture and want to learn mining. I have some construction certifications, too.”

“A jane of all trades?”

“Something like that. So, what do your parents think of your career?”

He snorted and held up his hands again. “They don’t use these; they use their heads. My dad is the Silvio of Silvio’s.”

Her eyes grew big. “As in Chief Justice DePonte!”

“That’s the one. The founder of the bank. too.”

She laughed. “Yeah, he may not appreciate your choice of livelihood!”

“I think they’re adjusting.”

“Congratulations. My parents found my decision to apply for Mars to be bizarre, since I could have done most of the same things a lot closer to home.”

“What got you on the flight?”

She held up her hands. “I can fix almost anything.”

“The one thing they really can’t teach at university.”

“They sure can’t.”

He looked at her appreciatively. “I’m really glad I met you.”

She turned to him and smiled. “I’m really glad I met you, too.”

“So: Alba Patera definitely can’t increase gold output,” concluded Jacquie Collins, a bit surprised.

“I’m very surprised,” added Park Hun-jai. “The geological report was quite thorough.”

“Well, like I said, the report was wrong,” replied Tom Halley, Commander of the outpost. He was on the video screen; Jacquie and Hun-jai were sitting in the Chief Minister’s office. “The seismic, gravity, and magnetic data all suggested a deeper, richer ore body. Maybe it is deeper and richer, but not in the places we’ve drilled. Can’t Uzboi increase PGM production?”

“They have the same constraint as you have; personnel, equipment, safety regulations,” replied Jacquie. “With falling PGM prices, I’d rather send any extra personnel we can scrape up to Alba. You said every extra miner could produce about 150 kilograms of gold per year?”

“If you can send equipment. I’d transfer people from Jumla or Cassini; they produce the least amount of gold per person.” Tom sighed. “I know that politically, that’s difficult, though. All the mining outposts want to grow and be permanent; none want to face the possibility of becoming a ghost town.”

“This is a major issue,” agreed Hun-jai. “Jumla and Alba face the greatest threat this way; they’re remote, expensive to run, and have the smallest gold reserves.”

“Even expanding Alba worries me,” said Tom. “I love this outpost and want to see it develop. But if we continue extracting twenty tonnes of gold per year, the reserves will last fifty or sixty years. If we expand the way you want us to, they’ll last that much less time. And every tonne we extract means the remaining gold is in less concentrated form; in ten years the average production will be under 100 kilos of gold per miner per year, and that’s assuming more automation and bigger machines. This place has already absorbed a billion redbacks of infrastructure. It’s way off the beaten path and it has nothing else going for it, except gold.”

“So far,” said Hun-jai. “There are industries we can locate there to help continue the outpost. We’re already considering those options with Cassini and Dawes, as their massive gold production falls.”

“We need to find more gold reserves,” said Jacquie. “We’ve only surveyed a third of the surface in detail. There’s every indication this world has a lot more gold than Earth.”

“We haven’t searched the other two thirds because the chances of finding gold are small,” replied Tom. “The old Northern Ocean basin is recent basalt covered by ocean sediments; no gold to be found there. The northern and southern polar terrains are huge piles of dust and ice; no gold there, either. We may still find major deposits, but it won’t be easy. How much is the PGM price dropping?”

“My estimate is that it will fall to about a quarter of its peak price,” replied Hun-jai. “Economic models are notoriously unreliable, and a lot of economists disagree with my forecasts vehemently. But so far I have been right about four times out of five. The hurricane that hit the northeastern United States forced a week-long closure of the stock markets and has precipitated a collapse of the insurance business because of the loss of confidence in the federal government’s guarantees. If the government extends its guarantees, inflation will be pushed up to twenty percent per year or more, because no one will buy more of its bonds; they’ve borrowed every penny and printed every spare dollar they could to rebuild after the nuclear attack. If the government doesn’t guarantee the insurance companies, the real estate market will experience a drop in values. Either way, the United States economy goes into recession or worse. This is threatening to pop the real estate bubble in the countries that weathered the last war relatively well, like India, Australia, and Brazil. The Chinese are cracking down in their economy, which has been damaged by the withdrawal of Tibet and Shinjang and by the nuclear attack. The big

problem is the global economy lacks global regulations and everyone is trying to regulate their piece to their own advantage.”

“National greed and mistrust,” commented Jacquie.

“Actually, it isn’t just nationalism,” replied Hun-jai. “In the United States, President Mennea’s coalition of educated professionals, bicoastal export-related communities, and businesses, has been insisting on too many spoils, so they are losing out to minorities, blue collar workers, and rural people. It’s a major political realignment, as large as occurred in the Great Depression over a century ago, when African Americans went from being Republicans to Democrats, for example. In China, the outwardly oriented, who also were reluctantly willing to let Tibet and Shinjiang go, have lost out to the nationalists who want to reconquer them and who want China to make a push to dominate the world. Meanwhile, Europe continues to be weak internally and refuses to let in the ring of nations at its edges, who have found the Grand Union to be a poor substitute.”

“The so-called Grand Union has practically fallen apart,” agreed Jacquie. “So, you don’t see this ending soon?”

Hun-jai shook his head. “There may be more major wars, even with nuclear weapons. The political will to pull together compromises is lacking. The balkanization of the media has continued to create communities that live in different worlds, where the facts are concerned. Meanwhile, sea level is up a meter and will go up two or three meters more in the next century. Earth is a mess. It simply won’t be a predictable partner. But if we are economically stable, we will potentially receive more investment than we can usefully absorb. Our danger actually lies in over development.”

“Okay, so what’s the solution?” asked Jacquie. “Because this conversation is all very abstract, but I’m not chief minister of an abstract place. I have an estimated 2 billion redback budget deficit looming because of the fall of PGM prices. I can fix that with the export of twenty more tonnes of gold or eighty more tonnes of PGMs.”

There was silence for a moment. “I’m not sure any of the existing outposts can raise gold production that much very quickly; not without another two hundred personnel and maybe a billion redbacks of equipment,” said Tom. “We can certainly get that much investment from Earth, but we’ll have to shuffle people around to get the workers.”

“We can get the investment, and we might be able to get the equipment within eighteen months,” agreed Hun-jai. “But the Marsian public is still very worried about increased terrestrial investment.”

“We’d be better off borrowing the money to buy the equipment,” agreed Jacquie. “But eighteen months . . . aren’t there new deposits that are known—relatively small ones—that we can utilize?”

“Yes,” replied Tom. “The problem right now is infrastructure. Outposts take a lot of investment to set up. Small outposts—suitable for small deposits—are pretty expensive.”

“I think we need a new approach, then,” said Jacquie. “Mars is dotted with oases suitable for a dozen or two temporary residents. Why can’t we set up oases, staff them with a half dozen miners, work a relatively small deposit, then when it runs out, pick up the entire oasis and move it? The workers would get paid well and would stay a few months only. They wouldn’t need all the services that outposts provide; they’d get that from an outpost when they visit or return to it.”

Tom nodded reluctantly. “We could try that. It has safety implications. Obviously, an oasis wouldn’t have the access to the medical care and emergency services that an outpost would.”

“True.” Jacquie turned to Hun-jai. “Can you and your economic team explore this? I’d like a rigorous analysis of the minimum size an oasis needs to be to be a viable contributor to our economy.”

Hun-jai nodded. “Okay. We can give you a report in a month or so. But I’ll also give you some options to cut the budget back, especially imports and terrestrial technological investment.”

It was only a few hours before Hun-jai had a summary of the issue ready for his economic team. Sirikit’s communicator beeped when it arrived, but she ignored it. She and Charlie were sitting in their compact quarters—a bedroom not much larger than their queen-sized bed, a small second room where one of them could work or watch television while the other slept, and a small bathroom—watching the end of the wedding reception for Bill Hollingworth and Suzanne Rivers in Genesis Crater, Aram. “Thanks, guys, for coming,” Bill was saying to them over the video link. “Even if you are fifteen million kilometers away! I hope you enjoyed the wedding as much as we did! We’re on our way to Tithonium for our honeymoon—thanks for the recommendation!—then we’ll live in Aurorae for six to twelve months and I’ll continue copiloting on the runs to Phobos and Deimos. Sometime next year, the Green World Community will conduct a flight to a near-earth asteroid and I’ll be pilot! So you guys won’t be the only ones visiting other worlds. It’ll be only the third private flight to an asteroid.”

He moved over so Suzanne could stick her head into view. “It was good to get to know both of you! Bill has some great friends. I hope your flight is going well. Thanks for ‘coming’ to our special sol. I’m sure our paths will cross again.”

She and Bill waved goodbye, then Wicahpi-Luta popped into view. He turned to watch the newlyweds go. “There, I’m glad you were able to see them. I hope you could take in the wedding pretty well; video is never as good as reality.”

Esther stuck her head in as well, so both of them were visible. “It was a really beautiful ceremony. Tree Rivers was very gracious; he gave away his niece since her dad is still on Earth, running the Green World Communities there. Well, you saw that part. I think Kurt and Anne Hollingworth were positively impressed.”

“That was the only time!” added Wicahpi-Luta. “Otherwise they sat through the whole ceremony looking pretty sour faced. I’m not even sure they ate much of the wedding feast, and it was quite a feast.”

“So, when are you guys tying the knot?” asked Sirikit, a tease in her voice. Wicahpi-Luta and Esther had not said anything about marriage, even though they had really enjoyed Charlie and Sirikit’s ceremony. She knew it would take 45 seconds for her question to reach them, though.

“Hope you guys are doing okay up there,” said Esther. “I watched your blue grass concert last night; *Mars This Sol* carried it. They’re pretty good! I’m glad your cultural events are getting coverage down here. Seems to me I heard there’s quite an audience of jovian wannabees on Earth, too.”

“I think you’re setting a high bar for the Uranus mission!” added Wicahpi-Luta. Then they both stopped talking; Sirikit’s question arrived. Esther smiled.

“Well, he’s got to ask me!”

“And she’s got to say she’ll apply for the Uranus mission!” he added, with a chuckle.

They looked at each other with a smile, like they were playing a joke on each other. “Don’t worry, we’ll resolve this impasse soon, one way or another,” added Wicahpi-Luta. “I think she’d make a great horticultural researcher out on the edge of the solar system!”

“And I think he’d make a pretty good husband right here!” she added, with a laugh.

“Maybe he has to decide whether he’s Marsian-Lakota-Maori or Mariner-Lakota-Maori.”

“Why not all four?” he responded, with a laugh.

“Well, we can’t wait to hear your resolution,” said Sirikit. “We can highly recommend marriage. It’s a lot of fun.” She looked at Charlie with a special smile. “Over the next week I’m organizing two more concerts—they’re really popular—and a painting class, none of which I have to actually do, fortunately. The store’s taking ten hours a week, which isn’t too bad. Looks like I’ll be branching out into lectures, though, and will give one of the first ones.”

She paused and the computer controlling the video screen decided to send the next comments from Wicahpi-Luta and Esther. “We’d better get back to the party,” said Wicahpi-Luta. “We’re missing the dancing. Bill and Suzanne are a good couple, and he seems pretty comfortable here, even if he keeps saying he’s not a believer. We’ll call you again in a few days; maybe Tuesol suppertime.”

“Bye,” added Esther.

“Bye,” replied Sirikit and Charlie almost simultaneously, then Charlie closed the circuit.

“It was a nice wedding.”

“Yes, it was, though I hope Bill knows what he’s getting himself into.”

“I’m glad to hear they watched the bluegrass concert, and glad to hear *Mars This Sol* carried it. Do you have ratings, yet?”

Sirikit shook her head. “We received an email saying the preliminary data looked good, though. Maybe two million watched the show on Earth, which is both huge, compared to Mars, and tiny, compared to the rest of Earth. Cai Xiaopeng was very happy. He complimented me.”

“He’s really pleased with what you’re doing to bring everyone together. Even the interfaith services!”

“They’re even getting pretty good attendance. Firuz is doing the bulk of the planning for them, though.”

“He’s a remarkable man; a sort of half mystic, half astrogeologist.”

She laughed. “Yes, that’s Firuz. He’s not ashamed to say he’s religious, and that makes it easier for others as well.” She reached into her pocket to pull out her communicator, because it had vibrated again to remind her of the message waiting. She opened it. “Wow. Park has added me to his ‘economic team.’ Chief Minister Collins has asked for advice about increasing gold production.”

“PGM prices have been falling and gold prices rising,” said Charlie. “That’s always a problem for Mars.”

“They’re discussing smaller gold harvesting crews; a half dozen or dozen would go out for a week or two, mine gold, then rotate back to an outpost. They’d have to be paid about double because of the hardship and danger, but they’d be in the position to go after smaller deposits farther from an outpost.”

Charlie nodded. “That’d work. I wonder why they don’t encourage small private companies? You don’t need a big company to do what they’re talking about. Heck, a couple with a mobilab for a home and some mining equipment could do it.”

“Really?” said Sirikit. “I bet you’re right. We could ask Giovanni about that; he’d know.”

“Yes, he would; he’s prospected, has been a miner, has repair experience with big machines, and has done construction. We should call him.”

“I’ll do that tomorrow,” Sirikit agreed.

10.

New Endeavors

Early August 2074

The small rocket drifted away from the *Galileo*, then at a distance of ten kilometers its engine came on, blasting out a flame of hydrogen and water vapor moving at 4.6 kilometers per second. The engine was small and underpowered; as tanks of hydrogen and oxygen were drained, they were jettisoned in pairs, lowering the mass being pushed until a cylinder ten meters long and half a meter in diameter was left.

The control room was tense until the engine finally finished its work, 40 minutes after it started. Beverly Lowell, the mission director, consulted with her two assistants, who were monitoring the vehicle. “Delta-v, 13.458 kilometers per second; right on the money,” she announced. “Penetrator 1 is on target to hit Penelope in 26 hours.”

“Fantastic,” said Firuz Moulin, and he began to applaud. Charlie and the other geologists applauded as well.

Bev smiled and took a little bow. “It’s all in service of science. If the volatile inventories continue to grow the way they have been, we’ll be able to launch Penetrator 2 at another target in four months.”

“Then let’s eat more steak!” said Charlie, and the others chuckled. Most of their food was grown from their ample volatile reserves, which amounted to a tonne per person, but they were carrying a hundred kilograms of food per person that they couldn’t produce on board, and as they ate it, it increased their reserve.

“Let’s hope Penetrator 1 manages to survive its impact,” said Firuz. He turned to Charlie. “Let’s go talk to Sirikit about the Sunday service. This is a good time.”

“You’re right; okay.”

“I want all you geologists out of the bridge now, anyway,” said Bev, with a chuckle.

“And we all have things to do!” replied Jean Paul. The geologists—a dozen or more crowded into the small space—rose and headed for the door. Most headed for their labs on the *Barnard*, but Firuz and Charlie headed for the Atrium, where Sirikit was located.

“So, you’ve got quotations on what theme; trustworthiness?” asked Charlie, as they walked up the stairs two levels.

“Yes, that was your suggestion, and I liked it. I found some good quotations from Buddhist texts, too.”

“It’s too bad reading and studying texts about being a better person doesn’t actually make people better!”

“I think it can; it’s just slow,” replied Firuz. “Poetry and philosophy have the power to make us reflect, and that can change us. Bahá’ís believe that the Word of God has a special creative power, though, so we particularly favor scripture.”

Charlie nodded; he wasn’t sure what he thought of that. “So, is that why you use revealed prayers, rather than your own words?”

“We pray with our own words, too; we do both.”

“But why pray at all? Doesn’t God already know what you are praying for?”

“Perhaps God does know; but do you know what you are praying for, before you pray?” replied Firuz. “When you pray, you have to decide what you will pray for, and that’s a good exercise in self-examination all by itself. What is right and wrong? What is good for me, ultimately, and what is not? What is my purpose; to become rich, to become a famous scientist, or to become a true servant? The revealed Bahá’í prayers are designed to ask for things that are

good; they help model our requests for us, you might say. And there's another aspect of prayer to remember, too: listening. If you don't ask for something, will you be ready to hear the answer?"

"But you don't literally hear God speaking to you, do you?"

"No, of course not. If one did, it would be an observable phenomenon, subject to scientific scrutiny and presumably would constitute a proof of the existence of the supernatural, and that would greatly reduce the freedom of individuals to believe or not believe. Human spiritual freedom is an important aspect of this world. We are free to believe or not; free to make spiritual and ethical choices. And the ultimate result is that we all learn, as individuals and as a species."

"Rather slowly and painfully!"

"Indeed. Look at the mess in New York and Washington, right now."

"I bet there are half a million people thinking they hear the voice of God right now!"

"Yes; LSD will do that, I'm told. But I don't think God speaks to people that directly; not very often, anyway. The best I can say is that I often feel the direction to go, after prayer."

"That makes sense," agreed Charlie. He pushed open the pressure door at the top of the stair and they stepped into the atrium, a circular space fifteen meters in diameter whose circular outer edge constituted a floor fifty meters in circumference and eight meters wide. After a while one mostly got used to looking up and seeing people upside down, fifteen meters overhead, and being able to look all the way around to see how one could walk to them. One wall of the atrium was covered with vines and potted plants; the entire other wall was a three-dimensional screen of immense cost. At the moment, various television channels were being projected onto smaller rectangular pieces of the wall, but they could project a single gigantic, awe-inspiring image if they wanted to. Dotting the atrium was much of their orchard of fruit and nut trees, with tables

able to seat everyone on board at once, if need be. One area lacking trees could serve as a performance space; another area, titled “The hangout,” had Sirikit’s store and after-hours self-service refreshments. They headed there. Sirikit was in her little office dictating a message to Giovanni DePonte, thanking him for his detailed description of how mining worked and how small groups of men and women could work smaller gold deposits.

She finished the sentence and hit pause. “How did the launch go?”

“Perfectly,” said Charlie. “The engine slowed the penetrator by 13.5 kilometers per second; more than the escape velocity of the Earth! So it’ll crash into Penelope at a mere 1 kilometer per second.”

“It’s amazing we can design anything to survive such an impact.”

“The deceleration will go as high as 300 gees,” agreed Firuz. “We’d be squished to pulp. But if all goes well, it’ll penetrate up to fifty meters into Penelope, and its battery will allow it to broadcast data back to us for two weeks. It’ll stop so fast, and its seismic sensors can be activated so quickly, it will detect the echo of its own impact.”

“And it can do chemical analyses.”

“Hey, it can even give us radiogenic dating on samples!” said Firuz, with a laugh. “And we’ve got four of these penetrator missions as we cross the belt. They’ll alleviate the boredom of the geologists.”

“Assuming our volatile inventory stays nominal,” said Charlie. He turned to Sirikit. “What’s the latest on Earth?”

“It’s amazing how many rich, famous, and powerful people drink tap water,” she replied. “Half the White House staff, half of Congress, half of Wall Street’s bankers and stock brokers. So nothing is going to operate for several days, yet. I’m afraid someone decided to drive their car

in the automatic drive only lane of interstate 95 and caused a 123-car crash, and so far there have been about a thousand deaths in accidents or from people going crazy. The police chief of Washington, D.C., says they'll waterboard the anarchists who poisoned the city's water supply to find who did the same to New York."

"And the whole rest of the country is drinking bottled water," said Charlie.

"You know it." Sirikit shook her head. "This is a terrible, terrible tragedy."

"What's it doing economically?" asked Firuz.

She laughed. "The price of gold is soaring. Platinum's doing okay, since it's used as an investment, but the other PGMs are plunging."

"I wish we could do without Earth completely!" said Charlie.

"We're getting pretty close," said Firuz.

"Trustworthiness," said Charlie. "I'm glad we're concentrating on that virtue this Sunsol. This incident shows how a society can't function without it."

"It can't," agreed Firuz. "Now all water reservoirs will require huge fences. Just about every large public facility already has metal detectors."

"And we don't need screening for anything!" laughed Charlie.

"Not yet, anyway," said Sirikit. "Let me finish this videomail, then we can work on the program. We only have to worry about this Sunday, right?"

"That's right," said Firuz. "The Buddhists and liberal Protestants are planning the one after that, then the Catholics, then the secularists."

"We should set this up as a proper monthly schedule," she said. Sirikit turned back to the screen, activated the recording, apologized for the interruption, and finished. She pushed send and it flew through space at the speed of light to Mars.

At that time, Giovanni was in his room getting ready to go to bed. Holly was already settled into his bed, waiting for him. When the communicator beeped, he picked it up and converted Sirikit's video into a text message; it was faster.

"Who was that?" asked Holly.

"Sirikit, thanking me for my advice about small mining operations. Thymiamata has done them; they sent out two mobilabs and some equipment with six personnel once. The Meridiani area is scattered with smallish gold deposits."

"From the sound of the reports you've been reading for her, there are small deposits in a lot of places."

"There are. I even know of a few of them personally, from my gold prospecting sols, and I was always amazed the companies didn't snatch them up. One or two of them are right next to the Circumnavigational Highway, too." Giovanni sighed and pulled off his last clothes, then jumped in bed with her. "I'd really like to go homestead at one of them and mine my own gold. No more hassle about bosses and contracts."

"By yourself?"

"No; with a suitable partner." He kissed her forehead.

That startled Holly. "You mean, two people in the range, by themselves? That's crazy."

"No, not at all. The Circumnavigational is going to be metaled over the next decade; that means an oxygen and methane pipeline and fast road will go through the area. There's already an old oasis in the area I'm thinking about; it has a water well and a radiation shelter."

"But you couldn't just take it over."

"Yes, I think we could."

"But where would you get the equipment?"

“I’d buy it, if I could persuade my rich parents to help.”

Her eyes opened wide; the entire plan was revealed. “Well, I have a one-year minimum contract here, and I’ve been here less than two months. For that matter, we’ve been together barely six weeks!”

“And it’s been a good six weeks.”

“It has.” Her voice sounded positive, but not too positive.

“My contract is for a minimum of six months, renewable; I can do that because I have a bit of seniority in the system. So I have two months to go. I suspect I could persuade Sam to let me go sooner, too; we go way back.”

“I bet all the kids up here knew each other.”

“Absolutely. It’s not so true now, of course, when every grade has several hundred. So I could get out of my contract. And if you married me, he’d let you out of yours, too.”

“Marry you?” She laughed a bit. “Maybe I will, but not after sleeping with you for just six weeks! I don’t want to be tied down, Gianni. Now, live with you; I’m already doing that.”

“If you don’t want to be tied down, there’s nothing freer than gold homesteading out on the range, but next to the Circumnavigational.”

She paused. “Well, I think you’re right about that, but I’m still not sure whether that’s a crazy idea or not.”

“Well, sleep on it, then. You know the safety stats. After almost forty years up here, we’ve designed some amazingly safe equipment. And I’ve been going out in the range almost my entire life; I went on my first overnight excursion and hike in our sixth grade summer geology camp. It’s not a picnic, but it’s pretty predictable.”

“I’m still not used to it, completely. From what I see, the newbies divide mostly into two groups: the overly brave and the overly cautious. I’m in the latter group.”

“And a good thing that is. They say the people with extensive scuba diving experience adapt fastest.” He kissed her. “But let’s stop talking.”

She smiled. “Alright.” And she kissed him back.

“I’m so glad you’ve joined us, Bill,” said Tree Rivers, as Bill and Suzanne entered the prophet’s private study. He rose and hugged both of them warmly.

“Thank you, Prophet,” replied Bill. “And thank you for overseeing my baptism in the four elements. I am very grateful for that privilege.”

“It was my privilege, I assure you. I am delighted to see my niece so happy.” He smiled to Suzanne. “Marabica? I’m afraid our own Aram-Kona just is not as good, so I still use Marabica!”

“Thanks, I’ll have a cup,” said Bill. Tree pointed to some seats; Bill and Suzanne sat. He gave both of them coffee and offered them milk and sugar.

“How are your parents?”

Bill nodded. “Pretty well; I exchanged videomails with them this morning. The flight to Saturn is going well. Everyone on board is excited to be preparing for service in the Saturn system.”

“They’ll have more than 500 personnel in two years. It’s very exciting. They’re the crown jewel of the settlements, other than Mars of course. For now, at least. Did you tell your parents about your baptism?”

“No, they’d freak out.”

Tree smiled. “Then don’t tell them, they don’t need to know.” He turned to Suzanne.

“How are you doing?”

“Quite well, uncle. The setting up of the ecology in the new enclosure is going well; we’ll drain the marshland and plant shade-grown grasses in December, when the dust storm season begins. That’s been really fun work and the courses I took at Martech were very helpful.”

“So I’ve heard. If they won’t come here to learn from us, we’ll go there and learn from them. I’m really proud of you, Suzanne. Your grades were stellar, you made lots of friends for yourself and all of us, you found a great husband . . . what a great privilege, to accomplish so much.”

“Thanks, uncle,” she replied.

“Good.” He took a sip of his coffee. “So, are you both ready for the next phase?”

“What do you mean?” asked Bill, curious.

“Well, my recommendation would be for you to start your family soon; I suggest one pregnancy with twins, because you’re both going to get a lot of exposure to cosmic radiation in the next few years.” He turned to Bill. “I need you to come to Phobos with me next month. I want to tour the caravel and galleon manufacturing facilities.”

“Are we purchasing vehicles?”

“Maybe; or maybe we’re leasing some. I don’t know yet. We have one caravel, set up for transporting 150 people from Earth to Mars. We need another one for personnel transport and one for exploration, set up for thirty to fifty crew.”

“Caravels are fairly available right now, I’ve been told,” said Bill. “Two new galleons have been produced for immigration and a third one will be ready in time for the next opposition,

so caravels set up for immigrants should be available. And the economic situation on Earth has compromised many national space exploration plans.”

“The Belgians have committed to an asteroid belt mission, then canceled it, then committed again, then canceled again, then committed again,” agreed Tree. “The Nigerians are in, but the Chileans seem to be out. Maybe we can lease their caravel.”

“To go where?”

Tree smiled. “Themis. I’ve found it. It’s 300 meters in diameter, on average; flattened on the southern hemisphere as a result of a nickel-iron impactor. Otherwise, it’s carbonaceous chondrite; probably an extinct comet. Its perihelion is inside the Earth’s orbit, almost to Venus’s; the aphelion is almost to Mars. It circles the sun once every 450 days. Its orbit is tilted in such a way that it passes ‘south’ of the Earth and Mars, so it can’t collide with either. There’s a launch window from Mars to it opening in January.”

“January! That’s five or six months away!”

“Correct, but the time is right. I had a series of dreams about Themis several years ago and I could see it rather vaguely. This place resembles the place I saw in the dream. More importantly, Mother Earth and Father Mars told me that I would know when the time is right.”

“And that’s now?” asked Suzanne.

“No question. The price of gold has quadrupled in the last year; half that increase has occurred in the last few weeks. We’re invested in Martian gold and the profits will be huge. Now’s the time to bring another 300 people here and prepare a series of flights to Themis. The multiple-layer enclosure for the asteroid will cost close to a billion redbacks and we’ll need several hundred workers to terraform the place properly.”

“So, the first flight will be to explore it?”

“To explore it and get started! Even thirty people can get the process going, especially if they haul with them some inflatable structures to bury. They can live there and the caravel can go get more people and return to expand the facility. We may even want to buy a galleon-hab and bury it, just like the ones on Phobos.”

They’re cheaper than the fully spaceworthy galleons,” agreed Bill.

“I need research,” said Tree. “Rental costs, purchase costs, the deals others have negotiated, composition of teams to do this sort of work, skills needed, certificates needed; can you do that?”

“Of course!” said Bill excited.

“Excellent. But we’re not telling anyone we have found Themis, that we are planning deep space travel, that we want to colonize an asteroid . . . nothing. Is that clear?”

Bill and Suzanne nodded. “Absolutely,” they both said at once.

“Comiskey and Fontein metals want to back out of the deal,” said Will. He sat facing Jacquie in her office; this was too important a problem to deliver to her via videophone. “He and I have exchanged several videomails this sol. The bank has withdrawn credit from Fontein. It isn’t their fault, of course; it’s the economy. That bank is a highly respected development bank and Fontein has an excellent credit rating. There are no banks on Earth willing to extend them the necessary credit right now.”

“None?” Jacquie was stunned.

“None. You can’t close down the United States financial system for two weeks without doing permanent damage. The housing bubbles in India, Australia, Brazil, and other places have popped, so their financial systems are now seriously endangered. The talks to reunify the euro

and latíñero have been suspended, so the geo is dead once again. There is vast economic uncertainty. Banks have put most of their loans on hold in order to see what will happen. Comiskey can proceed only if there's alternate funding."

"Us? How much?"

Will paused to break the bad news slowly. "We'll have to pay for the galleon ourselves; that's a big portion of the cost. No one else will be buying them from us and we have to pay the workers anyway. The rest of the cost is to fly specialized miners and equipment from earth; about 700 million redbacks."

"And why shouldn't we buy the equipment ourselves and hire our own miners?"

Will shrugged. "Maybe we should. But long-term relationships with terrestrial companies have their intrinsic advantages down the road. Miller Mining and Sibireco are solidly established here and have made important contributions back to Marsian society. Yes, they've made profits, and the profits have largely gone back to Earth; but the money has to flow both ways. This is not to say we should be exploited, but we also can't expect money to come here in the form of investments and nothing to flow back. We have to maintain certain social and economic advantages—reliability, stability, trustworthiness—and count on them to work for us."

"Let's cut back their role to something they can afford, then," said Jacquie. "Presumably with the falling price of PGMs, their profit will be down, anyway."

"How much can we afford to support their investment, though?"

Jacquie smiled. "I wish I knew! Our two-year income projection changes hourly, up, down, up, down . . . how did you manage it? Even Park is confused."

"Then we're in trouble, because I relied on him, and his long-term guesses were usually pretty good," replied Will. "I gather Ceres can shift to a higher-platinum source and so far,

platinum has a pretty good price. Last time this happened, we cut Uzboi back and expanded the gold outposts. That's hard to do politically, but it increases the gold production and made us a huge surplus."

"The problem now is that gold production is very hard to push up; the richest sources have been depleted. The remaining new deposits that we know about are small."

"I understand you have a commission to study the economic exploitation of the smaller deposits, though. Is that ready to go?"

Jacque shrugged. "I think it has to be. We'll have to cut down on surface exploration in order to shift vehicles to mining, and that will be politically difficult as well."

"We can now make vehicles, so it won't be that bad," said Will. "So, can we provide Fontein Metals with credit guarantees?"

"Let's keep it to 300 or 400 million redbacks, but let me check with Park first, and let me see whether we can get small mining operations going," said Jacque. "Give me two weeks to resolve those questions."

"Okay. Comiskey will have to wait."

Xiaopeng Cai read over the report about the Penetrator 1 mission with great fascination. The equipment had worked flawlessly. Penelope had not proved to be an extinct comet nucleus, as expected; the chemical analysis of the rock had showed that it had come from beyond the solar system. It was the largest extra-solar body they had ever found and was worthy of extensive future exploration. The *Galileo* had achieved some important science.

His communicator buzzed. It was Wang Chenguang. "Confidentially: It appears the Chinese government will reverse its advice to Chen Wei to minimize his cooperation with you,"

she said. "I've been calling dozens of people again and again for two weeks, now, and gently persuading them."

"Congratulations and thanks for your efforts. I don't mean to minimize your hard work at all, but to what extent do you think their change of policy has to do with the economy?"

Wang Chenguang considered, then nodded. "It was both. They were moving very slowly until last week, when the Shanghai Stock Market had to stop trading every afternoon to reduce the fall. Then they came around. I don't think China will be sending a galleon to Callisto in 2076, as planned. The economy is too shaky."

"That's what I thought; it's quite bad."

"What do you make of the rumor that Mars is going to encourage dozens of smaller companies to go after small gold deposits?"

"Well, everyone seems to have heard the rumor, and no one is denying it. Mercury's restarting its Caloris gold mining operation! I don't know how Mars will manage. But we are on our way and will be there in a year; we are a reality. We have funding."

"So, are you calling Chen Wei?"

"Yes, I'll call him. Thanks for your help, Commander."

"Glad to. See you later."

"Bye." Xiaopeng Cai closed the circuit and considered what to say. He decided it was time to exert a bit more force. He opened a videomail to Charles Vickers, the American/Marsian commander on Callisto. "Good morning, Charles. Have you seen the incredible scientific results of our first penetrator mission? Quite surprising. Say, I have just heard from a reliable source that the Chinese government is relenting and will encourage more cooperation with us. I plan to call Chen Wei and let him know that we will be landing on Pads 3, 5, and 6 as planned, then will

move the vehicles close to your side of the outpost. I'll copy the plans to you when I send them to him. We will plan our enclosures accordingly. We want forty tonnes of meteorite collected by the time we land; that's about one tonne a week. I hope I can count on your assistance, if I can't get it from Commander Chen. Bye."

11.

Gold Rush

Sept. 2074

“I thought I’d touch base with you about PGM production and sales,” Vasili Ivanov’s videomail began. Jacquie Collins sighed and leaned back in her chair; exports had taken most of her waking days in the last few weeks. “As I am sure you recall, during the American-Chinese War, PGM demand collapsed entirely and Parenago shut down. But this economic down-spiral is a very different situation. While the price has fallen to a quarter of its high two years ago, demand at that price level is still sufficient and PGM exports should still be profitable. Hence we are instituting all sorts of cost cutting efforts. We certainly won’t be importing any galleons adapted for gravitied surface housing; instead we are moving work areas into the existing galleons and housing out into buried habs and trying to guarantee everyone at least six hours per day of functioning in a minimum of 0.4 gees. That will allow us to increase our personnel here by fifty percent, and lunar PGM exports should increase by 75%, to about 900 tonnes per year. Our new volatile capture systems allow us to produce all the water, oxygen, and carbon monoxide we need from the refining process itself. As for electricity, the new 60% efficient thin film solar cells are so cheap, we can produce as much solar power as we need; storage as hydrogen and oxygen and as stored heat allow us to produce PGMs throughout the nightspan. So we won’t be importing Martian uranium or reactor technology, either. One reason we can do this, actually, is because of your new Prometheus reusable shuttle is so cheap, transportation costs to Earth are revolutionized.

“In short, Parenago Station plans to remain the world’s top exporter of Platinum-group metals. I’m not sure what your plans for Uzboi and Ceres are; you have considerably cheaper

energy supplies and volatiles than we have, but we have cheaper transportation and the ability to expand or contract our human resources quickly, which you can't do. I'm not trying to rub anything in, Jacquie; I just know your situation. I don't know what you can tell me, but anything you can share that helps all of us plan long-term would be welcome. I hope you and Mario and little Mary are doing well. We're fine here. Bye."

The screen faded to dark and Jacquie stared, wondering whether Vasili was being nice or underhanded. Parenago crater, just south of the lunar equator not far from the middle of the far side, had five hundred personnel living in two galleons imported from Mars, their centrifugal spin providing considerable supplemental gravity to the moon's feeble attraction. It produced a bit over 500 tonnes of platinum, palladium, and related metals per year. Its goal had always been to increase annual production to a thousand tonnes. Now it was importing 250 more personnel—easy with Earth a four-day trip away—and pushing production up, just when the prices were falling. Parenago could fly in workers or send them home easily, which Mars could not. Parenago had no elected chief executive, no civil spaces, no public schools; it was a company town of young, unmarried people, most of whom aspired to go to Mars in the next few years. If Uzboi shrank, there were political consequences, though ones Jacquie was prepared to push against if need be.

She decided careful honesty was the best policy; Vasili had always been a straight shooter with her and with Will Elliott previously. She hit reply. "Thanks, Vasili, for the update. I'm glad to hear you are doing well. Yes, we are well; Mario's enjoying his work and Mary just started kindergarten last week. I suppose you're calling because of our announcement, yestersol, that we will inaugurate a major program to encourage mining of smaller gold deposits. The gold mining companies are all prepared to send out rotating teams from the existing outposts, and we are

hoping to encourage several small companies to start. But the purpose of this is not to shift us away from PGMs, just to make up for the decline in our projected revenues, which are as much a product of flat or slightly declining gold production as they are of the drop in PGM profits. The fact is that after over two decades of gold production at Cassini and Dawes, our two largest gold reserves are working lower and lower ore concentrations all the time, and thus can't maintain their output. We anticipate that both Cassini and Dawes may shrink a bit. Uzboi may also shrink a bit because we can get more annual export revenue per miner if small teams go after smaller gold deposits.

"So that's the plan. We're not intentionally shrinking Uzboi and we're not postponing any efforts to expand Ceres over the next three years. PGM demand is still high enough for all three places to continue expanding production. Terrestrial production is what is taking the hit, since they can't compete with the lower prices. We knew that day would come. So did the terrestrial producers, all of whom have invested in Uzboi, Parenago, and now in Ceres.

"Good luck with your expansion plans. I'm sorry you won't be buying housing or energy from us. I gather Phobos is mostly feeding your people, though, and for that we are grateful. Bye."

She sent it and wondered whether her reply was mostly a bluff. Everything she said was true. The uncertainty lay primarily in the terrestrial economy, which was tottering on the brink of another depression.

Wicahpi-Luta was in a hurry. He and Esther had a study date at 1. He dashed into the Martech cafeteria at 12:45 and grabbed a plate of food. He rolled it through the automated cashier, swiped

his credit card, and headed for a table to eat quickly. He was surprised to see Bill Hollingworth and Giovanni DePonte talking, so he walked over. “I haven’t seen you guys for ages!”

They were surprised to see him. “Sit down,” said Bill, though Giovanni seemed less welcoming. “We’re both back in town for a few sols.”

“Coincidentally,” added Giovanni. “So, you’re on your way up to Phobos to lease a caravel?”

That startled Wicahpi-Luta. Bill nodded. “With Tree Rivers. He’s decided it’s time to launch an exploration mission in the next year or so and he has asked me to captain the vehicle.”

“Really?” said Wicahpi-Luta, surprised. “Your own command? Congratulations!”

“Thanks.”

“But at a price,” said Giovanni. “He joined their cult.”

“Gianni, it isn’t a cult!”

“Well, I don’t know what you want to call it; how about weird? Do you really think he’s receiving revelations from Mother Earth and Father Mars?”

“I don’t know where his ideas come from, ultimately, but I can say he’s a genius, if you want to put it that way instead! He has several hundred thousand followers and has brought almost 500 people to Mars, built a successful outpost here, and managed to build up quite a financial empire to fund the whole thing. How many people can do that?”

“Well, my dad has done something like the financial empire, Will Elliott has millions of fans and had 12,000 followers until he retired, and Wicahpi-Luta’s mom has won a Nobel Prize!”

“Oh, please, Gianni. I don’t want to argue with you.”

Giovanni turned to Wicahpi-Luta and pointed to Bill. “He was *baptized*! Do you know what that means? Immersion into a pool of water, dunking into a mud bath—that’s the earth element—getting covered by ashes for the fire element, and standing naked for immersion in the air element!”

“Hey, it’s a ceremony, okay, and a very meaningful one for some people!” He turned to Wicahpi-Luta. “My parents don’t know, so don’t spread it around.”

“Your secret’s safe with me.” He turned to Giovanni. “I thought you were in Thaumasia?”

“I am; for a while more, anyway. I’m going gold homesteading.”

“*What?*”

“You think joining the Green World Community is crazy,” commented Bill.

“Nothing crazy about it! I’m going down to the government vehicle pool this afternoon and selecting something; I was hoping Bill can come with me, but he’s busy. I need something with at least two pressurized spaces; a ranger with attached portahab, a conestoga, a mobilab . . . we’ll see what I can get. There’s used equipment in Thymiamata and a lot of old parts in the junk yard; I know, I’ve been there.”

“But you need to have someone with you! And you need a gold deposit!” said Bill.

Giovani smiled. “And I have both of them. Holly said she’d go with me. And three sols ago, I put in a claim on 100 square kilometers of land in the Meridani area.”

“How’d you pay for that?” asked Bill

Giovanni glared at him. “I have money, you know! I’ve been working five years! I put every penny of savings into the land claim. I’ve been there, I’ve walked it on behalf of Muller Mining three years ago. We found some scattered gold deposits, but they were too small for

Muller to buy the land. I've got the reports. I even know where I'd put a house, if I ever could actually build one."

"Who's Holly?" asked Wicahpi-Luta.

"My girlfriend; we've been together two months. She's great; we're in love. She'll go with me. And she is an *incredible* mechanic; I'm good, but she's better. Together, we can do it."

"But where would you go?" asked Bill. "Just park a Conestoga somewhere and set up some solar panels? That's crazy."

"No; there's an old oasis forty kilometers from my land."

"Commonwealth use fees are quite reasonable; with this new policy, I bet they'll let you stay for free," said Wicahpi-Luta. "But two months; that's not much time."

Giovanni stared at Wicahpi-Luta. "And how long have you and Esther been dawdling? Two years? Three years? Just sleep with her, man!"

"And you mind your own business. We're taking our time and focusing on our future."

Bill tapped Giovanni. "He's a good boy, and she's a good girl."

Giovanni laughed at that.

"Well, you go off on your space mission for a new age religion," said Wicahpi-Luta to Bill, "And you go off and homestead for gold out on the range. Meanwhile, Esther and I have some studying to do. We're in a Uranus seminar this semester. And I have an internship with the icy moon geology team, and I think they're going to accept me to the team. So when we apply for the mission next year, I'll be in a strong position. Esther's credentials are coming along, too."

"So, she wants to go to Uranus with you?" asked Bill.

"She does. We do plan to get married, maybe next year. We've attended two weddings this year, and we'll invite you guys to ours."

“And I’ll invite you to ours,” promised Giovanni. “Because Holly and I will get married. She wants a stable, predictable relationship, and I think it’s a good idea, too. We’re going to be out in the middle of nowhere, after all.”

“We’ll be there, unless you get married out at your homestead,” promised Wicahpi-Luta.

The crowd at the entrance to the new Acheron campus of Mariner Institute of Technology began to dissipate. The members of the orchestra that played three pieces began to leave with their instruments; a few stray people picked at the refreshment table, which was mostly bare. Marshall Elliott stood by the speaker’s platform up front, his tablet connected to a big piece of electronic paper, onto which a map of Titan was projected.

“I think the best route for the next leg goes this way,” said Chad Sutton. He traced a route across the moon’s surface with his finger. “There are some extinct cryovolcanoes right here, and the latest aerial reconnaissance data suggests they may still have some activity.”

“Really?” said Marshall. “I haven’t seen that. That’s a funny location for geothermal activity, too.”

“Exactly. The drone flew over the site yesterday; the data are very new. I can send you the infrared photos if you’d like.”

“Sure, I’d love to see them. But I agree if there’s potential geothermal activity in that area, we should move the route. Otherwise, we’re just rolling across ice plains and around tholin dunes. This seems to be a boring area.”

“Good. I’ll plot out the new route tomorrow and submit it to the team for discussion.”

“Great. Thanks, Chad.”

Chad nodded to Marshall and walked away. Marshall picked up his tablet and broke the connection with the electronic paper, causing the latter to go dark, while Sridhar Prathan walked up to him.

“Planning a change to the expedition?”

Marshall nodded. “We’re half way around Titan and will complete the circuit in another fifteen months. What an amazing trip, too! I’m glad we decided to try it. The equipment has held up well.”

“It helps if the mobilabs stay outside all the time, and stay close to the nuke and its power.”

“And it helps that no one lives there; we telecommute in every morning, inhabit android bodies a few hours, set them on autopilot to do geological tests until we return, set the mobilabs to drive to the next site while we sleep, then telecommute back in the next morning, see the results, and make another field trip. These new androids revolutionize everything.”

“They do the same for our outside construction work.” Sridhar looked around. “So, are you pleased?”

“Sridhar, this is a *beautiful* facility. Huge, compared to our population, with plenty of classrooms, labs, and offices. I love it that our android operations facilities are part of the university, but it makes sense; all our science is located here. And the entrance area and function room; they’re very dignified and stately.”

“I have to admit that I’m very pleased how they came out,” said Sridhar. “I suspect it’ll be a while before we build anything else in Acheron, other than clearing tunnels for bioarchive and ecology, that is.”

“Yes, it seems our ecology people always want more!”

“But it’s a good thing. We need big, green open spaces. The bigger ones are actually more efficient in terms of heat retention anyway.”

“But do we have enough power to heat them?”

“That’s always the question. We need to import even more LED panels from Mars; millions of redbacks worth of them.” Sridhar glanced around. “By the way, I thought I should mention something to you. My wife and I were talking the other day and decided that we will return to Mars in 2076.”

“Really? A *lot* of people are heading back. I’m surprised. The population here will barely grow after the *Ptolemy* arrives.”

“I was a bit surprised, too. Teresa Alvaro’s heading back as well. But I think it makes sense, Marshall. There’s not a lot of reason to stay here more than a decade. Mars keeps growing; its population more than doubles every decade. So there are always opportunities for advancement on Mars; the pie is always getting bigger. But that’s not true here. You come here, you do some interesting things, then you can’t innovate much more and you’re better off leaving and letting someone else try new things. I think that’s the way it’ll be with all these solar system outposts; people will rotate between them and Mars.”

“You may be right, but as you know, Amy and I are having another child in six months, so we’re committed to stay a lot more than a decade; probably more like a decade and a half, altogether. And we’re not the only ones adding to their families. The second baby boom is well under way.”

“You’re right; I agree. You younger ones are in the position to stay. But my kids are on Mars and will soon be starting families of their own. I’d rather be there.”

“And that makes sense, too. Teresa is unmarried and able to go back and forth as she wants. If I were her, I’d be looking at the new Center for Asteroidal Studies on Phobos, or the new branch opening on Ceres in 2077. It’s going to do incredible work.”

“So will you, here,” replied Sridhar. “I’m very excited about this new campus. Within ten years, there will be a Helium 3 mining operation here; wait and see. And the Acheron Campus will be central to it.”

“I hope you’re right. Because, as you know, we’re trying to get a contract to do exactly that.”

“I know. Good luck with that; the campus will have to grow if you do!” Sridhar extended his hand and Marshall shook it. Then Sridhar headed out, leaving Marshall as the last person standing in the function room. It was appropriate; he was Chancellor, after all. He headed out of the room, leaving it to the robots to clean up the left overs.

“Are you crazy?” Silvio said to his son that evening over dinner.

I’m hearing that a lot, lately, thought Giovanni. He felt his anger rising, but caught himself. There was no reason to repeat old patterns. He was an adult. He glanced at his mother, who looked sympathetic over her spaghetti. “Please hear me out,” Giovanni replied, patiently. His calm tone seemed to impress his father. “I’ve already bought a hundred square kilometers of prime gold mining land. I know it well because I explored it for Muller Mining. It has six gold deposits, two of which should yield several tonnes of gold. I know; I helped author the study. I can email a copy to you. The quantity’s too small for Muller Mining, so they never bought it. I have two years gold mining experience at Thymiamata and know how to recover the gold from that particular type of deposit. Holly has agreed to marry me and go with me, and she is an

incredible mechanic. So there will be two of us. My land is forty kilometers from an old oasis—Airy—that has a radiation shelter and a water well, and it's 240 kilometers from Kalgoorlie Outpost. I went to the Commonwealth's vehicle pool this afternoon. I can lease or buy a ranger with portahab, a Conestgoa, or a mobilhab; I'd like to buy a used Conestoga for 300,000. Thymiamata has old gold excavation and centrifugal separation equipment that is no longer used because they now use machines ten or twenty times bigger. It's available for free; that was published in *Mars This Sol*. It's able to crush and process a tonne of ore per sol; depending on the gold concentration, it could extract as much as a tonne of gold per year, worth ten million redbacks."

"If it can extract ten million redbacks of gold a year, why isn't it being used now?" asked Silvio, scowling.

"Because at Kalgoorlie, Meridiani, Thymiamata, and all the other gold mining outposts, the gold concentrations are down to 20 parts per million or lower. That's still ten times better than some terrestrial deposits. A machine that can process 300 tonnes of ore per year will obtain only 6 kilograms of gold; that's 600,000 redbacks. You might be able to make a profit off that now, but when gold was a third as much as it is now, salaries alone were more. Gold mining companies could move the equipment into the field, but with safety issues, solar panels, and other support infrastructure, it's a risk."

"And it isn't for you?"

"It is a risk. But it's worth it, in my opinion. I'll have my own land and my own income. I'm experienced in mining, pressure suits, and repair, and Holly has the latter two as well. We can make it work; I'm sure of it."

"This is something you really want, don't you?" said Julia.

“I do, mom.”

“Why can’t you just settle into a regular job?” asked Silvio. “Out in the middle of nowhere; I suppose it’s now legal, but it just isn’t done. This is *Mars*, remember? No air, no water, no food, remember?”

“Dad, I know the range a lot better than you do. I’ve accumulated almost 4,000 hours in a pressure suit; I bet your entire lifetime total is less than that. I’m not going to go to Martech, get an MBA, and go into business. I’m sorry, but that’s not my thing; not my path.”

“Look, I don’t need to accumulate 4,000 hours in a pressure suit to know the situation. Someone is injured every year outside and someone is killed every few years. Safety standards are well defined, but people don’t always follow them.”

“And I do; you don’t play with your safety, especially out in the middle of nowhere. You keep your equipment clean and inspected, too.”

“So, you’re talking about a Conestoga and a gold mining unit?” asked Julia.

“We’ll need more than that. The gold mining unit needs up to 1,000 kilowatts; it has to grind the ore fine. So I’ll need a lot of solar power units, plus methane and oxygen storage and a Sabatier unit. I need two automated drills because you have to use a lot of explosives to prepare the ore. The ice table is about 125 meters down on my land, so I need a water well about 150 meters deep. Then there’s lots of miscellaneous stuff; two spare pressure suits, lots of spare parts, etc.”

“How much?” asked Julia.

Silvio scowled at his wife. “Julia, don’t encourage him. If we give him the money and he dies . . .”

“I won’t die!”

“That’s easy to say, sitting here at our dinner table.”

“No, it’s not something to say lightly or easily, it’s something to say based on experience. I’m 25 years old and I have five years of experience in mining, repair, geology, and construction. Who do you think Jacquie Collins is expecting to go out and mine gold? The younger ones don’t have experience and the older ones are tied down with kids.”

“She has made it very clear that she wants small companies; five employees, maybe a dozen employees. She also wants the big companies to send out small teams and rotate them.”

“She has never specified a size,” replied Giovanni. “I’ve been listening.”

“He’s right,” said Julia.

“Alright, alright. I can’t argue with both of you.”

“How much do you need?” asked Julia.

“Five hundred fifty thousand. I have a budget; I know that’s what dad expects. I’ve even written up a business plan.”

“Really?” said Silvio. “Alright, show me your business plan and budget.”

The next morning Giovanni finalized the paperwork on his Conestoga, loaded up with the spares and equipment he needed, and drove off. He was vibrating with excitement and could not believe his good fortune. He knew of one or two people—rich people—who owned a ranger, but he wasn’t sure anyone owned a Conestoga. The vehicle was a cylinder eight meters long and 2.4 meters in diameter, divided into a driving cab that could serve as an airlock; a central area with a galley, a dining area, and a loft bedroom over the cab and galley; a utility module that included a bathroom and shower; and a back room for laboratory and mechanical work that could also serve as a very large airlock. The Conestoga had four airtight sections; lots of redundancy in case of an

accident. The roof had a flat metal frame for transporting cargo and ample side storage areas that also protected the airtight compartments. The vehicle pool threw in a tonne of oxygen and methane for free, enough for him to drive to Thaumasia.

It took him ten minutes of talking to the computer to lay in a course to Thaumasia, but once he did the Conestoga headed northward and got onto the Uzboi Highway, which was metaled for the first thirty kilometers. He was irritated by the slowness of the vehicle, but there was construction ahead, so he was patient. There were all sorts of vehicles coming and going, all at a standard 45 kilometers per hour, all communicating to each other's computers. Soon he passed a new solar power farm that fed its energy to a Sabatier unit next to a water well, where oxygen and methane were made and poured into pipelines built into the Uzboi Highway that carried them to Aurorae. Later he passed a mesa to the west of the highway that was getting high-capacity wind turbines that stood 200 meters high; their power was ending up in the pipeline as well. Shortly thereafter he passed a small "forest" of cactars.

Finally, he passed the gigantic metaling unit, which leveled and compacted the ground, laid a unit of metal paving three lanes wide and ten meters long, welded it to the previous unit, and staked it to the substrate. The Conestoga drove off the metal surface, around the unit, and onto the hard-packed dirt highway, which had a speed limit of 100 kilometers per hour in straight, flat stretches.

He let the Conestoga go another ten kilometers before taking over the driving. There was no traffic, so he stopped, took over the controls, and put his foot on the accelerator. The Conestoga jerked forward and he fought for control. Even at ten kilometers per hour he went back and forth across the roadway, the computer's emergency override keeping them on the road.

Driving was harder than he thought! He slowed down until he got the vehicle under control and gradually got a sense of how the steering worked.

The emergency radio line beeped. “Conestoga 5134, this is Aurorae emergency. We have received a distress call from your vehicle; apparently it is not under proper steering control and has almost veered off the road several times. Can we be of assistance?”

“Ah . . . no, everything is under control now. I took over the wheel and wasn’t prepared for it.”

“Do you have driving experience?”

“Ah. . . no.”

The emergency man laughed. “Okay. Well, take your time, trust the computer to keep you on the road, and be careful. I’d keep it under automated control until you can take lessons. We have them every month here.”

“Okay, thanks, that’s good advice. If I have any questions, I’ll call.”

“Just ask the onboard computer! Bye!”

“Bye.” Giovanni glanced at the screen; the line had closed automatically. He concentrated on the road and speeded up a bit. It was going to take some time to learn how to drive.

After an hour he had managed to get the Conestoga up to seventy-two kilometers per hour and keep it in the correct lane. He pushed the accelerator down further and found it was all the way down. “Damn, is this as fast as it can go!” he said out loud.

“With this load of fuel and freight, my maximum speed is seventy-one point three kilometers per hour,” replied the Conestoga’s computer, which startled him, because he hadn’t asked it a question.

“Thank you,” he replied. “Please resume automated driving.”

“Automated driving resumed, destination Thaumasia.”

“Thank you.” He considered. “Computer, from now on I am calling you Goldi.”

“Goldi. Acknowledged.”

“How long before we reach Thaumasia?”

“Our speed will gradually increase to seventy-eight kilometers per hour as the fuel and oxidizer are used up. We should arrive in twenty-two hours.”

Giovanni used the next twenty-two hours well. He explored every nook and cranny of his new vehicle and “interviewed” Goldi, where she asked him questions and he asked her questions, thereby setting up all sorts of programming choices. He watched a series of videos about driving and reviewed Conestoga safety information. At the end, he was amazed he had managed to buy the thing; the pile of range certifications he had really weren’t enough.

His arrival at Thaumasia late morning on Saturdays was a surprise for the outpost control center; he had not figured out how to forward his travel information to them. They opened the airlock for garage number 3 and he drove in. As soon as it had pressurized, he stepped out and a crowd entered the garage.

“What’s this?” said Sam Anderson, whose presence surprised Giovanni.

“My new Conestoga. I’m going to Meridiani to mine gold.”

“What? That sounds . . . crazy. How much longer does your construction contract run?”

“Three more months, but it also says I can give you two weeks’ notice, so that’s what I’m doing.”

“Are you sure you know what you’re doing, Gianni? You need more than a Conestoga and a shovel to mine for gold.”

Giovanni laughed. “Sam, I bought 100 square kilometers of land that has gold. I know because I was part of the prospecting team that explored it four years ago. Kalgoorlie Outpost has one-person gold mining and extraction units that haven’t been used for about ten years because the gold concentration there is too low, but they are available. I’ve got a solar power unit and a thousand square meters of thin-film panels in the roof storage unit, which are enough to power a gold mining unit for about half the day. I’ve got pile of other things, too.”

“God bless your mom and dad.”

Giovanni nodded. “You know it. “ He looked at Holly, who was in the crowd that had entered the garage. “So, what do you think?”

“Wow, it’s incredible! What are we calling it?

“Goldi. I already programmed it.”

“Goldi?” She was disappointed. “I wish you had asked me first.”

“I’m sorry, I should have thought of that. We can change it, if you want.”

“No, Goldi’s a good name.”

“Oh, are you going, too?” asked Sam, surprised.

“We’re getting married!” replied Holly, excited.

“Oh, congratulations!” replied Sam. Giovanni stepped over to Holly and kissed her.

“So, when’s the wedding?” Sam added.

“I suppose as soon as we can get back to Aurorae, so my parents can be there.”

Holly frowned. “Hey, let’s get married here, this sol! Why wait?”

“I can marry you, as Chief Executive,” said Sam.

“Alright, we can have another wedding for my parents later,” said Giovanni.

“I’ll even throw in a cancelation of your contracts, how’s that?” said Sam. “Gold mining: it sounds crazy, but you’ve got the land and the equipment, and the Chief Minister wants to encourage it.”

Sirikit finished skimming the business section of the *Wall Street Journal* and turned to the *Shanghai Business Daily* to see what they had to say about China’s rapidly contracting economy. She soon bored of the economic details and turned to the political news; sometimes reports about terrorist attacks and government ultimatums were more useful for economic forecasting.

She dictated a quick economic and political report, something she did six days a week. Hun-jai Park took it, added a few comments, and circulated it to his economic team, who added other comments; after a few hours a summary was made and sent to Jacquie Collins. Finished, she sent it and headed for the *Barnard*.

There was a fast game a striker in the zero-gravity gym between the *Galileo* and the *Gan De*. She stopped in the transparent passenger tunnel between the ships to watch briefly and make sure Charlie wasn’t there. The game raged around her; the tunnel was the only place people could watch and it was rather crowded. It was impressive to see how well Charlie had established the game on the mission. Four teams now competed regularly.

She crossed the *Gan De* and the space separating it from the *Barnard*. Charlie, Firuz, and Jean Paul were in one of the geology labs reviewing a paper about Himalia, one of Jupiter’s outer moons. “New data?” she asked.

“Yes. There won’t be anything left for us to do,” said Charlie, disappointed.

“Well, these worlds will require a near infinite amount of research,” replied Firuz. “But the folks on Callisto do seem to be scooping us, whenever they can.”

“That’s for sure!” exclaimed Jean Paul. “They had one orbiter with a half dozen penetrators left, destined for Europa; a JPL-built orbiter no less, not a Chinese one! And they sent it to Himalia instead. They said they’d leave the outer moons to us!”

“They’re retaliating,” said Firuz. “Probably because Xiaopeng Cai asked Vickersto start collect meteorites for us, regardless of Commander Chen Wei’s orders.”

“The folks on the *Gan De* are helping, too,” said Jean Paul. “The latest paper submitted to *Nature* about Himalia—we’ve been asked to peer review it—lists 27 coauthors, and two of them are geologists on the *Gan De*. They’re supposedly focusing their research on Europa and Ganymede!”

“That’s a major breach,” agreed Firuz.

“Well, this needs to be talked through, then,” said Sirikit. “Don’t ignore this; it’ll become the focus of gossip and resentment. Talk to Xiaopeng about it. Maybe he and you can go talk to Wang Chenguang. It’s possible the *Gan De* geologists don’t know about the informal arrangement.”

“Highly unlikely,” replied Jean Paul.

“I said ‘possible.’ You can’t let relations on board deteriorate over a misunderstanding. And if it isn’t a misunderstanding, the air needs to be cleared.”

“You’re right, Sirikit,” agreed Firuz. “But it might not be easy. We don’t want to sound accusatory.”

“Confrontations of this sort are not my strength,” said Jean Paul.

“Can I bring up the matter to Xiaopeng Cai, at least?” asked Firuz. “I was asked to peer review the paper, too; I have a copy that I can show to the Commander.”

“Okay,” said Jean Paul. “And if he wants my opinion, I can provide it.”

“Good, that’ll work,” said Firuz. He picked up his tablet. “I’ll take it to him right now.”
He headed out of the lab.

Sirikit looked at Charlie. “Do you want some lunch?”

“Sure.” He nodded to Jean Paul and the two of them headed out of the lab. “What’s new on Earth today?”

“Not much. There’s another big fight in Washington over the budget and Beijing has decided to print money and stimulate inflation in order to keep unemployment down. They’re counting on the currency to drop in value anyway and it is.”

“Have you seen the article about Giovanni?”

“What article?”

“Firuz saw it on *Mars This Sol* this morning. So far, he’s the only response to Jacquie Collins’ call for the establishment of small gold mining companies. He has bought his own Conestoga and headed for Meridiani!”

“Really? By himself?”

“No, he got married; someone named Holly. I didn’t catch her last name.”

“Holly? That must be a new relationship since we left Mars. He always has been a loner and has always wanted to be his own boss.”

“He was telling you mining could be done by homesteaders, right?”

“Oh, definitely! The more he thought about it, the more convinced he became! And I think he made a pretty good case. We’ve been on Mars thirty-eight years; the technology has matured. But the Commonwealth government had companies with half a dozen staff in mind, in two Mobilabs at least; they’d have much better safety margins.”

“The interview said he had two androids as well; that will help. He can do a lot of the work via virtual reality, safely inside.”

“Say, let’s give him a call! I’m really impressed that he has done this. *Really* impressed. He’s a brave man.”

“Brave, or foolish? I’ve never been completely comfortable around Giovanni. He’s got a wild side.”

“He does, but look what has resulted! Homesteading is an important development.” She paused for the outer pressure door of the *Barnard* to open for them. They floated into the space between it and the *Gan De*, a big observation gallery that was empty at the time. She pointed to a spot where they could look out at the stars and there was a light that would illumine their faces. She pulled out her communicator, found Giovanni’s number, and held it at arm’s length so that both of their faces would be visible. “Hey, Giovanni, this is Sirikit and Charlie! We hear you were interviewed on *Mars This Sol* about your plan to homestead and mine gold. I have to tell you how impressed I am that you’re actually doing this. It’s really important and will remind everyone that we can now go out on the range this way. And it’ll allow us to exploit a much wider range of resources on Mars, too. We no longer need to do everything big; we can now do some things small. It’s historic.”

“And hey, we hear you’ve married!” added Charlie. “Say hello to your bride—her name is Holly, right?—for us. She must be the perfect partner for this adventure. Keep in touch with us, okay? We can swop adventure stories.”

“Definitely, we should but yours will be more interesting, I’m sure!” said Sirikit. “We look forward to hear from you. Bye for now.” She closed the recording and pushed send.

The videomail flew from the *Galileo's* laser communications system to the receiver on Deimos, then by microwave to communications satellite number 6, then to the Conestoga's communications system. Ten minutes after Sirikit sent the videmail, Giovanni's communicator beeped and the identifying information popped up on a screen in front of him.

"Who's that?" asked Holly. The two of them were sitting in the cab of the Conestoga as it closed in on their land. "Oh, is she your economist friend?"

"Exactly. Let's see what Sirikit has to say. Play the video, Goldi."

Goldi didn't reply, but started the videomail. They watched Sirikit and Charlie's message together. "That was nice," said Holly. "Where are they?"

"About one hundred fifty million kilometers from here, on their way to Jupiter."

"Oh, that's an adventure, too."

"Of a very different sort, though; the opposite of homesteading, you might say."

"Yes, they're going to rebuild and recreate a broken community. Not your cup of tea, that's for sure."

"That's for sure!" Giovanni pointed to the screen. "Let's record a reply. Come on, snuggle next to me, so I can introduce you."

"Alright." She slid into the driver's seat with him and he hit reply.

"Hi Charlie and Sirikit! Thanks for your message. Let me introduce you to Holly!"

"Hi!" she injected.

"We've been married eight sols; just eight sols, and what a time it has been! We got married at Thaumasia and received an incredible send off, we surprised my parents—maybe shocked them would be better—with a two sol visit, then drove to Kalgoorlie, where we got a rather cold treatment until the article appeared in *Mars This Sol* last night! I guess Sam told

Thaumasia's publicity person to call us. Some of the Kalgoorlie people thought we were crazy, but I think at least half were really jealous! Frankly, I don't think 'homesteading' is all that unusual; Will and Ethel Elliott and Shinji Nagatani basically homesteaded Aurorae in 2038. Anyway, this morning we got nearly royal treatment. The equipment pool not only upgraded us to a better gold mining unit; they gave us a used B-75! The ultraviolet coating has some cracks in it, but we can paint them over and protect the bubble's layers from damage. So we have a huge greenhouse too! We left Kalgoorlie at noon—four hours ago—and we're just about at our land now. I have to tell you something that no one has figured out yet: our land is located at almost 1° west and 1° south. In other words, we're west and south of Airy Crater; we just passed the monument at zero-zero a little while ago. Thymiamata Borough is north and west of Airy; Kalgoorlie is north and east; Meridiani is south and east. In other words, we're actually in our own borough! Not that it matters; we're 200 kilometers from Kalgoorlie and they're our 'home base' for all practical purposes. But it adds a special twist to our plans.

"Yes, we will keep in touch. Sirikit, you are the only person who asked. My parents said 'stay safe.' Sam and Madhu Anderson promised to pray for us. Most everyone else said 'good luck.' But no one said 'stay in touch.' So we will. Good luck with your adventure, too. Bye." Giovanni reached over and pushed the send icon. The reply was on the way.

The Conestoga was rolling along a set of old wheel tracks; technically, it was segment 61936, a class 1 "exploratory track." Giovanni pointed to a long, low ridge on the northwestern horizon. "That's the rim of our crater; it's 5 kilometers in diameter and is completely on our land. It's pretty fresh; estimated creation date, just 3 million years ago."

"About the time the species homo arose in Africa."

“That’s right. And you see the long, low, snaky ridge of rocks? You can’t see the whole thing; it passes to the east of our crater and runs about ten kilometers to the south and west, until it ends. That’s an old igneous intrusion; we dated it at 4.25 billion, so it’s early Noachian. The minerals in the intrusion indicate it formed under 2 kilometers of overburden; can you imagine that this place was 2 kilometers underground then, when Mars was young? The hydrothermal alteration of the megaregolith from the hot fluids associated with the intrusion deposited the gold in zones and bands ten to fifty meters past the edge of the intrusion. So that’s the area we have to work.”

Holly nodded. “On both sides of the intrusion?”

“Yes, the gold’s on both sides, but there’s more on the eastern side.”

“And where are we going to set up the Conestoga?”

“When I was here four years ago, I didn’t consider that.” He looked over the landscape in front of them; the Conestoga had slowed to only twenty kilometers per hour because it was approaching the programmed end point of their trip. “Hey Goldi, please stop; I’m taking over the controls,” he said. The Conestoga dutifully stopped and he activated the controls. He turned it and drove toward the snaky intrusion, then along it.

After a few minutes, Holly pointed. “How about right there, in that little crater remnant! We can park close to the cliff; it’ll provide some radiation protection. The flat area is perfect for the greenhouse and the solar power unit. We’re right next to the ridge and our crater.”

“Okay, looks good to me.” Giovanni turned the steering wheel and brought the Conestoga over to the ruined crater. One entire side was missing; the other side had the cliff, which was just six meters high. The floor was a flat accumulation of sediments that were white with salts and sulfates, with a thin veneer of wind-blown dust. He pulled up parallel to the cliff and stopped.

“Alright; we have arrived. This is our new home.”

“Our new home.” Holly kissed him and he kissed her back. They had arrived.

12.

Challenges

October 2074

“The situation is very simple,” said Dai Guofeng, the leading cryogeologist on the *Gan De*. His tone was more defiant than defensive. “Our colleagues on Callisto have added us to their team as equals, but because of the distance, we are not included in most of the deliberations. Obviously, with a round trip communications time of nearly an hour, this is not possible. So we were not part of any meetings that decided to send the probe to Himalia, or even the meetings that chose the penetrator landing sites. Once the probe was there, as members of their team, we received the data, just like everyone else, and we offered our analysis. So naturally we were listed as coauthors of the article.”

“So, you didn’t feel you should protest to them their decision to violate the agreement with us?” asked Jean Paul.

“The decision to send the probe was already done when we heard about it, and we don’t know our colleagues up there very well. We didn’t feel in a position to comment.”

“Do you know why they decided to send the probe to Himalia?” asked Cai Xiaopeng.

“No, they never said.”

“And you never asked?” persisted Jean Paul.

“No, we didn’t feel comfortable doing so,” responded Dai Guofeng.

“When was the decision made?” asked Cai Xiaopeng.

“I don’t recall.”

“Because a Hohmann minimum energy trajectory to Himalia takes 55 days from Callisto, and the probe arrived about 50 days after my dispute with the commander there,” noted Cai Xiaopeng. “A remarkable coincidence, wouldn’t you say?”

“I have no idea,” replied Dai Guofeng.

“I can enquire about that,” said Wang Chenguang, commander of the *Gan De*.

“Not necessary; I have my sources.”

“Then why did you ask us; were you testing us?” exclaimed Dai Guofeng, irritated.

“I didn’t say I asked, just that I can,” replied Xiaopeng Cai. “There are a lot of things I can do that can make their missions difficult, too, so maybe a little cooperation would be a better route to take.”

“Well, there are a lot of possibilities for non-cooperation,” replied Wang Chenguang.

There was a moment of silence while everyone stared at each other. Then Firuz Moulin, whom Jean Paul had invited along—since he was a fellow peer reviewer of the article—said quietly, “I’m curious what everyone considers the proper ethical response to a breach of trust?”

No one responded right away, so after a moment he added, “For example, we have in this room three people familiar with the Confucian tradition. That tradition emphasizes *li*, proper manners and ethics. We are all professionals in this room, which is just another way of saying we are gentlemen. If you will excuse the expression, Wang Chenguang.” She nodded in acknowledgement.

“So, what are you suggesting?” asked Jean Paul.

“We’ve expressed our concern that an agreement between the scientists on the *Barnard* and the scientists on Callisto has been breached. What can we do about the problem? Based on professional, gentlemanly conduct, that is.”

More silence.

“I think we all feel regret that this happened,” Cai Xiaopeng finally said.

“Yes,” agreed Dai Guofeng and Wang Chenguang.

“I feel regret as well,” said Firuz, and he stared at his boss until Jean Paul added, “So do I.”

More silence. “I wonder whether it would be possible for our colleagues on the *Gan De* to request that the Himalia data be shared with the scientists on the *Barnard*,” Firuz added.

“After all, we’ll be visiting the moon in less than two years. The probe in orbit is solar powered and will probably last ten years, so it’ll be producing data for a long time. I understand the impactors had small RTGs that will power them for years and two of them had cameras that are able to provide imagery of the surface. All of them had seismometers. That data would be of great assistance to us.”

Dai Guofeng nodded. “Yes, of course, we will press them to provide the data to you. The first set of papers will appear in *Nature* in a few weeks. Further research on Himalia really depends on the visit of a crew. Your crew.”

“Thank you,” said Jean Paul.

“I agree, that’s essential,” said Wang Chenguang. “I will *insist* that the data be made available immediately.”

“And I will make inquiries about making sure peace and harmony are strengthened on Callisto,” exclaimed Cai Xiaopeng. He extended his right hand. “Thank you for this conference.”

Everyone shook hands, then Cai Xiaopeng, Jean Paul, and Firuz left Wang Chenguang’s office. As soon as they had crossed over into the *Galileo*, Xiaopeng said, “Thank you, Firuz. I think the meeting would have been a disaster if you hadn’t intervened.”

“I hope you weren’t offended by my intervention.”

“No, not at all.”

“Well, I think we should have pushed harder,” said Jean Paul. “I hope they get us the data, as promised, but of course even if they do it tomorrow, it’ll be too late. They’ve already characterized Himalia; all we can do is fill in the blanks. They owe us an apology.”

“I agree,” said Xiaopeng. “Especially when you consider that the Marsian crew on Callisto hasn’t actually collected practically any meteorite for us, nor has anyone objected to the place where we plan to set up our outpost.”

“I hope they apologize, too,” said Firuz. “But in one sense, it doesn’t matter. As professionals and as gentlemen we need to forgive and forget. If we retaliate, they will retaliate as well, and the chain of recrimination will go on and on. We need to seize the higher moral ground and break the chain.”

“I agree,” said Xiaopeng.

“I suppose,” replied Jean Paul.

They descended in an elevator to the atrium level, where Firuz said good bye to the other two and headed for Sirikit’s office. Charlie was there, too.

“How did it go?” asked Sirikit.

Firuz shook his head. “There’s still quite a breach. It could have been worse, though. Everyone expressed regret about the whole chain of events and our Chinese colleagues will press the Callistan scientists to release all Himalia data to us.”

“That’s great!” said Charlie. “Congratulations!”

“Thanks. But there’s still distrust, resentment, and anger. I wonder whether our Coordinator of Cultural and Artistic Activities can help.”

Sirikit sat up in her chair. “Yes, I’m sure. We can do Chinese cultural events, for example.”

“Definitely. But we may need more than that. I’ve got to work on Jean Paul, and maybe some of our other colleagues.”

“How can I help?” said Charlie.

“Brainstorm about ways to create unity.”

“Maybe we can read some Bahá’í passages about unity,” said Sirikit. “They may inspire some new ideas.”

Giovanni glanced at the chronometer in the cab of the gold mining unit. Exactly 1 p.m. It was time to shut down for the sol; the solar power system he had obtained was sufficient to run the unit only six hours a sol while they refilled the Conestoga’s tanks, and he usually got started about 7 a.m. “Goldi, please shut down the mining unit,” he said. An “acknowledged” flashed on the screen and the power down sequence began. It took a few minutes. The cutting tools pulled back from the face of the hole he had already cut, which in two weeks had grown to be three meters wide and long, but only two meters deep at the most. It was still a tiny excavation. He could feel the vibration of the grinding unit gradually decrease as the ore in it reached the requisite size—sand size—and was expelled to the centrifugal unit, where it was spun in a bath of liquid carbon dioxide. This expelled the lighter rock particles and left the gold particles behind. After five minutes he could feel its unique whirl decrease as well. The unit had completed its work.

By then, the dust the cutter raised had settled or blown away as well. It was always good to wait for that because Martian dust was a constant problem and cleaning ones pressure suit of it

was an important task. He opened the cabin door—he always ran the mining unit wearing a full pressure suit with an unpressurized cabin so he didn't have to maintain its life support system as well—and stepped outside. He stopped to pull out the gold collection cup; it had a disappointing skim of gold dust that probably weighed six grams or so. Still, at current prices it was worth 600 redbacks. He carefully poured it into a plastic bag and put the cup back. He walked around to the rear of the gold mining unit and pushed a button to empty the tailings hopper. Five hundred kilograms of chewed up, sand-size rock particles poured into a plastic tub resting in the back of his buggy, a golf cart sized vehicle. He closed the empty tailings hopper, hopped into the driver's seat, and headed for home.

The Conestoga was just one hundred meters away. They had christened the little half-enclosed depression it rested in "Home Crater." Next to it was a thousand square meters of horizontal thin-film solar panels, spread out in two-meter wide strips so they could walk between them to remove dust periodically. The panels generated up to 150 kilowatts of power during the day. Nearby was their "solar power unit," a plastic cylinder thirty meters in diameter and thirty-five meters long. At the moment it was rolled over on its "back," its aluminized mirror surface pointing straight up at the sun overhead, concentrating light onto the line of solar panels running along the top of the cylinder. The result was a continuous 200 kilowatts of electricity and 200 kilowatts of heat from the unit. A cable carried the former to the Conestoga's Sabatier unit and its oxygen and methane tanks; a tube carried heated air to the Conestoga and B-75, but most of it was expelled into the atmosphere.

The Conestoga was nestled against the southern cliff of Home Crater. Attached to vehicle's rear was a cubical "docking unit" to which their B-75 bubble was attached at right angles. The docking unit had a pressure suit cleaning porch attached to it as well, which emitted

a powerful blast of carbon dioxide to blow dust off. Giovanni backed the buggy up against the cleaning unit's porch, then climbed out of the driver's seat and opened the docking unit's door; at that moment it was depressurized. He lowered the buggy's rear ramp and slid the tub full of ground up rock particles into the docking unit. He closed the door of the docking unit and triggered the pressure suit cleaning system; for thirty seconds a powerful blast of carbon dioxide buffeted him while he brushed his suit with a duster. Suit clean, he entered the docking unit and turned a mechanical valve to fill it with air from the B-75. That didn't take long; the B-75 was inflated at only a tenth of an atmosphere. He opened the door to the B-75, dragged the tub of rock particles inside, and poured them onto a pile that rested on a plastic tarpaulin; after 14 days it was becoming substantial in size. A pile of sand and clay they had excavated from a sedimentary deposit nearby stood next to it. Eventually they would mix the two and start to plant in their greenhouse. Giovanni paused to look down the 75-meter length of the space, which was 35 meters wide and high; it was a huge enclosure and he couldn't wait to have it pressurized enough to use without a suit. The Conestoga was getting a bit confining, even with daily excursions outside.

He stepped back into the docking unit, closed the door to the B-75, and drained out the ozone-tinted air from the B-75, and flooded it with air from the Conestoga. A minute later he was able to open the door and step into the rear lab module of the Conestoga. Holly was waiting there to help him take off the pressure suit. "Good afternoon," she said, and he could hear her easily through the thick air of the Conestoga. He nodded back to her and closed and latched the door. Holly took an electrically charged cloth to the pressure suit to mop up any stray dust while he pulled off his helmet.

"Any news?"

“A bit. My emails have finally generated a response from the Ministry of Transportation. They have no idea how much they’d charge us for hauling a metal radiation shelter here. They asked me whether there was still one at Airy that they could move!”

Giovanni laughed. “They don’t even know what they have? The radiation shelter at Airy was relocated when the Meridiani Highway was rerouted to pass Kalgoorlie. That must have been twenty years ago!”

“But they did say the water at Meridiani is free if we can get at it. They weren’t sure the well was working anymore.”

“That’s a lot of help. There’s no power supply at Meridiani any more so there’s no way to get water out of the well. It’d all be frozen solid down there anyway, so the piping wouldn’t be of any use and we’d have to run new tubing down to get the water out.”

“There should be a big ice block in the shelter, though. Maybe a tonne of water.”

“We could go get it, bring it here, then replace it when our well starts to produce. How is it doing?”

“Nothing yet.” She paused to help him unzip his pressure suit and climb out, then put his life support pack in a recharging station. He was wearing just underwear and she watched him pull on shorts and a tee shirt. “The drill is down 110 meters; it made another 8 meters yestersol. The cuttings were five percent water by mass. So we’re getting close.”

“Airy’s well was just 120 meters. It sounds like we have another 50 meters to go.”

“I’m afraid so. How much gold did you get?”

“Let’s see.” Giovanni pulled out the bag and put it on a scale. “Five point five grams. I worked through 500 kilos of rock, so the spot is still running 10 parts per million.”

“Disappointing. Maybe we should start another hole.”

“I suppose. The problem is that it’s easy to spot a streak of gold on the surface, but you have no way of knowing how much there is underneath. For all we know, morrowsol we might recover 500 grams. Let’s eat, I’m starved.”

She nodded and opened the door to the main room of the Conestoga, where she had rice, vegetables, and a beef soup ready. They sat and Giovanni began to eat fast. “Slow down!” she said.

“Sorry; I’m hungry!”

“I’m sure. So, nothing broke?”

“Nothing broke, but I think we’ll have to clean the centrifugal unit in two or three sols. Maybe we can nurse it along until Sunsol, then haul the centrifugal unit and the grinding unit inside and do routine maintenance on both.”

“At least we’ve managed to go five sols without anything breaking!”

“It’s still not producing as much as they said it would, though. What about the remote control software?”

“It’s definitely for the AU-175B series, not AU-175A. I still haven’t heard from the Martech IT Department how much it’ll cost to modify it. We may be better off getting a 175B.”

“Does Kalgoorlie have any?”

“I’ll check. But I gather everything has been spoken for, by now, even though no one has come to pay for anything. We’re still the only ‘company’ that has responded to the call for small-scale gold recovery.”

“Consolidated is sending out teams to several deposits near Thymiamata, though. I suspect that’s how most ‘small scale’ gold recovery will happen.” He shook his head.

Holly was surprised by his reaction. “Well, don’t think everyone else is cowardly. They think we’re foolish!”

“And we’re doing pretty well! We’ve already recovered 5,000 redbacks of gold. Once we really get going, increase our hours running the unit to ten or twelve, and find a good spot, we should be bringing in several hundred thousand redbacks per year.”

“Gianni, we want to pay your parents back and we need a couple hundred thousand redbacks of more equipment. The Conestoga’s Sabatier isn’t designed to convert several thousand kilowatt hours of power into methane and oxygen per day; we’re going to burn it out eventually, and then we’ll have no power storage. We need two extra Sabatiers. Right now, if we drive the Conestoga anywhere, we have to turn off the solar power system entirely. Dust storm season starts in three months; we need more panels and a lot of power storage. But for that, we have to have a hydrogen source, and we still don’t have water.”

“We can go to Airy and grab the ice there. We could leave after sunset, drive up, get the ice, and drive back before sunrise, so we wouldn’t miss any solar power.”

“And we’d only get a tonne of ice. We’ll have water from our well in a week or so, anyway. That’s not the problem. We need two more Sabatiers, another thousand square meters of solar arrays, methane storage tanks, oxygen storage tanks, another buggy, eventually another gold recovery unit, a radiation shelter . . . it’s hundreds of thousands of redbacks of stuff. Not to mention food. We have two weeks left.”

“We’ll have to plan a trip to Kalgoorlie to buy more; we already have the gold for that. I think we need to go out and walk the deposit every afternoon, too, because right now we can pick up more gold than we can recover with the unit.”

“Are we going to get more sand and clay for the B-75 this afternoon?”

“Sure, but that’ll take us only an hour or so. Let’s go look for gold, too.”

“Okay. I have my chores done around here. Conestoga maintenance is on schedule. I’d like to start running the gold recovery unit, Gianni; I’m getting bored with the tasks I have. I think we can increase the hours to eight per sol and split it into two four-hour shifts, one for each of us. We’ve pretty much run out of spare water for making methane and oxygen; the tanks are full, so we can’t store any more power. We’re better off moving the mining unit a bit closer to the Conestoga and running a power cable to it. If we run it off the electricity from the solar power system, that’d reduce the strain on the Sabatier, too.”

“We wouldn’t be swapping methane and oxygen tanks every sol, too; that takes time,” said Gianni. “Let’s look for another spot, then.”

“Good.”

They finished their lunch, drank some tea, and suited up. Once they were outside, Giovanni put a pick, a hoe, and a shovel in the back of the buggy. They climbed into the two seats in front and headed for the gold bearing zone, the closest part of which was only sixty meters away. They parked the buggy and walked along the gold bearing zone, scraping the ground periodically with the hoe.

“Here’s one!” said Holly. She reached down and picked up a nugget the size of a pea.

“Pretty good; that weighs more than the entire bag of gold dust I dug this morning!”

“And it’s pretty.” She looked at him through his helmet. “I know we don’t believe in luck, but let’s move the digger here morrowsol.”

“We don’t need to believe in luck; we have evidence.” He pointed to the nugget. “Goldi, how far are we from the Conestoga’s electrical outlet?”

“Seventy-one meters,” replied the Conestoga, which was listening to their entire conversation.

“Good; we have a two forty-meter heavy power cables.” Giovanni looked around. It was 3 p.m.; they still had three hours of light. He pointed. “Let’s head for the rim of Holly Crater.”

“Do you have to name it after me?”

“Why not? I love you, and I’d kiss you right now if we weren’t separated by helmets!”

“Why are we going up there?”

“I don’t know. A hunch.” He pointed to the buggy. Then climbed in and he drove them over to Holly Crater, about a kilometer and a half away. The outer rim was rough and bouldery, but he steered around the rocks and worked his way up to the crest. They got out and looked over the big bowl, which had scattered dust drifts on its floor.

“We’ve hiked around inside here before.” Holly pointed to a trail of tracks that was still visible several hundred meters away.

Giovanni nodded. “I know.” He surveyed the rim. Nearby was a crater about a hundred meters in diameter that was much younger than Holly Crater itself; perhaps half a million years old. The layered remnants of dust accumulation showed that the crater had once been filled with wind-blown drift to its top, and that a shift in prevailing winds was excavating the dust.

He frowned and grabbed the shovel and hoe. “What are you doing?” she asked.

“I’m not sure.”

Giovanni walked over to the little crater and stepped onto the layered dust. It was firm and consolidated, not loose as it normally would be. He walked to the center of the crater and began to excavate with the hoe, which smashed the dust into chunks that could easily be pushed out of the way. Holly stood there, watching, puzzled.

He dug for about five minutes and had a hole well over a meter in diameter and a meter deep. Finally, the hoe hit something hard; Holly could see it and assumed that Giovanni had cut all the way through to the ground underneath. Giovanni scrapped around the bottom of the hole and reached down to pick up a hard piece of dust, which was dark. "Could you get me the pick?"

"Sure." She walked over to the buggy and brought the pick back. Meanwhile, he had exposed the dark floor of his hole; dark with flecks of white in it.

"He took the pick and swung it with great force, smashing a pointy hole in the dark layer. Three more swings, and a chunk popped loose. He picked it up, smiled, and turned it over. "Look! Ice!"

"Ice!" She hurried forward and took the chunk. Sure enough, the dark layer was dark because it was frozen dust, and underneath there was a layer of white. "How did you know?"

Giovanni paused to think. "I'm not completely sure. But wind-blown dust doesn't consolidate into hard layers very quickly. This is a little crater on the rim of a three million year old crater, so this little crater isn't very old and the dust should still be fairly fluffy. But it isn't, because there's a water layer underneath from Mars's last estival two million years ago, when there was snowfall at the equator. So this little crater filled with a snow drift back then, then the dust drifted over it, the estival ended and the snow layer very slowly evaporated. The water worked its way up through the dust, sometimes as vapor, sometimes as frost, sometimes briefly as liquid, and when it was in its liquid phase it cemented the dust particles together. That's why this dust is layered and a bit hard."

"So, you've seen this before?"

"Once on a high school field trip to a crater about twenty kilometers from Aurorae, but that crater didn't have any snow left. They usually don't!"

“How much water do we have here?”

“I have no idea; probably a few tonnes. Let’s drive the buggy over and fill the hopper in the back with as much ice and frozen dust as possible. We can put it in the B-75 where the heat will melt the ice and the dehumidifier can capture the water for us.”

“Can you help me with a purchase?”

Sirikit looked up from her economics reading; she had been so immersed that she hadn’t heard anyone step into her office at the store. The man who had entered was East Asian and about 30. “Certainly; how may I help you?”

“I wanted to purchase a traditional Chinese shirt and was told before launch that I could buy them from the store, but I can’t find anything on the website.”

“Yes, that would be a special order. You won’t find it in the catalog.”

“Even my personal assistant couldn’t find it!”

“It probably tried the wrong key words. Here, come sit.” She pointed to a chair next to her and moved over. She pushed an icon to clear the screen. “Eddie, this is a special costume order through the store,” she said to her automated personal assistant.

“Alright, how can I help you?”

“Oh, I had to use the word *costume*? That’s rather obscure!” said the man.

“I agree. Eddie, can you add more key words to *costume* order, such as *special clothing* or *traditional clothing* or substitute *outfit* for *clothing* where textually appropriate?”

“Certainly, Sirikit. Those are important clarifications,” replied Eddie.

“Oh, that’s right, you’re Sirikit.”

“Yes; Sirikit Thanarat Langlais. I’m using both last names. What’s your name?”

“Xianglong.”

“Xianglong . . . what’s your family name?”

“Chen. Chen Xianglong. But just call me Xianglong. They use both on the *Gan De*, but here I just use Xianglong.”

“Okay. I see you over here a lot, I think.”

“I work in environmental management on the *Gan De* and we have a lot of collaboration to do with environmental management here and on the *Barnard*. People move around, eat on different ships, leave their waste on the different ships . . . so we’re constantly transferring volatile inventories.”

“Oh, of course. But most of that can be done by email and web, right?”

“Sure, but face to face is always best, don’t you think? And while we can transfer gasses via the passenger tunnels, water has to be put in bags and transferred from a rotating environment to a non-rotating one, then to another rotating one. We could do that robotically, but again, isn’t face to face better?”

“Absolutely.” Sirikit smiled, delighted to meet someone so naturally friendly. “I think we need a lot more face to face, frankly, especially after the tension recently.”

Xianglong nodded vigorously. “That’s between the scientists and the managers, of course. The people in environmental management work together all the time. We have to. We’ve specialized our hydroponics and horticulture. The *Gan De* raises all the rice used on all three ships, but the *Barnard* raises the strawberries and the *Galileo* raises all the wheat, cotton, and corn. The *Galileo* does all special fabrication, like clothing.”

“Oh, yes, your costume. But first, let me ask you: how can we bring the scientists and managers together more? I’m responsible for cultural and artistic activities, but I don’t have

access to the talent database on the *Gan De* so I don't know who there can do what, and not many people have volunteered."

"Ah. That can be solved. Come have dinner and ask."

"Alright. Can I bring my husband, Charlie Langlais? He's part of the Center for Asteroidal Studies."

"Of course! Come to dinner and sit with my wife and me, we'll introduce you around and make you comfortable. I'm sure Commander Wang will let you make an announcement about cultural activities. I can introduce you to some people, too. We have several very capable musicians, including Wang herself."

"Really? She never told me."

"No, she wouldn't, and I doubt you can get her to perform, but it's worth asking."

"Oh, yes! Let's order that special item of clothing for you. We don't have real silk, of course, but we have several excellent substitutes. Do you have design specifications and a color scheme?"

"I have a photograph of myself wearing the clothing in question; I was told that would work."

"Yes, if the pattern is clear enough, and if we can input a few real measurements, like arm and leg length and waist size."

"I have that. How long will it take?"

"The team in fabrication promises three to five days max, and lately they've been turning around orders in 48 hours. A full suit of clothing, as I suspect this is, can only be ordered once every six months, you know, though we can arrange for extra orders with the Commander's approval."

“No, that’s not an issue. This is the only item I plan to order for this half year. Let me pull up the picture.” Xianglong pulled out his communicator and found the picture, which Sirikit asked him to email to her. Eedie magnified the image and said the pattern and colors were clear; he gave a few measurements and Sirikit used a tape measure to verify them; Eedie asked a few additional questions, because the costume had loose sleeves and generally looked baggy; Xianglong offered a few explanations; and that was it. It would be ready early next week, price 500 redbucks. Sirikit finalized dinner plans and Xianglong headed out of the store. She turned to her communicator and called Charlie.

“Hello, love,” he began the conversation. She loved to hear him call her “love.”

“Hello, love. Say, we now have dinner plans tomorrow evening. We’ve been invited to the *Gan De* by a member of the environmental management team.”

“Oh? How did you manage that?”

“He just came into the store. Chen Xianglong; a really relaxed and friendly fellow who is also concerned about relations between the two crews.”

“Excellent. Alright; it makes me a bit nervous, but if we have an invitation, that’ll work for sure. I’m very much a junior member of the team here, too, so I’m not a ‘target’ for anything.”

“Good. We’re meeting him and his wife at 6 p.m.”

“Are you sure mama’s down here, dad?” asked Willy to Marshall.

“Yes, she said she was in B-4. It’d not too far, don’t worry.”

“I’ve never been in B-3 or B-4, right?”

“That’s right. How was kindergarten today?”

“They gave me a birthday party!”

“I thought they would! Five years old! Cake and ice cream?”

“Strawberry ice cream and chocolate cake!” They were Willy’s favorites.

“Great! Did mama make it? I’m sorry I couldn’t; we had a Titan Council meeting.”

“Yes, mama was there. Are you still coming to read to my class tomorrow?”

“I am.”

They exited day care and entered Acheron Outpost’s main corridor. “What do you have in the basket?” asked Willie.

“Supper.”

They continued down the corridor fifty meters to a large doorway. Marshall said “open please,” and they entered N-7 “Acheron Park.” Their oldest biological enclosure, it was now mostly grass, with a few trees at each end; it was perfect for kids, and Willie began to leap across it in huge, high loops that carried him ten meters at a time. Marshall followed in smaller, lower leaps; raised in Martian gravity, he hadn’t fully adjusted to Titan’s 1/7th gee the way the “natives” had.

At the far end he asked the door to B-1 to open—all adults were able to do so—and they entered a tropical rainforest. The vegetation, just a year old, was already taller than Marshall; the heat and humidity made him instantly sweat. Willie hesitated, then followed his father. “What’s that hooting sound?”

“Little tiny tropical frogs. I’m told they’re deafeningly loud at night. Look at that gorgeous flower!”

“Wow! What is it?”

“I don’t know. You’re the Titan native; in first or second grade you’ll find out and then *you’ll tell me.*”

Willie chuckled. The trail running through B-1 bent to the left and went over a little brook flowing down the slope; in its 100-meter length, the enclosure dropped 10 meters. Acheron Creek meandered to the left as well, then headed right and disappeared into the baby jungle.

They reached the far end of B-1 and the dirt trail bifurcated; straight ahead a sign said “B-2 May” while the right fork said “B-3 November.” Willie read the signs aloud. “Why May and November?”

“Wow, one month into kindergarten and you’re reading November. I’ll show you.” Marshall led them along the right fork following the shore of a small, shallow pond resting against the downhill end of B-1. The water of the pond entered pipes that led to both of the next two enclosures. The door to B-3 automatically opened for them and they passed through a short airlock. Beyond it, another door opened and they were hit in the face by chilly, dry air.

“Oh, dad, did we have to go this way?”

“Well, you asked! This isn’t too cold, and it’s only 100 meters long. This will be a ‘temperate forest.’ ‘Temperate’ means it has winter; tropical climates have rainy and dry seasons, but no cold season. The winter in here will last only a month or so, instead of three months, like on Earth. ‘November’ means it’s late fall in here, which is the time when it’s cooling off before winter.”

“But all the trees in here are still babies. Shouldn’t they have some warm weather to grow first?”

“Don’t worry, they will. They can handle the cold weather just fine; they’re adapted to it. And B-3 won’t get very cold anyway.” He pointed left. “B-2 is the same size, but is half a year ahead; it’s almost summer in there and warm. And do you see that this enclosure is turned to the right, compared to B-1? The bioarchives will make a circle around Acheron outpost, but every pair of enclosures will go deeper. That’s a spiral; do you know what a spiral is? Marshall moved his right hand to demonstrate.

“Round and round, and down.”

Exactly. Let’s get out of here before we shiver.” Marshall pointed and they bounded across the grass, avoiding the saplings, which were clumped into groves. Willie went a bit too far on the last leap and landed in the shallow water of the pond at the downhill end of the enclosure. Marshall pulled him out of the water and helped him shake some dirt off his pants. “Your mom will kill us.” He looked up, puzzled. “Oh, what a pain; there’s a door here to B-5, but not B-4!”

“So do we go back?”

“No. Maybe there’s a connection; I’m sure there’s a connection at the far end. Come on.” Marshall led Willie toward the door to B-5, which didn’t open automatically. “Open, please,” he asked.

It did, so they went through a short airlock and entered B-5. Bare dirt and metal greeted them, much to their surprise, but it was warmer. The sky glowed like a thick, white overcast; plenty of light to see, but a lot less than in the other enclosures. “No brook!” said Willie.

“You’re right. I guess all the water goes into B-4. But you see at the end, the sign on the left says “B-4? Let’s go that way.”

“Alright.”

They started walking across B-5. The dirt was still bare, except a short fringe of baby grass growing in the first 15 meters of the enclosure. Two cottonwood saplings grew near the left wall; the metal wall on the right was covered by a plastic “wallpaper” scene of savanna stretching to the horizon. Marshall explained the idea that drier environments had grass instead of trees as they walked the length of the enclosure. Climbing down the three meter slope of emplaced “dirt” onto the metal floor was tricky and the metal floor was a bit slippery in the low gravity. They were both glad to get to the door to B-4.

It was actually a tunnel forty meters long, rather chilly and dark. But the far door opened and they walked into a warm, brightly lit, grassland. The grass was well established; some tufts were nearly three meters tall. The sky was a clear, bright blue with a line of very bright clouds along the far side. The walls were covered with scenes of open, hilly grassland with scattered trees. Amy was at the far end and was surprised to see them come in where they did.

“What are you doing there? You aren’t supposed to be in B-5.”

“The door opened for me; I didn’t know.” Marshall replied at an ordinary loudness of voice; Titan’s thick air transmitted sound very well.

“It must be because you’re a Council member. Anyway, welcome to Texas. You were just in Highveld.”

“It’s not done, yet,” said Willie.

“No, not yet; another two months. B-6 and B-7 are just metal shells; one’s going to be temperate rainforest and the other taiga, which is a very cold forest with fir trees. B-8 will be tundra, which is a sort of cold desert. But they won’t be ready for another year and a half.”

She had been walking toward her two men as they walked toward her. When they met, she grabbed Willie. “Happy birthday again! That was a great party, wasn’t it?”

“It really was. Monica’s birthday is next week, so we get to have another party then!”

“That’s fun. I’m glad you guys came here. I’m just about done with my field notes, too. This place is really growing well.”

“Are there any animals?” asked Willie.

“Just insects and a few insect-eating birds, but next week we’ll put in two fences to divide Texas into thirds, and we’ll put our cows in here. They’ll go in Highveld, too, once it’s ready. Come on, let’s go eat supper.” Amy headed up hill toward the exit to B-2. In a moment they entered a Mediterranean climate: hot and dry.

“Why does Earth have so many climates?” asked Willie.

“Because it’s big and some parts get more sunlight than others,” replied Marshall. “It’s a good thing because every climate has a different set of plants and animals, and this way we can have them all and benefit from them.”

Amy led them to a picnic table and Marshall began to pull out sandwiches, salad, and little slices of birthday cake. “The cows could eat the grass in here, too,” said Willie.

“We cut it and feed it to them in their stable. If they come in here, they’ll eat the trees, too. Those are cork oaks; they’ll make cork for us someday, which is a very useful, soft, spongy bark. Those are olive trees; in a few years they’ll bear olives, which are a delicious fruit. B-2 has orange, lemon, lime, grapefruit, pomegranate, and almond trees. B-3, which you must have walked through, has apples, peaches, pears, plums, nectarines, and apricots. Lots of good stuff! Some of its trees will be moved to B-6 and B-7 later.”

“Here.” Marshall handed Willie and Amy plates of food. They all began to eat. As they ate, the sunlight began to fade a bit as the enclosure moved toward dusk. When they all got to the birthday cake, Marshall looked at Amy, who nodded. “We wanted to tell you something special,

honey,” Marshall began. “You may remember that mom was kind of sick, until about a month ago? And now she is eating a lot; maybe you’ve noticed that. The reason is because she’s going to have a baby.”

Willie’s eye lit up. A baby?”

“That’s right, dear. You’re going to have a sister.”

“A sister? But I want a little brother!”

“Well, I’m sorry about that, but God has given us a little girl,” replied Marshall. “She’s going to be born sometime in early March.”

“A sister.” Willie looked down. “I wanted a brother.”

“It’s okay,” said Marshall, putting his hand on Willie’s shoulder. He looked at Amy, who was disappointed, and shrugged.

The cafeteria on the *Gan De* was crowded, and when Sirikit and Charlie entered, much of the crew paused and looked up at them. “There’s Xianglong,” Sirikit said, waving to him. He and his wife waved back and pointed to chairs at their table.

She and Charlie went through the food line, loaded their plates with various items—they weren’t sure what all of it was—and walked to the table. “Welcome!” exclaimed Xianglong.

“Thank you for coming! This is my wife, Xiaozhuang.”

“But call me Mia,” she replied.

“Thank you,” replied Sirikit. “I’m Sirikit Thanarat Langlais.”

“And Charlie Langlais,” added Charlie, shaking hands with Xianglong, then with Mia.

“Thanarat; is that Thai?” asked Mia.

“Yes, my father is Ananda Thanarat; who arrived on Columbus 6.”

“So, you were born on Mars?” asked Mia.

“Yes. So was Charlie, though he went to Ceres with his family about ten years ago.”

“So, your father is Helmut?” asked Xianglong.

“Yes, exactly.”

“Sit down, please,” said Xianglong. “Let me introduce you to my friends.” He proceeded to point to four others at the table, two couples, and to name each person.

“I apologize in advance that I won’t remember your names,” said Charlie. “I need some lessons in Chinese in order to remember the various elements making up the names.”

“Yes, exactly,” replied Lai Zicheng, who was an environmental engineer. “Our names always have a meaning, and if you know the meaning, you can remember the names.”

“So why did you want to eat here with us?” asked Wen Chonghuan, a systems engineer.

“Why not?” asked Sirikit. “All of us are free to eat on any ship. And I am the Cultural and Artistic Director for the flight. I have no way of know what talents are here on the *Gan De*; how else can I find out?”

“Sirikit wants to arrange Chinese musical concerts, plays, and lectures,” added Xianglong. “Wouldn’t it be marvelous if there were such events on the *Galileo*?”

“I’d love to see a film festival,” said Lai Zicheng. “There have been some incredible Chinese films released recently.”

“Yes, that’s true,” agreed Mia, nodding.

“If you name the films, I’ll arrange it,” said Sirikit. “That’s my job; I have the time. That’s not difficult to do, either.”

“Would you show the films here, or on the *Galileo*?” asked Wen Chinghuan.

Sirikit pondered that. “Why not alternate, so everyone goes back and forth?”

The Chinese nodded, that was a good idea. “Lai Zicheng is a sort of movie expert,” commented Mia. “He’s always offering his opinion.”

“So is Sun Taiji,” noted Lai Zicheng. “And we often disagree. Maybe the two of us can recommend the movies, then debate them afterward!”

“Good idea!” said Sirikit. “Everyone enjoys a lively discussion.”

“It’s something everyone can be drawn into, also,” said Charlie. “There are a lot of opinionated movie buffs on all three vehicles!”

“I have a question,” said Sirikit. “Is there anyone on board who is something of an expert on Confucian ethics?”

“Why? Those rules are 2,500 years old,” replied Lai Zicheng.

The others looked at each other. “I’d say, everyone here falls in one of three categories,” said Hong Cixi, a physician. “Confucian ethics are old, superstitious, and irrelevant; Confucian ethics are of no interest; and Confucian ethics have been modernized and therefore are interesting and relevant to us. I fall in the third category.”

“But there’s no one on board who can speak about them, I’d say,” said Xianglong to her.

Hong Cixi considered. “Yes, I agree. But there are some very interesting and important experts on Earth, like Li Wangming.”

“I bet we could sponsor a seminar with a few of them,” said Sirikit. “We have the budget to pay them to speak to us. One would speak, we’d respond and send questions, we’d listen to the second one speak, we’d send more questions, then we’d hear their responses. We can cover up the time delay quite skillfully.”

“But would we get an audience?” asked Charlie.

“I think we can get a few dozen from the *Galileo* and the *Barnard*,” replied Sirikit.

“And half our crew would participate,” said Hong Cixi. “We could ask them to address a subject relevant to us, like ‘Twenty-First Century Confucian Ethics for the Jupiter Settlement.’”

“Perfect!” said Sirikit. “Can you give me names of scholars to contact?”

“Absolutely; the top people,” said Hong Cixi. “And this is something the Chinese government will fund, I am sure. They’d love to get publicity for supporting such a conference.”

“I suspect you are right,” said Sirikit.

“What about more Chinese food on the *Galileo*?” asked Charlie. “These dishes are delicious but we don’t have them over there.”

“Easy to arrange; talk to the culinary departments,” replied Lai Zicheng. “But that’s really a token thing. Music, art, Chinese opera; these are better. But they’re also superficial. All of us know English, but none of you know Chinese.”

“Not ‘none,’” corrected Mia.

“Alright. Fine. Five people over there speak Chinese. Does that undermine my point?”

“Not at all,” replied Sirikit. “We could sponsor Chinese classes, too. I think that would be excellent.”

“No one will achieve fluency,” said Mia. “But any use of the Chinese language shows respect.”

“Yes, exactly,” said Lai Zicheng. “And by the way, I have a certificate in teaching Chinese as a second language.”

“You’re hired!” said Sirikit. “And you have two students already!”

“You do!” agreed Charlie, though he was more surprised than enthusiastic.

“Sounds like you have a full program,” said Xianglong to Sirikit, with a smile.

13.

Future Plans

December 2074

The sky overhead was gray; the sun was a ghostly yellow disk, barely visible. Jacquie Collins looked up at the dust storm and the talcum skim accumulating on the dome of Andalus some forty meters over their heads, then across the crowd of forty that had gathered on the top floor of the Gallerie to discuss Mars's future plans.

"Thanks, everyone, for coming, in spite of the Category 3 storm," she began. "I wonder whether we're better off out here watching the dust fall like snow, or inside? At least it isn't cold; those sols are past. I'm inclined to stay here among the potted plants for the morning, at least."

"Definitely," said Henry Smith, head of the Chamber of Commerce, so Jacquie nodded.

"Alright, we have our first agreement, then. I've invited all of you to discuss elements that will go into my 'State of the Commonwealth' address on January 3, 2075; just a month away. The address will define priorities and will shape the budget for the twenty-first annum that starts in August. Among the details: the size of the immigration wave for the twentieth columbiad, starting next fall; the tentative size of the immigration wave for the twenty-first columbiad; expansion of the private sector, ship building, mining, and university facilities; resources devoted to Uranus, Saturn, Jupiter, Ceres, and Mercury; and resources devoted to such important matters as corvet production, advanced space propulsion, space power production, cryogenic materials research, and Helium-3 production. We already have a pretty good idea what priorities we will pursue, but this is an opportunity to share, debate, and refine them. Hun-jai Park, will you start us off with an economic forecast?"

“Certainly,” replied Park. He rose and his first slide appeared on the screen up front. “I was afraid the slides would be hard to see in the sunlight, but that’s not a danger, unfortunately! You all know the situation on Earth. The ‘Cold Peace’ continues. The second failure to revive the Grand Union and the failure of plans to strengthen the United Nations reflect a paralysis of decision making and of will on Earth. The principal impact is the world economy, which has grown too integrated to function without regulation. On Earth they are saying, ‘without coordination’ but that is too weak; it needs more than coordination, there need to be international bodies—I won’t use that weasel word ‘transnational’—that actually regulate, levy fines, collect modest taxes of their own, etc. The collapse of the geo is the main consequence of this lack of will. Will the nations muddle through? Certainly. But if they muddle through, *all* they will do is muddle. Economies will remain stalled. Debt is too high in the US, Europe, and most nations in East Asia and Latin America, for them to borrow or print money to get out of the crisis. The US can’t expand its money supply because the rest of the world is no longer willing to absorb it.

He switched slides. “What are the consequences for us? First, gold prices will remain high; probably 2,000 to 3,000 redbacks per ounce, or 70 to 100 million redbacks per tonne. This is high enough for gold production to continue on Earth, by the way, and the Caloris mine on Mercury is reopening. The terrestrial middle class is now so huge that gold demand will remain strong. Our gold production should continue at close to 500 tonnes per columbiad or 250 tonnes per year. So far, we have not seen practically any small gold mining companies emerge, but that will probably change over the next year or so. They could push up production ten to thirty percent, but we will need some stimulus to bring it about.

“Second, PGM demand has not collapsed, like it did during the Depression five years back. The terrestrial economy is stalled at its level of 15 years ago, but that’s a level where

Platinum and Palladium, in particular, are in demand. The average price of Platinum is 800 redbacks per ounce and that's not bad; overall, PGMs are running 400 to 500 per ounce. Our production and shipping costs remain about 15% of that level. So Uzboi and Ceres are safe. So is PGM production on Mercury. Parenago is safe, also, so the economic basis of the moon is intact. If we manage to export 500 tonnes per year, PGMs will contribute 7.5 billion redbacks per year. Deuterium exports are running half a billion and gold about 22 billion, space vehicle production another 1.5 billion, and our domestic economy is now 3 billion per year, so overall, our GDP is 33 billion. We have a substantial economy, almost double what it was two years ago, and it permits substantial investments and developments.

“Next slide: Immigration. We have been planning for 6,000 and there's no reason to change it. The Prometheus has lowered the cost of a ticket to low Earth orbit to 75,000 redbacks; as a result, there are now a dozen LEO hotels with a total capacity of 500 guests and two or three passenger launches per day. Hotel space is expanding at an astounding twenty beds per week! When the new, larger passenger cabin accommodating 150 people goes into service in two months, tickets will fall gradually to 25,000 redbacks. Cargo launch costs are down to 95 redbacks per kilo, so orbital manufacturing is taking off, in spite of the economic malaise. With rising demand, cargo launches will be down to 33 redbacks per kilo in a year or two.

“At our end, the Prometheus has lowered our cost to low Mars orbit even more, because both stages here can serve as single stage to orbit vehicles and the lower delta-v to and from orbit puts much less strain on the engines and thermal protection systems. As a result, our cost to orbit is already 20 redbacks per kilo, 25 to Phobos, and those prices should halve in the next year or two. Consequently, Phobos can import raw materials cheaply. It can ship goods to LEO via solar sailer for 10 redbacks per kilo or 15 redbacks per kilo using chemical propulsion. Items made at

Aurorae can be sent to LEO for 40 redbacks per kilo; half the cost of shipping from Earth.

Everyone in LEO is buying food and basic goods from Phobos, which will need to expand to over 1,000 people in the next two years. Phobos has contracts to supply 10,000 tonnes of water per year to LEO. Even the moon can't compete, unless someone wants a rush shipment.

“So, what are our immigration costs? We are projecting a ticket of 400,000 redbacks next year, 300,000 redbacks in 2076, and 250,000 in 2078; at that point the ticket will be less than an average yearly salary up here. A lot of people will pay part of their way. Those are bargain basement prices. Six thousand immigrants in 2075-76 will cost us 2.4 billion; less than a tenth of our GDP! If we bring 10,000 in 2077-78, it'll cost us 3 billion redbacks. Can we afford it? How could we afford *not* to do it? We need to shift from caravels and galleons to corvets as quickly as possible, so we can indeed bring tens of thousands here. If the price of gold plummets later, we will already have built and paid for the vehicles, so we will still be able to afford to fill them. The surplus galleons and carvells can be cheaply retrofitted for exploration purposes, thereby continuing our solar system programs. We can also afford to subsidize import of 5,000 tonnes of new machinery and equipment from Earth over the next two years; that will cost us about a billion redbacks. So we are in the position to develop ourselves significantly, thanks to improving space economics and a lackluster terrestrial economy.”

Hun-jai sat among murmurs of surprise. Henry Smith raised his hand. “Obviously, this has huge implications for domestic consumer goods production, construction, the energy sector, education, health, etc.”

“It sure does,” said Jacquie. “We will need Ramesh’s huge domes, Moses’s metal roads, cheap solar panels, and a lot more. Clearly, Phobos must at least double in size, maybe triple.

Martech needs the multi-billion redback expansion that's already underway. Alexandra, can you give us a report about the Prometheus and the corvet?"

"Certainly." Alexandra Lescov walked to the podium. "I don't have slides; sorry. First, the Prometheus: So far, three are flying to LEO and one here; Mars will get one more next year, the moon will get one, Mercury will get one, and there will be three more flying from Earth by the end of 2075. Callisto and Titan will need two each eventually. These are small numbers because each vehicle, used optimally, can launch 180 tonnes to low Earth orbit per week!

"The corvet: We've been designing it, off and on, for several years. It is a 50% expansion of the galleon, so the design has been finished for several months. In January we started building the drydock on Phobos to manufacture it, and it is just about complete. Marcraft has been manufacturing parts for it down here for several months. The avionics and environmental management systems are identical to the galleon, so we have those crucial systems already available. We should be able to put together our first vehicle by September and start testing it on flights between the moons, test the aerobraking, etc. It won't be ready for the twentieth columbiad, but by the twenty-first columbiad—starting late 2077—we could have as many as three ready for a flight to Earth and back. Each one can accommodate roughly 1,200 people on a three-month trip, so with them we will have the additional capacity to raise immigration from 6,000 to 9,600. We'll also be able to make three more galleons in that time period.

"We are really at the point, with the Prometheus, galleon, and corvet, when the entire interplanetary transportation system needs to be privatized. It's now cheap enough for people and groups to pay their own way. We need to maintain some physical and mental health standards, but otherwise, we should set aside a budget to subsidize immigration and let the private sector do the bulk of the effort. I should add that the cost of transportation to Venus, Mercury, and Ceres is

only about fifty percent more than to Mars. Transportation to Jupiter and Saturn is only triple, if you exclude the cost of manufacturing the vehicle and the support equipment that has to be sent along, so there is no reason why smaller waves of immigration can't head to all of those places as well. I don't think we have yet wrapped our heads around this fact."

"It changes the entire notion of Mariner identity," added Jacquie. "It will change the character of Marsian society, for better and for worse."

"But the terrestrial economy is a limiting factor," objected Henry.

"Not very much," replied Hun-jai. "Yes, the Earth is in recession and people fear worse. But there is no recession in zero-gee manufacturing; the opposite, because it has so much potential and the transportation costs have dropped so much. Even a terrestrial economy in recession is a *big* economy. There are lots of very rich people down there. The Green World Community plans to launch their first mission to an asteroid this month and it will culminate in an asteroid colony! The Magellan Outpost in Venus orbit gets four small asteroids over the next four years. There's a utopian group in Arizona that wants to build a colony on the moon near the North Pole based on export of water and helium-3. If a billionaire decides to build a colony at a terrestrial Lagrange point, who will object? And who will they buy their stuff from? We are in a very different environment now."

"If that is the case, we need to free the private sector here to do much more," replied Henry.

"We need to *help* it to do much more," corrected Jacquie. "Low tax rates, subsidies for expansion, more research and development to support creation of new products for export to LEO; we need a whole new policy, Henry."

"Good!"

“I thought you’d say that.” She smiled; everyone else laughed. “Yevgeny, can you tell us about solar system policy?”

“Sure.” Yevgeny Lescov, Jacquie’s Minister for Solar System Exploration, rose and walked to the front. “The short form of my report is simple: everything is moving forward as planned. The long form is that it is moving forward in spite of political turmoil, diplomatic fights, and on-again, off-again financial commitments. The European commitment to Mercury is solid, partly because they fear it’ll drift into our sphere of influence, and plans for Concord Station to export PGMs are well advanced; they’ll start within the year. Nevertheless, we have pledged several hundred million redbacks in surface transportation, ecological management, and miscellaneous equipment, and that will make possible an expansion of the population to 350. In return, they are created a Mercury campus of Martech and placing surface exploration of that world under its jurisdiction. The recent election they held went fairly well and avoided the turmoil of their previous two.

“Venus is also quite independent of us and as we heard, is getting a series of small asteroids that together will provide it with a small moon. With the arrival of a galleon in the next year, the population will grow from 30 to 150. Venus badly needs extensive study and is the orphan child of the entire inner solar system right now.

“Ceres: What can I say? It is working its way through a major expansion and another expansion is in the planning stage. The plan to export nickel and cobalt to Earth is moving forward and that borough will soon be providing profits to support development of the asteroid belt and the outer solar system.

“Jupiter: The *Galileo* will arrive in seven months and cause a revolution there. Whether it will cause a social revolution remains to be seen. The Chinese appear to be backing down with

their plan to send a galleon in 2077, but I think we need to send one instead and offer them a generous share of berths. Jupiter is worthy of an extensive research presence and Callisto has the potential to develop into a significant settlement. It needs a permanent commitment in the vicinity of a billion redbacks per year.

“Saturn: There is no question that after a rocky start, Titan is our success story. Their population is growing through natural increase and will exceed 500 in the next year. Their Martech campus is vigorous and is planning extensive exploration of Titan and the other moons. Their innovative bioarchive system is developing very well and giving them a large living space. Their use of geothermal and wind energy has made Acheron Outpost, in theory, independent of nuclear power. Their population will grow again in a few years, though many people also plan to leave. Financial commitments total a billion a year and must continue, even increase gradually. The big question mark in its future is helium-3 extraction from the atmosphere of Saturn.

“Uranus: We have committed to launching three galleons, two caravels, and about 500 people to that world system in either 2078 or 2080. Over a thousand people are seeking a place in the mission. We have committed to providing six space power reactors; our basic fifteen-megawatt model has been upgraded to twenty megawatts. Because we are manufacturing a dozen units for use here on Mars to provide base power for the smaller outposts, their costs aren’t bad.

“What we don’t know is the propulsion system they’ll use to get to Uranus, and that’s why we don’t know whether the launch will be in 2078 or 2080. Our gaseous core propulsion team, with Chinese collaboration, will have a new engine with a specific impulse of 3,500 ready for testing next year; that’s an exhaust velocity of 115,000 kilometers per hour or almost 35 kilometers per second. It’d get a crew to Uranus in about three years; long, but adequate. The

Americans are working on an advanced ion propulsion system using argon that promises to give a specific impulse of 7,000, the Chinese are working on a magnetoplasmodynamic system that uses hydrogen and gives a specific impulse of 6,000, and the Russians are working on a VASIMR system that uses argon and can give a specific impulse of 6,000. In every case, they are spending billions of redbacks and sizing their system to a pair of our space reactors. We'll need to make a decision on which system to use for the first mission in early 2075. We'll probably use the gas core engines to get started and electric propulsion to shorten the flight time. Whatever system that can get a crew to Uranus in two years will get a crew to Neptune in three, and the technology needed in the Neptune system is basically the same, so there is no reason to postpone a Neptune settlement."

"What does that mean?" asked Moses Waigwa. "When will we go to Neptune?"

"Probably five years after Uranus," replied Yevgeny.

"And we're going to Uranus in 2078," said Jacquie. "That's my feeling, unless the propulsion systems make it impossible."

"Are any of these propulsion developments applicable to immigration?" asked Henry.

"Yes and no," replied Alexandra. "Yes, we can use them to get people here much faster; one to two months. But the cost will be high, so it isn't economic."

"Thanks, Yevgeny, for your report," said Jacquie. "Emily, can you summarize development priorities?"

"Sure." Emily walked to the podium. "I have slides." She projected the first one.

"Everyone knows about the expansion of Martech; we anticipate filling 1,500 new positions in 2076. One quarter of the immigration wave; we have to become a knowledge-driven economy, and to do that, Martech needs to become a world class university. We are adding another 100

faculty positions in planetary sciences, but the bulk of additions will be in nuclear, aerospace, mechanical, and electrical engineering, and in materials science. You've heard of two of the nuclear science priorities: improving the gaseous core nuclear engines and modifying the 15-megawatt portable reactor design to produce 20 megawatts in space conditions. There are two other priorities they will begin to pursue, an air breathing solid-core nuclear engine and Helium 3 extraction.

"An air breathing nuclear engine isn't needed here, where we have a well-developed air and surface transportation system, but it is perfect for moving cargo on Titan and could be used in an emergency to move a person in a small shielded cabin. It is also essential for helium-3 production in the atmospheres of Saturn, Uranus, and Neptune, because such an engine can power a vehicle that can descend to an aerostat, take on a cargo of helium-3 that the aerostat has extracted from the atmosphere, and fly the cargo back to orbit. There are preliminary designs for such an aerostat put together by a Martech team in collaboration with various universities on Earth and we hope to have a design to try in Saturn's atmosphere in a few years.

"We are also beginning design work on a helium-3/deuterium fusion engine. The potential is enormous; exhaust velocities could exceed 8% the speed of light! It may be several decades before a working engine is devised, but we want to start the theoretical work now.

"I should mention a few other projects. Our robotics factory is expanding so that we can produce a variety of robots here, rather than importing them. We're importing parts to build three or four more road-metalizing systems. We've renegotiated the license and can now make eighty percent of the machines here, which will save money and strengthen our capabilities. A connection from Meridiani to Kalgoorlie and Thymiamata is a priority because there are many small gold deposits in that region and the methane and oxygen pipelines will distribute energy

widely. Nearly a thousand workers supporting gold and PGM production will be arriving and they should stabilize gold production for several years. Electrical production for mining needs to double over the next few years, so we are installing new reactors, solar power systems, and wind farms.”

“Almost half the people coming are connected with construction in one way or another,” said Henry. “I hate to be the person complaining all the time, but all of this immigration is for the sake of immigration! If we ever stop growing, we’ll have to lay off a third of our workforce! And a lot more can be done to privatize construction.”

“It’s a third, Henry, and about a third of the immigration has always been connected with construction and related services,” replied Jacquie. “This time, the other two thirds are Martech employees, miners, or ship builders. The construction workers often go on to open small businesses, too.”

“What small businesses? We don’t have that many small businesses.”

“Henry, small businesses are dying on Earth, too,” said Emily. “The chains are driving them out of business everywhere. Mars will never have neighborhood grocery stores, for example. We have lots of family owned restaurants because we’re still too small for chain restaurants and a family, assisted by robots, can run a restaurant. “

“And we have plenty of large and semi-public businesses,” added Alexandra. “Marcraft, Marbuild, Agmar, Marcom, Margen, Marchem, Marfab, Spacelift: they’re businesses too! Our mining is done by Mars Metals, Sibirico, Consolidated, and Muller Mining. We have plenty of businesses.”

“Look, people here are used to working in large organizations, but we need more smaller ones, and especially midsized ones,” replied Henry. “Deseret and Silvios are midsized; so are

Afigbo Construction and Maryam Salih Fashions. If you include law firms, private medical practices, and beauty salons, we do have a small but important number of small businesses. As for neighborhood grocery stores, with robotic assistance a family can now run one, just like a restaurant. The problem is the supply chain; where will the store get its inventory? That's a medium sized business. But never mind; I dwell on that point too much. Three months ago the Commonwealth announced a policy of encouraging small gold mining companies, and what have we gotten? One couple. Where are the companies with eight employees and two Mobilabs? That's a good scale for mining gold more efficiently."

"There are two companies of that scale forming now," replied Emily. "They face two problems. One is the weather; solar power is seriously diminished for the next four months. Another problem is that known gold deposits are already owned by the big companies or they are extremely remote. The Meridiani region has a lot of small gold deposits that have been prospected. But the companies that prospected them bought them, unless they were very small."

"Lean on them to lease those small deposits," replied Henry.

"But the companies are now sending out small teams to exploit them, so they are catching on," replied Jacquie. "I don't want to spend too much time on mining, but I do want to do something about the problems we are identifying. Other questions?"

"Helium 3," said Lal Shankaraman. "I have been following its development closely, and it has a long way to go before it starts to produce lots of electrical power on Earth. Of course, the cost of producing it on the moon is very high; that's a factor. It should be much cheaper to extract it from the atmosphere of Saturn, Uranus, and Neptune. But it'll take many years to haul it back to Earth, and that's an insuperable problem."

“Yes and no,” replied Emily. “Phobos has basically the same problem; the moon can produce something and send it to low Earth orbit in a week, while Phobos has a transportation phase lasting three to eighteen months. The solution is to maintain an inventory at LEO or L1.”

“How much does Helium-3 sell for right now?” asked Jacquie.

“About five million redbacks per kilogram; about fifty times more than gold,” replied Hun-jai. “If the entire United States electrical system were converted to Helium-3 fusion, it’d need 100 tonnes per year, worth a half trillion redbacks. Its concentration in the lunar regolith is only 10 parts per billion, on average; Peary has to process 10 million tonnes of reg to extract 100 kilograms per year, using a staff of 400. It will be much easier to extract from the atmosphere of Saturn or Uranus, where Helium-3 is one part per 9,000 of the helium in the air and the entire process can be automated, so a small staff in orbit can run everything. The uncertainty is how many billion redbacks—tens of billions of redbacks—are necessary to establish an economically viable system. A simple calculation, however, reveals that considerable profit is possible once a viable system is set up. Furthermore, it means that settlements in the Saturn, Uranus, and Neptune systems are economically viable. Jupiter cannot be used as a source of Helium-3 because we do not have a propulsion system capable of lifting it into low Jupiter orbit.”

“But presumably fusion reactors won’t become common at that price,” said Henry.

“Correct,” replied Hun-jai. “But the moon can lower its price to perhaps a tenth of the current level, though no one knows for sure. Right now, it is keeping the price high so that it can expand production. Let us say, however, that the price declines from five billion per tonne to half a billion per tonne. A viable production system might cost five billion and an automated shuttle to haul it to orbit, ten billion. Assuming the operation can produce Helium-3 for 250 million per tonne, your profit is a quarter billion per tonne and you’ll pay for the entire system after

producing 100 tonnes of Helium-3. Those are rough estimates, of course, and the uncertainty can sink the entire plan. Banks probably won't loan money to develop the system right now. But governments will help, and we can devote our resources to it."

"And we should, because our goal is to open the outer solar system to exploration and make it pay for itself," said Jacquie. "We also need fusion propulsion systems, which will revolutionize transportation. We need to make this commitment while gold prices remain high."

"So, are we really talking about committing fifteen billion redbacks to a Helium-3 extraction system for the outer planets?" asked Yuki Tajima, the Minister of the Treasury, startled.

There was silence. Everyone looked at Jacquie; she turned to Yevgeny and Alexandra, who were their team for estimating projects of this sort.

"That's not a bad guess," said Yevgeny. "But it may be high. We know how to deploy balloons in the atmospheres of planets; we've done it routinely at Venus for two decades and we even retrieve and fly surface samples up to Venus orbit. We've deployed long-lived, radiogenically powered balloons in the atmospheres of Jupiter, Saturn, Uranus, and Neptune."

"There are balloons operating in the Jovian and Saturnian atmospheres right now," added Alexandra. "If we scaled them up by twenty, we'd have the mass for a system able to extract maybe dozens of kilograms of helium-3 per year. We'd start with something of that size, then build a second generation system with the profits, then a third generation that is even larger."

"What about the nuclear-powered shuttle?" asked Jacquie.

"That would be harder to scale up and harder to test. We couldn't test it here—the air is too thin—or on the Earth, because of radioactivity and the presence of oxygen. Even Venus would provide a poor model. We'd have to build a test facility to develop the engine and that

could be very expensive. The assembled vehicle would have to be tested at Saturn, and we'd have to send a team there to do it."

"We could do some of the testing here," noted Yevgeny. "We could fill the vehicle with liquid hydrogen at Phobos, drop it into the Martian atmosphere, and have it fly back to Phobos with its nuclear engine."

Alexandra nodded. "There's plenty of established engineering for supersonic and hypersonic engines; our jetwing engines are an advanced example. The basic shape of the vehicle would be an aerospaceplane and we know how to do that. We'd definitely need help from Earth, though, because there's expertise there that we don't have."

"If they're going to benefit from the Helium-3, they should pay anyway," said Henry. "You space engineers always emphasize that there is a cheap way to carry out a project and there are all the ways they are usually completed on Earth. One of the causes of inflated expense is trying to accomplish something that requires technology beyond what we can reasonably create right now. Another cause is trying to use—and justify—complex technology when simple technology will do."

"You're right, Henry," replied Alexandra, raising her voice slightly. "But we have the technologies already; we just have to put them together in a new way. I think a basic aerostat equipped with one of our space reactors and a Helium-3 separation facility can be designed and built for several billion redbacks over several years. A small nuclear shuttle to fly down, retrieve the Helium-3, and lift it to Saturn orbit will cost 5 to 10 billion. Mars could do both, with our own resources and some imported equipment, in five to eight years."

"Really?" said Henry.

Alexandra nodded. “Yes, that’s how much our capacities have expanded. We have the engineers and the equipment, and because we don’t have an oxygen atmosphere and a planet with 8 billion people to protect, our testing facilities are cheaper to build. We can do it.”

“Will you take the project, Alexandra?” asked Jacquie. She had hoped she could persuade Alexandra.

She hesitated before replying, then nodded. “Yes, I’ll coordinate the project. But this is not my strength, obviously, so I will need a strong team.”

“We’ll give you the best team we can get,” pledged Jacquie.

“I haven’t seen you in months! How’s it goin’?”

Giovanni looked at the blond man in Kalgoorlie’s heavy equipment pool. “Lars, right?”

“That’s right. And you’re Giovanni. I’ve seen you and your wife on tv three times, now.”

“Really? We keep getting interviewed; every week someone wants to do one with us. But we never watch tv, so we’ve never seen ourselves. You aren’t as isolated as you think, I’m afraid.”

“I’d find that comforting. We’ve received your thin-film solar panel array; is that what you’ve come for? Let me pop up the paperwork.” In response, Lars’s personal automated assistant brought the bill of sale up on his screen.

Giovanni leaned over and read everything quickly. Fifty thousand redbacks; the 1021 grams of gold he and Holly brought in had earned them 93,754 redbacks. He was still mad about that; he hadn’t anticipated that the sell price would be 15% lower than the price on Earth, but there were handling and transportation charges. Spending more than half of their income stung.

“Do you have a standard 1-tonne methane tank and a 4-tonne oxygen tank?”

“Sure; new ones. Shall I add them? Did you bring a trailer?”

“Yes, add them. I’ve got my trailer.”

“Ok, we’ll add them.” They appeared on the bill of sale; another 20,000.

“That’ll do it. Can you fill them? I suppose that’s not too much more.”

“Alright. It’ll be a strain for your Conestoga to pull them; I’d go slow.”

“Oh, we will! We’ve already had to change one fuel cell. What a pain! It took both of us an entire sol to clean it and get it working right.”

“Do you need fuel cell parts?”

“No, we still have spares. But we do need 200 meters of electrical cable.” He glanced at the bill of sale; a tonne of methane and 4 tonnes of oxygen added 10,000 redbacks, the cable another thousand. That hurt. “That’s everything.”

Lars saw him wince at the price. “I’ll throw in the oxygen for free, how’s that? We always have a surplus, anyway.” The bill automatically responded; the total dropped by 5,000 redbacks. Lars pushed an icon and the bill of sale was saved. Giovanni took his communicator, pointed it at the screen and said “approved.” His signature appeared on the screen, complete with credit card information, and a moment later “approved” appeared.

“Thanks, I appreciate your help.”

“No prob. Frankly, I’m really envious of you; I wish we could do the same. My wife is out on a small gold mining team right now and she’s tired of the grind. How has it worked out for you, so far?”

“Pretty well. The mining and concentrating unit tends to break at least once a week. Sunsol isn’t a sol of rest, it’s a sol of repairs or a sol of catch up! But Holly’s really good at repair. On a typical sol she does a four hour shift outside, we have lunch, and then I do four

hours outside. We have Conestoga maintenance, greenhouse work—we now have the B-75 filled with a mix of regolith, dust, and rock grindings and we've planted a starter crop of corn—and we do a certain amount of exploration.”

“Has the dust storm cut into your production a lot?”

“Oh, definitely. In the last two weeks we've been running the miner only two hours a sol. But we've made up for it by going out together with our buggy and with shovels and picks. The miner averaged almost ten grams of gold per day. Together, with picks and shovels, walking our land and looking for rich spots, we've managed about seven grams a day.”

“Not bad! And you've got water?”

“Our well had to go down 180 meters, which was a real pain, but we finally hit enough ice. We've been getting a hundred kilos a sol; slow, but enough. The greenhouse needs close to 100 tonnes of water and the well would take three years to provide it, but we found a small crater filled with dust drifts that had a buried ice layer, and we've hauled fifty tonnes of water from there; enough to get the greenhouse started. We're going there every day during the dust storm and getting two tonnes.”

“And you've got enough heat?”

“Yeah, the solar power unit has had two whole months to heat up the bottom of the well. We're pulling heat out, now. I'm not sure it'll last four months, though. We'll see!”

“It should, if you're careful. How's your radiation shielding?”

“It's adequate for a short while. We're parked next to a cliff, which reduces our cosmic ray exposure by a quarter. We've filled the rooftop water tanks over the sleeping area and the main cabin and that reduces solar radiation to zero and cosmic radiation by another ten percent. We really need a radiation shelter, but no one is set up to provide one!”

“No, they aren’t; radiation shelters have never been sold. Did you check with the Ministry of Transportation?”

“Yes, repeatedly. They don’t have anyone in this region who can do it; they aren’t setting up oases any more, just metaling highways.”

“That’s right. Well, we have some here.” Lars pointed to the back of the supply area. “I have absolutely no idea how much they would cost, if we could sell them; we don’t sell them. They belong to Consolidated, too. They can’t be that expensive because the nickel-steel is a waste product of the PGM production, so the material is free.”

“And they shoot it into a mold, then solidify it. Hauling it here is the big expense.”

“Exactly, then hauling it to your land. I have no idea how much that would cost.” Lars hesitated. “So, how much cash did you need to get started?”

“Three hundred thousand; the Conestoga, miner, drill, solar power system, and miscellaneous other stuff.”

Lars nodded. “Not bad. Celeste and I could manage that.”

“Well, if you’re looking for a place, I can tell you.”

“Really?”

“Really.” Giovanni put his communicator down next to a piece of electronic paper. “Project a Skyview of my land on the epaper to the right of the communicator, and add all property boundaries, please.” A moment later a standard satellite view of the land appeared. Giovanni pulled a magnetic stylus out of his pocket and drew a line. “This is the intrusion that created the gold bearing zone. It’s twenty kilometers long and about one hundred meters wide if you include the gold bearing zones on either side. This is the part on my land. You see these dust drifts, here? That’s as far as the original prospecting team went. But the intrusion continues six

more kilometers. Last week Holly and I walked it and we picked up gold nuggets along the first three kilometers of it. We never went any farther so I don't know what's after that. But the gold concentration seems to be about the same as on my land. There are pockets that are reasonably rich and other areas with very low concentrations. There should be placer deposits as well farther north, but I haven't searched for them."

"They'd be easier to mine, too." Lars looked at Giovanni with appreciation. "Thanks. This is very helpful. You may have a neighbor, soon."

"We'd welcome that, as long as you aren't *too* close! We rather like our privacy."

Applause echoed through the Atrium as the last speaker of the "Twenty-first Century Confucianism and Mariner Culture" seminar wrapped up his conclusions. The fifty attendees lingered a moment. "Thanks, Sirikit," someone added and everyone applauded her. She nodded in acknowledgement and smiled embarrassedly.

"This worked out very well," Firuz said to Dr. Hong Cixi. "The Confucian emphasis on harmony and on *li*, true humanity, has a lot of relevance to our situation on board."

"Especially the ethic of friendship," she replied, nodding vigorously. "Confucius lived in a highly hierarchical society and most of his ethic emphasized the relationship between unequal persons, including between men and women. But a milder form of hierarchy—we have a Commander, after all, and department heads—is essential. Otherwise an ethic of human friendship between equals must prevail."

"In a way, I wish this wasn't called Confucianism, though," replied Lai Zicheng. "This is self-evident, common sense philosophy, wrapped up in some traditional Chinese terminology."

Confucius was a medieval man and there's no escaping it. He emphasized sacrifice, the subordination of women, and all sorts of ancient values that make no sense anymore."

"I don't agree that this is common sense or self-evident, though" replied Firuz. "Maybe it seems that way to you, and I am glad it does. But for many people, what is self-evident is that they need to be out for themselves first if they are going to get ahead, and everyone else is a means to their personal goals. That self-centered ethic is destroying societies, enriching a small number and impoverishing millions, and creating a destructive social fabric. We need to anchor our ethic of service to others, and selfless sacrifice for the good of all, in the teachings of the ancients, the classical philosophers and prophets."

"Well, I certainly don't agree with that last comment," replied Lai Zicheng. "We're capable, as modern people, of anchoring an ethic of service in our own language and thought. We don't need to be dependent on ancients whose good ideas are mixed with a lot of bad ones."

"I'm glad we were exposed to the thinking of these three Confucian ethicists," injected Charlie. "I can see why their humanistic philosophy is becoming popular in many places, inside and outside China. It is a profound statement about what binds human beings together and makes societies work. There are 191 of us, floating to Jupiter on three ships that are bound together. We are a society of our own, and we need the Confucian friendship and its ethic of forgiveness to work together harmoniously."

"Yes, I think that is right," said Lai Zicheng. "Sessions like this, and the film nights, have helped to overcome some of the distance we have felt, too."

"I agree," said Charlie. He waved goodbye and walked over the Sirikit, who had been busy talking to two other attendees about the program. "This was a great success!" he said.

“I think so!” she agreed. She pointed cautiously upward to the main cafeteria area, which was overhead in the spinning center of the galleon. “I was just told that the twenty or thirty people who were up there drinking coffee were also listening. They didn’t feel comfortable coming here to sit, but they were curious. I did notice that the main screens up there were off during the entire presentation.”

“I noticed that, too. So, that makes the audience closer to seventy! That’d be just about everyone who was available!”

“That’s right.” She smiled.

“Congratulations, my dear.” He kissed her.

Just then Commander Xiaopeng Cai approached them. “This was absolutely marvelous, Sirikit. I’m very impressed. You must have spent a lot of time explaining our situation to the speakers and they addressed them very skillfully. The audience’s questions showed that they were very engaged.”

“I noticed that, too,” she agreed. “People were definitely engaged. I emailed all three of the speakers extensively; we had a four-way conversation. They were excited to offer their ideas to us, and the audience felt that, too.”

“I was impressed by the way the first speaker spoke about the power of forgiveness,” said Charlie. “He started with the practical reasons to forgive, then moved on to more humanistic, almost transcendental reasons for it.”

“I hope it helped to heal some of the distrust and animosity,” said Xiaopeng. “I suppose it’ll help a bit. But I’ll tell you, Sirikit, that you have convinced me of this strategy. I never felt that I was in the position, as a Chinese-Marsian, to push Chinese culture and philosophy. But the Chinese were the first ones to land on Callisto, and Chinese is the first or second language of

Callisto outpost. That needs to be respected by everyone. Since you did this independently, without my urging, no one can accuse me of pushing a Chinese agenda.”

“But I think we need to push a kind of Chinese agenda,” replied Sirikit.

“That’s what you’ve convinced me of. You push it, though, not me. I will give release time for anyone who wants to study the Chinese language; you’ve convinced me that we need to do that. I will issue a statement that the lessons have been going on informally for over a month, their success has been noticeable, there’s growing demand for them, we need to accommodate the Chinese position in the jovian system, therefore the study of Chinese is encouraged and anyone who does so can do it during the official staff time.”

“Really? Excellent!”

“It’s important, and it’s not like we are immensely busy on this flight, anyway. Continue the Chinese cultural events, too; I’d make them two thirds of the cultural events up here.”

“Alright. They have been bringing people together, especially the movie nights.”

“If there are non-Chinese movies included, and there should be a lot of them, too, be sure to run them with Chinese subtitles. After thirty years of speaking English daily, it is still easier for me to communicate in Chinese. Let’s make everything bilingual to the extent practicable.”

“Alright. I agree.”

“Great.” Xiaopeng extended his hand. “Well done.”

“Thanks,” replied Sirikit, sounding a bit giddy. She took his hand and they shook. Then Xiaopeng turned and headed for his office.

“Wow, you did it!” said Charlie. “This is a sort of breakthrough!”

“I think it is. But he took our effort several steps further. He gave it vision.”

“He’s commander!”

“Xiaopeng does a good job; except maybe pushing the Chinese commander on Callisto so hard in the first place. That was probably a mistake.”

“That’s why I made the comment about forgiveness. If there had been more forgiveness in the first place, a lot of this trouble wouldn’t have happened. Let’s go talk to Jean Paul; he’s up there.” Charlie pointed to the atrium over their head.

“But aren’t we late to talk to your parents?”

“Yes, but a few minutes more won’t hurt.” Charlie pointed and they set out to walk a third of the way around the atrium to the cluster of tables around the cappocino machine at the back of the cafeteria. Jean Paul Poirier had been there for most of the conference, listening to the program from afar.

“Did you enjoy the presentations?” Charlie asked, as they approached.

“What presentations? You mean the Confucianism conference? Yes, it was interesting, the parts of it I heard, anyway. I was catching up with my reading of *Le Figaro*.”

“So, what’s new in France, then?”

He shrugged. “Not much.”

“So, are you still interested in studying some Chinese?”

“Like I told you before, I don’t have time. It’d be very hard to squeeze it into my free time.”

“Commander Cai just told us that he will let people take Chinese lessons on official time; they don’t have to use personal time.”

“But even so, I have a lot to do; I’m in charge of twenty planetary geologists.”

“Jean Paul, please! This is important.”

“But Charlie, I happened to be very bad with languages.”

“Jean Paul, your English is perfect; your accent sounds vaguely New York, not Paris. It’s important because when we learn some words and grammar, even if we can’t speak very usefully, we can learn and remember people’s names. And we don’t have to be fluent to use a little Chinese. It’s a question of respect.”

“Not enough people respect French!”

“We can’t all learn all the languages of the world. But in this case, we have thirty Chinese on this flight, and the commander on Callisto is Chinese, and the Chinese were the first ones there. If it had been French instead of Chinese, don’t you think we should all be studying French right now?”

“No, I think everyone on board should already have known French!” He smiled. “But I get your point. Alright, you can count on me. When?”

“I’ll talk to Lai Zicheng and get back to you. Probably next week.”

“Great.” Jean Paul turned to Sirikit. “That was a great program. Will the video be available?”

“Yes, we’ll put it up on the ship’s website.”

“See you later,” said Charlie, waving to Jean Paul. He and Sirikit headed around the ship to elevator number 3, which led straight to their quarters on the second floor. “We did it!” he said to her once they were in the elevator. “We’re healing the rift!”

“Bit by bit. This won’t heal completely for a long time,” she replied. “What’s the time delay today?”

“Still about twenty-five minutes.”

They reached their quarters and Charlie said open; the door responded and they walked in. They had already received their first message, so Charlie pushed play as soon as he and Sirikit had sat on the couch.

“Good evening to both of you,” said Helmut. “Or maybe I should say good afternoon. I hope you’re well. Mom and Oskar aren’t here yet; the doctors are running another test on him, because he has been really sick lately. It’s allergies.

“I just checked the *Galileo* website and see you’re going to fly by Adriana in three days, but not drop a probe. I couldn’t find the reason; is the approach speed too high? It’s in a pretty elliptical orbit. I hope the Confucian philosophy conference went well. Will the video be available? Maybe we could play it here and arrange for the speakers to answer our questions as well.

“Things are going very well here. Charlie, believe it or not, I’m now flying every sol! My doctor said I needed more exercise. The leaping is good for the legs and the flapping is incredible exercise for the arms; my upper arms are noticeably bigger already. We finally have all six B-75s set up, complete with their kevlar-shielded solar augmentation mirrors, and they are incredible places for flying. We’ve installed ‘perches’ way up high, close to the top, 33 meters off the ground, so you can fly up and rest a bit, then drop and glide. From the perches you have a great view of the solar augmentation mirrors, which make each B-75 look like an elongated, super-sized silver flower. The SAMs give the B-75s terrestrial levels of lighting and they reduce micrometeoroid penetration by 65%. They are turning green incredibly fast and the trees in them are growing like weeds. Together the six give us fifteen thousand square meters of green space; 700 square meters per person, or four times as much as the new Mars standards. Helmut, you’d

love the space! Two people have broken bones from hard landings because they get going too fast, so I'm being very careful.

“Sirikit, you'll be glad to hear that our PGM mining is proceeding quite well. The automated trucks are hauling 500 tonnes a week from the Mahuika octahedrite, 400 kilometers east of here. In Ceres' low gravity the trucks can transport absurdly large loads if you keep the velocity down to about 15 kilometers per hour. Mahuika alone will produce 4,000 tonnes of nickel, 1,200 tonnes of cobalt, 50 tonnes of germanium, 2 tonnes of platinum, and 2 tonnes of gallium per year. The ataxite body here at Central is now yielding 100 tonnes of PGMs per year and we should have production up to 150 tonnes in a few more months. Carter Levine is still tinkering with the equipment's settings and productivity is getting better every sol. We're also producing 30,000 tonnes of nickel and 10,000 tonnes of cobalt per year, and we now have the equipment set up to cast them into twenty-tonne spheres with four chambers in them, per your design. Starting next week, we'll be producing six spheres a day! They'll accumulate like a bunch of giant bowling balls outside the processing facility until we can launch them. We do have fifty interplanetary flight control modules—IFCMs—designed to control the flight of a capsule containing twenty to thirty tonnes of PGMs, so we can export 1,000 to 1,500 tonnes of PGMs and cobalt. Martech is developing a special flight control module for our metal cannonballs that we can manufacture here.”

Helmut paused and looked off camera. “Oh, here's Clara and Oskar,” he said. A moment later they stepped into the field of view and waved. Helmut was struck by how gray his mother's hair had turned, even though she was just 50; he had to wonder whether it had to do with the Ceres environment. Oskar, who was about to turn 13 in another month, had shot up. His nose was red.

“Hi, honey!” said Clara. “I hope you and Sirikit are doing well. Not much news up here, though I hear you just had a conference, so tell us about that. Oskar’s got a sort of bad cold, but it isn’t a virus; he’s probably allergic to something, but we can’t figure out what.”

“I’ve been feeling pretty sick for several weeks, now,” said Oskar. “It may have to do with pollens drifting into the caravel’s air supply from the B-75s.”

“They are overwhelming environmental management,” agreed Helmut. “We’re trying to separate everything again and see whether that helps. He’s not the only one having a problem.”

“Let’s call them back after we get their message,” suggested Clara.

“Okay. Talk to you later.”

“Bye,” all three of them said. The screen went dark.

“So, dad’s flying. He never did when I was there!”

“Really?” said Sirikit. “Maybe he didn’t want to look like a klutz next to his teenage son.”

“Maybe. Let’s record our reply.” Charlie motioned her closer. “Record our reply, please.” He paused and the record light turned green. “Hi mom and dad and Oskar. It’s good to see you again. We’re doing pretty well here. The flight’s smooth, routine, even boring, except for the tensions among the crew. Some people think they’re pretty bad; other’s think there’s none at all. Basically, the twenty members of the Center for Asteroidal Studies are mad, in various degrees, with the dozen planetary scientists on the *Gan De*, because several of them participated in the Himalia probe, and in turn they are mad in various degrees with us. I think most of the 125 people on the *Galileo* are gossiping about the bad feelings. Sirikit’s conference on modern Confucianism as it is applied to space gave all of us something to talk about in common, especially about Chinese ethical values and such issues as forgiveness. I think it helped, too.”

“Well, it built on the Chinese food nights in the cafeteria and the movie nights. I think the movie nights were particularly enjoyed by everyone,” said Sirikit. “I’m spending more time as cultural, artistic, and maybe I should add recreational director, than on economics! It’s like having two full-time jobs.”

“Plus the Chinese lessons we’re taking with Lai Zicheng and only one other student,” said Charlie. “That has taken a lot of time. But now I can write my name in Chinese characters! And the classes should grow in popularity; Commander Cai has said people can take the classes on staff time.”

“He said we’re going to be bilingual from now on, to the extent we can do it conveniently. Charlie, Firuz Moulin, and I are eating on the *Gan De* several times a week and getting to know people over there, and more of the Chinese crew has started coming to the *Galileo* as well. So I think we’re making some progress. Things, inevitably, are going to be tense when we get to Callisto, so I hope we can build up relations.

“But let me come back to PGM production. I wish we had developed our plan sooner, though it sounds like you are developing some clever alternatives. Uzboi is using more and more of their waste metal, 3,000 tonnes of it for every tonne of PGMs they obtain. When will you pursue that?”

“I think that’s it up here, so back to you,” said Charlie. “Bye.” He paused; the record light turned red. “Send that, please.”

“So what now? TV?”

“I think we can watch all of *Lady of the Abbey* if we skip the commercials, before they reply.”

Sirikit nodded and they found the latest episode, which was popular with half the crew and therefore had priority in the communications channel. Sure enough, the show was ending when the reply arrived. They waited for the credits to start before playing the reply.

“We’re back,” said Helmut. “Or Clara and I are, because Oskar has declared these video exchanges ‘boring.’”

“That’s alright,” added Clara. “He really hasn’t been feeling well, with these allergies. A lot of kids up here have them because the air is so filled with pollen, germs, and everything else. We need to get the kids into the B-75s, vaccinate them against their reactions, and help their immune systems adjust.”

“Anyway, Sirikit, you asked about the 300,000 tonnes of waste iron we produce every year,” said Helmut. “We are using Uzboi’s plans, but of course they can’t use more than a tiny fraction of their 1.5 million tonnes of waste metal. Our mold for producing 20-tonne ‘tunnels’ ten meters in diameter and long is coming along and it should be ready in February. We’ll bury them for pressurized space and for storage of liquids and gasses. In Cereian gravity, they’ll be pretty easy to move around.

“The mold for ‘roadways’ is almost finished as well. It’s a near copy of the mold for Mars’s metal roads, but adapted to Ceres. It’ll produce a corrugated road surface ten meters wide, with spikes on the bottom surface that push into the regolith for stability. Oxygen and methane pipes are built into the undersurface. Vehicles traveling on the roadway will be equipped with magnets to give them a stronger grip, especially when accelerating and decelerating; that’s something one doesn’t need on Mars. The road has a built-in guardrail as well. At ten tonnes each, eventually we’ll be making 30,000 of them per year, 80 per sol, which can form a line 300 kilometers long! It’ll be a year before we have enough molds, though, and we won’t have enough

robotic welders or trucks and cranes to build roadway very quickly until the *Hershel* arrives in three years. The first road will extend to Mahuika and will allow trucks to haul ten times as much ore. Eventually we'll circle Ceres with metal roadways and connect all the potential resources to Central's energy production facilities and processing plants.

"I have a question for you, also, Sirikit. I'm worried about the rumors that Mars plans to push Helium-3 production. Saturn has managed to obtain quite an investment in Cererian PGM production, but they'd be the first place Helium-3 production would be tried. Do you have any sense that Ceres could be adversely affected by the Helium-3 plans? I'm curious. Bye."

Charlie turned to her. "He's got you in a box."

She considered. "I think I'll tell him what I know, or most of it, anyway." She nodded; Charlie said "record reply, please." The green light went on.

"That's a good question, about Helium-3. Jackie plans to make an announcement in her annual 'State of the Commonwealth' address. That was published in *Mars This Sol*. I know they're working on a multi-billion redback plan stretched over maybe a decade. Helium-3 fusion is now commercially viable but is limited by the high cost of lunar production, which will fall, but will still be expensive. But Helium-3 isn't for Mars; it's for the supporting the settlement of the outer planets. Mars still needs gold and PGM production for its trade balance. No one is talking about phasing out gold and PGMs or reducing the investment in it. I suppose Saturn's investment in Cererian PGM production is safe; certainly Jupiter's is because no technology exists that can lift something from the atmosphere of Jupiter to low orbit. So I wouldn't worry. This is good news all around."

Marshall Eliot listened to Jacquie Collins's State of the Commonwealth speech again. The section about Helium-3 wasn't too long, but it was packed with details. "Ivy, can you give me a transcript of the Helium-3 paragraphs?" he finally asked.

"Certainly," replied his automated personal assistant. A moment later a transcript appeared on the screen. "This is taken from the text on *Mars This Sol*," added Ivy.

"Okay, thanks." He read the text over. It was slightly different from what he had heard, but the differences were unimportant.

His communicator beeped with a reply from his father, whom he had videomailed an hour earlier. He played it. "Happy New Year, Marshall! I hope 2075 will be as happy up there as it can be down here. Certainly it has started better here than in New York and that terrorist attack on Times Square. Nothing seems safe on Earth anymore.

"I listened to the State of the Commonwealth speech closely. Jacquie did a good job. Overall, I am impressed by her first year; she has kept us moving forward. The problems the new diplomatic team on Earth faced appear to be getting resolved. Of course, the economic instability down there is a lot of the problem.

"Yes, the Helium-3 plan is very serious. Alexandra Lescov has agreed to direct the project and she has been talking to experts for several weeks and reviewing all the existing proposals. They think phase 1 can be done for 10 billion. That may be low, though. It will probably come to Saturn first because even if it is ready for the first Uranus launch, a Saturn launch will occur at the same time and Saturn's only half as far away. Saturn can return Helium-3 back to Earth sooner, so the return on investment happens faster. The Uranus settlement will be busy getting established for the first year or two, also. If you go to the website for the Chief

Minister, you'll see preliminary information. They just put it up. I suspect *Mars This Sol* will summarize it in a matter of hours.

"I hope Amy's doing okay; give her a kiss for me. The little one's coming in less than three months now, and I can't wait to see her. Take care of yourself, son. Bye."

Marshall felt a tear in his eye as the screen went dark. Sometimes the two billion kilometers of distance was erased. As his father got older, he was getting more tender. But the information about Helium-3 was what Marshall had wanted. It was hard to be sure what was going on, without asking insiders. He rose from his desk and headed down the hall to the office of Dr. Sydney Kilgore, the Director of Saturn Atmospheric Science.

The New Zealander was in her office. She looked up, saw him, and stood up. "Good morning and happy new year!"

"Thank you. Did you have a nice New Year's day?"

"Yes, Taka and the kids and I slept late, then picnicked in B-3 in the afternoon. Did you go to the concert last night? Taka was the cellist."

"Yes, we were there. It was a great concert. Say, did you listen to Jacquie Collins's State of the Commonwealth address?"

"Parts of it; why?"

"What do you think of the Helium-3 section?"

"I was excited that they're finally supporting it. I wish there was some sort of timetable."

"There is. I was just talking to my father and he said they might have it ready by 2078, and it'd come here as well as Uranus. So don't think this is a Uranus project; it's for all three of the outermost planets. Of the three, we're the only system currently inhabited and have a meteorology team on site. Any technology that can get people to Uranus in three years can get

them here in less than a year and a half, and if you were a space vehicle engineer, which trip would you prefer?”

“Good point. I worry about commercializing this place. Most of Mars is mining, construction, and space vehicle manufacturing. What’s the percentage of the population doing space science?”

“Tiny; but the number is much larger than it would be if the miners and builders were absent. Right now we have a team of twelve running a 1-tonne aerostat in the atmosphere of Saturn, four atmospheric satellites, and we have five atmospheric probes. If we had a fifty-tonne aerostat in the atmosphere with a 20-megawatt nuclear reactor on board and a team of fifty people running it, we could accommodate a lot more atmospheric science. What could you do with a multi-kilowatt tunable radar system? How far down could you probe?”

“A long way,” she agreed. “We could have an entire little airport with deployable planes with rechargeable batteries.”

“How many meteorology balloons did your aerostat have? A dozen? You could have several dozen, and more could be sent down.”

And there are times we want samples returned, too.”

“There you go; they want to be able to return tonnes of Helium-3. If the entire system proves safe and stable long-term, it may even be possible for people to descend to the aerostat for a visit and return to orbit. Who knows? But it’s safe to assume that the study of Saturn’s atmosphere and interior will move forward much faster, not slower!”

“That’s true,” she agreed.

“I’ll contact Martech and find out who’s planning the aerostat. Shall I put them in touch with you?”

“Oh, definitely! It sounds like a lot of collaboration is necessary.”

“You can say that again!”

14.

Visitors

February 2075

“Are you sure he’s coming?” asked Holly.

“That’s what the email said; he was leaving Kalgoorlie this morning with the radiation shelter,” said Giovanni.

She looked at the clock. “It’s 1 p.m. here, and Kalgoorlie is 4 hours away.”

“And it’s now 2 in Kalgoorlie. I don’t know.” Giovanni shrugged. He leaned over and looked out a northeast-facing window. Dusty sunshine, rolling reddish-brown terrain, but no vehicle towing a radiation shelter.

“Who is this guy, anyway?”

“His name is Lars. Norwegian; I think his last name is Peterson. He’s in charge of mining and vehicle supplies at Kalgoorlie. Blond; you met him once.”

Holly nodded. “I vaguely remember him. At the time you were the only man I was paying attention to.”

“As it should be.” He smiled.

“How much is he charging? Why’s he doing this?”

“I guess he isn’t charging, and I don’t know why he’s doing this. He knows there’s no system to get radiation shelters out to private owners; I told him.”

“Why did you mention that?”

“Because it’s a frustrating situation. We’re sitting out here, frying in the cosmic rays! I also told him about the gold bearing zone as it runs westward of here.”

“Oh? Why? I thought you didn’t want any neighbors.”

“I don’t if they’re close, but that spot’s about twelve clicks from here. That’s a lot of privacy.”

“I suppose. I used to think I wanted neighbors, but now I’m not so sure. I rather like walking around in the B-75 with you, naked, and making love on the grass.”

“We’re Adam and Eve in our own Garden of Eden.”

She laughed. “Not much of an Eden! We can’t get anything to grow right.” She picked up her coffee cup and drained the rest. “Well, it’s 1:05. If they show up, Goldi will notify us. Let’s go outside and hunt for gold.”

“Okay. You got in three hours with the mining unit this morning?”

“Yeah, the sun’s coming back. It has been a light dust storm season, fortunately. You should be able to get in two hours later this afternoon. Did you fix the buggy’s fuel cell?”

“Yes; I had to change a filter. We’re running out.”

“We’re running out of everything, but fortunately we have another 300 grams of gold. We’ll have to go to Kalgoorlie in another week or two. “

“If we had known Lars was coming, we could have asked him to bring us some stuff.” Giovanni stood up and put the dishes in the sink, then he and Holly headed for the Conestoga’s rear lab, where they suited up. From there, they stepped into the docking cube, which connected to the B-75, and from there into another docking cube they had added that served as an airlock. In another minute they were outside.

They grabbed shovels and picks—they had gotten good at using picks in pressure suits—and jumped into the buggy to drive along the gold bearing zone to a spot 400 meters to the east that had proved rich and easy to work by hand. But as they were about to move, Goldi interrupted then with the announcement, “Ranger and trailer approaching from southeast, 3

kilometers away.” They turned to look and sure enough, there was their radiation shelter, a half cylinder of thin nickel steel ten meters long and wide and five meters high. The ranger was towing it upside down attached to two small cranes at each end of the special trailer bed. No wonder they hadn’t been able to rent the equipment to move it!

They paused to watch the ranger approach, and as it stopped they waved, and two people inside—a man and a woman—waved back. “Welcome!” exclaimed Giovanni on the common frequency, and a minute later Lars replied ‘Thank you! Lovely spot!’

“Thanks, we like it! This is very kind of you, Lars; unbelievably kind!”

“Oh, it’s nothing. Hold on while I maneuver the trailer into place; this will be tricky.”

Lars slowed the ranger, turned it around so that its nose had driven well past Giovanni’s Conestoga, and slowly backed up to place the trailer parallel to it and just three meters away from it. Meanwhile, Giovanni and Holly walked along the space between their Conestoga and the cliff, moved rocks out of the way, and reported to Lars that the radiation Quonset had to be placed so that the edge was 2.3 meters from their Conestoga. Lars made a calculation and moved the trailer again, because the Conestoga was 2.4 meters wide; the radiation shelter’s wall had to be 5.3 meters from the Conestoga.

“Are you sure you know how to do this?” asked Holly anxiously. The shelter weighed several tonnes and if it came crashing down on their Conestoga, it would destroy it.

“It’d be better if you could move your vehicle out, then put it back later,” replied a female voice from inside. “I’ve done this once before.”

“We can move it, but it’ll take a little time,” replied Holly. She and Giovanni walked to their Conestoga and began to depressurize the docking cube and detach it from the vehicle, and

to disconnect power cables and other objects. Meanwhile, Lars suited up and came outside to watch.

It took fifteen minutes prepare the Conestoga for the move. Holly stepped into the cab and drove it twenty meters, then walked back to watch. Celeste Petersen had already placed the trailer's stabilizing anchors and the two men detached the cables holding the shelter in place on top. Then Celeste activated the cranes to lift the right side of the radiation shelter upwards, thereby tilting the whole thing. Once it was clear of the flatbed, she slowly swung the shelter off the trailer and lowered the left side until it was resting on the ground. Then she swung the right side of the radiation shelter farther from the trailer until it wanted to fall. She played out the cables from both cranes until the right side rested on the ground as well. The entire maneuver took ten minutes. "Wow, that's impressive work!" said Giovanni.

"Thank you," replied Celeste, from inside the cab. "You can drive your Conestoga back and dock it. I need to deactivate a few systems, then I'll be out."

"I'll do that," replied Holly. "Then please come inside and have some coffee and food with us."

"Delighted," replied Celeste.

Giovanni turned to Lars. "I don't know how we can repay you! How much did this thing cost to rent?"

"I was able to get it for free; the Commonwealth is encouraging small mining companies, and I argued this was an important part of that policy. So no pay is necessary. But I am sure we can use your help in other ways and at other times. Remember how you pointed out the gold bearing zone to me, last month? Celeste and I bought the rest of it. We're going to be neighbors."

"Really?"

“Yes. But don’t worry, we’ll be about twelve kilometers away.”

“Twelve kilometers; that’s a good distance, not too close or too far,” replied Giovanni.

“I think so, too. The back of the ranger we rented is full of supplies and equipment, and if we can store it here with you, we’d be much obliged.”

“Oh, sure. After you rest, there will still be an hour or two of daylight, so we can go look at your land, if you’d like.”

“Yes, we’d like that very much.”

Holly backed the Conestoga into the radiation shelter, which was four times wider than the vehicle, so there was plenty of room. The Conestoga’s automated docking software took over and steered itself very precisely to a soft dock with the docking cube. Giovanni and Lars moved in and set the manual latches on the outside, completing a hard dock. By then, Holly and Celeste had come out of their respective cabs.

“So, I suppose we can find a website about how to bury the radiation shelter?” asked Holly.

“No, I doubt it,” replied Celeste. “The work has always been done by the Ministry of Transportation, so public advice has always been unnecessary. But we brought you the simplest system. First, you throw a net over the shelter and anchor it on both sides with 11 stakes driven deep into the ground, one per meter. Then you spray on a layer of moistened dust; we brought a machine that can hold up to 300 kilograms of water and a tonne of dust. The machine warms the water to 1 Celsius, warms the dust to a similar level, then blows a stream of air over the dust and out a nozzle, where it is wetted before it flies through the air. It lands on the radiation shelter and freezes instantly; the net provides a stable anchor. Once you have half meter of frozen dust in

place, you place a second net over it and stake it to the ground. The same with a meter of accumulation, then two meters, then three meters.”

“That’ll take a very long time!” exclaimed Holly.

“We’re talking about 150 square meters of surface, 3 meters of depth, 2 tonnes per cubic meter? That’s close to a thousand tonnes of dust!”

“And several hundred tonnes of water,” agreed Celeste. “You may need to deepen your well. Once you’re done, you buy a white plastic cover to keep the sunlight off and keep the water in, so the mix stays frozen. It’ll take a few hours a day for a year or two, but when you’re done, you’ll have insignificant levels of exposure to cosmic radiation. Even half a meter of accumulation provides significant coverage.”

“We can program the androids to do a lot of it, I think,” said Giovanni. “They certainly can dig the dust and haul the water.”

“Have you been able to use them at all to run the mining equipment?” asked Lars.

Giovanni shook his head, disgusted. “They aren’t smart enough to be trained by doing; I tried and the android almost damaged the miner. They can move dust to the outside of the B-75, though, and our berm under the bubble is almost finished, as you can see. We’ve shoveled the dust into its final place, but the androids can move it to within half a meter of where it should be.”

“I bet you didn’t know this: Consolidated Mining has the software that allows an android to run a miner. They’re using them in the very large miners, but I was told the software can be modified for any piece of equipment. But it’s proprietary; no one can buy it.”

“Naturally.” Giovanni shook his head. “Let’s go inside.”

“Let us go first,” said Holly.

The men nodded, so Holly and Celeste stepped onto the porch and cleaned their pressure suits, then stepped into the airlock. While it was pressurizing the men stepped onto the porch and cleaned their suits; the blower had enough gas for two uses. They went through the airlock into the docking cube, and removed their helmets, but the women were changing inside the Conestoga, so they couldn't enter it yet. Lars pointed to the B-75. "How has it worked out?"

"I'll show you; it's pressurized with a breathable atmosphere." Giovanni opened the pressure door and led Lars into the bubble, 75 meters long and 35 meters in diameter. The huge, curved floor was mostly covered by a heavy tarp, though the ten meters at the far end had plants.

"A lot of potential," said Lars.

"Yes, that's one way to put it," agreed Giovanni. "We are grateful you gave it to us; it's an amazing gift. But what homesteaders need is something about a fifth as big. This thing has 4,000 square meters of curved floor. If we install all the terraces, it'd have 2,500 square meters of flat floor. Now, if Holly and I had the time and we wanted to grow all our food, we'd need maybe 400 or 500 square meters, depending on how good we were. So it's way too big. If you want to cover all this with ten centimeters of soil—which is usually considered the minimum—we're talking about a thousand tonnes of eolian dust, clay, and sand, and several hundred tonnes of water. It'll take us years to set it up."

"I see what you mean."

They started walking across the long, wide space, larger than many urban lots or suburban back yards. It was difficult to see the outside because of the buildup of dust on the bubble. At the far end was a ten by ten meter terrace with a patch of grass and a patch of corn. They stepped onto the grass.

"The corn doesn't look so good. How old is it?"

“Almost two months. As you can see, we blow the dust off this end of the bubble, but with the dust storm season raging, the corn just doesn’t get enough sunlight. The grass isn’t doing great, either.”

“But it’s a bit yellow; I think it isn’t getting something it needs, or is getting something it doesn’t like. Are you desalinating the regolith?”

“No, not really.”

“We can show Celeste. She’s anxious to set up a bubble for us. She doesn’t know a lot, but we have good contacts in Kalgoorlie’s horticultural department. You haven’t been using the androids to set up this space at all?”

“They’ve hauled in a lot of the regolith mix, but we haven’t been sure what sort of mix to make, so we’ve been waiting to see how the corn and grass do.”

“She knows about that, too. We can ask her.”

“They should be done with their pressure suits by now.” Giovanni and Lars walked back across the B-75, verified that the women had moved out of the work room, and opened the pressure door to enter it. They quickly stripped off their pressure suits and plugged the life support backpacks into the recharge stations, then moved forward into the Conestoga’s main cabin. Holly and Celeste were busy making coffee and pulling out the few refreshments available.

“It’s not much; we haven’t been to Kalgoorlie in almost a month,” said Holly.

“Oh, this is great hospitality; thank you so much,” replied Lars. “Celeste, their B-75 is just getting started. You may want to take a look. The corn plants are yellow.”

“I’ll be glad to. I want to get a B-75 for us, too. If nothing else, we can raise corn or some other simple crop and sell it in exchange for food!”

“When do you plan to make your move?” asked Holly.

“We can move any time; our jobs are open ended,” replied Celeste. “But we’ll wait for the end of dust storm season.”

“That makes sense,” agreed Giovanni.

“We’ve bought a miner, a thousand square meters of solar array, methane and oxygen tanks, and a ranger; the one we drove here,” said Lars. “It looks like we can get a portahab trailer for the ranger, too.”

“That’d be pretty crowded,” observed Holly.

“But we can get a radiation shelter and weld onto it a floor and walls at each end,” replied Lars. “The metal walls are thick enough to hold in atmosphere. Once pressurized, it’d be a pretty large house!”

“That’d be nice to have,” said Holly. “It’ll take us a year to get enough dirt onto this shelter to make it useful!”

“But you have two androids; they can do a lot of the work once you have a better water supply,” replied Celeste.

“How has the mining been, so far?” asked Lars.

“Well, I’d be lying if I told you this was easy,” replied Giovanni. “Right now we’re working for half salary and can’t pay back the loan from my parents. On a good sol we find ten grams of gold; a hundred redbacks. We’ve actually done better since the dust storm season started because picking up nuggets from the ground is still faster than digging them up and separating them from the regolith! It also preserves the mining machine, which constantly breaks.”

“The old models were heavily used,” agreed Lars. “We’ve bought a later model.”

“Also used,” added Celeste.

“How long have you been at Kalgoorlie?” asked Holly.

“Three years,” replied Lars. “Since we got married. It’s a nice place; we like it. I guess, out here, we’ll still be part of it.”

“Technically, no,” replied Giovanni. “We’re in the borough northwest of Airy-0; that’s a separate borough, though it has only two residents, and when you move in it’ll have four.”

“Oh, that’s right!” Lars began to laugh. “Maybe we should elect officers once we arrive, then.”

“I doubt the Commonwealth government will appreciate that,” commented Celeste. “But they still don’t have very good support policies. I suppose they’re torn between supporting gold production and maintaining safety.”

“I think that’s right,” agreed Giovanni. “This is a very risky business. If we hit a small pocket of ore, we’d be rich overnight. Otherwise, we just scratch out a meager living.”

“Still, over time, everything should balance out, don’t you think?” said Lars. “We know where the gold bearing zone is.”

“That’s what we’re counting on!” laughed Giovanni. “I love having my own land and my own business. I love this land, too. I’ve walked a large portion of it. But every sol you have to worry whether a mistake will kill or injure you before anyone can help.”

“Or your spouse,” added Holly.

“But don’t you get lonely?” asked Celeste. “It’s just two of you out here, 4 hours from the nearest outpost. The internet can’t provide company.”

“No,” agreed Holly. “It is lonely. I think it’ll be nice to have some neighbors.”

“We’ll be about fifteen kilometers away,” said Lars. “I’ve explored our fifty square kilometers by virtual reality and I think I’ve found the spot we’ll homestead. It’s next to the auriferous zone and has dust drifts, gravel bars, and sand, so we’ll have the resources we need, and it has an interesting, knobby hill to look at. We’d kind of like neighbors, too; this is a big, scary enterprise for us.”

“We’ll be glad to help,” said Giovanni. “No question about that. You’ve been very generous to us. I think we’d enjoy collaborating with you.”

“Yes, we would.”

Holly glanced at her watch. “You’ve been here 90 minutes; it’s now 2:30 p.m. and sunset’s four hours away. That means you can barely drive back to Kalgoorlie in daylight.”

Lars glanced at Celeste. “Loading the trailer with the radiation shelter and all our stuff took forever, so we couldn’t get here sooner. We figured we’d drive over to our land and spend the night there, then drive back to Kalgoorlie morrowsol.”

“In a ranger?” said Giovanni. “That’s a pretty small space.”

“Why don’t you drive into the radiation shelter and dock your ranger to the cab of the Conestoga?” said Holly. “That way, you can use our bathroom and shower, if you want, and you can use our cab as additional private space.”

“That’s very kind of you,” said Lars. “Yes, we’ll do that. Thank you.”

“We can show you around the areas of your land we’ve explored,” added Giovanni. “Morrowsol morning we could all drive over, then Holly and I can come back here, leaving the two of you to explore it more and drive back to Kalgoorlie.”

“That would be good,” said Lars. “I’d like to see your mining setup. Celeste has run miners before, but I haven’t.”

“If you could help us get the net set up on the radiation shelter, I’d appreciate that,” said Giovanni.

“Oh, sure,” said Lars. “It’s pretty simple.”

“And I can take a look at the B-75,” said Celeste. “I was raised on a farm in southwestern Uganda. We had about two hectares and it was all farmed by my mom; every square meter. I’d like to do the same thing up here.”

“In a very different environment,” said Holly.

Celeste shook her head. “Not with mirrors and some grow lamps to augment the sunlight. Most of mom’s crops are available here; some have even been genetically modified. It’ll just take a while to get the soil established.”

“Alright, we have a plan, then,” said Giovanni.

Tree Rivers did not expect the visitor to his office. He looked up when he heard a sound at the door. It was Bill Hollingworth, and that surprised him. “Bill, how are you! I thought you were in Aurorae, getting ready for the flight to Phobos.”

“I was, Prophet; the flight to Themis is just two weeks away, now. But Suzanne hasn’t been feeling well for the last week and she went to the doctor. She’s pregnant.”

Tree smiled. “Congratulations! My niece is going to be a mother! I’ll have to be great uncle! And of course, you’re going to be a father! What happy news!”

“But there’s one problem: she’s going to have the babies—they’re twins because you recommended we use Geminalis and have our whole family at once—in late August. But I won’t be back from Themis until at least December. Why did you recommend we start our family right away? How can I be a father if I’m a hundred million kilometers away!”

“I’m sorry, Bill. I recommended it because you’re going to be in space a lot, remember, and that’ll expose you to a lot of cosmic radiation. Suzanne and the babies will have to stay on Mars for the time being. But you’ll be able to be reunited with them; don’t worry. I see that in the future. This is the sort of sacrifice we all make to serve Father Mars and Mother Earth.”

“But . . . how can I abandon her? It isn’t right!”

“She’ll be here with the community and with me. It’s a sacrifice, Bill. I know it isn’t easy for you, and I appreciate your concern for your children. But they’ll be fine.”

“But, I’ll miss their birth! Don’t you understand that?”

Rivers paused and decided he had to try a different argument. “Bill, I understand that. But this mission is of higher importance. Don’t you trust me? This is a very significant development in the history of humanity, as significant as the founding of Aram in the omphalos of Mars. It’s part of the voice of Mother Earth and Father Mars; they have called for this mission and have blessed its success. The greening of Themis is a guaranteed success if we do our part. And your part is commander of the mission. What an amazing privilege for so young a man!”

“But, prophet . . .” Bill looked down and tears appeared in his eyes.

Tree put an arm around his shoulder. “This is hard; I understand. But you will be a great commander and will go down in history. Your children will thank you later and our historians will praise your sacrifice. This is a truly amazing mission.”

Bill said nothing and looked down at the floor, dejected.

“Is everything in preparation?”

“Yes, all the mining and manufacturing equipment is loaded on board. We’ll be able to feed ourselves; we have fully ready hydroponics. I suspect we’ll be able to bury the caravel under regolith in a month or so, so the radiation exposure won’t be that high.”

“Good. Maybe you can have more children later! And a fast connection would allow children to go there as well. In three or four years, once the water dome is completed and filled, Themis will be safer for a family than Mars is. Keep that in mind, Bill.”

Bill nodded. “I know. I know the plans.”

“Then don’t be sad! Trust. Everything will work out just fine if we do our part. I feel it.”

Bill nodded again. “Alright, prophet, whatever you say. I do trust you. It’s hard, but I’ll manage.”

“And so will Suzanne; don’t worry about that. I’ll do everything in my power to make sure.”

“Well, I do appreciate that.”

Lai Zicheng did not like visitors to his class, especially Chinese ones. When Dai Guofeng, the head of the cryogeology team on the *Gan De* stuck his head in, it looked like he was counting heads. The class wasn’t all that large that day, either; it consisted of Charlie, Sirikit, Firuz, and Jean Paul. Lai Zicheng wondered whether the cryogeologist, who sometimes acted like he was from a superior class of crew, was judging his efforts.

But when the class ended he was seated on a chair in the hallway not far from the door of the classroom, patiently waiting for Jean Paul to come out.

“Ni hao,” said Jean Paul, greeting him in Chinese.

“Thank you,” replied Dai Guofeng, replying to the Chinese words rather than the sentiment expressed. “How is your Chinese coming?”

Jean Paul shrugged. “After four lessons, there’s not much to report. When your vocabulary is limited, most of what you can say is nonsense, like ‘I have a spacecraft in my pocket.’”

Dai Guofeng laughed. “You’re right. But it’s a start. Come have some cappuccino.”

Jean Paul nodded and the two men walked across the corridor into the *Gan De’s* cafeteria, where there was a machine. They ordered their favorite from a robot, who made it while they watched, then they sat at a corner table where they had some privacy.

“How’s your preparation going?” asked Dai Guofeng.

“Pretty well. The Himalia data has moved us forward. Rather than planning phase one of the exploration, we’re planning phase two based on the phase one already done. It’s hard to believe that little, remote place had cryovolcanoes.”

“Yes, that is surprising, but it’s evidence that its orbit used to be much more eccentric.”

“Or it’s evidence of radiogenic heating right after formation. That has to be one of our central research questions.”

“Definitely. Have you requested additional orbital reconnaissance?”

“We want to.”

“You should. I’m sure they’ll honor your request.”

“Then we will. Thank you for the suggestion.”

“No problem.” Dai Guofeng sipped his coffee and considered his next sentence carefully. “Part of the problem stems from a misunderstanding, I think. The cryogeologists on Callisto and my team here are ‘icy moon’ specialists, as we like to think of ourselves. You all are from the Center for Asteroidal Studies. But the snow line lies inside the asteroid belt.”

“Exactly. The outer bodies of the asteroid belt are little different from icy moons. I fear your colleagues on Callisto may not have appreciated the reason for our interest in the outer moons of Jupiter, some of which are captured asteroids.”

“Right. We are approaching the same study from two different directions. But keep in mind that my colleagues on Callisto haven’t studied Himalia in the past because they didn’t have a spare caravel to get there, and very limited numbers of automated probes to send to priority targets. They were doing the inner, icy moons because they were close and important starting points, not because they represented the team’s entire interest. Perhaps your team hasn’t appreciated the reason for their interest in the outer moons of Jupiter, too.”

Jean Paul was startled by that and reflected about it a moment. “I see what you’re saying. The Galilean moons are mini-planets to us, not captured ice asteroids.”

“And to my colleagues, they are icy moons, not asteroids,” added Dai Guofeng. “But they are all members of the same spectrum of objects.”

Jean Paul nodded. “Yes, certainly.” He sipped his coffee a bit more and reflected. “So, the Center of Asteroidal Studies comes off as an interloper, parachuting into a situation for a few years, trying to make it right, then leaving.”

“That’s part of the perception, and one reason they sent the probe to Himalia. It’s their field of interest, too, not just your team’s. I’m sure of this because the plan to send the probe to Himalia predates Cai Xiaopeng’s interventions on Callisto. It was in the planning stage starting several months before our launch from Mars. One doesn’t just launch a probe to another place without prior planning.”

“That’s true. Commander Cai was under the impression the plans were abrupt.”

“And that would be an insult to your team. But it would also be very unprofessional scientific conduct. We’re professionals, both up on Callisto and here on the *Gan De*.”

“Yes, of course.” Jean Paul nodded in appreciation. “I apologize for our misapprehensions and mistaken assumptions.”

“I appreciate that, but the apology, I think, needs to go to them.”

“I agree. I’ll call.” Jean Paul took another sip of his coffee, contemplating the biased assumptions behind the blame they had imputed to the Callistan cryogeologists. “Perhaps it’s time we get our respective geology teams together.”

Dai Guofeng nodded. “I think so. Because after we arrive, we’ll all be looking at the same moons. I’m sure some of your people will want to study Callisto, Ganymede, and Europa; maybe even Io. And members of my team are already working on the outer moons.”

“Then we definitely need to get together.”

15.

Births and Beginnings

March 2075

“In conclusion, I can’t say this is a piece of cake,” said Alexandra over the flickering, jerky video link tying Mars to Acheron Outpost, Titan. “But in two months of steady work, I think we have a basic design that can be implemented by mid-2078 when the next mission departs for Saturn. Our 15-tonne, 20-megawatt reactor defines the basic size of the aerostat. A fifty-tonne design can accommodate one reactor, hydrogen storage tanks, helium-3 storage, and the cryogenic extraction system. The waste heat of the reactor will keep the aerostat’s balloons inflated with hot hydrogen. The cryogenic processes we can run with 20 megawatts should be able to process a tonne of atmospheric helium an hour and that will accumulate a tonne of helium-3 in about a year, worth five billion redbacks at current prices.

“Our SCN-50 nuclear engine defines the basic size of the shuttle that goes from orbit to the Saturnian atmosphere and back to orbit. To answer one question that I see has already arrived, we had originally thought we had to develop air-breathing technology, but the shuttle can fly down with enough hydrogen to dock to the bottom of the aerostat, which can refuel it for the return to orbit.

“Let me turn to the questions you all have sent based on the Powerpoint slides we put up on the website last night. Yes, the shuttle—we’re calling it the Peregrine—can be expanded. The hydrogen storage capacity could be doubled in size with the existing engine and increased even more if we gave it two SCN-50 engines. The estimated lifetime of an aerostat is three to five years, depending on the lifetime of the balloons. If we send along extra balloons, it’d last longer. The reactor should last at least ten years and we might be able to design the aerostat so that the

reactor could be replaced, though it's the most expensive part of the aerostat and after ten years we might as well chuck the whole thing and replace it. How many will we launch: two in 2078, one for Saturn and one for Uranus, but you'll have yours a year earlier than they. In 2080 we'll probably launch two more and if we are able, they'll be upgraded versions. How much scientific payload can an aerostat accommodate: right now we can design it for two tonnes, but keep in mind that when a Peregrine arrives, it can bring down new meteorological balloons and probes, probably about two tonnes. The Peregrine will be designed to fly two tonnes of helium-3 to orbit, so we are projecting it will fly once every two years. Could an aerostat accommodate humans eventually: are you crazy? It'll fly at the half bar pressure level where the temperature is 100 Kelvin; basically, the same conditions as Titan, for which we have well developed technology. I suppose in a decade or two we will be confident in the technology and there might be reasons to fly daredevils down and back. How reliable are the development cost estimates: our track record is pretty good and cost overrides have rarely exceeded twenty percent. This system will be profitable within two years if the price of helium-3 holds up. The current guess, though, is that the moon can double its efficiency and the price will halve. How big will the maintenance staff be: 10 to 20, depending on the maintenance schedule we finalize. How much testing will we do here on Mars: not much! The gravity, temperature, pressure, and atmospheric composition are all wrong. But we know how to build small aerostats for the Saturnian atmosphere. A dozen have been flown there in the last few decades. The Peregrine will be the trickiest piece of technology, so all we can do at this end is built two units and fly them, with a team, to Saturn, with any spare parts you can't make there. The Peregrine won't even be needed for two years after the aerostat is deployed, so there will be plenty of time to test it.

“That’s all the questions we’ve received so far. We’re taking a break for supper, now, then we’ll resume down here with additional questions you’ve sent and a closing statement. Thanks for this opportunity to collaborate with all of you.”

Marshall Elliott rose and walked to the podium, where the camera was pointing. “Thanks, Alexandra. I can’t begin to tell you how delighted we are to collaborate with you on this project. We’re all extremely excited about the possibilities. If anyone should get a Nobel Prize in spacecraft design, it is you! From what I can see, the design is characterized by simplicity whenever possible. It’s elegant as well. Even better, it can be done in three years. We’re now breaking for lunch, except for the Saturn atmospheric science department, which plans to meet over sandwiches to refine basic science requirements for the aerostat. Our mission control team will meet separately to discuss command and control, communications, and other issues. So take a nice, long, relaxing dinner and by the time you’re done, you’ll have our comments and questions. From the Acheron Campus of Martech, we’re signing off now.” Marshall looked at everyone and started to applaud, so they did the same.

Everyone rose and headed out of Martech’s main conference room. Marshall walked over to Sydney Kilgore. “Can I join the atmospheric science team for lunch?”

“Sure, Marshall,” she replied. “We’re meeting in the small conference room across the hall.”

“I doubt I can offer much, but we need to be sure that the science component of this project doesn’t get lost in the profit side, and as Chancellor of the Acheron campus I’m in a good position to defend the science aspect, so I want to know as much as possible.”

“I suspect you’ll have some good ideas, too. And we don’t have sandwiches, like you said; that’s the mission control team. We opted for buffet, so there may be extra food.”

“Oh, good to know, but it’s the Bahá’í fast right now, so I’m not eating.”

“I hope you don’t mind that we’ll be eating.”

“No, of course not. And I’ll try to have good ideas to contribute, even if my stomach growls a bit!”

“We’ll pretend we don’t hear it. I’m really surprised Alexandra and her team expect to have something ready in three years. That’s amazing!”

“If a testing team is coming here, they’ll have the one-year flight to finish up anyway. Alexandra’s a genius about spacecraft design. I don’t know what Mars will do when she retires in a few years. It’s not just a matter of replacing her with a talented team; a talented team would compromise with each other’s priorities and produce a vehicle that’s twice as big and expensive. She has the ability to see what works and to say no to the rest, even if it’ll be a great addition to the vehicle later on.”

Yuri Severin approached. Sydney noticed and backed away a bit. “Well, come on across the hall when you can,” she said.

Marshall nodded and she walked away. Yuri came over. “Thanks for planning this briefing session,” he said. “Alexandra is working fast; I don’t think anyone would have expected the project to take shape so quickly. If we hadn’t gotten involved at this early phase, all sorts of complaints and resentments might have resulted later.”

“Experts parachuting into an existing situation are seldom welcomed. They need to know we have good people with solid plans that can complement their efforts. The Saturn science team already has their 2078 equipment in the final design phase, so they have to make changes in the next few months. It’s a crucial time.”

“An aerostat can provide more reliable data transmission back to Titan than a satellite,” said Yuri. “The probes they’re designing are supposed to be able to descend a thousand kilometers before they’re crushed. A powerful radar system on board the aerostat, which can be maneuvered around the planet as far as the north and south poles, can also provide incredible data.” Yuri sighed. “We’re beginning to do some incredible research up here.”

Marshall was startled. “Why are you sighing? It’s really amazing.”

Yuri lowered his voice. “Because I’ve decided to leave next year. I haven’t announced it yet. I’ll have been commander of the Saturn effort since launch in 2068; that’s eight years. Add in the two years of mission preparation and it’ll have been ten years. That’s plenty. I’ll be back on Mars in 2078, when I’m 65, or maybe I’ll go to Earth for a few years and visit with my daughter, whom I haven’t seen in twenty years.”

“Your son’s on Mars now, right?”

“Yes, working at Martech in Cassini. So I have family on both worlds, now. There are a lot of things I can do on Mars, too. I might even offer to command an asteroid mission! They’re always appointing commissions of gray-haired experts to study problems or accidents, so I’m sure I’ll be busy.”

“I’m sure you will be, but I can’t imagine this place without you, Yuri.”

“Thank you for that. But these outer settlements shouldn’t have career commanders or chief executives. Someone should stay, work their way up, command for four or eight years, retire from it, then go back to Mars, where they can do other, bigger things. We have to be careful about becoming little cliquish, gossipy villages. We need new blood, and the people here need to have a sense of advancement. I think that’s another piece of the Mariner puzzle; Mars is

the pool of explorers, mostly young, who go out, explore, acquire great experience and skills, then come back to Mars and enrich its human resources.”

“Really?”

“Well, maybe it’s just a personal theory.” Yuri shrugged. “I’m going to lunch. See you this afternoon.”

Marshall nodded and watched Yuri go. He couldn’t help but wonder whether Yuri was telling him because the three top vote getters on the Saturn Council—Yuri Severin, Sridhar Prathan, and Andries Underwood—were all planning to leave in less than two years, leaving just him and Shiyoko Takashima, who were both members of the next generation. That guaranteed a big change in the Saturn Council’s membership and in the position of Chief Executive. A thought both exciting and frightening.

His communicator beeped, distracting him from his thoughts. Marshall pulled it out and read the text message from Amy: *Contractions now twenty minutes apart, I’m heading to the hospital.*

“Whoa!” said Marshall. Amy hadn’t thought that today would be the day; she was wrong. He walked across the hall to the small conference room, where the Saturn science team was sitting down to lunch. “Sorry, Sydney,” he said. “Amy’s having the baby now!”

“Go, we’ll manage without you!”

“Tell Yuri he has to chair the wrap-up session this afternoon!” Then Marshall turned and headed for the *von Braun*, their spinning galleon that contained Titan Hospital.

“What the hell are they doing?” exclaimed Giovanni, looking at a satellite photo taken just that morning. He moved his fingers on the screen, magnifying the image of Lars and Celeste’s land and looking at all the ranger tracks crossing it.

“It’s really not nice to spy on the neighbors, dear,” replied Holly.

“I wouldn’t call this spying. The satellite goes overhead every morning at 10 a.m.”

“But you have to request the photo for the satellite to take it. Do you want them asking it to photograph our land?”

“They can; it’s perfectly legal. Don’t you think it’s strange that they drove down on Thursol evening and here it is Saturdays and they haven’t stopped by?”

“I would have thought they would, but there’s no legal or moral obligation for them to do so. Besides, I thought you were hesitant to have neighbors.”

“Well, now I’ve gotten used to the idea, and I think it’ll be nice to have them a short drive away.”

“I’ll ask them, then.” Holly turned to her communicator. “Please send a text message to Lars and Celeste. ‘Hi. On Thursol afternoon we saw your rover go by at a distance and see you’re still down here. Please stop by, maybe for supper tonight. It’d be nice to see you.’”

“Okay,” said Giovanni. Holly nodded, proofread the message, and hit the send icon. She went back to washing dishes.

“Goldi, I don’t see Lars’s ranger on this morning’s satellite picture,” exclaimed Giovanni. “Can you locate it for me, please?”

“Sure. Give me a minute to scan the latest images.” The automated assistant paused, then added, “The ranger is nineteen point three kilometers northwest of their tentative settlement location, outside the property. Shall I show you?”

“Yes, please do.”

The satellite image on Giovanni’s screen updated. It was zoomed out to show both of the land claims; a yellow X marked the location of the ranger. “Interesting; it’s located next to an ancient river channel, right?”

“Yes,” replied Goldi. A blue line appeared on the screen, snaking southeastward to a spot between their properties. “This is the early Hesperian channel. I believe I can make out the ranger’s tracks, which show that it has been following the channel.” Goldi added a dashed red line.

“Interesting.” Giovanni contemplated. Holly was so curious, she stopped washing dishes and walked over. “Would those channel deposits have gold in them?”

“Oh, they do; our geology team checked. Scattered placer deposits washed from the gold-bearing zone. I wonder whether they plan to enlarge their claim.”

Giovanni said the last sentence with an upward interrogative tone, so Goldi took it for a question. “Someone has made a new land claim,” she replied, adding a white property line to the photo.

“So, someone bought the entire Hesperian channel deposit for 12 kilometers,” exclaimed Giovanni.

“Really?” Holly came over to look. “Wow, that’s a good sized chunk of land.”

“Goldi, who bought this land here?” Giovanni touched the screen.

“It is registered to Thorvald and Monica Erstad of Kalgoorlie.”

“I wonder whether they’re Norwegian,” said Giovanni. “Maybe they’re friends of Lars.”

“Thorvald and Erstad are listed as Norwegian names,” replied Goldi. “A search of social media sites shows that both Thorvald and Monica are friended to Lars and Celeste Petersen.”

“Ask, and ye shall receive,” commented Holly, with a smile.

“That’s what people always say,” injected Goldi.

Just then Giovanni’s communicator buzzed. “Speaking of the devil; it’s Lars.” He pushed the activate button. “Hi, we see you’re down here.”

Lars’s face appeared on the screen. “Yes, but I’m here with a friend, Thorvald Erstad. Celeste couldn’t come. We were just scouting out his claim.”

“I just noticed someone had bought the placer deposits in the Hesperian streambed.”

“Yes, that was Thorvald. Shall we stop by? We’re finishing up lunch and we’re about to drive back to Kalgoorlie. We can be there in fifteen minutes or so.”

“Sure that’d be great. We’ll make a pot of coffee. Drive on in and dock against the cab.”

“We’ll do that. Bye.”

“Bye.” Giovanni closed the circuit. “Well, let’s prepare to meet the new neighbor.”

“Three couples; it’s almost getting crowded down here!” Holly turned to the freezer, where she had some frozen pastries while Giovanni pulled out their fancy flavored marabica coffees. By the time the pastries were hot and the raspberry marabica was brewed, Goldi informed them that a docking was underway. Three minutes later, two men stepped into the conestoga’s main cabin.

Giovanni was startled. They were both in their late twenties, tall, thin, and blond; at first he wasn’t sure which one was Lars, until he noticed that Thorvald had a mustache. Otherwise, they could be brothers. He extended his hand. “Giovanni DiPonte; glad to meet you, Thorvald.”

“Thank you, pleased to meet you too, Giovanni.” They shook hands. “I guess you heard that I just bought a long, thin claim about fifteen kilometers northwest of here.”

“Yes, it’s already on the regional map. The placer deposit. I see you’ve explored it, too; are you pleased with it? Here, sit down and have some coffee.”

“Thank you.” He turned to Holly. “Pleased to meet you, I’m Thorvald.”

“Pleased to meet you, too. And good to see you again, Lars. Sit down, gentlemen, and have a pastry.” She put one on a plate for each of them.

“Thank you, and raspberry flavored marabica is my favorite,” replied Thorvald. “Yes, I’m pleased with it; we’ve walked about ten kilometers of the Hesperian stream bed and we found three nuggets, one massing 55 grams.”

“Not bad,” said Giovanni.

Thorvald looked around. “This is a comfortable arrangement. It’s rather overwhelmed by the radiation shelter, though.”

“Yes, they don’t make narrow radiation shelters, for some reason,” said Giovanni.

“Plenty of room for expansion later,” added Holly.

“I see you’ve got a good amount of ice and reg covering it,” noted Lars.

“So, you’ve been here how long; six months?” asked Thorvald.

“Just about,” replied Giovanni. “We’re making some progress.”

“And you go to Kalgoorlie every few weeks for supplies?”

“About once a month; it’s nice to see other people and walk in greenery. Our B-75 is still pretty bare!”

“It’s coming along, though,” noted Lars. “I see you’ve got a third of the floor terraced and covered with reg.”

“Yes, the android has done a good job,” replied Holly. “We still don’t have enough spare heat to warm up the mass of rocks it has added to the bottom of the slope, though, so the space is still pretty cold.”

“That’ll slow down your plant growth pretty severely,” said Thorvald. “I’ve taken some courses in horticulture.”

“What’s your expertise?” asked Giovanni.

“I’m an artificial intelligence engineer. I may be able to help redesign some of the autonomous operation software created for more advancing mining units to work with the equipment down here, too.”

“That’d be good!” exclaimed Giovanni. “We work under some pretty ridiculous limitations!”

“So I see. But you’ve done alright, right?”

Giovanni considered what to say for a moment. “Yes, I guess we have. We’re averaging nine grams of gold per sol. Basically, we’re each working for about half the usual annual salary, and we’re working long hours. But we enjoy the work, we have our own land, and we’ve begun to pay off the loan to my parents.”

Thorvald nodded vigorously. “To have your own range: that’s the best! Monica and I can’t wait to move down here. It’ll be a few months, still; we have to give notice at our jobs and assemble all our equipment. Maybe June or July.”

“When are you and Celeste moving down, Lars?” asked Holly.

“I think next month,” he replied. “Though we may wait and move when Thorvald and Monica can move.”

“It’ll be easier if all four of us transition at once,” said Thorvald, and Lars nodded.

Giovanni glanced uneasily at Holly. “Well, if you need any help, let us know. We want to be good neighbors. We’ve deepened our well and it now yields much better, so we have water to spare.”

“Oh, that’s good to know,” said Thorvald. “Water is essential for these operations. How well have you handled the dust storm season?”

“We’ve managed,” replied Giovanni. “On sols when the sun was badly obscured we walked our claim and picked up nuggets. That actually yielded more gold than mining it!”

The four of them laughed at that. “Yes, the easy to find stuff is still pretty accessible. I’m not sure that’ll be true during the next dust storm season,” said Lars.

“By then we may have spare power for the mining equipment,” said Giovanni.

“So . . . no mother lodes?” Thorvald smiled when he said it.

Giovanni shook his head. “No, not yet, I’m afraid. It’d be nice.”

“Yes, it would! I wouldn’t mind getting rich!”

They all laughed, though Giovanni less so. “It would really help. But I’m not into getting rich quick and settling into a big house at Aurorae. I like this place.”

“But . . . all your life?” asked Thorvald, surprised.

Giovanni shrugged and smiled.

“Okay,” said Thorvald, chuckling. He downed the rest of his coffee and looked at Lars.

“We’ll be late if we don’t get going soon.”

“I know; we promised the wives we’d be home for supper.”

“Take the rest of the coffee with you,” said Holly. “Do you have a thermos? If not, we have a spare.” She rose and walked to the kitchen cabinets.

Lars and Thorvald rose, so Giovanni did as well. They shook hands and exchanged goodbyes, then the two Norwegians squeezed back through the tunnel to the mobilab's cab, and from there, back to their ranger. In a few minutes they undocked and drove off. Giovanni looked at Holly uneasily. "I guess it'll be good to have a second set of neighbors."

"I guess."

"I wonder whether we'll be the odd couple out, though," continued Giovanni. "Thorvald and Lars, obviously, are close friends."

"No doubt Lars recruited Thorvald," agreed Holly. "Well, we'll have to wait and see, I guess."

"I guess." Giovanni picked up the coffee cups and plates and took them to the sink, where he started to wash them. Holly began to suit up; they planned to spend the afternoon walking their claim looking for nuggets.

The communications system rang. "It's your father, Giovanni," announced Goldi.

"Put him on the screen here, please," replied Giovanni. He picked up a towel to dry his hands while he turned to the screen. His father's face appeared. "Hey Gianni, how are you all doing?"

"Pretty well, dad. We're plugging away. We just had some guests; another couple plans to homestead down here in June."

"So . . . that'll make three?"

"Yep. I think he's here to get rich, though."

Silvio laughed. "That's not too likely, I think! How are you doing? Do you need anything?"

“No, we do not need anything, dad! We’re managing just fine, in spite of the lack of government support! We never could have gotten the radiation shelter or the B-75 without a little informal assistance from Lars. The well has been a real pain. And no one seems to be willing to release proprietary software to automate our mining equipment. Half the time, we can’t even figure out who to talk to purchase a spare part. So we have to deal with Consolidated or Muller Mining directly, and they aren’t set up to sell spares. When we go to Kalgoorlie, we have to spend most of our time talking to a succession of people to get some crucial parts.”

“I know, I remember you told me. Jacquie keeps saying she wants to encourage homesteading, but they haven’t followed up. They’re busy.”

“I’m sure they are, but so are we! We don’t need your money, dad, but we sure could use some bureaucratic streamlining!”

“I hear you. I’ll make some calls; do you mind if I do that?”

Giovanni hesitated. “No, I guess I don’t. It’ll help everyone, after all. Lars has been working on it, since he’s a supply officer in Kalgoorlie, but I think he’s gotten in trouble helping us.”

“That’s too bad. I was talking to some mining officials the other sol and I definitely got the feeling that they were very nervous about gold mining homesteaders. They were talking about buying up all the scattered gold deposits that are known or inferred in your area.”

“No, they can’t do that! There’s room for dozens of people within a hundred kilometers of here. The deposits are all pretty small; a mining company might go after them robotically, if that technology is perfected, but otherwise they’re too low grade for a team.”

“Unless they send a team of two for a month and rotate them; a sort of company homesteading system.” Silvio paused to consider the situation. “Don’t worry about the mining companies buying up the land; I’ll see what I can arrange. And I’ll call Jacquie.”

“Okay, dad. I guess it’s time for us to get at least that much help from you.”

“It’s okay. I want to come up and visit some time! I really do, but your mom says no, I don’t have enough range experience, and she’s right; I was a banker and store keeper, not a geologist. A lot of arrivals have more range experience after six months than I have after almost 30 years! Anyway, I’ve got to go.”

“I’ve got to get suited up, too. Holly must be wondering where I am!”

“Okay. You take care, have a good and safe EVA, and we’ll talk again in a few sols.”

“Okay. Say hello to mom for me.”

“I will. Bye.”

“Bye.”

“Our family is complete,” said Will, looking at the image of Marshall, Amy, Willie, and little baby Milly frozen on the screen.

“For the next generation, anyway,” agreed Ethel, with a smile.

“Willie and Millie; that could get confusing,” said Liz, looking at the still video. “But she is a sweet looking baby.”

“It’s a shame we can’t pick her up and hold her,” said Ethel, sadly.

“Shall we send a reply?” asked Mike, and when the others nodded, he reached over and pushed the “reply” button on the screen. Will tapped Ethel to start.

“Hello up there on Titan,” she began. “We have held the last frame of your videomail on the screen so we could savor the picture of the four of you, and you look so happy together! Willie, I’m so glad to see you are happy about the baby. She’ll be very dependent and demanding for a while, but in a few years she’ll be talking and looking up to her big brother, and the two of you will be great friends. Amy, I wish I could have been there with you; I wish I could be with all of you now! But we hope that, God willing, we will all be together, face to face, at some point soon. Please kiss Milly for me.”

She turned to Will. “I can’t tell you how happy I am and how blessed I feel right now,” Will said. “Not to mention how amazed I am that I have a son, daughter in law, and two grandchildren a billion and a half kilometers away in a rotating station on the surface of an icy moon! Even that is hard to imagine. But in spite of our technology, life goes on. I’m so glad that you are well and the birth was without complications. We’re all looking forward to see what Milly does with her life. That’s the real miracle, isn’t it?” Tears began to come to his eyes and Ethel leaned over to put her arm around his shoulder.

Liz and Mike chimed in with their comments, then Shayda and Jason said hi. Mike reached over and pressed send. “You don’t cry much, dad.”

“No, I don’t, but the older I get, the more I come to appreciate all that we have,” replied Will. A tear formed in one of his eyes and he hesitated a moment to find the right words. “It really is a gift, a divine blessing. It really doesn’t matter what planet we live on; where we live. That’s an amazing feat of technology, of course, but the real point is simply *living*. The fact that we can do that, not where; that’s the blessing.”

“A blessing we have to struggle with, to benefit from,” added Mike.

Will nodded. “Indeed.” He rose from the couch. “I have to walk a bit; I’m feeling stiff.” In the last few months he had been very unhappy about how his joints felt, especially his knees and ankles. He stretched his legs a bit and walked across the living room while the grandchildren went back to playing and Ethel walked into the kitchen to get more coffee.

Will’s communicator buzzed. He looked at the caller i.d.; it was Silvio DiPonte. “Hi, Silvio. I haven’t talked to you in a while, how are you?”

“Pretty good, Will. Congratulations on the birth of another grandchild.”

“Thank you, but I didn’t do anything, and now all we can do is look at the sweet little baby by video! It’s rather frustrating. I wish they’d come back.”

“I know; that’s how all our parents felt when we came here! Say, Will, I’m worried about something. As you know, Giovanni and his wife, Holly, are homesteading in the Meridiani region. They’re struggling, but they’re okay; they won’t accept financial help from me or anyone else, but they have said I can talk to people about bureaucratic issues. They have two couples moving into the region to join them in a few months, which is a big relief to me; they’ll have someone to help them if there’s an emergency, which they don’t have right now.”

“That’s what would worry me more than anything else,” injected Will.

“Exactly. I wish we didn’t allow homesteading at all; it’s very risky. But that’s not why I’m calling. Consolidated and Sibireco, in particular, are very unhappy with the homesteading situation. I was talking to an official who will remain nameless the other sol and he said they were considering the purchase of fifty thousand square kilometers of Meridiani rangeland with scattered gold deposits just to keep it out of the hands of the homesteaders. That strikes me as immensely unfair, though of course it’s perfectly legal.”

“I agree, it’s not right. Do you want me to call a few people? We may be able to dissuade them.”

“I’ve tried, and I’d love it if you were to try as well. But I was thinking of a different strategy: buying up the land myself so it can be resold to homesteaders, or even leased to them under a profit-sharing arrangement that would eventually return some profit, but wouldn’t burden them with startup costs. The potentially gold bearing blocks sell for ten thousand redbucks per square kilometer.”

“Wow, that’s a lot of cash for isolated range.”

“Exactly, but if it has a million redbucks of gold, it’s worth it. The problem is, no one is sure what blocks have the gold. Giovanni had prospected the area and had personal knowledge, so he selected a block that had a supply, and he has proved to be right. I’m trying to assemble an investor’s group to buy as much of the range as possible for resale or lease back to homesteaders, *not* mining companies. If we can get something going, we can publicize it, and that will put pressure on the companies to leave the homesteaders alone, and even on the government support them better. Right now they have no support at all.”

“What sort of support?”

“Well, when a new outpost is to be built, the Commonwealth invests in power, water, roads, communications . . . you name it. Why not do the same for the homesteaders? They’re more scattered, but let’s say you wanted to serve everything within a radius of one hundred kilometers from some point. That’s about 30,000 square kilometers. You can accommodate a lot of homesteaders in that much area.”

“I see your point.” Will considered. “I’ll need to talk to Ethel later tonight when we’re home alone, but I bet we could commit . . . five million.”

“That’s great! That will really help. Érico has agreed to help, and Madhu, and Sebastian. If we can scrape together about twenty-five million, I can hire someone to purchase the blocks most likely to have gold. We can leave the rest, since it sells at a much lower price and no one wants it right now. It’ll be enough to secure most of the area, I think. Thanks, Will, that’d be great.”

“I think it’s a great idea, Silvio; thanks for thinking of it. It may even make some profit, and that’s even better, obviously!”

“Yes, it needs to be a good investment, otherwise everyone has better places to put their money. I’ll email you a report morrowsol with the details of the plan, then.”

“Great. Thanks, Silvio.”

“Bye.”

“Bye.”

“Well, Mr. Ambassador, I have good news and bad news,” said Jacquie Collins, looking Arthur Danforth straight in the eyes. For a moment she seemed to see the majesty and power of the United States of America reflected back, but that didn’t deter her.

“And since this is Mars, you’ll give the good news first,” replied Ambassador Arthur, with a wan smile.

“Alright. It appears NASA’s advanced ion propulsion system will be ready by 2080, and if it is and we have it in plenty of time, we will use it that year on the Saturn and Uranus launches.”

“Excellent. I suppose the bad news is, you’re launching to both in 2078 anyway with the Chinese magnetoplasmodynamic system.”

“Partly. We are indeed committed to 2078. We know the United States favors 2080, but we see no reason for it; we have the technology, the best way to refine it is to send a large mission to the Uranus system with the equipment to refine their system as they go. Jovian and Saturnian technology will work quite well.”

“With nearly a half billion redbacks of Americium heaters!”

“We have used up the Earth’s entire supply, haven’t we? But as long as gold prices hold up, we can afford it. But we can’t help cover the four billion redback development cost overrun for the advanced ion system. Our memorandum of understanding was quite clear.”

“If you postponed the first launch to 2080, you certainly could.”

“But the plans are well advanced and the propulsion bottlenecks are on your side, not ours. The Chinese system will definitely be ready; it’s coming here next year and will be tested in Mars orbit for a year before the launches. The reactors are ready and will be launched in a few months. Their cooling systems will be tested extensively on Deimos, then with the magnetoplasmodynamic system. The Chinese system, using hydrogen, also gives us better flexibility, since the gaseous core engines that get the launch going will use it as well. If there are problems with either propulsion system, the other one can serve as a backup.”

“Our system’s argon could be used in the gaseous core engines as well.”

“Certainly, but the specific impulse would be pretty low. Hydrogen also makes better cosmic ray shielding, and we want the launch complex to be well shielded.”

Danforth sighed. “Well, I appreciate it that you’ve given me a warning. I’ll convey the news to Washington. I think you can predict there will be financial retaliation; most likely, money to cover the costs of American astronauts will be cut back.”

“And the publicity will say that because the propulsion system has had cost overruns, the money had to be shifted. It won’t amount to much money, and it will shrink the number of Americans on board somewhat.”

“I wonder? The screening process is largely blind to nationality.”

“True. But any Americans selected can also be expected to complain to the media about Washington’s avarice. I hope Washington will keep that in mind as well.”

“I’ll remind them.” Danforth rose. “This is very unfortunate, Chief Minister Jacquie. I am sure I will be asked to convey my government’s protests about your unwillingness to help with the cost overrun. But privately, I concede that we have to do better, where cost controls are concerned. New technology is always unpredictable.”

“It is, Mr. Ambassador, but we have done a better job of predicting the unpredictable than NASA has.” Jacquie rose and offered her hand. She and Danforth shook, then she escorted him to the door.

Jacquie returned to her seat, relieved that Danforth had been reasonably understanding. She also contemplated the issue of whether the Chinese really would be ready; the reports were not as optimistic as she had suggested. Even getting the vehicles and equipment ready had some uncertainties.

Her email beeped. She leaned over; it was yet another email from Silvio, the fourth in three sols. She skimmed it; it had more ideas about supporting the homesteaders. “Miki, can you take Silvio’s email address off the whitelist?” she said to her automated assistant.

“Certainly.”

She considered further. “Miki, cancel that. I’ll continue to receive his messages directly; you don’t need to send a summary. What time is it in Kalgoorlie?”

“Ten p.m.”

“Rather late. Well, that’s alright. Put a video call through to Giovanni DiPonte.”

“Here we go,” replied Miki. Jacquie turned to the screen on her desk and made sure her hair was alright. She could hear the ringing at the other end, then a started Giovanni DiPonte answered.

“Chief Minister Jacquie, what a huge surprise! Hello!”

“I’m sorry to call so late, Giovanni. Is Holly there as well? I wanted to call both of you directly and ask about what problems you’ve encountered in the course of your homesteading. Your dad told me some of the story, but I wanted to hear it from you directly.”

“What problems did we encounter?” Holly laughed and moved into the field of view. ‘Yeah, I’m the one to ask; Gianni would go out and run the equipment while I sat inside, fixing things and making phone calls to dozens of people. Have you any idea how hard it is to buy replacement drill bits for a model 537 gold driller-separator? The big companies gave them up, we got one for free, and it turns out no one orders replacement parts from Earth any more. We were lucky to find three spares in Cassini, after a dozen calls. Multiply that by twenty or thirty parts. Martech can special manufacture some of them, but at prices that are higher than Earths!’

“You can’t homestead without a minimum of several hundred thousand redbacks of stuff,” added Giovanni. “We were lucky to get a used Conestoga. Our friends just have a ranger, which is pretty risky. The free used mining equipment is old and requires three times as much time for maintenance. The 537, theoretically, can be set up for automated operation, but the software is proprietary and unavailable to us. We thought we were lucky to get a B-75, but it’s so huge we still only have a third of it set up after six months; we needed a B-25, but none were available. Our little Conestoga is parked in an enormous radiation shelter we’ll never be able to

cover properly; it looks rather ridiculous. Our water well yields very poorly and the type of drill we bought really can't go any lower. It would have been better if we could have leased a deep drill, but you can't lease them; no one does that. If we could buy power as we needed it, it would be much better than having to buy a huge solar array, set it up, and maintain it; our android is busy half the day cleaning the panels."

"I'm sorry about all these problems," replied Jacquie. "I think you would agree that the role of the Commonwealth is a delicate one; if we subsidize you, we have to subsidize everyone else, including the big companies."

"But the Commonwealth has already been subsidizing the big companies," replied Holly. "That's how the outposts get set up."

"You have a good point; I set up Tithonium. And I suppose we could do something similar for your area. But you're part of Kalgoorlie borough, right?"

"No," replied Giovanni rather emphatically. "We are north and west of Airy crater, so we aren't in Kalgoorlie, Meridiani, *or* Thymiamata boroughs. This is a borough of its own, unless we get annexed."

"I see. I hadn't realized that. So, no borough government is responsible for you."

"Correct. We're closest to Kalgoorlie, but it's four or five hours drive from here."

"That's good to know; it means the Commonwealth government has even more responsibility. Thank you for your time, Giovanni and Holly. I really appreciate it. I'll see what I can do."

"Thank you very much, Chief Minister Jacquie," replied Giovanni. "We're out here because we want to be on our own land and earn a good living on it, but we're also here to

contribute to the Commonwealth and to the exploration of the solar system. In our own way, we're doing our own exploration, after all. But we could use the support of the community."

"I'll see what we can do. Bye."

"Bye."

Jacque closed the circuit and watched the faces of Giovanni and Jacquie disappear from her screen. She pondered a moment. "Huma? Can you come in here?"

"Sure," replied Huma Mubarak, who had continued in the job of chief of staff under Jacquie Collins. She stepped into the office a moment later.

"You heard the conversation," said Jacquie. "I need someone reliable and capable to pursue this matter. I want us to set up an oasis somewhere within twenty or thirty kilometers of the three homesteaders, preferably in a geographically central place as the homesteading expands further. It needs a very deep, reliable well, a radiation shelter, and lots of solar power converted to methane and oxygen, so that homesteaders can come and refill their tanks. I also want someone to figure out what equipment these people need and how to be sure it's available at a reasonable price."

"That may be hard."

"Have the homesteaders call him or her, and the person can call around to obtain the equipment. That will save them time and frustration and allow us to build up an inventory. This won't cost us all that much money—maybe a million redbacks—but if it produces a great increase in homesteading, it will pay for itself manifold."

Huma nodded. "I'll get on it right away."

Plot Summary

1. Chief Minister 2
 Nov. 2073
 Jacqueline Collins inaugurated as Mars's Chief Minister; introducing Charlie, Wicahpi-Luta, Sirikit, Bill, Guillermo, Esther; Future of Saturn Forum discusses plans there; Arnold Comiskey of Fontein Metals calls Helmut Langlais re PGM production and Helmut decides to look for other Cererian PGM resources.
2. A New Era 24
 Dec. 2073
 Jacquie gives her inaugural address and Will reflects with Ethel; Charlie, Sirikit, Bill, Esther, Wicahpi-Luta reflect about the inauguration; Charlie meets Corey Kubota, the zero-gee volleyball expert, who invites him to Phobos for December break; Jacquie replies to various solar system settlements and meets Zhao Tao, who essentially demands that Mars pay more; Charlie and Firuz talk about Charlie acquiring some faculty status and a trip to Callisto; Sirikit has a solar system economics project with Park and considers going to Phobos as well, as does Esther and Wicahpi-Luta; Marshall is elected to the Titan Council (with Thomas Racan right behind him).
3. New Missions 45
 December 2073
 The foursome arrive at Phobos and explore the outpost and visit with Maaka; Madhu Anderson, Mindy, Victor, and the Manyhorses arrive at Thaumasia; Charlie plays zero-gee handball and Corey says a zero-gee sports league could be formed on Phobos; Charlie meets Firuz and Jean Paul Poirier, who invite him to apply for Callisto; Helmut visits an octahedrite impactor at Mahuika Crater 400 km from Central and talks to Clara about Charlie's invitation; Sebastian is at Ethel's retirement party and talk to Will and Ethel about Charlie; Charlie talks to his friends and to Sirikit and Father Greg shows up; r
4. Synergy 84
 Feb. 2074
 Sirikit and Park talk about her going to Earth and he dissuades her on the grounds that the terrestrial economy will fall apart. Sirikit talks to her father about her plans to stay. She goes to Charlie's grandfather's for a family dinner. They talk about Ceres plans to export metals. Helmut says a solar system economic plan is needed. Marshall Elliot visits Mimas by android, then the Mauna Ulu geology team on Titan. The latter is concerned about a diapir and Titanquake.

5. Mother Nature 104
 March 2074
 Sirikit, Wicahpi-Luta, and Charlie calculate a new way for Ceres to export metals to Earth. Bill and his girlfriend arrive and invite them to Aram for spring vacation. They get into the interborough and meet Giovanni DiPonte. Jacquie deals with a shuttle landing problem, delays in the road building system, and Ramesh Prathan, who wants to eliminate the divider in Caspian because construction's behind schedule. The seven of them arrive at Aram and see the opening ceremony. The Likoma Power line for Acheron Outpost goes live and Marshall goes to bioarchive to see the result of the full power. Charlie and Sirikit walk the length of Aram and see coyote pups.

6. Vision 142
 May 2074
 The 164 Bahá'ís who arrived from Earth meet at the Aurorae House of Worship and Will Elliott addresses them about Marsian values and what they can do to contribute, as Bahá'ís. Then he and Sirikit talk about funding Ceres expansion and Will points out other outposts could invest in Ceres. The *Bode* lands on Ceres with 70, raising Ceres population to 146. Helmut and Carter discuss expansion plans and the politics. Kurt and Anne Hollingworth talk to Bill about his plans to marry Suzanne and move to Aram. They object to the religion behind it. Jacquie and a team of 15 discuss the solar system financing plan using Ceres and approve it. Helmut sends a congratulatory videomail also. Charlie and Sirikit admit they are in love, but that they are going to be separated.

7. Making it Work 170
 May 2074
 Sirikit talks to her mother and cries. Charlie talks to Wicahpi-Luta, then Firuz, who suggests Sirikit come along. Sirikit and Charlie agree to get married and see whether it is practical for her to go on the Callisto mission. They lunch with the Thanarats and supper with the Langlais. They videomail Poirier and Cai and Sirikit agrees to run the store and serve as arts and culture coordinator. The mission is taking 185 adults and 6 children to Callisto, which has 81.

8. Whirlwind 184
 May 2074
 Will Elliott asks Sirikit to meet with him and asks her to explore the ethical implications of the term "Commonwealth." Sam Anderson returns to Thaumasia from the Council sessions in Aurorae with 4 trucks, 8 Quonsets, 80 dome builders. He introduces his mom to Giovanni DePonte. Mindy answers a question from Sirikit; Sirikit and Charlie talk about the cultural director job; Saturn Council meets to discuss pros and cons of investing in Ceres and decides to seek govt investments on their behalf. Sirikit and Charlie's

wedding; Jacquie drops by and Will talks to her about a strategy to obtain private investments in Ceres.

9. Launches 208

Late June/July 2074

Six-hour launch to Callisto; Charlie and Sirikit go to the observation deck and see Mars. Will and family come back from the service for the Hurricane Catherine victims at the House of Worship; Mike about to go to Gradivus; Arnold Comiskey and Will negotiate about Ceres; Commander Cai complains about the interfaith service and receives an email from Commander Chen Wei of Callisto that they won't help with tunnels or accumulating meteoritic materials; he forwarded the message to Wang Chenguang and walked over to get her opinion. She'll call Chen Wei and Beijing about the matter. Giovanni explores the area around the pegmatite mine and meets Holly Swan. Jacquie and Hun-jai debate ways to increase gold and PGM production, with PGM prices plunging, and decide to support small temporary outposts. Sirikit and Charlie watch the wedding of Bill and Suzanne at Aram Crater and ask Esther and Wicahpi-Luta when they will get married. They discuss small-company gold mining and Sirikit decides to call Giovanni.

10. New Endeavors 238

early August 2074

Penetrator 1 is on its way to Penelope; Giovanni advises Sirikit about gold mining and talks to Holly about homesteading. Tree talks to Bill after his baptism and recommends they start a family and Bill to get ready to be a pilot to an asteroid for them and go to Phobos with him. Comiskey wants to back out of the Ceres deal because of the terrestrial economy. Wang Chenguang tells Cai the Chinese government will start to cooperate on Callisto, partly because of economic troubles; Cai calls Commander Vickers and asks him to start collecting 40 tonnes of meteorites.

11. Gold Rush 253

Sept. 2074

Vasili Ivanov tells Jacquie Parenago will continue full production at the lower (1/4) price and will slash costs, so no Marsian galleons or reactors, and Jacquie confirms they'll push small-scale gold production; Wicahpi-Luta sees Bill and Giovanni in the Martech cafeteria and Giovanni announces he and Holly are going homesteading and getting married. Marshall and Chad discuss moving the route of a Titan exploration expedition and Marshall and Sridhar agreed the campus is beautiful and Sridhar tells him he and Teresa Alvaro are both heading back to Mars; Silvio is furious Giovanni wants to homestead but agrees to give R550,000; Giovanni drives to Thaumasia and he and Holly decide to get married that sol. The geologists on the *Barnard* discover the Chinese

geologists on Callisto have sent a probe to Himalia; Sirikit and Charlie call Giovanni over his decision to homestead just as he and Holly arrive on their land.

12. Challenges 278
 October 2074
 Dai Guofeng defends the *Gan De*'s involvement in the Himalia mission and Firuz moves everyone toward a compromise and brainstorms with Sirikit and Charlie about creating unity; Giovanni heads back home with 6 grams of gold and 500 kg of chewed up rock for the B-75 and Holly reports their lack of support and they talk about their failure to hit gold, then they go outside and find snow buried on Holly crater's rim. Sirikit meets Chen Xianglong, in Gan De's environmental management, and gets a dinner invitation. For the next evening. Marshall and Willie go find Amy for a picnic supper in B-4. And tell Willie about the baby. Sirikit and Charlie have dinner in the Gan De and make plans for programs and language classes.

13. Future Plans 304
 December 2074
 Jacquie holds a future of Mars gathering. They discuss the transportation revolution the Prometheus has created and the radical privatization that is now possible, and developing Helium-3 production in the outer planets. Giovanni buys stuff at Kalgoorlie and Lars says he wants to come down to homestead, too. Sirikit organizes 21st Century Confucianism and Mariner Culture conference and a group of them debate its relevance afterward; Cai says he is convinced he should push Chinese culture and language more; Jean-Paul agrees to learn some Chinese; Helmut waxes proudly about Ceres's six B-75s and its PGM mining and Charlie talks about the situation on board; Helmut asks about Helium-3 production. Marshall talks to his father about Jacquie's State of the Commonwealth speech and its Helium-3 section and talks to Sydney Kilgore about cooperation of her meteorology team.

14. Visitors 339
 February 2075
 Lars and Celeste Peterson bring Giovanni and Holly a radiation shelter and the couples get to know each other. Celeste can help with the B-75. Bill confronts Tree Rivers about Suzanne's pregnancy and Tree tells him not to worry, Themis is more important. Dai Guofeng and Jean Paul Poirier meet after Chinese class and talk about Himalia. The Chinese geologists planned to send a probe there before other issues came along and saw Himalia as another icy moon, not as a captured asteroid. They agree that the two teams need to work together.

15. Births and Beginnings 356
 March 2075

Alexandra gives a report to Acheron about the Helium-3 mining system being ready to launch by 2078. Yuri talks to Marshall about it and says he plans to leave next year. Amy goes to the hospital to have their second baby. Lars comes to Meridiani with Thorvald, who has also bought land with Monica. They meet Giovanni and Holly, who wonder whether they'll be the odd couple out when the others move down. Giovanni talks to his father about the problems. Will and family, on Mars, call Marshall and family and congratulate them about the new addition. Silvio calls Will, who agrees to help buy up Meridiani land to sell back to homesteaders. Jacquie Collins tells Ambassador Danforth that the Chinese propulsion system gets the contract for 2078 and he protests. She calls Giovanni and Holly, pledges help for the homesteaders and asks Huma to get on it.

Opposition 19: Feb. 14, 2074

Autumnal Equinox: Oct. 24, 2074

Dust Storm Season begins: Dec. 15, 2074

Dust Storm Season ends: Apr. 10, 2075

Vernal Equinox: Aug. 25, 2075

Opposition 20: March 19, 2076

Autumnal Equinox: Sept. 10, 2076

Dust Storm Season begins: Nov. 1, 2076

Dust Storm Season ends: Mar. 26, 2077

Vernal Equinox: July 12, 2077

Mars-Ceres Opposition: Dec. 6, 2077 (launch 172 days earlier)

Opposition 21: April 27, 2078

Autumnal Equinox: July 29, 2078

Dust Storm Season begins: Sept. 20, 2078

Dust Storm Season ends: Feb. 15, 2079

Vernal Equinox: May 30, 2079

Autumnal Equinox: June 15, 2080

Opposition 22: June 16, 2080

Dust Storm Season begins: Aug. 7, 2080

Dust Storm Season ends: Jan. 2, 2081

Mars-Ceres opposition: Feb. 12, 2081

Vernal Equinox: April 16, 2081

Autumnal Equinox: May 3, 2082

Dust Storm Season begins: June 24, 2082

Opposition 23: Sept. 1, 2082

Dust Storm Season ends: Nov. 19, 2082

Vernal Equinox: Mar. 4, 2083

Autumnal Equinox: Mar. 20, 2084

Mars-Ceres opposition: Apr. 18, 2084

Dust Storm Season begins: May 11, 2084

Dust Storm Season ends: Oct. 6, 2084

Opposition 24: Nov. 10, 2084

Vernal Equinox: Jan. 19, 2085

Autumnal Equinox: Feb. 6, 2086

Dust Storm Season begins: March 28, 2086

Dust Storm Season ends: Aug. 23, 2086

Vernal Equinox: Dec. 7, 2086

Opposition 25: Dec. 7, 2086

Mars-Ceres opposition: June 24, 2087

Autumnal Equinox: Dec. 24, 2087

Dust Storm Season begins: Feb. 15, 2088

Dust Storm Season ends: July 10, 2088

Vernal Equinox: Oct. 24, 2088

Opposition 26: Jan. 31, 2089

Autumnal Equinox: Nov. 10, 2089

Dust Storm Season begins: Jan. 1, 2090

Dust Storm Season ends: May 27, 2090

Vernal Equinox: Sept. 11, 2090

Mars-Ceres opposition: Aug. 30, 2090

Opposition 27: March 6, 2091

Autumnal Equinox: Sept. 28, 2091

Dust Storm Season begins: Dec. 19, 2091

Dust Storm Season ends: May 14, 2092

Vernal Equinox: July 29, 2092

Opposition 28: April 11, 2093

Autumnal Equinox: Aug. 15, 2093

Dust Storm Season begins: Oct. 6, 2093

Mars-Ceres opposition: Nov. 5, 2093

Dust Storm Season ends: Feb. 28, 2094

Vernal Equinox: June 16, 2094

Opposition 29: May 26, 2095

Autumnal Equinox: July 3, 2095

Dust Storm Season begins: Aug. 25, 2095

Dust Storm Season ends: Jan. 20, 2096

Vernal Equinox: May 3, 2096

Mars-Ceres opposition: Jan. 11, 2097

Autumnal Equinox: May 20, 2097

Dust Storm Season begins: July 11, 2097

Opposition 30: July 31, 2097

Dust Storm Season ends: Dec. 5, 2097

Vernal Equinox: Mar. 21, 2098

Autumnal Equinox: Apr. 7, 2099

Dust Storm Season begins: May 29, 2099

Opposition 31: Oct. 18, 2099

Dust Storm Season ends: Oct. 23, 2099

Mars-Ceres opposition: Jan. 17, 2100

Vernal Equinox: Feb. 6, 2100

Autumnal Equinox: Feb. 23, 2101

Dust Storm Season begins: Apr. 14, 2101

Dust Storm Season ends: Sept. 9, 2101

Titan northern spring equinox: Aug. 11, 2009; (+29 yr 5 mo 17 days); Jan. 28, 2039; July 14, 2068; Dec. 31, 2097. Northern summer solstice is late Feb. 2077