MARINERS

Vol. 6

Space Exploration Initiative

Contents

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Future of Uranus

June 2082

"Where are the kids now?" asked Wicahpi-Luta to Vahid. They had been in a rather involved discussion about the Marsian Futbol League and whether they could ever play futbol—the Marsian modified version of soccer—in their carrier.

"They're way up there!" exclaimed Esther. She pointed nearly straight overhead. Miranda and Maxwell—32 and 24 months old respectively—had run almost half way around Avalon's "Greenway," the belt of temperate vegetation twenty meters wide that ran the entire 600-meter circumference of their home.

"How will we get them back?" said Tahirih, quite irritated.

"Don't worry," said Esther, pointing. "They're running all the way around and they're already on their way back."

"They'll be exhausted!" said Vahid.

"Just as well," replied Esther. "This Future of Uranus Forum will be long and boring for them. Let them tire themselves out."

"I'll bring them back," said Wicahpi-Luta. He jumped up and began jogging toward the two children in the direction they were coming.

A moment later, Anand John Tian stepped up to the platform. Nearly the entire population on Miranda was present; the fifty personnel on Titania were similarly gathered in their atrium and were visible on a giant screen set up to the right of the stage. They had decided to hold the forum in the "Greenway" because it was more or less set up with fruit and nut trees and areas of grass and flowers. The stage was set up next to the spiral ramp that took people up to the exit along the axis, 100 meters above them; it was the emergency exit if the carrier ever had to be evacuated. Built against the carrier's "bottom" (from the point of view of Miranda and that moon's feeble gravity; from within the cylinder, it was one of the end caps) was a ring of construction four stories high and ten meters wide. It was followed by the twenty-meter wide "Greenway" of temperate climate species, then a ring of construction four stories high and twenty meters wide that would run all the way around the circumference that served as their primary housing. The main building also served as a "dam" 13 meters high to hold in the cool air when the Greenway was set on "winter" mode.

The remaining fifty meters of width to the other end cap of the cylinder would be a tropical area called "the Park"; it would have grass, trees, and some crops. Eventually a public square would occupy part of the Park and serve as their principal place to gather, but so far the Park was still a partially completed metal surface devoid of plant life. Underneath everything was an agricultural level and underneath it was a water level with fish and other aquatic species, the water also providing additional shielding against cosmic background radiation.

Anand looked around at the crowd, very pleased. "Welcome, everyone, and it's great to be able to see everyone at once!" he began. "In the galleons it was impossible for all of us to crowd into a single atrium, nor would it be safe if we could. But Avalon is surrounded by 10 meters of concrete-hard ice, so we are perfectly safe in our rapidly advancing new home. We think by the end of summer, everyone will be able to move in; in fact, some move-ins will start by the end of this month.

“As all of you know, the Urania Council has finally started drafting a five year plan in response to Mars’s request last year. We couldn’t respond then, but we can now. Since it is up on the website and all of you have presumably looked at it, I won’t summarize it here. Rather, I hope this Forum will provide us an opportunity to discuss it. Then after our election next week, the new Council will be able to finalize the plan and send it to Mars, to assist them in their planning. What comments and questions do you have? Just raise your hand and we will pass the floor to you. We aren’t such a huge crowd we can’t see and hear each other.”

Anand looked for hands. None shot up, which surprised him, since he had expected some comments. He waited patiently. After ten seconds, no hands had been raised.

“Ah . . . perhaps I should summarize some aspects of the plan, then. Currently our population stands at 686, with thirty pregnancies underway and perhaps a hundred planned, so our population will grow to about 800 in the next 18 months. Meanwhile, Uranus-2 is on its way and will arrive with 300 more residents this December, pushing our population over 1,000. We are asking Mars to send three more missions—one every other Gregorian year—with 300 more, pushing our adult population to 1,800 in eight or nine years, with our total population rising to over 3,000. After that, we don’t know, but we think this system can support twice that population eventually. Uranus-2 is arriving with a second aerostat and Peregrine, which will double our annual production of Helium-3. The price Saturn is getting is very good and demand seems set to rise, suggesting that Saturn, Uranus, and Neptune can all export two tonnes of Helium-3 per year and expect market demand for it.

“As for housing, we’ll build a carrier on Titania next to house our main industrial facility, followed by Avalon 2 next to this carrier. As we need more space, we will double the length of

Avalons 1 and 2 to 200 meters, giving us 250,000 square meters of first floor space; with multiple floors, that will double or triple. Housing will not be a problem and we can anticipate having plenty of living space.

“As for exploration, the plan calls for a vigorous effort to visit every moon over the next five years, establish a vigorous telepresence on all of them, and double our research about Uranus itself. Our effort will be undiminished and should yield new information about this system steadily. Does that help to stimulate comments?”

There were still no hands for several seconds. Then finally Karl Forbes, who was Director of Fabrication, raised his hand. He rose when Anand nodded.

“I think the housing arrangements possibly need to be reconsidered,” he said. “I just spent most of the past year on Titania as commander of the borough there. There were 75 of us extracting nickel-iron and nitrogen and utilizing the low gee for industrial processes that are harder to accomplish here. Then we rotated back here and were absolutely amazed by Avalon, even if it was only partially finished. None of us wanted to go back to Titania. We were replaced on Titania by a crew of only 50 because people didn’t want to leave here.

“And who would? This place is amazing; who would have imagined a crew of 600 could build such a large, sophisticated enclosure in a year? I know the plan is to build a carrier on Titania as well, but now I wonder whether that is necessary; or perhaps I should say, ‘premature.’ The argument has been made that a carrier on another moon provides crucial back up habitat in case of emergency, but so can a second carrier buried underground and a hundred or so meters away from the first. It was also argued that since Titania’s gravity was the same as Ceres and we knew how to produce things in Cererian gravity, we could use Titania as our main manufacturing center. But a carrier is so large and has so many levels of gravity inside it, we can just as easily build a carrier here for manufacturing and utilize any level of gravity we want, including micro-g, which is not available on Titania. So my suggestion would be that we recall the Titania expedition and set up their equipment here."

Anand was visibly surprised by that suggestion. "There are two problems with that, Karl," he replied. "First, our charter specifies that the Urania Council consists of representatives from all the boroughs in the system; it assumes the existence of more than one borough. Second, Titania has the most interesting geology and needs the presence of a geology team."

"I don't know that the Council must have representatives from more than one borough," commented Karl.

"But wouldn't one borough undermine our claim to the entire system?" asked someone.

Everyone looked around to see who would answer. "We don't know," replied Anand, finally. "When we arrived we hadn't yet visited any moons and we were concerned that our claim wouldn't stick. But we've been here almost a year and a half now and have visited a lot of the moons. We have a plan to visit most of the rest in the next year or two. And no one is sending a rival team to colonize the system."

"Exploration's another issue to discuss," exclaimed Jane Hudes, rising from her chair. She was in charge of surface geology. "We have two problems. First, we are backlogged with sample analysis and writing up our results. Second, we have a lot of people planning leaves to have babies. We can launch an expedition to Sycorax this summer, and perhaps a short expedition to an inner moon to set up robotic facilities, but we won't be launching a lot of missions to moons soon."

“There are 300 more settlers who will arrive in December,” noted Tahirih. “We should leave some of the moons for them to visit.”

“Definitely,” said Jane. “We have plenty of time; we aren’t leaving and no one else is coming to take this system from us, so we have plenty of time to explore it.”

“Now that we have Avalon, we are in the position to start building our Uranian civilization and culture,” said Gandhimohan. “We have a lot of talented musicians, singers, poets, writers, painters . . . we need to give them the time to express our experience in art.”

“That’s why we are moving toward a 35-hour work week soon,” replied Anand. He saw Tahirih’s hand up, so he pointed to her.

Tahirih rose. “Regarding the issues of exploration and settlement, I have a suggestion. I gather, once we have Avalon completed, the galleons will head back to Mars to transport more passengers here. The next expedition arrives with one galleon and two caravels, so we will have four caravels. If we send them out in pairs, we will have a robust capacity for exploring. Furthermore, parents could take children along because most expeditions would require short flight times and after landing we could shelter the caravels against radiation pretty quickly. We could visit Titania regularly that way. We don’t need to keep a scientific team there all the time.”

“That’s true,” agreed Jane. “We have geologists and exobiologists on Titania because we have a borough there, not because we *have* to maintain a team there all the time.”

“Really,” said Anand, not happy to hear that.

“Ah, may I make this suggestion?” exclaimed Tahirih. “Maybe we need a sort of ‘floating borough.’ Whenever we send out a pair of vehicles, maybe the crew can elect a representative to the Council for the duration of the expedition. If we can send out two pairs of caravels, that would be two representatives on the Council from somewhere off Miranda, but not always from the same place."

"I think we could do that," said Anand.

"We would have to modify the charter," said Kofi Phelps, the store manager, who was also their legal expert.

"But we could do that," said Anand. "It sounds like our plan needs to be rethought."

"That's what the Future Forum is for," noted Adla.

Anand nodded and pointed to Crystal Parker. She rose and spoke about the philosophy club's plans to start a series on ethics. She was followed by Reverend Varma, who offered a summary of Protestant church plans. Johann Koch, director of ecology, noted that if there were no plans for a carrier on Titania, it would be better to dig deep and plan the next one underground so that the manufacturing facility was well buried, with the bioarchive above it but still buried. Samantha Augustine rose and noted that the plan for two-caravel expeditions would work well with their nuclear power equipment. Carlotta Singh spoke about the advantages of having one primary settlement, where building community was concerned.

After a few more comments, the Forum had gone 90 minutes and it adjourned. Everyone headed home. "That was an unusually innovative forum," said Esther.

"Pretty rough on Anand," said Tahirih.

"It blew apart the Council's plans," agreed Vahid. "We'll need to rethink everything."

Tad was walking nearby, so Tahirih said, "Hey Tad! I'm surprised you didn't have anything to say!"

He looked at her, surprised. “No, I didn’t have any brilliant ideas,” he replied. “But it was interesting to see how well he dealt with the changes.”

“Yes, he dealt with the ideas very well,” said Tahirih. “We have a good council, don’t you think? You don’t need to criticize them all the time.”

“I suppose,” said Tad.

Entering into the shell of the new hab was like stepping into a gigantic rotating tire, Bill thought, though the hab was made of metal and not rubber.

The hab sat a dozen meters from the *Materra* and the *Patares,* the Themisians’ two caravels, in which 120 people maintained a packed existence. At least the hydroponics had been moved out, replaced by agriculture that covered three hectares, or about ten percent of Themis’s surface. The new hab was thirty meters in diameter and 12 meters high, roughly the same size as a caravel. So far, only the outer structure and the rotating shell had been completed; three stories of housing, workshops, and classrooms still had to be built. But the open shell made an incredible gathering spot, a “park” with close to terrestrial gravity 95 meters long and 12 meters wide. The kids loved it and were running around wildly when Bill floated in.

“Where’s Jeremy?” he asked Suzanne, once he spotted her.

“Over there somewhere!” she pointed vaguely overhead at the strip of metal where a group of kids were shouting. “We’ll have to keep as much of this hab as open space, Bill. That’s obvious.”

“It is; everyone loves it. Or maybe we should build an even bigger hab and leave it as an empty rotating shell, to give ourselves an even bigger gravitied park.”

“Amen to that!”

“What’s new with our guests?”

Suzanne gestured to them with her head. “They seem to be enjoying the banquet, so far. But I had to rescue Ted this afternoon. Basically, he tried to walk on the Sea.”

Bill laughed. “Just with his shoes?”

“No, barefoot!”

He laughed again. “You can sort of keep yourself up out of the water, but the viscosity is so low, you can’t control your movement!”

“He eventually began to tip over. I was wearing wings, so I flew over and had him grab my feet, then I flapped like crazy and managed to lift him out of the water and fly him to the shore. He was embarrassed and *very* grateful.”

“He needs to take flying lessons. They’ve been here a month and he’s the only one who can’t fly.”

“After this, I think he will. It’s by far the easiest way to get around in this microgravity.”

“It is. But I also agree with them that if we had backpacks with fans built into them and we could steer the exiting air current, we’d be able to get around much more easily.”

“Definitely, but with all the construction going on, we can’t spare anyone to develop such a device.”

“I know. At least the bulk of the work on their mansion is finished. I better go talk to them.” Bill gave Suzanne a quick kiss and headed over to the Quints and their female friends.

Earl saw him coming. “Thank you for this banquet. We’ve met many of the people here, but now we have a chance to meet everyone.”

“You’re welcome. We also wanted to show you the full range of foods available here. They aren’t anywhere nearly as diverse as on Earth, but they are fresh and delicious.”

“I’m surprised you aren’t vegetarians,” observed Marie-France.

Bill shook his head. “A good ecology has plant eaters and meat eaters, and we are the cap species here. Themis will never have coyotes or tigers; in fact, it doesn’t have any mammals, outside of our rotating spaces. Birds and fish can manage fine in the wild, and that’s all there will be. We eat both of those groups of animals, and we have cows to provide milk, so we eat a little beef. That’s it.”

“So, the choices are determined by necessity,” said Alan.

Bill nodded. “Mammals are helpless here in zero gee, but birds adjust fairly well. We need some raptors here to keep the population in balance. So, how is your house?”

“Excellent, as far as it goes,” replied Earl. “We can all move into bedrooms, a comfortable living room, and a functioning kitchen. Our robotic cook will cook us breakfast there tomorrow, rather than on board ship. Of course, there are a lot more rooms to enclose and complete.”

“Yes, we plan to tackle them right away.”

“I understand you want to slow the construction, though. I don’t want that, I want to see the place finished.”

“I know, but we need to complete this place.” Bill pointed to the hab around them. “This is the outer floor. We want to install a second floor and eventually a third floor. This level provides us with 1130 square meters of gravitied space, and we badly need it. We have arrivals who came with you and over the last few years we've had several more children. We're getting really cramped."

"I'm sure, but you've managed here for almost seven years, sometimes under conditions of much greater crowding. We're talking about two more months of construction and my place will be pretty much complete. Some of my crew is helping, after all. I paid for you all to do all the work!"

"I know."

"So, let's get it finished!"

"Alright," said Bill.

"These are really good," said Ted, holding up a chip.

"Banana chips. Not the Thompson's yellow bananas you get in supermarkets on Earth. We have six varieties of bananas here, and they grow really well on Themis for some reason."

"They're fantastic. Can you send us a kilo of them tomorrow?" asked Alan.

Bill nodded. "We can add that to your tab."

"My crew and I are drinking ten liters of your milk a day, too," said Earl. "It's just delicious!"

"That's because it's fresh, it isn't pasteurized—there are no germs here to worry about—and it isn't homogenized. This is what milk *really* tastes like. It's what milk tastes like on Mars, too, because of the clean conditions there."

"We'll need more of it," said Earl.

"Ah . . . I'll see what we can do. We have a lot of infants who drink it and the cows can't increase their production because we want more. We hadn't anticipated needing to feed your crew as well."

"Well, we have reciprocated by providing you some of our food supplies as well," said Earl.

"Yes, that's true, but you can anticipate that sometimes we'll have shortages. We didn't know what you and your crew would want, and you increased our population by ten percent."

"True, but you'll need to compensate better," said Earl. "Because we're very pleased with this visit and have checked the various launch windows. Rather than returning to earth via Mars in August, we want to head for Venus instead in October, so we plan to stay here six months rather than three. And we'd rather not dip into our freeze-dried backup rations much on the flight back, which will take much longer than the trip to Mars."

"Really? How much food do you anticipate needing?"

"About six months' worth."

Bill's eyes grew large. "Frankly, I don't know whether we can do that. Our reserves aren't that great. We also don't have pre-prepared foods of the sort you want on board."

"No, our chef can manage with frozen things; vegetables, fruits, fish, chicken, etc. That's what we'll need."

Bill shook his head. "I'll see what we can do."

"Are you launching out of Gate 1 or Gate 2?" Mike Tobin asked his father in law as they entered the spaceport hanger.

"Gate 1. It should be pretty obvious, since there's only one launch today," replied Will Elliott. The six of them came around the corner and Gate 1 had an open door to the transport bus and a robot attendant, so it was indeed obvious which gate they had to go to.

"This is the one," agreed Ethel. She sounded a bit nervous; she hadn't flown to space in twelve years.

"It'll be fine, grandma," said Shayda. She and her twin, Jason, were ten sols short of their twelfth birthday.

"I know, dear. It'll be a good flight, and I promise I'll bring both of you birthday presents from Earth." She put down her garment bag and hugged Shayda and Jason.

"You guys be good," added Will.

"We will," replied Jason.

"It's hard to believe, last time I was on Earth, I met you as a graduate student at MIT," Will said to Mike.

"That's when I met you and Liz," said Mike, with a smile. "Twenty years ago. Well, have fun and give them hell."

"I wish I could give them heaven; they're making Earth into a hell. But I'll have something to say about that."

"We're counting on it, dad," said Liz.

"I'm glad Chief Minister Helmut declared you Mars's 'good will ambassador.' That may strengthen your hand," said Mike.

"I think it will, because I have actual ambassadorial rank. I hope the external affairs people on Earth don't mind!"

"I'm sure they won't," said Ethel.

Liz hugged her father and gave him a kiss. "Have a good flight."

"Thanks."

"We'll be back in October," promised Ethel, hugging Liz and Mike. "The two of you relax a bit and count on Jason and Shayda to do more around the house."

"No, that's what robots are for!" said Jason quickly.

"No, not really. Everyone has to pick up for themselves," replied Ethel. "We're looking forward to this trip," she added to Liz.

"Our last hurrah," added Will, who, at age 81, knew he would not be going to Earth again and had even worried aloud whether he'd make it back to Mars.

"No, don't say that, Will," replied Mike. "You still have contributions to make."

"I hope so. It's more fun being Commissioner, First Minister, or Secretary-General, but I really don't have the energy to do those things any more. But I have a few things to say as Ambassador."

"You always have things to say," said Ethel. "Well, let's get on board."

They had another round of hugs—more tearful this time—then Will and Ethel picked up their bags and headed for the gate. "Welcome on board, Will Elliott and Ethel McGregor," said the robot, who was programmed to recognize everyone on Mars. "Have a good flight."

"Thank you," they both replied. They turned to wave goodbye, then walked down the tunnel and into a waiting bus.

"Here we go," said Ethel.

"Are you still nervous? Please don't be. You'll handle the gee fine."

“I suppose. I did fine in the centrifuge. But I’m not in quite as good shape as you are.”

They stepped through the tunnel and into the bus. Its fifty seats were pretty full, but they spotted a pair of seats that were empty half way back. They placed their garment bags into the large overhead compartment and sat.

“So, are you going to Phobos, or Earth?” asked a familiar voice. Will turned and saw Anne and Kurt Hollingworth seated behind them and across the aisle.

“Good sol! We’re going to Earth; what about you?”

“We’re going to Earth, too,” said Kurt. “July and August are a lousy time to give university talks, but we’ve both been invited and have a heavy schedule across Australia, the US, and Canada.”

“You should be busy; you’ve been to Mars and Saturn. Not many people who’ve been to Saturn have returned to Earth!” said Will.

“We’re just about the first,” agreed Anne. “Are you speaking in Oslo?”

“Yes, the Nobel Committee wants me to give the Nobel address I was never was able to when they gave me the prize. Vanessa will speak at the same time.”

“And you’re speaking before Congress?” asked Kurt.

“That’s our first stop. We’re trying not to pack in too many public events, though, I’m not as young as I used to be!”

“We’re feeling our age, too,” agreed Anne, though she was 66 and in good shape.

“Overall, Mars hasn’t been that bad on our health, thanks to exercise, diet, and pills,” said Ethel, with a chuckle.

Will looked around the cabin. “This flight to Earth will be full of veterans. I guess that’s why they had to press a second ship into service for the interplanetary leg.”

“Especially the trip back,” replied Kurt. “The trip inbound won’t be full, but the return will be.”

“We’ll be falling almost straight toward the sun,” said Anne. “It’s amazing we can fly from Mars to Earth in just thirty days.”

“It really is amazing,” agreed Will. “We’ll be traveling 1.8 million kilometers per sol; fast enough to travel from the Earth to the moon in four hours. The first time I went to the moon, it took three days!”

“That was a long time ago, Will,” said Ethel. “We’re going to earth with two gaseous core engines, so we have redundancy if one fails, and Earth will give us a gravity assist away from the sun, so we don’t have to worry about falling into it if the engines fail.”

“Oh, I know,” said Anne. “I suppose just about everyone on this bus will be lobbying for space exploration, too. It’s a veritable invasion of Earth!”

“It is,” agreed Will. “I’ll speak up for Mars and Saturn, you will speak up for both and for Themis, Vanessa will be speaking up for Uranus . . . the media will have a lot to cover in the next few months.”

The last people got on the bus and filled the last seats, so the hatch closed, the bus undocked, and it headed across the range to Pad 18, where a Prometheus 2 awaited them. The bus docked to the launch tower and they all disembarked, took the elevator to the appropriate level, and stepped into the passenger compartment. Will and Ethel were on level three. They placed their garment bags into the storage areas and strapped in.

Right on time, the methane-oxygen engines roared alive and the Prometheus rose rapidly into the sky, accelerating at two gees toward space. Less than four minutes later the engines cut out and they were on their way to the *Sequoia* and the *Ponderosa,* awaiting them at the Mars-Phobos Lagrange 1 point.

2.

Robots

July, 2082

"We're late," Marshall Elliott said to his son, Willie.

"Don't blame me. You had to take the last voice mail."

"I know." Marshall speeded up his jog. "We should have grabbed a taxi."

"It's not that far."

They passed the last row of condos on the right side of Cathedral West and entered the enclosure's newest section. Foundations of future buildings spread out on the right, with construction robots crawling all over the steel beams to install wall sections. Scrawny saplings, the beginning of a new forest, dominated the left, and again there were robots, planting trees, unrolling sod, and watering flower beds. The earlier segment of Cathedral West now had a vigorous forest well established along its left side and housing on the right. The old segment also had vines growing as much as 50 meters up its sides; the new segment had bare walls of sheet steel, with a mix of stony meteorite and gray plastic sprayed on to simulate a rocky cliff.

Between the new foundations and new saplings, however, West Cathedral Road diverted around a beautiful Japanese garden, fifty meters wide and seventy-five meters long. A pond filled the middle, with little bays breaking up the garden into smaller sections. A waterfall brought water into the pond; its slow fall in Titanian gravity always intrigued Marshall. An island in the middle was connected to the shore by a high-arched bridge and rocks placed strategically along the shore made it look wild and natural, even if every boulder had been very deliberately positioned. A footpath circled the pond, weaving around beautifully trimmed trees, clusters of sculpted bushes, and little beds of flowers. The grass was perfectly trimmed. As Marshall approached the garden, he automatically slowed down, amazed by its beauty. The crowd that had gathered for the dedication watched as he strolled along the footpath to the observation platform. They understood.

“Ryoko, these gardens are . . . stunning.”

She smiled. “Thanks, Marshall. We Japanese know how to create gardens.”

“I guess so! Are we ready to get started?”

“Yes,” she confirmed. She seemed to be a bit irritated he was late, though he was only 2 minutes late. She queued the Cathedral Orchestra and they started playing a rousing piece, perfectly appropriate for the dedication. The construction robots instantly stopped their work, so as not to make noise.

Marshall sat, listened, and wondered what he should say. He had not stopped by a day early, as he had been urged to do, so he was not prepared. He looked around at the perfect naturalness, for the garden looked natural, wild, yet it had a perfect wildness he had never encountered before. Well, no, he corrected that: once he had gone to the Zen Monastery on the escarpment overlooking Aurorae. The floor of their crater was a perfect garden as well and also perfectly wild, with the “Mars witnessing Buddha” standing against one cliff. He had almost forgotten that sublime experience.

The musical piece ended. Marshall rose and welcomed everyone, then introduced Takeo Nishimura, a member of their ecology team, who was also a Pure Land Buddhist monk. He spoke briefly about the nature of Japanese gardens and then chanted briefly from the Amitabha Sutra. Then it was Marshall’s turn to speak.

“Thank you, Takeo, for explaining the origin and inspiration for this incredibly beautiful garden,” he began. “And thank you, Ryoko Furukawa, for collaborating with Takeo in the design and setup of this garden, and making sure it would happen.

“In many ways, this garden represents the maturity of Saturn civilization. The Cathedral enclosures now have a total of 120,000 square meters of floor, an eighth of a square kilometer. This garden occupies almost four percent of the total area. But it is not a luxury or a waste; not by any means. We have plenty of other caverns where we can grow our food. Cathedral represents living space, intentional park land, because we can and must have such space to live well. This garden is not just a Japanese garden or a Zen garden; it is a Titan garden and a Saturn garden, an integral part of Saturnian civilization and culture, for our culture has roots in many societies and we are proud of all our heritages. The opening of this garden thus is an important milestone in our development as a civilization because it represents a further diversification of our cultural and aesthetic experiences.

“And what an incredibly beautiful experience it is! Imagine what it will be like in a few years when the enclosure’s walls will be covered by vines, and the trees along the edge will have grown up, and the ugly heaps of dirt are replaced by neat, attractive housing! I hope the landscaping of our buildings will represent a continuation of this garden, so that it is rooted in the land here. And I hope this garden will influence other gardens, as we add another 100 by 200 meter segment to both Cathedral branches. No doubt the time will come when the low gravity and the range of genetically modified species will push us to yet another garden aesthetic, which this garden has established an important standard for us.

“So, rather than further talk, let us cut the ribbon and start to explore the garden. Ryoko, Takeo, please step forward and the three of us will cut the ribbon together.” Marshall beckoned to them, then stepped off the stage to a spot where a big multicolored ribbon was stretched across the footpath. Marshall grabbed the large scissors that had been provided and motioned Ryoko and Takeo to take hold of the scissors. He maneuvered the scissors around the ribbon. “Here we go!” he said, and the three of them slowly closed the scissors.

The ribbon cut through and fell to the ground. Everyone applauded; the orchestra struck up another tune. A few started onto the path, but most waited for the music to finish. Then the crowd—perhaps 300 people, out of Saturn’s 1,300—started onto the footpath to walk all the way around the pond.

“This is so pretty, dad!” said Willie.

“Isn’t it? Be sure to tell Ryoko and Takeo, and thank them. It was their idea.”

“Can we picnic here?”

“Not in the garden itself, but there will be a picnic spot over there.” He pointed to a spot between the garden and an irregular line of newly planted saplings. “I can’t wait for the Bahá'í community to come here and pray during a holy day. The garden can be used for worship. The Christians plan to do a sunrise Easter service here next year.”

“Could we have a Bahá'í temple here?”

Marshall looked around. “You never know,” he replied. “We’d have to get permission to cut back the forest and that would be controversial. But maybe a little Bahá'í temple could be built near here.”

They completed the stroll around the pond and lingered a few minutes to talk to the other people there. Willie went to Takeo and Ryoko to thank them, then walked from rock to rock to look at them, because some were real stony meteorites while others were fake tholin boulders whose bright colors lent a uniquely Titanian aspect to the garden. He gave Marshall a report about each one on their walk back to Cathedral Square and they talked about the garden further, and the merits of adding fake rocks to a garden that looked wild, but was actually planned in extreme detail. Willie did not like the idea at all.

From Cathedral Square, Marshall walked Willie back to school in Titan 1. The spinning enclosure was 200 meters in diameter and 100 meters high; between centrifugal force and Titan's 1/8th gee, the outer level of Titan 1 provided 0.85 terrestrial gravities. All classrooms and offices had been relocated there and everyone was expected to spend a minimum of six hours a week in Titan 1 in order to keep their bones and muscles strong. A large athletic facility with a circumferential jogging track occupied part of the lower floor, as did time-share condos that families stayed in on alternate days.

Marshall's office as Chief Minister was located on the second floor, which was as high as the construction went for now. Its windows overlooked a big soccer field, for soccer was much easier to play in a higher gee than in a lower one. "Hey mom and dad," he said in a videomail to his father, Will Elliott, "here's a link to the dedication of our Japanese garden, which just happened. The Media Center was quick; they got the edited program up before I was able to walk back to the office! It's really a beautiful spot. It's in 'Cathedral West 2' if you're keeping track of our geography. We'll be opening to the public 'Cathedral East 3' in a month and 'Cathedral West 3' in six months, at which point both arms of Cathedral enclosure will be 300 meters long. Both are delayed because we've constructed an area underneath their floors that can accommodate at least two levels of agriculture. We can't use it all yet, but we need to build it so we can use the floor of Cathedral. Together, the levels will give us 80,000 square meters of agricultural space. This place is getting really big! I wish you could come here to see it, rather than go to Earth!

"I hope you are well. We're fine up here. If you look at the video, I think you'll see Willie, because I brought him with me. He's getting almost as tall as me! His growth spurt is continuing; we're buying him new clothes and shoes every few months. We miss you and love you! Bye."

Marshall hit send and his message headed for Mars. A millisecond after arriving, the message was rerouted to the *Sequoia,* the caravel that was taking Will and Ethel Elliott from Mars to Earth. Less than 90 minutes after Marshall sent the videomail, it simultaneously popped up into Will's and Ethel's in-boxes. Ethel listened first, then watched the video.

"Wow, Willie is getting so tall! It's nice to see him walking around with other people; you can see how big he is!"

"Well, he's just a few months from his thirteenth birthday." Will leaned over to see Ethel's screen. "He may be taller than me, especially now that I've shrunk a centimeter or two!"

"He might be," she agreed, looking at her 81 year old husband with an appraising eye. "I just hope we get to see him face to face some day!"

"If we can make it until he goes to university, we might. That'll be another six years."

"Let's hope he stops at Mars before going to Earth, assuming he goes to Earth for his education," she said. She looked at the "porthole" on the wall of their small stateroom. It wasn't really a porthole, but a three-d screen, and at the moment it was focused on Earth. If they looked closely, they could see its disk.

Will followed her gaze. “Seven days and eleven million kilometers to go. Starting tomorrow, the round-trip communications delay drops below one minute and I’ll start doing interviews.”

“We’ll essentially have arrived!”

He nodded. Then as if on queue, his inbox beeped with an email. He turned to look. “Hum . . . the FBI.”

“Really?” Ethel leaned over to look as he opened the message.

Dear Dr. Elliott: The Federal Bureau of Investigation has become aware of at least two threats on your life in the last twenty-four hours. One of them appears to be credible. We do not want to alarm you, but assure you that we are on top of the situation and are keeping a close eye on any possible problems. As you know, U.S. society right now is torn between various camps and ideologies, and your longstanding positions about internationalism, negotiated efforts to bring about peace, and reconciliation between peoples has made you a lightning rod for many groups. We want to meet with you as soon after your landing as possible in order to brief you in person about the situation, so that we can ensure your safety.

“Wow,” said Ethel.

Will sighed. “Not everyone in the U.S. has been convinced by a nuclear war and a major depression that they have to unite with the rest of the world. President Lee has survived an assassination attempt and President Mennea was killed.”

“Not to mention the economic extremes and the poverty,” said Ethel. “And knowing you, you’ll speak out.”

“I have to; it’s my obligation,” said Will. “And it certainly will be controversial.”

Vahid Davidson looked at the construction robots scrambling around the far end of Avalon. He and Tahirih and 2 year-old Maxwell were sitting and eating supper with Wicahpi-Luta, Esther, and 2 ½ year old Miranda on the just opened “Main Square,” which intruded into Avalon 1’s “the Park” area. “They’re always so busy,” he commented.

“I like the idea of filling the far end with a sort of ‘mountain,’” said Wicahpi-Luta. “Complete with cascades and little waterfalls.”

“It’ll be very pretty for hiking,” confirmed Esther. “And underneath the cliffs will be quite a bit of office and light manufacturing space, with skillfully hidden windows so that we can’t see them.”

“Are they planning to keep ‘the river’?” asked Tahirih.

Esther nodded. “It’ll go all the way around, but it’ll be only three meters wide in spots, and it’ll go through a tunnel or two. Good for swimming and canoe races, but I wouldn’t try to jet ski or water ski all the way around.”

“Have they finalized how these flat areas are going to be used yet?” asked Patrick O’Hare. He and his wife and two children were sitting at the next table over.

Esther looked to see where he was pointing. “Not other than ‘Parkland.’ The last twenty meters of the enclosure are reserved for ‘the Mountain’ and it’ll be pretty wild and pretty. That leaves the thirty meters where ‘Main Square’ is located, but it’s only thirty by sixty, and that leaves almost five hundred seventy meters of circumference to design. The River will take up five meters of that width, on average."

"Because I'd really like to see a Japanese Garden, like the kind they inaugurated on Titan the other sol."

"Wasn't it beautiful? I was really impressed by their design. We don't have any garden designers here, but I suppose we could commission a design. We've got the range of plant species the garden would need."

"I'd favor a really wild patch instead," replied Tad Lind. He and Susan were sitting at another table nearby with their son. "The Japanese Garden is 'fake nature.' It isn't really wild at all. It may lack the symmetry humans like to impose on gardens, but it isn't real, either. Now, a thick tangle of forest: that would be something."

"It might also be an eyesore," said Patrick, scowling.

"Eyesores are in the eye of the beholder. I think it'd be really beautiful."

"Unnaturally natural or not, Japanese gardens have a real charm," concurred Esther.

Tad shook his head. "So, a tree grows a branch, and as soon as it gets long enough to shoot out a twig, they cut off the end of the branch and force it to continue growing via the twig. Then when it shoots out another branch in another direction, they cut off the end of the twig and force it to make yet another zig zag. So the trees have all these twisty, turny branches, with puffs of leaves in spots. Weird! And a heck of a lot of work to maintain."

Patrick shrugged. "The robots do the maintenance. They can keep a garden absolutely immaculate at almost no cost."

"What's the point, so you can tiptoe through them? I want to be able to get lost!"

"You know, Tad, there's no such thing as 'natural' here," said Esther. "It's a contradiction in terms. We're living inside a big, spinning drum! As for the plants, there are a few bioarchive species that are unmodified. Just about everything here—from radishes to prairie grasses to oak trees—have the Photophore 250 gene complex spliced into them, which quadruples their photosynthetic efficiency."

"Frankenplants," exclaimed Patrick. "Banned on Earth because they'd overrun wild species."

"But perfect for us; they grow incredibly fast here and on Mars, with half the illumination of Earth."

"I know, but they'll produce a thick tangle of vegetation anyway, in fact they'll do it faster," replied Tad. "My objection is to plants as sculpture, not to plants that grow faster."

"You said you wanted wildness," replied Patrick.

"Well, what I meant was wild in appearance!"

"I bet that'll require a lot of robot labor as well," commented Patrick with a smile.

"We got it," said Vahid. "In fact, I have to go to a council meeting; this discussion has made me late! I'll bring up both points of view."

"You had better go," said Tahirih, glancing at the chronometer on the building nearby.

"Yes, I had better." Vahid rose and picked up his tray. Some people left theirs for the cleaning robots, but he preferred to bus his own. He dropped it in the return area and walked into the main building next to their tables. The council meeting was on the fourth floor, and he really was late.

The Council had started when he arrived, but he wasn't the last person there: eight of nine were present. "We voted to move two galleons semi-permanently to Titania, so that the geology program there would have plenty of space," said Anand, interrupting Adla's presentation to catch Vahid up. "So it will continue to be a borough for us for at least a year. Then perhaps the galleons will move to Oberon and the borough will be set up there instead."

"Sounds good," replied Vahid, looking at Adla. She nodded to him.

"Mine is just a report," she continued. "The envelope for Avalon 2 has started to go up. We have a team of robots steam-drilling the pilings that will support the inside of the ring. It'll take them two months to go all the way around. Meanwhile, a second robot team is steam-drilling the second, outer wall, which we have decided to offset fifteen meters. Work on the envelope of Avalon 1B, above us, will start next month as well. Inside Avalon 2's envelope, a metal floor is being placed, and in two months it'll completely cover the ground. At that point, the steam excavators will really start to ramp up. It'll probably take us 3 years to excavate a hole 220 meters in diameter and 200 meters deep; it's a lot of ice to melt."

"Will there be room in the envelopes for all that water?" asked Kofi Phelps.

Adla smiled. "Yes and no. We'll build up Avalon 1B's envelope so we can start construction on that enclosure inside a nice, smooth, hard, radiation-proof, airtight shell. Avalon 2 will have 200 meters underground and 200 meters above ground, so it will need an envelope 200 meters high. The envelopes will be 15 meters thick, but even they won't use up all the water, so we'll spray the rest on the outside of the envelopes. The water will go somewhere, don't worry, and will give us immense protection."

“Avalon 2 will be 400 meters long, then,” said Anand. “And Avalon 1 will be 200 meters long. How long, to complete all that interior space?”

“Depends on how quickly we want to complete them; if we make more robots, we can complete them faster. But nominally, Avalon 1B will take two years. At that point, we’ll start on Avalon 2B because the bottom of the hole, where 2A will go, won’t be completely excavated yet. I estimate each can be done in two years, so twelve years altogether. They’ll give us the capacity to accommodate a population of at least six thousand.”

“It’ll take a lot more than ten more years for us to get to that number,” said Anand. “But that also means we’ll have a lot of spare interior to get lost in.”

“For a soccer field,” noted Kofi.

“For a big lake,” added Jane Hudes.

“For Japanese gardens and wild forests,” exclaimed Vahid. “I’m late because there was a debate on Main Square about them. Some people wanted a Japanese garden and others said, ‘no, too artificial, let’s have a wild forest instead’ and someone else pointed out that it’s hard to create something ‘wild’ inside a spinning drum using plants with 400% efficient photosynthesis.”

Gandhimohan laughed at that. But Johann Koch scowled. “People are constantly asking for changes in the Park! Some people asked for personal garden plots. We found room for sixteen two by three meter plots, then we had a few more people ask, then when assigned plots, people said they didn’t want them! We do have a Versailles-style French garden scheduled.”

“Could you replace it with a Japanese garden?” asked Vahid.

“We’d have to spend a million or two on Earth or Mars to get a design. There are plenty of designs—rich people are showing off all over Earth now with Japanese gardens, all tended robotically—but they're for flat, not curved spaces, and that requires extra planning. Besides, some people *like* French gardens!"

"Could we put in both?" asked Vahid, patiently.

"We could do one to the right of Main City Square and one to the left. But what about a wild forest? That would require a lot of soil; big trees send their roots deep. That's a lot of mass, and it would keep increasing as the trees grow taller. We'd probably need two, opposite each other, to maintain balance. You're redesigning the whole space!"

"It would be complicated," said Anand. "Don't worry, Johann, we'll figure this out. Some people can wait until Avalon 1B or Avalon 2, to get the park area they want."

"I hope so, because this is not fair to me and my team!"

"Alright," said Anand. "We do want some tall trees because we do want some lumber."

"Eventually, Anand. Eventually."

"Eventually it is, then," replied Anand, trying to calm his Director of Ecology.

The thirty-day flight passed very quickly, and in early July the two gaseous core nuclear engines roared alive and slowed the two ships into an orbit around Earth. A few hours later, shuttles began to dock to transport the passengers to various spaceports across the surface of the Earth. Will and Ethel encountered a most unexpected delay in their departure, but soon they were on board with just five other passengers who were bound for the northern United States.

Once they had landed, Will unbuckled his seat belt and slowly rose from his seat. "Well, we made it," he said to Ethel.

"We did. I forgot how rough 3 gees can be," she said, relieved. She undid her seat belt and rose as well, a bit wobbly.

"You alright?"

"Yes. You?"

"Yes. I'm glad we're being met by Mars's Consul General, whoever he or she is! The change in plans is quite jarring."

"I find it hard to believe the threat to shoot down the shuttle was credible."

"Well, over the last decade, five commercial jet liners have been brought down using drones, so you never know."

They headed for the shuttle's exit. The flight attendant hurried over to help, uncertain how to treat octogenarians. The shuttle had only five passengers because the diversion to the Mid-Atlantic Spaceport, east of Washington, D.C. on the Delmarva peninsula, had been unscheduled and unannounced. Their scheduled landing at Canaveral was delayed a day until after Will Elliott's landing at Mid-Atlantic was announced.

The shuttle's door opened and they stepped into a standard jetway. A short walk took them to its end, where a young woman awaited them. She waved slightly. "Dr. Will!"

"Hello," replied Will, walking over to her and pleased to hear himself addressed Marsian fashion. "I'm glad someone could meet us on such short notice."

"Oh yes, no problem. My name is Maryam Islami-Larui and I work for the Mars Consulate in Washington."

"Maryam Islami," Will smiled warmly. "Ruhullah and Nadia's daughter. I haven't seen you since you were a baby!" He leaned over and gave her a hug, followed by Ethel.

“Oh, thank you. Yes, I’m a Marsian, though I’ve lived most of my life here on Earth.”

“How are your parents?” asked Ethel.

“They’re well. My dad’s 85, you know, and his health isn’t so good. They’re in Tehran; it’s safer than Tunis, and his doctors are all there. Mom’s just 56 years old and working at the Tehran Institute for Space Medicine. We talk every day.”

“Of course! I thought you were at Harvard?”

She smiled. “I graduated a year ago and came to Georgetown for a Master’s Degree in international diplomacy; I’m now in their doctoral program. I work part time at the Mars Consulate; in fact, my title is Consul General, and I must be the youngest consul general in the city, since I’m just 22!”

“Doesn’t Mars have an embassy in Washington?” asked Ethel.

“Yes, and the consulate is within the embassy. But there is no ambassador permanently stationed in Washington. Ambassador Szulc—Veronica Szulc, you’ve probably met her—is based in Bermuda with Foreign Minister Indira Robinson and handles all of North America, South America, and Europe. She’s in Washington about three days a month.”

“And you’re in charge the rest of the time?” asked Ethel.

“Well, sort of; I have a staff of two and we all report to Veronica, but someone needed the title, and the two staffers are not from Mars. She sends her regret and will see you tonight or tomorrow in Washington. She’s currently on a flight from Melbourne, Florida.”

“Yes, the sudden change in plans has thrown everyone off,” said Will.

“The FBI felt the threat was credible, so your flight to Canaveral had to be canceled. I’ve got a limousine here to take you to a hotel in Washington, where you would have arrived anyway. They also said your hotel reservation had to change; the hotel website was hacked and your reservation may have become known."

"So, where are we staying?" asked Ethel.

"The Willard; it's classic. Come on, let's get your luggage and go." Maryam pointed the way and they followed her, marveling that they were seeing someone they had never thought they'd see again. When Ruhullah had married Nadia, he had been 63 and she 34, and they had not expected to have children. But Sam Anderson, son of their old friends Madhu and Roger, and Corazon, daughter of their old friends Érico and Carmen, had unexpectedly gotten pregnant out of wedlock. The child—daughter of the second and fourth children born on Mars, the first grandchild born on Mars—had been adopted by Ruhullah and Nadia. Then Ruhullah had been sent to Earth as one of the newly independent Commonwealth's ambassadors, so Maryam had headed to Earth at age 7. Ethel couldn't wait to call Madhu and tell her about her birth granddaughter.

Maryam led them to passport control, where they were waved through; the Mid Atlantic Spaceport did not worry about illegal immigration from low Earth orbit and they had diplomatic passports anyway. Maryam flashed her diplomatic passport as well and walked right through. They stopped in the luggage area to identify their luggage, which was already loaded onto robotic carts; like loyal dogs, the carts dutifully followed them out of customs and outside to the waiting limousine. "I think the driver is an FBI agent," Maryam whispered. "They arranged for the limo."

"I see," said Will, surprised.

The driver stepped out and walked to him and Ethel. “Welcome home to the United States, Dr. Elliott.”

“Thank you so much.” They shook hands. “And you are—?”

“Call me Harry. Harold Swanson, at your service. Let me get your luggage.” He turned to the first cart and grabbed the suitcase while the trunk automatically opened to receive it.

“I thought all cars were self-driving now,” said Will.

“They are, and this limousine is self-driving, but I’m on board in case something unusual happens, shall we say.”

“I see. Thank you.”

Harry tossed the second luggage into the trunk and opened the back door for the Elliotts. They climbed in with Maryam and the limo took off.

“So: I find it hard to believe there are people out to assassinate me,” said Will. “I’ve dealt with some pretty crazy hate speech and even crazier conspiracy theories, but I never expected this. I was reasonably safe last time I visited earth.”

“That was over twenty years ago,” replied Maryam. “Security has deteriorated immensely since then. There are terrorist attacks and random shootings. All public and commercial buildings have metal detectors. Every intersection has cameras. There are all sorts of conspiracy theories on the web and many people believe them. Trust of the government is pretty low just about everywhere. So you can’t be too careful.”

“I see,” said Will, who looked at Ethel. She looked distinctly uncomfortable.

They drove by a big construction site surrounded by men in faded jeans and tee shirts, picketing. Ethel frowned. “Oh, they’re protesting robotic construction work,” said Maryam. “They’ve all lost their jobs.”

“There are hundreds of them!”

“It’s a big expansion of a telecommunications firm. They’re probably all getting unemployment and there are some funds available for retraining, but the fact is, there aren’t a lot of jobs available for them.”

“What’s US unemployment?” asked Will.

“It’s down a bit, but it’s currently eighteen percent. The automation revolution has permanently displaced a quarter of the job force and it’ll be some time before they can get work. Meanwhile, they can live, at least.”

“But not work; that’s devastating to one’s pride and identity,” said Ethel.

“And it can’t be easy to live on unemployment,” added Will.

“There’s a lot of drug dependency, but goods are pretty cheap because of three-d printing and automation. But of course the wealthy have gotten immensely richer in the last few decades, so power has increasingly shifted to them.”

“And that’s undermining democracy,” said Will.

“Exactly. The robots and the automation revolution that has made expansion into the solar system possible—and that has made life comfortable from Uranus to Mercury—has also made the rich here richer than ever, and has rendered over a billion workers unemployable. And that’s one reason you’re in danger; the Marsians and mariners have become a symbol of this roboticized new world.”

“What has made us prosperous had created a huge income gap on Earth,” said Will, shaking his head.

“So that people on Urania can argue over Japanese gardens,” said Maryam.

3.

Wealth and Poverty

July 2082

Washington, D.C. was almost three hours away, so they sat back in the limousine, relaxed, and enjoyed watching the verdant, swelteringly hot countryside of Virginia roll by. About the time they entered Maryland, Will's cell phone rang.

"Mr. Swift, what a pleasant surprise," said Will, holding the phone in front of him to see Zeke Swift III's face easily.

"Thank you, Dr. Elliott. I just heard that your flight was diverted from Canaveral because of protesters. I'm very saddened to hear it and hope you won't take it personally. The protesters really aren't protesting you. They're taking advantage of your arrival to protest the system."

"I was quite surprised because I visited the Earth two other times and I was popular both times! Sort of a returning hero! And now I hear of protests and terrorist threats. It's very disorienting."

"You are still a hero; the 'George Washington of Mars' some people say, and you have very high popularity, I assure you. It's a group on the political fringe who decided to make you a political issue. Mars wouldn't be where it is as a leader in space exploration without automation. Your people were among the leaders of the robotics revolution. The war pushed it along immensely, too. Mars needed self sufficiency, so you were interested in it, but the war also broke all the ties in world trade and forced every country to automate. They really can't blame Mars!"

“That is certainly true! The other reason we’re leaders in space exploration is because just about every country lost its nerve and decided it had to focus on domestic issues. The ten percent of our GDP dedicated to exploration could easily be overwhelmed by even small countries.”

“Very true, very true. I’d love to get together with you some time, and I have some friends—space entrepreneurs—who’d like to talk to you as well. When will you be in Washington? I’m there now and will be here for the next week. I gather you’re speaking to Congress in two days.”

“Yes, right before they start a summer break. I’d love to get together with you as well; I enjoyed our conversation over dinner in Aurorae, two years ago. Your company’s partnership with Mars has been very helpful for everyone. I’d love to hear more about your earth orbit plans and your plans for a city in Marius.”

“There’s a lot to talk about, too. Name the time.”

“Well, we’ll be at the Willard in a few hours!”

“The Willard in Washington! Excellent! Would you and Ethel like to do supper, then? I can send a car to pick you up. My house is just outside the city, about half an hour away.”

Will looked at Ethel, who nodded. It was just noon; plenty of time to rest. “Certainly, that would be lovely. What time? Six?”

“Sure.”

“Tell him I’ll drive you,” said Harry.

“Our limousine will take us to your place,” said Will. “Just text me the address and we’ll be there.”

“Alright, that’s excellent. Thank you, I look forward to it.”

Will asked the limo driver to take them through Washington's poorer neighborhoods on their way to Swift's estate. The contrast, as expected, was stark: abandoned houses and apartment buildings and vacant, weed-filled lots on the one hand, contrasted against a thirty-room mansion set at the end of a tree-lined hundred-meter driveway, with a formal garden and gushing fountain in front of the main entrance. A real butler—not a robot—met them at the front door and ushered them into a very elegant room with very comfortable antique French furniture.

"Thank you so much for coming!" said Zeke, rising to welcome them into the sitting room. "It's an honor to be one of the first to welcome you to Earth! And welcome to my home!"

"Thank you so much," said Will, shaking Zeke's hand

"You have a beautiful home," added Ethel, shaking his hand next.

"Let me introduce you to some friends. Ted—Tadeusz—Bukowski works at NASA headquarters here in town and is in charge of advanced mission strategies. Joan Chiu is President of AIBuild, the company in charge of building the lunar mass driver."

"Oh, yes, I've heard of both of you," said Will, shaking hands with them. "This is my wife Ethel, former President of PGM-Mars."

"I've heard of both of you, too," said Joan, with a smile. Bukowski and Chiu looked barely thirty—young, confident, and capable leaders.

They all sat on the antique furniture and Swift offered them drinks; he had forgotten the Elliotts didn't drink alcohol, but had plenty of choices for them as well.

"So, one billion redbacks to refine the artificial intelligence systems, and the mass driver was back on schedule," Ethel said to Joan.

Joan smiled. “After a year behind schedule and two billion in overruns, we took over and got it done. It’s too bad you can’t come to the dedication.”

“I wish we could, but it’s right before our departure for Mars,” said Will. “You can’t stop celestial mechanics.”

“I’m not convinced it’ll make money,” said Zeke. “My prediction is that it’ll go bankrupt and have its debt restructured once or twice. But twenty or thirty years from now it’ll be a crucial piece of infrastructure for the space economy.”

“Zeke, you always say that, but you’re wrong,” replied Joan matter-of factly. “If we had gotten the contract from the beginning, there’d be no problem. But the two billion can be paid back. The LEO economy is growing fast.”

“It is, but with the version 2 of the Prometheus, launch prices are going down again,” replied Zeke. “They have to, to compete with the mass driver! By next year we’ll be putting finished goods in low Earth orbit from the Earth’s surface for 50 redbacks per kilo. From the lunar surface, it’ll be 22 redbacks.”

“And from Mars, 35 redbacks,” said Will. “Ceres can export carriers with 400,000 tonnes of water and metals for as little as 5 redbacks per kilo.”

“That’s what I’m counting on,” said Zeke. “We’ve got our first load arriving in six months and it’ll be really cheap, partly because of robotic construction, Joan. Then there will be an economic basis for advanced industry in low Earth orbit to manufacture items for use there, on the moon, and elsewhere in the solar system. Swiftville will grow fast, then.” Zeke was referring to a carrier 200 meters in diameter and 100 meters long that was already under construction seven hundred kilometers above the Earth's surface that would hold a thousand people and many advanced factories.

"Well, don't forget Phobos," exclaimed Ethel. "It already has two carriers and will soon have four thousand people."

"And stuff can reach Phobos from Ceres for two thirds the cost as Earth orbit," added Will.

Zeke smiled. "It's amazing, isn't it? Did you ever think you'd live to see this day?"

Will shook his head. "When I was born, it cost 20,000 redbacks to put a kilo into LEO with the old space shuttle! Now we're talking about *five* redbacks to get stuff from Ceres; four thousand times less. No, I could never have imagined it. How many people are in LEO at any time? A thousand?"

"Or more," confirmed Zeke. "And 1,500 on the moon. There are babies being born there. We've got 1,300 on Callisto, 1,300 on Titan, 1,000 on Mercury, 800 in Venus orbit, and we'll soon have a thousand in Urania. People will reach Neptune in six months. Mars will have over 90,000 in another six months."

"'In the future, space travel will assume great importance,'" quoted Will. "`Abdu'l-Bahá, son of the founder of the Bahá'í Faith, said that in 1913. In less than two centuries, His prediction has come true."

"He said that, huh?" said Zeke, impressed.

"Well, I'd like to see it assume a new dimension," exclaimed Ted, speaking up for the first time. "Are you familiar with the latest observations of Helia?"

"The brown dwarf that's not supposed to be there?" asked Will.

Ted chuckled. “I’m glad NASA’s not the only agency that missed it for years and years, but now we know there’s a brown dwarf just 1,000 astronomical units from the sun, nipping through the Oort Cloud. They just found three more planets orbiting it; they now know of four of them. The farthest is 150 million kilometers, about one astronomical unit. The closest one is 125,000 kilometers away from Helia and has volcanoes, just like Io. Helia 2 is in resonance with Helia 1, is 200,000 kilometers out, has a carbon dioxide atmosphere about as thick as Earth’s, and with the resulting greenhouse effect should be the right temperature for liquid water.”

“Really?” said Joan. “It’s in the Goldilocks Zone?”

“Barely, but with 1 atmosphere of CO_2 it has brought the Goldilocks Zone to it. Helia 2 is about 10,000 kilometers in diameter—half way between Earth and Mars—and its gravity should be half way, also. It’s got liquid water and clouds. Probably no life, but you never know. It’s half a billion years old.”

“Fascinating,” said Will. “But it’s a long way away, so it’d be hard to reach.”

Ted shook his head. “You’d do a gravity assist with Jupiter, then use advanced ion or fusion propulsion. It’s forty times farther away than Neptune and we can reach Neptune in less than three years. With a fusion engine, we should be able to get a probe or a carrier there in thirty years.”

“A carrier?” said Will. “You’re talking about a multigenerational mission. Those people won’t be returning for a century. We don’t know how to do that.”

“We don’t?” Ted frowned. “Let’s say we sent a big carrier: 200 meters in diameter, 300 meters long, with 5,000 people. We’d want two meters of ice for radiation shielding around a third of it and a big ice mass in front to shield against micrometeoroids; that’d mass 200,000 tonnes. The rest could be much more lightly shielded. We'd want the most advanced robotic factories we have and 250 megawatts of power. The advanced ion propulsion we'll have in ten years could get the carrier there in fifty years, but by 2100 we could use fusion propulsion and that'd cut the travel time in half. With 10,000 tonnes of various elements and isotopes, they'd get there."

"They probably would, but it'd cost many tens of billions to perfect the necessary technology and launch the mission," said Will.

Ted nodded. "Nothing the U.S., Mars, and a coalition of other countries couldn't afford to do over two decades."

Will smiled. "You're probably right."

"That would make us a truly multiplanet species," said Zeke. "We'd actually be a multi-solar system species!"

"Of course, the people leaving would *never* come back," said Joan. "That's not true of the people going to Uranus or Neptune. Most plan to return to Earth or Mars when it's time for their kids to go to university."

"And many will stay anyway," said Ethel. "But you are right; psychologically, there's a big difference, because of the *possibility* of returning. That really wouldn't exist with a voyage to Helia."

"And they might not want to stay forever," said Will. "After a century of exploring the system, they might decide to abandon it and return."

Ted shook his head. "No, I don't believe that. The Inuit never abandoned their icy Arctic islands. When people settle somewhere, they come to love that place. And who'd want to return here?" He pointed out the window. "This is such a screwed up world! Helia would be much safer. It'd be a new start. I'm not even sure this place will be able to launch an expedition of that sort in twenty years!"

"Really?" said Will, surprised. "GDP is still going up two percent a year! The US is six times wealthier than it was in the year 2000. Earth is ten times wealthier."

"Yeah, but the so called 'middle class' is just about gone!" said Joan. "The top ten percent is twenty times wealthier than it was in 2000. Median income has actually dropped; people now earn the same as *one hundred years ago*! That's why there's anger, demonstrations, terrorism, assassinations . . . and it's getting worse."

"I have more people wanting to move to Mariustown and Swiftville than I can accommodate," said Zeke. "Can you believe it? Mariustown was sized to accommodate five thousand people and we have five thousand people who have put down deposits on condos. In a lunar lavatube! Now I'm planning an even bigger development. I anticipate spending fifteen billion redbacks over ten years to build thirty thousand units, and I bet demand will exceed even that! Why do people want to move to the moon? Safety. They'll pass through a rigorous security check to get on the shuttle, and at the other end there will be no security checks, because they won't be needed. No poor people. Robotic everything."

"But if there's a revolution here, what will be the economic basis of all those people?" asked Ethel.

Zeke smiled. "Good question. I'll be financially safe because of the way the debt is structured. How could terrestrial banks foreclose on lunar condos when the people there have no place to go and there will be lunar courts functioning under a lunar sovereignty? People would struggle to obtain basic necessities, but they'd attach to the Martian economy, and for the foreseeable future, Mars will have more people. You guys are our model and our safety net."

Will was startled by that. "I don't think Mars realizes it's your safety net!"

"Well, you are. That's why I'm so concerned to work closely with Mars, frankly. On Mars, people are suspicious that I want to steal your technology and ideas and do one better, to outcompete you. But partnership is essential. So is getting as many people into space—off Earth—as possible."

Joan nodded. "Sea level is already up 1.2 meters. Half the Florida Keys are underwater. It's going up two more meters in the next century. Cities are spending trillions to raise their streets and shorelines. Can we solve the problem? Yes, but will we? No! There's no political will to do anything. The lobbyists spend billions and cancel each other out."

"But the United States joined the Grand Union and even agreed to give up the dollar!" said Will, surprised.

"Yes, it did, in a time of desperation, guilt about the nuclear war with China, and financial collapse," said Joan. "Even then it was very controversial. President Lee is a fiscal conservative. He was able to do these things on two conditions: he was conservative, so he brought the resistance along; and he didn't upset the economic arrangements more than absolutely necessary, so the rich could continue to get richer. The economy has recovered because of the new arrangements and because of inflation to buy down the huge debt. Automation is driving a huge expansion of the economy. But that means more people are unemployed for the rest of their life, living on 'early retirement,' and are frustrated that their lives are going nowhere. A lot of them are zoned out on drugs."

“And their lives won’t go anywhere because the government won’t subsidize education and training,” said Zeke. “I hate to say it, but taxes on the upper income need to go way up.”

“Though not all at once,” said Joan.

Ted laughed at that. “I’m in the wrong field.”

“No, you stay where you are!” said Joan. “We need visionaries in NASA! Zeke and I will lobby to get you the money, too!”

Zeke laughed at that, and nodded. “So, what do you plan to tell Congress?” he asked Will, changing the subject.

“The more I talk to all of you, the less certain I am about that!” Will replied. “Seeing the US, talking to Americans, is very different than just watching the news.”

“It’s much more raw,” said Ethel. “We’re going to Scotland to see my relatives and I wonder what that’ll be like.”

“We’ll see five continents,” added Will. “I plan to talk about the ‘Mars Model.’ Clearly, it’s needed more than I thought.”

“Very, very badly,” agreed Joan.

“To the extent it’ll do any good,” said Zeke. “The forces of greed are against changes of that sort, here.”

“And the problems are vastly more complex,” added Ted. “That’s the other reason so many well to do professionals want to move to Mariusville!”

“But I’m not sure they really can run away from the problems,” said Ethel. “They have a tendency to come back in another form.”

“You may be right,” said Zeke. “We’ll see.”

4.

Congressional Address

July 2082

The next day was busy and started early. “We apologize we were unable to brief you yesterday, but we were at Canaveral,” said FBI Agent Ferris. “When you were diverted to Wallops, we had to get here to brief you, and that took until last evening, when you were already at Zeke Swift’s place.”

“That’s fine,” replied Will. “The formal welcome has been shifted from Canaveral yesterday morning to NASA Headquarters at 11. What have you found?”

“We’ve arrested three people for making threats against you and the Prometheus shuttle that was scheduled to land at Canaveral yesterday. Two of them were plotting together and posting threats all over social media, but neither of them had accumulated weapons or made specific plans, as far as we can determine so far. The threat to shoot the shuttle during its landing sequence came from the Lashkar-e-Shaam, one of the Islamist terrorist groups. They have shot down an airliner with a portable surface to air missile—the one that blew up approaching Atatürk Airport last year—and they have been making threats ever since. But there is no evidence they have a cell in the U.S. capable of such an act. It appears they piggybacked on the existing threats in order to gain additional publicity. We had to cancel the landing, of course; we needed time to investigate the threat. But we no longer regard it as credible.”

“What about all the demonstrators at Canaveral?”

“Your landing was receiving a lot of publicity, so naturally there were protestors.”

“Not protesting *me*?”

“Not particularly. You are a symbol of our space achievements and most people are proud of them. But the cost, the automation . . . these are ambiguous legacies.”

“Of course,” said Will.

“So, what do you recommend?” asked Ethel.

“As you know, Harry, your driver, is an agent. You can stick with him or hire a private security firm. We do recommend you have some security with you and we can recommend some firms. Your security person will contact all venues where you are speaking and determine the best way to get you in and out easily and safely. We can’t say you are completely safe. That said, we doubt any organization or group is planning to assassinate you. But lone wolves have become quite a problem, so you need protection from them. Public appearances that are spontaneous and unpublicized should be safe.”

“That’s helpful,” said Will. “I’m giving 35 talks in 36 days, so I’ll be traveling and speaking constantly.”

“You have a private jet?”

“Of course. The Mars Commonwealth is helping plan the tour.”

“We’ll email Ambassador Szulc. She’ll have people who know what to do.”

“Good. Anything else?”

“No, I don’t think so.” Agent Ferris rose. “Best wishes with your visit, Mr. Chief Minister. You are a hero for my son; you're a hero for me, too! Mars seems like a dream. If we could move there, we would.”

“I’m glad to hear Mars has been such a beacon of hope. Here, let me give your son an autograph.” Will reached into his bag and pulled out a photo that he had already signed. He wrote the boy's name on the picture and handed it to the agent. The agent thanked him profusely all the way to the door.

"Well, that's that," Will said to Ethel, after the agent had left.

"It's not quite as bad as we thought," she said.

He nodded and turned to Maryam Islami. "As much as I like Harry, I think we need a limo driver who is a private security agent. Text the FBI and get the names they suggest, then forward them to Veronica Szulc. She knows the situation best and should decide."

"Alright, I'll do that right away. She says I can travel with you as an assistant, if you want one."

"Oh, we'd love that!" said Ethel. "That would help two 80 year olds quite a lot!"

"Thank you, Maryam, we'd really appreciate that," agreed Will.

The official welcoming ceremony at NASA headquarters was a blur of speeches, hand shaking, and excessive praise. Will kept Ethel at his side and deflected as much of the rhetoric onto her as possible. The ceremony ran long and they had to hurry to the Capitol for his speech before the joint session of Congress, scheduled for 1 p.m.

There was another round of handshakes, but blessedly short introductory speeches by the Vice President and the Speaker of the House. Will walked to the podium to sustained applause. As he looked out at the crowd through the teleprompters, he felt tears form in his eyes. He nodded in thanks to the enthusiastic reception several times.

"Ms. Vice President, Mr. Speaker, ladies and gentlemen of the Congress of the United States, and other guests, thank you for this very warm welcome," he began. "I must state at the outset my gratitude to the United States of America, its congresses, Presidents, scientists, and ordinary citizens for their support of space exploration. Just about one hundred years ago, the space shuttle began operations to take humans to low earth orbit. Fifty-four years ago this summer, humans returned to the moon, post-Apollo. Fifty-three and a half years ago, I made my first flight to the moon on Northstar 2; it seems like it was just yesterday, but also seems like it was an entire lifetime back. Ethel landed on the moon a year later, in 2030. Both of us landed on Mars on February 28, 2036; I should add she beat me by several hours, too! That was over forty-six years ago.

"No one could have imagined, that day, what Mars would be like today. Once the current wave of 25,000 immigrants arrive by the end of this year, counting in the 8,000 children born on Mars over the last two years the Commonwealth of Mars will embrace 91,000 people. This is eighteen times the population Mars had when it achieved independence, seventeen years ago. In another month, Saturn will receive arrivals and its population will grow to 1,700. Callisto has 1,300 people; Ceres, 1,000; Mercury, 1,000; Urania, 600; Venus, 300. The various stations on the moon have fifteen hundred and will soon have closer to ten thousand. The hundreds in earth orbit will soon grow to thousands. Neptune is scheduled to receive hundreds of migrants later this decade, a large multi-decadal mission to Pluto and the Kuiper Belt is in the planning stage, and I have just been talking to NASA experts about the possibility of a carrier flight to Helia and its planetary system.

"These mundane facts represent a miraculous development not just of technology, not just of economics, but also of social organization, and Mars is at the center of the social and cultural innovations. How did Mars do it? What was its secret? How did it come to represent, in the minds of hundreds of millions of people, a place of hope, of change, of opportunity, a better place to live and raise a family? How did its leadership win two Nobel Peace Prizes for their achievements? The answer, I believe, can provide ideas for solving some of the problems the United States, and all of Earth, face.

“Mars presented those of us living there with several key challenges. First, there were never enough of us; we had to rely on very complex machinery for survival, machinery that required expertise to repair and that had to be imported from Earth at a tremendous cost. Second, we were utterly dependent on each other; we truly had to work together to survive, knowing that one major failure would not only lead to loss of life, but to a possible cut off of the funding for Mars exploration and the end of the entire effort. Third, we had to work together in spite of our diversity, for we were from many countries, spoke many languages, worshiped in different ways or not at all, and had different cultures. We were truly a nation of immigrants.

“These facts forced us to take certain steps. First, the talents and skills of every person had to be valued and augmented. Mars could not afford unemployment. It had to have a skilled workforce, so it had to provide virtually free university through graduate school. Even our children with Down syndrome and other limitations go to college. It could not afford discrimination by sex, race, religion, or any other criterion, because they would simply exacerbate our labor shortage. It could not afford poverty because poverty limits human potential, and that would exacerbate our labor shortage, so it had to provide fair wages and incentives that allowed people to purchase their housing and start businesses. It follows, if we couldn’t afford extreme poverty, that we also couldn’t afford extreme wealth, for that would concentrate so much resources in the hands of a few, that there would be poverty. We could not afford ill health, so we had to provide very comprehensive health care; so comprehensive that, in spite of the radiation and other hazards, life expectancy on Mars is longer than it is in many developed countries on Earth.

"Finally, we couldn't afford a political system that sought votes through misleading voters; through the bribery that is called political fundraising; through fear mongering that would make one ethnic group suspicious of another. Consequently, we held all our elections without campaigning, nominations, or electioneering. Instead, we held 'Future of Mars' forums where everyone could speak up about what they thought Mars needed. Mars has functioned without political parties, partisanship, and polarization of the electorate for forty years. I am always amazed, looking at a gathering such as this; how uncomfortable my statement makes people; yet privately, afterward, they admit they are envious.

"How does all this relate to Earth, with its eleven billion human beings? You may say: Mars had a labor shortage, so it had to take these measures, but we have a labor surplus here on Earth. To that assertion I beg to differ quite strongly.

"You have a labor shortage on Earth as well. Eleven billion people need the material means to live a comfortable life, to raise their children and get ahead in the world, and you provide this necessary condition to only half of them. If you aspire to raise all of humanity to a modicum of prosperity, you have a labor shortage. It is a shortage that cannot countenance discrimination; all must have access to education, training, employment opportunities, and the social support that will make their success possible. It is a shortage that cannot countenance ill health, that great debilitator of human potential. It is a shortage that cannot countenance poverty, that great limitation on human development. It is a shortage that cannot countenance war! And it is a shortage that cannot countenance political infighting, partisanship, bribery, misleading the voters to gain power, and pitting one group against another. These are the reasons four American cities have experienced nuclear attacks in the last thirty years. These are the reasons several Chinese cities still lie in radioactive rubble. These are the reasons the American dollar collapsed in value, thereby wiping out everyone's savings, sinking banks and businesses, and forcing impoverished nations to band together and launch the world dollar. These are the reasons sea level has risen over a meter since the beginning of the century and is rising at an accelerating rate.

"Robots will not help you with your labor shortage. On Mars we have nine or ten robots or other automated systems per person, and we *still* have a labor shortage. We are spreading out across the solar system and reaching for the stars, so we need every bit of human potential and every bit of artificial intelligence we can get. The same is true here on Earth. If people are unemployed, there is something wrong with the economy, the educational system, the health system, and the political system. And it can be fixed.

"We on Mars can help. It sounds strange to say that 90,000 people can help 11 billion, but it is true. We are an imperfect example; you can help us make our systems better, and we can help you to make yours better. Tens of millions of people—perhaps hundreds of millions of people—look at Mars and wish they could live there. We have acquired the ideal status that the United States of America once had for many people around the world. You proved that democracy could work; that life, liberty, and the pursuit of happiness could be the ideals of a society; that hereditary status did not confer superiority; that all people truly are created equal; that it is possible for a poor, struggling youth to become prosperous and successful. These have become values in every society on Earth. But your generosity and creativity have brought into existence a new imperfect ideal on another world, one that millions wish to emulate. Partner with us. Let us expand out into the galaxy together. Continue to reform your economic, educational, health, and political systems and we will, as a species, become a mature civilization, worthy to partner with any other sentient life we encounter. That is our destiny, together, as human beings. Thank you."

Will wasn't sure what response he would get to a speech that was, to some extent, a criticism wrapped in praise. But everyone applauded, and some did so with enthusiasm. He nodded in gratitude and some began to stand. Then others stood as well, giving him a standing ovation. He walked from the podium to the Vice President and Speaker of the House.

"Thank you," said the Speaker of the House, not quite sure what to make of the speech.

"It was marvelous, Dr. Will," said the Vice President with a smile, addressing him in Marsian fashion.

"Thank you very much," he replied, with a warm smile.

It took an hour to get out of the Capitol because so many wanted to speak with Will. Several space exploration societies had banded together to host him at 4 p.m., so there was no time to rest and again people thronged around him, making it difficult for Will to get any of the refreshments. He and Ethel got way at 7 p.m. and rested for an hour and a half to recover. As they rose, Will got a text from Zeke Swift. *Ted Bukowski wants to get together with you again. That was a great speech; I watched it on tv. Congratulations.*

Will noted that Ted had been copied on the message, so he dictated a text back to both of them. *Thanks, Zeke. The reception was mixed in Congress, but the space people just loved it. Ted, come on over tonight if you'd like.* He hit send and a few seconds later Ted replied *I'm on my way.*

"Oh?" said Ethel, when mentioned it to her. "I just invited Maryam over."

"Good, they'll be interesting company."

Ted showed up fifteen minutes later. "I live a half mile behind the Capitol," he explained. "I could practically walk over."

"A good location," said Will. "Have you talked to Jimmy Khan?"

"Yes, thank you for making the contact. I have wanted to be in touch with him. We exchanged three emails and one videomail. When I told him about the Helia project, he said 'Why think small? We could send a much bigger carrier than a C-200.'"

"He and the team at Martech have been computer modeling carriers up to 500 meters in diameter and 2,000 meters long. They could accommodate 50,000 residents and would mass in the vicinity of 3 million tonnes. It'd have to be constructed in Ceres orbit, or maybe somewhere the lunar mass driver could launch lunar material."

Ted whistled in surprised. "That'd be incredibly expensive!"

Will nodded. "Perhaps a hundred billion, but the price could come down with more robots and automation. Ceres has the 'waste' metal lying around from its PGM production and it only takes 300 meters per second to put something in orbit. It has nearly infinite amounts of water, carbon dioxide, and nitrogen, and is in the process of setting up a very large plastic manufacturing operation."

"To export to Phobos?"

"There or LEO; anywhere in the solar system. It's really in a unique situation. It's close enough in so that solar power works well and is cheap. Its gravity is low enough so that carriers on its surface can provide artificial gravity very effectively. It has almost every element one needs for manufacturing. And Mars has agreed to send them a dozen gaseous core nuclear engines every launch window, or three and a half years. Ceres could send to Earth orbit a million tonnes of water at a time. That'd use up the entire life of four gaseous core engines, but that'd cost $400 million redbacks. The metal structure to hold the water and the effort to extract the water from Ceres, purify it, and launch it to Ceres orbit would cost maybe 600 million, so for a billion redbacks, low Earth orbit could have a million tonnes of water; one redback per kilo! Even the lunar mass driver can't match that."

"That's amazing. I suppose they could send some of their 'waste' iron or nickel instead of water, too."

"Yes, for about the same price. It'd take 18 months to arrive; that's the drawback. But with careful planning, that's not a problem. Ceres' gravity is only a thirtieth of Earth's, so it isn't hard to design very large vehicles there."

Ted shook his head. "It's really amazing what Mars is doing. The U.S. has a lot more money, but in a way we can't compete! We're down here, at the bottom of a deep gravity well; you're in much shallower wells."

"We can immediately innovate," agreed Will. "If we want to test a nuclear engine, Deimos is an eight-hour ride from Aurorae. We can simulate any gravity cheaply on Phobos. The Martian poles and the poles of the moons can simulate just about any temperature in the outer solar system. I'll tell you what the U.S. needs to do. It is already doing this, but it needs to do it more: collaborate with Mars and many other nations. A quarter of the people on Titan were put there by the U.S.; a third of the people on Urania as well. The U.S. has probes orbiting all four of the outer planets and one on Pluto. The technology was jointly developed by many nations. Mars invests heavily in research carried out in the U.S., usually in partnership with NASA. Our gaseous core engines were partially developed at Los Alamos. Overall, the United States has probably invested 300 billion redbacks in Mars; in our agriculture and environmental systems, propulsion systems, space suits, surface transportation, robots, artificial intelligence, even our construction techniques. I could go on and on. When you add European, Indian, Chinese, and Marsian investments, over a trillion redbacks have been sunk into the technology that has made Mars possible.

"But the United States has never coordinated its efforts well with Mars's efforts. What NASA needs is someone on Mars, at Martech, interacting with Jimmy Khan and his team, building a stronger liaison between the space programs. Jane Kohl used to do it, but she left last year and hasn't been replaced. The days are long gone when a nation pursues a project using technology developed in its country alone. Mars still imports a lot of components for its space vehicles and it buys licenses for a lot of American, Chinese, European, Indian, and Russian patents. If the U.S. wants to send a carrier and 5,000 people to Helia, why not build it in Ceres orbit?"

"That's an intriguing idea! NASA is at a crossroads right now, too. The United States economy is stabilizing—probably—and the government budget is moving out of an emergency condition. Cash is still tight, but NASA does have more money than it's had in two decades. It's also a young agency; most of the veterans were laid off during the Chinese war when the agency was temporarily taken over by the military, and others left afterwards. I'm 33, and I'm fairly senior in the administration! Ambassador Danforth is supposed to provide coordination between NASA and Mars's Ministry of Space, but he doesn't do much."

"Neither does Ambassador Szulc," agreed Will. "The external affairs ministries are busy with other tasks and are ill suited to serve as technical liaisons. Danforth has been particularly difficult where Mars's plan to use nukes to vaporize the polar caps is concerned. NASA needs to have their own person on Mars. That person will know Mars's capabilities and can coordinate concrete plans to collaborate."

"I see what you are saying." Ted nodded. "That's very important. And in NASA headquarters, I haven't heard any concerns about the plans to nuke the polar caps."

"That confirms my suspicion that Danforth was echoing the views of various conservatives," said Will. "There's still a ship leaving for Mars in a month. It's not too late for the liaison to travel to Mars!"

Ted laughed. "How much?"

"The ticket? About 250,000 redbacks. Close to the annual salary of a professional. My first flight to Mars cost several thousand times more!"

"That's right; Mars is importing 25,000 people this year at a total cost of about 6 billion redbacks."

"Using about 150 billion in infrastructure," added Ethel.

Ted nodded. "I'll take that to the Administrator."

Just then there was a knock on the door. Ethel said, "Come in!" and the door unlocked for Maryam Islami. "It's good to see you, dear," said Ethel, giving her a kiss.

“Thank you. The Congressional speech was incredible! I’ve been following the liberal media and they all loved it.”

“The conservatives are furious, though,” said Ted. Maryam turned to him, puzzled. “Sorry, I’m Ted Bukowski, NASA Advanced Mission Strategies. And I don’t agree with them, but I do follow what they say.”

“It’s good to know the other side,” said Maryam, with a nod. She extended her hand. “Maryam Islami, Mars Commonwealth Consul General for the United States.”

“Wow, you’re Consul General! Impressive.”

“Thank you, but the Commonwealth has a tight budget.” She laughed, so he did as well.

“Dr. Will, here, has been telling me that NASA needs a liaison with Martech, in Aurorae, so that our space programs could be better coordinated.”

“That’s a great idea. I have always wished we could do more in the Embassy, but Ambassador Szulc isn’t here much and I’m not qualified to do anything of that sort. My degree is in international diplomacy.”

“And your father . . . is Ruhullah Islami? I’ve heard of him.”

“Correct. He’s retired now, and his health’s not great.”

“I’m sorry to hear that. He’s older than Dr. Will, isn’t he?”

“Yes; 85. I was born when he was 62. But I’m adopted.”

“And we know her birth parents quite well,” added Ethel. “In fact, I emailed them both this morning and both said they were glad to hear you were well.”

“I’d like to meet them, some time.”

“They’d like to meet you, too. You can always videomail them.”

“I may do that; their contact information is easy to get. I have some updates on your travel plans. And my dad said if you have a spare day in Tehran, he can arrange for both of you to visit the new Bahá'í House of Worship there.”

“Oh, that would be marvelous!” said Ethel.

Will nodded. “Right now, we have three spare days built into the schedule, on the theory we’ll need to rest! We could probably spend one of them in Tehran.”

“He and mom would love that. Ambassador Szulc asked me to remind you of your luncheon with the Director of NASA and your afternoon meeting with the Secretary of State.”

“I’ll be at the luncheon,” added Ted.

Will nodded. “We’ll be ready. Any word on the ‘informal’ evening visit?”

“It appears to be on; the President has it on his schedule.”

“Good,” said Will.

“Where do you go from here?” asked Ted.

“Generally westward: Chicago, San Francisco, Vancouver, Osaka, Beijing, Canberra, Bangkok, Kolkata, Tehran, Haifa, Paris, Scotland, Oslo, Lagos, Brazilia, then Kourou and back to orbit.”

“Wow! In twenty-five days?”

Will nodded. “I just hope it doesn’t kill us!”

5.

Tehran

August 2082

The next two weeks were a whirlwind of receptions and talks, but Will and Ethel made sure they got good sleep every night, took off at least half a day whenever they crossed three or more time zones, and made their private jet into their home away from home. Will was amazed they did as well as they did; he felt fit and energetic, in spite of his age.

But Tehran was a different situation. When he had left Earth 48 years earlier, the Iranians were still martyring Bahá'ís, and now he, one of the most famous Bahá'ís in the world, was visiting. It made him very nervous. But Ruhullah Islami went out of his way to make Will and Ethel comfortable.

"You will be fine," he said, over a huge dinner of fessenjan and ghormeh sabzi over saffron-tinged rice that Nadia Larue-Islami had prepared in their home. "You have to understand the situation. The Fundamentalists are still around and they're still a strong presence, but they are rather like the Southern Baptists in Texas. Their temptation to use violence has been exhausted by decades of killings, assassinations, and terrorism in the name of Islam that did them no good in the end. The first half of the twenty-first century was our Hundred Years War, when the Protestants and Catholics realized they couldn't wipe each other out and would have to tolerate each other. The Peaceful Revolution that swept Iran after that period of repression was made possible because the vast majority of Iranians had essentially given up on Islam, but they had decided that the only way to overthrow the government was nonviolently. In many ways, the Iranian Bahá'ís were the prime examples, because they absorbed decades of martyrdom, repression, and discrimination and responded with love and a desire to serve the country that was trying to wipe them out."

"It was amazing," agreed Will.

"It was, and they gained hundreds of thousands of converts. Now Islam is making a comeback here, but in a much more peaceful form. The majority remains Muslim culturally, but that's about it. Iran is about as religious as western Europe!"

"So, will people ask us about the Faith?" asked Ethel.

"Some might, but most know the basics, and information is readily available on the web. Your trip to the House of Worship might generate a huge crowd, though. People will be doubly curious, in you and in the temple. Many Muslims won't go there and your visit may provide an excuse."

"Talking to people here, you may get a sense there's a sort of schizophrenia about the Bahá'í Faith," added Nadia. "People are repelled by the idea of a prophet after Muhammad because of Qur'anic passages that deny the possibility, but if someone is going to make the claim to be such a prophet and is successful, he might as well be Iranian!"

"People do seem a bit proud that because of Bahá'u'lláh, Iran has been spread around the globe," agreed Ruhullah. "Yet they are also distant. You will have an afternoon with the Foreign Minister, and that will be a great chance for us to talk about Mars and Marsian-Iranian cooperation, but I suspect if you weren't a Bahá'í, you'd be meeting with the President as well. I think she was hesitant because of the fundamentalists."

"The Foreign Minister is the appropriate person to meet anyway," said Will.

"Exactly. So, tell me about Mars! I don't think I'd recognize the place!"

“Oh, you wouldn’t,” agreed Will. “Aurorae is now twenty times larger than it was right after the Cinnamon Revolution, when you left for Earth. Martech alone is bigger than Aurorae was! In two years, we’ll break the 100,000 mark.”

“You should see the size of some of the enclosures,” added Ethel. “They are now designing enclosures that are two kilometers wide, five kilometers long, and one kilometer high! The air alone will provide decent radiation protection, but they’re building into the dome itself water reservoirs up to three meters thick. You won’t even see them. The result will be a completely safe radiation environment. The water can also be used to radiate excess heat out of the dome.”

“And all built robotically, I am sure.”

“Of course, like everything now,” said Will.

“But what about the spirit of the place? I hear the stores there are great, life is comfortable . . . are people focusing on how many sets of clothes they have and how much money they’re earning?”

“No, it’s not as bad as Earth,” replied Will. “Things are more materially comfortable; in fact, even on Saturn and Uranus, things are more comfortable than they were on Mars before independence. But Mars has retained its idealism and optimism, and that’s primarily because we control immigration and the people who come are really determined to contribute to a civilization oriented around exploration. That’s the Marsian dream: scientific and technological exploration and taking humanity to new places.”

“And the kids?”

“They usually don’t have the drive of their parents, of course; they were born on Mars and take it for granted. But once they grow up, they are immersed in a sea of Mars idealists of their age who have just arrived, and that effects them, for better or for worse."

"For worse?"

"Some become hippies!" said Ethel, with a chuckle. "But even that can be alright. You can now go off and 'homestead' you know, and people go out to find gold all by themselves. We have a few second generation kids who are doing that."

"That's one way to find yourself. There are second generation kids all over the solar system. But what if immigration shrinks? It can't keep growing forever."

"No, it can't, but who would have thought that 25,000 in one columbiad would be possible? The price per person keeps dropping. Carriers able to transport 10,000 at a time are certainly possible, as are shuttles able to take 500 or more to orbit at once. So we haven't reached the limit yet. Let's say we find that 50,000 is a practical limit, though. If those 50,000 all have two children, it'll be twenty years before a generation of 50,000 children grows up and encounters 50,000 arrivals, so they'd still be exposed to a large number of idealists."

"And that's beyond anything we can imagine or plan for," said Ethel. "That's a Mars of maybe 2 million people and a Mars where the majority of adults still are immigrants."

"And a young Mars, because of the constant immigration of young people. A dynamic, exciting place. Such a contrast to old Earth."

"Yes, I am terribly worried," said Will. "Earth's problems, which we thought were nearly intractable several decades ago, are now much worse, and much more complex."

"That's right. The problems of poverty and unemployment are immense and there's no political will to solve them. The nations don't trust each other, yet they are economically dependent on each other. They will cooperate enough to avoid another disastrous war, but no one can inspire them to work together positively. No one can give them a plan, a common goal. So the bright ones go to Mars to get away from the mess! I've been following your trip and you talk about Marsian example on every occasion. But are people listening?"

"A few are, but at least as many are outraged and angered by what they perceive as criticism of their approach to the world. I was hoping for a better reception."

"At least at Oslo, you'll get a favorable response," said Ethel.

Will nodded. "Yes, the Scandinavian countries are perhaps the most successful ones, economically and socially, but they have built in chavinisms about immigrants that are hard to overcome, and they are small places."

"Easier to transform," said Ruhullah.

"Exactly. I don't know what's going to happen to Earth itself, with rising sea level and resource deterioration. Space resources, renewable energy, and space-based solar power systems certainly can help, but at enormous cost. How can Earth provide for eleven billion people! Certainly it'd be possible with enlightened governance, but that's in short supply!"

"Exactly." Ruhullah sighed. "Well, I certainly won't be going back to Mars, as much as I wish I could. My health has deteriorated quite severely in the last year." He leaned close. "I have cancer, and it has spread too much to be operable. Chemo controlled it a while, and now immunotherapy is holding it at bay, but that treatment is slowly failing, too. I've probably got about a year left."

"I'm sorry to hear that, Ruhullah. There's nothing the doctors can do?"

He shook his head. "No. I was traveling, speaking a lot, and not stopping to get a comprehensive screening every six months. I skipped two of them very foolishly, and that was enough to give the cancer too much of a head start. Now, it's a race I can't win." He paused and looked at Nadia and Maryam. "But I've had a good life, I've had some good accomplishments, I've served humanity and I served Mars. I have you to thank a lot for that, Will. You trusted me and gave me a chance in Marsian administration, then gave me a chance to serve as diplomat."

"And you did a great job, Ruhullah."

"Thank you. It was a great honor to serve, and now things are in the able hands of the next generation." He looked at Maryam with an affectionate smile.

"Thanks, dad," she replied.

"But if you want to serve in the Marsian diplomatic service, you need more Marsian experience! You need to go to Mars some time!"

"I know! Let me get my Ph.D. in foreign relations first!"

"Alright," Ruhullah said with a smile. He turned to Will. "Foreign relations: that's something you still can't study at Martech!"

"No, but you would be amazed by Martech's arts offerings. We have an excellent symphony orchestra, a theatre company, some skillful composers, some renowned painters, Liz had put together an amazing ballet company, we have professional sports . . . it's become quite a civilization."

"And that's not materialism; that's culture," said Ruhullah. "Maybe that will capture and transmit the spirit of Mars better than anything else."

"I hope so. Better than my speeches, anyway!" said Will.

"So, what do you have for me?" said Helmut Langlais, as he stepped into the meeting room. Crystal Kern, Minister of Space Exploration, and Lily Estrella, Minister of Immigration, were waiting for him.

"You always have a story for us, so what do you have?" asked Lily.

"And when do you get your new office?" added Crystal.

"The Executive branch won't move out of Capitol for at least eight or nine months. The borough has moved its offices, so City Hall is now empty, but it can't be renovated to become the executive office building until the immigration wave ends. As for news: have you heard about Ceresolar?"

Crystal nodded but Lily shook her head, so Helmut continued. "The circumnavigational metal highway around Ceres's equator is just about finished and it has methane, carbon dioxide, and oxygen pipelines built into it, so a public electric company, Ceresolar, has been set up to erect solar arrays anywhere along the highway where there's abundant ice deposits. The solar arrays will convert CO_2 and water into methane and oxygen and they'll flow to Central. This will allow a nearly infinite expansion of Ceres's electrical supply."

"And they need that to produce metal and plastic products," said Lily.

"Exactly. Also, Joe Abdullah has revised the master plan for expanding our metal highway system, which will be announced next week. Cassini-Dawes will be extended northwest to Borealis Station, partly because it's the headquarters for the project to nuke the north polar cap. That will make transportation much easier. But the road will also go through some of the thickest Noachian ocean deposits and there's evidence that they contain methane, so we might start drilling—even fracking—to extract the methane. That's quite a potential source of energy."

“When is the first explosion? March?” asked Crystal.

“Or April, depending on when everything is ready. So, Lily, how’s immigration?”

She nodded. “We’ve had 5,000 arrive so far and the pace now picks up to about 4,000 per month before it drops down. The new Prometheus-E is working very well. The engines are still a little fickle and we’ve had three launch delays, but they were software related and the problems have been fixed. The new cabins that can accommodate 350 passengers have proved quite comfortable and will reduce the strain on the spaceport significantly. Housing is on schedule, but we have the usual furniture shortages, of course. Australia will fill up in two months and people will start to settle in Europe enclosure. America South will be ready next year, so we plan to settle the bulk of the 2085 immigration there; the layout is complete and designs of the units has already begun.”

“How many people have moved from the old enclosures to Australia and Europe?” asked Helmut.

“Several thousand. The immigrants will be settling all over the city. Cassini, however, has encountered serious delays in housing construction. Some people will probably relocate to Dawes or here. Mayor Amina is getting a lot of criticism.”

“I’ll make some calls,” said Helmut. “I need to encourage her but also put her on notice, and I probably better call the construction companies and find out what needs to be done. Does Phobos have enough housing?”

“Yes, it’s ready to provide emergency accommodation for up to 5,000. Its population grows to 4,000 and they were among the early arrivals, so they would be available to help, and currently they’re essentially stuffed into temporary dorms, so there’s a lot of extra space. Once the immigration ends, accommodations will be set up apartment style instead."

"Is Phobos-C ready for any use at all?"

"It's pressurized and spinning, but that's about it."

"Good; I was wondering when they'd overcome the delays. It doesn't bode well for our Pluto and Kuiper contracts. Crystal, what's your news?"

"All is proceeding well with Neptune-2. The crew has it almost completely set up and will finish some features en route to Neptune. The 650 crew already have 50 children and 28 babies have been added in the last year. Most likely a population of 800 will arrive, so Neptunia will start with 900! They're preparing for the flood of data that starts to come back once Neptune 1 arrives in December. They're also configured to accommodate up to 600 people if there's an emergency on Phobos.

"The design phase for the Kuiper and Pluto projects is on schedule. The commander of Kuiper will be named in the spring, after Neptune-2 departs. We've winnowed the list to eight candidates. Ceres has 'laid the keel' of the carrier-100 for Kuiper and will have the skeleton enclosed and filled with water for launch here in six months. That work is on schedule. The carrier for the Pluto Project, however, won't be ready for this opposition; it's simply impossible. Phobos will have to do the assembly. The metal is available at Ceres and can be launched with the Kuiper vessel. Phobos and maybe Uzboi will have to redirect workers for us to achieve the 2086 launch date the Chinese have requested."

"Sounds like the 2084 immigration wave will have to include a lot of Phobosian construction workers," said Helmut.

"There's something new to report," added Crystal. "And this is exciting.

Martech-Aurorae and Martech-Deimos have work on a fusion engine well underway. The first design will be crude; a standard thousand-ton, 1-gigawatt He-3 fusion reactor that will leak its hydrogen and helium plasma through a shaped magnetic field to produce thrust. Big and clumsy. They should run it for the first time in early 2084. They think they can bring down the mass of the system tenfold over 15 or 20 years with proper funding. That's the biggest issue, because a fusion propulsion system is just a leaky fusion reactor with the leaked material directed magnetically to provide thrust. Developing the reactor is the hard part, and it's now well developed and commercialized on Earth."

"What sort of specific impulse?" asked Lily.

"If you just let the fusion products escape, it's a substantial fraction of the speed of light, but the resulting thrust would be incredibly tiny. A fusion reactor in the terawatt range would be needed to produce appreciable thrust and that's beyond our capabilities for some decades. But if one adds hydrogen to the exhaust, one can turn up the thrust a lot and still get a better specific impulse than gaseous core nuclear engines.

"But the exciting part is the applications they are coming up with. With purchase of some licenses from terrestrial firms and guidance from Martech, the outer planet settlements can build their own fusion reactors. Martech thinks it can design a 500-tonne, 250 megawatt plant that Saturn, Uranus, and Neptune can build in 2 to 4 years, depending on the size of the engineering team. Since all of them are producing Helium-3, they'll have a ready supply of fuel."

"Freeing them from fission reactors," said Helmut, impressed. "That's fantastic. It's rather large, though."

"That's the smallest size they can build right now, and its power output can be turned down somewhat. It means that Enceladus, Miranda, and Proteus can all have reliable power from local resources; they won't have to worry about being unable to obtain uranium or plutonium. Once smaller reactors can be built, in a decade or so, stations on any outer planet's moon can have a permanent, reliable source of power. Since fusion engines are reactors, they will also be able to provide power to large spacecraft. So we are on the verge of a very important development."

"Is the fusion team also asking for more money?" asked Helmut.

"I think they will, but they'll have a report with very specific plans for spending it."

Helmut nodded. "Good. This is something we can take to our various partners, like NASA, for joint funding. Tell them that we need a solid, well-argued report."

Crystal smiled. "I'll do that right away."

"Can we join you?" Tad asked Esther and Wicahpi-Luta, who were eating supper with almost three-year-old Miranda. Tad was accompanied by Susan and their boy, three year old Paul.

"Sure," said Esther, pointing to the empty side of the table. The Linds sat and Esther said, "Sorry you didn't get your wild tangle of forest, Tad."

He laughed. "That's okay. The English garden should be really pretty." He glanced at the area to the right of Avalon Square, the first part of "the Park" to be set up; they now ate their meals in the tropical section of Avalon, and the English Garden was rapidly taking shape, thanks to robots working at that very moment.

"Are you all moved into your apartment?" asked Wicahpi-Luta.

"Yes," said Susan. She turned to the right, then pointed to a third story window. "We're right there, overlooking the English Garden! We scored really high in the lottery."

"It's comfortable," added Tad, though it sounded like a complaint. "We still need some furniture, but it's coming."

"Three bedrooms; plenty of space for another kid," added Susan. "How's your bioarchive?"

"Booming," replied Esther. "Now that we have half the bottom level of Avalon, we have plenty of space. My prairie biome is 20 meters by 60 and very happy!"

"Good. My tilapia are very happy, now that we have the nutrients and the plant production balanced. Looks like we'll be in the position to start raising salmon in a few months, too."

"That'll be delicious," said Wicahpi-Luta.

"Avalon is becoming very impressively productive," agreed Tad. "Though the artificial salmon is pretty good, too."

"But we won't need it any more, pretty soon," said Esther. "When we were confined to the galleons, we had to use every cubic meter for food production, and converting algae and mushrooms into artificial protein sources was necessary. But now we have 200 square meters per person, including the two underground levels and the interior surface of Avalon. So we have the luxury of going the 'organic' route, maximizing species diversity, building up the fertility of the soil, and managing the efficient recycling of everything."

"Which actually means we have a wide variety of things to eat," noted Susan.

"My prairie biome wouldn't thrive properly if animals didn't go in there, eat some of the grass and forbs, and deposit manure," added Esther. "We let the dairy cows in every few days to do their thing. At other times, the robots cut sections of the grasses for the cows and haul some of their manure over to the biome. So the dairy cows aren’t just a luxury so we can have real milk. They’re also a necessity for the biome!”

“Paul will drink to that!” said Tad, as his son picked up his glass of milk.

“Can we join you, too?” asked Tahirih, as she, Vahid, and two year old Maxwell approached with their trays of food.

“Yes, we can make room,” said Wicahpi-Luta. He rose, moved his chair, and pulled another small table over, to make their table bigger.

“How’s everyone?” asked Vahid.

“Good,” said Tad, with nods all around.

“Did you all hear about the nickel-iron nodules all over Sycorax?” asked Tahirih, excited.

Tadd nodded, a bit dismissively, but Esther and Susan shook their heads. “The team has been there only three days, but everywhere they go, they find these nickel-iron nodules scattered across the surface and mixed in impact ejecta. They appear to be solidified metal droplets; some also have chondrite-enstatite and chondritic inclusions. We found a few similar ones on Puck back in the spring, but they were smaller and quite rare. We also found one on Titania in an ejecta blanket, and two on Oberon. The isotopic analysis is quite peculiar.”

“Depending on your interpretations,” injected Tad.

“Yes, certainly. The assumption, when we had picked up a half dozen of them, was that a metallic asteroid had broken up in a Uranus-crossing orbit and the debris had hit the three moons. But there are millions of them on Sycorax.”

“So what are they?” asked Esther.

“Now the theory is that we have fragments of Hemera, or possibly Hemera and Aether. ‘Hemera’ is what we’ve started to call the planet that collided with proto-Uranus while it was forming, tilting it onto its side. If Hemera was really, really large and proto-Uranus was relatively small—we still don’t know—then proto-Uranus is ‘Aether’ and Uranus is the product of the collision.”

“Hemera and Aether being the parents of Ouranos, according to one version of Greek mythology,” adding Vahid. “The usual myth is that Gaia, the goddess of the Earth, spontaneously created Ouranos or ‘sky.’ But we didn’t want to call the thing that whacked Uranus ‘Gaia’!”

“I’m pretty skeptical,” said Tad. “Or maybe I should say the identification is premature.”

“Why aren’t there more nodules on the big moons?” asked Wicahpi-Luta.

“Because they’ve been completely resurfaced,” replied Tahirih. “It appears Hemera collided when Uranus and the moons were mostly formed. If it was as large or larger than Earth—which is necessary, for it to tip Uranus’s axis by 98 degrees—it would have thrown out a massive cloud of debris. Uranus probably had a much larger system of moons and the cloud of gas and debris would have caused many of them to spiral into the planet. The moons left were heated up to a high temperature; we know that because they have retained much less water and other volatiles than the moons of Jupiter and Saturn. In consequence, they are denser. Part of Hemera’s nickel-iron core and silicate mantle were blasted into orbit and they now lie underneath the thick coat of ice covering the major satellites. But, the theory goes, Sycorax was an asteroid that had been captured by Uranus when it was still forming from its protoplanetary disk. Sycorax is 12 million kilometers from Uranus on average, so the expanding cloud of debris from the collision was thinner and cooler when it reached Sycorax. Rather than melting it, the debris pelted it severely. Subsequently, impacts have gardened the surface and mixed the debris in with the original material making up Sycorax."

"It's clear that something with nickel-iron and mantle-type silicates pounded Sycorax," said Tad. "The question is, what?"

"Well, we just did additional studies on the nodules we have here, and on some of the 'mantle silicates' we've recovered, especially from Oberon, which is the least resurfaced major satellite," said Esther. "The elemental and isotope ratios reflect the differentiation of a very large, planet-sized body. Furthermore—and the geochem team just concluded this a few hours ago—Hemera would have come from the inner solar system, inside the asteroid belt."

"Really?" said Vahid, who hadn't yet heard that detail.

Tahirih nodded. "It's really quite remarkable. That suggests the inner solar system was a *really* crowded place; eight planets."

"Eight?" said Esther.

"Yes. There's Mercury and the object that collided with it and blasted off most of its silicate mantle, leaving a big core. There's Venus and the thing that whacked it, sending it into a slow retrograde rotation. There's the thing that whacked Earth, thereby creating the moon from the debris cloud. There's Mars. And now there's Hemera."

"Maybe," said Tad. "There are theories now that characterize the thing that hit Mercury, and we'll probably recover enough stuff from Venus eventually to make guesses about the thing that hit it. Maybe we'll have enough data someday to characterize 'Hemera.' We'll see."

"Take a look at the paper the geochem team plans to write," said Tahirih. "It looks pretty good to me."

"I'll be sure to read it very carefully."

Susan punched him very lightly on the shoulder. "Always the curmudgeon!"

He smiled. "Hey, it's useful. It keeps people from making mistakes."

"Or it gives you attention," she replied.

6.

Homeward Bound

"Oh, Gina, it has been so good to see you again!" exclaimed Ethel to her sister, hugging her again for a long, time. There were tears in her eyes. "And this is it; we will almost certainly never see each other again."

"Well, you'll probably never come back to Earth, and I'll never go to Mars," replied Gina, matter of factly.

"You never know; if we're still in good shape in ten years, maybe we'll be back," offered Will.

Ethel looked at him sternly. "No," she finally said. "I was barely in good enough shape for this trip, and I doubt I'll be able to manage it at age 90!"

"Who knows, I might emigrate," said Karie, Gina's daughter. "My kids are grown up and I have nothing tying me to Edinburgh."

"It's funny you say it, because I feel very tied to Edinburgh and Scotland. I'm going to lay my bones on Mars, and that's fine, but . . ." her voice trailed off. "I very much miss this place. I've been dreaming about it for months."

"Years," corrected Will.

"I'm glad we were able to go to the Highlands and walk around Auntie Euna's old farm, then," said Gina. "Even if we were trespassing without permission!"

They all laughed at that. "Yes, that was very special. And to see the old house here in the city, and to visit mom and dad's graves; that was very, very special for me." Ethel's voice broke again and Gina hugged her again.

It was a long hug, then she pulled away. “We have to go, or we’ll miss our flight.”

“Have a safe flight to London, then to Lagos, then South America and home,” said Gina.

“Thank you.”

“And thank you, Gina, for three days of quiet and privacy,” said Will. “We really needed it after Oslo.”

“Your talk created quite a controversy, and thank God it did,” said Gina. “Godspeed, Will.”

“Thank you.” He hugged his sister in law and her daughter one more time, then they stepped outside, where the limousine was waiting. They waved, stepped inside, waved again, and were on their way to Edinburgh Airport.

“I never realized how much you missed this place,” said Will.

Ethel sighed. “Oh, very much. The two other times we were here it was very nice, full of family time and reminiscing, but this is different . . . maybe because I realize I’ll never be here again.”

“Yes, that makes a difference. I miss Connecticut some, but I especially miss all the places along the East Coast where I went hiking. They’re too scattered about and too numerous to miss them all. But you had the house here in Edinburgh. Auntie Euna’s farm, and few favored vacation spots in the Highlands.”

“And in three days, we managed to see them all. I hope you weren’t bored.”

“No, I really enjoyed seeing the places that were special to your childhood.” He leaned over and gave her a kiss.

She smiled. “Thank you. Will.” She kissed him back. “Now, the rest of the trip almost feels anticlimactic. Lagos, Brasilia, Kourou, then back to space.”

“We’ll be back on Mars six weeks from today,” said Will, a note of amazement in his voice.

Their last six days on Earth was a blur of talks and receptions. Their last day in Kourou was actually restful; they had intentionally given themselves the time, so they could be ready for the launch. The Prometheus shuttle performed well and in twelve hours—with one refueling stop in low Earth orbit—they were back on board the *Sequoia.* Twenty hours later, its two gaseous core engines lit up and accelerated the *Sequoia* and *Ponderosa* to a velocity of over 60,000 kilometers per hour relative to the sun, setting them off on a 35-day voyage to Mars.

The next day, Will and Ethel went to the cafeteria for breakfast and were surprised to see Ted Bukowski sitting at a table, reading the *New York Times.*

“What are you doing here?” said Will, surprised.

“I’m NASA’s new official liaison with the Marsian Space Agency! I took your suggestion to headquarters, they deliberated, and appointed me to the job, and as you said, there was still some space on board the *Sequoia,* though I think it took some arm twisting to add me.”

“Can we join you for breakfast?”

“Oh, of course! I’d be delighted and honored.”

“Well, we’re honored to be with the new NASA liaison as well,” replied Will, sitting. Ethel followed him and sat opposite Ted. “It seems to me while I was in Lagos—or maybe Brasilia—I read an article about the dedication of the lunar mass driver and it mentioned you were there."

"Yes, I was one of the three NASA representatives in attendance. It's an amazing accomplishment; a huge piece of lunar infrastructure, and very sophisticated. But it will revolutionize cislunar and earth orbit operations."

"It definitely will, but from the Marsian point of view, the big impact it will have is on competition. Ceres is already considering how it will compete, and it turns out Ceres can deliver liquid hydrogen and some metals to Earth orbit more cheaply than the mass driver if it uses big enough shipments. It'll be able to do that in two or three years. Phobos is also restructuring to compete, mostly by expanding."

"I hear it'll have 4,000 people once this columbiad ends."

"And 6,000 after the next columbiad," said Will. "It's going to be really big and have capabilities available nowhere else in the solar system. And the investment to grow Phobos is coming from Earth, too, not just from Mars. It has a solid reputation. The same with Ceres."

"They both face an uncertain future, it seems to me, with low Earth orbit industrialization taking off, lunar surface manufacturing taking off, and the mass driver tying them together. Ceres is facing asteroidal mining of PGMs, too."

Will shrugged. "There's room enough for Phobos and Ceres as well, don't worry. Mars will support both. All three are stable and have good government, and that's as important as a technological edge or an economic advantage."

"When you get to Phobos, you'll see," added Ethel. "Plan on spending a week or two there, meeting people."

"I'm already scheduled to descend to Aurorae on the second flight. But maybe I can change it. So, how did your trip go?"

Will considered the question a minute. "I guess that depends on what one expected. It would be good that I had an impact on worldwide public opinion and perhaps helped to pull humanity back from the brink of various collective crises. I got a lot of publicity and was quite controversial. But will it do any good?" His voice trailed off, then he shrugged.

"I heard your Nobel Laureate speech in Oslo, and of course the one before Congress. They made basically the same points, excellent points I think. But they were dismissed by many as interference in politics or supporting an internationalist mindset against the various hard nationalists."

"Well, that's certainly what it was; how could Marsians look at Earth any other way? But I did not mention specific political parties or people; I stuck to principles. That's the high road; the ethical road."

"I agree with your point," said Ted. "I suppose what concerns me is that Mars was able to adopt a principled approach from the very beginning and stick to it, because it was made up of idealistic, well educated, scientifically aware individuals. The Earth, on the other hand, is huge and has entrenched customs that are often corrupt, and a population that is poorly educated and often unaware. So Mars is of limited use as an example of what Earth can achieve."

"Yes and no. You have hit on some of the reasons Mars was able to evolve socially very fast, but that does not mean Earth is incapable of such changes. I believe that in the long run, ethical principles win out, just as love ultimately trumps hate. Consider the American experiment: a fairly small country of relatively well educated people was able to create the world's first long running, successful democracy. It took most of Europe almost two centuries to catch up; South America, over two centuries; and parts of the Earth still have not fully embraced the idea of representative democracy. The Marsian experiment will have its severe tests, just as the American experiment has been having through much of this century. But its ideals represent the new wave of the future. Give Earth a century or two and it will come around. So in answer to your question whether my trip was successful, the answer lies a century in the future: did my trip help speed that day or not?"

"I see." Ted pondered a moment. "You are more of an optimist than I, I think!"

"You are on your way to Mars! Marsians are optimistic about the future!"

"About the future of Earth?"

Will chuckled. "Maybe not as much as me!"

Ted chuckled at that response. "I gather from comments the NASA Administrator made to a group of us, your visit has helped improve NASA relations with Mars."

"I hope so. My work behind the scenes, usually with Foreign Minister Robinson or Ambassadors Szulc or Ming, was at least as important as my talks, and of course was covered much less extensively. I met with six heads of state, 14 ministers of foreign affairs, and 15 heads of space agencies. With the space agencies we emphasized cooperation in space, that Mars wanted to work with everyone, that if someone else put up more money we were willing to be the junior partner, and that we were always looking for research partnerships to advance technology. Space is a win-win environment, not winner take all. Up till now, many space programs wanted to go it alone or have very junior partners only. Usually, they resisted being number two. They were also jealous of our success and found it hard to duplicate it because we have always run a very lean, efficient program. In fact, they usually wanted to slow a program down and pack it with technology we didn't want because it wasn't ready. But I think our conversations have helped change the tone. I think there will be a lot more cooperation."

"Good; sounds like I'm going to Mars at the right time. Is that what you talked to foreign ministers and presidents about as well?"

"Sometimes. But it may be our diplomatic conversations will do more to improve the situation on Earth than my speeches." He shrugged.

"And, of course, we went to Earth to see our old houses and our family," added Ethel, changing the subject. "It made the entire trip worthwhile. Otherwise my 80 year old body was subject to gee forces that I thought might kill me—especially the flight from Kourou—an exhausting travel schedule, and heat like I am not used to any more. Oslo and Scotland were quite pleasant, but everywhere else was hot enough to melt me!"

"There are very few enclosures on Mars with extreme climates," added Will. "Most of the large residential and commercial enclosures are 25 Celsius in the afternoon and 15 Celsius at night, with fairly low humidity and no overnight dew. In short, they are barely hotter or cooler than the interior of a building would be. We do have a desert enclosure with roasting temperatures and a tundra enclosure with cold temperatures, and a few temperate enclosures with hot summers and cold winters, but they are not common. Earth was a bit of a shock to us."

"I've been doing virtual reality tours of Aurorae, Cassini, Uzboi, and Phobos. They're so interesting."

"They are beautiful," said Ethel, leaning forward. "Every square centimeter of polder—of pressurized, interior space—is planned carefully. The outward architecture of the newest enclosures is fresh and original, a blend of many terrestrial styles. Robotic gardeners keep the flower boxes full and bright. Inside, the units are mostly manufactured in robotic factories on several standard sizes and emplaced by crane—then covered by vinyl siding to shape the exterior—and are bright and attractive, as well as airtight in case of problems. Australia enclosure consists mostly of three story condominiums opening onto wide, sunny streets. It's an extremely attractive cityscape. But if you climb up three stories, you discover the roofs of the buildings is farmland or park spaces, and up there the street canyons largely disappear and the enclosure looks mostly natural. It's quite surprising."

"Have you bought an apartment yet, Ted?" asked Will.

He shook his head. "The embassy said I could stay there for a few months while I hunted for a place."

"Oh, that's good, because housing will be tight for several months. Many migrants made their down payments on property before leaving Earth or on route to Mars. They're busily reviewing fabric patterns for drapes, sofas, living room chairs, bedspreads, and linen sets, ordering what they need, and setting a date when it should arrive. There will be shortages of furniture and such for several months. Then the 2084 columbiad's housing will begin to become available and that will set off a domino effect as older couples with children move into new, larger housing and more recent arrivals move into the housing they have vacated."

"I hear underground housing is the cheapest."

"Yes, the area between enclosures is usually filled with large metal cylinders that are buried. They usually have skylights, so they aren't completely underground. They hold up to three stories of construction, plus some little gardens and parks. A lot of work spaces are located in them because they're fairly cheap to make."

“The second cheapest housing would be used spaces in some of the older domes,” added Ethel. “And some of those places can be charming. You can get more square meters for the price. Mortgages have been made very easy on Mars because people rarely go bankrupt and the title is easy to clear.”

“I hear little urban gardens are very popular now, too.”

“Yes, you can get them all over Aurore; you can get then as small as two meters square or as big as ten meters square,” said Will. “People grow vegetables, flowers, herbs, all sorts of things, and a weekend farmer’s market has opened. There’s a ‘back to the soil’ movement that is encouraging people to stay close to nature. It’s complemented by an effort to get people into their pressure suits and go outside, to buy their own piece of range—most people own land outside—and to visit it occasionally. There are also more and more hiking trails being created outside. People have some leisure time now—more than we had twenty years ago—and these are the result.”

“I understand there’s a lot of exercise, too.”

“You have to exercise close to an hour a sol to stay healthy, in the low gravity,” said Ethel.

“I think you’ll love Aurore,” said Will. “People work hard, but they have their hobbies and their leisure time, and they usually aren’t trying to impress people with their clothes or other stuff. We have tried to create a practical, hard-working culture that has a sense of direction and purpose, but recognizes that there’s more to life than just work.”

“I’m looking forward to it. Can I call on you for some introductions?”

“Of course!” replied Will. “I’ll be glad to show you around and help you make some contacts. Nothing would please me more than to see Mars working more actively with the United States."

"Thank you, I would love to see that, too," said Ted.

The video had to be slowed down so that they could even see what happened. A robot arm loaded a torpedo-shaped aluminum capsule onto a maglev track. Then the video's speed slowed way down, but even then, the torpedo shot down the track at an amazing speed and disappeared off the far end in just a few seconds.

"You should see it without the slow down," said Sirikit to Helmut Langlais, Jimmy Khan, Zhang Bao-zhi, and Crystal Kern. "Or perhaps I should put it this way: without the slow-down of the video, you don't see anything. The payload simply disappears, because it goes down the 1.6 kilometer track in about one second, and it's too small to see when it's half a kilometer away."

"That's amazing," said Helmut. "So, what do you think of the price?"

Sirikit smiled. "They're in a very precarious financial situation and the chance of bankruptcy is pretty high. But bankruptcy would be worse for us, because almost half the annual cost of the lunar mass driver is payment of interest on the bank loans. The driver has enough power to launch 100 kilograms to the Lagrange-2 point every 1.6 minutes. That would put 35,000 tonnes at L2 per year. If they could sell that much mass at 10 redbacks per kilo, they'd break even. But right now demand is way too low; they're estimating a throughput of 3,500 tonnes per year, and that costs 100 redbacks per kilo.

"Furthermore, the biggest demand for mass in low Earth orbit or lunar orbit is propellant, generally hydrogen and oxygen. But the launch generates enormous heat in the payload, so it can't be used to launch cryogenics. It can launch ice, but it has to be wrapped in a thick metal container because the heat not only melts the ice, but vaporizes it. The water then has to be concentrated and electrolyzed into hydrogen and oxygen, cooled to cryogenic temperatures, stored, and moved to its destination, and the moving uses up as much as a quarter of the original water. As a result, a 100 kilogram payload will result in transport of only 50 kilograms of propellant to low Earth orbit, and the cost triples. So right now, lunar hydrogen and oxygen propellant costs 300 redbacks per kilo in low lunar orbit, about six times as much as launching with rocket power from the lunar surface or from Phobos or Ceres."

"And they end up with tonnes of aluminum," added Jimmy Khan. "They usually use platinum or other PGMs to make the casing and transport them to the Earth's surface, and use that income to subsidize the transport of the water. That's what they are doing now."

"But that still doesn't save them money, because they can launch the PGMs to Earth with Prometheus rockets more cheaply than that," said Helmut.

"Exactly," said Sirikit. "In short, until demand for lunar-launched mass increases about ten times, the mass driver won't cover its expenses. And that raises the question of what our responsibility is. Most likely, we can sink it or save it."

"Well, our first responsibility is to the Commonwealth," said Bao-zhi.

"I agree," said Helmut. "But our second responsibility is to space, and that includes the moon. Furthermore, the annual operating expenses are a small fraction of the total, so once the interest and construction costs are covered or forgiven, that mass driver is a serious competitor."

"It won't go away," agreed Sirikit. "And I didn't mean to imply that paying their interest payments, for example, is our responsibility. I meant to suggest that we do need to consider what the mass driver legitimately can contribute to Mars, and what we decide may determine whether it declares bankruptcy or not. As I noted, that may or may not be good for us."

"So, what are our possible responses to it?" asked Helmut. "What do you have?"

"Quite a lot," replied Bao-zhi. "Both Ceres and Phobos can do a lot to compete with the mass driver. The key thing to remember is that the mass driver can launch only 100 kilograms at a time, and at 200 gees of acceleration, so it can't launch anything finished. All it can launch is raw material. We can get products from the Martian surface to low Earth orbit for 35 redbacks per kilo. From Phobos, it's 18 redbacks per kilo; from Ceres, about 30 redbacks per kilo. This compares to 25 redbacks per kilo using the same Prometheus boosters from the lunar surface, and 50 redbacks per kilo from the Earth's surface. Right now, Prometheus is still the cheapest way to transport items and the prices just quoted reflect the delta-v and the time in transit.

"So, we need to do better than the Prometheus, and we can by launching in bulk. Prometheus engines are the most reliable methane-oxygen system ever made and they have a long firing life, so they can be attached to any large cylinder and move large quantities of material between planets.

"The breakthrough is the new iron carbonyl extrusion system that just started operating on Ceres last month. Rather than extruding parts at the refinery, hauling them to a construction site, and assembling them, the liquid iron carbonyl is transported to a construction site—in this case a launch pad—and the parts are extruded right where they are needed in the size that is appropriate. First, a metal base plate is extruded as a series of metal beams and sheets that are cut into a circular surface and welded together robotically. Then beams for a metal frame are extruded; they can be continuously extruded up to fifty meters long. They are placed by crane and welded to the base plate. Then the top cap of the cylinder is extruded and hoisted by crane to its place on top of the frame.

“Then the extruder is placed on a platform that can be elevated. It rolls in a circle around the base plate, extruding a ten meter wide metal sheet that is welded to the vertical members of the frame as it goes. It can go all the way around a carrier that is 100 meters in diameter in about three days and when it is finished, it is jacked up another ten meters and completes another circular extrusion of metal skin. In a month it has reached the top of a 100 meter high cylinder.

“The result is a cylinder 100 meters high and 100 meters in diameter; the perfect size for a C-100 carrier. The top and bottom caps actually take the longest; a single extruder can complete one in six months. Ceres will soon complete a second extruder that will cut the manufacturing time in half. A C-100 will hold 750,000 tonnes of water or about half a million tonnes of hydrogen/oxygen propellant or about 62,500 tonnes of liquid hydrogen. In Ceres’s low gravity, six Prometheus engines would be sufficient to launch that much water into Ceres orbit, and Ceres can manufacture the engines themselves now. The water costs nothing; Central’s deep wells have access to an infinite supply. The cylinder can be made for only about ten million redbacks because the iron carbonyl is essentially free waste metal. The cylinder can either be sold or reused, also; it’s a salable product. Filled with hydrogen and oxygen propellant, two thirds of which is used up on a flight to Earth, the cylinder can transport 150,000 tonnes of propellant to low Earth orbit for no more than 15 million redbacks. That’s one tenth of a redback per kilo; ten cents per kilo. The cost of electrolyzing the water into hydrogen and oxygen on Ceres is more than that, so we’re talking about maybe 25 cents per kilo.”

Helmut stared, then laughed. Then the others laughed as well. “The mass driver can never compete against that," he said.

"Actually, it probably can once the construction and other upfront costs are amortized, demand increases enough, and the technology matures," said Sirikit.

"And there's a catch; it'll take two years to get stuff to Earth from Ceres," continued Bao-zhi. "It'll require planning. But Ceres can substitute PGMs, raw metal products, or finished products for propellant mass, so they can be transported to low Earth orbit just as cheaply. Furthermore, a cylinder can come to Phobos, pick up cargo there, and transport it to low Earth orbit, at a considerable reduction in propellant being transported of course, but it can get products from low Mars orbit or Phobos to earth orbit for about 1 redback per kilo."

"So the solution is bulk transport," said Helmut. "That's has been the case for ocean transport on the Earth as well. You didn't include our technology development costs; how much are they?"

"Half a billion," replied Sirikit. "Martech did most of it. It's all part of the development of carbonyl extruders to make roadway sections, airtight modules, and other very large objects. Each extruder costs about 100 million redbacks to build and about 10 million per year to maintain. In the future when Ceres builds more of them, even larger cylinders will be possible."

"Ceres can also build a series of 'nested dolls' cylinders," said Bao-zhi. "If someone wants a carrier that has a two or three-meter outer water envelope for radiation shielding, Ceres can build a second cylinder that's 94 meters in diameter, transport water to Earth or Phobos in it as well, then the smaller cylinder can be nested inside the larger one. With this new construction system, Ceres will assume a very significant place in the solar system economy."

"Which is why its population is expanding so fast," added Sirikit. "It needs to grow to

1,600 in the next three years and its power production needs to reach 150,000 kilowatts."

"At which point, it may be able to build the world's largest particle accelerator," said Bao-zhi. "We're also looking at a 200-meter telescope, a stepped up exploration of the asteroid belt, and possibly a station on a second asteroid, if it can be justified economically."

"It's a matter of time," said Helmut. "Thank you, everyone, for all your work. I feel a lot more confident we can stay competitive with the lunar mass driver."

The *Ponderosa* and *Sequoia* were incredibly crowded ships. The latest in corvet technology, possessing 48,000 cubic meters of volume each, each was transporting 1,250 people, a capacity made possible only because the flight to Mars was a brief 36 days. Because of the very rapid transit, occurring close to the planets' opposition or closest approach, the passengers were exposed to minimal cosmic radiation, so the flight was packed with families. It made sleeping difficult at times.

The two ships' cafeterias were always packed and chaotic. Each ship possessed three "time zones" separated by eight hours, so at any particular time one third of the ship was sleeping; that alleviated crowding. The eleventh morning after departure from Earth, Ted Bukowski made the mistake of going to breakfast late—9:30 a.m.—and discovered that the 5:30 p.m. dinner crowd from the next group had begun to arrive. Breakfast was still available—barely—but there was no place to sit. Finally, a table for two opened up. He headed for it at the same time as a woman of East Asian background carrying her dinner tray.

"Oh, sorry," he said, not wanting to take it from her, but not wanting to abandon it, either. "Can we share the table?"

"Oh, sure," she said. She pointed to the seat opposite her, so they both sat.

"Thank you. I'm Ted Bukowski from Washington, D.C."

"Oh, you are?" She was quite startled. "Do you know who I am?"

"No, sorry, I don't."

"Dr. Lin Changying." She extended her hand; they shook.

"Pleased to meet you. How do you know my name?"

She smiled. "You are the new liaison from NASA to the Marsian Space Agency, and I am the new liaison from the Chinese Space Agency to the Marsian Space Agency!"

"Oh!" It was his turn to be startled. "I've heard of you, but I didn't realize you were on the same flight."

"And probably for the same reason; Dr. Will came through and urged us to establish better relations with the Marsian Space Agency, and we agreed that was a good idea. Our ambassador has picked up quite a lot of technology, but his expertise is Chinese language and literature!"

"Our ambassador may not be much better. He's a career diplomat and doesn't teach anything."

"What's your field?"

"Artificial intelligence as applied to vehicle systems; life support, environmental management, power management, etc."

"Fascinating stuff. I'm an electrical propulsion engineer; we're working a new 6,000 second ISP system using up to 100 megawatts."

"Outer solar system?"

She nodded. “Where else?”

“I’ve heard about the research; Nanjing Institute of Technology, right? Very impressive. Of course, if fusion propulsion comes along, as seems inevitable, that may be rendered obsolete.”

“Maybe, but people have predicted the demise of chemical propulsion for almost a century and it has found a place. We think ion will find a place as well. Certainly, the upcoming missions to Pluto and the Kuiper Belt will benefit from it.”

“I suppose that’s true as a supplement to gaseous core, which can’t manage that high of an ISP.”

“Precisely. The carriers would use gaseous core to get quickly out of gravity wells and ion to speed them up on the cruise. In deep space, also, they’d need a lot of power anyway for their ecosystems, so some of it could be diverted to propulsion. Were you involved in the new software for the Prometheus 2?”

“Yes, I was one of the team leaders, and since then some of the innovations have been used right here on the *Sequoia.*”

“Yes, that was an impressive project, though I suppose it will be obsolete in two or three years.”

“Some say it already is obsolete! Artificial intelligence is moving very fast. Martech is quite a leader in it, so I’m looking forward to meeting their researchers. I suppose you’ll be going to Deimos?”

She nodded. “Two sols after reaching Phobos, in fact. Our Chinese Propulsion Lab there is doing incredible work and I look forward to meeting the personnel.” She looked at him. “I’m pleased to meet you, Dr. Bukowski. I suppose we had better not talk about our work, though!”

"No, definitely not." He looked at her as well; she was pretty, smart, and shared a common love of space, so he couldn't help but feel attracted. "So, where are you from in China?'

"Where? Do you know the geography?"

"I was there for a semester in college, so I know it a bit."

"Chungqing; a big inland city."

"Ah Sichuan province. Hot food, beautiful mountains, and a lot of manufacturing."

"That's right. Where are you from originally?"

"Los Angeles."

"Ah, freeways and movie stars."

He laughed. "And a lot more, of course."

"Well, Sichuan has a lot more than hot food and mountains, too!"

"That's true."

"I have been to Los Angles once; to Caltech, actually, and JPL. Fascinating places."

"I worked at JPL one summer during the landing of the Sedna rover, and that was a really exciting time."

"You were there then? That's when I visited!"

"Really? Small world!"

"It really is. It turns out we've crossed paths before."

"And I'm sure we will on Mars, it's a relatively small place."

"I'm sure we will."

"Sorry we're late," said Sirikit, as she entered her parents in law's house, almost 3 year old

Andrew in hand. “I had to get a report finished.”

“That’s alright; the food’s here, but it isn’t cold,” said Clara. Everyone was at the dinner table, waiting.

Charlie rose. “Sorry about the misunderstanding about Andy. I could have picked him up from day care instead.”

“That’s alright; it was right next to my office anyway.” Sirikit kissed her husband, who then gave his son a hug and kiss as well.

“Well, sit and eat,” said Helmut. “Let’s dish out the food. It just arrived ten minutes ago.” He pulled off the plastic covers on the rice, cashew chicken, beef with broccoli, and a few other toppings. The containers began to go around and they all filled their plates. “Did you all see the latest from Ceres?” asked Helmut. “The Belt Exploration Department has proposed hauling a PGM-rich nickel-iron asteroid—about a million and a half tonnes in mass—to Ceres in 2095 and crashing it into the surface about 60 kilometers east of Mahuika.”

“To maintain the supply of PGMs?” asked Oskar, who was now twenty and had recovered some of his growth from the long bout with leukemia. “Isn’t there plenty for a century? How would they do it, too?”

“The century supply is shrinking to about thirty-five or forty years,” replied Helmut. “They keep increasing production. A carrier-100 filled with a half million tonnes of liquid hydrogen and oxygen can now be produced for about 15 million redbacks, and the asteroid they have in mind requires less than a kilometer per second of delta-vee to intercept Ceres. It is now cheaper to bombard Ceres with nickel-iron meteorites and process them there than it is to process them in situ, because Ceres has such a large and efficient facility.”

“So, their future is assured,” said Charlie. “That’s very good news.”

“It really is,” agreed Helmut. “They just have to be very careful where they drop the new supply!”

Several of them chuckled at that. “About ninety percent of the way around from Central, to minimize the seismic waves,” commented Charlie. “These new, huge propellant transporters will revolutionize the economics of space.”

“Immensely,” agreed Sirikit. “The biggest problem is the infrastructure to make them and fill them. Ceres has to increase its power production quite a lot. But they have a plan to do that.”

“How many kilometers of metal road and pipelines do they have now?” asked Oskar.

“Over three thousand kilometers,” said Helmut. “Pretty soon they’ll have a circumnavigational, more or less around the equator, but with detours to important locations, and spurs are being built to both poles past other important spots. They are planning a station at the South Pole to test equipment under cryogenic conditions and explore the accumulated layers. And it appears at next opposition with Earth, there will be a direct flight with 300 more personnel. We need to get more people there.”

“I miss the place and wish I could go back,” said Charlie. “The Asteroid Department of Martech-Ceres is doing great work. It’s both practical—finding asteroid resources—and theoretical, reconstructing the history of the Belt.”

“Well, you’re grounded for the next decade and a half, dear.” Sirikit looked at the others, especially Clara. “I wanted to postpone this until my parents get back from Earth, but maybe this is the right time: we’re going to have another baby.”

“Fantastic!” said Helmut. “How marvelous!”

“Congratulations!” said Clara. She got up and walked over to Sirikit so they could hug.

“The completion of our family,” said Charlie. He looked at Andy. “You’re going to be a good big brother?”

“I want a boy,” he replied.

“I know, but we don’t have a choice. We’ll take what we get,” said Sirikit.

“You told me,” he replied.

“He’ll be a very good big brother,” said Helmut. “He’s such a good boy.”

“There’s always one good boy in every family,” muttered Oskar.

“So, when are you due?” asked Clara.

“April. Maybe I had better call mom and dad tomorrow and tell them.”

“The time delay won’t be too bad; they’ll be at Phobos in eight sols,” said Helmut. “How was their trip?”

“They had a great time; ten days in Thailand with dad’s family, ten days in Texas with mom’s, and about ten days traveling. We’ve got to visit Earth some time, once the kids are big enough to travel and appreciate what they are seeing.”

“We will,” said Charlie. “And I hope we get back to Ceres some time, also. We won’t recognize the place.”

“Just the terrain,” said Helmut. “I think the entire original base has been mothballed by now!”

“Callisto, too, has changed so much,” said Sirikit. “Its population’s slightly bigger than Titan’s, and now it has a carrier under construction to provide proper gravitied accommodation.”

“Their robotic exploration of the inner moons is fantastic, too,” added Charlie.

“And the Chinese are ready to start granting them more autonomy; that’s the real breakthrough,” said Helmut. “They’re even bending a bit on the use of Chinese as the official language.”

Sirikit grabbed the rice and broccoli-beef and spooned out seconds for Andrew. Everyone took more and conversation turned to the flood of immigrants and some of the more amusing problems that had been reported. After a long day of work, Helmut got a good laugh or two.

Once supper was over, it was getting close to Andy’s bedtime, so Sirikit and Charlie had to go. As Helmut was walking back to the dining area from the front door, where he had bade them good night, Oskar said, “dad, can we talk?”

“Sure.” Helmut motioned to the comfortable living room chairs, so they sat.

Oskar took a deep breath. “I want to drop out of Martech.”

“Oh?” Helmut wasn’t totally surprised; Oskar had never been happy at Mars’s only institution of higher education. “The fall semester starts in two weeks. This is the beginning of your senior year. Wouldn’t it make more sense to push on through and get your degree?”

“Why? What am I going to do with it? There’s no demand for people who major in English, and the English Department here really doesn’t offer anything that I want. All the music courses I took were a dead end, too; I can’t make a living here as a musician!”

“Maybe not, but how would you make a living *without* a degree? There isn’t much demand here for people lacking a college education. For that matter, even most people without college on Earth are facing unemployment.”

“I don’t know. I just don’t know.” Oskar shook his head several times, feeling lost. “Maybe I should move to Elliottville and prospect for gold. That would be an adventure.”

“A dangerous adventure; two people there have now died, out of a total scattered population of 63! There’s talk of shutting the borough down completely until better safety measures are implemented.”

“I know. It’s rather suicidal to move there by yourself; you really need to have someone with you. But I have to do something with my life.” He was silent a long moment. “I think I have figured out my problem with music. I’m great writing the lyrics, but I can’t compose the tunes very well.”

“I think that’s true. Your words are very powerful.”

“Which makes me wonder whether I should be a poet.”

That caused Helmut a long pause. “Well, I’m not sure there are practically any poets anywhere who make a living from poetry. That’s even more difficult than music.”

“I know. Mars doesn’t even have a poet laureate!”

“We should do that,” said Helmut. “How’s Dr. Callahan?”

“She does a decent job teaching poetry, I suppose. But she does one course every two or three years.”

“Our English Department only has three professors, and they concentrate on literature and writing,” said Helmut, nodding. “Have you looked for online courses? We’re in the MIT Consortium. What’s that really good university that has cornered the market in poetry? Southwestern Missouri State University?”

Oskar nodded. “Yes, everyone in their English Department teaches poetry online, and they’re part of the Consortium. I really would rather not take poetry that way, though. I’d miss a lot of the dynamism of the live courses, because of the time delay.”

“Well, you can’t have everything. If you started in two weeks, it’d be right after the closest opposition in 50 years. The time delay would be only 6 minutes round trip, which really isn’t bad. By the end of the semester the delay would double, and that’s still not too bad.”

“Well, that’s true, I suppose.”

“I think you should give that a try. Dr. Callahan loves to help out students taking courses on Earth; she’ll meet with them, answer questions, and provide a human touch. You *are* good at poetry, Oskar. There’s no question about that. So why not take four poetry courses this semester! Martech will let you and Callahan will help.”

“But what am I going to do with poetry? I can’t become a poet!”

“Who knows what might happen in the long run. Who would have thought that Will Elliott’s daughter would have become a professional ballerina. Mars will have 100,000 people in less than two years. In ten years it’ll have a few hundred thousand and by then you’ll be *good.* Don’t sell yourself short.”

“And until then?”

“Once you have a Bachelors, there are lots of possibilities. High school English teacher, English teacher at Martech. There are lots of writing jobs here. But you need the degree.”

“I suppose.” Oskar seemed uncertain and Helmut looked at his son yearningly, wishing he could help him resolve his dilemmas. The boy’s childhood leukemia had been a terribly difficult test, had permanently stunted his growth, and had made him sensitive and introspective. It had forced the entire family to be uprooted from Ceres and had severely tested all of them.

Finally Oskar nodded. “That’s a good idea. I’ll talk to Dr. Callahan morrowsol about registering for some poetry courses this semester.”

“Give it a try.”

“I will.”

7.

Phobos

Sept. 2082

Thirty-three days after leaving low Earth orbit, the *Sequoia* and *Ponderosa* reached Mars' sphere of gravitational influence. The two vehicles shared a pair of gaseous core nuclear fission engines, each capable of 250 tonnes of thrust, and they fired almost 2 hours in order to slow the vehicles and their combined passenger load of 2,500 people into a safe approach trajectory. Thirty-six hours later, as the ships approached the top of the Martian atmosphere, the engines fired again and injected the ships into an orbit around Dusty Red; if they had failed, both vehicles were moving slowly enough to use aerobraking safely. The gaseous engines detached after doing their work, to find their own way to the Phobos-Mars L1 point. The *Sequoia* and *Ponderosa* separated as well and used their chemical propulsion systems to heads for Phobos. Ten hours later, both vehicles landed at pads two kilometers apart just west of Stickney Crater.

Will and Ethel collected their possessions, placed them in their backpacks—which was the easiest way to transport items in zero gravity—and headed for the exit, where there was quite a crush of people. "When are you going down?" Will said to Anne and Kurt Hollingworth, as they floated at the ends of two long lines.

"Morrowsol," replied Anne. "We're on the second flight. We want to get home!"

"How was your trip?" asked Ethel.

"It was great," replied Kurt. "It was good to see old friends in Perth and Sydney, and we got to the U.S. and Europe, too."

"We gave some good talks at universities; people were fascinated," added Anne.

“We spoke about Mars, the Asteroid Belt, Saturn, and exploration in general,” added Kurt. “I think we were only the second group of Saturn residents to return to Earth, so there was a lot of interest.”

“And in Themis; I think we were able to help their fund raising, too,” said Anne.

“I’m sure Bill will be grateful for that,” said Will. “From what I have heard, they’re struggling, but they’re doing pretty well.”

“They really are, if their infrastructure doesn’t fail them,” agreed Anne. “Regulating the gas release from Themis, keeping the atmospheric pressure under control, making sure the methane and ammonia releases don’t cause an explosion or fire or poison the atmosphere, managing a wild ecology . . . they’re learning a lot and so are the scientists and engineers assisting them all across Earth and Mars. Their experiment has received a lot of free expertise and government research grants because it is so cutting edge. Everyone can be grateful for that, because a century from now, for all we know, there may be dozens of worlds like Themis circling the sun with villages or towns or even cities on them. Deimos has a bit more land than New York City; imagine a dome around a world of that size!”

“Of course, we don’t know what the economic basis of such a world would be,” said Will.

“You never know,” said Anne. “In another century, if Earth doesn’t destroy itself, anything is possible.”

“True,” said Will.

“When are you heading down?” Ananda Thanarat, Sirikit’s father and another Mars veteran, asked Will.

“We’re staying up here a week,” replied Will. “We’re getting a tour of the place and we’ve been asked to give some talks—reminiscences—about Mars.”

“Will and I were among the first three people to step on Phobos, remember,” said Ethel. “So we’ve been asked to talk about that.”

“We’re visiting with Mahidol and Sylvie and the kids for two weeks,” said Kim Irion Thanarat. “We don’t get to see them so often. Then we’re heading down. Sirikit, by the way, is pregnant with their second child!”

“Our fourth grandchild!” added Ananda, with a smile.

“Congratulations!” Will, Ethel, Kurt, and Anne all said at almost exactly the same time.

“It’s good to have them close by,” added Ethel. “Liz and Mike and their kids are right in Aurorae and we really enjoy that. I wish Marshall and Amy weren’t a billion kilometers away!”

“They’re doing a good job with the kids, too,” said Anne. “I came to appreciate Marshall’s intelligence and judgment a whole new way when we were on Titan.”

“Thank you, Anne, that’s very kind,” said Will, knowing how difficult that relationship had been.

At that point the parallel lines they were in moved forward differing amounts and they were no longer able to talk together easily. It was fifteen minutes before Will and Ethel’s line finally moved forward enough for them to pass through the automated customs post, a statement of national sovereignty of dubious importance with tens of millions of kilometers isolating Mars from the rest of humanity. They floated into an automated shuttle that would transport them to Phobos Main Station and sat across from Ted Bukowski.

“So, welcome to Mars; or Phobos, at least!” said Will to him.

“Thank you! It was quite a flight, though the thought that we were moving in excess of solar escape velocity was a bit unnerving!”

The Commonwealth always keeps two caravels with gas core engines ready as chase ships, in case something goes wrong,” replied Will. “We wouldn’t have gone far, if the gas core engines had failed!”

“When are you heading down?” asked Ethel.

“Tomorrow; er, morrowsol, second flight.”

“No, you really should stay up here for a week or so and meet people,” said Will. “And right now, Zhang Bao-zhi, Minister of Space Industrialization, is up here on a visit. He was Chief Executive of Phobos until Helmut invited him to join the cabinet, but he has to get up here a few times a year for his new job, and everyone loves to see him.”

“I would like to meet him. I emailed him and he said it’d be a month or two.”

“I can arrange a meeting in the next few sols,” replied Will. “We’re having lunch with him on morrowsol. But beside him, you need to meet the dozen or two people here who are in charge of ship construction; the people who run the ship yard, building carriers as well we corvets, galleons, even an occasional caravel. And Bao-zhi can introduce you, so you want to start with him.”

“This is a really amazing place,” added Ethel. “Arguably, the most important human settlement in the entire solar system, because they have a lot of people—a critical mass—zero gee, land—which means they can anchor things to someplace, which you can’t do in orbit—cheap access to Cererian water and metals, and access to Martian minerals and manufactured goods. This place can grow and grow.”

“And it will grow, because Mars understands its strategic importance,” added Will.

Ted nodded. “Okay, I’ll reschedule my flight for a week from now.”

The automated shuttle drove down the long metal tunnel, magnets pulling it against the floor to give its tires a grip in the microgravity; on Phobos, the feet of a 100 kilogram human being barely could feel the weight of one candy bar each. The gravity was so low that the moon could carry out most forms of zero-gravity manufacturing, and those that needed absolute zero gee for lengthy periods of time could be carried out at Lagrange station, a facility that hovered 2.5 kilometers above Stickney crater in the gravitational watershed between Mars and Phobos.

The shuttle slowed and entered Stickney main station, which was the end of the line. Everyone got out and some arrivals were puzzled, though Will, having transited through several times knew the way. “The destinations are on top of each corridor,” he said, pointing. “Phobos 1 and 2 are down the corridor straight ahead; the ‘old station’ and the industrial park are down the right-hand corridor.”

“What’s the ‘old station’?” asked Ted.

“That was the entire place, pre-carrier. It was a series of galleons, ultimately 4 of them, built here to serve as housing. People who have accommodation on Phobos while waiting for transit to the surface of Mars are usually there; the carriers are designated Alpha, Beta, Gamma, and Delta.”

“How do we get to the agriculture modules?” asked someone.

“Get in a shuttle going to Stickney Rim Station, which is also the way to the Stickney Rim Marriott and its spectacular views. They’re mostly located west of here on the anti-Mars side of Phobos, because Mars takes up so much of the sky, the Mars-facing side of Phobos gets a quarter less sunlight than the back side."

"Thanks!"

"And where are we going; Phobos 1?" asked Ethel.

"Yes, to the Hilton there." Will looked around, then pointed to a railing. The station was a confusing spider web of handrails that sometimes joined and sometimes went over each other, rather like freeway ramps. People traveling in one direction never crossed a line of people going in the other direction; they went over or under. On Phobos, everyone wore a belt that included a short length of cord with a latch on the end, so they could attach themselves to a railing. Will turned to a hand rail nearby and once he was sure it would be available to catch, he jumped slightly to pull his velcroed shoes free from the carpet and floated over. He and Ethel made their way along the railing with a crowd of people heading for Phobos 1 and 2 as well.

The corridor to Phobos 1 and 2 was a circular tunnel ten meters in diameter, divided into a top half and a bottom half by a heavy metal surface. On top, vehicles attracted themselves magnetically to the floor and rolled on wheels; automated taxis could move people for a very small fee, and trucks carried goods. The lower section was divided with transparent plastic walls into long one-way pedestrian tubes. Will and Ethel latched themselves onto the "Phobos 1" rail and pulled themselves along it for five meters until they reached the section where fans began to push air along the tube. They just floated in the breeze with one hand on the rail to provide control with everyone else for 250 meters until they reached the exit for Phobos 1, which they grabbed onto.

A revolving door led them onto the floor of a large circular room thirty meters in diameter. The top half of the walls and the ceiling overhead were rotating. The flat floor curved gradually like a bowl and met the lower half of the wall, which was not rotating; the Velcro carpet and hand rails ran up the non rotating part of the wall in a spiral. Once through the revolving door, they clipped themselves to the railing and pulled themselves along it until they reached the rotating upper wall. Stepping onto it, they had enough gravity to proceed cauriously without a railing. Phobosian residents dashed past the newbees with breathtaking confidence, walking quickly around the nonrotating wall, without velcroed shoes, fast enough to generate their own centrifugal force and keep their feet on the surface, then they hopped onto the rotating part and continued around until they reached one of two pedestrian corridors leading into Phobos 1.

Will and Ethel took their time; they had passed through transitions from nongravited to gravitied spaces many times, but at their age they had no intention of risking a fall. The newly arrived Marsians had had very little experience, except entering and leaving their corvet, and were usually careful, though one of them bumped into Ethel and almost knocked her over once he was on the rotating, gravitied part of the wall. “I’m sorry, I thought there was more gee!” he said, apologetically.

The rotating wall led them to “Corridor 1: Phobos Square, Hilton” and they followed it. Phobos 1 was a cylinder 200 meters in diameter and 200 meters long, three quarters underground, the top part barely sticking up above the mound of excavated rock. They had entered at the rotational axis, so the curved outer wall of the cylinder was 100 meters “down” from them, and it had two Martian gees or 0.76 terrestrial gravity. Corridor 1 was a spiral ramp that wound half way around the cylinder before it reached Phobos Square, so they had a 300 meter walk ahead of them. “We should have taken the elevator!” Ethel said when they finally reached Phobos Square.

They stepped out onto a curved metal surface 100 meters long and 30 meters wide, with a most amazing view; buildings and green spaces extended 200 meters ahead of them along "Main Street" to the far end of the enclosure, then ran up each side and around, completely overhead, obscured only by a stretch of clouds that ran along the axis. It was an entire inside-out world, with buildings, trees, and other greenery visible everywhere one looked. The far end of the cylinder was a sort of vertical park, completely covered by vegetation—the windows of the buildings under the greenery were well disguised—with a fifty-meter waterfall dropping in a long Coriolis-shaped spiral to a pool, a sight both strange and spectacular.

The entrance to the Hilton was next to Silvio's department store, the Cinq a Sec Dry Cleaners, a Chinese-Thai restaurant, and a Mediterranean restaurant. They stepped inside, said hello to the hotel manager—he was at the front desk greeting people while he worked, because no one needed to check in with a person—then they went up to their room on the "Martian gee" level to rest.

"I'm very sorry I'm late!" exclaimed Ted Bukowski, hurrying into the "Windows" restaurant and to the table where Will Elliott, Ethel Elliott, Zhang Baozhi, and Calvin Grant were sitting. "I thought I just walked down Main Street to the restaurant entrance."

"No, it's Greenway," replied Bao-zhi. "But no harm, we just got here ourselves." He extended his hand. "Call me Bao-zhi. Zhang is my family name."

"Very pleased to meet you, Ted Bukowski, NASA representative to Mars." They shook hands.

"And I am Calvin Grant, Chief Executive of Phobos Borough. Pleased to meet you." Calvin offered his hand and they shook as well. Ted was not too surprised that Bao-zhi was in his 50s, but Calvin was a distinctively boyish looking man in his mid to late 30s.

"Very honored to meet you both. I'm grateful that Dr. Will introduced me to both of you."

"We're always glad to meet the NASA rep, and this is a delightfully informal gathering, which is the perfect opportunity to get to know each other without having to negotiate something." Baozhi pointed to a seat. "We saved you the seat closest to the view. Some people find it eerie; others find it absolutely fascinating."

"Fascinating, indeed." Ted walked toward his chair, located where the carpeting ended and a transparent, hard plastic surface began. He ventured to the edge, almost not daring to stand on the transparent part, even if it was perfectly safe. Looking "down" at the plastic by his feet, he was looking out onto Stickney Crater. In contrast, if he looked "straight" in front of him, he was looking at Phobos's horizon and the space above it, and it was dominated by Mars, which filled one quarter of the sky.

"Wow," was all he could say, staring.

"It's beautiful and disorienting," said Bao-zhi. "Straight ahead of you: we call that 'heavenward' since it isn't up in our centrifugal gravity. And what you want to call 'down' because of gravity, we call 'Phobosward' or 'sideward.'"

"As you can imagine, this restaurant is immensely popular," continued Calvin. "It's a ring wrapped all the way around the outer edge of the cylinder. It just opened a year ago; it's new. People needed an observation deck, basically, because the carriers, by definition, can't have windows. They're rotating 2.65 revolutions per minute and are buried under rock and dust for radiation shielding. The corridor that brought you here passes through 20 meters of regolith, and this restaurant is located on top of all that."

"It's just so beautiful. And I can even see Lagrange Station!"

"Yes, it's just 2.5 kilometers above Stickney," agreed Bao-zhi. "Some day we may even run a cable up to it and install an elevator in order to get there easily. It's a true zero-gee facility and some cargo vehicles—solar sailers especially—can dock there, but can never land on the surface. A 5 or 10 kilometer cable connected to various docking facilities would really enhance our cargo capacity."

"Fascinating." Ted couldn't take his eyes off the scene. "Ah, here comes Phobos 4 and 5."

"Yes, you'll see everything every 25 seconds!" said Bao-zhi. He leaned over to see what Ted could see. "As you can see, Phobos 4 is complete; it's just a mound. You can see it has an observation level, too, like this one. Phobos 5 is under construction. They have the upper part of it enclosed, and you can see some of the metal structure, but underneath they are still excavating downward, extracting all water and carbon compounds from the debris, adding the silicates to the mound, and lining the hollow with a metal wall. They're almost all the way to the bottom. In a few months they'll install the metal floor. Then they'll construct the cylinder, 200 meters in diameter inside the hollow, which is 206 meters in diameter. That cylinder will be completed in about a year, then they'll pressurize it, start it rotating, and build the housing and other construction inside."

"When will it be done?"

"Two years from now, in time for the twenty-fourth columbiad in late 2084."

"And when will you build Phobos 3 and 6?"

"For the 25th and 26th columbiads respectively," replied Calvin. "Each carrier can feed, accommodate, and recycle the wastes of about 2,000 people. In a pinch, they can handle 4,000, and with additional levels they can grow to 8,000, but that would be overcrowding. Last columbiad, Phobos grew to 2,000 people and Phobos 2 opened. Each carrier had only a thousand people, but that gave us a lot of redundancy if there had to be an evacuation. This columbiad we have 3 completed carriers and will grow to 4,000 people; roughly 1,300 in each one. In late 2084 we'll grow to 6,000 people, 1,500 in each of four carriers. We'll probably add close to 2,000 people in each of the next two columbiads, but that remains to be finalized, of course."

"Of course," said Ted, mesmerized by the sights around him.

"Come sit down," Will finally said.

"Oh, of course." Ted looked at the others, embarrassed, and sat, facing away from the view. "I really appreciate this opportunity to meet all of you. I was scheduled to be on the flight that left a few hours ago, but Dr. Will said I should spend more time here first, and he was right."

"Have you been exploring?" asked Calvin.

Ted nodded emphatically. "It took me hours yesterday afternoon and evening! I walked all around Phobos 1, 2, and 4. I tried to enter Phobos 5, but I was turned away, since it was still under construction. I saw the old station and someone graciously allowed me to enter the galleon drydock. It was very impressive to see a ship under construction. Then I went up to Stickney Overlook and took a cable car the length of the agriculture cylinders, all the way to the Neptune carrier. They wouldn't let me in, but I emailed the commander and she met with me for breakfast this morning in the Neptune carrier, so I managed to get in there as well!"

"Even I haven't been there!" said Will, impressed.

"You've really gotten around, then," said Calvin. He pushed his communicator to Ted; it had the restaurant's menu on it. "Here, order."

"I need to pay for my own."

"No, I'm paying for everyone," replied Will. "This is my treat."

Ted looked over the menu quickly, dictated an order, asked a question about the wine, and completed his order.

"So, what do you think of Phobos?" asked Calvin.

Ted smiled. "It's incredible. It's . . . the advantages of reliable solar power, dirt, and an extensive investment by a big neighbor. The moon and low Earth orbit both have the investment, but low earth orbit lacks the dirt and the moon lacks the reliable solar power. I was amazed to see the size of the solar arrays, over on the back side of Phobos near the agriculture modules. And by 'dirt' I'm not just referring to the resources you can extract from Phobos's reg. I refer to the fact that you have land. Swiftville has enormous solar wings that have to rotate constantly as the station orbits the Earth, and it has to have a long docking facility for ships and cargo modules. You can just expand across the surface of the moon. Mariusville—huge, fascinating, beautiful—has to have huge energy storage facilities. Its growth has stalled for a while because no more people want to move there for privacy and safety. It doesn't have a good private school, for example. It's also located well over a thousand kilometers from the mass driver, so it can gain only so much from its operation."

"I see you said 'for a while," noted Calvin.

Ted nodded. "It'll succeed; it's inevitable. But it was a premature effort. I think the mass driver will as well, and I hope it avoids bankruptcy. There's been a big rush to expand low Earth orbit facilities in the last decade. Swiftville needs to move into more zero-gee manufacturing, and that's what they are doing now. More and more zero-gee products are proving useful on Earth and that trend will only accelerate."

"We're very interested in that development as well," agreed Bao-zhi. "Phobos is beginning to get into that marketl, but our problem is the transportation delay. We have to maintain an inventory in orbit in order to be a reliable supplier."

"And zero-gee pharmaceuticals don't have a long shelf life, so you can't provide them," noted Ted. "But zero-gee produced alloys have a big future."

Just then an automated cart arrived with their food. They paused to take their dishes of food and start eating.

"Wow, this is excellent ham," said Ted. "And it's real."

"Oh, definitely real, and rather expensive," said Calvin. "It's imported: from Phobos 2, that is. They have an excellent animal husbandry facility, including a 15 meter wide strip of "grassland" that goes all the way around level one. The chickens, turkeys, pigs, cows, sheep, and goats all take their turn on portions of it, and they love the 'outdoors.'"

"Obviously, most of our 'meat' is manufactured, nowadays," noted Ethel.

"That's true on Earth as well," said Ted.

There was a lull in the conversation. "So, what interest does NASA have in outer planet exploration?" asked Bao-zhi.

"Well, as you know, we got a new Administrator eighteen months ago, and she has brought in a whole new team at the top and set a whole new set of priorities. Our pure research side is very strong, and Mars has benefitted immensely from propulsion, life support, ecology, materials, and automation developments we have produced for decades. I have heard people say people wouldn't be here without them."

"Very true," agreed Bao-zhi. "And we have been able to do some collaboration with NASA research labs, particularly JPL and Goddard. We'd like to do more."

"Well, that's one reason I'm here, and I'd like to see more collaboration on research projects as well. The potential—the synergies—are enormous. Martech engineering is larger than some of our research centers now, and it has ready access to conditions at the Martian poles and on Deimos that we don't have access to. So that's an obvious area of collaboration. The other is exploration. As you may have heard, NASA sent research teams to the moon in April, May, and July, and we plan to send them monthly from now on. These will consist mostly of qualified university faculty who have a research question to study, just as NASA still sends teams to the Antarctic occasionally. They're usually gone for one month total. Next columbiad—2084—I hope we can fill a caravel with fifty researchers and send them here on a one-month trajectory, give them two months for research here with Martech colleagues, then fly them back to Earth in a month. They'd be away four months and would need a Sabbatical, but I think we can find people to apply. They would need to have research collaborators here, or at least sponsors. Setting up that program will take a lot of my time. Because there are flights between Mercury and Earth up to three times a year, we plan to do the same thing with Mercury; it's badly understudied. We're also looking at longer duration exploration flights of two to four years involving caravels or galleons with gaseous core nuclear engines. The *Sequoia* brought me here in 35 days; at that speed, it could have reached Jupiter in six months and Saturn in a year. It's not the fastest vehicle we can fly, either; flights to Jupiter in 4 months and to Saturn in 8 or 9 months are possible. Why shouldn't NASA sponsor expeditions to both? They could stay at Jupiter or Saturn about a year, do their research, and return. Other nations could sponsor scientists as well, or they could sponsor flights and we could send our scientists along. We can do the same in the asteroid belt as well; many nations are mounting expeditions there."

"Of course, Mars has a lot of Americans, so you could sponsor some of their research as well," said Bao-zhi.

Ted nodded. "I think we could do that as well. We need a lot more collaboration. The number of unmanned probes is growing exponentially! NASA will send out ten this year. Phobos and Ceres are sending out a similar number. Titan, Miranda, Callisto: they're all sending probes to their nearby moons, and soon they'll be sending probes to centaurs and plutinos. Mercury is manufacturing a dozen walking probes every year for exploring the surface. It's gotten cheap and the technology's pretty reliable. And the cutting edge is Project Kuiper and other trans-Neptunian objects nearby, which NASA and Mars are partnering."

"I am encouraged to hear you say all this," said Bao-zhi. "I think it is safe to say that it is in considerable contrast with the approach Ambassador Danforth has taken heretofore. At times, collaboration has not been the easiest idea to emphasize with him."

"So I gather, and I have yet to speak to him. That's one reason I had planned to be on this afternoon's shuttle flight to Aurorae; I wanted to be sure to speak to him right away, before I began my official duties here. So this meeting needs to be regarded as purely informal. I can say that the new NASA Administrator wants a new, more cooperative relationship with Mars, and that should affect the relationship as it is currently being managed."

"I was very impressed by Administrator Elwood," added Will. "She's very competent, a good communicator, and someone with vision. I sense that a new era is possible."

"That will be very welcome," said Bao-zhi.

There was another lull in the conversation. Ethel, who was sitting opposite Ted, looked up a bit and saw a bright streak crossing the face of Mars. It was faint, but persisted several seconds. Then it flared and went out. "Oh!" she said.

"What is it?" asked Will.

"I think it was a meteorite. Quite a flare at the end."

"Sometimes you can see them enter the Martian atmosphere from up here," said Calvin. "We're several thousand kilometers away, though, so they have to be pretty bright."

"So, what do you see as the future of Phobos?" Ted asked Calvin.

"We're already a good sized town and we're moving toward becoming a city," he replied. "Mars has been growing thirty to fifty percent every columbiad, but we've been growing fifty to one hundred percent. And we aren't filled with retirees or people writing novels, either; this is a working outpost. The only way we can stay competitive is to grow and invoke economies of scale. Now, we have a crucial relationship with Ceres, because it has near-infinite supplies of nickel iron and volatiles, which we need and which Ceres can supply in bulk cheaply. So we are all very optimistic."

"This is the place where humanity will learn to go to the stars," added Bao-zhi. "Because this is the place where we will learn how to build and manage very large artificial environments. This C-200 is spectacular, but it's nothing compared to what's coming in the future. We'll learn how to build carriers a kilometer in diameter and several kilometers long, capable of housing tens of thousands of people. Even Ceres has too much gravity to launch something that big, but we could do it here. Like you said, this place has dirt. When we receive our next shipment of half a million tonnes of water from Ceres, do you know where we'll put it? We'll pump it into Phobos, where it'll fill existing void spaces! It has land, 1,500 square kilometers of it, so there's room for more people, more ag modules, more industrial plants, all just a subway stop away. The fact that we have dirt and land gives us an advantage over the empty space of low earth orbit or the moon with its long nightspans. This place has a big future."

Calvin and Will both nodded to that. Then suddenly, Bao-zhi's communicator went off with an emergency beep. Startled, he picked it up and looked. "Oh my God."

"What is it?" asked Will.

"The Prometheus shuttle heading down to Aurorae has had a terrible accident. Helmut has asked all cabinet members to stand by. I've got to go."

"Go," said Will, and he did the same thing everyone else around the table did; reach for his communicator and turn to the news website *Mars This Sol.* It showed a stretch of Martian terrain with a cloud of smoke and dust rising from it. "This is a shot from the long range camera up at the Dacha on the Marineris rim," the anchor was saying. "It really doesn't show us anything more. It's clear from the size of the cloud, though, that the vehicle must have completely disintegrated."

"I was supposed to be on that flight!" exclaimed Ted, shocked.

"Kurt and Anne Hollingworth were on it!" added Ethel, pained.

"It would have been a full flight, with all the people needing to head to the surface," said Calvin. "It holds 300 passengers and a crew of 5."

“And families often go down first, because waiting here at Phobos can be hard on the kids,” said Will, shaking his head.

“We now have long-range video from the spaceport,” reported the anchor. “The telescopic cameras follow a flight path automatically and the imagery is posted to a website. We have rewound the recording, and here we go.”

There was a pause, then the screen shifted to a faintly pink Martian sky and a very faint dot moving across it. It was far away and small, but it steadily moved closer and soon they could see the ionized gases streaming behind it as it hit the atmosphere at some 13,000 kilometers per hour. As it slowed, it grew closer and closer until the vehicle’s blunt bottom and streamlined top were clearly visible.

Then its engines came on to burn off the last few thousand kilometers per hour of velocity. The methane-oxygen flame shot out a hundred meters below the descending vehicle from eight engines arrayed along the bottom edge of the vehicle. Suddenly there was a flare from one of the engines, followed by an explosion that appeared to destroy one side of the ship. The other engines continued to fire, tipping the ship sharply to the side, then they subsided. With no engines left on one entire side of the bottom of the ship, the other engines could not stop its descent. The vehicle fought for control, alternately tipping, then righting itself, until it slammed into the ground.

A great cloud of dust, debris, and smoke shot into the air.

No one said anything for a moment, for it was not a survivable crash. Will pushed an icon on his communicator to pop up a Bahá'í prayer book and began to recite a prayer for the departed as the others bowed their heads.

“You’ve never had a crash before, right?” said Ted, when he finished.

“Correct, this is the first,” said Will. “I suppose it was inevitable, but that doesn’t make it any less shocking.”

“We have fifteen thousand more migrants on the way from Earth; the wave has just begun,” said Calvin. “And now there’s no way to deorbit them to the surface.”

“Sounds like Phobos is going to get crowded,” said Will.

“I had better go,” exclaimed Calvin.

8.

Recovering

October 2082

From the sunbaked plains of Mercury to the frozen craterscapes of Miranda, all work in space stopped for three hours and everyone who could, turned to a screen to follow the tragedy. Chief Minister Helmut made it to spaceflight control in a two-minute dash and converted a table in the back of the space into his office. Clustered around him were his head of staff, Rory Mayerovitch; his press secretary, Steve Abbas; Crystal Kern, Minister of Space Exploration; and Lily Estrella, Minister of Immigration.

Emergency personnel reached the crash site 20 kilometers east of Aurorae—ironically, not too far from where the *Olympus* made its emergency landing in Columbus 1—in fifteen minutes. “No one could have survived,” exclaimed the chief officer to Helmut.

“I can see.” Helmut had a good view of the crash site from the helmet camera of one of his colleagues. The spacecraft had excavated a crater five meters deep, out of which a smoking heap of debris overflowed. Bits of spacecraft were flung over the ground up to one hundred meters away. “No electrical signals?” he verified.

“No, no communicator signals, no ear piece signals, no nothing. It must have struck at over 500 kilometers per hour.”

The man whose camera was broadcasting the image back to spaceflight control was walking around. At one point, he passed a severed arm. “Don’t broadcast that to the public,” he exclaimed.

“Someone might recognize it,” added Steve.

“Impact was 727 kilometers per hour, according to radar,” announced someone at a terminal.

Helmut nodded grimly. “Film it all, but we won’t release any of it to the public yet. We’re getting drone footage now from the air, and it won’t show any human remains, so release that.”

“We’ll keep it up more than seventy-five meters for the public shot, then bring it lower,” confirmed someone else.

The drone’s cameras were broadcast on the control’s big screens. It was actually hard to see much because of all the smoke; a lot of materials on the spacecraft had been heated by the explosion of the remaining methane and oxygen propellant and were still breaking down. The oxygenless Martian atmosphere, at least, meant there was no fire.

“We can’t get close yet; it’s too hot,” confirmed the chief officer.

“No, it’s cooler over here,” said someone else.

“Procedure says, if there are no survivors, we need to wait for the wreckage to cool off, then go through everything forensically to recover remains and determine the cause of the crash,” said Helmut. “I suggest you call off your men, head back to the spaceport, and come back with heavy equipment.”

“We want to stay. You never know what we might find.”

“Alright. I understand.”

There was a pause. “Actually, there are signals from three or four ear pieces,” said a man at a console. “But . . . everything is flat lined, no heart rate, no respiration, and the temperature is either way too high or way too low.”

“The heavy equipment will be on the way in about 45 minutes,” announced someone else.

“Should we start to notify the next of kin?” asked Rory.

“We need to be sure. Can you pull up the passenger list for me?”

“Sure.” She pushed on some icons and handed him a tablet. Helmut scrolled down through the list of 330 passengers as tears came to his eyes.

“So many families. So many families.”

“The littler kids get priority for the earlier flights, and this was just the third flight for passengers on the *Sequoia* and *Ponderosa.*”

“Oh, those two corvets?” That alarmed Helmut; not only were Will and Ethel on those flights, but so were a lot of other veterans as well. “Oh God. Anne and Kurt Hollingworth.”

“They were on it?” said Rory, shocked.

Helmut nodded. “She was Mayor of Aurorae, he was Commissioner of the Asteroid Belt Commission when I commanded the mission to settle Ceres, and they were both members of the Saturn Council. They were incredible mariners.”

“And Bill is in charge of Themis.”

“I’ll have to call him.” He turned to Steve. “Get someone started, drafting a personal letter of condolence from me that I can send to all the next of kin.”

“Okay.”

“We’re getting some processed telemetry now,” said a woman at a console. “The Prometheus vehicle had excellent, intelligent, responsive software. It began to broadcast all data to us immediately within a millisecond of the anomaly, including stored data from the previous minute of flight.”

“So we have everything?” asked Helmut.

“Everything. The ship even broadcast to ground all the data from everyone’s ear pieces. We have everything. If anything we have too much.”

“How long before you can pin down the cause?” asked Crystal Kern.

“The telemetry makes it clear what happened, but it may not tell us why. We may need to recover equipment and study it to determine exactly what went wrong. An explosion occurred right above engine 3 where the turbine exhaust gasses enter the engine bell. It doesn’t seem to have been very big, but it was badly placed; in fact, it was in a place where explosions aren’t supposed to be possible. The debris went above the Kevlar shield surrounding engine 3 and hit the turbo-pumps of engine 4, right next to three, and knocked it out of commission as well, and it breached a methane tank. At first the ship’s computer turned off the engines opposite 3 and 4 and relied on the other two pairs, but the methane pressure dropped and within seconds engines 5 and 6 were failing as well. The computer angled the other engines as much as possible and fired them alternately to keep the ship pointing in the right direction, then it started the ship to spin so the uneven firing wouldn’t tip it over, but it didn’t have enough thrust or time to achieve a safe landing.”

Helmut turned to Crystal. “I thought an accident of this sort was impossible.”

She nodded. “So did we.”

“We’ll have to ground everything until we can establish a preliminary cause.”

“I wonder if that’s necessary. The Prometheus fleet here and on Earth have amassed a flawless safety record of over 4,000 flights. They are very reliable and safe vehicles.”

“I know; I’ve flown in Prometheus spacecraft a dozen times. But people want to know what broke before they get on one again. The safety record is one thing; people's sense of comfort is another."

"Well, that's true," she conceded.

Helmut turned to Rory. "Let's draft a speech to the nation."

She nodded and the two of them headed to the conference room across the hall. Steve bopped in and out with news or questions. "Ambassador Zhao has expressed China's condolences and asked whether there is any assistance they can render."

"Ask Shirley in the Spaceflight Center if they need data analysis assistance."

"Spaceflight Control at Peary Station. Lunar North Pole, has a Prometheus launch scheduled in six hours and seeks our advice."

"Tell them we have grounded the vehicles."

Steve nodded and hurried back out. He was back sometime later. "The radar velocity data was wrong, the ship crashed at 383 kilometers per hour."

"Thanks. This is why we wait; to be sure we have all the facts right."

"The heavy equipment has arrived at the crash site, but the crew there is going through everything by hand right now, and they're finding human remains."

"Bodies?"

Steve shook his head. "Just parts, so far."

Helmut sighed. "How terrible. Alert Mariner Hospital, they may need counseling."

"Okay."

Steve left again. Rory pointed to the next to last paragraph. "This needs something."

Helmut nodded. "It does, but we're getting there. Let me proof read it from the top. Send out a notification that I will address the nation in 20 minutes."

He started at the top and worked his way down, making minor changes as he went. Once the address was ready, they went into Spaceflight Control for a final briefing, which brought some additional information. Then he walked to the broadcast studio and got ready. All across Mars and on the far-flung outposts throughout the solar system, people tuned in to watch.

"Good sol to my fellow Marsians, to my fellow mariners all across the solar system, and to the citizens of the many nations of Earth," he began. "This afternoon at 1:20 p.m. Aurorae time, a Prometheus 2 shuttle with 330 passengers and 5 crew was approaching Aurorae spaceport when one of its engines exploded, knocking out a second engine and breaching a propellant tank. This deprived the craft of the propulsion it needed to make a safe landing, resulting in a crash 10 kilometers to the east of the spaceport. Everyone on board was killed instantly.

"This was the greatest tragedy in space, to date, in terms of loss of life. Our hearts and thoughts go first to the terrible loss of life and to the loved who are now in grief. We extend to them all the love, condolences, and prayers that we can offer. They can be sure that our emergency crew, which has been augmented by the Martian ranger corps and many volunteers, is doing its best to recover all human remains, which we will identify and assure a proper and dignified resting place. We are in the process of contacting all next of kin, and once that is done, we will release a list of the deceased. We can confirm the rumor that among the victims were Anne Hollingworth, former member of the Saturn Council and former Mayor of Aurorae, and Kurt Hollingworth, also a former member of the Saturn Council and a Commissioner of the Asteroid Belt Commission. Of the 330 passengers on board, 71 were children.

"To the next of kin of those who perished, I can assure you that we will determine the cause of this crash and fix any defect that the Prometheus shuttles may have. The Prometheus series has proved exceptionally reliable, making almost 1,500 flights in Martian space and over 4,000 flights in terrestrial space over a service lifetime exceeding ten years. It builds on the best technology produced in the 140 years of work on rockets and spacecraft. But no vehicle is perfectly safe, and no matter what the precautions taken, sooner or later an accident was bound to happen.

“We are immensely confident in the vehicle manufacturing capacities here at Aurorae and the maintenance crew here at the spaceport. Nevertheless, in the upcoming weeks an accident investigation panel will examine every procedure, every engineering assumption, that goes into building and service the Prometheus spacecraft. We highly recommend that a similar safety panel be established on Earth to offer a parallel set of recommendations.

“We have decided to ground the entire Prometheus fleet until we are confident the vehicles are safe. While we know step by step what happened during the tragedy because of the detailed telemetry we received, we don’t know why it happened. That will require recovery of vehicle parts and numerous simulations of various scenarios. Be assured that we will turn all our efforts to the investigation and we will determine the cause.

“Meanwhile, vehicles will continue to arrive from Earth and land on Phobos. Additional landing pads will be pressed into service and all the spare housing available in the outpost will be made available. The borough has ample supplies and other capacities to accommodate ten thousand people, which is most of the incoming immigration wave. The Minister of Immigration, Lily Estrella, is working hard to make sure we can minimize the disruption this tragedy could cause.

"It is a cliché to say that space is hard. We already know that. The important thing is our response to our inhospitable environment. This is just the latest is a string of challenges that Marsians and mariners have faced. The *Olympus,* one of the two landing vehicles of Columbus 1, had a near tragedy of a similar sort. On Columbus 2, a midnight air leak in a ranger nearly killed Will Elliott. On Columbus 3, one of the rangers returning from completion of the Circumnavigational Trail struck a rock and an astronaut died. During Columbus 7, a sunwing passenger flight crashed, with the death of the pilot, and I was on board that vehicle. During Columbus 10, Aram lost several of its enclosures to depressurization accidents. During Columbus 13, in 2062, Mercury lost its main enclosure to depressurization. Yet in spite of these tragedies, we persisted, we learned, and we got stronger. In 46 years, Mars has gone from 6 people to 80,000. We have launched or helped to launch expeditions to Ceres, more asteroids than one can easily count, and the four outer planets. We took in the Venus station when the US-China war looked like we would all be cut off from our terrestrial supplies. We are set to grow to a million people in the next two decades, to head to the distant reaches of the solar system, and you can be sure we will lead humanity to the stars. This terrible tragedy will be remembered best if it helps us mature and grow as a civilization. I am determined that the true lesson of this crash will be a stronger, more flexible, and more capable Mars. Thank you."

For three hours after the accident, Bill Hollingworth sat at his favorite "perch" overlooking the Themis community's gardens and the "South Sea," thinking about his parents. They had texted him just after they got on board, asking how he and the family was doing and telling him they were on their way to Aurorae. When he heard about the loss of the vehicle on its approach to

Aurorae Spaceport, he was glued to the screen, like everyone else on Themis. But after a while he left for the perch, because he knew they had been on board.

The perch was 90 meters above the ground, on one of the four 100-meter pylons anchoring Themis's multi-layer dome. One could literally jump up to the perch from the ground, though one could easily miss and bump into the dome; similarly, one could jump off it and drift to the ground, but it was dangerous because one couldn't control one's speed. Bill preferred to strap on wings and fly. He flew to the little world's equator, flew all the way around—a bit more than a kilometer at that altitude—then settled onto the little platform, where he strapped himself in place so he wouldn't drift off.

Looking up, he could see the two meters of sterile, transparent water overhead that sheltered them from anything the sun could throw at them and the worst of the galactic cosmic rays that filled interplanetary space. It reminded him of his mother, who had helped make the contact with Mars's enclosure design team. Above that was Themis's gas storage envelope filled mostly with carbon dioxide; it was slightly reddish because of a deposit of tholins produced by solar ultraviolent bombardment of the traces of methane in it. His father had made contact with the atmospheric scientists on Titan, who had advised the engineers on Themis how to coat the dome with a chemical to reduce the problem.

Looking down, he could see baby forests spreading over half of the asteroid's thirty hectares of surface. His mother had put him in touch, at different times, with experts in tropical fruits and nuts, because most of the species they had planted were high-use trees; some of them thrived in low gravity and alien soils, while others died. The vegetable gardens, corn and wheat fields, even the vineyard had all benefitted from contacts his parents had helped provide.

Looking southward over the "South Sea" that covered over a quarter of Themis, he remembered the huge work stimulated by his father to dig up and remove three-hundred tonnes of nickel iron meteorite from the floor of the crater before it was flooded.

And now they were gone. It was hard to believe, and he shuttered to think about their last seconds, plunging toward the surface at an impossible speed. He tried not to replay the scenario in his mind. He wondered whether the data dump from the Prometheus included the last data transmissions of all 330 passengers' ear pieces, and hated to think about it.

Toward the end of the three hours, his perch was rotating around toward the dark side of Themis and he began to search for Mars in the sky. He pulled out his communicator and looked up its position and used that to find the bright red star, which was visible through the layers of dome and water in spite of their obscuring tendencies. Then Suzanne texted him.

Helmut Langlais is speaking in one minute.

She had left him alone the entire time; most likely, she had realized what had happened. With a sigh, Bill turned to Helmut's broadcast and watched the entire speech.

It brought tears to his eyes, for it confirmed the worst, but also reinforced his hope, just as gazing at Themis from the perch had. They were never completely in control of their fate, but they could build, advance, progress. It was the best they could do. It was what they had to do.

Then his communicator beeped. He looked and saw, to his surprise, it was a personal videomail from Helmut. He pushed play.

"Good sol, Bill. I saw that in the press reports, about an hour ago, they reported that your mother and father had died in the crash. I'm sorry no one notified you first; the media shouldn't have done that. We are now in the process of writing the next of kin of every victim, but I wanted to start with you. Your mother and father were pioneers here, stalwart contributors whose contributions were historic. When they arrived on Columbus 6, Mars's population went from 40 to 87. They preceded me by one flight and were some of the people who welcomed me very warmly. Kurt was my boss as Asteroid Commissioner when I commanded the expedition to settle Ceres. His explorations in the Saturn system and service on the Saturn Council were distinguished and important. Your mother's service as Mayor of Aurorae during the crucial five years after independence set the direction of the city's growth and established the city government's reputation for efficiency and service.

"We will miss both of them gravely. My personal condolences, and those of the Commonwealth go out to you, Suzanne, and your children. We will hold a befitting memorial service for them in a few weeks, and no doubt we will need to consider what fitting memorial to establish for them.

"Finally, I want to extend my personal wishes to you, from the head of one community to the head of another. I'm sorry we haven't been in better communication, but we don't know each other. Perhaps we can find the time to talk more in the future. I would like it. Bye for now."

The screen faded and went blank, and Bill felt tears forming in his eyes. In Themis's near-zero gee, they didn't stream down his cheeks; he had to wipe them away in order to see. The combination of kindness, reminiscence, and recognition was unique and completely unexpected. He sat, stunned, a few minutes, trying to see the red dot of Mars through the hazy dome and the veneer of tears.

Then he hit reply. "Thank you, Helmut, for your great kindness in contacting me. I will treasure your message forever. The memory of my parents will never fade. We'll both be sure of that."

He sent the message, strapped on his wings, and flew back to the north pole. Next to the *Patares* and *Materra* was their new rotating enclosure that they still simply called *the Park.* They had enclosed a lower level of rotating space to provide 1140 square meters of badly needed housing and had decided, for the time being, to leave the rest as an open, rotating park, where the kids could run and adults could hang out in the open air, watching the sun play against the dome far overhead. It was suppertime and everyone was sitting at their tables eating. When Bill landed on the outside and walked down the spiral ramp to the park level, everyone saw him and applauded.

Irene Langlois stood. "We're so sorry, Bill," she exclaimed. "We heard Helmut's address a few minutes ago. We had no idea."

"I knew because they texted me after they got on board, and as soon as I heard of the accident I texted them back, but they never replied. But Helmut just called me personally to express his condolences, and he was very kind and generous. I was . . . comforted."

"We were thinking just now," added Zachary. "The area we call 'the Badlands' really isn't bad; it's cut up with crevices and little caves that makes it quite fascinating to explore, and creates a lot of surface area for vines and even trees. We were thinking to rename it 'Kurt Fossae' which is geologically more correct anyway. And the pond near the gardens, which is the headwaters of the creek that flows through the fossae to the sea; it should be named 'Anne Creek.' That would be one way to honor your parents."

"Thank you, that's very kind. Very enduring, since this community is permanent. We're here to stay; Themis is now a permanently settled world all of its own."

“And we want to do a special memorial service for them on Sunday,” added Susanne.

“And we need a monument to them,” added Cynthia, who was in charge of fabrication. “I have some ideas. We could put it next to the pond, where it flows down into Kurt Fossae.”

“That really would be great,” said Bill. “Thank you. I am in favor of all of these ideas. But long term, our best response to this tragedy is to build up this home world of ours, and make sure it is secure against any disasters of its own. That’s the main way I want to honor my parents.”

“The Center for Expression has never had so many people in it before,” said Calvin Grant, as he, Will and Ethel exited onto the Greenway. “It was probably so many, there were spin compensation anomalies.”

“Twelve hundred people add almost ten tonnes of mass to one side of the enclosure,” acknowledged Will. “I suppose there are pumps to pump ten tonnes of water to the opposite spot in the outer shell?”

“Yes, exactly, to maintain the spin axis. Thank you for your words. I think they brought great comfort to everyone.”

“There’s not a lot one can add to Helmut’s comments. These events frighten us, they bring us great grief, but in the long run they toughen us and they teach us.” He pointed to the magnificent enclosed space around them. “Look at the beauty, the symmetry, the engineering elegance of Phobos 1! But think of all the ways it could spin itself into pieces and kill all thousand or two people inside. We’ve tried to anticipate all those scenarios and prevent them, but who knows which scenario we have failed to account for adequately. We must be vigilant, we must be disciplined, and above all we must manage this place as well as we can. Earth doesn't have to worry about the sorts of disasters we do."

"Although they have some pretty big disasters slowly developing down there," said Ethel.

"True, they have to manage professionally and thoroughly as well, but I guess because we have to worry about our oxygen, we've learned the lesson first!" replied Will.

"I worry about getting onto a Prometheus and returning home," said Ethel.

"You are free to make Phobos your retirement home," replied Calvin, with a smile.

"Thank you, but I suppose I'll overcome my fear, once the shuttles are flying again!" replied Ethel, chuckling.

"Oh, I'm sure you will."

"Have you any idea when the launches will resume?" asked Will.

Calvin shook his head. "Sol 4, and they are still clearing the debris and cataloguing human remains. At the briefing this morning they said they still hadn't found all the engine parts, so they still can't do a full analysis. It'll be a week or two at least."

"Maybe a month or two; that's not an easy analysis," said Ethel. "I used to work on gryphon engines, forty years ago."

"Ah yes, the gryphon. I've seen pictures; I'll have to come to Aurorae museum some time and see the one on exhibit there. It's a huge crisis because we're counting on the ships to turn around and fly right back to Earth, so they're there in time for the next columbiad. A delay of two months strains our liquid hydrogen supply quite seriously."

"Not to mention the crowding."

"Exactly. If no one flies to Mars for two months, the population of Phobos will balloon to twelve thousand. We have designed for an expansion of our residential population to four thousand, of course, and we can accommodate maybe a thousand more in Phobos 4. Everyone else will have to stay in their quarters in the caravels, galleons, and corvets that brought them here, so they'll be pretty tightly packed. At least they can come into Phobos 1, 2, and 4 to walk around and eat, but even that will be a strain on our resources. We don't even have enough landing pads and tunnels for all the ships; we're scrambling to add metal pads and snake inflatable tunnels to them, all the time working the construction crews extra hours to finish as much housing as possible and expand life support capacities! It's crazy."

"There must be construction workers destined for Mars you can press into service," said Ethel.

"Oh, I assure you, we are! Even Neptune 2 has pledged to provide us 100 construction workers and to take in 200 temporary residents, especially planetary scientists and ecologists. They'll be completing some of their construction on the flight, which is a pretty significant modification of their schedule."

"Two months of additional accommodation on their ships really won't be too bad, if they have access to the big enclosures," said Will. "The big problem is cabin fever."

"And people can go outside and walk around Phobos," added Ethel. "This is a manageable crisis."

"I hope so, because if people stay more than two months, we'll have food shortages!" said Calvin. "We only export to Earth orbit and the moon enough to feed 2,000 people, not 12,000!"

"I'm sure by then, cargo flights will be possible," said Will. "Mars can always fly up foodstuffs."

"We're already putting together contingency plans." Calvin sighed. "As you say, this will toughen us. We'll get through this crisis."

"I'm sorry I'm late," said Wicahpi-Luta, as he approached the table where his family and friends were eating supper. "We encountered another big stony meteorite and that slowed down the excavation work."

"Don't the robots do most of the work?" asked Tad, frowning.

"Yes and no; you might say I am a robot when I'm doing the excavation work, because I am the brains of a huge machine blasting out ten thousand kilowatts of superheated steam through a dozen nozzles and sucking up the resulting meltwater, all while I'm sitting in a room fifty meters from here. It's augmented virtual reality. But we managed almost a meter today, in spite of the stony meteorite in the way, and we got most of another ten meter band of nickel steel anchored to the wall, all the way around."

"How far down are you?" asked Tahirih.

"Fifty meters. Not bad, for a hole 215 meters in diameter, after a bit over 100 days. We'll reach the bottom—210 meters down—in less than a year, and they said it'd take three. Recycling most of the heat has made a huge difference."

"And you're installing the metal enclosure as you go?" asked Susan.

"Yes, that's done by two other big machines. They install strips three meters high, anchor them to the ice wall with steam-heated 'staples' two meters long, and weld each strip to the one above it. When we reach the bottom next year, we'll have a reasonably warm enclosure that can be pressurized, and we'll build Avalon 2A inside it. Meanwhile, Avalon 1B is going up above us pretty quickly, and the water we're discarding is creating a very thick, strong shell around it."

"I think it's crazy that we're building two enclosures at once," said Tad.

"Why? We have the equipment and personnel to do it, we need the water from one to enclose the other—we'll use it to enclose Avalon 2B as well, way before we actually build it—and the enclosures do different things. Avalon 2A is buried deep underground and will be our industrial facility. The other two will be residential."

"We won't finish any of them for at least 3 years," added Vahid, repeating information Tad already knew. "This construction schedule has been designed to be optimal, based on resources."

"I know," growled Tad. He ate more of his pasta for a moment. "What do you think of the flight suspension? You know Prometheus engines pretty well."

"I do," confirmed Wicahpi-Luta. "I even worked on them for a few months, before we left Mars. They're very good engines; an elegant, capable design. I was shocked that the accident happened. It's the sort of thing that shouldn't happen even one time in a million."

"So, do you think the flight suspension is justifiable?"

"I'm not involved in the investigation, but it seems wise not to resume flights until the cause has been pinned down. It appears to have been a problem in the turbopumps that caused engine damage; the telemetry suggests that quite clearly."

"But if the chance is one in a million, why not resume the flights? No one else is going to be killed, and the error can be corrected later. It seems to me this is going to destroy Langlais."

"Why would it do that?" replied Wicahpi-Luta. "He holds a press conference about the investigation every sol."

"Well, a lot of people think this has sunk his administration."

"A lot of your father's friends, you mean," said Esther.

Tad scowled at her, irritated. "Anyway, the risk is just one in a million."

"Maybe," replied Wicahpi-Luta. "But it's a risk, and people naturally are hesitant to board a Prometheus right now."

"Emotionalism! I thought we had outgrown that!"

"When will people ever outgrow emotions?" replied Vahid. "Besides, your response was emotional."

"Well, I am worrying about whether it will delay our expedition to Cordelia. The caravel's engines are very similar, are they not?"

"Yes, they're a variant," said Wicahpi-Luta.

"The Council is meeting morrowsol and will decide whether to postpone the expedition," said Vahid.

"I hope not; there's not a lot of time left before the arrival of Uranus 2 in two months!"

"You just have to get in another expedition before a new geology team arrives and wants to make their own discoveries," said Susan, scowling at her husband.

He scowled right back. "Just leave me alone," he said.

9.

Return to Flight

November 2082

“So, no grades at all this semester?” Helmut asked Oskar, when his son finally appeared at the breakfast table.

“Well, it’s just mid semester, remember.” Oskar sat and grabbed the plate of scrambled eggs.

“Leave some for your mother! Surely you should have a grade in something by now.”

“My course in advanced music composition focuses on a big project that I have to turn in at the end of the semester. It’s coming along pretty well. My course on the geology of Phobos is stuck because we can’t get to Phobos; the field trip for that course is postponed until next semester, which is a real pain. And my two poetry courses are independent studies with Dr. Callahan. Both involve big papers I turn in at the end.”

“How are they coming?”

“Pretty well. I’m sitting in on video lectures for two courses at Southwest Missouri State and drafting short reflection papers every week so she knows I’m keeping up. You can ask her, if you want. I have both papers outlined and they’re going to take a lot of time, but I’m enjoying the work.”

“Good,” said Helmut. “I’m glad this change has worked out.”

“Well, we’ll see; I don’t know what I’ll do next semester! I still need an introduction to engineering course, and that’ll be a real downer.”

“You keep saying you want to go prospect for gold in Elliott. You can’t do that without some basic mechanics and engineering."

"I know, but that's an argument against going there."

"I suppose. Have you been looking at writing jobs?"

"Not since the crash last month, but you are right; there are a lot of them. I think I may take a journalism course next semester because the most interesting writing up here seems to involve it."

"There are a lot of terrestrial magazines and websites who want articles about Marsian life and culture. Of course, there are a lot of Marsians earning extra money or even a partial living writing for them."

"Yes, and I find that intriguing. There's a lot one can write about up here, and it isn't all politics or science."

Helmut smiled and nodded. "Good. Sounds like you have some ideas."

"Maybe. The fog feels like it's lifting a little."

They both turned to their breakfasts, and a moment later Clara arrived to join them. They chatted briefly about the latest terrorist incident in England, the battle in Russia to pull out of the world dollar, and the arrival of 300 more people at Concordia Station, Mercury, which raised that world's population to 1300. Then Helmut's communicator buzzed. Seeing it was Crystal Kern, he stepped away from the table to take it in his office. "What do you got?"

"Sorry to call so early, Helmut, but I just got a call from Sergei in the accident investigation team. They think they found the problem in the turbo pump; evidence of a manufacturing defect."

"That would explain the telemetry. Did they find the parts in the wreckage?"

"Yes, because the initial problem blasted its own debris out of the ship and it fell to the ground separately, so we have recovered it."

"Are they sure?"

"They're running their conclusions past some experts in Moscow and Denver. That should be done in a few hours and then they'll be ready to participate in a press conference."

"What about return to flight?"

"Immediate, because the turbopumps in all the Prometheus have been taken apart and studied intensively in the last month. We know this defect is not present in them."

"Excellent. Phobos is getting pretty crowded; they now have 9,000 people up there waiting. We need to get them down here."

"Once we resume flight, we should be able to run a round trip every sol for both shuttles. We have the crews. That's fourteen flights per week, capable of bringing down 4,500 people. So we should catch up pretty fast."

"Good. I'll alert Steve to call you. We'll need a public statement and a private memo to various parties with additional information, released simultaneously."

"We'll get on it right away, Helmut."

"Thanks. Bye."

"Well, there they go," said Marshall, watching the telescopic camera images of the *Intrepid* and the *Courageous* shrink in the distance. He looked at the others in Saturn Spaceflight Control area. "Two years to Mars, and we're 66 people fewer."

"A bit less than two years," noted Christine Niehaus, who was in charge of Saturn

System Exploration, and therefore ran the control facility. “Saturn 6 will get here in just eighteen months, though, and will be here next August, and the *Intrepid* and *Courageous* will be back in a little over three years, assuming we continue to receive arrivals once per Martian year.”

“Which raises the question whether we should grow at the rate of 300 plus people every two years; or over 400, if you include their children born here,” said Corinne Fullerton, Saturn’s Director of Communications.

“I think that’s now the wrong question,” replied Marshall. “Transportation only requires four galleons, and they’re already built and dedicated to the job. We’re self sufficient enough, and Helium-3 sales cover our other costs.”

“There’s an infinity of research to do here,” said Sydney Kilgore. “We’ll never run out of need for scientists. And the bigger the outpost, the safer it is.”

Marshall turned to Oscar Pereira, who had been commander of the Saturn 5 expedition on its outward leg, and who now occupied the new position of Director of Engineering. “So, what are the results of your conversations about getting Enceladus a fusion reactor?”

“It appears to be premature by about five years. The technology is advancing and the cost is coming down, but it still costs a few billion redbacks to make a thousand megawatt fusion plant, and Enceladus doesn’t need even five percent of that. The people I talked to thought it’d be down to a billion redbacks in five years, though, and that units able to put out 100 megawatts would be practical at that point.”

“Of course, Enceladus has plenty of geothermal heat, just like us,” noted Christine. “Of all the outer solar system commonwealths, ours is the most energy self sufficient.”

“We may want to get one, anyway,” replied Oscar. “The Chinese are considering building one for use on Callisto, and both Uranus and Neptune will need them. But more important, for now, have been my discussions about building a Peregrine 2."

"Are Uranus and Neptune interested in collaborating?" asked Marshall.

"Not any time soon. I spoke to the Director of Engineering for Project Neptune and he referred me straight to Mercedes Patel. She said, basically, to get back to her after they leave Phobos, reach Neptune, and set up their outpost! And that's reasonable; they don't need a larger Peregrine now and might not then. But I was hoping some of their engineers would have time to assist during their flight to Neptune. Uranus said that right now all their engineers are busy helping with the construction of Avalon 1B and 2A, so they don't have anyone to spare."

"Neither of them really need a larger Peregrine anyway," said Christine. "We need a Peregrine to carry passengers and cargo in and out of Titan's atmosphere. Uranus and Neptune have no moons with significant atmospheres. But Venus does, and they're getting more populous, and they're just about at the point where they want to send people down to their aerostat, so they are a possible partner."

"I'd talk to Jimmy Khan because if anyone could use a nuclear aircraft, it is Mars," said Marshall. "Venus needs a regular Peregrine, not the larger size version we need. The standard model could transport up to 4 or 5 to a Venusian aerostat, with cargo, and back to orbit without any problems. That's all they'll need for a long time. We need a vehicle able to fly up to 100 people or 50 tonnes of cargo to Titan orbit and back, one designed for our dense atmosphere. If Mars won't help, we'll need to develop it ourselves."

"But it'll take us 100 engineers and fabricators several years," said Oscar.

"We've got the people coming next summer, though," said Marshall. "And we don't need a larger team for expanding our caverns or rotating modules. Construction is fine. Let's put together a plan to develop the larger Peregrine 2, Oscar."

He smiled, delighted. "I'll be glad to do it, Marshall."

The Prometheus 2 blazed through the Martian atmosphere, fired its engines, and slowed for a landing onto Aurorae's Pad 7 on a hundred meters of blue-orange methane-oxygen flame. The landing legs deployed and it settled to the ground with barely a bump. The engines cut out and in the passenger cabin, 330 tense passengers erupted into loud and relieved applause.

Will unstrapped himself and turned to Ethel. "I think we're supposed to be the first ones out."

"I know." She unstrapped her belts as well and rose, wobbly in the Martian gravity. She flexed her knees a few times. "It's good to be in home gee again."

"Yes, without any Coriolis."

"I'm not going to space again. I'm too old for this."

"I understand." Will reached up and grabbed their bags from the overhead compartment.

They were seated near the main exit hatch and within a minute they heard scraping as the exit tunnel swung around and docked to the side of the shuttle. Then the door opened and a man stood on the other side. "Welcome to Mars!" he exclaimed.

Everyone cheered again. He beckoned Will and Ethel and they followed him out the tunnel, down the elevator, and into the shuttle bus. The pad had two bus docking ports and when one bus filled, the passengers were routed to the second, while the first bus exited an airlock and a new bus entered. That way, six busloads of passengers were quickly moved to the Aurorae

Welcome Center, which was filled with relatives and "buddies" assigned to the new immigrants.

Will and Ethel, again, were the first to step off the bus into the welcome area and they were greeted by thunderous applause as well as eager reporters. Liz, Mike, and the twins were standing just ten meters away, waving, but the reporters had to be first. "Dr. Will, how was the flight?"

Will walked over to the reporters. "It was a great flight. Quite routine; the usual six hours of weightlessness, followed by seven minutes of atmospheric entry, with all the noise that makes, the heavy weight, the roar of the engines, and the silence of touchdown."

"Were you frightened?"

"We were all apprehensive, of course, because that's the natural human reaction right after a disaster. But we knew, at every step, that everything was nominal, so we were patient."

"How was the trip to Earth?"

"Fruitful, I hope, and fascinating. The place has changed immensely since my last visit. It is tied together more through legal and diplomatic arrangements than ever, and I applaud the progress that has been made. But society is torn by economic disparity, hobbled by unemployment and drug addiction, rent by racial tensions, and disrupted by terrorism. I have done my best to emphasize the Marsian way as a possible approach to reducing the difficulties and calming the crises. The Commonwealth's diplomatic staff carried out a blitz of diplomacy as well. We are hopeful that we may help our terrestrial cousins make a little progress."

"Has this accident tarnished Mars's reputation?"

Will thought about that a moment. "I don't think so because we never said this place was completely safe and we never promised that everything here is easy. We all know that this is a harsh world and that spaceflight is inherently dangerous. If anything, that helps us keep our edge."

"What are your thoughts about our growth to 90,000 people?"

"It's an ongoing miracle. When I first landed here in February 2036, I never could have imagined that in my lifetime Mars would have a thousand people, let along 100,000, and I might live to see a million people! I firmly believe we are humanity's advance guard. To us, the torch has been passed. We must lead humanity, not in wealth, not in strength, but in cultural innovation, in civilizational wisdom. That is our destiny." He looked at the reporters one more time as several shouted questions. "I won't take any more questions this sol, because my family is waiting. Ciao to you all."

He took Ethel's hand and they walked the last ten meters to Liz, Mike, Jason, and Shayda. The twins were 12 and had grown.

"I think you're both a centimeter taller!" said Ethel, as she hugged and kissed her grandkids.

Meanwhile, Will hugged Liz and Mike. "It's good to see you both again and good to be home!"

"We missed you, dad," said Liz.

"Well, you gave them hell," exclaimed Mike.

"I tried. I think they'll give themselves hell first, though," replied Will. "It was a worthwhile trip. We met a lot of good people and did a lot of good for Mars. In some ways, Tehran was the highlight of the trip. They were so nice to us."

"You got good press there, too."

“So, what’s the news here?” asked Will to all four of them.

“Let’s get out of the crowd and go home for some lunch. You must be starved,” replied Liz, as she picked up her mom’s bag. Mike grabbed Will’s. “I’m about to announce that I am retiring completely from ballet,” she continued. “I just turned 40 and I can’t do all the moves like I used to be able to.”

“No!” said Ethel, surprised.

Liz nodded. “Yes. I’ll still teach it, of course, and I’ll still run the Cultural Center, which is really thriving now. We’re adding a poetry program; we have quite a crop of young poets, and they need a place to deliver their creations. Unfortunately, the orchestra’s new first violin was killed in the crash, so that is quite a blow to their plans, but they’re pushing forward with a full season anyway.”

“We heard about her death,” said Ethel. “I think I met her once, too. I’m glad the orchestra is continuing their plans, they are really good! We heard their symphonies twice on Earth.”

“They’ve developed a pretty good reputation, as has the reparatory company. We’re blessed with a lot of physicists and engineers who are pretty good musicians and actors! The budget for the arts has expanded thirty percent this year, too, and that really helps.”

“How’s your research?” Will asked Mike.

“Pretty good. My application to join the Jupiter Magnetic Field Investigation Project was accepted. There are four of us here, a dozen on Earth, and six physicists on Callisto, who are overseeing the construction of the equipment.”

“Satellites?”

"A dozen of them on various orbits, and two probes that will go down with the aerostat into the jovian atmosphere next year. So, what are you going to do, now that you're back?"

"Nothing," replied Will. "I'm going to rest; this trip has taken a lot out of me. The crash didn't help, either; I was in the spotlight, and then we had to come down on the first shuttle in order to help assure the public. Very stressful, and the older you are, the more you feel the stress. I'm not doing anything for a while."

Two men were not looking forward to meeting each other.

Arthur Danforth, United States ambassador to Mars for the last sixteen years, had been primarily concerned with cooperation—or noncooperation—between the U.S. and Mars in space, and was not happy that NASA had appointed Ted Bukowski as their direct representative. He was to some extent disappointed Bukowski had changed his reservation at the last minute and had not descended to Aurorae on the doomed shuttle. Bukowski, on the other hand, wondered how much Danforth would insist that he was Bukowski's boss, something the Administrator of NASA had specifically said he was not.

Ted went straight from Arrival Hall to the new apartment he was renting. He looked around, made a note of everything else he needed to buy, and decided he'd head straight to Silvio's after visiting the embassy and meeting Danforth.

He was familiar enough with Aurorae to head straight to Andalus enclosure. What once been a huge public space and the pulsing commercial heart of Mars was now a quiet governmental enclosure that felt slightly old and small. The fashionable houses lining the south side of Andalus Square had all been converted into embassies and headquarters of various international and nongovernmental agencies, such as the International Atomic Energy Agency or IAEA, which monitored Mars's nuclear reactors and now its use of nuclear explosives. The Emporium forming the north side of the square, which had housed all of Mars's major stores, was now Commonwealth offices. The Aurorae City Hall on the east side of the square was in the process of being converted into the offices of the Chief Minister and executive branch. The Capitol Building was to be the offices of the Mars Council only. A new Marsian Supreme Court building was envisioned on the southeast side of the square.

The American embassy was a pair of houses on the southwest side of the square, right next to the Capitol. It had originally been one house only, but its staff had expanded and Danforth had needed more personal space. An American flag fluttered in an artificial breeze next to the main entrance, and Ted walked right up to it with some pride. Ceci Hughes Tobin, the ambassador's chief assistant, greeted him at the door and ushered him upstairs to the ambassador's office. The men smiled broadly at each other, but looked the other over thoroughly as they approached each other for a handshake: Danforth was in his late 50s and balding; Bukowski was barely 31 and had a mop of brown hair that begged for a barber. They shook hands.

"I'm very pleased to meet you, Mr. Ambassador."

"Very pleased to meet you as well, Dr. Bukowski. Here, sit down. Coffee?"

"Thank you; I'm acquiring a taste for Marabica."

"Good, because it's all you'll get up here. Except at the embassy; we keep a supply of imported Kona coffee, which I actually prefer." Danforth poured Bukowski a cup and pointed to the sugar and cream, then poured himself a fresh mug full. "So, I understand you have changed your mind and won't be staying here at the embassy after all."

"Correct. On the flight out I was able to arrange the lease of an apartment in Australia Enclosure very close to City Square, but it wasn't available until November 1. The crash delayed my arrival until after that date, so this morning I moved right in."

"Good, I'm sure you'll be more comfortable there. All I could have offered you was a small room. We have a contract with a security company; they can sweep your place to make sure it isn't bugged and can install monitors to make sure no one enters to add any. They'll also install encryption software on all your electronic devices. They'll route all official communications through the embassy's website and to the U.S. through our encrypted line."

"So I was told. I'm surprised that's necessary."

Danforth shrugged. "Mars is sovereign. The U.S. is sovereign. We can and do spy on them and I presume they spy on us. They have a counterintelligence agency."

"Really?"

Danforth nodded. "So, who have you talked to?"

"Zhang Bao-zhi was stuck on Phobos and he didn't have a central role in the accident investigation, so he gave me two hours and reviewed their development efforts and their current capacities. A lot of the information was public, but not all, and it saved me a lot of time. He was very friendly. I also talked to 2 or 3 people in the spacecraft construction facility and got tours of all four drydocks. I was able to visit Neptune-2, too, got a tour of the craft—they call it an ark!—and talked extensively with Mercedes Patel. The Martech Asteroid Studies Department gave me a tour and a lunch, too."

"Good, you really got around! I'm sure you'll want to meet with Jimmy Khan, Crystal

Kern, Mi Sanda, and a few others. They're all very friendly, very open, and they love to talk. It's the Marsian way," He said it diminutively. "But remember that you are here to advocate for the United States. We don't want *us* to be collaborating with *them*. We want *them* to collaborate with *us*. And I don't mean something is just 51% American. We need to be the dominant partner. Always."

Bukowski looked at him a moment, wondering what to say. "But we have collaborated with them where we aren't the dominant partner."

"Correct. I've been overruled many times. But now I've got you to help; you can persuade NASA, and you have the time to talk to the Marsian officials in detail. So, that's our strategy; we push Mars harder to work with us and we push NASA harder to innovate and plan more boldly. Project Kuiper is a good start; we're supposed to be the main partner. But of course the Marsians think that American personnel on the 'ark' can be Marsian-Americans. I don't want Marsian Americans counted as Americans! And I don't want everything built on Phobos, either, I want American equipment on board!"

"But a lot of the equipment built on Phobos includes American licensed parts. Anything imported from the US costs 100 to 150 redbacks per kilo, too. It's pretty expensive."

"And NASA can get the money! They cut corners to make things cheap rather than buy American! It's ridiculous."

"I am sure we can arrange to buy more US made stuff, assuming we can figure out where something is made."

"I know, it's complicated. But that's our policy here, and once you are here, you are my staff and I am your boss. So I set the agenda."

“I’m afraid that’s not my understanding, Mr. Ambassador. I report directly to the Administrator of NASA.”

“No you don’t, you report to me, and any reports to the Administrator go through me. You send them to me and I send them to the Administrator. If you want to talk to your Administrator about it, go ahead, and I’ll talk to my President about it as well.”

“I see. Alright, I understand what you are saying. Do you have a written statement of policy about working with Mars, say, from the State Department?”

“No, and I think I just made the policy pretty clear. Have I been clear?”

“Yes, sir, I think you have.”

“Good. I look forward to your service to the interests of the United States.”

Ted left the embassy confused and angry. He had gone to Mars filled with idealism to strengthen collaboration between the two greatest space-faring nations. Now he was told that he couldn’t do that, that everything had to be a contest for control rather than a win-win partnership, and that he might be spied on to boot! He didn’t know who to talk to; he was tempted to go talk to Will Elliott, but felt he couldn’t; he was tempted to call the NASA Administrator but knew that would get him in trouble with Danforth. So he walked the length of Aurorae, depressed. He ascended Boat Rock to look down on the enclosures, walked all the way around Baltic Lake, then returned to City Square by suppertime. He discovered a bar there and was surprised that he could get drunk, all by himself, without anyone objecting. He staggered home at 1 a.m. when the bar closed.

He had a splitting headache when his communicator rang at 9 a.m. It was the man from

Mars Security, Inc; before Ted had left the embassy, Cici had helped him set up an appointment to get his apartment safed. Per-Olof Grenander arrived fifteen minutes later, before Ted had had time to figure out how to make himself coffee in his new kitchen. Grenander scanned the entire apartment quickly with equipment, then began to install sensors. “We need one in each room with windows,” he explained. “It can detect the use of infrared lasers scanning your windows. Your voice makes the glass vibrate and the laser can pick up the vibration. This thing can also detect all radio and infrared emissions from devices located in the room.”

“Like bugs?”

“Exactly. They have to transmit their results; this thing can pick them up.”

“You didn’t search the place very thoroughly.”

“I didn’t search it at all; I just got a general sense of the setup. Nowadays, audio transmitters can be the size of a grain of sand. They can spread them on the ground outside your door and hope you track some in on your shoes. The technology is very sophisticated. I have to place apps on all your electronic devices; even the appliances. I see you haven’t bought everything, so I’ll have to be back. Anything that goes on the internet has to be registered in the security system.”

“And will I have control over the system?”

Grenander shook his head. “The controls are in the embassy.”

“Oh.” He didn’t like that thought at all. “So, have you ever found bugs?”

Grenander smiled. “I do this work for everyone; the Commonwealth, all the embassies, all the international agencies, and the Mariner League. They all use the same technology; it’s the latest, manufactured in Germany, very expensive to import, but I pass the costs along, of course.

To my knowledge, no one has ever found evidence that anyone else is bugging them. I am pretty sure of this because I am always involved in the testing phase."

"Yestersol I was told I had to be very careful because of espionage."

Grenander shrugged. "Some people are more paranoid than others. The US and Chinese embassies upgrade their systems every columbiad. Everyone else goes four or six years. The only known case of bugs was during the US-Mars War. The US embassy had bugs in the capitol building in several places, but they were found and removed."

Ted pointed to the ceiling. "Doesn't this place have cameras and microphones in case of an emergency?"

"No. They used to be standard, but they haven't been installed in new construction for ten years. The enclosures are now so large, they can't depressurize quickly, and most housing has pressurized escape routes. Yours is that door in your kitchen."

"I know, I read the instructions. So, you install security for everyone? And they all trust you to do it?"

Grenander nodded. "I'm trustworthy, and they know it, but it is really strange to be the counter-espionage contractor for *everyone!* But Mars is a small place."

"I guess so. So, how intense is the competition between, say, the U.S. and China?"

"I don't know much about that, but everyone up here is pretty friendly. We believe in win-win, after all. I think some people are more competitive than others," he added darkly.

"That sounds right," said Ted, with a sigh.

12.

Contrasting Arrivals

December 2082

The galleons *Carina* and *Vela* approached Uranus with their gaseous core engines expelling pale blue hydrogen at 150,000 kilometers per hour. After a few hours, they settled into orbit around the electric-blue giant and headed for Miranda. Two days later the vehicles separated and landed on two separate pads 200 meters from Avalon1. Each bore 150 settlers.

Wicahpi-Luta and Esther awaited their friend Gregor Lyubin and his wife Sophia in the zero-gee entrance foyer underneath Avalon-1. When he appeared, they waved vigorously. He spotted them and floated over.

“Welcome to Urania!” exclaimed Esther.

“Welcome to Miranda and Avalon!” added Wicahpi-Luta. He didn’t know Gregor as well; Gregor had gone to the Catholic church with Esther, even though he was Ukrainian Orthodox, because there had been no Orthodox congregation for most of his childhood. Gregor was two years younger than them, too, so their memories of him in High School were faint.

“Thank you, we’re delighted! This is my wife Sophia; she arrived on Mars in 2079, so you never met her. Esther’s dad was our Catholic priest in church, and Wicahpi-Luta’s half Lakota, half Maori; his mom is Vanessa Smith, former Chancellor of Martech and the Nobel Prize winner.”

“Yes, I know your mom.” Sophia extended her hand. “Pleased to meet you. I’m an eobiologist and I’m here to study organic precursors on the moons and in Uranus’s atmosphere.”

“Fascinating work. Pleased to meet you.” Wicahpi-Luta shook her hand.

“And I’m an ecologist,” said Esther, offering her hand.

“I’m Greek and arrived on Mars right after getting my Master’s. I’m now ready to research my thesis.”

“And we’re ready to start our family!” added Gregor. “The two galleons were not considered a safe environment for pregnancy.”

“No. We flew out here in three corvets; big vehicles with very low radiation exposure,” said Esther. “Avalon has lower radiation than the surface of the Earth.”

“How was the flight?” asked Wicahpi-Luta.

“Long! Two years, flying through space it two galleons, doing Uranus research remotely, and a lot of studying,” said Gregor. “My field is engineering and fabrication.”

“And I’m a propulsion specialist—nuclear engines—plus fabrication and construction, because we do everything up here,” exclaimed Wicahpi-Luta. “Here, let’s go inside.” He pointed to the entrance area.

Gregor and Sophia nodded and the four of them floated over to the vertical entrance area. They attached their Velcro-bottomed shoes to the ramp that soon became the side wall, walked up it, and stepped across onto the rotating side wall, which now had a little centrifugal gravity. They walked up it until it converted into a ramp that spiraled down to the outer edge of Avalon cylinder where gravity reached two Martian gees or 0.76 terrestrial gees. They took off the Velcro sleeves and left them in a basket at the end of the tunnel, which opened onto the Greenway.

“Wow!” said Gregor, looking up 200 meters at the opposite side of the Greenway, upside down above his head.

“A lot more space than in the *Vela*!” added Sophia. “It’s so beautiful!”

“We won’t be happy and comfortable in a space that isn’t beautiful!” replied Esther. “This is our home, and most of us don’t ever go outside.”

“You can’t exactly go for a hike outside. Miranda’s gravity is pretty low,” noted Wicahpi-Luta. “We can’t afford cabin fever in here.”

“And all the agriculture is in lower levels?” said Sophia.

“Exactly,” said Esther. “The Greenway, here, is temperate climate; it has a winter. On the other side of the buildings is the Park, which is pleasantly tropical. That’s where the Square is, where we eat and socialize. This way.” Esther pointed to a large, arched doorway. As they approached, a door opened to let them in, and at the other end of the passage another door opened, admitting them onto the Square.

From there, they could see all the way to the far end of Avalon, just fifty meters away. The enclosure’s end cap was a simulated mountain cliff covered with growing trees and vines, with a waterfall curling in Coriolis manner to a pool opposite the Square. The Lyubinins stood and stared at the Park for a good minute, drinking in the patches of grassland, the baby forests, the lines of fruit trees, and all the singing birds, for Avalon was full of them.

“Wow, this is such a relief!” said Gregor. He pointed to the path running around the enclosure in front of the four-story building that formed a ring between the Greenway and the Park. “I want to run all the way around!”

“Go ahead! Just remember, if you run clockwise, you can increase your gee; run counterclockwise and you decrease it,” said Wicahpi-Luta.

“Alright!” said Gregor, and he dropped the suitcase he had been carrying and dashed off in a clockwise direction. Six hundred meters around; it was a long way to run! Sophia stood, looking embarrassed, as her husband dashed wildly around Avalon. It took him three minutes and he returned quite winded. "I'm sorry, I just *had* to do that."

"That's alright." Wicahpi-Luta pointed to another path that took off from the square diagonally. "If you take that path, there are various alternate routes that take you around the enclosure and along it. You can jog about a kilometer and a half before you have to repeat a path. There's also a tunnel underneath the 'mountain' that takes you to an observation deck where you can see Miranda, Uranus, and the stars. If you include various corridors through the agricultural levels below our feet, there are several more kilometers of places to walk. Finally, there are swimming areas in the outermost level, all with fish."

"A lot to do, even without Avalon 2," said Gregor.

"Let's get to our apartment; 3425," suggested Sophia.

"Alright, that's on the third floor, the 400-block, and it's odd so it faces the Park. This way," said Esther. She led them along the building ring and watched the numbers count down; there was a door at 600, 550, 500, 450, and 400. They took the last door, walked to the center of the building and up a spiral ramp to the third floor, and followed a corridor to 3425. The door unlocked as they approached.

They entered a comfortable living room with all the furniture and carpeting the Lyubinins had ordered, with paintings and photos on the walls where they wanted them. "The robots set it up perfectly," said Sophia, with a smile.

"They're good, and we had months to plan everything," said Wicahpi-Luta. "We'll leave you now, but will you join us for supper?"

"Thank you, we'll be glad to," said Sophia, with a smile.

Anand John Tian had a lot to be proud of. The three hundred arrivals were greeted that evening with a remarkable feast that had been planned for months. There were huge platters of rice and vegetables, more than a half dozen different protein sources to add—real chicken, mushrooms, real pork, real tilapia, real turkey, artificial beef, artificial lamb—a giant ice cream bar, a table of pastries, a table covered with real fresh fruit, several types of bread, a pasta table, and far more. "We'll be freezing some of the extra, converting other items to soup, making jams from the leftover fruits, etc.," he explained to Anthony Renfrew, the Commander of Uranus 2.

"You really wanted to show off!"

"We did, I admit it. And we have a lot to show off, too, with Avalon 1 and all our other efforts."

"I am impressed; you have an incredible home here, and I get the impression people have a lot of stuff, too."

"We don't have a mall, like Mars, and we do have to ration stuff; basically, people can spend 2,000 redbacks a year on clothing, additional furniture, electronics, and gifts. You won't find closets here stuffed full of clothes. But people have plenty to wear."

"And sell used stuff?'

Anand nodded. "We have a flea market right here, the first Satursol of every month. We've focused our manufacturing resources on Avalon, and we've done pretty well, in just two years since our arrival."

"I'm glad we're staying a year before returning to Mars, so we can complete some of the exploration goals and see this place grow further."

"In another year, Avalon 2A may be pressurized. We'll see."

"And this young man who was talking to me in the food line, who wanted a commandership. . ."

"Yes; Tad Lind. Do you know his father, Johnny?"

Anthony smiled. "Oh, he's Johnny's son. Yes, I know Johnny."

"Well, Tad's a chip off the old block; a very similar personality. He's very capable and he knows it, let us say."

"I know the type. That clarifies a lot!"

Anand chuckled. "Yes, it does. It looks like most people have finished eating, so I think I need to make my little speech. Otherwise, people won't stay around for the Miranda Orchestra."

"You guys love the arts! On the flight out, everyone watched the *Miranda Variety Hour* religiously!"

"Yes, and you know, that program actually makes money for us. I think it's better than the *Titan Follies*. It may even be better than some of the programs Mars puts out! We emphasized the arts throughout the voyage and told people we wanted the arts to become a cultural habit once we arrived here. As a result, they are more important here than on Mars or even Titan; it's a characteristic of Uranian civilization. A characteristic we are very proud of. We want life here to be a balance of research, resource utilization, fabrication, sales, the arts, and family time."

"That's good, and I appreciate that idea very much. But everyone says you don't maintain that balance very well in your personal life, Anand."

Anand laughed. "That's very true! I am a workaholic! But I hope my people aren't. I had better get started on my speech."

John Anand Tian rose and walked to the stage, which was located along one side of the square. He tapped on the microphone. "Welcome, everyone, to our arrival banquet. We have a song of thanksgiving to start our program this evening."

He stood back from the podium so Kofi Phelps, who had a powerful singing voice, could come forward. He sang a moving African-American spiritual that uplifted the audience and left a sense of beauty in the air, even though the song was not overtly religious.

"Thank you, Kofi for that song of struggle and hope," said Anand. "It feels very appropriate, for it reminds us we face the unknown every day and may face extremely dangerous struggles, yet was are also filled with hope and optimism that we can make the future bright.

"As of today, Urania has received 337 additional citizens, raising our total to 1025, We've broken the magic 1000 mark! It's hard to believe we left Mars four years ago with 505 people, almost all adults in their 20s and 30s. Now, two years after arrival, we've built this beautiful enclosure, explored all five of the major moons and two of the smaller inner moons, and we have our first load of Helium-3 ready for export, when Uranus-2 leaves for Mars next year. By then, our population will have exceeded 1,100, which is good, because about sixty-five plan to head back toward the sun at that time.

"We have a very busy time in store. Commander Renfrew—nephew, I should add, of the renowned Paul Renfrew, who was the first astronaut to die on Mars—will be supervising his two galleons on a series of missions staffed by both new arrivals and old hands. The goal is to visit all the small inner moons down to five kilometers in size, and probably a few of the small shepherd moons for the rings as well. That means that, by the time Uranus-2 departs for Mars in a year, we will have a very thorough understanding of the satellite system. We also hope to conduct an expedition to one outer retrograde moon, probably Caliban. That expedition will also launch probes to the other four larger retrograde satellites, all of which will land within the next two years. Therefore we anticipate, before Uranus 3 arrives in 2084, that we will have ground truth from every major moon in the system."

He paused for applause. "We also have important goals for the two years before our population grows by another 300. The hole for Avalon-2A is advancing downward and will reach its intended depth in less than a year, at which point the enclosed metal walls will be finished and it will be pressurized, so that the rotating cylinder can be built. Meanwhile, Avalon 1B is being built directly above our heads, and it, too, will be pressurized in about a year. Both can be built at once because our construction personnel has nearly doubled in number, and we have an augmented robotic workforce. The two new enclosures will also have rudimentary emergency construction completed within a year's time. Consequently, when Uranus-2 departs, it will leave one galleon here and take one of our corvets, which is needed to transport migrants from Earth to Mars. Uranus-3, which leaves Mars shortly, will consist of 1 galleon and 2 caravels and will bring us 300 more people. When it returns to Mars, it will take our other two corvets but will leave us 2 caravels. At that point we will have 4 small caravels for continuing our research in the Uranian system. Because we will have three separate rotating enclosures, we will no longer need the corvets to provide emergency shelter.

"The other important capacities to note are our second aerostat and our second Peregrine, which will double our Helium-3 harvest from the atmosphere of Uranus and guarantee a steady supply of it for sale. Uranus-2 is also bringing us two more 25-megawatt nuclear reactors, doubling our power supply. This is important because Uranus-3 will come here faster than ever—18 months from Mars to Miranda—and we will need to produce the liquid hydrogen to permit 18-month flights back. A 36-month round trip will enable a round trip every 4 years, and thus a total of two pairs of vehicles will be able to maintain our connection to the inner solar system on a two-year basis.

"In short, we are entering into an exciting time. I can't even tell you what music, poetry, essays, paintings, and sculpture our people will produce to express in symbolic form our life and experience here, or how many children we will bring into this world and raise up here. Uranian civilization is firmly rooted into the rock and ice of Miranda and can only grow further. We now look outward to Neptune and wish the arrival of human beings to that system Godspeed. They brake into orbit around the last major planet in the solar system in a mere two weeks. Our hope is that they will be able to found a branch of human civilization as vibrant and happy as ours."

The two caravels of Neptune-1—the *Carina* and the *Dorado*—plummeted toward Neptune, fired their gaseous core engines, and blazed into orbit. A day later, as they neared their apoapsis 118,000 kilometers from the dark blue world, the engines blazed alive again and placed the caravels into orbit around Proteus, a polygonal tholin- and stone-covered iceball some 400 kilometers in diameter.

From his seat in the bridge, Commander Jamison Rideout looked at a live television shot of the battered moon—the largest non-circular moon in the solar system and Neptune's second largest natural satellite—and contemplated its tar-colored surface. Pharos—the largest crater, 230 kilometers in diameter—was visible on the western limb and rotating progressively into view. A small, fresh crater on its floor that they had named HQ for “Headquarters” was their destination.

“Wondering about what we’ll find?” asked Chen Jiaying, the expedition’s science officer. “Hoping it’ll be interesting!”

“It should be,” said Rahmatullah Khan, their director of fabrication. “The nickel-iron impactor is visible and it churned up subsurface material pretty deeply.”

“True, but that’s not all *that* interesting. We’re pretty sure we know what Proteus is made of.”

“But figuring out the history of Proteus will take some time, and it’ll tell us when Triton arrived and disrupted the whole system,” exclaimed Jiaying. “That’s very important.”

“But surely you really want to go to Triton! It’s a planet of its own.”

“Of course! Captured by Neptune and slightly bigger than Pluto, with nitrogen geysers and cryovolcanoes . . . a really interesting destination. We’ll get there eventually.”

Jamison turned to Rahmatullah. “So, Rahmatullah, shall we build our own little enclosure on Proteus; say, fifty meters in diameter and fifty long?”

He chuckled. Jamison had been joking about the idea for months. “Sure, Commander. We’ll need about a hundred tonnes of nickel iron to make the outer pressure envelope and another hundred tonnes to make the rotating vessel. We can make the magnets to hold the vessel in place and we can spray water on the outside for radiation protection.”

“Silly,” said Jiaying, shaking her head at Jamison.

“I don’t know,” said Jamison with a smile, so she couldn’t tell whether he was serious or not. “Our first priority is landing, anyway. How long before release of the engines and the orbit module?”

“Fifteen minutes,” replied Barry Adler, the chief of navigation, and therefore responsible for all maneuvers. “The gas core engines are just about cooled down from their firing. We’re also waiting for a third navigation satellite to come into view, allowing us to triangulate our position more precisely. Our orbit appears to be 100.1 by 100.0 kilometers and a slight adjustment can be carried out about an hour from now to circularize it.”

“Good. So, is landing still scheduled for 16:30?”

“Yes, a bit over three hours from now.”

Jamison nodded. “Good.”

They had a lot to do in three hours. Attached to the two caravels was a pair of gaseous core nuclear engines, a large cluster of liquid hydrogen tanks—now nearly empty—and an orbit module with a small hab, communications, a plutonium RTG, and an orbital maneuvering system. Once the engines had cooled down properly, the entire orbital assembly undocked and slowly pulled away; it would circularize its orbit later. Then the *Dorado* and the *Carina*, which had been docked together for the entire two year flight, separated. Each contained half the expedition’s 75 personnel and headed for HQ under its own power.

The *Dorado,* where Jamison Rideout was located, was scheduled to land first. Proteus’s gravity was very weak, seven thousandths that of Earth, and a low orbit around the moon involved a speed of only about 400 kilometers per hour. A brief, very weak burn from the *Dorado’s* chemical engines halved the vehicle’s speed and set it on a collision course with the Protean surface. A second brief burst canceled out the remaining velocity some thirty meters above the moon’s surface. The *Dorado* fell the remaining 30 meters in about a minute and would have touched down at 3 meters per second if a final engine burst hadn’t slowed it further.

The bounce was quite noticeable. “The *Dorado* has landed,” announced Jamison. His voice was transmitted by radio to an orbiting communication satellite, which beamed it via laser to Mars, over 4 light hours away. It was strange to think they were that far away from their starting point. “Landing team, please assemble,” he added, then he rose and headed to the ventral egress area.

The initial landing party consisted of six: himself, Jiaying as their chief science officer, Rahmatullah Khan as the second in command, and three geologists. The space suit donning area was in the rotating section of the ship and was crowded. Jamison had the privilege of carrying the flag of Neptunia, blue with a circle of fourteen yellow stars representing the major moons with a trident, symbol of the old Roman god, underneath. Rahmatullah and Jiaying brought the flags of the Marsian Commonwealth and the United Nations, respectively.

By the time they were suited up, the elevator tube had been extended to the ground and the elevator had been tested. They stepped into the later and held on as it descended to the surface. When the door opened, Jamison stepped out onto the frozen surface of Proteus. Using his maneuvering pack, he fired a short burst of gas to push himself forward, out from under the caravel, then used the bottom of the flagpole to stop himself.

He stood very still for a minute, partly to let the others catch up to him and partly to get a feel for the gravity. Between himself and his space suit, he massed 130 kilograms, but his weight was the equivalent of 100 grams or a quarter pound. Any quick movement could propel him across the surface, so the maneuvering unit was the best way to get around.

Rahmatullah and Jiaying joined him a few seconds later. They looked across the dark, rubbly surface, which was covered by blackish pebbles and sand of an organic/ice mix. Bits of pristine ice sparkled like gems; some was tinged red like a pale ruby. The rolling surface was pitted from impacts, large and small; HQ crater's rim was a kilometer away and displayed a series of dark layers in the cliffs. The sun shone high in the east like a big, fiercely bright diamond, more star-like than the sun they knew. Hovering high above the eastern horizon was Neptune, a glorious azure beauty eleven times as wide as the Earth's moon, casting a cold blue light on the landscape even though only a crescent slice of it was illuminated. Low in the west was Triton, which was about the same size in Proteus's sky as the Earth's moon and very white, but because the solar illumination at Neptune's distance was only 1/900th as much as at Earth, it was not blinding to look at.

"Proteus is beautiful," said Jiaying, and Jamison automatically nodded. Then he pulled a short metal "grabber" from his waistbelt and used it to pick up a fragment from the surface. He brought it to his visor and activated a helmet light; a hand lens feature displayed a close up just above his line of sight. "Tholin-ice mix," he commented. He didn't have a degree in geology, but he had picked up plenty on several expeditions from Phobos to the inner asteroid belt.

"Yes, quite typical," she agreed. "We'll have to take some inside and do a detailed chemical analysis. Have you looked at the stratification in the crater wall?"

Jamison lowered the sample and turned toward the crater wall. The camera on his helmet that served as a magnifying glass for looking at samples now served as binoculars and a detailed view was projected above his line of sight. "Wow, how many layers? I count . . . four?"

"There's a fifth one down near the base of the cliffs. The third one is enormous; if that's all crater ejecta, it was a big impact. We'll get samples from them all this week and try to date them, but this is typical of what we expected, since Triton's capture would have reduced

Neptune's system of satellites to chaos."

"Proteus is a gigantic rubble pile. It's a shame we'll never figure out how many moons Neptune started out with."

"Depends on how you define 'started out.' We might be able to reconstruct several distinct sources of material making up Proteus. The full story will have to await the reconstruction of the history of Triton and Nereid as well. Nereid appears to be a survivor from Triton's arrival."

"This is fantastic. Lots to celebrate tonight." He glanced at the "private" icon in the upper left corner of his vision until it lit up. "In bed as well."

There was a pause, until her reply came in private as well. "Yes, definitely."

A moment later, the three geologists came out from under the ship and alighted near them. Jamison glanced around at the terrain until Rahmatullah pointed to a nearby hillock. As Director of Fabrication, geology wasn't his thing, but he had thought about the best spot for the flag planting ceremony. Jamison nodded and set out in that direction using a "tiptoe" walk he had learned on his expedition to the asteroid Astrea; it mostly involved forward motion and a minimum of vertical propulsion, since that would send them way up above the surface. The geologists were really good at it, and he didn't want to look like an amateur, so he was careful to use it well.

The hillock proved to be the rim of a small crater, but that was alright. He beckoned the others to form a line with Rahmatullah to his right and Jiaying to his left, as was the plan. They faced the caravel and waited a moment for the long-range cameras to focus in them. Jamison wondered briefly where his script was, but he wasn't sure where to find it, and he was too excited to wait anyway.

“This sol, the Neptune-1 expedition has landed on Proteus, the largest moon in the Neptune-Triton double planet system,” he began. “We come in peace as representatives of all of humanity in order to found another branch of civilization. To that end, we claim Proteus and the entire Neptune-Triton system for the Commonwealth of Neptunia, which we establish on this sol, December 21, 2082.” Jamison took his flag and pushed the butt into the loose rubble of the ground; he pushed so hard his feet came up into the air.

He let his feet settle back to the ground and turned to Rahmatullah. “We thank the people of Mars for funding this expedition by planting the flag of their Commonwealth,” he said, jabbing the Marsian flag’s pole into the ground.

“We thank the people of Earth for funding this expedition and, by planting the flag of the United Nations, we recognize that Neptune and its moons are part of the common heritage of all mankind,” said Jiaying, planting the U.N. flag. Jamison nodded; she had said part of his script he had forgotten.

“These moons, Neptune himself, and the resources they contain are now the common property of humanity and will be exploited on humanity’s behalf, and on behalf of the Commonwealth of Neptunia, by the citizens of the Commonwealth of Neptunia,” added Jamison, remembering yet another piece of his script. He let go of his flag, tiptoed back away from it, and saluted it. The others did the same.

It was a good television moment; no doubt several billion people would see it in the next few hours. Two of the flags started to tip over very slowly, so after they saluted them, they turned back to the flags to push rubble against their bases to keep them in place.

"Okay, folks," said Jamison. "Let's turn to our real work: geology!"

The others laughed. It was the signal for the next contingent of geologists to come out of the *Dorado.* They all scattered to look at various craters and boulders.

The live broadcast rode a laser beam to a communications satellite high in Martian orbit, and from there it was beamed in various directions: to Mars, to Phobos, and to the Earth. Sitting in the control room of Neptune-2, Mercedes Patel, Director of Project Neptune, sat up in her chair. "What did Jamison say?"

"Not the script!" replied Jeremy Wambleeska, the Lakota Director of Neptune Science.

"But . . . are all the pieces there?" asked Kwesi Osei, their Ghanean Director of Health Services.

"Maybe, but 'Neptune-Triton double planet system'?" said Mercedes, shaking her head. "That doesn't sound like a legal description!"

"Especially when Rahmatullah didn't use it," noted Jeremy.

They listened to the rest of the exchange. Mercedes pulled up the script their lawyers had very carefully drafted and shook her head. "Well, he didn't claim the Neptune system for us. He claimed it for the Neptune-1 expedition!"

"Jamison has never been very careful about legal and administrative stuff," said Kwesi. "I was worried about this."

"Should we recognize the claim?" asked Jeremy.

"We don't have a choice. We really can't recognize it in an official sense while we are here on Phobos because we aren't a sovereign body; we won't acquire that status until we leave Mars's Hill sphere next month. But by then, Mars will have recognized the claim, and once they do, so will everyone else. If Mars doesn't recognize the claim, we'll have an anomalous situation where a group is living in a planetary system with a claim over that system and the claim is rejected. That might be even more dangerous to our situation."

"They'll have to recognize us as part of Neptunia, once we arrive," said Kwesi. "We'll have the Helium-3 extraction equipment, after all, and that's the only way to pay for one's stay in the Neptune system."

"We sent them and we have no reason to assume they're rebelling," said Mercedes. "I had better call Helmut and let him know of the situation. If Mars holds off recognizing Neptunia overnight, which they could do, considering the hour, that will give me some time to call Jamison, and maybe a few of the others. That way, we can be sure this was just a slip up."

11.

Seron

January 2083

Oskar Langlais read the last line of his last poem, paused, and bowed slightly as the audience applauded loudly. The loudest table by far was the one occupied by his beaming grandfather, Sebastian Langlais, his proud parents, Helmut and Clara, his brother, Charlie, and Charlie's wife, Sirikit. Oskar exited stage left and came around to return to the table in the audience.

A very talented flamenco guitarist took the stage and began to play, but they all shook Oskar's hand and pounded him on the back. "That was great!" whispered Helmut, comforted that the flamenco would drown out his talking over a very short distance. "I'm so glad Dr. Callahan made a public performance part of your plan to take those two poetry courses for credit. Don't you agree?"

"I was terrified, but yes, I'm glad now. People loved them!"

"She said you had real talent, Oskar. And you got an A in the geology of Phobos course as well. Of course, biology wasn't so hot."

"But it's finished and I didn't flunk. I think with two more poetry courses this semester, I can manage to get done, and she said there was no problem taking them."

"Good. The music course will be good for you, too, because you'll be more successful converting your poems into lyrics."

"That's what everyone says, and I will do some of that, but I really want to write poetry, dad."

"I know. You'll need to find a writing job once you graduate; that'd be the best use of your skills. But I suspect you can apply for arts grants through the Cultural Center and get them most of the time. That'll give you 5 or 10 hours a week to write poetry."

"I know. I'm glad they've broadened out their grants to include poetry."

"It was time. The program can support 100 full time equivalents in the arts; that's 400 to 800 people, part time. You'll have a good chance of getting a grant most of the time, I think, if you keep producing. Dr. Callahan's right; you have talent."

Oskar nodded. He was beaming with pleasure. He still needed some sort of job, and he wasn't sure he liked that, but the prospect of doing poetry for pay even part time thrilled him.

The flamenco guitarist was followed by a hilarious skit, then the *Frisol Coffeehouse* ended. The hundred or so people who attended began to file out, though many came up to congratulate the various performers, including Oskar. Dr. Callahan came over to shake his hand as well.

"He earned an A tonight," she said to Helmut. "You know what I think has given him his talent? All the suffering he went through with the leukemia."

"He's only felt good in the last year and a half," said Helmut. "And in that time, he has really blossomed."

"He's internalized his pain and found a way to express it," agreed Clara. "The poetry has been really good for him that way."

"It's cathartic," agreed Callahan. "The lives of the arrivals are usually well planned and organized, and most of the time, statistically, they're first born children! But the native born kids here; they're the real Marsians. They suffer a wider range of personal problems than the arrivals!"

“We can’t screen them out,” agreed Helmut. “But I’m glad that can become something good, like poetry.”

“Yes, definitely,” agreed Callahan. “The arts, and a strong counseling program!”

Helmut laughed. “We have that, too.”

“I’m so glad we finally had a chance to talk, Ted,” Jamshid “Jimmy” Khan said to Ted Bukowski, as they wrapped up their meeting. “I’m sorry that the crash and the subsequent investigation have delayed our conversation by months. But I had to be involved in the investigation. We can’t have a disaster like that happen again.”

“Of course, I understand completely, and I agree. The Prometheus has an impressive safety record of one crash out of some 6,500 flights, but even that is too much.”

“The stakes are very high, especially if the same technology were to fail out at Titan or Neptune. They don’t have the redundancy we have here. Mars has now received almost the entire wave of arrivals for columbiad 23; we have a population of 90,000 people. That’s a lot of people to transport in and out of space, and every columbiad the numbers increase. We welcome NASA’s collaboration to make the process safer, easier, and cheaper.”

“We’re delighted to collaborate with you, too.” Ted glanced at the list of tasks he had typed on his communicator; they had all been covered. “I stay in contact with most major NASA department heads weekly, so it will be easy to write them about specific opportunities for collaboration we discussed.”

“That’s great. I always thought that was the ambassador’s main job!”

“Well, he can’t; he doesn’t know the people in the US.”

“But don’t you think he should?”

“Well; that’s not a question for me to answer.” Ted pointed to a circular sensor array on the wall behind Jimmy’s desk. “I’m amazed how many people have anti-bug sensors in their offices.”

Jimmy shrugged. “Frankly, I don’t know how useful they really are. We have to replace them every two years with the latest technology, which is expensive, and I have never heard of any nation trying to bug our offices for intelligence purposes; not since the war, anyway.”

“I’m told all the embassies take the same precautions against Marsian bugs.”

“No, not against us; against each other. Our counterintelligence service consists of three or four people who are busy maintaining the latest counter-surveillance systems, but they don’t plant bugs. I’m sure of that. This is a small place and we don’t have that many secrets.”

Ted nodded. “So I’ve learned, in my two months here.”

“Are you enjoying Mars?”

“Yes, I love it. Some of it is just the relaxing atmosphere; no metal detectors or bomb threats. Some of it is the culture. Some of it is the purposeful focus. Some of it is the interesting people. It’s a special place.”

“We think so! I’d never go back to Earth, in fact, I’m trying to convince my parents to emigrate here. They’d have to work a few years, but their health is good enough, there are things they could do here, and they could help with their grandchildren! Anyway, it was good to talk, Ted. I’m glad I was able to give you an extra 45 minutes. But I have another appointment in 15 minutes and I have to make a call first, so we’ll have to continue our discussions another time.”

Delighted.” Ted rose, shook hands with Mars’s chief spacecraft designer, and walked out of his office. He was very happy with the meeting; it had gone long, had been relaxed and informal, and had produced a long list of possible contacts.

Exiting from Martech was tricky; most of the university consisted of a maze of underground corridors connecting modules with offices and labs, which generally opened up on a pressurized courtyard. It was easy to get lost and the courtyards often looked alike, unless you knew what distinctive features to look for. Consequently, when Ted came to the first courtyard, he scrutinized it carefully to make sure it had a grove of purple jacaranda trees. It did; he was on the right path out. But he was surprised to note Dr. Lin Changying, the new liaison for the Chinese Space Agency, sitting in the courtyard. She noticed him as well. “Good morning,” she said.

“Good morning.” He paused. “How are you doing?”

“Pretty well. I came to Aurorae only a few weeks ago; mid December. Since then, I’ve been settling into my place and getting familiar with Aurorae.”

“Quite a place, isn’t it?”

“Yes, really fascinating. It’s hard to believe that we human beings have managed to dome over and terraform two square kilometers of the Martian surface and convert it into an artificial Earth. I’m still dazzled by the technology.”

“Yes, and this place is the epicenter.” He pointed to Martech all around them.

“It is indeed. So, were you just meeting with Dr. Khan?”

He hesitated. “Yes; a nice man. You?”

“I have an appointment with him in less than fifteen minutes. But I wanted to be sure I could get here! I’m told there’s an app one can use to navigate the corridors here.”

“Yes, and I used it for a while in November and December, but now I’m pretty comfortable walking around. I’m surprised you just got here three weeks ago. Surely there were flights earlier?”

“There were, but I had other things to do elsewhere. From Phobos, I went to Deimos for two weeks to get to know the Chinese team there working on gaseous core technology. As you probably know, they’re paid half by China and half by Mars. Originally it was an exclusively Chinese team and we had exclusive rights to a reservation consisting of the southern third of Deimos, but after the war China was so broke, we had to surrender our claim to southern Deimos and make the nuclear research a joint effort. Same with our nuclear reactor facility at Dawes, where I spent another two weeks. The arrangement has been difficult because of split loyalties; most of the Chinese staff are now Marsian citizens and proud of it. So I’ve been working on resolving conflicts and coordinating policies better. The result will be better for everyone.”

“I haven’t gone to New Hanford yet, but I suppose I will.”

“I’m going next week! New Hanford’s research overlaps with our Dawes facility and even with our Deimos facility, and there’s not full coordination. New Hanford is no longer under U.S. management, but I suppose better coordination with Los Alamos and JPL is possible.”

“Definitely; they work with Los Alamos a lot. I gather there’s some collaboration between Deimos and Los Alamos as well.”

“Yes, a little over gaseous core propulsion technology, but some breakthroughs are classified and therefore they can’t be shared. I gather Los Alamos has been struggling to find a testing facility.”

“Yes, the American facility on Deimos was crucial to their work before the war. They’ve done some testing at the Earth-moon L2, but it's expensive to get there and hard to recover the test equipment if it's accelerated away from you at a high speed. No one wants nuclear propulsion testing in Earth orbit and there have been 'environmental' objections to testing on the moon."

"Environmental?"

"Yes. The exhaust could interfere with satellites and possibly with the telescopes."

"Ah." She nodded. "I wonder if there's a way we develop collaboration between Los Alamos and Deimos."

"Hum. I think my ambassador would be furious."

She laughed. "So would mine! But the people who did the work for Los Alamos are still at New Hanford, and the U.S. facility on northern Deimos is still there; we've even rented it occasionally! The New Hanford people use it sometimes in their collaboration with our Deimos facility."

Ted nodded. "This is worth pursuing. Deimos could also be used for advanced electric propulsion as well, and we're doing a lot of that in earth orbit. The disadvantage with low Earth orbit is the lack of a big electric power source. But Deimos already has that."

"It does, and Martech is coordinating that research with NASA already."

"It is." Ted looked at Changying with a smile. "It's nice to meet someone else who believes space exploration can be a win-win opportunity! Everyone on Mars thinks that way, but I haven't encountered that approach as much on Earth!"

"That's very true, and it is a shame. It holds us back."

"Let's get together for lunch and discuss this further; how about tomorrow?"

She nodded. “I’m free then. I’d welcome it.”

Neptune-1’s blast off from Phobos was watched live by billions.

No one ever expected to see a metal “drum,” 100 meters or 328 feet in diameter and 50 meters or 150 feet high, massing 5,000 tonnes without propellant, to fly. But the two dozen small engines that ringed its exterior together generated 500 tonnes of thrust and Phobos’s gravity pulled on Neptune-1 as if it massed 3 tonnes, so Phobos easily lost. In just a few seconds, Neptune-1 was in Mars orbit.

Within a few hours it docked with its interplanetary module, which hosted four gaseous core nuclear engines and a tank 100 meters long and 100 meters in diameter, storing fifty thousand tonnes of liquid hydrogen, an enormous amount for Phobos to produce. A busy week followed as the interplanetary module was mated to the C-100 and tested. Finally, the time came to leave Mars. The four gaseous core engines produced 800 tonnes of thrust together and ran for over 1 sol to accelerate the vehicle to 50 kilometers per second. They were on their way on a two-year trip to Neptune.

That evening, everyone gathered on the “patio”--the roof of their habitat, inside the drum’s huge central open space--as usual for supper. Mercedes Patel looked over the thousand residents and felt a flush of amazement. Most of the “drum” was a tightly packed space with small private rooms, floors with intensive agriculture, storage areas for equipment and materials, and a small park that wrapped all the way around the interior, but was only 20 meters wide. The real habitat for them had to be built over the next two years in the empty liquid hydrogen tank “below” the drum, which would provide far more open space and a real ecology. A smaller tank "above" the drum held ten thousand tonnes of liquid hydrogen for their arrival burn, and it provided significant protection against cosmic radiation, although a powerful magnetic field diverted much of the cosmic radiation away from the vehicle anyway. The result was an environment safe for children (though the expedition only included 50 kids).

Mercedes had things to say about their launch, and she was further inspired by the vista in front of her. She rose from her table and walked to the podium on the stage. "Good evening, everyone, may I have a few minutes of your time," she began. "Take a look at your fellow human beings, in all our diversity of skin color, hair color and cut, clothing, and language: we are a microcosm of all of humanity. And now we have cut ourselves free from the gravity of Mars, even the sun; if we do nothing, we will head toward Aldebaran! Of course, by the time we get there in a million years, our reactors will be dead and cold, this enclosure will be airless, and there will be no life left. But that won't be a problem when we reach Neptune in January, 2085.

"We are now an autonomous, independent, sovereign human community. If we have problems, no one can rescue us; we have to take care of ourselves. We are the first expedition to set out for a planet with a thousand people; we are the most self-sufficient expedition that has ever set off into space. And no one has set out in an ark like this; it is completely unique. We are a major dress rehearsal for a twenty year expedition to the Kuiper belt, and who knows what will follow that?

"We are on our way to a remarkable world system; Commander Rideout called it a 'double planet system' and this is true, since Triton is a captured planet. Neptune is fascinating in its own right; its rings and moons are fascinating worlds; and Triton is particularly dynamic in its geology and possible biology. We will be the people to settle that double planet system, discover its mysteries, and build a new branch of human civilization there.

“You all know that already, of course, and the vote we took to name this enclosure reflects that understanding very clearly. The contest is now over; the Council met before supper and approved your choice, which was a clear majority. The choice was Seron, the mythical first town that Noah’s family founded after they exited the ark.”

She paused; everyone smiled and applauded, because it had been the clear favorite. “It’s an excellent choice. Rather than declaring ourselves ‘Neptunia’ before we reach our destination, we now have a name: the Seron community. Seron was ‘the place of the dispersion’ and that is what our Seron will be as well: the starting point, the nucleus of a new civilization, which will spawn many other enclosures on the other moons of the Neptune system, until, who knows, millions of people reside there. It is our privilege to be the pioneers, to break the ground, to harvest the first Helium-3, to discover the bare outlines of the history of the Neptune system, and thereby contribute to humanity’s own advancement. We have much to be thankful for, and I am grateful to all of you for your dedication, sacrifice, and idealism. Thank you for all you do.”

12

Nuke

March 2083

Helmut looked out of the windshield of the ranger at white extending to the horizon in every direction.

The northern polar cap was a vast, flat expanse of slightly dusty ice. They were driving on a sheet of fresh carbon dioxide ice a meter or so thick, fairly transparent, deposited after a winter of extreme cold atop the permanent cap of water ice some three kilometers thick. It was amazing to contemplate that if the entire northern polar cap were to evaporate into the air and fall as rain, it would cover Mars with eleven meters—36 feet—of water. The southern cap would yield a similar amount, giving the desert planet a substantial supply of life-giving H_2O. And this was after 3.5 billion years of the steady drying of Mars, as its atmosphere and hydrosphere escaped into space; it made Helmut marvel at the abundance Mars displayed in the Noachian, when its single-celled life forms thrived in rivers, lakes, and seas.

“There’s the chasma,” exclaimed Wilhelm Steiner, who was in charge of the Nuclear Engineering Program. Helmut turned and nodded, but since the sun was balanced on the horizon straight ahead of them, it was hard to see much. They were driving at 83 degrees north and the sun had just arisen there after half a year of darkness. Spring had just come to the North Pole a week earlier.

A minute or two later, however, the entire Chasma Borealae became visible in front of them. Helmut was startled; it was rather like a white Grand Canyon, a terrestrial landform he had visited as a boy. From their vista point it consisted of cliff after cliff of white, streaked with red and brown layers of sand and dust, tumbling downward nearly two kilometers to a bottom a dozen kilometers wide. Closer to its mouth, the canyon was 100 kilometers wide, but near its top it was much narrower, though still impressively deep.

Unlike Arizona's analog, Chasma Borealae did not have piles of boulders and debris at every cliff base. In many cases the slope was steep, but not cliff like. The track the ranger followed had been very carefully laid out along natural terraces in the side, with short, steep ramps allowing access to the next level. The ranger drove the route autonomously, allow the passengers plenty of time to admire the remarkable scenery. It took 45 minutes to reach the bottom, where they drove along the sides of enormous sand dunes for a dozen more kilometers before reaching their destination in a deep, narrow side canyon.

The stopped before a spherical object some 5 meters across and suited up. There was another ranger there and a team of nuclear engineers completing work on a large fuel cell power plant a dozen meters away. It took them twenty minutes to exit and walk across the 147 Kelvin landscape to what everyone called "the bomb."

"So, this is it," said Helmut, admiring the large, shiny sphere. He reached out and touched it with his gloved hand.

"This is it," repeated Wilhelm. "If the calculations are correct, it will produce 100 megatons of yield, matching the largest hydrogen bomb ever exploded by the old Soviet Union. Located here at the bottom of the chasma, relatively little of the heat energy will be directed upward at space; three quarters of it will be absorbed by the cliffs and the sand dunes. We're still not sure how much ice will be vaporized, but the computer models put it in excess of one cubic kilometer. Imagine that much water rising up, spreading out, then falling as rain and snow over thousands of square kilometers of polar landscape that otherwise is at -126 Celsius. Much of the seasonal carbon dioxide cap will evaporate.”

“I hope Boreal Station really can handle the result,” said Helmut. The winds will get up to what; 300 kilometers per hour? I am not confident that we can model the result accurately.”

“Frankly, that worries me as well,” agreed Wilhelm. “Computer models can only go so far. But we have to run an experiment of this sort to refine the models. And as big as 100 megatons sounds, to really thicken the atmosphere, we need explosives of even greater power; perhaps 100 times as much. We have to work our way up, because it isn’t easy to design explosives of that size, even with the fast computers available to us.”

“And what’s the current thinking about our first explosion at the South Pole?”

“I suspect we can manage 500 megatons, maybe 1 gigaton. I’m hoping we can set off at least two next year, too, preferably in tunnels under the CO_2 deposit to maximize the vaporization in summer and the heat release in winter. But remember we have to vaporize 2,500 cubic kilometers of carbon dioxide to raise atmospheric pressure by just 1 millibar!”

“I know. It’s a daunting task, but it is possible, and it is well worth pursuing. I want to thank the entire team at dinner tonight. This is very significant work.”

“Thank you. Let me give you a tour of our bomb.” Wilhelm said it affectionately. He pointed to the sphere and they walked over. Several others approached and they began to explain to Helmut the large fuel cell pack that would charge the capacitor, the powerful laser trigger that would start the reaction, the reflecting material that would bounce escaping neutrons back into the critical mass, and the huge quantity of lithium deuteride that would carry out most of the actual fusion, producing conditions for a millionth of a second far more energetic than found in the core of the sun. The resulting surface explosion, if targeted at a city on Earth, would destroy every concrete structure within a 10 kilometer radius and every wooden structure out to 21 kilometers, and cause third degree burns out to 65 kilometers. The power of the explosion was almost unimaginable.

Helmut retreated back into the ranger after that to contemplate the implications. Sally Katongole, the chief inspector for the International Atomic Energy Agency, went back in with him.

“Quite amazing,” he said to her, after they had taken off their pressure suits and sat in the cab.

“It really is. I’m used to inspecting plutonium production reactors and isotope separation facilities. I don’t need a pressure suit for that work. But here, the extreme cold, the limited light at the bottom of the canyon, and this . . . thing. I don’t know what to think of it.”

“As an inspector, you have no thought?”

“It’s really none of my business. Mars isn’t doing anything illegal because you haven’t signed any of the nuclear nonproliferation treaties, and since you aren’t on Earth, this experiment has no global environmental or proliferation implications. Still, it is truly . . . amazing that you are doing it. I wouldn’t call it shocking. Maybe startling.”

“Because it’s bold?”

“I guess it’s bold. It’s big. The U.S., China, the European Union, and various other nations have come out against it, but I gather their condemnation will be rather weak. No one thinks you’ll send one of these things flying toward Earth.”

“If we wanted to destroy a city, we’d divert an asteroid. It wouldn’t produce fallout, either."

"I know, you've repeated that several times in public. But even so, there's a visceral, emotional reaction to setting off something like this. Science isn't the only factor to consider."

"That's true," conceded Helmut.

Just then, there was sound at the airlock as someone else entered it. They turned towards it as the lock expelled all dust from the person's suit, then filled with regular air. When the airlock opened several minutes later, Andrea George stepped in.

"We completed installation of the seismometers a few hours ago," she said to Helmut. "The nearest one is 8 kilometers from here in a side canyon that probably will survive the explosion, at least for a few seconds. We have others as far out as 60 kilometers."

"And cameras, right?"

"Yes, special ones; the nearest one is thirty kilometers away and will broadcast live. It probably won't survive."

"I wonder whether Borealis Station is safe."

"We should be, but we may be buried under some debris. We won't be able to go anywhere for a few sols."

"No. So, Andrea, what do you think of this?"

She looked at Helmut directly. "We're playing God."

"I think that's true, but so is enclosure and pressurizing an area of the Martian surface and a million other things that human beings do, like modifying species and damming rivers."

"True. But . . . Helmut, the northern and southern layered terrains are *beautiful.* I don't just mean that as a geologist, either; they are physically stunning places. That's why we bring tourists here. They are unique environments in the solar system. And now we plan to destroy them."

"That's true. Of course, we could always preserve a piece of it for tourists and ourselves to enjoy. But these polar terrains are the products of the current obliquity of Mars. They come and go depending on the amount of sunlight the poles get. Six hundred thousand years ago, these terrains did not exist. The planet's tilt is increasing again, slowly, as you know, and the terrains are evaporating away again anyway. All we are doing is speeding up the process."

"I wouldn't say that's *all* we are doing. Even if we decided to leave a portion nuke free, it would still be swept by the wind blast, dumped on by the freed water vapor, and contaminated by radioactive fallout. This is a permanent change; by permanent I mean for thousands of years. What we are doing won't look like a regular onset of an estival in the geological record. And how many bombs will we need to explode? A few thousand? It's mind boggling, Helmut. Especially for me. Studying the layered terrains is my career. And now I'm collaborating in the destruction of my area of study." She shook her head.

"I'm . . . sorry, Andrea," replied Helmut. "But if we can triple the thickness of the atmosphere, or even quadruple it, cactars will be able to exist in the wild, Martian life forms will survive in many places, dome construction will be simplified, water will be easier to obtain, there will even be a certain amount of oxygen in the atmosphere to extract. It will be better for everything."

"Don't forget the dust storms. The geological record suggests they get pretty bad, too."

"There will be down sides, I'm sure, and dust storms probably will be much worse unless we can warm the place with chloroflorocarbons and increase the atmospheric humidity. We all concede that."

"Well, I guess that's something. The underground explosions, remember, will churn up and destroy strata laid down over billions of years. It will erase part of the record of the development of this world. When I say we're playing God, I'm not referring to trivial changes like building dams or modifying species. Terraforming, even if it's partial, is of a totally different magnitude."

"Well . . . I concede that, too," agreed Helmut.

At dinner that night, Helmut thanked everyone for all their work. It was a strange evening because the nuclear engineers were excited and anxious, while the geologists were in grief. They were sitting at separate tables, indicating a history of painful conversations.

But everyone was up early the next morning. Helmut stepped out of the buried collection of metal cylinders that made up Borealis Station into its small enclosure briefly to take one last look at the layered terrain around them, wondering what it would look like in a few short hours. The enclosure was not large—just thirty meters in diameter—and it was extremely cold, but it gave the station personnel a small bit of "outside" to alleviate cabin fever. Sometimes they went out with heavy coats and played basketball. Helmut wondered whether the enclosure would survive.

At 10 a.m., the engineers and seismologists went into the control room. Helmut went in with them, scanning the dozen screens that carried the live feed from cameras scattered around the area. Equally interesting, though, was the north facing window—facing away from the explosion—that provided a view of the enclosure and the terrain beyond.

"Here we go," said Wilhelm, when the laser's capacitors were fully charged and everything was go. "Ten . . . nine . . . eight . . . seven . . . six . . . five . . . four . . . three . . . two . . . one." He pushed the "ignite" icon.

There was much too much to see, all at once. Helmut focused on the window, where an unnaturally bright light poured fiercely into the room. They were over 100 kilometers away and the thin, Martian atmosphere was not very reflective, but many kilometers of white ground reflected and transmitted the flash to them. Helmut turned to the screens. Some were blank; the cameras had already been burned up. Others had dead centers where the flash had burned out part of the camera. But the cameras that were farther away provided a spectacular view of an immense fireball breaking through the ground, expanding, and rising into the sky. The mushroom cloud rolled upward while an expanding ring of white raced toward them. It quickly became obscured as vaporized water and carbon dioxide, rising from the terrain near every camera, produced a fog that hid everything.

Helmut looked at the window again. The flash had faded away, followed by an obscuring of the sun as well, as the land around the station yielded its vapor. It got darker and darker outside as the vapor, filled with dust, blotted out the sun.

Then the wind began, and it picked up fast. The vaporization increased the atmospheric pressure and the gas rushed away from the explosion; at the edge of the fireball it expanded outward faster than the speed of sound. Within a few seconds there were already gale force winds outside from the many kilometers of vapor released nearby; the shock wave from the fireball was still many minutes away.

The shock wave transmitted through the ground arrived first. Two minutes after the explosion, an earthquake began with a sharp jolt, followed by a rumble and a steady shake. Depressurization alarms went off. “We’re okay, we’re okay,” exclaimed the environmental control officer. “The leaks are between modules, not in them.”

“Oh, there goes the enclosure!” said Helmut, noting the data from the enclosure indicating a sudden drop in pressure.

“That was expected,” said the environmental control officer.

Helmut looked at the window. It was dark as night outside and almost nothing could be seen.

Then then heard the wind—they actually heard it, in spite of the thinness of the atmosphere. Cameras outside the station faintly showed debris racing by, but one by one they were wiped out as well. Data from all the remote cameras scattered around the area stopped as well. “There’s too much stuff in the air for the transmission,” said Wilhelm. He looked at Helmut, frightened. Helmut looked back to him, frightened as well.

But the shaking was rapidly dropping, and the roar outside began to decrease as well. In another two minutes, it was quiet, though the window still dimly showed material racing by.

“We’ve got a satellite view,” said someone, who had been playing around with the various feeds. She put the image up on a screen, which showed a huge glowing white cloud rising up into the Martian atmosphere.

“We will be sending dust and gas all the way up into low Mars orbit,” said Wilhelm. “But most of the gas will come back down eventually. Not too much will actually escape from the planet.”

“The preliminary data from the seismometers suggests a full yield,” reported Sally.

"If that wasn't full yield, I don't want to think what a full yield would feel like!" exclaimed Helmut.

"The shake will be felt as far away as Cassini Borough, 6,000 kilometers away," said Sally. "When we start setting these off at the South Pole, Uzboi will feel them."

"And this one won't even thicken the atmosphere significantly," said Helmut, shaking his head. "We are embarking on a sobering path."

Ted Bukowski didn't get up at 5 a.m. to watch the live feed from Borealis Station; it was an important and controversial event for almost everyone in Aurorae, but wasn't a concern of his. When he did rise, though, he turned on *Mars This Sol* and saw the cloud-obscured outline of a crater over a kilometer in diameter where Borealis Chasma used to be. Unlike the impact craters that dotted Dusty Red, this one had no raised rim or ejecta blanket. It had been melted and vaporized into the three kilometers of water ice covering the polar plain. Special data processing had been necessary to reveal the crater at all because the miasma of dust and snowflakes had extended hundreds of kilometers from the explosion point and was still expanding. At Cassini, several depressurization alarms had gone off. Even Aurorae's seismometers had detected the shake.

Ted contemplated Mars's newfound power and its implications for NASA cooperation while he took a shower. As he was drying off, his automated assistant, Buzzy, said, "You just got an email from Sandy Coates with an angry videomail from the Administrator."

"What?" Sandy was the NASA liaison at Goddard Station on the moon. Buzzy just repeated itself, so Ted said, "Play the message right here."

The bathroom had a screen and it started to glow, then the angry face of Britton Elwood. “Mr. Bukowski, what the hell is going on up there? You’ve been on Mars how long now? Four months? And I’ve gotten a total of five bland reports from you! Are you talking to anyone up there? You must be, because I was talking to Rand OMalley at Los Alamos a little while ago and he said his team is in touch with June Addison at New Hanford about collaboration over a new gas core design! Why haven’t you mentioned that to me? I want to hear from you right away about this matter, or your commission will be at risk!”

He stared at the screen, shocked. He sent reports to her almost every sol; probably five per week, and after 16 or 17 weeks that would total nearly 100! There could be only one answer: Ambassador Danforth had decided not to forward them through the embassy’s secure communications line.

And that also explained why the Administrator hadn’t used the secure system as well, but had written his private email account via the public communications system and had forwarded the message through Sandy. The more he thought about it, the more it made his blood boil.

He pulled on a shirt, so his videomail would look professional. “Buzzy, send this video reply to Sandy Coates.” He paused. “’Sandy, thanks for forwarding me the Administrator’s message. I’m about to forward you dozens of reports to the Administrator. Please send them on to her immediately. It appears that someone in the embassy did not like the nature of my work and decided not to forward them to her. Bye.’ Buzzy, how many reports have I sent directly to NASA Administrator Elwood since I landed on Mars on November 3d?”

There was the briefest of pauses. “Twelve videomails with written attachments and 74 written emails.”

“Buzzy, please send them all to Sandy Coates via my personal email.”

“You have to forward them through your government account, not your personal account.”

“I know and understand that, Buzzy. Someone in the embassy has refused to forward them to Administrator Elwood on my behalf. She has written me via Sandy because she suspects the problem; otherwise, she would have written me through my government account. But she sent me government business through Sandy to my personal account. Please send all the videomails and emails I previously send to Administrator Elwood to Sandy Coates immediately.”

“I understand. It is done.”

“Thank you.” Ted wondered whether Buzzy was programmed to do as he asked, or whether Buzzy would just report the violation, or both, but suspected Buzzy would do as he said and store the violation for a later time. After he finished dressing, he went into the electronic communications system by hand and saw the messages had indeed been sent.

The bigger question was what to say to Ambassador Danforth. No one else in the embassy could authorize the blockage of communications. It was possible the blockage occurred in the State Department, which had to forward the messages to Administrator Elwood, but he doubted it. With any luck, Elwood would advise him.

Distracted and uncertain, he went out of his place and walked to City Square for a quick breakfast. But out of curiosity, he diverted to Andalus Square instead to get breakfast and see whether there was a debate about the nuclear explosion. He was right; as soon as he entered the Square he saw a demonstration in front of the Capitol. It wasn’t huge—just a few dozen people—but it was noisy.

“We must stop this destruction of our poles,” John Hunter was saying from the steps of the Capitol. Ted was startled to see the veteran resident of Mars and among the first 50 arrivals leading the demonstration. He was even more surprised that his wife, Nobel-prize winner Vanessa Smith, second Chancellor of Martech and advocate for native Martian life, stood next to him. “They are Mars’s water treasure. They are a unique landscape, with a unique beauty. They are a precious resource. Throughout the history of Mars, they have come and gone naturally. Just because they are now slowly going away does not mean we have the right to blow them up, smash the record of sedimentation they have left us, and convert them into a radioactive waste! Leave them alone! Why spend billions when the result will be a very weak estival at best, a tripling of atmospheric pressure, and an enormous expansion of the dust storm season! We don’t need dust raining down on our domes and a perpetually gray sky. The only things that will gain are the unnatural cactars we have created for the outside environment, which aren’t needed for anything. The native life forms won’t be able to spread over the surface because it will still be too cold, too dry, and too drenched in solar UV for them to survive. So why are we doing this? As a foundation for a much larger terraforming effort later? If so, why not wait until later when our capacities will be so much greater, our understanding of the processes so much better, our technology so much more powerful? There will be ways to melt the poles without nukes, to accelerate the natural processes without doing profound damage to the land. Marsians must respect this world, not tear it up.”

The crowd applauded. “I advocate for Martian life more than just about anyone else,” said Vanessa. “Everyone knows that. They can wait a few more centuries or millennia for a natural estival; they’ve been waiting several hundred thousand years already! Because the approach we are taking is poisoning the land. These are thermonuclear *weapons.* We are not planning to turn them against ourselves or against the Earth, but we are turning them against our own land, the Martian range. Their advocates minimize the damage, note that the range is already bathed in cosmic rays, and that the radioactivity can't get into our enclosures. But why make the radioactivity outside worse? And how do you know we won't drag some radioactive dust inside on our pressure suits? We do that all the time. Why spend the money to blow up the poles when we can wait and avoid these problems?"

The crowd applauded again. Then they began to march back and forth in front of the capitol building chanting "Stop the nukes! Stop the nukes!" while the cameras of the news media captured the whole thing.

Ted came up close to watch. When the demonstration ended—which was quick, considering how small it was—he walked to the old Emporium building, which used to be the commercial hub of the borough, but was now a government office building. The exception was the first floor, which was still filled with cafes and restaurants. Of course, most of the demonstrators, and a few of the media people had gone there for coffee as well. "Helmut Langlais isn't here yet, is he?" he asked one demonstrator, who had sat at a neighboring table.

She laughed. "He won't be back for a week, maybe 10 sols! Borealis Station is buried under debris, it has some leaks, and the Borealis Trail has been destroyed. Both Cassini and Aurorae are sending down heavy equipment to reopen the trail!"

"Sounds like they'll have to set off future explosions underground, to minimize the debris, as well as the radioactivity."

"If we get our way, there won't be any future explosions!"

“Do you really think you can stop them?”

The woman considered a moment. “Yes, I think we can. The argument that we’re making an emotional argument is really not taking the issue seriously, and it has to be. Maybe the nukes aren’t poisoning the Martian environment extremely, but why do it at all, really? Langlais’s popularity did suffer some from the accident. He handled it well, but it took off some of the polish on his record. He needs to retain his popularity, and this is an issue that can undermine it. I don’t think most people will care if he cancels the program. More will care if he doesn’t.”

“That could be.” Just then, Ted felt his communicator vibrate. It was Administrator Elwood. “Well, thank you for your view. I’m new to Mars and I’m still figuring out the politics up here.”

“It’s a bit hard to figure because there are no political parties and therefore the various positions are diffuse,” she acknowledged.

Ted nodded, picked up his coffee, and headed outside. The square was quiet now. He went to the very center and played the videomail through his earpiece, so no one could pick it up.

“Thanks, Ted, for your quick response. As you can see, I am replying directly to your personal email. I suggest you go explain to Mr. Danforth that you work for me, not him, and that I am the only person who can fire you. From now on, send me your official reports through the embassy as usual, but send a message directly to me via your personal email that you have sent it. If it doesn’t show up, I’ll let you know, and we’ll both inquire as to why. Bye.”

He watched her face disappear and wondered what to make of the sleuthing. Then another email arrived, from Sandy. It was another message from Elwood. “To be absolutely clear: we report to the Vice President, and she has said that the nuclear explosion is not to interfere with our relationship with Marsian space agencies and personnel *in any way.* Ambassador Danforth reports to the Secretary of State, and their position is to condemn the explosion and limit contact with Marisan agencies and personnel. You are to continue your current work, on authorization of the Vice President herself. I hope that is abundantly clear. Bye."

Her face faded from the screen. Ted sighed and said aloud, "Shit, I hate politics!" He suspected this set him up: he could be fired by her if he stopped his work, and he could be fired by her if he continued it and the Secretary of State complained to the President loudly enough. His relationship with Danforth was ruined, too.

But he preferred to ignore the explosion anyway, because he loved the work Mars was doing and wanted the role of the United States maximized. He'd go get drunk later. First, he'd go confront Danforth. He walked across the square to the embassy.

Danforth was available and immediately admitted him. "I need to speak to you anyway," he said, "because we are condemning the nuclear explosion and are cutting off all contact with Marsian space personnel, effective immediately. The condemnation has already been issued. The Secretary of State will discuss the matter in his daily press conference in another two hours, at which point I will issue a statement reiterating the Secretary's conclusions. I'll be meeting with Chief Minister Langlais as soon as they dig him out of Borealis Station and get him back here."

"I see," replied Ted. "I'm here because Administrator Elwood is extremely upset that only five of my reports have been forwarded to her over the last four months. In that time I've composed about one hundred of them."

"Yes, I have felt that they were getting us too involved in the Marsian space efforts, so I have withheld them pending clarification from Washington. Now, of course, the issue is moot, because you have to stop your efforts anyway."

Ted swallowed. "Well, sir, you have your orders from the Secretary of State, and I have mine from the Administrator of the National Aeronautics and Space Administration. Mine are to continue my work and send my reports to her, either through proper channels or through an alternative means of communication at my disposal."

"Alternative means? There are no allowable alternative means, and using them is against regulations. I will fire you if you communicate to the Administrator any other way than through our secure system."

"Sir, you cannot fire me because you are not my boss. The embassy is my proper home base and means of communication, but my work is independent of it and it is to continue. My communications to the Administrator must also continue, preferably through proper channels."

Danforth waved a finger at Ted. "Mr. Bukowski, you will do as I say or you will be without any work, without the means of getting work—I can arrange that as well—and you will be on the next ship back to Earth."

"I'm sorry, Mr. Ambassador, but you have your orders and I have mine. I think I have made my request clear: I want my communications to Administrator Elwood to go through without interference. I now repeat that request, not in anger or fear, but simply as one servant of our country to another. Please allow and assist me in my efforts to complete my duties."

Danforth shrugged. "You're clear, now get out. I think I've been clear, too."

Ted nodded. His hand was shaking a bit as he rose, even though he tried hard to hold it still. He turned, walked out of the embassy, and headed straight to the bar he had found. It wasn't open yet, so he walked around Aurorae several hours until it was.

“The nuclear testing facilities on Deimos are in good shape,” June Addison said to Ted. “I can send you the video and evaluation report the engineers on Deimos have sent me.”

“Send a copy to me, but send a copy to the Los Alamos team as well, because they’re the ones who need it.”

“You don’t want to forward it?”

“I’ll forward it to the Administrator, but meanwhile, we’ll save time if it goes straight to them from you.”

“Okay. But I gather we can’t sign any agreements.”

“We can’t until June or July. That’s my guess, anyway; the State Department’s ban will last that long, I think.”

“We won’t be ready until then, anyway. We need to revise our budget and reallocate personnel.”

“That takes some time.” Ted looked at the facility around them; they were drinking coffee on the “midway.” “New Hanford is very impressive.”

“We’re not the largest nuclear research facility, but we file more patents than anyone else. Our gaseous core research lies behind all the engines used in space today, by all nations. Our breeder reactor and heavy water reactor technology is cutting edge. It’s hard to find an area of nuclear engineering we haven’t influenced.”

“I know; it’s remarkable. And it was an American-Marsian partnership, more or less, all along. We want to strengthen that relationship.”

"And you're sure we can do this?" June pushed.

"Yes. Administrator Elwood is in favor, and I report straight to her, not to Ambassador Danforth. I do have to lay low a bit. It took me two days of indecision and depression to realize that the suspension of relations can't last forever and that I needed to talk to people, but cut back on the reporting. I can lay the foundations without reporting much progress; people can do a lot of the networking directly with terrestrial colleagues rather than through me. That's working."

"Good, I'm glad. Because with Danforth, we had no way to make contacts."

"I know, but I can do it." He didn't add that when he contacted people on Earth to establish a relationship with Marsian colleagues, he asked them to email Administrator Elwood and clear the relationship with her.

June downed her coffee. "Helmut has a press conference in a few minutes and I want to watch it. Whatever he says about the nukes effects our programs pretty significantly, as you can imagine."

"I can. Can I watch with you?"

"Of course. Let's go back to my office." She rose and he followed her back to her big, beautiful office. She had a large wall screen and as soon as they entered, she put *Mars This Sol* on it.

"He's going to speak from the steps of the Capitol!" exclaimed Ted. "Is that a reply to the demonstrators?"

"Probably, and Marsians are too polite to interrupt or heckle him."

Just then, Helmut came down the steps to a microphone set up half way down the steps. The camera pulled back, revealing a big, attentive crowd.

"Good afternoon, my fellow Marsians," he began. "It's good to be home, safe and sound! Borealis Station will be putting everything back in place for a few months. The enclosure was popped and it actually blew away; at its peak, the atmospheric pressure increased fivefold and the winds hit four hundred kilometers per hour. The ground vibration shook loose several seals between modules, and they were fixed within a few hours. But the debris blocked the garage doors for several sols and the Borealis Trail was a mess. We now have it cleared and traffic is back to normal.

"The explosion vaporized several cubic kilometers of carbon dioxide, as predicted. The radioactivity generated was as predicted; there are 100 square kilometers of terrain where people can cross via vehicles, but cannot get out and explore for at least 20 or 30 years. The dust blasted into the air was more than expected; as a result, the polar atmosphere is warmer than usual, and therefore the seasonal carbon dioxide cap will evaporate faster than usual. As you know, the north polar cap has no permanent CO_2 cap so this does not affect the atmospheric pressure permanently, but it will mean that the planetary atmospheric pressure will be about five percent higher than its seasonal normal for about six months. The atmosphere will also be wetter than usual by a very small amount because the explosion created a crater several kilometers in diameter and over a kilometer deep. That extra water will not persist, however, because our atmosphere will not be significantly warmer.

"Overall, we are pleased by the results of the explosion. The next explosion is scheduled for late March of next year. It will take place two kilometers underground; the site has been identified and all during the southern hemisphere winter the tunneling effort will proceed. The resulting fireball will be confined underground, but the overburden will collapse into the hole.

This will confine the flash; there will be no instant vaporization of thousands of square kilometers of permanent cap. But the majority of the overburden will be converted into water vapor and it will spread out, cool, and produce rain and snow, which will vaporize CO_2 over several weeks. This will provide a more gradual release of the carbon dioxide cap. It will also reduce the radioactive fallout, because much of it will remain underground.

“In short, this event has confirmed us about the value of the approach we are taking. As the explosions get larger, they will be set off deeper underground. They will have the ability to clear hundreds of square kilometers of their permanent carbon dioxide deposits quickly and accelerate the natural vaporization of dry ice over thousands of square kilometers. We think we can put the entire permanent cap into the atmosphere in several decades. The thicker atmosphere will serve us well; our air vehicles and space vehicles will benefit, our enclosures will need less reinforcement, there will be parts of Hellas Planitia and Valles Marineris where Martian lifeforms will be able to grow outside, and cactars will be able to reproduce on their own. There will be much worse dust storm activity, but the pros will outweigh them. Outside the polar areas, radioactivity will be barely detectable. We think a continuation of the healthy debate Marsians have already had about this issue is important, valuable, and will reinforce the existing consensus. I will now take questions.”

“Oh, that’s a relief,” said June. She turned off the program. “I’ve been quite dismayed by the negativity and emotion the explosion has stirred up.”

“I was watching the demonstrations, the morning the explosion was set off. It struck me as more than just emotion. John Hunter and Vanessa Smith were both there, leading the discussion.”

“I was shocked to see that, and it is most unfortunate. But they’re the only ‘veterans’ in the anti-nuke camp. Radioactive dust is completely harmless on the outside of a pressure suit, and if those suits are cleaned thoroughly—which is already necessary because micron-sized dust particles are carcinogenic even without any radioactivity—then none of it will get into the enclosures. Back in the mid twentieth century, radioactive fallout was an issue with Strontium-90 being taken up by the grass, then eaten by the cows and concentrated in dairy products. That was dangerous. But that can’t happen here. Fallout can’t get into the enclosures.”

“What about new enclosures?”

“Precautions can be taken to avoid that. The top ten centimeters of regolith can be dug up and removed from the enclosure. The rest can be thoroughly mixed so that any remaining dust is diluted. The construction people have already thought through their procedures.”

“That’s good. I’m new here, so I don’t know the usual details Marsians take for granted. I really appreciate your time and the tour of New Hanford, Dr. June. Let me know if you encounter any problems or need other contacts or introductions.”

“I will, thank you, Dr. Ted.” Ted rose and they shook hands, then he headed out of her office and toward the transportation center. All the way back to Aurorae, he contemplated his conversation with June Addison. He was beginning to figure out how to work for Elwood without raising the ire of Danforth.

When he got off, he was in Cochabamba Enclosure. He walked back to his apartment overlooking City Square. As he approached the square, he saw Will Elliott walked out if it.

“Ted Bukowski, how are you?” said Will, stopping to shake his hand.

“I’m well; how are you?”

“Not bad, for a man approaching 82. I try to walk 7 or 8 kilometers a day. I just finished it.”

“How long does that take?”

Will shrugged. “Ninety minutes. How’s your work?”

Ted laughed. “That’s a good question, and I don’t know whether I can begin to tell you! Well, why not, if you can keep a confidence.”

“Yes, I can, and perhaps I can advise you. I know something about politics.”

“I suppose. Come up to my place.” Ted pointed to a door nearby and Will followed him up the spiral ramp to Ted’s apartment. “Please excuse the mess; I don’t entertain. Would you like something to drink? Wine? Beer?”

“I’m a Bahá'í and don’t drink that stuff, but I’ll take coffee, tea, or plain water.”

“Oh that’s right, I apologize. Buzzy, please bring us two waters and put on the water for Marjeeling. I’ve already had two cups of coffee.”

“Marjeeling’s fine.” Will sat. “Looks like you got all your furniture.”

“Yes, it took a month or so, but I’m comfortable now.” Ted sat next to him; a robot entered the room with two glasses of water, which they took. “It’s complicated. Administrator Elwood wants me to build as many collaborative projects with Mars as possible on a win-win basis, and the possibilities are immense. Ambassador Danforth wants me to do as little as possible and agree to deals only if the U.S. is the dominant partner and gains more than it gives. Elwood is my boss. Danforth thinks he’s my boss. Danforth has blocked my official communications with Elwood. I have been sending them in a clandestine fashion. I have had to arm my apartment with anti-spyware—” he pointed to the device stuck on the living room wall.

“And I have been told everyone wants to bug my conversations, but others have told me no one has bugged anything since the American-Marsian War. The Secretary of State wants to shut down cooperation with Mars and NASA’s administrator, who reports to the Vice President, wants to expand it. Anything I do could get me fired.” He shook his head and downed the glass of water.

Will understood the drinking gesture. “That’s tough. What have you done?”

“After Elwood realized she wasn’t getting reports from me, we started communicating via a third party, but not through the embassy. It’s against regulations, which is a problem in itself. Now I’m talking to people here, connecting them to people on Earth—at Los Alamos, JPL, and other places—then writing the people on Earth through my personal email and asking them to email a report to Elwood. That keeps her informed.”

“Clever, and a ridiculous situation for you to be in. Who is going to intercept your personal emails? The Chinese have no ability to do so. Why would the Marsian government care? They don’t intercept emails; you have my word on that. But if they did, why would they want to interfere with your work? It’s to their benefit!”

“I know, it’s crazy! But are you sure they aren’t spying?”

“I’m sure. I still get briefings. The US, China, and Mars all spend millions every year to prevent the use of spyware, and no one has ever detected any, but they spend the money anyway. I suppose it’s unavoidable.”

“I haven’t slowed down my efforts, but I have postponed any semi-final or final agreements, because of the nuke.”

“That’s wise. The US was one of a dozen nations who condemned the test. But wait and watch. The time will be opportune to finalize them all, probably in 4 to 6 months."

"That's about what I figured."

"Good. You're getting the hang of the place! We like win-win situations; Mars is built on them. Danforth has been here since 2070 and he has never understood that. He was an astronaut before he was a diplomat, but he has never understood this place and has always felt he needs to defend America against Marsian interests. When I was Chief Minister, I was never able to establish a rapport with him. The Chinese have been more cooperative."

"It's really a shame."

"It is. But it puts you in a difficult position. You are NASA's workaround; a solution to a problem they have. So you have to be very careful. It sounds like you understand that well, too."

"Can I bounce the problem off you periodically?"

"Of course, I'll be glad to help. But meanwhile, you can get your own encryption, so you can communicate to Elwood without using an ordinary private email."

"I can? How?"

"Contact Per-Olof Grenander. He installed this stuff, right? And installed apps on your electronics, to route communications through the embassy, right? He can install aps to encrypt communications and route them through another node, such as NASA's. You'll probably want both options."

"I will, but how much will it cost?"

Will shrugged. "Have him bill NASA."

Ted looked at Will, then laughed. "Thank you, I had no idea!"

"You need to ask an old expert. Contact me any time!"

13.

Conversation

April 2083

“That’s the final report about immigration,” exclaimed Lily Estrella, Minister of Immigration. “The short summary: when you include the crash and the loss of 300 people, it was our worst immigration wave ever, and the only one with loss of life. But we recovered from disaster quickly; it demonstrated the resilience of our systems. It even demonstrated the capability of our vehicles, since the cause of the accident was a freak defect that hasn’t been found in any other vehicle. Phobos handled the temporary backlog of arrivals quite well, and once people got to the surface they were accommodated quickly. Housing, furnishing, employment, orientation, and skill certifications all went pretty smoothly.

“The question now is what number to set for the 2084-85 immigration wave—columbiad 24. Our population is now 85,000. We’ll receive a second wave in autumn of 9,000 people, and we currently are experiencing 800 births per month. We’ll hit 100,000 in December. That’s something to celebrate.”

“Our current plan is to fly 40,000,” said Helmut. “Jimmy, that’s supposed to include a C-100 carrier, but development is behind schedule.”

“Yes, the crash delayed our space vehicle construction and design efforts because so many engineers were diverted to the crash investigation and the inspection of all Prometheus vehicles. But the delay can be handled if the carrier-100 flies back here from Earth with 4 corvets and construction is completed en route. A C-100 is 100 meters in diameter and corvets have an external diameter of 62 meters, so 4 of them can be docked to the top of a carrier. The other end can accommodate up to 8, even 10 gaseous core engines. Corvets normally transport 1,250 in a 120-day flight configuration, but if they're attached to the open volume of a C-100, they could be converted into dormitories, basically, with all food, recreation, and open space moved to the C-100. As such, each corvet could accommodate 1,800 to 2,000 people. With some people actually living in the carrier as well, the complex can transport 8,000 to 10,000 people."

"How many would be employed in construction during the flight?" asked Helmut.

"As many as we can train, and a big team of robots. If we fly them to Mars on the slow side—5 or 6 months—they could get a lot completed, and by the end of the flight their living quarters would be much more comfortable."

"What about radiation protection?"

"Magnetic deflection will eliminate a lot of the cosmic radiation and the mass of the ships will provide protection from solar storms. The corvets would slip into hangars horizontally; they'd have hydrogen tanks above them. Below them, there'd be a ten meter high pressurized zero-gravity volume with corridors connecting the vehicles to each other and the carrier, with gymnasium spaces in between, and several observation decks."

"This is an excellent design for future use, too," said Lily. "Because the corvets would provide robust lifeboat protection for the entire complex."

"If we had several C-100s available, what could you do with them?" asked Crystal Kern, Minister of Space Exploration. "Because in March of next year, Mars and Ceres are at opposition. Ceres is preparing three C-100s that will leave Ceres this summer and fly to Mars. Two are supposed to arrive here next summer. They'll perform a gravity assist maneuver that sends them straight to Earth so they arrive in February and March 2085, 3 and 4 months after opposition, respectively. The third C-100 arrives here next spring and will supply Phobos with three hundred thousand tonnes of water and twenty thousand tonnes of metals. We can certainly speed up the third C-100, unload its metals and water, and send it to Earth on a faster trajectory that would get it to Earth a month or two before the November 2084 opposition with Mars."

"So that gives us two C-100s," said Helmut. "What about the two with water and metals for LEO?"

"One has been sold to Swift, and he may want the other one as well," replied Crystal. "There's no place to offload that much water in LEO, but it might be possible to empty one of them into the other, since they'll arrive half empty. We'll have to look into that. It might also be possible to empty one most of the way and use the leftover water as propellant for the gaseous core engines. We have run engines on water propellant before, though we prefer to use hydrogen supplementation."

"Well, that should be possible," said Lily. "The specific impulse takes quite a hit, but it's better than a solid core nuke, and the delta-v back to Mars doesn't have to be high."

"If we could get three C-100s, then our existing fleet of twelve corvets would be sufficient to transport 24 to 30 thousand," noted Helmut. "A second flight via the inner solar system back to Earth, then back here mid-columbiad could bring us 10 thousand more. We'd also make substantial progress toward the use of C-100s for columbiad 24."

"Another option would be to stack two levels of corvets onto a C-100, eight altogether," suggested Jimmy. "That wouldn't be difficult to do, and there's time to construct the docking facility we'd use. Even if we had only two C-100s, we could still accompany each one with as many as eight corvets. That would mean even more workers for in-flight construction of housing in the C-100."

"So, we have a lot of options, and with a C-100 coming from Ceres, we can still order more metal and plastics," noted Helmut.

"Well, time is running out for that," said Zhang Bao-zhi. "But the C-100 coming from Ceres is bringing more water and metal than we have made plans for. The water can be pumped into the hollows inside Phobos. We'll recover ninety percent of it later."

"What about the C-100s going to Earth?" asked Helmut.

"We're sending two C-100s because Mars is perfectly positioned for a gravity assist," replied Bao-zhi. "The gravity assist cuts the delta-v from Ceres to Earth in half. Our own need for hydrogen and oxygen propellant in LEO is about 200,000 tonnes per columbiad. Ceres is planning to send a lot of nickel and cobalt to Earth on those C-100s because they can, even though it won't earn them much money."

"Then let's explore this option thoroughly," said Helmut. "Jimmy, Lily, Bao-zhi: you're the task force. It sounds like we can even slow down corvet production and shift people to creating the materials for the C-100s."

"We'll see," said Jimmy. "We'll need to manufacture the life support systems either way."

"Good. Now, let's turn to our exploration plans."

"We have an asteroid expedition departing in three weeks that will work its way to Ceres over the next two years," said Crystal. "Another expedition follows three months later, and two expeditions will depart Ceres for Mars in the same time period. The immigration delays have not affected them. Negotiations about the vehicles to send on the Pluto and Kuiper expeditions are making progress. We should have designs finalized in the next six months. Both vehicles will go from here to Earth, then depart for the outer solar system. We're still recovering from all the work necessary for the departure of the Uranus and Neptune expeditions, so the schedule right now is quiet."

"Just as well," said Jimmy. "Because the vehicle design department is exhausted!"

"Well, now you need to complete the design to dock corvets to a C-100," said Helmut. "So don't rest too much! Anything else?"

"I'm curious why you didn't release the final immigration report before the Future of Mars forums," said Bao-zhi.

"I debated it," replied Helmut. "I wanted to wait until after the midterm elections for two reasons. First, the summary was released a month ago, and it made clear that everything went pretty well, other than the crash of course. There were plenty of experts and neutral voices who then said that the preliminary report was a fair representation of the situation. But I knew that various people—Johnny Lind in particular—would attack the preliminary report, say the final report would reveal things we were hiding from the voters, and would paint a conspiracy theory around the delay. On the other hand, if I had released the full report three weeks ago—when it was complete—Johnny and his friends would accuse me of getting out good news prematurely to influence the midterm elections. Either way, they'd politicize the report."

"But Johnny and friends did reasonably well in the midterm elections," said Crystal. "The report might have taken some wind from their sails."

"Maybe," replied Helmut. "But when we release the entire report, all the neutral observers and experts will say Johnny and his friends were wrong, and a few people—Will Elliott in particular—can be just about guaranteed to write a column saying this is yet another example of fear mongering and manipulation of the truth for political purposes. I'll probably add my voice to the criticism, too. I am hoping to do some permanent damage to Johnny Lind and his friends."

"So, a sort of trap," said Bao-zhi.

"You could say that, but I didn't know what they would do, and it was also a risk. And we're the government: we have the right to decide when to release a report. It's hard to accuse me of politicizing a report when in fact they did it, and I took a chance they would succeed."

"Good point," said Bao-zhi.

"Anyway, let's all get to work. We made good progress today. We set ourselves on a good path to achieving our immigration goals." Helmut nodded in thanks to his colleagues. He rose and headed for his office.

It was just a dozen meters away. Once the last arrivals had landed on Mars in late December, a large construction team had turned to the old City Hall and had completed its transformation into the Executive Building, opposite the Capitol, which was now the home of just the Mars Council. Helmut had moved into his new office just a week earlier. He had to pass next to the office of Rory Mayerovitch, his chief of staff.

"Will Elliott is waiting for you in your office," he said.

"Oh? Interesting coincidence, I just mentioned him a few minutes ago. What does he want?"

"He has a suggestion about relations with terrestrial space agencies."

"Good." Helmut was never sure he wanted Will's ideas, which were always good, but weren't always achievable. But usually Will emailed them. He must have considered this one a real brainstorm.

Helmut opened the door. “Will, good sol.”

Will was standing and looking out his window. He turned. “Good sol, Mr. Chief Minister Helmut.” He walked a few steps toward Helmut and shook hands. “I like your new office. It must be twice the size of my old one! And the view; it’s interesting to be looking across at the Capitol.”

“Yes, it’s an interesting perspective. They’ve started demolishing and refurbishing the old executive suite in the Capitol and plan to have it ready for the representatives and their staff in three months, when the Council next meets. But they’re preserving your office as a sort of museum.”

“Yes, I know, they asked me for the furniture, and I gave it to them. What do you think of the elections?”

“What do *you* think?”

Will smiled. He sat in a comfortable chair next to his cup of tea, so Helmut sat as well. “Midterms usually indicate some level of distress with the administration, so we usually see people who have come out in favor of controversial government policies losing some support, and opponents gaining. The arrivals are usually optimistic and support well known and mature people. And that’s what happened this time. And that in spite of two huge issues: the first nuke and the crash. I’d say, Helmut, you did better than either Jacquie or I did.”

“Really? That’s very flattering, Will.”

“You did a good job with the crash. I know that utterly exhausted you, too; it was a huge crisis. As for the nuke, most people had already made up their mind that the effort was worth it;

the fallout is a minor problem on a planet with a near-lifeless surface and the accelerated destruction of the polar layered terrains is more of an aesthetic issue than anything else."

"We now plan to leave a thousand square kilometers of the north polar layered terrain relatively undisturbed," noted Helmut. "The underground explosions will destroy only one percent of the strata anyway. Most of the dust deposits that have accumulated since the Noachian will still be in place."

"How many explosions will you set off next year in the south?"

Helmut hesitated. "Probably three, one gigaton each. Long tunnels are expensive!"

"You'll need all the heat of a powerful portable reactor to melt and vaporize a lengthy tunnel."

"Exactly, and we won't have that capability for another three years. If we can develop an aircraft or a missile capable of flying high and dropping a bomb, an aerial explosion about 20 or 30 kilometers up may be the cheapest option, and it will produce almost no radioactive debris at all. We can design explosives out of the right materials to produce almost no radioactive isotopes, if we can convince the IAEA to allow it."

"And we do need to keep their inspectors happy. Say, I have an idea I wanted to share with you. I've been having conversations with both Ted Bukowski and Lin Changying, the new liaisons for the American and Chinese space programs. I met both of them on the flight back to Mars, but I've seen both of them in the last few weeks. I just had lunch with Changying the other sol. Have you met them?"

"Yes, very briefly."

"I suggest you invite both of them to lunch; not at the same time, of course. I'll tell you why. Their respective ambassadors have the responsibility of conveying governmental positions to us, but the liaisons have the responsibility of networking with our space personnel, so their approaches to us are positive and cooperative. My impression, from conversations with Jimmy Khan, June Addison, Zhang Bao-zhi, and Mi Sanda, is that both of them are being very effective, but are being frustrated by their ambassadors to one degree or another."

"I see. And that's consistent from what I've been hearing, too, about their efforts."

"I think there are things we can do that will make their work easier. Ambassador Veronica gets to Washington several times a month. She should make an appointment to meet with Administrator Elwood and start regular meetings. If she can't do it, Maryam Islami is the Consular Officer. She's quite young, but she traveled with Ethel and me for several weeks, so we got to know her. She's quite capable. I'd send her to every NASA reception and meeting we can get her into. The same with Ambassador Christopher and our Beijing consular officer, who is older and experienced."

Helmut nodded. "That makes sense. Ambassadors Danforth and Zhou will have less control overall because we can go around Ted and Changying, so it will be to their advantage to encourage Ted and Changying to be active, so they at least know what's going on."

"Exactly. But I have another idea as well, which will give our space agency liaisons a goal to work toward. Back during Project Northstar, which returned humanity to the moon, space exploration summits were held every year, sometimes more often. It was necessary to keep the partnership together and to get everyone on board for Project Columbus. I went to several of them. But once there was a Lunar Commission and a Mars Commission, the summits stopped, replaced by these other representative bodies. There hasn't been anything like a space summit since about 2038; over forty years. Why don't we propose to reestablish them every year or two? We could host the first one, with simultaneous sessions here and at our terrestrial home base on Bermuda."

Helmut's face lit up. "That's a great idea! It would get all the agencies talking together directly, without the interference of diplomats."

"Exactly. The U.S., Russia, and China had severe differences—they were even in a Cold War a few times—but they continued cooperating in space. We aren't even close to a Cold War with any of these countries, and every few years some diplomatic difference causes a delay in cooperation. By now, they should know that these things really don't punish us; they just make us more independent. If they cooperated more, they might actually have more leverage over us!"

Helmut chuckled. "That's true. Can you write this up for me, so I can forward it to Minister Indira? I may get back to you with a few changes, then I'll send it."

"Sure, glad to do it."

"Thank you. And by the way, we're issuing the full report about the immigration wave morrowsol. I held onto it so that its release wouldn't look like an effort by me to gain support in the midterm election."

"Yes, Johnny and his friends politicized the report. Well, it'll serve them right when the report shows no cover-ups."

"And it has no cover-ups, I assure you. It just elaborates on the points in the summary. Maybe this time, the people who vote for him will see his motivations more clearly."

"I wouldn't count on that! But it means they'll come into the legislative session with a weaker hand, at least."

I think that's true."

Ted didn't usually go to the gymnasium in late afternoon; he preferred early morning or late evening. There were three gyms around City Square, all fairly large, because gym memberships were automatically included in one's health insurance. They had a wide variety of gym machines, too, locally three-d printed based on licenses from terrestrial exercise equipment manufacturers, though all the designs were modified in some way to optimize their effectiveness in Martian gravity.

When he exited the locker room, he was surprised to see Lin Changying come out of the women's locker room at exactly the same time. He waved and she waved back. "I didn't know you go to this gym," he said.

"I just started. For several months I've tried to run every day, and then I added daily meditation up at the Buddhist monastery, but my doctor said it wasn't enough and I needed to do weight lifting. So here I am."

"I think the doctors really push the new arrivals to go to a gym. I joined right away, but I'm just now finding equipment that I'm comfortable using."

"Yes, they want to form the habits early, so we avoid trouble. And I have to be careful; my mother has serious bone loss, back on Earth."

"So it may be genetic. How have you been doing?"

She nodded. "Pretty well. Sometimes I feel like I am following you around. I go visit someone and they say 'oh, I just saw Ted Bukowski two sols ago.'"

"And when I visit the person a second time, they say 'the Chinese representative is so nice, I saw her last month.'"

They both laughed. "Our work does overlap," she acknowledged.

"But so far, I haven't felt we have been competing. June Addison's propulsion team is now working with engineers in Beijing and Los Alamos."

"Yes, I'm surprised that has worked out smoothly. In fact, I suspect the work Los Alamos needs to be done on Deimos will partly be done by the Chinese engineers stationed there."

Changying nodded. "They're Marsian citizens as well as Chinese citizens and do work for both, so if they do work for Los Alamos it'll be as Marsian citizens. None of the work is top secret; it's all supposed to be published in peer reviewed engineering journals."

"I know, but it'll be a bit disconcerting, for NASA officials anyway."

"How will you handle that?"

Ted shrugged. "I'll tell them at some point before the work is actually done. It'll be the fall anyway, and by then the nuclear explosion will no longer be an issue."

"That's been a problem for me as well, but China reacted less strongly than the U.S. It has all worked out well, too; the CO_2 cap at the North Pole is vaporizing faster than usual and the atmosphere will actually be very slightly thicker as a result."

"Even the Marsian resistance seems to have died down, at least until another bomb is set off next year. Say, you want to have a little supper? Do you have the time?"

Changying considered, then nodded. "Sure, that would be nice."

"Greek? The Parthenon has good food."

"Sure."

Ted was pleased. They headed out of the door of the gym and straight into the square, which was at its busiest. The Parthenon was just fifty meters away but was fairly crowded; they ended up seated next to a rather loud table with three men and a woman. As Ted pulled up the menu on his communicator and was about to order a souvlaki dinner, he couldn't help but hear the conversation occurring right behind him.

"The bastard, he must have screwed us on purpose."

"I don't know, he doesn't strike me as smart enough."

"Langlais? He can plot pretty well, he has always been good at that."

"So, what's our next move?"

A pause. "I'm not sure. Probably downplay our criticism of the summary and drop the whole thing."

"That's what you have to do, Johnny," injected the woman. "You shouldn't have criticized the immigration report summary in the first place."

"Well, it was just a summary! Naturally we thought he was hiding something, right before an election."

"It was a rational conclusion," added another man.

"Once burned, twice shy," added the third, who had a Spanish accent.

Ted turned to Changying, startled. She had been listening, too. "Who are they?" he whispered.

Changying peered over Ted's shoulder for a second, then leaned close. "I think it's Johnny Lind."

Ted opened his eyes and nodded.

The conversation continued. "I think we lay low for a while," said Johnny. "The criticism of the crash didn't work, the criticism of the problems of the immigration wave didn't, and neither did the accusation that the report was a cover-up."

"There is a long-duration distrust of Langlais, though," said the second man. "I think we have achieved that much. We have two years to develop an argument."

"There's always the usual complaint that the immigration wave is too big and disruptive," said the third.

"We'll certainly offer that, but I don't see it doing very much," said Johnny. "I think we need to complain that the Commonwealth is getting too cozy with other spacefaring nations and giving up too much control. The Pluto and Kuiper missions are both majority-Chinese or majority-US missions. I gather, from my friends in space propulsion and planetary science, that there is a lot of talk about collaboration."

"Johnny, why are you criticizing that?" asked the woman, who apparently was his wife. "We went to Saturn as a result of cooperative arrangements. Tad's at Uranus on another one. These are good things. People won't agree with you."

Ted's eyes grew big with alarm. He reached down to his communicator and clicked on the "record audio" button.

"They will if we're ceding too much control. Mars was in charge of the Saturn and Uranus missions and sent out Neptune-1 in its own. Earth has recovered from a lot of the economic damage and is doing much more in space now, but so are we. Look at the mess the Chinese made at Jupiter! It's still not an independent entity, like the other outer planets. What sort of limitations will they put on the Pluto mission?"

"That's an argument that might get some traction," agreed the third man. "Of course, Callisto did hold an election a few months ago, so they seem to have settled into the same administrative system as everyone else out here. But who knows what form the Pluto mission might take?"

"How much control can any government exert over a self-sufficient community of a thousand people setting out for a twenty year mission?" said the woman. "No, you're grasping at straws. The Pluto community will be the most independent community ever sent out. It has to be, by definition."

"Still, we might be able to make some trouble," said Johnny. "The perpetual source of dispute, of course, is the budget, and that will come out for the Mars Council meeting in a few weeks."

"There are always places where you can argue about how money is spent," agreed the second man. "The cost of the immigration wave, the cost of the nukes, the subsidies for the outer planets, the investment in Ceres and Phobos, the research and development budget, and investment in natural resource extraction . . . they are all subject to question."

"I think we had better focus there," said Johnny. "Those are always fresh issues; they'll push the crash report out of people's minds." There was a pause as he downed the last gulp of coffee. "Anyway, good to meet with you guys again."

"Thanks, Johnny, good to get together with you, too." The four of them rose from the table and walked out of the restaurant.

Ted's hand was trembling as he stopped the recording. "The bastards! I thought Mars was free of that sort of politicking!"

"Apparently not. I've been following *Mars This Sol.* He's the man who accused Helmut

Langlais of delaying the full crash report in order to cover up the bad news before the midterm elections. Of course, the final report showed no cover up at all, so he was embarrassed."

"Oh, that guy! Johnny Lind." Ted nodded. "I've heard of him, too. He's a thorn in the side of the government."

"He seems to have a vendetta against Langlais. Looks like he has two friends with vendettas, too."

"Yes, they were really opposed to Langlais. I'm sorry I didn't record that part of the conversation."

"What are you going to do with it?"

"I don't know." Ted thought about it. "Maybe supply it anonymously to *Mars This Sol*? I could put the recording on a fresh drive, put it in an envelope, and slip it under the door of their office."

Changying nodded. "That's a thought. Did you order yet?"

"Oh, no I didn't!" He turned back to the menu and pushed on a few icons, then put the communicator back down on the table. "There. I'm sorry for the delay; I was distracted. I wish we could have both put the order on my account, so I could pay."

"No, we had better not do that. So, what are your impressions of Mars, after five months here?"

Ted thought a moment. "Until a few minutes ago, I would have started by commenting on their amazing unity of purpose, and I think I'd still single that out. Because almost everyone here is an immigrant, they made a conscious decision to come here and they had to compete against others for a slot, so they are true believers. That's an almost trivial observation, of course; every journalist who comes here says that. But what the journalists don't mention is that the level of disillusionment is low. People arrive as idealists and by and large, they don't lose it."

"Yes, that's true. And since everyone arrived with a skill, they all have employment, so there's no poverty. Drugs can't be smuggled in, so they have no drug abuse."

"Though there's a pretty active drinking scene."

"Really? I haven't seen that. And they have the strongest counseling system I've ever seen; almost everyone sees a psychologist at one time or another. So the divorce rate is pretty low."

"Which is also a function of income and education," said Ted.

"True. And there's never been a murder up here, and there's almost no theft."

"That would be risky, with cameras in all public areas. Children are really safe, too; they can go talk to any stranger, and people look out for kids."

"I've noticed that, too. And since the population is very young—only one person in a thousand is retired—they can put a lot of resources into education, rather than health care, and that keeps the population's educational level very high."

"Which in turn produces intelligent elections, little demagogy, and transparent, responsive government."

Changying laughed. "And they want to be a model for Earth? Earth can never duplicate these conditions!"

"Maybe in a few centuries, with a lot more education. But we have put our finger on the source of Marsian success, and therefore of the Marsian dream. It attracts people, and in turn they make it successful."

“A strong argument in favor of a high immigration rate.”

Just then, a robotic cart rolled up to their table. “Welcome to Parthenon, Dr. Changying,” said a face on a screen on top of the cart. “Our records indicate you’ve never eaten here before.”

“No. I haven’t, and the food looks delicious!” She said that as Ted reached over and picked up her plate, putting it in front of her. Then he retrieved his own.

“Thank you. Since this is your first visit, you are entitled to a free dessert, either today or another time.”

“Oh, thank you! I think I’ll order it later, or maybe next time I visit.”

“Very good. Please enjoy your meals.” The face disappeared and the cart drove on to another table.

“That’s very nice. I guess a free dessert is standard in restaurants up here.”

“Yes, and I think I can eat at a different place for most a year to get them all! If you go to the older section of the outpost there are a lot of ethnic restaurants. Have you been in Punjab? They have several really good Indian places.”

“No, I haven’t. But if I eat too much here, I’ll have to spend a lot of time in the gym!”

Ted laughed. “They recommend an hour a sol, and it seems wise, considering the low gee and all the good food! The fruits and vegetables here are so fresh and tasty.”

“Yes, they live well, really. I love the breads, too.”

“You said you go to the Buddhist monastery for meditation, right?”

Changying nodded. “Yes, I discovered them back in December and I try to get up there Satursol morning, and sometimes Wednesol evening. It’s a Japanese Buddhist monastery, but the Chinese forms of Buddhism are mostly the same. The monastery was established by Zen monks, but now there are Pure Land and Nichiren monks as well. I stay away from the Nichiren ones; we don't have that form of Buddhism in China. I prefer the Pure Land monks because they are very flexible about how you meditate. They teach you the mantra 'Namo O-mi-t'o Fo' which is very powerful."

"What does it mean?"

" 'Praise be Amitabha Buddha.' If you truly praise him, trust in him, resolve to be reborn in the Pure Land after death, and strive to live a virtuous life of service to others, he will aid and assist you in this life and in the Pure Land, which is the land of bliss."

"Heaven?"

Changying considered. "Sort of."

"Unfortunately, it is very hard for me to sit cross-legged."

"Have you tried in Martian gravity? It isn't so bad. But you don't have to sit cross-legged, they have chairs as well. The Zen people: they're the ones who sit cross-legged!"

Ted laughed at that. "That's intriguing."

"Why don't you come up Satursol with me? Escarpment village is a fascinating place. There are about a hundred people who go meditate Satursol morning. It's quite a crowd. They're not all Japanese and Chinese, either."

"Really?" Ted thought about it for a moment. "Alright."

Ted was surprised by how early he and Changying had to meet; they had to catch the 7:30 a.m. bus. Even though the Escarpment Village was only 30 kilometers away, it took an entire hour to get there because the route was dotted with private developments. There were two of them in the first five kilometers from Aurorae itself. The canyon—called Little Colorado—was a spectacular ride in itself, and there were three private developments of homes in it at various wider, flatter points. Fortunately, the bus stopped only if someone had to get on or off, and it was early enough so that only one stop was necessary. On top of the escarpment, almost 2 kilometers higher than the Outpost, it stopped at Little Tokyo and they exited there.

Little Tokyo consisted of a single round enclosure 200 meters across and a series of underground modules that opened onto the enclosure, which was packed with buildings, some five stories high. It was a tiny area of dense construction, necessitated because of the difficulty hauling water all the way up to the plateau. Without it, the dry ground under enclosures was porous and leaked too much air, requiring metal or plastic membranes underneath.

The monastery was a series of tunnels and caves carved into a layer of dry, porous sandstone, carefully sprayed with a plastic coating to make them airtight. The Zen, Pure Land, and Nichren monks each had their own separate complexes, but they all opened into the same 200-meter crater, which was an exquisite Japanese garden. A small pond filled the center, with grasses, reeds, and water iris strategically arranged around it. Trees, carefully pruned into pleasing shapes, dotted the space, which also had walkways and a Zen rock garden. But the centerpiece of the space was a large Buddha partially carved into the wall of the crater and carefully molded, sitting cross legged in a meditative position, his hand pointing downward in what on Earth was called the "Earth witnessing position," as He swore by the Earth that he would never fall to the temptations of Mara, the Buddhist devil, who promised Buddha all the women and power He could ever want if He would just abandon His quest for enlightenment. Here, the statue was called the "Mars witnessing Buddha" instead, and the space in front of Him was a grassy meditation area. There, Changying and Ted sat to repeat *Namo O-mi-t'o Fo* contemplatively for half an hour with a hundred other Marsians.

There was a brief gathering afterward with very spare refreshments, then Changying led Ted into a tunnel. "This takes us to Escarpment Village."

"Oh? At the very edge?"

"Exactly. I'll show you." She led him down the tunnel, which was wide for the first hundred meters and had side tunnels branching off to the various monasteries and to Little Tokyo. They passed through a pair of heavy pressure doors that opened for them automatically and entered a long, rather chilly, dimly lit tunnel.

"How far is it?"

"This stretch is 700 meters, then the tunnel makes a right angle turn and runs 500 meters more."

"I am amazed these tunnels don't leak more."

"I think they do, but the air is humid and the moisture freezes the cracks shut. That's one reason they keep these tunnels at about 5 Celsius. Periodically they spray new sealant on the rock, too. So, what did you think of the meditation session?"

Ted thought a moment. "Peaceful and satisfying. And I managed to sit pretty comfortably. And not fall asleep."

"I guess that's an achievement!"

"It was. I can't say that I am a religious person. I don't know what I think of God; I suppose I believe in a God."

"It isn't required in Pure Land Buddhism, you know. The Amitabha Buddha was just a man who achieved enlightenment and vowed he would help all of humanity to achieve the same spiritual state as he, so he created the Pure Land and promised rebirth in it for those who have faith in him."

"I understand that, but that's still pretty supernatural for me! Maybe it's true, maybe not." Ted paused. "Marsian society must be the first society in history that isn't based on a single religion. There are lots of Catholics, Protestants, Buddhists, Muslims, and Bahá'ís up here. I gather there are Mormons, Jews, and Hindus, too; actually, I've seen the Hindu temple in Punjab Enclosure. But there are a lot of non-religious, too."

"And some atheists; they're noisier than the conservative believers. There are interfaith gatherings as well, but I've never been to one."

"It's a pretty tolerant place."

They reached the pressure doors at the end of the tunnel and they opened automatically, to reveal a second pair, which opened for them as soon as the first pair had closed tightly. In front of them the tunnel turned 90 degrees to the right, but there was a little door straight ahead. "I should show you this, if it'll open." Changying approached the little door and it opened. They walked down the corridor to another pressure door, then finally a third. When it opened, sunlight poured in. "Wow!" said Ted. But Changying raised a finger to her lips. There was 3 more meters of corridor, then a pair of simple glass doors to keep sounds out of the chamber in front of them.

The glass doors opened silently for them and they stepped into a niche in the escarpment. Six meters of flat rocky floor covered with tough, airtight plastic stretched between them and the cliff's drop off, which dropped straight down hundreds of meters. But there was no guardrail because there was tough, transparent, airtight plastic between them and a fatal fall. The niche was about twenty meters long, up to ten meters deep, and six meters high; the plastic above their head had a little bit of rock debris on it that had fallen from the rock overhead. They walked to the very edge and gazed southward at the horizon half a hundred kilometers away. Aurorae borough stretched out before them as a complex of bubbles and cylinder domes filled with tiny buildings; what was really quite large looked tiny from twenty kilometers distance. The spaceport and its circular cleared pads, some with towers, could be seen beyond. A hundred huge wind turbines rotated in the wind far to the right, looking like tiny pinwheels. Beyond the human infrastructure were the craters and scattered bluffs of the western edge of Aurorae Chaos.

Ted stared, awestruck, but he didn't dare say anything because a dozen people were sitting in the niche along one side, reciting prayers. They drank up the scene for a minute, then she pulled on his shirt and they exited. "We'll see it more up on top," she said, as they passed through the first pressure door.

"Wow, that's really amazing! We're 2,000 meters above the valley!"

"You can see why Columbus 3 wanted a dacha—a vacation spot—away from the outpost, so they chose this area. The monastery, however, built the tunnel to the niche and enclosed it with a custom-made bubble. They make it available to any religious group, though."

"Yes, those were Bahá'í prayers I heard."

They returned to the main tunnel and made the right-angle turn. After 500 meters, they reached a pair of pressure doors and passed through them. The tunnel before them stretched only one hundred meters to another pressure door; to the right was a wide spiral ramp leading upward, with a sign that said "Boardwalk 2." They hurried up about 10 vertical meters and exited a small alley onto the "boardwalk."

The boards were vinyl, of course, but they looked like real wood, and the walk—ten meters wide—ran all the way to the far end of an enclosure 100 meters away, along the very edge of the escarpment. A sheet of plexiglass and a guardrail kept people's hands away from the plastic barrier that kept in their life-giving air. The enclosure—a half cylinder of plastic that soared 50 meters overhead and was tucked under a heavy metal foundation sheet below—was 100 meters long as well as wide. Heavy cables every ten meters gave it added strength against the upward and outward tug of the air pressure; they were anchored deeply into the basalt capstone and the thick sandstone stratum underneath.

Lining the Boardwalk were stores, restaurants, and residences. Ted and Changying strolled slowly and poked their heads into the little stores. The restaurants overflowed onto the Boardwalk; they had to walk around tables placed right at the edge.

"Today and tomorrow are their big sols," said Changying. "It'll get pretty busy, starting about lunchtime. If you want night life, this is the place to come!"

"I see," said Ted, stopping to note a plaza that extended fifty meters back from the Boardwalk, with a stage for music and a big dance floor. "This place looks incredible!"

"I'm surprised you haven't been up here."

He pointed at the place. "I've heard people talk about 'the Overlook' but I didn't know what they were referring to. It's kind of out of the way."

"There's transportation to Aurorae all night, though; shared autotaxis, mostly."

"Ah. I'll have to give it a try some time."

"Near as I can tell, this is the weekend singles scene. City Square is for regular meals, family nights out, routine shopping, and an hour of drinks on a weeknight."

“That’s for sure!”

They crossed the enclosure and entered Boardwalk 1. It was dominated by two department stores—Silvios and Deseret—and the Golden Nugget Casino. “Gambling?”

“Of course; you didn’t know?” said Changying. “It has some slot machines, card game tables, and some other games of chance, but the gambling part is small. The restaurant and auditorium in back are big, though. This place and Boardwalk 2 might have a thousand visitors on the weekend.”

“That’s a lot of going back and forth.”

“Not as much as you think; this place has 300 hotel rooms, too!” She pointed up, and the building was impressively tall; ten stories at least. He could see that five stories up, there was a wide terrace, too. The two department stores were carved out of the much larger building and took up relatively little of its space.

They wandered inside the enormous curved entrance of the casino. The sound of the slot machines on the left poured out onto the Boardwalk, because there was no separation from them; the restaurant on the right also spilled out toward the escarpment. They occupied one big space and the walls were continuous 3-D screens, displacing peaceful décor in some spots, magnificent scenery in others. Some screen also displayed *Mars This Sol* and the *Mars Sports Channel.* Just as Ted was scanning the huge open space, the left side already busy, the *Mars This Sol* screens flickered and were replaced by the words “Breaking News.”

“I wonder what that is?” said Ted.

“Did you give them the audio recording?”

He nodded. “Anonymously; on a drive in an envelope taped to their door. Let’s see what's happening."

She nodded and they moved with a sense of urgency over to one huge screen, where the sound—turned almost all the way down—was audible. A moment later, Jacaranda Chamberlain, the chief news anchor for *Mars This Sol,* appeared. "We have a breaking news story about a scandalous collusion of three Aurorae members of the Mars Council to set up opposition to the Langlais Administration. Yestersol afternoon, someone anonymously deposited an envelope outside our door that contained a drive with an audio recording. It was relatively poor quality, but it was easy to clean up. We subsequently ran the voices through our voice recognition software, which matched them against the thousands of voices and voice recordings in our data library. The voices you will hear are those of Johnny Lind; his wife, Betty; Lyle Quincy; and César Alvarez. They are all well known figures here in Aurorae and have a long standing reputation for opposing bills put forth by the Chief Minister, all the way back to Will Elliott. You will now hear the recording."

There was a pause, then the recording began to play, with closed captioning underneath. People across the space had seen the headline on the screen and began to gather around the screens carrying the news flash. As the crowd grew, the software controlling the environment turned up the audio on the screens so it was easier to hear.

"Those bastards!" exclaimed someone nearby.

"No wonder the Mars Council functions so poorly!"

"They should be impeached!"

"They should resign!"

"This is ridiculous, to oppose things arbitrarily!"

“Very unscientific and irrational!”

People talked so much, it became difficult to hear the recording. Ted looked around nervously, wondering whether he looked guilty, fearing maybe *Mars This Sol* would mention his name. Changying smiled through the whole thing, fiercely proud that people were outraged.

The recording ended and the camera turned back to Jacaranda. “As many of you know, almost two months ago a preliminary report about the crash was released. Lind was a fierce critic and demanded that the entire report be released immediately, calling the result a ‘cover up.’ When the full report was released earlier this week it became clear that there was no cover up. At first, Lind demanded all the drafts of the report and a subpoena of the records of the Commission, but it quickly became clear that the drafts and notes also would reveal no cover up. Chief Minister Langlais reacted, saying ‘this was a typical effort to smear the government, whichever government was in power, in any way possible.’ Former Chief Ministers Will Elliott and Jacquie Collins both criticized Lind’s position as a ‘politicization’ of the Commission’s work.

“We turned to Johnny Lind, Lyle Quincy, and César Alvarez for comment. Alvarez initially denied that the entire conversation occurred, but when we said we would play the recording on air, he refused to comment. Our discussion with Lind was lengthy and we will play it now.” There was a pause and a videophone recording appeared on screen.

“So, Dr. Lind,” said Jacaranda, using unusually formal language, “You’ve heard the recording. What do you say?”

“Jacaranda, someone has recorded a private conversation—only part of a private conversation, or more likely they edited out the earlier part of the conversation to slander us—and unethically turned it over to *Mars This Sol* in order to impugn our reputation. If we ever find out who recorded this, I will sue them for libel. My guess is that the Langlais administration hired a private eye to spy on us; to follow us around, record our audio in any way they could, and wait for us to say something that is perfectly legitimate to repeat in private. We have freedom of speech up here, after all. Let's remember that."

"Mr. Lind, freedom of speech is not the issue. The issue is that you appear to be saying to two fellow members of the Mars Council that you will oppose the government, regardless of their position. Regardless of what the administration says, you will find a way to attack it. Isn't that an unethical position for a member of the Mars Council to take?"

Jacaranda, if the administration takes a misguided position about an issue, if they offer plans to misallocate or waste our precious tax monies, they need to be opposed."

"Mr. Lind, that's not what I asked. You appear to be casting about to find something to oppose."

"That's really not so difficult."

"Then why did you run through a list of potential positions to oppose and eliminate them, one by one?"

"We were just speculating, is there anything wrong with that?"

"But why were you speculating now, six weeks before the Mars Council meets? At the end, you said you'd just wait for the budget to come out because you were sure there'd be something to oppose in it. You are known to oppose just about anything the administration does."

"Well, I am known for my strong opinions, am I not?"

"You are, but don't you think this is a great way to get attention for yourself, rather than move our Commonwealth forward in a positive manner?"

"Jacaranda, there's nothing wrong with promoting yourself, but that is not why I oppose various government bills. They need to be refined, and I have a history of doing just that."

"Actually, I took a look at your voting record. It appears you lose about 70% of the time."

"Well, that means I win 30% of the time, and my constituents are grateful for that, as are the Marsian people. If we can get a stronger opposition voice in the Council, then we'll win more. You will note that my vote grew this time, as did the votes of many of those who oppose the current administration."

"Were you embarrassed by the results of your claim that the full crash report would show a cover up?"

Johnny thought a moment. "I have no regrets."

"Thank you, Mr. Lind."

Jacaranda's face returned to the screen. "That was our interview with Johnny Lind, recorded just an hour ago. We also called Will Elliott and played the recording to him. Here is his reaction."

There was a pause and a videophone recording began to play. "So, what is your reaction?"

Will had a pained look in his eyes. "This is a typical political ploy on Earth. It's actually quite mild for Earth, where politics often is cut-throat. But in the Marsian context, I find it shocking. The purpose of a legislative body—the purpose of legislators—is to consider a law dispassionately, independent of its author, deliberate on its implications, and vote based on whether it is the best thing, long term, for the Commonwealth. When legislators enter the chamber with a pre-existing bias, the entire process becomes sullied. Votes end up being based on emotion, on grudges, and on personal ambitions. Money is wasted, the effectiveness of the government is damaged, the confidence of the voters is undermined, cynicism spreads, and everyone feels they can cut corners a little bit more in their lives. People want to come to Mars to get away from behavior like this. If we don't expose cynical, prejudicial behavior like this and punish it, it will grow. The reputation of Mars will be damaged on Earth. Our moral authority—which, for a small country, is one of our great strengths—will be weakened. It is a sad day when something like this comes to light."

"Do you think the administration spied on Lind?"

Will shook his head. "No, I think Lind and his friends were talking too loudly in a restaurant—that's what it sounds like, from the background noise—and a citizen was outraged and recorded them. I salute that citizen!"

"And if it is spying by the government?"

"That's illegal and would require punishment."

"And Lind?"

"He should resign from the Mars Council or be impeached."

"Thank you, former Chief Minister Will."

The screen returned to Jacaranda Chamberlin. "There you have it. Tonight we will have additional information and commentary. We now return to our regularly scheduled programming."

The crowd that had gathered around Ted, Changying, and the screen, began to disperse slowly, but a lot of people were angry. "Yes, impeach him!" several said.

"Let's stick to scientific politics, rather than dirty tricks!" said someone else.

Ted looked at Changying, and she could see he was frightened. "You did the right thing," she whispered. "And it was a brave thing, too."

"As long as my identity doesn't come out. I might have to resign."

"But sometimes that's what you have to do, when you do the right thing."

"That's true." He nodded.

They walked slowly out of the crowded casino and back to the Boardwalk. They continued along it and came to another set of pressure doors, which opened before them. It put them in a small, crescent-shaped bubble with a small building in it. Its plastic floor actually lapped out past the cliff edge.

"This is the original dacha, isn't it?" said Ted.

"Yes, I believe so. It had a swimming pool, but they removed it because the casino has two big ones."

Ted walked across the space to the cliff and walked out onto the plastic floor so he could look straight down at the air below. Changying came "out" to join him and they stood, staring both down at the talus below and out at the rolling stonescape.

"I came here to strengthen cooperation between the U.S. and Mars, not bring about government reform."

She smiled and put her hand around his waist. "That's okay. I was with you! I think you did the right thing." She added in a whisper, "And your secret is safe with me."

"Thank you. You know what I usually do, in this sort of situation? Drink myself silly."

She tightened her grip around his waist. "Well, I have a better idea. It's almost 11. Let's get an early lunch and have a bottle of wine, or maybe two; the Chateau Aram's really good. And then let's get a room, here in the Dacha."

That startled him, but he smiled. "That's a great idea," he said.

14.

Ego

Early June 2083

Jamison Rideout floated through the tunnel connecting the *Carina* to the *Dorado,* ignoring Proteus's nearly negligible gravity. He pushed himself up the access shaft into the *Dorado* and grabbed a handrail on top so that he could settle himself down onto a rotating surface so that he had some gravity. He proceeded from the ship's access down a ramp to section 2, where the bridge and the office of Rahmatullah Khan were located.

"Morning," he said, as he reached Rahmatullah's door.

"Morning, Jamison. How was the trip to eastern Pharos?"

"Pretty good; we obtained the samples we wanted, made another stop at the central peak complex on our way back, and visited the grabens south of the crater as well. Coming in for a landing, we saw the progress on the landing pad."

"Yes, we were able to drive two more pylons into the crust and weld several key girders into place."

"How long to finish the pad, then?"

Rahmatullah shrugged. "Maybe six months at most. The robotic welders are trained quite well now, and we have plenty nickel-iron for fabrication."

"Good, because Seron won't arrive for 18 months." He paused. "Jiaying and I were talking over breakfast with the geological team. We've been on Proteus five entire months now, and we've explored all the major geological features. This is a pretty small place; the size of Texas, basically."

"So, time to move to Triton? We've got the propellant, now."

"Yes, I know. We do think it's time. Triton will take a long time to explore even in limited fashion; it's the size of Africa, almost the size of the moon, and has incredibly dynamic geology. We even have researchers anxious to study its atmosphere. But we think the best way to explore Triton is with both galleys together."

Rahmatullah frowned. "Both? Why? We need to keep the engineering staff here, to continue preparatory work for the arrival of the *Seron*. That'll totally wreck our schedule."

"I know, but there are lots of couples who will have to separate if the two galleons aren't together."

Rahmatullah shrugged. "But we knew that. We'll leave some geologists here and we'll need some engineers on Triton, anyway. Some couples can separate; others can stay together. Once every six months or so, one ship or the other can visit, we will reunite, and have a big party. That's the plan. That's the only way, really, to keep all our work going."

"But you won't get much done, with only one reactor."

Rahmatullah shook his head. "No, we'll manage fine. We've had the equivalent of one reactor for most of the last five months anyway because the other reactor has been devoted to hydrogen propellant production. We won't be able to create a big underground pool of liquid water to provide the *Seron* radiation shielding when it arrives. But if the *Carina* returns a month or two before the *Seron* lands, we'll have the power to make some of the water."

Jamison shook his head. "I want all of us on Triton. First, we need to stay together as a community. Second, all the geologists want to go to Triton; this rock is nothing in comparison. Third, you will be able to continue some of the work here robotically."

“Not much of it, Jamison. We need to keep some people here to go see and fix some things the robots can’t fix. The speed of light delay isn’t much, but the software isn’t designed to accommodate it, so that will indeed mess up our oversight. No, we’ll get only a tenth as much work done.”

Jamison shrugged. “Well, that’s what I want, Rahmatullah. We’re all heading to Triton in two weeks.”

“Why are you doing this? I think you and Jiaying are trying to maximize your scientific exploration before the *Seron* arrives. The engineering and construction work we’re doing won’t go down in history the way exploration will, but it’s just as important. How many moons are you planning to visit after Triton? You can leave some primary exploration to the scientists on the *Seron*!”

Jamison shook his head rapidly. “I am *not* doing this for my own glory, or that of Jiaying’s team! How dare you accuse me of that. That’s outrageous. This is an order, Rahmatullah: we’re all going to Triton in two weeks. Tell your people to get ready!”

Rahmatullah shrugged. “Have your way, Jamison, but I’m talking to Mercedes.”

“Going over my head, huh? Do you really think that’s wise?”

Rahmatullah sat impassively. “She’s the ultimate boss. Let’s consult with her about what’s best for Neptunia.”

“Suit yourself, but tell your people to get ready.” Jamison turned and strutted out.

“We really shouldn’t be doing this,” Ted said. He rolled closer and kissed Changying. “I say that to you every morning.”

"But not every night. For four weeks, now." She kissed him back. "Good morning."

"Good morning." He smiled, then got up out of bed, naked. "I'll make the coffee."

"Thank you. I need to get out of here quickly, though."

"I remember," he replied from the kitchenette. She watched him go, then she rose, grabbed a bathrobe—but didn't bother to put it on—and walked into Ted's bathroom. She dashed through the shower very quickly and when she emerged with a bathrobe on, he had the coffee ready. "Have half a Danish. I had one in the fridge."

"Great, that will help. By the time I get home, change, and get completely ready for the day, time will be getting tight."

"Good luck with your meeting. Busy day?"

She nodded. "You?"

He nodded. "Very." They never discussed their work in front of each other, but Ted added, "I'm meeting with the ambassador. He asked for the meeting."

"I know that makes you nervous." She put her hand on his shoulder.

"Thanks. I may be smart and articulate, but sometimes I'm pretty anxious! You have really been a great help."

"You've been a great help for me, too. I was—we were—very lonely up here. We've been able to fill a big gap for each other."

"It's true. And it's partly because we share a great love of space exploration."

"Yes, and ironically, we can't talk about it very much!"

She laughed. "Oh, I don't know. As long as we stick to topics about ten years into the future, we're alright!"

“True! Mars with half a million people, the outer planets and Ceres and Mercury with ten or twenty thousand each, several other outposts in the belt, a hundred thousand or more on the moon, expeditions departing for distant Kuiper Belt objects, plans to send a robot to Alpha Centuri by the turn of the century . . . it’s very exciting.”

“Let’s just hope our countries continue to cooperate.”

“At least if the Earth blows itself up, we’re safe.”

Changying smiled at that. “That won’t happen, but it is a mess down there, that’s for sure.”

“That’s for sure. *Two* big terrorist incidents yesterday . . .” Ted shook his head and his voice trailed off.

She shrugged and swallowed the rest of her coffee in a big, hot gulp. “Let me get dressed and go.”

He nodded. She retreated into the bedroom to put on yesterday’s clothes—except for fresh underwear, because she kept a drawer of them in his bedroom—and came back out in two minutes flat, the Danish finished as well. They kissed again. “See you tonight.”

“Supper at the Indian restaurant in Punjab?”

“Yes, good idea. A new place; we need to avoid a pattern.”

“Maybe tomorrow we should try the Steak House in Liberty Enclosure.”

“No, we can’t eat out together every night. Too risky.”

“Alright.” He waved goodbye as she stepped out the door. He watched her go and wondered how their affair would end. He loved her; she loved him. But if anyone found out, they’d lose the jobs they love.

The control area of the Seron was a cross between the bridge of a ship and a town hall. There was a large control room, dominated by screens on the walls and screens in front of people; it controlled the environment, communications, the vital signs data coming from each person, and had extra space to control equipment or space vehicles if necessary. Mercedes Patel's office was off the control area to the right. Her principal lieutenants for ecology, health and education, power and communications, and science all had offices surrounding the control areas; the Director of Fabrication was one level below, next to the factory area. When Rahmatullah Khan's protest message arrived, she immediately summoned everyone.

"This is so typical of Jamison," complained Fred Klaas, their head of construction and fabrication. "He can be a real loose cannon. What he is proposing would definitely be very disruptive for construction and fabrication efforts."

"How well can the command software accommodate delays caused by the speed of light?" asked Mercedes.

Fred shook his head. "When Proteus and Triton are on opposite sides of Neptune, the delay is two seconds each way, 4 seconds round trip. That's a big delay. Furthermore, the U-75 wasn't set up for automated use; it was set up for human intervention, because we didn't envision leaving it. We can't leave people behind in the U-75 because the expedition lacks the nitrogen they need to complete its atmosphere. Right now the U-75 has one sixth of an earth atmosphere of pure oxygen."

"I wouldn't leave people there anyway," exclaimed Dr. Daisy Chandra, their chief physician. "It's essentially zero gravity, and the U-75 is not properly set up for people. In another few months it could be, especially if they bring back nitrogen from Triton."

"Can they take propellant manufacturing equipment with them to Triton and make enough propellant to return both vehicles to Proteus?"

"It'll take five months to make enough propellant to return both vehicles to Proteus," replied Fred. "Because Triton is retrograde and Proteus is prograde, the delta-v to go from one to the other is 12 kilometers per second; roughly, the escape velocity of the Earth. Since they arrived, they've made enough to get both vehicles there, or almost enough for one vehicle to take a round trip."

"That's what I thought," said Mercedes, considering. "I'll write him asking for a detailed explanation; maybe he has thought of reasons we haven't. If not, one vehicle goes and one stays."

"I think that's a good idea," agreed Fred.

"Good," said Mercedes. "Fred, how's construction?"

"We'll be finished with the new plant gallery next week and at that point the horticulturalists will begin to rearrange the allocations to our plant species. That means more food diversity. More plant waste means more fish and meat, because we already have all the plant waste the cows and chickens need for milk and eggs. And yes, Mercedes, more chocolate."

She smiled. "Good!"

Ted hadn't met with Ambassador Arthur Danforth since January, so he was quite nervous the ambassador had asked him to come in. He wondered whether the ambassador had heard about his affair with Changying; one could never be careful enough because you never knew who one might run into in public. He walked to Andalus Enclosure with some reluctance.

As he entered the enclosure, he saw a group with signs organizing themselves in front of the Capitol Building. He had a hunch he knew what they were about, but he diverted over to see.

"Are you going to protest Johnny Lind?" he asked a man with a "Resign!" sign.

The man nodded. "Yes. He isn't fit to serve on the Mars Council. We need honest people, not plotters."

"Of course, he didn't say anything that should be censored. Mars has freedom of speech, doesn't it?"

"Of course. But let's say three men get together and plot to steal something and someone overhears them. The police can arrest them for plotting, and the men can't reply 'we have freedom of speech!' Freedom of speech isn't the issue. Behaving in a way contrary to the best interests of the Commonwealth is the issue!"

"But don't you think this is typical behavior of politicians?" Ted asked that question because he was really curious how the man would respond. He had been outraged by Johnny's comments, but primarily because they attacked cooperation in space. His concern about the political tone had been secondary.

The man scowled at him, "You were raised in the United States, right? That's my guess from your accent. Are you proud of the fact that your Congressmen plotted like this—and lied about it—on a regular basis?"

"No, but I didn't think it could be prevented."

"That's why your Congress has such a low approval rating. Well, this is Mars. A long time ago, politicians on Earth used to poison and assassinate each other. They don't do that anymore, either. The voters ultimately set the culture, and we won't tolerate this. Did you see the poll released by *Mars This Sol* last night?"

"The one that said 68% of Marsians disapproved of his behavior? Yes."

"Not only that; they asked people in his district. Even among the people who voted for him, 53% disapproved! This kind of talk is no more tolerable than sexual harassment language or hate speech. We have every intention of making sure it stops *here*."

"I see. And I suspect it will, too. But the Mars Council won't meet for another nine sols."

"That's right, and Lind has nine sols in which to resign. We'll be here, protesting, until he does."

"I see. Good." Ted nodded and turned to walk to the embassy.

He was noticeably nervous when he entered Ambassador Arthur's office.

"How are you this sol?"

That was not the sort of greeting Ted expected. "Ah . . . pretty well, you?"

Arthur shrugged. "Alright, I guess. Sit down." He pointed to a chair and sat opposite. "The very brief reports you've sent to Administrator Elwood via the embassy have been very tantalizing. They have irritated me, even angered me, but I was also appreciative to get that much, at least, I couldn't stop the progress they suggested, and now the Secretary of State has said I should cease to interfere. He contacted Administrator Elwood and asked her to forward to us all your reports you sent to her via your NASA secure communications line. From now on, please send a copy to me as well and I will forward a copy to the Secretary of State."

"I wasn't aware of the fact that the Secretary of State was interested in the reports."

"Normally, she wouldn't be. But the Commonwealth has proposed an international space exploration summit, to be held in Bermuda and on Mars in late July. In the last few months, the Commonwealth has appointed a special liaison to NASA: Maryam Islami. Have you heard of her?"

"I met her in Washington, D.C., in the Elliott's hotel room when they were in the capital. I was able to arrange a meeting with them through Zeke Swift. She's smart but very young. I'm surprised she's serving as NASA liaison."

"Why?"

"Her field isn't science, engineering, or space related. Her degree is in political science or diplomacy or something."

"I see. Have you heard about this idea of a space summit?"

"No. My work lately has focused on two projects, as my summaries have indicated: the Kuiper Project and advanced propulsion technology. There are some possible collaborations involving Saturnian meteorology and improving Helium-3 production, but they're less developed."

"What do you think of the idea of a summit?"

It was a dangerous question; Danforth would be inclined to oppose. But he had a feeling he was in a position of strength. "It reminds me of the old discussion about international trade on Earth; should countries do bilateral agreements only, or international, multilateral ones? There are a lot of countries, so bilateral agreements take a lot of time to negotiate and update, but they can be quite precise. Multilateral agreements take less time, but are cruder instruments in some way. But in this case, a multilateral agreement could be very useful. Participants could coordinate their space investments more effectively."

“I thought you’d say that. What about this: terrestrial nations could coordinate their investments to minimize the role of Mars.”

Ted nodded. “Yes, that’s true, too. Do you think the Marsians haven’t thought of that?”

“No, you are right; they undoubtedly have thought of that. And their win-win philosophy would accommodate it, too.” Danforth contemplated that a moment. “This propulsion partnership: how will it use Deimosian facilities? Ours were mothballed years ago. The only ones left are Chinese.”

“Correct. The idea was to un-mothball our facility under the aegis of Martech, splitting the cost with the university, and run it with Marsian engineers. But many of those Marsian engineers will be Chinese, ethnically, because most of the Chinese team members are dual citizens and do research for both governments.”

“I see. Complicated. I’m told gas core propulsion is not classified work, though.”

“Exactly. We could collaborate directly with China, if we wanted.”

“Why don’t you explore that possibility? A little more Chinese funding, a little more NASA funding, and the Marsians will become minority partners.”

“They will, but they’ll have the technology anyway, so you’ll save them money.”

“I understand that; but it’ll also be *our* technology, and they’ll need a license. That’s fine. Can we get Americans on the Project Pluto flight?”

“Yes, of course, especially if we agree to add Chinese to Project Kuiper.”

“Interesting. These are all summit issues, you see; I’m already thinking in terms of what we can offer at the summit. The more we offer, the more likely we can host the *second* summit. This is a directive from the Secretary of State and beyond that, from the Vice President.”

“I see. So, should I be building a list of collaborations?”

“Absolutely. There’s a Chinese liaison here, and there are part time liaisons for the European Union and India. It seems to me that we have a cleaner, simpler procedure up here than on Earth; there are fewer people to work with. So maybe you should talk to them as well. Are there people at Martech and on Phobos you still need to talk to?”

“Undoubtedly, but I’ve already been in touch with 25 players. Mars doesn’t have a huge number of administrators.”

“Well, go over your list again. The summit is only 7 weeks away. We want have a lot of ideas. You’ll need to talk to a lot of people in the US, too.”

“Over a hundred, but I can send out email blasts and follow up.”

“Good. I want us to be in a position of strength in the summit, and you are the one to do it. I want a report twice a week; Tuesols and Frisols.”

“Okay.” Ted nodded, then saw Arthur was finished, so he rose. “I’ll get started immediately.” He nodded a goodbye and headed for the door.

But as soon as he was outside on Andalus Square, he thought about next steps. Does he go talk to Changying? Maybe he had to wait until the conference was announced. Should he talk to Administrator Elwood first? Definitely, but it was 2 a.m. in Washington, so that would have to wait at least 6 hours. Doubts surfaced and he was tempted to go have a drink. But if he did that, she’d admonish him and ask why, and he didn’t want either of those outcomes. No, he’d think the situation through himself. He had an afternoon of contacts to pursue anyway; he’d do them, and start developing new ones as if there were no conference looming. He had plenty of time to draft an email to her, outlining a plan.

Mercedes got relatively little done that day. Part of it was the slow-motion back and forth with Jamison, who was 7 light hours away, round trip; it was bed time before she got tired and sent her third message to him. The situation on Mars, with polls showing the majority wanted Johnny Lind to resign and the chorus of condemnation growing, was also distracting; it made everyone think about what sorts of political discussions were proper, even if, with freedom of speech, just about anything was legal.

It was clear to Mercedes, when she finally received Jamison's second response, that he had no rational reason to move both ships to Triton. Rather, he had decided to put his own independent stamp on the expedition, thereby upsetting the hours of discussion they had had as a group before leaving Mars. "Jamison, thanks for videoing me back," she began. "I appreciate the determination you and Chen Jiaying are showing to explore the Neptune system. But we don't need to visit every moon to secure our claim; it already is secure by virtue of your boots on the ground at Proteus. Moving both ships to Triton is not a necessary safety measure. It is not necessary from the point of view of ecology, even if each ship currently is growing only part of the full diversity of crops and species. Separating the ships will result in a necessary restriction in dietary diversity, but not a serious inconvenience. The robots really can't continue the work on Proteus without some direct supervision, and the U-75 does not provide accommodation for a skeleton crew that meets minimum standards of comfort or safety. The work being pursued on Proteus is valuable, if not essential, for the development of our settlement there.

"I appreciate your comment about how Triton really would make a better site for our settlement. But we've already discussed this in great detail and made a decision. The Saturn expedition could have settled Enceladus rather than Titan; they debated that, and yes, they chose Titan because of the geothermal energy, diverse geology, and diverse resources. Triton offers similar advantages, without the disadvantage of an extremely dense atmosphere. But the *Seron* is not designed to land on Triton, even though it is theoretically possible. I am not going to jeopardize the lives of a thousand people by making that change. Proteus is safer as a landing site for an enormous ark. We can always import nitrogen and other resources from Triton; we have the spacecraft for that task and the time to do it. If we had decided to settle on Triton, we would have come in three corvets rather than in a carrier.

"Therefore, Jamison, you are to commence immediately with plans to take the *Dorado* to Triton, leaving the *Carina* behind on Proteus. The *Dorado's* mission will last six months. It will then return to Proteus for crew reunion and rotation. After a month, it will set out on another six month mission, either to Triton or to the other inner prograde moons. We've already discussed this, Jamison. In your two years in the Neptune system before our arrival, the primary mission involves six months on Proteus, 2 missions of up to six months to Triton, and a mission of up to six months that will visit Larissa, Galatea, and perhaps Despina. There is no reason, nor an authorization, to change the plan."

She reviewed her comments one more time, then hit send, with the thought "the bastard" rolling around in her head.

"Johnny, you've got to do it." Betty looked at her husband with a pleading expression, not knowing what to say to get through to him.

"Look, I didn't do anything wrong. I had a complete right to say what I said. I had a right to do what I did! No one can tell me not to coordinate my plans and actions with fellow members of the Mars Council. This is harassment and persecution, pure and simple. Resign? Hell no!"

"You really don't get it, do you? You really don't understand. You don't have any more right to say the things you said than someone in a crowded theater standing up and shouting 'fire!' You expressed a prejudice against someone without expressing a cause, and you can't do that against the Chief Minister any more than expressing a prejudice against someone because of their skin color or gender."

"It wasn't a prejudice! He does a bad job and needs to be opposed!"

"Johnny, your problem is that you want to be Chief Minister. Let's get it out; that's the truth! You came close, two years ago, too. Not many people knew Helmut; he hadn't been back from Ceres very long. He beat you because he is likeable and has a positive attitude. And what did you offer? Opposition against immigration, opposition against a dozen things, but nothing positive. The people who like you are also dissatisfied, but most Marsians aren't dissatisfied, and they don't like it when people try to make them feel dissatisfied. What's the purpose of government?"

"The purpose of government? Don't lecture me about that, I'm *in* the government, and you aren't!"

"Then tell me what the purpose of government is!"

"Governments exert power to organize and develop society."

She shook her head. "Power; that's what you want. But Marsians want service. They want a rational decision making process, not people using power to oppose other people."

"Betty, this idea that people can't run for an office, can't campaign, can't be nominated;

this is crazy! No other government works that way. It’s an infringement on my freedom of speech and that of my friends; a violation of human rights! It must be fought and the system must be changed.”

She shook her head. “Johnny, it’s too late for that. We’ve been an independent country, operating this way, for eighteen years, and we held elections this peaceful way for decades before that. You’ve lost the fight over that issue. In fact, you put a nail through the coffin by saying what you did, because if you don’t resign, when you go to the legislative chamber later this morning, there’s going to be a bill to impeach you, Lyle, and César. The majority of the population wants you to resign; do you think the Council will go against that? The people want clean government, and what you did, they consider corruption. Corruption. You’re going to be kicked out of office and humiliated.”

“I don’t think they’ll do it.”

“You don’t? Oh, I think they will; they’ll have to. Elliott and Collins both called for it. Do you *really* want to fight that fight?”

“I . . . can’t resign, it’d be admitting that I was wrong.”

“But the majority think you were wrong, and they’ll kick you out of office over it.”

He took in a deep breath. “It’s not right.”

“Look, at this point, what’s best for Mars? We’ve had pretty good, pretty clean, efficient government for the last eighteen years. Our population has grown something like sixteen fold in that time. We’re stronger, richer, and hold a bigger place in human affairs than ever before. I’ll tell you what I think is the best way out of this situation. Go stand in front of the Capitol building, say you were wrong, that Mars needs rationalized and impartial deliberation and governance, and resign from the Mars Council. Because that's the best way to get re-elected later. That's the best way to preserve your dignity and avoid humiliation."

That idea surprised him. He thought about it, then nodded reluctantly. "I suspect you are right. And that's the sort of show that people like."

"It is. But remember this: if you do it, you will have to abide by the rules. You won't be able to cut corners anymore."

He shrugged. "I suppose."

Will Elliott thought it strange Ramesh Prathan wanted to meet him at Place de l'Etoile. The office of the head of Marbuild was now east of Plaza de Exploración, the central square for South America enclosure, which was nearly two kilometers away. But he checked his communicator as he came up from the Transpo Station and saw from their exchanged GPS data that Ramesh was right outside the station. He stepped out into the sunshine and saw Ramesh sitting in a golf cart, waiting.

"Dr. Will, good sol."

"Dr. Ramesh! I was wondering whether you were going to make me walk a few kilometers."

"No, not yet. Hop in. I wanted to show you the Etoile, if you hadn't seen it already."

Will glanced around. He had been to the Etoile dozens of times on his daily walks around Aurorae. The heart of Europe enclosure, it had twelve radiating avenues leading from it in all directions, just like Paris's Place De Gaulle, or as it used to be known, the Place de l'Étoile. Two hundred forty meters in diameter—just like the Parisian space—it was the largest single public open space in Aurorae. The only thing it was missing was an Arc de Triomphe in the center. He suspected it was Ramesh's ego that had brought them together here.

"Yes, I've been here quite a few times; very, very impressive, Ramesh, except it lacks a central object."

"I know, and something will get built in the center eventually. We need something suitably grand. Here, get in."

Will nodded and climbed into the cart next to Ramesh. Ramesh ordered the cart to drive back to his "last location"—suitably ambiguous—and it took off on its own at 20 kilometers per hour, the maximum speed allowable to a surface vehicle. He pointed. "Aren't the buildings beautiful and grand? The architecture around the Place De Gaulle in Paris is some of the most impressive and beautiful in the world."

"They are gorgeous; extremely impressive. I'm surprised we were able to make metal structures in the necessary shapes."

"No problem, the computerized equipment can do just about anything, and the vinyl outside looks almost exactly like limestone."

"There aren't many businesses here yet."

"No, but there will be more eventually. Europe enclosure now has ten thousand people living in it, but after the next columbiad it'll have fifteen thousand, and even that's not the maximum." He pointed to the tree-lined avenue they started down. Spain Avenue: It ran east, toward South America Enclosure; Britain Avenue ran westward from the Etoile toward Australia Enclosure. The northward and southward avenues were Germany and Italy Avenue, respectively. The avenues were 75 meters wide, unlike the other eight, narrower streets that converged on the

Etoile. “Isn’t Spain Avenue beautiful?”

“It really is, Ramesh. You’ve outdone yourself.”

“Thank you.” He was pleased by that.

“How’s the family?”

“Pretty well. Rajiv’s twenty; can you believe it? He’s doing well, studying architecture at Harvard, and plans to come back in a few years. Hridaynath and Jayanti are seventeen and just finished high school. They’ll be at Martech this fall.”

“They grew up so fast! My grandkids are 13, 12, 12, and 8.”

“And your health?”

Will shrugged. “Not bad for 82! I’ve had cancers cut out four times, but none of them have come back.”

“Yeah, I’m 56 and feeling a bit of a creak in my bones. So, the Mars Council is finally starting business this sol.”

“It was a good idea to postpone a few days. Once Johnny Lind resigned, his co-conspirators needed time to consider their options, and now that they have resigned as well, and the three people with the next highest number of votes in their districts needed a sol or two to adjust to the fact that they were now representatives in the Mars Council,”

“It’d be a shock. I think it’s a shame this happened, Will. People need the freedom to speak their mind. This will force political correctness on the reps.”

“I don’t know, Ramesh. I have no problem with people speaking frankly, but I do have a problem with people opposing something because they don’t like the author. Ideas in the political sphere need the same dispassionate treatment that theories in science need. One shouldn’t oppose a new scientific theory because you don't like the author of the paper. I've heard several people compare that to sexist or racist language, and I think that's a fair comparison."

"Well, I understand your position."

"And I understand yours."

Ramesh sighed. "In some ways, Johnny's stupidity has caused your position to win."

"For now, but egotism will work its way in again and again. That's the real issue in my mind, Ramesh: people who serve in government have to understand it is a burden and a privilege, not an award or a source of prestige. It is a challenge to the ego; it shouldn't feed the ego. It calls one to sacrifice yourself, not make yourself more prominent. But that's very difficult. Marsian government works better than just about any other government around because the representatives and civil servants have a better understanding of this than any other government."

Will paused as the cart slowed. The door to a short tunnel automatically opened and they rolled in. The door on the other side opened and they drove into South America Enclosure. Spain Avenue was replaced by Avenida de Bolivar. The architecture shifted, also, to southern Spanish classic, part Renaissance and part Moorish. The vegetation became more tropical and the air warmer.

"South America is really impressive. The enclosure is 1.5 kilometers wide and 2 kilometers long and the dome in the center is 750 meters up. We could easily set off fireworks in here! We could fly airplanes! The air alone adds 300 kilograms per square meter of protection against cosmic rays, which is equal to the entire Martian atmosphere overhead! And of course the dome has 3 meters of crystal water built into it, which basically eliminates all radiation dangers."

“I’m amazed by the water; this dome has what, 9 million tonnes of water in it?”

“That’s right; massive forces to control, the water weight downward and the 27 million tonnes of air pressure upward. It took Martech’s supercomputers a long time to figure out the best combination of cables to manage them. We’re still tinkering with the design of Africa and Asia; they’re even bigger. Asia will be 2 kilometers by 4.”

They rolled into Plaza de Exploración, the central plaza for the enclosure. “The statue in the middle is a copy of the ‘Spirit of Mars’ Androgyne that welcomes everyone, up on Phobos. Of course, if this was a real South American square, the statue would be of Christ instead!” Ramesh laughed at that. “This enclosure has just four thousand people in it, so far, but can accommodate up to thirty thousand eventually. Right now, eighty percent of it is farmland. When we finish building through Asia, we will be able to house and feed over 200,000. After that we’ll add agricultural enclosures north and south of these, and we’ll be able to house and feed half a million.”

“That won’t be long.”

“Longer than you think, because of the push to build up the Central Highlands. Personally, I think that’s crazy. We don’t need to scatter our population all over the planet this way. If most of it is in one place, compact, we have much greater economic efficiency.”

“I don’t know, Ramesh. With the metal highway reducing transportation costs and hyperloop speeds, things can be spread out pretty well. That also protects us against disasters.”

“I suppose. But think of the cost. I now have two enclosure construction systems running here. Each cost a billion redbacks to create; it’s expensive infrastructure. I now have an enclosure construction system at Dawes as well, and we’ll have one operating at Cassini later this year.

They want me to set up systems for Uzboi, Thymiamata, and Meridiani in the next four years; that's 3 billion redbacks more, and several hundred employees for each one. Then I'll need another one here and one at Kalgoorlie."

"But immigration is growing 35% per columbiad, and you need to keep up."

"But consider just the water problem! We have a long horizontal tunnel drilled into the escarpment and we're extending it five kilometers every year. It's drilling through permafrost and can supply us with the millions of tonnes of water we need here. But at Cassini, Dawes, and the other places, we have to drill deep vertical wells and pump water up from several kilometers down. It's expensive. We have to haul all the metals from Uzboi and all the plastics from here, thousands of tonnes of freight rolling down the metal highway. Storing the oxygen, inflating the enclosures; these require massive infrastructure. We'd save money putting everything here. Most people want to live at Aurorae."

"I suppose that's true, but the other boroughs are now pretty comfortable."

Ramesh shrugged. The cart slowed again because it had crossed all 1.5 kilometers and had reached the eastern side of South America enclosure. To Will's surprise, the cart rolled up to a tunnel door and the door opened. They rolled inside and the door at the far end opened as well.

"Wow! You've inflated North America!"

"We have! It was finished just last week! I thought you'd like to see."

"I do!"

The cart slowed and detoured to the right onto a temporary avenue of dirt. Where the future avenue would be located was a long hole fifteen meters deep, and into the hole, tunnel segments were being placed by robotic crane and welded together robotically. Eventually they would allow two levels and six lanes of traffic, with the outpost's electrical and communications cables running overhead and pipes for water, sewer, and air running underneath. On one side of the future avenue was a five meter deep excavation and a series of mounds of boulders, gravel, and fine material; on the other side next to them, prefabricated metal boxes three meters high, ten wide, and twenty long were being placed and welded together. At one street corner they were stacked four high to make a building with a basement level and three stories above ground.

"Quite something, eh?" said Ramesh, noting Will's gaze. "Every module is pre-designed based on its use, the interior décor, wiring, and plumbing was installed in the factory, and then they are placed and sheathed in the appropriate vinyl exterior. These buildings will take the look of the latest architectural styles on Earth."

Will nodded, a bit irritated Ramesh told him something every adult on Mars knew. Ramesh pointed around him. "The enclosure is 1.5 kilometers wide and 3 kilometers long; 4.5 million square meters of polder, initially holding up to 22,000 people, but once we move the agriculture out into North America-North and North America-South, its population could reach 90,000. This is Washington Avenue; it connects to Bolivar Avenue in South America Enclosure. On the other side of New York Circle, which is right in the middle of the enclosure, Martin Luther King Avenue runs to Africa Enclosure." He pointed to New York Circle, which they were slowly approaching. "We've zoned this area for skyscrapers; why not, it's New York, and the dome is 750 meters above it! That's twice the height of the Empire State Building!"

"But I doubt we'd ever build anything that high." Will glanced upward and could barely see the dome, over 2,200 feet above him. It was very impressive.

Ramesh shrugged. "I hope we do. Land is expensive to pressurize, so why not? The main transportation and services access under this avenue can handle the traffic. New York Circle will be slightly larger than the Etoile; 250 meters, and the middle will be like Central Park, which is lined with skyscrapers. Why not think big?"

"I guess so." Will pointed southward. "I owned fifty hectares down there and had to sell it for this enclosure to be built. We had planned to expand Aurorae westward, so I modestly decided to buy land to the east instead. But we've expanded in both directions."

"How much did the land go up in value?"

"I think I sold it for six times as much as I bought it. We old timers didn't have much to spend our salaries on because there were no consumer goods, so we bought a lot of land!"

Ramesh nodded knowingly. The cart slowed as they approached New York Circle. The transportation and service access continued straight across the future park and met a north-south street there; another large area was the future transpo station, where one could catch automated vehicles. The excavation was even deeper there so that the north-south traffic could pass under the east-west traffic.

Ramesh stopped the cart when it reached a temporary metal bridge over the north-south avenue's future complex of tunnels. He pointed northward. "Since this is a 3-kilometer long enclosure, it has a prominent north-south axis, with Quebec Circle 1 kilometer to the north and Atlanta Circle 1 kilometer to the south. Two grand avenues meet here at New York circle, both on the surface and underground. I want to name this north-south thoroughfare Elliott Avenue."

Will looked at Ramesh, startled. Ramesh stared at him looking for a sign of pleasure. But Will shook his head. "No, Ramesh, please don't."

"This enclosure's streets are named for famous North Americans, and you qualify; not to mention you are our first Chief Minister, and that after a long and distinguished career. You are a historic figure."

"Ramesh, please: I said no. It is precisely honors like these that are unhealthy for me. People do civic service for the reward of service only, not for adulation. I'm constantly dealing with fawning people as it is, and I don't like it. If you are looking for a suitable choice, use Columbus. I know he has a bad reputation, but NASA named the first Mars project for him, so he can't be all bad."

"Will, you agreed that a borough be named for you."

"It's small, remote, and it represents the spirit of Mars; besides, they invited me and told me when I was there, and I couldn't refuse them. But this is different; it is from the planner, not the people, and it is big, central, and prominent."

"Politicians name things for themselves all the time."

"I know, and frankly, I don't approve. It's part of the egotism problem we were just speaking about."

Ramesh shook his head, amazed. "Alright, Will, suit yourself."

15.

Like Scientists, Not Politicians

July 2083

Oskar Langlais stepped out of the headquarters of *Mars This Sol* with a quick and confident step. His first week at work was over and he was very happy.

He headed down the stairs into Cochabamba Enclosure's transpo stop. He pulled out his communicator as he descended, clicked on the transpo icon, and tapped on the stored request for transportation to Australia, which was just one station away. A text immediately appeared:

Vehicle 557, Stop 15, 1.5 minutes.

He knew exactly where that was; autocars going to Australia usually parked at stop 15, 16, 17, or 18. He walked straight to stop 15 and arrived just as the unstaffed 12-vehicle car pulled up. He stepped in, swiped the quad code on the communicator's screen, and walked back to one of the few empty seats left. He ended up next to a friend, Samantha Barnes. "Hey, Sami, good sol!"

She smiled. "Good sol, Oskar how are you? You look happy."

"I just finished my first week at *Mars This Sol* and my boss complimented my work, so I'm thrilled! He said, 'Earth may have too many English majors, but Mars has a shortage.' He had me editing all sorts of things; the editing software can only go so far."

"That's great! And I suppose if anyone need writers, it's *Mars This Sol*."

"I'm mostly editing web copy, and we have a lot of it. How are you doing?"

"Pretty well. I have a summer job in the environmental studies department studying various genetically modified species for photosynthetic efficiency. Really interesting, and good research for Ceres. We think we can get the growth rates up to a decent level at 10% of the usual terrestrial solar insolation levels."

"Really? What about here?"

"They'll grow even faster!"

Oskar smiled. "I'll have to tell my uncle Kristof. He owns all of Ukraine Enclosure and a chunk of Baltic North. Say, a bunch of us are going up to the escarpment this weekend; we're planning to hang out at Oakley's, listen to the music, and drink some beers."

Samantha smiled. "That sounds like fun. I'll talk to my friend Mandy. Maybe we'll both go up."

"You know Oakley's, you'll find us there."

"Yes, I know Oakley's." She smiled.

The autocar pulled into Australia Transpo Station. Oskar smiled, waved, and got up. In a few steps he was out of the vehicle and headed up the ramp to the surface. He headed home in the early evening sunshine feeling very happy. He was an independent adult with a great job. He had many ways to continue his poetry. His long bout with leukemia was finally behind him. He felt like life had really begun.

When he walked into the house, he could smell supper; it must have just arrived. Charlie, Sirikit, and 3 ½ year old Andrew were there, and that reminded Oskar of another step: he had to find a girlfriend and move toward marriage! He was feeling quite ambitious, that sol.

"You look happy," said Charlie to him.

"I am. Work is really great." He turned to Sirikit. "Did you see the story about the Marsian economy on *Mars This Sol?* They quoted you about the extra 2 percent growth."

“I haven’t seen it, no. The Cassini surface vehicle factory has expanded faster than expected, Marcraft was able to add more robots than planned, and Phobos’s production of space vehicles is ahead of schedule.”

“I edited the transcript! They put it up this afternoon.”

“So, you’re editing transcripts?” asked Charlie.

“That’s what they’ve started me on. They may let me start to write or produce my own stories. They don’t cover the arts scene here much, so I mentioned that to my boss. He was interested.”

“That’d be great, if you could do that!” said Sirikit. “*Mars This Sol* only expanded ten percent this columbiad, so they shrank compared to the overall population. They prefer to stretch out their growth and hiring.”

The front door opened and Helmut entered. “Good sol!” he called out to everyone.

“Hey dad!” said Oskar. “How was your day? *Mars This Sol* put up an article about the upcoming debate in the Mars Council about the budget.”

“I saw it; it was good. You’re still enjoying the job?”

“Yes, it’s great. I’m getting to know the rest of the staff and they’re really friendly. It’s a good place to work.”

“And they’ll let you work on stories?”

“Eventually.”

“Good, just stay away from politics!” Helmut laughed at that idea.

“Oh, I will, I want to focus in the arts.”

“That’s a good idea.”

“Let’s eat,” said Clara, emerging from the kitchen with a pitcher of lemonade and pointing to the table.

Everyone headed for their seats. “I saw the article about the Mars Council debate, too,” said Sirikit, as she put food on Andrew’s plate. “I was surprised you decided to appear before the Council and debate the budget.”

“I think it’s a good move,” said Helmut. “Three of the most stubborn opponents of anything I do have been removed, so we have a situation where a real exchange of views is possible. Besides, there are some real issues that need to be cleared up where the Capitol region versus the Central Highlands is concerned.”

“I wish those terms had never been invented,” said Charlie. “The ‘Central Highlands’ are not central to anything, and a lot of the region isn’t even high.”

“True, but it could have been called ‘the gold mining region’ legitimately,” replied Helmut. “Dawes, Cassini, Meridiani, Thymiamata, and Kalgoorlie all share a common origin and history, so they are a logical unit, whatever you call them. Uzboi, Thaumasia, and Tithonium are logically tied to Aurorae as well, even though they share the same origin and history as the other mining boroughs. We used to be heavily dependent on gold export revenue, but now Aurorae is the biggest contributor to the economy, and the metal highways allow the creation of a single market. So we should spread around the growth, if for no other reason than to prevent a major disaster.”

“But at what ratio?” asked Sirikit. “That’s more a government decision than anything else.”

“I know; we have to allocate infrastructure resources, and that determines everyone’s growth," said Helmut. "That's why it's so controversial. If it was a simple matter of economic competition, it wouldn't be."

"So, what ratio?" asked Oskar, suddenly realizing his father's role in Marsian growth.

"Ah." Helmut smiled and waved a finger. "This discussion does not go beyond this dinner table, and certainly not to anyone at *Mars This Sol.*"

"I know that, dad, you've already reminded me of that several times!"

"I know." Helmut paused. "Dawes is on the equator, so it can have an active spaceport, it has the former Chinese nuclear facility, and it has a lot of gold. Meridiani, Thymiamata, and Kalgoorlie have decent gold supplies, but little else, except they're on the highway connecting Dawes to Aurorae. That's an advantage of sorts. Cassini is 2,300 kilometers from Dawes on a spur of highway. It has just as much gold as Dawes and has some uranium and other minerals, and is the oldest borough in the Highlands, but it's more isolated. It has excellent solar power, especially during global dust storms, though. How would you balance them? I have more or less pledged to make them collectively as large as Aurorae, so they'll have 40% of the population, Aurora will have 40%, and the rest will be at Phobos, Uzboi, and the other smaller outposts."

"Dawes would be the biggest," said Sirikit.

"I think so," agreed Helmut. "The spaceport is the main reason. Let's say it's 15% of the population, Cassini 10% because of its diverse mineral production, and the other three 15%, or about 5% each. I think that's where we end up, and that's why Dawes gets a major enclosure-production system first and Cassini second, then Uzboi, which will also be about 10%, then the other three. Uzboi actually will be hard to constrain because it produces just about 100% of our metals, so it exports everything down the highway to Aurorae. Cassini is farthest from

Uzboi, so that limits its growth and explains why it also produces nickel-iron, though it's now cheaper to import nickel-iron from Uzboi."

"And that will actually shrink Cassini," noted Sirikit.

Helmut nodded. "A little, unless we can put something else in Cassini. I'm working on that problem. Getting surface vehicle manufacturing moved to Cassini was a key victory in its growth."

"But why do we really need to spread out the population so much?" asked Clara.

"I think it's a question of fairness and diversity," replied Helmut. "If everyone lives in one place, except for a fringe of small mining settlements, you have one place dominating the others, rather than balance. Each of these places will develop separate subcultures and identities, so a certain amount of diversity will arise. And if a major disaster strikes one borough, the others can help more effectively if they have more resources."

"And besides, the Central Highlands are lobbying for people," added Oskar.

"Yes, but in the current climate of 'scientific politics' that counts for less," said Helmut. "We'll see how the debate unfolds."

There was a pause in the dinner conversation. Sirikit again turned to Andrew and helped him with his plate. Then Oskar said, "As soon as we're done eating, I'm going up to the escarpment."

"When will you be home?" asked Clara.

He shrugged. "I don't know; I might spend the night there."

"The bars close at 1," observed Helmut.

"Well, be careful," said Clara. "Why not hang out in City Square? Won't you find friends there?”

“Some, but most are going up to the escarpment.” Oskar turned to Helmut. “I think I’m going to rent an apartment next month.”

“Oh?” Helmut was startled and looked at his younger son, who was now 20 and a college graduate. “Why not. You’re earning enough. You don’t want to buy?”

“I think I’ll wait a few months or a year and see what renting is like. There are lots of places becoming available.”

“We’re six months after the arrival wave, so housing for the next columbiad is becoming available,” said Helmut. “This is a good time. Where will you look?”

“I don’t know; maybe in Europe Enclosure. It’s pretty and there are a lot of places available.”

“You are always free to stay here, Oskar,” said Clara. There was a pleading in her eyes.

“I know, mom, but it feels like the right time to get my own place.”

“I understand,” she said, her voice trailing off.

“It’s a big move,” said Helmut, looking at Oskar and Clara. “Take your time and plan it carefully.”

“I will.” Oskar finished his last fork full of dinner and rose. “I got to get a few things in my room, then I’m heading up the escarpment.” He rose from the table and walked to the stairs, where he disappeared down into the family quarters.

Helmut looked at Clara. “Courage, my dear.”

“I know,” said Clara, her voice quavering. “But he’s the last one.”

“An empty nest,” agreed Helmut. He looked at Charlie. “In some ways, your departure was worse, because you were leaving Ceres for Mars and you were much younger!"

"And I didn't realize it'd be hard on you, but boy, was it hard on me!"

A few minutes later, Oskar reappeared with a backpack. Maybe he'd be back that evening, or maybe not; he brought his toothbrush and toothpaste and some deodorant. As he stepped out, he asked his communicator for the schedule of share autocars for the Escarpment. There were already three scheduled by different people, and the next one still had one empty space. He tried to reserve it and a moment later received instructions to head immediately to the Australia Transpo to catch a certain autocar heading to Cochabamba Enclosure, where the shared autocar would depart for the escarpment in three minutes. *God Bless Transpo,* Oskar thought. So quick and easy, and because the whole system basically was shared or private robotic taxis, it was fairly inexpensive.

Thirty-nine minutes later he was walking into Oakley's, a large western-themed open-air tavern and restaurant with a space for a band to play and room for dancing. A band playing western music was already performing; for some reason, Marsians had fallen in love with songs about cowboys, and Oakley's was riding the fad. Because many people had come up straight from work, the place was packed, and since it was Frisol night and people often splurged a bit that night, there were lots of plates covered by real steak, ribs, and chicken. Samantha wasn't there, so he stepped back on the boardwalk for a few minutes where it was less crowded and where the music was more to his liking. Several people were either singing or playing guitars or flutes there, a basket for Marsian dollars open next to them, though no doubt all of them were also getting a subsidy from the Marsian Ministry of Culture to perform in public. While he waited, Samantha came along with another woman.

"You made it!" said Oskar, happy she really had come.

"Yes, I like Oakley's. This is Mandy Grossman."

The second young woman extended a hand. "Pleased to meet you."

"Pleased to meet you, too." Oskar liked what he saw; she was pretty and blonde. "Oskar Langlais."

"Oh? Related to the Chief Minister?"

"He's my father. But that means I get treated worse, not better!" Oskar said it with a smile, so she laughed a little.

"Yes, that can happen. I'm in artificial intelligence, or at least that's my plan; I have one more year to finish at Martech."

"I'm surprised I haven't seen you around."

"Well, I arrived from Earth with my parents almost three years ago, now, and I left Earth when I was still 17, so I was a minor and could accompany them. If they hadn't been accepted that columbiad, this columbiad I would have been 19, would have been an adult, and would still be on Earth!"

"I hope you want to be here."

"Oh, yes! I pushed them to apply. I'm the one who wanted to come to Mars! Dad and mom are both bankers and they never thought they would be needed up here, but it turns out there's a desperate need for bankers!"

Oskar laughed a bit at that, but nodded. He turned to Samantha. "Shall we all go into Oakley's? It's crowded, but I'm sure we can find a table."

"Yes, let's. I like the music," agreed Samantha. The three of them turned and started walking toward the entrance, then Samantha got a call. She pulled out her communicator and they waited, because it was too noisy inside to hear a call. She listened, nodded, and said “okay, I’ll be there in an hour.” There was disappointment in her voice.

“What is it?” asked Mandy.

“There’s an emergency in the plant genetics lab; I didn’t get the details, but they’re calling in everyone to help salvage. It sounds like there was a pipe leak or something.”

“How bizarre; that’s a new lab,” said Oskar.

“Maybe that’s the problem. Anyway, I’m sorry, Mandy, that I brought you all the way up here. I apologize for that.”

“I’ll try to be good company instead,” said Oskar cheerfully.

Mandy looked at Oskar. “Thanks, Samantha, I think this will work out fine.”

“Mars is a safe place,” said Oskar. “I’m sorry you can’t join us for a drink, at least.”

“No, I had better go, but maybe next Frisol.” Samantha waved. “Ciao.”

They watched her walk down the Boardwalk to the transpo station next to the Dacha. Then Oskar said, “Let’s go in and find a table.” Mandy nodded, so they walked in and were greeted by a robot, which led them to the bar, which was the only place to sit. Another couple, a European man and an East Asian looking woman in their 30s, had to move over by one seat to free up two seats for them. “Sorry to disturb you,” Oskar said to them as they sat. “The place is pretty crowded.”

“That’s okay,” the man said. “We’re glad to give you some room.”

“I’m Mandy,” said Mandy, seemingly relieved that there were some other people around, since she didn’t know Oskar at all.

"Changying."

"I'm Ted."

"And I'm Oskar; Oskar Langlais." He loved to add his last name to see the reaction it produced.

"Langlais?" Rather than being impressed, Ted appeared startled, even frightened.

"Yes; the Chief Minister is my dad."

"Good to meet you," said Changying quickly. "We don't want to interrupt the two of you, either."

"That's alright," said Mandy. "I can pull up their menu on my communicator, right? I've never been here before. I just turned 20, so I can now drink. Until then, I had never sat at a bar!"

"Yes, just ask the communicator," said Oskar, and he held up his screen.

"I highly recommend their Mai Tais," said Changying, pointing to her drink.

"I'll have a screwdriver," Oskar said to his communicator, which immediately transmitted the order.

"And I'll try a Mai Tai, I guess," said Mandy. She turned to Oskar. "So, what do you do?"

"I just started at *Mars This Sol* as a copy editor and researcher, but on the side I'm a musician and poet, and I hope to cover the arts for the website eventually."

"They'll let you do that?"

"It's a small operation, so they encourage everyone to write and report, but first I have to prove myself. They don't cover the arts much. My boss has said that I can work 35 hours a week if I get a cultural grant to write poetry, too, so he'll let me go part time."

"That's a great thing about Mars; the laws require work flexibility. I know people who work three different jobs because they want to, and they don't suffer financially all that much from it."

"It's true. We're small, so we need a flexible, agile, creative workforce. So, you just arrived three years ago? From where?"

"Canada; British Columbia."

"Really, my mom's from there!"

"Really? Small world."

"And your last name, Grossman, is German. My father's family is German."

"Another coincidence! So, you were born here?"

"Yes, in Aurorae. But when I was four, my family departed on Ceres 1, which my father commanded. We were the first self-governing settlement that was sent out; now they are all set up with a basic law and elections before they go out. We were on Ceres twelve years and had to leave because I developed a very serious case of leukemia that couldn't be controlled by the medical facilities there. So we flew back here, I was carted out of the landing shuttle on a stretcher and taken to Mariner Hospital, and with the proper genetic diagnosis they were able to beat the leukemia."

"Wow, I had no idea. That must have been hard!"

"I didn't have much of a teenhood, but it made me an artist." He said that with a smile. "Seriously, with counseling, I think I have made the most of the experience, and what more can anyone say?" He shrugged. Just then a robot brought him his screwdriver, so he took a sip. "I could drink a bunch of these to cope, but fortunately, I don't. Writing is a more positive outlet."

"I should say so," said Mandy, admiringly. "I lived a pretty comfortable, even sheltered childhood. That's the advantage of growing up in Canada; we didn't have the nuclear war that the U.S. and China did, and our economy managed alright most of the time. Almost as sheltered as growing up here!"

"Yes, Mars has done pretty well, but we still have our angst, our anxieties, our existential crises. You can't avoid those."

"That's for sure. So, what are your career plans?"

"I want to be a poet! But how to get there . . . I guess I'll research and copy edit for *Mars This Sol* for now, and maybe report on the arts for them when they let me. It uses the standard civil service pay scale, which just about everyone here uses."

"So pay starts out decent and goes up, but slowly," said Mandy, nodding. "I'm still living at home with my parents, since I have one semester of senior year left, though I'm spending it completing courses for my Master's degree, so I'll be that much farther ahead when I graduate. You have to get a PhD in AI. The joke is that computers program themselves faster than we can program ourselves in grad school!"

Oskar laughed at that one. "Probably true. But computers now program other computers, so do you program the computers that program the computers, or do you program the computers that program other computers that program computers?"

Mandy laughed. "I think we're four or five levels removed, now! They're talking about building a robot to belong to, accompany, and assist every single arrival at the next columbiad; all 40,000 people! It can be done, too. The only way to augment human brainpower up here enough so that we can compete is to give everyone a robot."

"Sounds right to me," Oskar said. "They can be great assisting in writing as researchers, even in stylistics. But I'm not sure I can use one full time."

"Wait and see; in six months it'll be irreplaceable."

"I suppose." He smiled at her; he liked her.

She smiled back. "I sense you are someone who has had a great weight lifted off you."

"Yes, that's true! The constant danger of death, my stunted growth, and the struggle to catch up in school . . . it's been hard, but I finally feel like I've arrived as an adult. This sol was my first paycheck from work!"

"Congratulations! Yes, I know a bit of that feeling. You wonder when you cross that threshold to adulthood. My parents have been treating me as an adult for two years, now, so I feel I am, even though I don't have that first paycheck."

Oskar decided to take a big chance. "Well, if you want to stay with me tonight, there are other ways to cross that threshold."

She shrugged. "I like you, Oskar, but if you want to see where this is going to go, maybe we'll cross that threshold on the second or third date."

"Okay," he said with a nod, relieved she hadn't rejected him.

Just then, the couple next to them rose. "Good evening," Changying said to Mandy.

"Thank you, very nice to meet you," replied Mandy.

Oskar watched Ted as the couple moved away, and Ted eyed him nervously in turn. Then Ted turned away and looped his arm through Changying's as they exited Oakley's.

"You were so nervous!" said Changying, once they were on the Boardwalk.

"He's the son of Langlais and works for *Mars This Sol!"*

"Yes, but he's a poet and not looking for a story. Looking nervous is the worst thing you could do. Did you see how casual I was? I bet they'll forget completely about us."

"I suppose so. I hope so. It's just . . . our jobs hinge on our relationship remaining secret."

"I know," she replied. "And I'm confident that it will, if you just calm down!"

Helmut strode into the Mars Council's Chamber with some confidence. He wasn't completely sure why he felt confident. It was partly that Johnny Lind and some of his other critics had had to resign from the Council, and now the legislative body was much more positive toward his budget and the projects it embodied. Unlike Will Elliott, Helmut had never gotten comfortable inviting the representatives to his house, feeding them, and schmoozing with them informally, especially with Johnny coming in second, both in the Chief Minister election and the subsequent Speaker of the Council election. He had come to the Council twice previously to argue his case, and that was what he planned to do that sol.

Various people approached him right away and he was busy talking to them for several minutes until Yuri Severin, the Speaker, called the Council to order. Helmut sat for the opening meditation, then Yuri gave him the floor.

"I want to welcome the representatives of the sixteenth Mars Council to their deliberations, thank you for your service to the Commonwealth, and express my gratitude that you have welcomed me to present my budget to you on this sol," he began. "We have seen tumultuous and challenging times in the last year, but in spite of them, we have come through as a united and purposeful people. It is that sense of purpose that distinguishes us from our terrestrial cousins, who live in nations whose main purpose is to battle terrorism while fighting internal culture wars over their relationship with the rest of humanity, and whose citizens often have no employment and no particular purpose other than raising children while debating what to purchase next. In contrast, we are reaching across the solar system and we are already looking beyond to the Kuiper Belt and perhaps the nearest star. The budget I am submitting for your consideration on this sol is an exploration budget, an expansion budget, and a vision budget for the growth of the Marsian Commonwealth.

"Over the next annum, our Gross Domestic Product should exceed eighty billion redbacks. The budget of the Commonwealth is only twenty-six billion of that, but it is important to note that the private sector will spend money strategically as well. The construction industry alone will spend eight billion to construct housing and work space for the 2084 immigration wave, and the Commonwealth will spend four billion more on enclosures and infrastructure to house and feed them, plus four billion to bring 40,000 people here. That's one third of our budget, right there, but it pays us back amply because those 40,000 people will increase our GDP by thirty percent every year.

"You will note that forty thousand is slightly smaller than the original projection of fifty thousand immigrants in 2084-85. We have not begun to run up against natural limits in immigration across the vast gulf of space that separates us from Earth. Rather, we have made a strategic decision to slow the rate of immigration somewhat because of the strain it puts on our society and culture. Immigration is both a blessing and a curse and has always been somewhat controversial. Perhaps if we try a slightly slower rate of growth, it will be less controversial and less disruptive.

"The budget for this annum inevitably includes three billion for education from preschool through high school and two billion for health care and pensions, which remain a small fraction because we are a young nation. Another billion goes to Martech and its non-space related research. Space related engineering research gets two billion, with two billion more going to automated probes and staffed expeditions to the asteroid belt and other inner solar system targets from both Phobos and Ceres. Saturn, Uranus, and Neptune get a billion each, as do the Kuiper and Pluto projects. When you include the four billion to bring immigrants to Mars, our total space budget is thirteen billion, or two thirds of our total. Because of our efficiencies, we use that money more effectively than the United States, which has a government space budget four times larger.

"Terraformation gets half a billion, split fairly evenly between nuclear heating of the poles and production of greenhouse gases. Although it is small, it remains controversial. The results of the 100-megaton explosion three months ago are now thoroughly studied. Radioactive releases, including tritium, were exactly as predicted. The seasonal thickening of the atmosphere proceeded a bit faster than the computer model because the increased amount of dust in the atmosphere accelerated solar heating. The result is a likely shift in our strategy for the South Pole, where the bulk of the planetary reservoir of carbon dioxide is stored, favoring a mix of air bursts to stir up atmospheric dust and underground explosions to add heat to the CO_2 reservoir steadily from below. All of this gives us confidence that within a century we can triple or even quadruple the thickness of the atmosphere, trigger another estival, release Martian lifeforms back onto the planet's surface, and enjoy a world that is safer for us as well."

He paused and there was a burst of applause, which surprised him. Terraformation was controversial, but the partial terraformation they were aiming for was gaining acceptance, because more and more Marsians were feeling responsible for the resurgence of the Martian ecology.

“There isn’t much left to mention in the budget,” Helmut resumed. “The budget for the arts, at 100 million redbacks, will support theatre, music of all sorts, visual arts, poetry, and dance. Public support in the form of tickets, subscriptions, and purchases doubles the amount available and creates a vigorous cultural scene.

“Finally, transportation gets a billion redbacks. Some of that goes to maintaining spaceports and flying our jetwings to connect the boroughs together by air, but we plan to phase out jetwings entirely over the next two annums. Flights to Jumla and Elysium from Dawes and Aurorae will continue but will use Prometheus shuttles, which are already tying the Martian surface to Phobos and Deimos. The bulk of the billion redbacks will go to continued upgrade and extension of the metal highway system. Currently, we have surface vehicles cruising them at up to two hundred kilometers per hour, which allows a trip from Aurorae to Uzboi in 9 hours and Dawes to Cassini or Meridiani in 12. These are reasonable times for surface transport, but they are not adequate to tie the Capital region to the Central Highlands via surface transportation. Aurorae to Dawes takes two sols, even at that speed.

“Therefore, we need to invest in a serious upgrade in our metal highway system. Most of it is straight enough to allow hyperloop speeds, but certain stretches on the Uzboi route and the area around Aram go through chaotic terrain. There, elevating the highway above the buttes and canyons can produce the straight track necessary to allow speeds in excess of a thousand kilometers per hour. Because the highway surface is nickel-iron, magnetic levitation is possible, reducing friction and allowing faster transport. Better software will allow vehicles operating at different speeds to pass each other safely as well.

“Our goal is transportation at 1,200 kilometers per hour within four years.” He paused for the gasp in the audience. “We are finally constructing a hyperloop, and because the Martian atmosphere is so thin, it need not be in a partially evacuated tunnel. Slower speeds will be necessary for as much as a decade while some sections of the metal highway are upgraded and pull outs are added to make passing safer. At that speed, Uzboi will be less 90 minutes from Aurorae; Tithonium, 3 hours; Dawes, 5 hours; Dawes to Cassini or Meridiani, 2 hours. The metal highway being extended to Jumla will be designed to accommodate the higher speeds, as will the Jumla to Elysium segment that can probably completed in ten years. Once 1,200 kilometers per hour is established, the 13,700 kilometer run from Aurorae to Elysium will be possible in 11 hours.

“I can’t underline the importance of this development enough. Hyperspeed will make us one community in a way nothing else can. It will allow the spreading out of our population across many boroughs, thereby developing regional diversity and reducing the dominance of any one place. It will set the stage for a larger Marsian population with access to more of this world. It complements our plans to explore and settle the solar system as well. In short, the budget I am submitting for this annum is a future-oriented budget that will take us across the sands of Dusty Red and lead us to the stars.”

Helmut stepped back from the podium to strong applause. Yuri stepped forward, waited a while for the applause to abate, then said, “The Chief Minister will now take questions.”

Hands shot up; the protocol did not include use of electronic devices to signal one’s interest to speak. Ramesh was waving his with particular vigor, but Yuri chose to look away for now. “Cassandra.”

Cassandra Fuller, the secretary of the Council and therefore the number two in the Council's organization, rose from her seat. "Chief Minister Helmut, when we were growing 50% per columbiad, some said it was too fast. Now we're growing at 40%. Is that a permanent change? And could you comment on what is 'too fast' and what is 'too slow'? I suspect some people will say 40,000 immigrants per columbiad is still too many, but others will say it is too few."

Helmut smiled. "I'll take your last question first. I don't think we can define too many or too few in a purely scientific manner. We can define it financially; we can afford 40%, but we could afford 50% if we chose to devote the resources. We could probably afford as much as 75% per columbiad with careful planning and extensive devotion of our resources to it. On the other hand, very rapid growth is quite disruptive. Institutions have to grow twenty to fifty percent every two years. It's quite hard on private business and is a factor in our heavy dependence on government and semi-public corporations. As we get more complex, managing rapid growth gets harder.

"On the other hand, we don't want to stop growth, either. Old age pensions and health care for senior citizens are easy to afford when less than 1% of the population is over 70. The larger we are, the more influential we can be in the human community. But we also have to ask how many qualified people want to come to Mars. We are getting about 100,000 new applications every columbiad. Perhaps we could double or triple that number. If we want to retain our unique character, we probably need to be selective.

"I've talked to various experts and the cabinet has discussed this matter several times in the last year. We think there probably is an upper limit on our immigration rate of, say, a few hundred thousand per columbiad. If so, we are now a tenth of the way there. That argues for a slowdown in the percentage rate of our growth. If we bring 40,000 in 2084, let's aim for 50,000 or 55,000 in 2086, then 70,000, then 90,000. At that point, growth will be closer to 25% per columbiad, but that's fine."

"So, we'd hit an immigration rate of 200,000 in about 14 years?" asked someone. "And after that we'd stay at or near that number?"

"Or perhaps the number would continue to increase, but slowly," replied Helmut. "It would depend on the size and quality of the applicant pool. We need to grow; there's no question about that. We have as much dry land as all of Earth; 145 million square kilometers. At 1,000 people per square kilometer, which is one fifth of our current density, this planet could accommodate 145 billion people! There is no reason to assume that eventually, Mars can't have a population rivaling China or India."

Ramesh shot up his hand again and this time, Yuri called on him. He rose. "I am very concerned about the policy of decentralization. You have stated that the Central Highlands region should have a population as large as Aurorae. I see absolutely no reason for this policy. Most people want to live in Aurorae. It is more efficient to put the bulk of the population in one place or region, with other boroughs developed to provide specific essentials to that central concentration. Why are you pursuing the decentralization policy, and how much is it costing the Commonwealth that could otherwise be saved by centralization?"

"There are various reasons to pursue decentralization," replied Helmut. "While it is difficult to imagine a single disaster capable of destroying all of Aurorae—it now has several dozen enclosures, after all, and it is hard to imagine a disaster capable of breaching more than 2 or 3 of them—nevertheless, a multitude of boroughs are in a better position to help each other than one large borough might be.

"But beyond that matter, there are issues of fairness, political power, and diversity to consider. Inevitably, if one place dominates, there will be jealousy. There will be a sense that the place is out for its own benefit at the expense of the common weal. A multitude of boroughs with some similarity of size to each other will balance each other's priorities better. Political power will be more evenly distributed; people everywhere will have a better feeling they are able to make their voices heard. And each place has already developed its own uniqueness; there are slight differences of accent and heritage already. That diversity will be enhanced if each borough has a greater chance to develop itself, rather than remain a small appendage of a large central location.

"As for cost, material cost is only one measure. I don't think it is significant because the metal highway already makes movement of goods cheap and fast enough. There are also non-material costs to consider such as the ones I just mentioned, and they favor decentralization."

"If I may, Mr. Chief Minister, I disagree," continued Ramesh. "I can be very precise about the additional cost: a billion redbacks per borough. That's how much it costs to install one of our new enclosure systems. You have budgeted for one per annum, one billion redbacks of your 26 billion redback budget."

"No, that is not a true measure because if Dawes didn't have an enclosure making system and Cassini wasn't slated to get one in 2084, Aurorae would need at least one more. So yes, there is an extra cost. But it is because you do such a fantastic job, Ramesh, and I really mean that.

People come here from Dawes, enter South America, look up at the dome 750 meters overhead, and are awestruck. And naturally, they want the same for their borough. We yearn for open space. I remember when I arrived here on Columbus 7 and we had a total of four enclosures at Aurorae, the biggest just fifty meters across, and everyone was saying two things: thank God we have so much open space now, compared to earlier years, but oh, I wish we had more! The residents of all our boroughs deserve open space. Yes, it costs money. But 500 meters of air is more than just a huge oxygen reserve; it's a sense of freedom."

That remark generated powerful applause from much of the chamber, much to Helmut's surprise. Ramesh, defeated, sat. David Hamm, Dawes's executive, rose. "Mr. Chief Minister, will the Central Highlands get more support from the Commonwealth, beyond your pledge that we will equal Aurorae in size? After all, our gold production is a huge engine for Mars's economic growth."

"David, my pledge is that the Central Highlands Boroughs—Cassini, Dawes, Meridiani, Kalgoorlie, Thymiamata, and Elliott—together will equal Aurorae in population. That presumably means both will have close to forty percent of the Marsian population. Uzboi will always tend to have close to ten percent, because of its metal output. Phobos and Ceres together will generally be close to ten percent of our population as well, because of their roles in the solar system economy.

"I think we will get to this 40/40 division in a few more years, but after that, we have to see what innovations for growth the boroughs can initiate for themselves. Let's look at history for a moment. Aurorae was it for the first decade; it was the only economic engine Mars had, and it was a little one. Then we found gold and established, in ten years, five more boroughs. They had less population than Aurorae, but dominated Marsian exports. They were the larger economic engine, while Aurorae continued to provide coordination, planetary services like Martech and Mariner Hospital, and emergency services. Then Aurorae grew to exceed both the Central Highlands and Uzboi in economic output; Aurorae's economic engine was and remains the largest. Government policy is now one of balance between the capital and the Central Highlands. If you all can pull ahead of Aurorae, the government will not stand in your way.

"But you all will need to look at your growth plans, your innovations, and your tax and investment policies, and make them better. We already have a Commonwealth Development Bank you can borrow from and liberal policies about the issuing of bonds, so you have access to investment capital. Let's see what you can do with the resources at hand. If we need to grow the Commonwealth Development Bank, we can look into that. Because the Commonwealth can't continue to coordinate—micromanage—the Marsian economy. It's too big and complex."

"So, are you saying Dawes and Cassini should stop competing against each other and work together?" asked Cassandra, who also was from Dawes.

"Cassandra, Dawes and Cassini should be vying with each other, not competing. To vie together is to stretch each other, challenge each other; it is cooperative competition. You can undercut each other and block each other's progress. I have occasionally seen some of that, and I'm sure you have as well. But Mars is a win-win society, remember? That means accepting that sometimes the other gets something you want, but it's okay, because now you can move on and seek something else, and both of you will be better. That's the spirit Mars needs."

"What would you say to summarize your appeal to the Council?" asked Yuri.

"That we take this new slogan I have been hearing over the last few months: that we look at governance like scientists instead of politicians. If we do that, the Mars Council will make changes to improve the budget, and I will be delighted. I will also be glad to come back and discuss proposed changes."

"And we will welcome you back, Mr. Chief Minister," replied Yuri.

16

Working Together

early Sept. 2083

Ted was jealous of Changying's apartment. She had negotiated a larger salary from the Chinese Space Agency than he had managed to extract from NASA, and as a result her place was a fourth floor condo with a birds-eye view of the Etoile, which was so much prettier and more peaceful than his view of City Square. When she came out of the bathroom, she saw him standing, naked, in her living room looking at the view.

"You love my place, don't you?"

"I really do. The setting is magnificent." He sighed. "But I've got to shave, wash, and go."

"Early meeting?"

He nodded.

"Elliott?"

He was surprised she mentioned someone by name; they never, ever, discussed their work with the other, except in the most theoretical and philosophical ways. But she had had an early appointment three sols earlier. He was tempted to ask her whether it had been with Will Elliott, but he decided he'd assume it.

"Yes, coffee in the big café in City Square."

Changying smiled mysteriously. "Maybe we'll talk about it tonight."

He didn't say anything to that; he was determined to keep their relationship strictly separate from their work. She was out of the bathroom, so he hurried in to shave and shower.

When he came out, she was ready to leave, so they kissed goodbye and he hurried out the back door while she went out the front; he was very concerned that someone would see them together. He had a little time to run back to his place and check messages, then he descended the spiral ramp to City Square and walked to the café. Will Elliott arrived at the same time.

“Good morning; there’s a table where we can have a private conversation,” said Will pointing. “How are you this sol?”

“Pretty good,” replied Ted, following Will to the table. “You?”

“Excellent, for an 82 year old. I was up at 6 and got in a five kilometer walk, including the top of Boat Rock. Got to do it every sol.” They sat. “Have breakfast on me.”

“No, that’s alright.”

“No, I insist. It’s not fancy; it won’t violate any rules.” Will picked up his communicator and dictated an order into it, then handed the communicator to Ted so he could do the same. Ted ordered a fish taco. “Unusual, for breakfast.”

Ted shrugged. “I like fish a lot. My dad and I used to go fishing almost every weekend.”

“Do you miss it?”

“Yes. That’s something you can’t do up here.”

Will shook his head. “Wrong. Baltic Lake and Snow Crater both have trout. Snow has Lake Trout, and they can get pretty big. You can get a license to catch and release as many as you want. You can keep one that’s at least 30 centimeters every six months.”

“Really? I thought Snow was our water supply.”

“It is, and it’s very clean. But it’s oxygenated and the air inside the dome is standard Marsian pressure. There’s boat and fishing gear rental there. My son in law and I go once a month or so. You can join us some time, if you'd like."

Ted smiled. "I'd enjoy that. Thank you."

"You're welcome. It's very relaxing and we'd be glad to have a third person with us."

Just then, a robotic cart approached with their orders; the cafe was known to be very quick with orders. They grabbed their orders. "So, what do you think of the legislative session?" asked Ted.

"It went well; I suppose I'd say it represented a new level of maturity. The pettiness and self-centered politicking was greatly reduced, with three colleagues replaced."

"I was amazed by the reaction when *Mars This Sol* released the recording. In the United States it would have been a mere embarrassment! People would have said 'business as usual; politics is dirty.' But here, everyone seized on the argument that politics should be run like science—not that science is apolitical, it can get pretty dirty, too—and that what they were doing was equivalent to racially biased language."

"Yes; it was chauvinism," agreed Will. "And I have to admit, I had a lot to do with the reaction."

"Yes, your op-ed pieces on *Mars This Sol* thundered in righteous anger."

"Without even mentioning anyone by name! I was dealing with principles, not personalities. But back to the legislative session: The Council called in a lot of ministry heads, asked them about their priorities and their long-term version, asked how their priorities meshed with those of other departments, called in Helmut twice more and asked him about several major modifications to the budget based on the thinking the Council had generated, he agreed they were good ideas, and the budget was passed. I worked with the Mars Council as Chief Minister, I’ve sat on that body when Jacquie was Chief Minister, I’ve worked with Mars legislative bodies for decades, and I’ve never seen such a deliberative, mature process. I suppose it won’t last, but this session has set the standard. The purpose of the legislature is to review and improve, not make arbitrary changes and add personal pet projects.”

“Do you think the rivalry between the Central Highlands and Aurorae was healed?”

Will shook his head. “Improved a bit, but not eliminated. Maybe the Central Highlanders now realize that if they want to equal Aurorae in size and influence, they need to work together more, to coordinate more. The rivalry between Cassini and Dawes has been a big limiting factor. They need their own steering group, and it sounds like they’ll form one.”

“Even so, a steering committee really can’t make up for the fact that the Central Highlands has six settlements scattered over an area the size of the United States, and the metal highway can’t overcome distance completely.”

“I agree. Cassini and Dawes are 2,300 kilometers apart; that’s equivalent to half way across the United States. It’s a long way. Meridiani is just as far from Dawes, so it’s twice as far from Cassini. Aurorae is one place and it has a close relationship with Uzboi, even though it’s pretty far away.” Will shrugged. “I hear you’ve established some important relationships between NASA research centers and various Martech departments. I’m impressed that you’ve arranged for new gaseous core research using the facilities of Deimos.”

“Yes, that has worked out well, even though the engineers that the NASA people are working with are Chinese!” Ted smiled.

“Did you talk to Changying Lin?”

The question startled him. “No, I have been working strictly on my own.”

“Well, congratulations. I wanted to talk to you about the interagency conference. The Commonwealth has asked me to coordinate our side. It’s scheduled for early November.”

“Nor long after conjunction.”

“Yes, the time delay will be over 20 minutes each way, so we’ll need to have two panels alternating their presentations, with questions staggered. But we don’t want to wait until opposition next fall. We’ll do the second interagency conference then, and thenceforth we’ll run them once per columbiad when the time delay is five minutes or less each way.”

“Much easier to deal with.”

“Exactly. The main thing that will reduce the impact of the time delay is interaction of all the agencies on both worlds; in other words; you will represent NASA here and can help negotiations at this end at the same time our reps on Earth are negotiating with NASA directly. We’ll need protocols, of course, to avoid contradictory results, but that can be laid out ahead of time.”

“Everyone’s headquarters agency makes the final decision.”

“Exactly, NASA can overrule your negotiating positions and we can overrule our representative’s positions on Earth. Both sides, however, can work together to bring about consensus. To do that, we really need to get started ahead of time and pre-digest as much as possible. The live interagency presentations will simply help make clear the written statements circulated ahead of time.”

“I suppose I shouldn’t say this, but why couldn’t the entire conference be held on Earth?”

Will shrugged. “Why not the whole thing on Mars? Our space funding is almost as large as NASA’s and is larger than anyone else’s, and so far we have dominated the planning because our funding is focused, rather than scattered among a dozen agencies focusing on hundreds of theoretical engineering projects. No, we want a major role, and that is best assured by holding the conference simultaneously on two planets so that the headquarters personnel are involved and not just representatives. We'll run the sessions in Washington and Beijing simultaneously as well, either morning or evening, depending on the city. What I want is you to serve on the Mars planning committee, to ensure maximum coordination."

"I'll need to check with NASA headquarters, but I'm sure they'd agree."

"I think so. You and Lin Changying are essential for this to work."

Ted coughed and almost spat out his food. "Oh, you're inviting . . . her?"

"Well, yes, of course; I can't invite you and not her! We'll invite the European, Indian, and Japanese ambassadors as well, so that they can provide feedback to their agencies. You haven't been banned from working with her, have you?"

"No, nothing like that."

"That's good! I assure you, she's a perfectly lovely person; extremely smart and articulate, an excellent representative of her agency here, and easy to work with, but principled."

"Oh, I'm sure . . . I wasn't saying I wouldn't work with her."

"So . . . will you?"

"Yes, sure. Of course."

Will looked at him, puzzled. "I assure you, you will enjoy collaborating with her."

"I'm quite sure of that."

"Good. I want to hold our first meeting next Monsol, 1 p.m. in my office suite in Martech library. Will that work for you?"

“I’ll make sure it does. If I have any schedule conflicts, I’ll clear them.”

“Thank you. That gives you plenty of time to clear your participation with NASA headquarters, too.”

“Yes, I’ll write them this afternoon.”

“Good.” Will looked at Ted closely. “So, have you adjusted well to life here? What do you think?” He had asked the question before. But Ted’s strange behavior caused him to ask again.

“Me? I’ve adjusted fine! It’s a relief to live in a place where you don’t have to go through security checkpoints everywhere, where there’s no danger from your fellow human beings, and you can relax in a plaza with a coffee and chat for hours. The ‘frankenfood’ gave me pause for a while—strawberries the size of plums with incredible flavor, made possible because of genetic modifications illegal on Earth!—but hey, up here there’s no natural ecology to protect from excessively vigorous superplants.”

“What about friends? It must be hard to make friends when you represent a competitor.”

“It’s . . . tricky, yes.”

“That’s another reason to come fishing with Mike and me. Or go down to the Center for Arts and Culture and hang out there with all the people who make ceramics, blown glass, and jewelry in their spare time. You’ll meet some interesting, multi-talented folks there; Marsians are amazingly capable people.”

“Yes, that’s a good idea.” Ted was becoming quite uncomfortable with the drift of the conversation. He downed the rest of his coffee and stuffed the rest of his fish taco in his mouth. “I’m afraid I need to go. What time on Monsol? 1 p.m.?”

“Yes, 1 p.m. Thank you for agreeing to participate.”

“I’m honored, Dr. Elliott.”

“Will, call me Will. I hope I haven’t offended you with my personal questions!”

“No, that’s alright. I would enjoy the fishing trip, too. Let me know and I’ll plan around it.”

“Alright.” Ted stood up, so Will waved. “Ciao.”

“Ciao.” Ted waved back, then headed across the plaza. His head was spinning; his relationship with Changying was suddenly changed. He felt “outed”; it made him very uneasy. He retreated back to the privacy of his apartment and videocalled her.

She didn’t answer right away, but a minute later she called back. “So, did you say yes?”

“Why didn’t you tell me?”

She laughed. “We have an agreement not to discuss business, remember?”

“But . . . what are we going to do?”

“Serve on a committee together very professionally. What else can we do? We can’t say no to Elliott.”

“God, this is a big complication!”

“Ted, you worry too much. If we start looking a little affectionate to each other . . . is that so bad? People will just think we’re getting to know each other and becoming friends.”

“But what if they figure it out?”

“We’ll cross that bridge if we come to it. *Don’t worry!* You worry way too much.”

“I don’t want to lose my job! What would I do up here otherwise?”

“We could both get jobs up here if we wanted to. A little committee work together won’t expose us. It'll be fine. Sneaking around together at night is much riskier."

"We really should eat in."

"I agree, and go to Oakley's less on the weekends. Anyway, I have to get back to my meeting. See you tonight?"

"I'll order food for us from the Parthenon."

"Okay, good. Ciao."

"Ciao."

"Welcome, Irit," Helmut said to Irit Goldberg, Mars's chief climatologist. "Come in. What do you have?"

"Some possible changes of plans," she replied. She came in and sat in a chair in the front part of Helmut's office; he came out from behind his desk and joined her. "The Nuclear Science people have been analyzing the results of the nuclear explosion at the north polar cap, which has allowed us to refine our computer models quite a lot. It appears that air bursts, or bursts in low orbit that heat up large areas of the polar cap, can provide a complementary effect to subsurface explosions. The big issue, of course, is EMP and its effect on satellites. But we can tweak the orbits of the communications and meteorology satellites so that once every month or so there will be a 30-minute period when no satellites pass over the South Polar region. During that window, we can send an orbital explosive down to a low altitude and detonate it."

"Really? I'm surprised that's useful. With the high albedo of the snow, most of the radiant energy will be reflected away."

"It isn't quite that bad. A lot of the radiant energy is at very short wavelengths that are absorbed rather than reflected."

"And when are they proposing to set off the air burst?"

In late March of next year, right after the first subsurface explosion. The thickened atmosphere will retain more of the release from the underground explosion. I should add they want to use a plutonium fission bomb to set off the thermonuclear fusion reaction."

"Really? Why?"

"Because the laser flash to set off the thermonuclear fusion requires more energy than can be stored on board a bomb."

"I see." Helmut thought a moment and shook his head. "We may not have signed any of the terrestrial nonproliferation treaties because they all have language that simply can't apply to Mars, but Elliott and Collins both affirmed that Mars would 'abide by the terms.' That means we can't use a fission device to set off a fusion device."

"The Nuclear Science people were hoping that you could change that."

Helmut shook his head. "No. I don't think so. Even our public finds the affirmation to be assuring, and the political cost with Earth would be too high. We have pledged to follow terrestrial nuclear treaties, so plutonium and uranium fission explosives are banned here. Changing our mind about that would be very difficult and politically costly. I was really worried the North Polar cap explosion would damage our relations with the U.S. and other countries with strong environmental movements."

Irit shook her head. "They really have no right to tell us what to do with our planet!"

"True, but we need to consider the potential trouble. We're building stronger relations with the major space-faring nations now and we need that to continue."

"Alright. That eliminates aerial explosions."

"They can give me a report, but it'll be dead on arrival. Did they also have a revised plan for the subsurface explosions?"

"Yes, but it also involved use of plutonium and uranium to set off the fusion reaction. The device can be designed to maintain a low-level nuclear reaction for months ahead of time, allowing the device to melt its way down into the cap. That will be an especially effective and inexpensive way to emplace the explosives under the carbon dioxide cap."

"In other words, no more tunneling or drilling. But the new tunneling machine they are using is extremely fast and automated, and when it works its way through the carbon dioxide cap it just produces waste gas! It's pretty efficient."

"That's true. They were just trying to come up with something faster and cheaper. A fission trigger is easy to mass produce and a low level reaction produces a shaft very fast. But I understand what you are saying."

"I appreciate their creativity, but this one won't work."

"We'll have a written report in a week or so; shall we send it to you anyway?"

"Sure, but warn them that the reception won't be positive."

"I think they'll hope for a miracle! Okay, I'll tell them. We'll get you the report next week."

17.

To Decentralize or Not

Early Oct. 2083

The twelve men and women in the room were all young. That was Helmut's first impression when he entered the conference space in Dawes's borough hall He went around the table and shook hands with everyone: Amina Omeroglu, Chief Executive of Cassini, and Gaspar Landaverde, the Development Officer; David Hamm, Chief Executive of Dawes and his Development Officer, Anika Matadeen; Seo-Yun Park Chief Executive of Meridiani, and Garry Henstridge, her Development Officer; Jeph Fletcher, Chief Executive of Kalgoorlie, and Nova Zacapa, the borough Development Officer; Kendra Jones, Chief Executive of Thymiamata, and Gordon Wright, the Development Officer; Celeste Petersen, Executive Secretary of Elliott borough, and Giovanni Diponte, the borough's chair. Finished, he sat at the chair reserved for him at the head of the table.

"Thank you so much for encouraging this meeting and coming at fairly short notice," said David Hamm, the host. "The Central Highlands region is here; every borough is represented, even Elliott. We look forward to hearing from you."

"And I look forward to the discussion. I have a few announcements that some of you know about. Last week Anika, Amina, and I completed negotiations with Marfab. They've agreed to spin off their surface vehicle construction division as a separate company, Marwheel, which will be headquartered in Cassini. It plans to double its vehicle production next columbiad. Cassini's southern annex is rapidly gaining accessibility as a metal highway is extended across it, and Margen plans extensive wind farms and solar arrays in the area, because it rarely has severe dust storms. Cassini gets a new enclosure creation system next year. It'll produce one 1,500 by 1,000 meter enclosure every columbiad, capable of feeding and housing 7,500 people.

"Dawes also has some important good news. Last month Dawes Robotics got a very big contract for industrial and domestic robots, and because of its excellent electronic work, Marsat will locate its new satellite and robotic probe facility in Dawes as well. This means the majority of the communications satellites, weather satellites, GPS satellites, asteroid probes, etc., will be made in Dawes. Its new 1,000 by 1,500 meter enclosure will be finished soon and another one will be started immediately.

"As we know, Kalgoorlie gets a major expansion of its spaceport next year, sufficient to handle all traffic for the four boroughs of the eastern Highlands and to take pressure off of Aurorae's. There are some encouraging negotiations going on regarding MacDonald Fabrication; it appears they'll get a contract to manufacture a range of plastic parts. Meridiani has been hauling in and inflating scores of B-75s for Meridiani Harvest, and it is now exporting food to Aurorae and Dawes as well as other nearby boroughs. It shows what you can accomplish with determination and existing technology.

"I don't have anything to report about Thymiamata, except to note that its gold production has continued strong because it is exploiting remote deposits telerobotically. Currently, its future is closely tied to gold production.

"I have nothing to report about Elliott.

"In the next columbiad, we anticipate that Cassini and Dawes will both double in size and have about twenty thousand each. Meridiani, Kalgoorlie, and Thymiamata will expand fifty or sixty percent. Their expansion is slower because they are smaller and unable to attract or accommodate a doubling of their populations. By late 2085—once the immigration wave is complete—Aurorae will have about 77,000 people and the Central Highlands will have 45,000, which just about equal to Aurorae's current size. So you are catching up."

"But Helmut, too slowly," said David, using a gentle tone. "Currently our combined population is 47% of Aurorae's, and in two years it'll be 58%. At this rate, it'll be a long time before we catch up!"

"I know, but as long as Aurorae's bigger it has economies of scale and a broader human resources foundation. Businesses want to expand there, rather than locating elsewhere; people prefer to live there because it's more exciting. Both Cassini and Dawes are twice as big as Aurorae was when we gained independence, but Aurorae is so much bigger and economically diverse. We can overcome those factors, and we have been; but it takes time."

"We have to have hyperloop," exclaimed SeoYun. "If Dawes is just two hours from Meridiani and Kalgoorlie and Thymiamata are less than hour, the situation is changed radically."

"Which raises the question why hyperloop service is supposed to start first between Aurorae and Uzboi," pressed Garry Henstridge.

"The hyperloop team is based at Martech in Aurorae. "There is about 150 kilometers of roadbed on the Uzboi line that requires straightening or replacement with bridges to allow hyperspeed. That's about the same amount as the Dawes to Cassini stretch. Dawes to Meridiani requires almost none—mostly some side tracks to allow passing—but there's 550 kilometers of highway upgrading near Aram in the chaotic terrain there and that's a big barrier. It'll be some years before they can get hyperloop over here."

"Look, that's not acceptable," exclaimed Amina. "Hyperloop skates can negotiate curves and slopes, just at a slower speed. How long would it take a hyperloop skate to go from Dawes to Cassini *right now*? Four hours instead of two? That's still a huge improvement over eleven hours."

"And it's not like there's heavy traffic on the Cassini Highway right now," added David. "Pull-outs are not that urgent."

"The engineers know all this," replied Helmut. "And I'll keep pressing them. Right now, they only have one experimental hyperloop skate and they're testing it. Once the design is complete, the skates will be made by Marwheel in Cassini."

"So, when can we anticipate some limited hyperloop service?" asked David.

"I'll have to ask, but I think it's a year or so."

"Please press them," said Seo-Yun. "This is very important for us."

"I will see what we can do to speed things up, but hyperloop may not make much difference. How many people need a two-hour trip to Cassini or Dawes? How much economic advantage will it really create?"

"Helmut, we don't know until we have it," replied Jeph Fletcher of Kalgoorlie. "Certainly for the eastern Highland boroughs, commuting will be practical and our three principal outposts will be able to function as one. Being two hours from Dawes and three hours from Aurorae will be huge for us. Furthermore, our stretch of our highway requires almost no upgrading. We need to be the first place with hyperloop service."

"Well, it's pretty important for Dawes, too!" exclaimed Anika. "A lot of our development hype relies on the hyperloop, you might say! It strengthens the importance of our spaceport. Indeed, it may render Kalgoorlie's redundant."

“Not really,” objected Jeph and Nova simultaneously.

“Kalgoorlie’s spaceport is both a regional development keystone and an important redundancy,” replied Helmut. “Where does Marwheel get all its vehicle parts? I know it manufactures the metal parts at Cassini, but what about the vehicle interiors? Could the plastic parts be made at MacDonald Fabrication in Kalgoorlie? What about the fabrics?”

“Right now, plastic parts and fabrics are imported from Aurorae, but we are hoping to start production of them in Cassini,” replied Gaspar.

“Why not spreads the wealth around more?” asked Helmut. “If you want to rival Aurorae, you have to think like a regional unit.”

“MacDonald does top quality work, but it has trouble getting contracts,” agreed Jeph. “With the metal highway and the electricity, methane, and oxygen it brings us, we can make just about any plastic in quantity. But people worry about out-sourcing to a place so far away.”

“A problem the metal highway is supposed to eliminate,” emphasized Nova.

“The only place that produces fabrics right now is Aurorae,” said Helmut. “Maybe a second source should be established, for the sake of competition and for the sake of redundancy.”

“In Dawes and Cassini, the population is supposed to double in two years, and that means manufacturing about 5,000 residences and work places,” noted Anika. “That’s a lot of rugs, upholstery, drapes, and other fabric items to import from Aurorae.”

“Maybe a fabric manufacturing company can be established in the eastern boroughs,” suggested Helmut. “It also occurs to me that Meridiani, with all its B75s, is able to produce agricultural surplus. Why not go into a wider range of agricultural products? There are plant products that can or are used in fabric production, cotton being an obvious example.”

"That's a thought!" said Seo-Yun. "But it would be much easier if we get an enclosure making system. If we could enclose 1,000 by 500 meters of polder every two years, that would feed and house 2,500 people. That'd last Kalgoorlie about four years, I suppose, so the system could move to Meridiani, then to Thymiamata, then come back to Kalgoorlie in six years, get expanded, and make a 1,500 by 700 meter enclosure able to feed 5,000. That would keep all our boroughs growing."

"You are scheduled to get an enclosure manufacturing system next columbiad," said Helmut. "I doubt it can be sped up much. It will move among the three eastern Highlands boroughs."

"Meanwhile, we need something bigger than a B-75," said Kendra Jones of Thymiamata. "We have three smaller gold mining oases, each with a hundred or so workers at any time. A B-75 can feed about a dozen and recycle their wastes, but that leaves no 'park' space to just roam or sit in. People need that, too. Any word about the B-100 design?"

Helmut thought. "I think the project is stalled because of all the emphasis on big enclosures that can accommodate thousands. The B-100 has a really good design; the bubble has three separate membranes, and the volume between the outer two is filled with carbon dioxide and set up to radiate excessive heat to the atmosphere. The floor consists of two layers of nickel-steel for insulation and to protect the bubble from moisture. They completed the programming to manufacture all the parts robotically, too, so it shouldn't been too expensive; maybe half a million. But there's no market."

"They never asked us!" replied Kendra. "We'd order several dozen, and I bet Kalgoorlie would as well!"

“And Meridiani!” added Seo-Yun.

“So would we,” added Celeste. “Elliott now has 150 people and we have 4 B-75s set up to produce just basic food stuffs. We can barely provide most of our basics.”

“Do you have an ag company?” asked David Hamm.

Celeste shook her head. “Not exactly; we have me! The Petersen and Erstad families have connected homesteads in Erstad Crater, which is Elliott borough’s village center. My mother was a very successful farmer back in Burundi, and I have inherited her green thumb. We have three B-75s and the DiPontes have one, fifteen kilometers away, which is used to raise corn and wheat robotically. My three mostly raise vegetables, berries, and fruits, with the help of three spider bots and a lot of work by the children.”

“The children?” asked David.

“Yes; Monica Erstad and I run the Elliott borough elementary school. We now have 33 children, aged two through nine. Under the agriculture of our first B-75 are the borough offices, two classrooms, a big meeting room, and my store. When the kids are dropped off or picked up every day, people come to the store to buy and sell, or I prepare the packages and stick them in the robotic vehicles with the kids. The kids know the farm very well; they work an hour or so a day helping the robots. A B-100 would be a great help for us. Not only would it expand the farm; it would allow a much larger playground.”

“It sounds like you have a rather unique arrangement!” said Amina.

“We’re a small place,” replied Giovanni. “”And we’re scattered all over several thousand kilometers. Some kids ride over an hour each way to get to school. Fortunately, we now have a metal highway that runs along the main gold vein in the borough, so most people are just a few kilometers away from it. We do have one company, a fabrication company, Leong-McCord, and they make quite a wide range of plastic and metal parts for the rest of us. I am sure they'd appreciate a contract as well. They're right on the metal highway, so they have access to plenty of methane and oxygen and lots of power. They could run their equipment 24.7 hours a sol."

"Give us the details and we'll see whether we can send work their way," replied Nova, Kalgoorlie's development officer.

"And all of you should send me emails stating how many B-100s you'd like," said Helmut. "If the number is large enough—probably about fifty—I think Martech can send the project out for a bid."

"I bet we could find someone to make them," said David, "Dawes has some pretty capable engineers, and we have an enclosure making system that already uses the same materials."

"I have a question for you, Chief Minister Helmut," said Gaspar Landaverde, Cassini's Development Officer. "The idea that we could make our own fabrics has made me think about the importance of multiple sources and competition. If the Central Highlands are roughly the size of Aurorae, why shouldn't they have most of the manufacturing services as Aurorae, to serve as competitors? That's a lot of companies!"

"And a lot of products," agreed Helmut. "I think that's a legitimate argument to make. Obviously, because of limited demand, some things are best made in one place, like surface vehicles in Cassini and satellites in Dawes. But I think the Central Highlands could be making all their furniture, electrical equipment, clothing, many of its consumer goods, etc. You'll need to find people willing to open those businesses. The development fund will certainly help them get established."

"I think that's a way for us to go," said Gaspar.

"But you need a Highlands development strategy, for it to succeed," added Helmut. "You need to hire a regional coordinator who will have a staff and who will have an office somewhere in the Highlands and an office in Aurorae. He or she will have to force the rest of you to agree who will get what, rather than competing against each other."

"I agree," said Gaspar. "Competition weakens us." He looked at Anika Matadeen, his counterpart in Dawes, and after a second she tentatively nodded.

"Good," added Garry Henstridge, Meridiani's Development Officer.

"I hope you all mean it," said Helmut. "Because competition has certainly weakened you in the past. "If you want to be a collective equal to Aurorae, you'll have to work together. Commonwealth money can do only so much."

"I agree," said David Hamm, looking at Amina Omeroglu, and she nodded vigorously.

"Thank you, everyone, this was a good session," said Will Elliott.

"Thank you, Dr. Will," replied Mariella Fsadni, the European ambassador to Mars, and quite a capable space exploration negotiator. Ted nodded in agreement with her thanks, but admired her toughness and brilliance.

The six of them—Will, Mariella, Ted, Changying, and the Japanese and Indian ambassadors—rose from their seats in the conference room of the Aurorae Hilton, said goodbye to each other, and headed out. Ted smiled and nodded to Changying; they had managed a friendly professional relationship in the meetings that had worked well and had perhaps eased tensions among the others as well.

He stepped out into the bright light of City Square. He headed to his condo to sit and write up a report when his communicator rang. It was Ambassador Danforth.

“How was the meeting?” he asked immediately.

“It was excellent. We reviewed plans to explore the asteroid belt and Near-Earth asteroids today and got a report from Venus as well, because they plan to start some expeditions as well.”

“Really? They’re so small!”

“They’re growing to 600 within a year and hope to hit 1,000 in two or three years; bigger than you might think. I’ll write up a report for the Administrator and copy you, don’t worry.”

“Just don’t give anything away!”

“Asteroid exploration really doesn’t work that way. Everyone does their own thing and plans as many or as few missions as they want, then arrange their own crew exchanges with others. We’re planning two a year for the next five years; the Chinese are planning the same, Europe six, Japan and India five each. Both Phobos and Ceres are sending out two per year, or twenty in five years. There was some negotiating over destinations; the Japanese and the Cerereans were both planning to visit Magnya in two years, so Ceres gave it up. But no one overlapped with us.”

“Good. What about support for the outer planet settlements?”

“We’ll get to that Frisol, Ambassador Arthur. Look, just leave me alone to do this. I report to Administrator Elwood and I’m copying you about everything. So far, the arrangement seems to be working.”

“For you and Elwood, maybe!”

"Look, we're all doing our jobs. The President has approved this setup. I'm glad to provide you reports and welcome your advice." That wasn't true, but at least he was free to ignore it.

"Welcome my advice, my ass. Remember not everyone wants to cooperate with Mars as much as Elwood does. You represent America first."

"What else would I represent?" said Ted, irritated.

"Alright, alright. I see the picture. I look forward to the report. Bye." Arthur Danforth closed the line.

Shaking his head, Ted put away his communicator. He'd get Danforth a copy of the report. But it might take him 24 hours.

It was a leisurely three-day float from Titan to Enceladus. Marshall tried to get there once a year, but in fact he had been there only once since becoming Chief Minister in 2076, eight years earlier. This was his second trip.

But Enceladus Outpost was small, after all. As the ship descended they caught a glimpse of the facility: A U-75 was at its heart, a cylinder 75 meters long and 35 meters in diameter lying flat on the moon's surface and encased in many meters of ice to protect the zero-gee interior from cosmic radiation. A galleon, the *von Braun,* was attached to the U-75 to provide spinning, gravitied quarters for up to 150 people. Three large spherical tanks a kilometer away held a thousand tonnes of liquid hydrogen each; a tank of similar size held liquid oxygen and another had liquid methane. Nearby, a Peregrine nuclear-powered shuttle sat, awaiting its next mission to dive into Saturn's atmosphere, rendezvous with the aerosat, drop off supplies, and pick up several tonnes of Helium-3. Two caravels sat on pads as well, awaiting the time when they would take human crews to a nearby moon. Two hydrothermal wells tapped the heat of Enceladus's liquid water ocean and used it to generate 10 megawatts of electricity each. A fission reactor stood encased in ice blocks a kilometer away to serve as a backup source.

It was a small place, but quite capable, and Marshall wasn't sure he'd be able to constrain their enthusiastic plans, which were partly his fault for encouraging them in the first place.

The landing involved the slightest of bumps; quite smooth, partly because landings had to be gentle in Enceladus's one percent gravity. It took ten minutes to attach the pressurized tunnel to the ship and then Marshall could walk—or float—to the spaceport terminal.

"Welcome, Chief Minister Marshall!" exclaimed Iris Geyer, the borough's chief executive officer. She extended her hand and they shook. Then Seiji Takada, in charge of the borough's spaceport and space operations, offered his hand as well. "Welcome," he added.

"Thank you, I'm glad to be here. It's been five years and I'll be sure it won't be five years again. Enceladus is always doing exciting things."

"Thank you; we think so. Shall we take you to your quarters, so you can rest?"

"I don't need to rest; floating through intermoon space for three days gives a lot of time to sleep! I can meet with everyone any time."

"Good; they're anxious to meet with you, too! Shall we go to the conference room, then?"

"Definitely," replied Marshall. Iris nodded; Seiji retreated to text the others so they'd assemble right away. She led Marshall across Gate 1 to the corridor that led to the U-75. It was a large, brightly lit, verdant space with plants growing across its floor and up its walls; a few trees were 15 meters high and climbed most of the way to the center of the cylinder. Above, a few people lazily floated in the air, occasionally flapping strap-on wings. Iris and Marshall lingered a few minutes in the space, then descended through three levels of agriculture, admiring the packed plant areas that fed the borough's hundred residents. Finally, they exited into the galleon and headed to the conference room. By then, the other two were present: Oscar Pereira, commander of the Saturn 5 mission, who was in charge of engineering, and Rosa Chen, who was in charge of fabrication.

"It's good to see you both again," said Marshall. He shook hands with Oscar, then Rosa. "How's Chad?" he asked of Rosa, referring to her husband and a close geological friend of his.

"He's well, and the kids are enjoying Enceladus. They're connected with their friends on Titan by video every day at school."

"Willie and he have been talking, too. I'm glad they've adjusted well." Marshall sat and turned to the others. "So, let's start with the nuclear Prometheus."

"We're not calling it that anymore," replied Oscar. "We're calling it the Nike." He pronounced it "knee-kay." "It's the Greek personified goddess for 'victory' and that's what we think it'll do for us. We've been running our design past Jimmy Khan and the entire spacecraft design crew at Martech, and they've upgraded it quite a lot. Venus definitely wants a design that can use methane instead of hydrogen; inevitable when they have a planetary atmosphere of carbon dioxide and almost no hydrogen."

"Considering the density differences, that's better for us anyway," said Marshall.

Oscar nodded. "More or less; methane's almost ten times denser, so the same tanks will hold a lot more. But Enceladus has a lot more hydrogen than carbon, which complicates our design for the refueling plant."

"We could always haul methane from Titan."

"True, but we want to avoid that." Oscar looked at Marshall, knowing that the relative role and size of Enceladus was at stake. "An advanced solid core nuclear engine, run with methane, will give a specific impulse of 560; over twenty percent better than hydrogen-oxygen chemical propulsion. The new designs release relatively few stray neutrons during firing and cool off fast. Of course, the Peregrine engines were designed for hydrogen and are somewhat too small to power a Nike, but we have a preliminary design for a Nike engine."

"Really? Already?"

"We've been working on it for a year, and Martech decided to devote a team of thirty to the support the effort, which will soon expand considerably. Venus has followed the work closely, and last week they tentatively threw their support behind the effort, which means the Europeans and Indians will devote resources. Venus is sending four of their top engineers to Martech to participate directly. We anticipate the Americans will support the project as well, so they aren't left behind technologically. Engines that can use either hydrogen or methane—which the Nike will—provide a lot of flexibility for missions to asteroids and centaurs. The vehicle will have two propellant tanks, so it will be able to store either. In a pinch it could even use chemical propulsion, with oxygen and either methane or hydrogen, though that would damage the propulsion system."

"Payload?"

"That will vary depending on configuration and mission. It'll be a one-stage lifting body. For Titan to Enceladus it can move fifty tonnes of cargo. That's also true of Mars to Phobos or

Deimos. From Venus orbit to the aerostat and back it'll be able to move about five tonnes; not much, but more than they need for some time."

Marshall frowned. "What's the chance Mars will use it?"

"We don't know yet. They're willing to invest in it because the release of radioactivity is quite small, so their spaceport won't become radioactive from takeoffs and landings. The big problem is that the engines raise the overall cost of the vehicle fifty percent or more, and the savings on propellant is inadequate to cover the increase. So it is difficult to see how the Nike will decrease the cost of Mars launches and landings."

"And that's a key issue, with the lunar mass driver potentially lowering launch costs."

"Exactly."

Marshall nodded, thinking. "And what's the updated budget?"

"Mars is devoting 300 million redbacks to design refinement, materials research, software development, and supercomputer simulations. They'll get partial reimbursement from Venus, India, Europe, and the United States, probably totaling about half. Basically, that's 250 people at Martech for three years, half paid for by others. Here, we'll build the thing. It'll take 35 people in fabrication and 50 in engineering over two years, so our cost, at half a million per person per year, is 85 million; more if it takes longer. It doesn't sound like much, but that's because we're scaling up the Peregrine for most things, like the lifting body and engines, and we have spare Peregrine and Prometheus electronics we can use, once Martech writes the code."

"It doesn't sound like much, but our budget is a lot smaller than Martech's. They've got 3,000 engineers and other specialists. I'm amazed we were able to get that much of their resources."

"Timing; they just finished a major carrier design and a new gaseous core design. Same with us."

Marshall nodded. "I'm sure the engineers are anxious to do this, and we don't have any emergencies or any big priority projects, and it will lend some prestige to the Saturn Commonwealth to be spearheading a project like this, so I am in favor of it. The construction mostly has to be done up here, doesn't it?"

"It'd be much easier to test the engines here than on the surface of Titan. We'd start flying it to haul cargo back and forth, then use it for passengers. It should enable a 48-hour trip between the two moons. It'll be particularly good for landing on Titan, because it will be aerodynamic."

"The caravels and galleons are not so good," agreed Helmut. "Do we have all the materials we need?"

"More or less. Saturn 7 leaves Mars on March 30, 2084, and arrives here 12 months later; the fastest flight yet. It can bring the few things we are lacking and can replace electronics we are diverting from the replacement inventory."

"And at that point, the Saturn Commonwealth's population will exceed 2,000," noted Iris. "This project will require Enceladus to grow to 150, which is the max this galleon can hold. When we're at 2,000, we'll be launching 3 or 4 missions a year to the moons, and the point of departure will be here. Enceladus will need a permanent population close to 200 and will have to be able to accommodate up to 300 as people come and go. In short, we'll need a carrier."

"I figured that would come up," said Marshall, with a smile.

"Of course! It's been a part of the long-term plan for this place for several years. We're talking about a drum 100 meters in diameter and 100 meters long; nothing as big as the Avalons that Uranus is building. I need 50 fabricators and 25 builders."

"And Project Nike needs 85 altogether; that's 160, which is already more than this place can hold."

"No, we can squeeze in a few more and can use one of the caravels in the spaceport. We'll need a total of 200, including agriculture, environmental management, spaceport, and other essentials, but we can do it. It'll take 2 years to build, too, but the carrier will be able to accommodate 500 people if it has three interior levels. It'll ensure Enceladus a future."

"I know, and there's the issue of emergency capacity if one of the galleons coming from Mars is damaged. I'm familiar with the arguments." Marshall paused, a bit frustrated this had come up now.

"This is only a one-year acceleration of the original plan," added Seiji.

"True, but you're taking engineers away from Cathedral's expansion at a crucial time. We made a goal of raising our space to 200 square meters per person and in eighteen months we'll have 2,000 people. That's 400,000 square meters. And this is a crucial time because we are manufacturing two more cavern-melting systems, and they take up a lot of engineering resources."

"Yes, but they're more automated and efficient than ever. Furthermore, we don't need two more systems to reach 200 square meters per person. We're going to reach that number with the two systems we already have. Furthermore, each cavern has a lower level for agriculture, so we're really creating 400 square meters per person. Mars's standard is 200 square meters, and they have to deal with dust storms. We have complete control over the environment. We also have 120,000 square meters inside Titan 1 and all the space in the original caverns we melted to start Titan Outpost.”

“But Marsians can go outside; and many people do. Even if they can’t go outside, they can see outside; we can’t.”

“Cathedral is so big, it really isn’t necessary to go outside. And people can go outside here. It isn’t that much harder than on Mars.”

“Seiji, we have a plan based on a rational, deliberative process. It was drawn up carefully and with a lot of inputs.”

“Keep in mind that the carrier we build here will provide 30,000 square meters of open space, and with two sublevels it’ll provide 60,000 square meters for agriculture and manufacturing. That should count toward the 200 square meter total, too.”

“Seiji, you’re tinkering with a plan that was finalized a year ago!”

“We can still change it,” urged Oscar. “The plans have built in flexibility, and so far we haven’t needed it. We may be able to get the equipment for the two new cavern building systems finished. Perhaps Cathedral North or South will have to be delayed by the time Saturn 7 arrives, if we build Enceladus 1. Isn’t the future of Enceladus more important than completing a few square meters of Cathedral that really aren’t crucial to survival?”

Marshall scowled at him, but thought. “Look, we’ll need to talk to the construction folks on Titan before we make this change, and we should get the endorsement of the Saturn Council, because the plans to expand Cathedral are very popular. It isn’t just a matter of building a few more robots, though even that is a complex process; it’ll tie up engineers you want for the Nike project. I’m not saying no, but I am saying we’ll need to pursue a process.”

“That’s fine,” said Iris, who was on the Council.

“I agree,” said Seiji. “This is very important for the future of Enceladus. We’re the center of exploration of the entire Saturn system, and as our population grows, Enceladus will need more robust launch capacity.”

“You’re already planning beyond the carrier, Seiji,” said Marshall.

“Of course; that’s what you have to do, too!”

“True, I do, but I have to keep the entire Commonwealth in mind,” Marshall replied.

Ted was impressed by how peaceful Snow Crater was. Two kilometers across, it was filled with a beautiful, blue lake almost up to its rim; fir trees climbed the unimproved rim until they brushed the dome overhead. The only sound was the distant rumble of a waterfall as water was added to the crater-reservoir. At the moment, Ted, Will, and Mike Tobin were the only humans in the space.

Mike pulled on his fishing pole. “I think I’ve got a bite!” Will and Ted turned to the pole, which tugged back and forth as Mike pulled. He began to reel in the line. But after a few seconds, the tugging stopped.

“Oh! He got away,” said Will.

“Another time,” said Mike, shrugging.

“About done for the day?” said Will.

“I think so. I’ve got to get to my office some time.”

“Me too,” said Ted, with a smile, though he rather enjoyed the peace and quiet.

“Okay, let’s head in.” Will turned to the rowboat’s electric motor. He pushed a button to turn it on and steered it toward the dock a kilometer away.

“I’m surprised more people aren’t here,” said Ted.

“It’s pretty busy on weekends, especially during the summer.” Mike was referring to the equinoxes when the sun stood over the equator and beamed its heat straight down on Aurorae outpost. He pointed to the beach. “There are dozens of swimmers and sunbathers here, then, and all the boats are rented.”

“It’s amazing that we have this much water stored up.”

“You should see it drop when they’re adding water to an enclosure,” said Will. “They add 2 meters of water per square meter to the regolith and pump three meters per square meter into the dome overhead. This place can drop seven or eight meters in just a month when that happens.”

“And we don’t use any of this for drinking?”

Mike shook his head. “That’s all extracted from the dehumidifiers. Our residential water is processed and used for irrigation, or run straight into a septic field under the agricultural areas. The plants transpire it into the air and the dehumidifiers capture it, and round and round it goes.”

“Not to mention, all the water entering Snow Crater has flowed twenty kilometers from the wells in the side of the escarpment to New Hanford, has had its deuterium extracted, then it flows back here as pure water and pours into the crater. We get billions of redbacks every year from the deuterium,” added Will.

“I know; it’s quite a system, and it gets bigger every columbiad.” Ted turned to Mike. “So, when does Jupiter eclipse your neutrino source again?”

“Three sols,” replied Mike. “I wouldn’t call it an ‘eclipse’ exactly because only one neutrino in trillions is blocked by Jupiter. But when the data comes back, we'll be able to align it with the data of the previous passes using Martech's new supercomputer, and we're slowly building up a map of the layers inside Jupiter. Then we run that past the geophysical models and do more testing of hydrogen and helium under high, high pressure conditions."

"And you figure out why the interior is the way it is."

"Exactly. The coolest research in the world. We can combine it with gravity and gravity wave data, too. We need a bigger and more sensitive neutrino telescope on Callisto, though."

"Something to add to the space exploration conference," commented Will.

Ted nodded. "I'm sure Crystal has it on her agenda. She's been checking with everyone in Martech."

"That's an easy collaboration with the Chinese, too," said Will.

"Sounds like it's going to be huge," said Mike.

"We have to include fifteen companies with large space exploration efforts, plus thirty countries," noted Will. "This is nothing like the joint agency conferences that planned Project Northstar that returned humanity to the moon, then approved Project Columbus to Mars."

"But you've handled all the work pretty well," said Ted, admiringly.

Will laughed. "I sleep well at night; I'm exhausted!"

They reached the dock. Ted jumped out and tied up the boat for the others and all three of them walked back to the rental hut to return their fishing equipment. Ted had caught and kept one trout, which was his point of pride, since he was the newbee. They waited a few minutes while Ted put the fish into the cleaning machine, then retrieved a fresh filet, ready for cooking.

"This will be a fun supper."

"Share it with someone," said Will, with a smile. He had picked up on Ted's affection for Changying.

"Maybe I will," said Ted, noncommittal. "I'd like to show this place to friends, too."

"Good."

The three of them exited the rear of the rental hut and into a tunnel that crossed under the rim. At the other side, an autotaxi awaited them. They hopped in and were soon on their way back to Aurorae. The autotaxi skirted along the end of an excavation. "It looks like people will be able to get here directly pretty soon," said Ted.

"Once North America is open to the public, Snow will be just a few hundred meters away. They'll probably install a pressure tunnel," said Will. "They might even extend an enclosure over it and incorporate it into the city."

"That'd be ambitious," said Mike.

"Say, one more question," asked Ted. "What do you think of the Central Highlands Development Commission?"

"It's about time," said Will. "Helmut pushed them, and this time they responded. It's a good arrangement, to include the chief executive offices and the development officers of each borough on the Board of Trustees. They've hired a very competent man to be their Commissioner."

"But should the Central Highlands borough collectively equal Aurorae?"

Will shrugged. "That level of redistribution of population is pretty dramatic; I was never willing to go there as Chief Minister. But Mars is richer and more populous now. I suppose it's a luxury we can now afford."

The autotaxi slowed as they approached the airlock for Cochabamba Enclosure. It slowly entered, the lock filled with air, and the taxi exited into the station. They stepped out and Mike offered his hand. “Good to meet you, Ted. Maybe we can do this another time.”

“Thanks, I’d like that.”

“Dad, see you tonight.”

Will nodded; he and Ethel were having dinner with Mike, Liz, and the kids. “See you then.”

Mike headed out. Will turned to Ted. “So, is Ambassador Arthur driving you crazy?”

“I think he and I now have an understanding; at least, until the Secretary of State overrules the Administrator of NASA.”

“I think the President is behind her, though. Good, I’m glad that mess is resolved.” Will smiled. “Now I just have to herd cats.”

“Good luck, because I’m obligated by the government of the U.S. to be one of the cats!”

“I know!”

18.

Exploration Conference

November 2083

Marshall often glanced up anxiously to the door to him office, wondering where Oscar Pereira was. The Council was meeting in a mere half hour and their meeting had to occur beforehand. Oscar was late, and Marshall had to wonder whether it was because Oscar was embarrassed or worried.

Finally, the 45-year old engineer appeared in his doorway. “Thanks for coming,” said Marshall, rising from behind his desk. He stepped forward and shook Oscar’s hand.

“You’re welcome. I don’t get to Titan very often, now; most of my engineering work is on Enceladus. I thought you might want me to meet with the Council about the plans.”

“I don’t think that’ll be necessary.” Marshall closed the office door and sat in a chair opposite Oscar. “I’m not sure there is anyone who knows the allocation of engineering and fabrication personnel in this system better than you. Again and again, when we face a setback to one construction schedule or another, you come up with the best solution to the problem. It’s very impressive. So I took a look at the allocation of human and material resources necessary to complete the first Nike nuclear shuttle in 30 months plus build the Enceladus-1 Carrier. I was quite surprised to see that it required suspension of work on the third and fourth cavern excavation systems—even though we are close to completing one of them—and required suspending work Cathedral North and South entirely, and possibly slowing work in Cathedral West.”

Marshall stared at Oscar, who stared back, poker-faced. The man considered his words very carefully. “I think with some improvements in efficiency, all of that won’t be necessary. I suspect the third cavern excavation system can be finished in 15 months; three months before Saturn 7 will arrive, and work can then begin on Cathedral South. Cathedral North would have to be postponed another year, most likely. But in March 2085—sixteen months from now—Titan will have 2,000 people and Enceladus will have 200, and Titan will have 440,000 square meters in Cathedral, 60,000 in Titan 1, and 30,000 in the old outpost caverns, for a total of 530,000 square meters. Titan will need 400,000 square meters. Enceladus could end up with 2,500 square meters. That doesn’t make any sense. Several of us have tried to convey that to you, Marshall, but you seem stuck on the Cathedral project. I understand; it’s big, it’s popular, and it was your suggestion. But it isn’t a rational allocation of resources.”

“Oscar, that’s not your decision to make! I’m Chief Minister here, not you! Why should I trust you with a huge project like this if you are misinforming me about the schedule?”

“I never said that we’d be able to continue our regular construction schedule, Marshall, and sooner or later you’d find out that we had committed the same engineers and fabricators to two projects at once. This wasn’t going to work as deceit. But it was going to get the subject before the Council. That was my goal. Because the Council, knowing the resource issues, would probably delay Cathedral in favor of Enceladus. Iris knows the situation and she would have brought it up to the Council.”

“Why didn’t you just *tell* me?”

“I did, and with the implication that we had enough people, you barely agreed to take it to the Council. Would you have agreed if you knew the full picture?”

“Do you realize how embarrassing it would have been, if I found out in the Council meeting that the plans for Enceladus and for Cathedral can't be pursued simultaneously?"

"I figured you'd discover the overlap, or Iris would tell you. We're really desperate to see Enceladus grow, and I wasn't sure you would accept that."

"Really?" Marshall was startled by the accusation he would be biased. "Oscar, please just come to me about matters like this. I'd like to think that I'd listen!"

"I apologize that we didn't trust you, Marshall. I think it's clear that you would have listened, too."

"We can't run Saturn using deception and half truths. There aren't enough of us, way out here . . . we have to trust each other."

"I agree. 'Scientific administration,' as they're saying on Mars . . . that's what we need."

"Exactly. Alright, I think we have cleared the air, and I appreciate your honesty when I asked. I apologize I came off as closed minded. You make a good point; Titan has plenty of redundancy in its space and Enceladus doesn't. We can delay Cathedral North and South in order to build up Enceladus's capacity."

"Enceladus has to move from a little outpost to a full-fledged borough in the Saturn Commonwealth. It has unique resources and a unique role to play. Saturn is now growing large enough for that to be possible."

"Yes, I think that's true. As much as I'd like to keep things centralized and all in one place, I agree that that really isn't possible. And we are growing past the 2,000 mark in two years."

"I think it is time for Enceladus, especially with the Nike project. Thank you, Marshall."

"And thank you, Oscar." Marshall reached out to shake Oscar Pereira's hand, and Oscar extended it in friendship.

Oscar rose and headed out of the office. Marshall walked to the window and looked out on Cathedral Square and the tunnel that extended beyond, 200 meters wide and 150 meters high, that split into two tunnels turning northeastward and northwestward. It was the beginning of a network that someday might cross much of the moon's subsurface and house millions of people. But it wouldn't the only inhabited place in the Saturnian system. And that was good.

He headed out of his office to go to the Saturn Council meeting.

When it was over he headed home. Willie and Amy were watching one of their favorite t.v. shows. "Where's Millie?" he asked.

"Young rangers," replied Amy. "You looked beaten up and exhausted."

"I suppose I am." He sat and sighed; Amy turned to him, though Willie kept watching the show. "I called Oscar Pereira here from Enceladus to explain to me why he had scheduled engineers and resources essential for starting Cathedral North and South and expanding Cathedral East and West to build the new Nike nuclear shuttle and build a C-100 carrier for Enceladus. It turns out, the reason was because I have been so obsessed with expanding Cathedral, several people have considered me unreasonable and biased. Oscar basically pointed this out to me and . . . I think he was right."

"Really?"

Marshall nodded. "I have resisted the development of Enceladus in favor of Titan; that is true. But that is no longer possible."

"Don't beat yourself up about it. You are agreeing only to a one year acceleration of the plan," pointed out Amy.

“Why do we need Enceladus, anyway?” asked Willie.

“That’s a good question. Part of the answer is rational, but part is emotional. Titan has a very thick atmosphere and it is hard for caravels and galleons to take off and land here. They’re interplanetary vehicles, after all. So Titan is not a good base of operations for exploring the Saturn system.”

“So, why didn’t we build a station in Titan orbit?”

“Because it’d be expensive; because of the thick atmosphere, we’d have to take the station up to orbit in small pieces. We’d also have to get hydrogen, methane, and oxygen propellants there through the Titanian atmosphere, which would be expensive. On the other hand, Enceladus has an internal liquid ocean and bionts. They seem to be a variant of the biochemistry of Titanian bionts, which suggests a common origin, so they need to be studied. Enceladus has a dynamic surface geology worthy of study. It also has a power source because of the tidal energy that keeps the internal ocean liquid, and with that energy Enceladus can make propellants. It has low gravity and no atmosphere, so it is our logical spaceport. Those are the rational reasons to establish an outpost there. Then the emotional reasons kick in.”

“What are they?” asked Willie.

“People who live there love it. They have a stake in its development, so they want to see it grow.”

“Oh, I see, that makes sense. What’s the problem?”

“There are only so many resources. At the Council meeting I told everyone that we could slow the development of Cathedral in order to build the Nike shuttle and the carrier on Enceladus.”

"No!"

"I love Cathedral, but if Titan's population grows by 400 people every two years, Cathedral needs to gain 80,000 square meters during that time, because our rule is that the average person needs 200 square meters for housing, agriculture, recreation, etc. That includes the levels under the floor of Cathedral, and right now we are installing one 4-meter space under the floor, which can be divided into two sublevels because robotically raised plants don't require much headroom. Our two cavern-making systems can make 20,000 square meters per year each, so that's 80,000 square meters of floor space every two years *without* the lower level. So you see, we can make plenty of space on Titan already. Cathedral East and West have now diverged from each other so far that they can now continue due northward and a 200-meter wide tunnel can be melted between them, which will be Cathedral North. So our outpost will consist of three parallel tunnels with 100 meters of ice between them. Cathedral South will take off from Cathedral West heading southward and will run around the far side of Titan 1. It'll continue southward as far as we want to make it and eventually it could have parallel tunnels to it as well."

"How long can they be?" asked Willie.

Marshall shrugged. "As long as we want them to be, and we can keep adding parallel tunnels, too. Let's say Titan has 10,000 people, eventually. If we keep to 200 meters of width—which we don't have to, we could make the tunnels 300 meters wide if we wanted to—then the tunnels would need a total length of 10,000 meters. But if we ever get that many people up here, which certainly is possible, Enceladus will probably have several hundred people, and we may have permanent outposts on other moons as well, because all of them are worthy of study."

“They wouldn’t be very big, though,” said Amy.

“Probably not,” agreed Marshall. “But let’s say each major moon needed space to accommodate fifty people permanently. Most likely, geologists would go there for six months or so, then come back here for six months, then go to another moon for six months. These would mostly be people without families; once they have kids, they’d want to settle down here. An outpost with 50 to 100 people would need at least a 50 meter drum, maybe a standard C-100 carrier, 100 meters in diameter and 100 meters high, which would provide a very nice, comfortable spinning interior space. I could see us building carriers like that on all the larger moons; all seven of them.”

“So, that’s where we’re going,” said Amy.

Marshall nodded. “I think so, but at a population growth of roughly 450 every two years—2,250 per decade—I suspect it’ll be a decade before we need a third borough, and after that we’d add them pretty fast. That’s my guess, anyway.”

“To summarize, the lunar mass driver now has contracts for 5,000 tonnes of metal per year,” said Joan Chiu, President of AIBuild, the company that took over the lunar mass driver. “With the metal highway completed to Parenago, ‘waste’ nickel and cobalt can be exported straight to the Earth’s surface at a small profit, and PGMs can be hauled there more cheaply than by Prometheus rocket. We anticipate exporting 10,000 tonnes to Earth next year. What we need is stronger demand for nickel-steel and other steel alloys in low Earth orbit. We are especially hoping to get orders from Swiftville; please take note, Zeke! There is the possibility of a contract to build an experimental solar power satellite at L1 and we are very excited about that. We are the future of construction materials in LEO, and I think everyone knows that! The lunar mass driver is already an important element in the solar system economy and will assume a bigger and bigger role every year."

Joan nodded to the terrestrial crowd in thanks and it broke into fairly enthusiastic applause. The two hundred-fifty people on Mars participating in the International Space Exploration Conference didn't bother to applaud because the sound wouldn't reach Earth for some twenty minutes.

The camera shifted to the three hundred people in the auditorium, and one man had his hand up. Then he stood; it was Zeke Swift. "Joan, if I may respond to your comment, Swiftville will purchase raw materials from the moon if they can be delivered for less than ten redbacks per kilo, and you can't do that yet. We already have contracts with Ceres—long-term contracts—for metals, plastics, and gasses for no more than ten redbacks per kilo, and we anticipate that the prices in three years will be much less than ten redbacks per kilo. You'll need to lower your costs a lot more to accomplish a price like that."

"Zeke, we anticipate that we will be able to lower costs significantly, thanks to the cobalt contracts."

"Cobalt, yes, you can make a profit on it, though not a big profit. But Joan, you said nickel, and the only way you can make a profit on nickel is to subsidize the cost of its launch with platinum group metals."

"We're building the capsules to launch PGMs and cobalt out of nickel because of its magnetic properties, and the capsule actually amounts to ten percent of the total mass launched. It is perfectly legitimate to sell the capsule materials as well."

"I see. Still, to launch materials to low earth orbit at ten redbacks per kilo, you'll need to get them off the moon for about five or six redbacks, and the only way to do that, cover your operating costs, and pay off your three billion redback debt is to launch about 40,000 tonnes per year at five redbacks per kilo. You don't have the electricity to do even a tenth of that! So you have to build up your infrastructure—at more cost—to be able to make money. You have a ways to go, I think, Joan."

"We do, Zeke, and with the support of Swiftville, we'll get there."

Zeke smiled. "You've already got the support of Mariusville!"

The audience laughed; the mass driver's control center was located at Marius, even if the mass driver was a thousand kilometers to the east. The chair of the terrestrial session rose. "I think we're finished for the day," she announced. "Tonight is devoted to informal discussions. Tomorrow we'll hear from Swift Aerospace and from the representatives of the Indian, Japanese, South African, Nigerian, and Argentine space agencies. It'll be packed with fascinating new ideas and lively debate. Thank you, everyone, for coming today. See you at 9:30 a.m." The terrestrial audience applauded and rose from their seats.

Will Elliott rose and walked to the front. "We're done with the formal sessions as well and we'll reconvene at 8:45 a.m. morrowsol. I was very impressed by the Marsian, Chinese, Russian, and American presentations this sol; so much is going to happen over the next decade! This conference appears well on its way to be the historic gathering we hoped it would be. So ciao and see you in the morning."

The two hundred fifty present applauded as well, then rose from their chairs. Changying looked at Ted. "I wish Zeke Swift would make a special deal with the lunar mass driver. He really could help it become financially viable."

"He made his position pretty clear," replied Ted. "Swiftville is taking shape pretty fast and it already has contracts with Ceres, and they can give him a better deal."

"Only because the Marsian Development Bank provided Ceres with two billion redbacks in expansion funding that they don't have to pay back any time soon."

"Sure, but they can do that."

"Well, the mass driver has three billion in debt to banks, and two billion of that is owned by Chinese banks, so naturally we're concerned."

"Everyone is struggling to cut costs as much as they can, as fast as they can," said Will, approaching them. "If both of you have time, I'd like to suggest we meet with Crystal for a few minutes to discuss the sessions earlier this sol."

Ted nodded. "Sure, I have time."

"Me, too."

"I'll get Crystal." Will walked across the room to Crystal Kern, Minister of Space Exploration, who was talking to Helmut Langlais. A moment later she walked with Will toward Ted and Changying. Will pointed to the main door, so they walked out the Martech auditorium and to Will's office nearby, where they sat and he closed the door. "I think we're off to a good start," he began. "This is nothing like the conferences fifty years ago that planned Northstar and Columbus. It has three times as many players; on day three we'll hear from the Europeans, individually and collectively, and from the Mariner settlements from Mercury to Neptune! It's amazing. But the pace will largely be set by the big three: the U.S., China, and Mars."

"I am very impressed, too," said Crystal. "There's a lot coming in the next two sols as well. I just received an email today that India is proposing to send a carrier to Makemake via Jupiter in 2096. Jupiter has three missions to asteroids planned in the next seven years. Saturn plans to launch a probe to a centaur every two years. Venus wants to obtain a small nickel-iron asteroid, preferably ataxite. An asteroid mining company proposes to bring PGMs to Ceres for final refinement and launching to Earth. It goes on and on. But the important thing, I believe, is the willingness to partner with others. Venus is partnering with the Europeans, India with Mars, Saturn with the U.S. and Mars, Jupiter with China and Vietnam. The partnerships are important for the peaceful expansion of humanity into the solar system, for the sharing of technology, and for national relations on Earth. Any arrangement can and probably should have a primary partner because ultimately, decision making should rest with one party. I sense that we saw a lot of potential partnerships this sol."

"I agree," said Will.

Ted looked at Changying. "I think that's true, too. In the last several months, since arriving here, Changying and I have worked behind the scenes to arrange some partnerships. The Chinese facility on Deimos has helped with engine technology partnered by the U.S. and Mars, for example. NASA is also prepared to agree to extend its partnership with Mars in the Kuipwew Project--now the Sedna Project, since it's going to an object beyond the Kuiper Belt--to other nations as well. We want to maintain a 51% share of the project, but we will accept Chinese involvement in the project if China accepts U.S. involvement in the Pluto Project."

Changying nodded. "Our space agency will agree to U.S. participation in Project Pluto as well as long as the astronauts will learn Chinese, because Chinese will be the primary language of the mission."

“Do you think a ten percent reciprocal commitment would be reasonable?” asked Ted.

“Yes, I think that’s approximately right.”

“The Indians will probably accept a similar level of contribution from both of your countries in the Makemake Project,” said Crystal. “Mars would also welcome American and Chinese participation in our asteroid belt projects. We plan to send out two missions a year from Phobos and at least one mission a year from Ceres.”

“I’m sure we will commit resources to those missions,” said Changying.

Ted nodded as well. “I think you can count on a U.S. mission for asteroid exploration sent out every year. It’ll depart Earth, visit a near earth object, visit an asteroid belt object or two, stop at Mars or Ceres in the process, then return to Earth. Marsian scientists will always be welcome, as will Chinese and scientists from other terrestrial nations. We will launch the missions, but want multinational crews.”

“We will be happy to participate,” replied Crystal.

“And China.”

“What about Prometheus 2?” asked Crystal. “That’s mostly a Russian-Mars project, but other partners are welcome.”

“We’ll take a small stake in order to benefit from the technology development,” said Ted. “That’s guaranteed.”

“Similarly, we have an interest in the Nike project, which is a joint Saturn-Mars project,” said Changying.

“Saturn wants partners, I’m sure,” replied Crystal.

“We would also like to send more Chinese to Saturn, Uranus, and Neptune,” said

Changying. “Research on those planets and their moon systems is very important. All of those commonwealths are receiving 300 arrivals every other year, generally young people who will raise families there and stay a minimum of twenty years. We would like to contribute 30 to each flight, and in return we will be happy to allow up to 90 non-Chinese to settle in the jovian system every other year.”

“With a requirement that they speak Chinese?” asked Ted.

“No. Callisto is predominantly Chinese speaking, but it has never been exclusively Chinese.”

“We’ll take you up on that commitment,” said Ted. “I’m sure the U.S. would be willing to send at least 25 or 30 to Jupiter every other year. We’d like to send a similar number to the other outer planets as well.”

“We have had a longstanding policy to accept commitments of that sort,” said Crystal. “So that is not new, but it is welcome. Now, what about a mission to Helia in 2099? That’s 15 years from now. Mars would like to lead that project, committing 30%, with perhaps 20% each from the United States and China and the remaining 30% split among Europe, India, Brazil, Japan, Russia, and others. What do you say to that?”

“Helia, huh? How big of a mission?” asked Ted.

“The details are negotiable, but right now we are envisioning two carriers attached together, each 200 meters in diameter and 200 meters long and each holding about 2,000 people, each with a complete and independent life support system, bioarchive, and fusion power and propulsion system. That way, either one can provide the other a lifeboat in an emergency. We think by the end of the next decade, we can design a system that will get people there in 25 or 30 years."

"Ion propulsion, or fusion?" asked Changying.

"Either. We'll have to see which is more practical in about ten years. We can build ion systems capable of exhaust velocities of 100 kilometers per second; a specific impulse of about 10,000. But if we're trying to accelerate a ship massing 20,000 tonnes—to take one possible number—we would need a power plant capable of creating several thousand megawatts for years, which would be massive. Perhaps in ten years we can create a fusion reactor in that power range that won't mass thousands of tonnes. A fusion engine is more likely."

"What's the total cost?" asked Changying.

"We think it'll be about three billion per year for 15 years, 45 billion altogether."

"A lot of money," said Ted, whistling. But he nodded, and a moment later so did Changying.

"We'll need a detailed plan in writing," she added. "Where will the research be conducted? Deimos?"

"No, probably Phobos, because the power needed is immense," replied Crystal. "The cost of developing the engine is really unknown, too."

"So, are we sure these agreements will hold up?" asked Will.

"We need them in writing and they need to be reviewed in Beijing," replied Changying. "Once that happens and they are signed, they're binding."

"Or as binding as they can be, because in the past agreements have been modified later for various reasons," said Ted. "But no one in Washington wants China to get ahead, and vice versa. Consequently, there's a good chance they'll hold up."

“Exactly,” said Changying.

“It’s a new era,” said Crystal, impressed.

“Four sols have produced some impressive results,” said Helmut Langlais, as he wrapped up the Space Exploration Conference. “Presentations by over thirty representatives have brought us a tremendous overview of everything that is going on. More importantly, behind the scenes there have been all sorts of small group formal and informal meetings, some occurring in three locations at once. People in low Earth orbit have discussed collaboration with people on the moon and Phobos simultaneously; people on the moon, Ceres, and Mars have had very productive conversations; people on Venus have consulted with the Commonwealth of Saturn. Old projects have been revived or restructured and new projects have taken on life. Overall, we anticipate more collaboration, more sharing of resources, less duplication of efforts than in the past. The solar system is a win-win place. It can be a role model for many on Earth.

“Strengthening our cooperation will be a new nonprofit organization, the Space Exploration Initiative. It will have offices on Mars and three places on Earth and exists to share information about space exploration plans. We are delighted to announce that Dr. Will Elliott, the first Chief Minister of the Marsian Commonwealth, has agreed to serve as president.”

There was strong applause in the auditorium as Helmut sat down and Will Elliott strode to the podium, trying to look as vigorous as he could. “Fortunately for all of us—and particularly for me—there is a big difference between being President and being the Chief Executive Officer,” Will noted with a smile. “At 82, I have finally gotten half way to retirement! We will find a Chief Executive Officer quickly, I am sure, and she or he will handle the hiring, the procedures, and all the details of functioning. My role will be to set and maintain the tone. And that tone will be based on what we have achieved in this conference. I have witnessed levels of cooperation and trust over these last four sols that we have not seen for some time. It bodes well for humanity's future in space, which is a very difficult and dangerous place that calls for the best technology, training, and professionalism we human beings can muster. That excellence is an inspiration for all our societies. Above all else, we must preserve a quest for excellence, a mutual respect and trust, and a desire to sacrifice together for the common good. If we do that, the Space Exploration Initiative will be a great success. The rest will be details; important ones, but details nevertheless. Thank you, all of you, for making this unity of purpose possible."

19.

Surprise Destinations

December 2083

"Where are we going?" Changying asked again, as they stepped into the pressurized taxi.

"You'll see. A great place to sunbathe and swim in comparative privacy, if you don't mind cold water."

"How cold?"

"I'm not sure; maybe 10 Celsius."

"I suppose that's endurable."

The doors of the taxi closed and the pressure seals clicked into place; the taxi began to roll toward the airlock. Changying frowned, puzzled. There were pools up on the Escarpment, but they were heated and often crowded.

The taxi exited the airlock and turned eastward immediately, heading toward a bubble barely visible several kilometers away. "What is it?"

He decided he couldn't keep the secret any longer. "Snow Crater."

"Our water supply?"

"Yup. The dome holds in Martian standard atmosphere. It's a beautiful reservoir with boats and a beach. You can even get a license to fish there!"

"I remember we ate that fish you caught last month!"

"It was pretty good, too!"

She smiled. "I think I'll just swim a little; no fishing for me!"

"That's fine. There's a hiking trail around the rim, too."

“That’ll be interesting.”

The taxi accelerated to a pretty rapid speed along the straight, smooth road of duricrete and in six minutes it was slowing as it approached Snow’s vehicle airlock. It entered, the doors opened, and they stepped into the arrival area. Ted pointed and Changying followed him down a short tunnel that opened abruptly onto the tree-lined cliffs and terraces of the crater rim. “Wow, it’s pretty!” said Changying.

“I told you. The bathrooms are over here. We can change there.”

She nodded and disappeared into the women’s bathroom. Ted headed into the men’s room and quickly put on his bathing suit. He came out with a tee shirt as well. When she saw that, she nodded. “I have sun screen; I can put some of it on you and then you can take off your shirt.”

“Good, I forgot the sun screen.”

“Typical man. Which way?”

“The beach is around the front of the building and to the left. We can grab towels on our way.”

She nodded him and followed him around the front of the boat rental building, which was robot-tended. They grabbed beach towels and hurried over to the stretch of sand nearby. There was a terrace in the rim of Snow Crater that was very close to the lake level and that provided he boat rental a perfect spot for a dock. The sandy beach was on the terrace as it continued to the left of the building.

They spread their towels on the sand and put sun screen on each other; Snow Crater did not provide as much protection from ultraviolet light as the Earth’s atmosphere, so they had to be careful. Then they headed to the water. “Oh, it is cold!” said Changying.

“It is.”

“We can get used to it quickly,” she replied. She turned and splashed him. He laughed and splashed her back, and in a few seconds they were soaked and getting used to the water. Finally Ted laughed and jumped and she swam after him to a raft about 15 meters away. A net and buoys marked the edge of deep water.

“How deep is the water in here?”

He shrugged. “At least fifty meters in the middle, I think. This place has lake trout, and they require cold water!”

“Well, they sure have it!”

He laughed. “This is fun.”

“It is. Who ever heard of a dome that’s 2 klicks across and empty; *no one at all*!”

“I know, it’s amazing. But it won’t last because once North America is opened to the public, they plan to add a short tunnel to here. North America will end just fifty meters short of the crater.”

“Wow, then this place will be crawling with people.”

“Let’s enjoy it while we can!”

“Definitely.” She pointed to the trail that could be snaking up and down the crater rim, around cliffs and across terraces. “That looks like a pretty walk, too. It must be 6 kilometers all the way around, too.”

“It’s all fir trees, a few aspens, grass, flowers . . . very pretty. I looked up the fauna. There are chipmunks in the trees and marmots living on the ground. Eagles eat them and eat some of the fish. There is a mountain goat family, too.”

“And they don’t eat the dome?”

“Apparently there’s a really strong metal edge to the dome all the way around.”

“Ah.” Changying laid down on her back on the raft, looking up at the pink sky—Snow Crater did not have any dome tinting to hide the color of the Martian sky—and relaxed. Ted laid down next to her, gave her a kiss, and put a hand on her breast.

“We need to do this more often.”

“Especially after the conference; that was exhausting.”

“It was, but we had a big impact on it by setting a tone of cooperation. It was a win-win situation for everyone.”

“It was.” Ted closed his eyes and relaxed in the sun. But before he could fall asleep he heard the sound of a motor start up, followed by a beep. He raised his head and looked at the dock. “Oh my God, it’s Elliott!” he said in an urgent whisper.

“What?” Changying raised her head and saw Will Elliott, accompanied by his son in law, Mike Tobin, motoring toward them. She pushed Ted’s hand off her breast. “Just be cool.” She stood up, so he did as well. “Good morning!” she exclaimed as Will came close. “Ted was just showing me this place. It’s incredible!”

“Isn’t it?” said Will. “I can’t get enough of it. The big limitation is Mike’s schedule.”

“You’ll be a lot busier now, too,” she observed.

Will nodded. “I anticipate spending 20 hours a week doing work for the Space Exploration Initiative. We’ve already got a pretty good candidate for executive director lined up; if she says yes, I think you’ll both be pleased.”

“Excellent,” said Ted. “I’m surprised to see you here this sol, though. I thought yo had three days of medical appointments."

"Three days reserved for them, yes. But I had the full body MRI yesterday morning and they found only one tiny problem; my pancreatic cancer keeps regenerating. It has to be caught early, and with the MRI it always is. So I have nanites inside me right now, chewing up the cancer lesion." He raised his hands. "Half a century of exposure to space radiation, and I'm 82; I can't complain, I'm in pretty good shape."

"You've got another ten years at least, dad."

"As long as I do the MRI annually, that's probably true. I take heart medication to keep it strong and immune system medication to keep it running well." He turned to Ted. "So, what did you think of the conference?"

"It's was very good and very successful. It was incredible to hear all the plans, and many of them were made *because* of the conference. Thanks for inviting me to serve on the planning committee."

"I'm glad you were able to do it. Both of you." Will turned to Changying as well. "Because of the unique . . . friendship the two of you have, it was possible for the entire conference to focus on cooperation and collaboration."

"Well, my role may not last much longer," said Ted. "Next year is 2084; an election year. President Lee is finishing his second term and it's hard to say who will win."

"And if it's the other party, you're out," said Mike, nodding.

"Exactly."

Well, you'll find something, if you choose to stay here," said Will. "As I told Congress, we're set up so that we always have a labor shortage." He looked at Changying. "It may be better for both of you, anyway."

She chuckled at that.

"I just hope we can keep everyone cooperating," continued Will. "We've had bursts of cooperation, followed by distrust and hostility, about once per decade! I'd like to think Earth has turned a corner, but international institutions are still pretty fragile and nationalism is still very strong."

"The win-win argument, however, works pretty well up here," said Ted. "Space is nearly infinite and there's always something new for someone to do."

"True, but that doesn't prevent hostility. Human selfishness is potentially infinite, too. I'm afraid it takes convictions—moral values—to combat selfishness. They're potentially infinite, too."

Ted nodded. "Well put."

"We're going to leave you now," said Will. "The fish are calling us. Have a good sol."

"You too, Dr. Will," replied Changying.

Will started up the motor and turned it away from the raft and toward the deep center of the crater. He was smiling. "They're good people."

"It looks to me they were fraternizing more than would be considered appropriate."

"Conflict of interest."

"Exactly."

Will nodded to Mike. "It's none of our business. And besides, it has proved good for international cooperation!"

Kristoff Langlais was surprised by how far Aram was from Aurorae; 1,000 kilometers of cliffs, canyons, crater rims, and chaotic terrain. But he left on the overnight transport, and as the sun rose the next morning, Aram's complex of domes hove into sight. In a few minutes the transport slowed and pulled into Aram's transport station. Victor MacLeod, the borough's Chief Executive, was waiting for him as he stepped off.

"Good morning, Mr. Langlais." He extended his hand and they shook. "I hope you got a decent night's sleep."

"It wasn't too bad, though the steep corners sometime jostled me."

Victor looked down at the hyperloop skate underneath the transport. "How many hours to get here?"

"Just six."

"That's pretty good; a bit faster than in the past. The stretch from here to Aurorae will be the hardest stretch on Mars to rebuild for hyperloop speeds. Hundreds of kilometers will need to be straightened. They say they need to tunnel or bridge three hundred kilometers of highway, so that it can stay straight and flat!"

"We went through one tunnel and I saw a few construction sites on the way. They were brightly illuminated so the robotic equipment could see. The AI Conductor also asked me whether I wanted to see the scenery several times and it turned on the spotlights mounted on the roof. Incredible!"

"The scenery is some of most dramatic on Mars. I'm glad they turned on the spotlights. They're designed to give you a good view, even when a cliff is a kilometer away from the road."

"Hard to believe some day this will be just *one hour* from Aurorae."

“And just an hour from Thymiamata. We can’t wait. We really need it. Are you ready for breakfast?”

“Sure, but I’d really like to see your place before any serious discussions.”

“Of course. Would you like a quick tour?”

“Sure, that’d be great.”

“There’s a cart we can take over there, and I can pour you a nice hot cup of marabica for the ride.”

“That’d be great,” said Kristoff, with a smile.

Victor took his overnight bag and carried it to the cart, then filled up a ceramic mug with steaming coffee. Kristoff added milk and sugar and they walked to the cart.

“Aram Outpost is pretty big,” began Victor, as he sat in the cart. “In addition to our original enclosure of Genesis crater—160 meters in diameter, circular—we have 22 cylindrical enclosures. The oldest ones were 120 meters long and 30 wide—pretty small. But now we’re making 500 meter by 150 meter enclosures, and we have six of those.”

“How much polder do you have?”

“771,100 square meters.”

“Really? That’s three quarters of a square kilometer! For how many people?”

“I’m afraid since Rivers died, with the conflicts and the financial troubles, our population has dropped from 500 to 350.”

“Then you have . . . not 200 square meters per person as is the standard, but closer to 2,000 square meters!”

“That’s correct. But remember that our goal is to enclose the entire floor of Aram crater.

That's 61,000 square kilometers."

"That's . . ." Kristoff reached for a proper adjective and almost said "insane." Not only was Aram huge; it was rugged chaotic terrain. "That's amazing."

"Increasingly, it's aspirational. At our current rate it'll take almost a million years. Tree Rivers said he'd had a vision that the Garden of Eden on Earth had been in Aram, which is the area around Damascus, and that Aram Crater shared the same spiritual characteristics. We took that very seriously. But now . . ."

Kristoff looked at Victor closely. "Not so much?"

"Correct. We have had time to reflect about the visions and the man. The result is much lower confidence in him, and that means there is much less unity of thought, and . . . a lot of people have left."

Kristoff nodded. Victor started the cart forward and they entered the first enclosure, a small one with a stream running down the middle. Bamboo and various shrubs crowded the edges while short palms and fruit trees pressed up against the dome in the middle. The cart ran along a narrow path in semidarkness with plants brushing it on both sides. "So lush!"

"All of Aram's this way, but this enclosure is almost 24 years old, so it's very mature."

They reached the end of the enclosure and the airlock door to the next enclosure automatically opened for them. It was 200 meters by 70, with a much higher center. A team of robots was cutting down a tree in the middle, cutting it into logs, and stacking them on a trailer. "High quality wood is one of our main exports. We also make beautiful wooden furniture."

"Yes, I've seen some of them. You have master craftsmen."

Victor nodded, pleased by the comment. They continued across the enclosure and into the next one, then the next; altogether they traveled over 2,000 meters through larger and larger enclosures, the last one 500 meters long and 150 meters wide. "It's swampy in order to improve the ground," Victor noted, as they reached the end of the last enclosure. "We always start our enclosures out this way, to soak the ground thoroughly and wash out the salts. It's full of sedges, reeds, algae, little fish . . . they're quite beautiful. We have four of these, side by side, and our two rivers now have two tributaries each."

"And it's hot in here!"

"We send as much excess heat here as possible to thaw the ground, especially in the middle of the enclosure. It's also one of the big ways we get rid of trapped solar heat."

"That's a problem everywhere." Kristoff pointed to the exit, so Victor nodded and started the cart forward. It went through the airlock into a second swampy enclosure, then a third. Rather than entering the fourth one, he turned the cart southward, back toward the arrival area.

The first enclosure they entered was dark and very cold; barely above freezing. Kristoff looked up at the mylar reflective blanket covering the dome. "Wintertime?"

"Yes, this enclosure raises winter wheat. We give it thirty days of cold, then warm it up gradually over a week and push it to harvest. We also store racks of strawberry plants in here that go out to our vegetable field when 'winter' here ends." He pointed.

"Who do you sell the wheat to?"

"Usually Thymiamata or Kalgoorlie. They're close and they can't grow all their own food." He pointed to the airlock at the other end of the enclosure and the cart took them into it automatically. When the other airlock door opened, they rolled into an enclosure full of vegetables, with an extensive area of red raspberries.

“So, this is where you grow your red raspberries. They are *so* good! I think you are charging too little for them.”

“Really? People say we should make preserves from them, too.”

“And maybe wine. I suspect it would be very good.”

Victor nodded, absorbing the idea. In a minute they rolled into another agricultural area full of corn and rice, then another enclosure with tomatoes, which a team of robots was picking quickly. Kristoff was impressed by the scale of the operation.

They rolled through five more agricultural enclosures, following another stream all the while, until they entered a large enclosure with a pond full of rice into which Aram’s two streams emptied. Noting that that was the end of the tour, Victor drove back into the transportation center, then across it and into a tunnel that led to Genesis crater, 160 meters in diameter, their lush residential area. They climbed off the cart and walked down steps to a guest house. There, they joined three other leaders of the community: Nicole Ravier, Superintendent of Schools, member of Mars Council; Patrick Stern, Director of Ecology; and Anselm Michelson, Director of Construction. A table was set with one of the most sumptuous breakfasts Kristoff had ever seen.

“If you need to settle in a few minutes, your room is back there,” said Victor, pointing past the fireplace with a real wood fire burning in it. “But I suggest we sit and eat before the food gets cold.”

“Yes, I agree,” said Kristoff, admiring the spread. Victor pointed him to a chair, so they all sat and began to pass around the bacon and eggs, biscuits, pastries, pancakes, yoghurt, fresh fruit, and various fruit juices. “Is all of this local?”

“Yes, indeed,” replied Patrick Stern. “This guest house is for tourists and we usually have three or four, though currently you're it. It also serves as our fancy restaurant. It has excellent food."

"So I see. I must say, I am impressed by your immense facility. I take it that half is forested, and it's also a source of many of your exports."

"We harvest from everywhere, obviously," replied Victor. "There is no such thing here as wilderness for its own sake. Our deer herd produces venison. Agriculture, forest products, and finished products generate eleven million redbacks of income per year. Even our photosynthesis generates waste plant matter and oxygen, so we put the oxygen into the interborough pipeline under the highway, and we reduce the plant matter to methane, which we also put in the pipeline."

"Eleven million; that's not much. I'm sure you can make more money than that."

"Well, tell us how," said Anselm.

"That's why we invited you," added Victor. "You are Aurorae's biggest farmer and it's largest land owner—"

"No, I'm not so sure of that," interrupted Kristoff. "I don't own all the land I farm; I lease most of it. If I owned it I'd have to pay for maintenance costs, and I don't need to accumulate the personal wealth that the land represents. It'd just raise the cost of my agricultural production and decrease my competitiveness."

"Even so, you must be the largest land owner on Mars."

"Hum . . . of polder, yes, There are people who own thousands of square kilometers of range."

"At any rate, we need advice, and we've tried to get it from anyone who would offer it."

"Our construction is stalled," said Anselm. "We try to complete two 500 by 150 meter enclosures per columbiad, but we don't have the cash flow to buy the plastic and nickel steel we need."

"Can't you borrow from the bank and buy more robots and materials?"

"We've reached our credit limit," said Victor. "Because 150 people have left, we're understaffed, and we barely have the income to pay off the loans that covered the purchase of the robots."

"Which was one of the problems," added Nicole. 'The people who left were fanatically against robots. We used to do everything ourselves, but it was back-breaking work, and now we're shorthanded."

"I'm not sure what I can suggest. Are you exporting to the terrestrial market? Marsian wine, for example, fetches excellent prices; 100 redbacks per liter, typically. The quality is always the highest because we control the climate and nutrients, half the water can be removed to make the product lighter for shipment to Earth, and the unique isotopic balance in our soils makes the wine easy to authenticate and nearly impossible to fake. A hectare of vineyard can yield 20 tonnes of grapes, which make 12,000 liters, which is 1,200,000 redbacks. Of course, you'll be lucky to get half that as profit. Twenty hectares will yield you 12 million redbacks of profit and that's only a third of your polder. Now they're doing the same with olive oil. The export market is potentially huge because there are billions of people who'd like to try a bottle of Marsian wine."

"We have thought about the terrestrial market," agreed Victor. "And you said you thought we could have charged more for our raspberries?"

“Because your quality is excellent. You need to study the commodities prices; they’re on the web. I think you can *create* commodities, too, like preserves from Aram. But you’ll also need a marketing plan so the public hears about the brand and wants it.”

“More expenses,” said Patrick.

“Look, I’m not an economist, but Martech has plenty of them, and so does the Commonwealth. You’ve got how many adult workers here? Two hundred fifty? If they earn average wages, that means they collectively earn about 62.5 million redbacks. Right now, they’re bringing in eleven. The average Marsian farmer has to feed 100 people to earn a decent income, so if you want to earn a decent income through agriculture alone, you’ll need to feed 25,000 people, and you have only a third that much polder. Tourism will help, but at 300 redbacks per sol per tourist that’s about 100,000 redbacks per tourist-year, so you’ll need 625 of them to cover all your expenses that way. Your handicrafts are valuable, so they’ll earn some as well. You need to figure it out. I’m sure you can get development grants and loans from the Commonwealth; that’s what the Mars Development Bank is for.”

“Maybe we need more confidence,” said Anselm. He looked at Victor; it would seem he was criticizing the latter. “We are a part of the Commonwealth and they have a certain obligation to help us, just as we serve them.”

“We have to pull our weight,” replied Victor. “And that isn’t easy, in a highly automated society when you want to minimize the use of machines and artificial intelligence.”

“Trying to do without machinery and living on Mars are a contradiction in terms,” said Kristoff. “Survival, by definition, depends on machines. Anything more than survival definitely needs machines. If you want to live beyond poverty, you’ll need more machines and more AI.”

Victor sighed. “This is our dilemma. Tree Rivers at first set this place up to absolutely minimize life support equipment. Air flows from enclosure to enclosure naturally because of differential heating and the fact that the enclosures are on a slope. Water flows from one enclosure to another through a deep underground loop; if one enclosure were to lose pressure, the water would keep flowing through and the surrounding enclosures wouldn’t lose pressure. Then we had a major depressurization event and several people died. The Mars Commission cracked down and we had no choice but to install more sensors and a central environmental control area. No one objected; it was law. Tree even allowed us to get a few robots, because after all, by then he wanted space ships to carry people to Themis and terraform it. That required a lot of machinery. But now that he is gone, additional machinery has been controversial.”

“And expensive,” added Anselm. “But we can get development grants, Victor.”

“Anselm, we really need to live within our means,” scolded Nicole. “The Green World Community is ecological, above all else.”

“Are we?” asked Patrick. “Is there still a Green World Community? The terrestrial movement is split in two, or even into three, if you include the anti-robotics terrorism gang. Bill is struggling on Themis to keep the atmosphere from degenerating into an explosive mix of oxygen, methane, and ammonia while trying to maintain a complex and leaky set of three domes. And here we are, living in our own set of bubbles in the Martian wilderness, pretending we can live close to the land like our ancestors, when in fact our life doesn’t resemble them in the least.”

“That’s why we have to re-invent the philosophy for ourselves,” said Victor, patiently. “I’m trying to steer us on a middle path, because that seems to have been where Rivers was going when he died.”

“But it isn’t working,” pressed Anselm.

“We can manage,” replied Nicole.

“I see this is a very active issue,” said Kristoff.

“It is, and if you were willing to buy some of our land—maybe an entire enclosure—that would give us some of the cash we need to move on,” said Victor.

Kristoff was startled by the suggestion. So, that was what they had hoped to get from him! He shook his head. “No, that really wouldn’t be practical. I can’t be getting here on a regular basis to supervise work in an enclosure. You know, a third of your land is tied up as swamp right now. Drain those last four enclosures—or even three of the four—and you’d have a lot of new land to experiment with. I think you could almost double your income with them.”

“That’s a good point,” said Victor, seizing on anything he could. “We could plant them all in grapes.”

“Or grapes and olive trees,” replied Kristoff. “Aurorae has plenty of both to sell, too. I can give you names and help with contacts, but that’s really all I can do. I am extremely busy managing the robotic planting and harvesting of 200,000 square meters. That may not sound like a lot, compared to your 750,000, but it keeps me busy all day, every sol. There’s really nothing more I can do for you.”

“Well, we will appreciate even that,” said Victor. “Let’s finish breakfast, and we can give you a tour of our tourist facilities. Then, while you are here, you should at least relax and enjoy our hospitality.”

“I would appreciate that,” said Kristoff with a smile, relieved the arguing was over.

"They do have beautiful tourist facilities, I will say that," exclaimed Kristoff in conclusion. "I stayed overnight, was free to walk throughout the enclosures—and I went on some very long walks because their enclosures are really beautiful—ate extremely well, and enjoyed a very nice hour in the hot tub. The overnight transport back here was pretty smooth, also. I'm surprised more people aren't going there for a few days."

"I think they haven't been marketing themselves right," replied Helmut. He paused to chew his lasagna. "Generally, they haven't done a good job selling their products and services. They need advice."

"Some of them are too proud, and others are too timid, I think," said Kristoff. "I plan to make some connections for them, but they need professional assistance." He looked at Sirikit.

"Me?" She considered it. She glanced at Angela, 9 months old and struggling to eat baby food, and Andrew, now 3 years old next to his sister. "I really don't have any time. I'm finishing up a huge analysis of interplanetary transportation costs and their impact on solar system development."

"How's that coming?" asked Helmut.

Sirikit nodded. "Pretty well. Ceres definitely can send water and hydrogen to low Earth orbit more cheaply than anyone else. That's also true of plastics and finished goods; the lunar mass driver's acceleration is too high for them to be launched from the lunar surface. Ceres can now send nickel and cobalt to the Earth's surface profitably, also. Phobos's prices for finished goods are barely higher than Ceres, so the two of them can coordinate production to make their goods complementary. The moon's main advantage is speed; they can fulfill a manufacturing contract in a few months rather than a few years."

“Aren’t we best off sending raw materials and let Swiftville do the manufacturing in LEO?’ asked Helmut.

“That’s what Swiftville wants, but there are a lot of items Ceres can make and export cheaply, as long as they go to Earth orbit on a carrier-class vehicle. The price assumes a 200 meter wide, 100 meter long carrier full of water, but much larger sizes are possible and they enable even more automation. It should be possible to get the price down to 2 or 3 redbacks per kilo, eventually, and even the mass driver can’t compete with that! At that price, Ceres can export almost any raw material you can imagine. It’ll be cheaper for Phobos to get its propellant from Ceres than to extract it from the heart of the moon itself. So both Ceres and Phobos have to keep growing.”

“Good,” said Helmut. “That’s the news I like to hear. When will you have the report done?”

“Next month. And after that, maybe, we can think about Aram.”

“You really need to go there and tour the place. I suggest you both go, take the kids, and have a relaxing few days, because it’s a really nice place. And while you relax, you can talk to them.”

“You know, we visited Aram a long time ago; I think it was ’74, right after I got here,” said Charlie. “A bunch of us went down to help cut timber. We met Tree Rivers, too.”

“And talked to him about economics, even then,” said Sirikit. “And we encountered those coyotes.”

Charlie smiled. “I remember that. But we can’t go back for a few months because I’m going to Phobos for a month in February.”

“Oh, you are?” said Helmut. He glanced at Sirikit. “Angela’s still pretty small.”

“I said I’d help,” replied Irma, Kristoff’s wife. “With Mark and Niki out of the house, it’s so quiet! I’d like to have a baby around a dozen hours a week.”

“I can help, too,” added Clara, Charlie’s mom. “Helmut went away a few times and the little boys—Charlie and Oskar—almost drove me crazy! And Mars didn’t have grandmothers then!”

“Or aunts,” added Irma.

“Well, it sounds like we’re going to be helping, too,” Helmut said Kristoff. “And we should. What’s the purpose of the trip?”

“We’re assembling a team to review the geology of Hungaria. It needs to be a face to face gathering because we’re going to talk intensively sol after sol. We’re flying up a half dozen faculty and graduate students and we’ll work with a dozen more at the Asteroid Study Center. A launch window to Hungaria opens in 13 months.”

“For a probe?” asked Helmut.

Charlie nodded. “A spider with solar panels; Hungaria is in the inner edge of the Belt, so there’s plenty of sunlight. We won’t do sample return, but Hungary, naturally, wants to launch a manned expedition to the asteroid, so we’re collaborating with them and providing ground truth.”

“A collaboration that stemmed from the conference,” said Helmut, nodding. “I remember now.”

“Maybe we can get to Aram after that, as a bit of vacation,” suggested Sirikit.

20.

Power Sources

Jan. 2084

“Happy New Year, Tad,:” said Wicahpi-Luta. “Can we join you?” He, Esther, and 4 year old Miranda were approaching the Linds’ table with their supper. They had made Tad, Susan, and four year old Paul a sort of family project.

“Sure; Happy New Year.” Tad pointed to the rest of the table. We can make room. Did you have a relaxing day?”

“It was pretty good. We saw the new Superman movie.”

“That is fun,” confirmed Susan. “We plan to watch it next weekend. We went to the concert and then we were too tired for the movie.”

“How’s the dating going on the Titania geological units?” asked Esther.

“Not much new since the paper I posted in *Uranian Geology* last month. But we do have some new dates for Miranda based on small crater counts and radiogenic analysis. The last orbital resonance event—with Umbriel—was 250 million years ago, so this place is completely and totally dead, geologically speaking.”

“Which is what the heat flow data and the seismic models all indicate, too,” agreed Wicahpi-Luta. “Even Titania is pretty much dead.”

“Well, it does have a global ocean,” replied Tad quickly. “It’s just under sixty kilometers of ice crust. We won’t be drilling down to it any time soon, especially since we decided not to set up a borough there. If we had, we could have started a deep drilling project to reach the ocean, and it would have given us a source of geothermal energy as well.”

"Not to mention access to the prebiotic organics we know are there," said Esther. "They're a lot harder to study in three-billion year old cryovolcanic deposits."

"It's a shame we decided not to build a carrier on Titania," reiterated Tad, more emphatically than ever. "Once we have a few thousand people here, it's inevitable, I think. Not only are we cutting off our instant and constant access to the most interesting geology in the system, we're also putting all our eggs in one basket by building here and relying exclusively on reactor power."

"Avalon will be perfectly safe, though," replied Wicahpi-Luta. "As you know, we've now reached the bottom of the hole for Avalon 2. It took a bit longer than we expected because of the problem of disposal of all the water, but we now have a 210 meter deep, 215 meter in diameter hole finished. It's quite something to see! We should have it pressurized in another month, too."

"The ice disposal problem was solved cleverly, but it worries me," said Tad. We now have the outer metal shell of Avalon 1b and Avalons 2C and 2D erected hastily and encased in 15 meters of ice; as hard as concrete, I'll admit, but it is exposed to micrometeorites and cosmic radiation that will crack and weaken it over time."

"It'll take a century, Tad," said Wicahpi-Luta, trying to model calmness and kindness when he was feeling irritation. "Before that happens, we'll wrap the ice shell in Kevlar or nickel-steel—whatever is fastest and easiest—we'll spray more water on the outside to encase the wrapping as well, and it'll become an impenetrable barrier."

"Congratulations, by the way, on completing the hole," said Susan. "Anand's congratulatory message was really beautiful."

"We all really appreciated it. And it appears we'll manage to pressurize all five new

Avalons in the next few months. They'll be empty and zero gee, but won't they be fun to float around in!"

"The world's biggest game of striker," said Esther, with a smile.

"Or even soccer, because as long as you keep moving on the curved surface, you'll experience enough 'gravity" to get traction," said Susan, with a smile.

"They'll love it," said Tad, pointing to the kids. "I suppose Avalon 1 and 2 are far enough apart and armored enough to avoid a common disaster. What are the calculated odds? One point two million to one? Of course, the risk of losing a carrier on Miranda and Titania at once is zero."

"Tad, never mind," cautioned Susan gently.

He rolled his eyes. "The bigger issue, though, is dependence on fission reactors. It's problematic, as we found out when reactor-3 shut down last month. Here we are exporting two tonnes of Helium-3 per year to Earth and we have no access to fusion power."

"That's because a fusion reactor cost a a billion redbacks," said Wicahpi-Luta. "Which means if engineering decided to take a blueprint and build one—we have the materials and equipment—it would take us 2,000 person-years. Not practical. Maybe in five years it'll be a quarter billion redbacks and we'll have more people."

"True."

"Reactor 3 is back on line, but we may have a solution to our dependence on fission," said Wicahpi-Luta. "And you won't believe it. Solar."

"Solar? Shit." Tad saw Susan wince. "That's crazy. This is the *outer solar system.*"

"Twenty times farther from the sun than Earth, with only one four hundredth the solar intensity. But we are on the equator of Miranda; we can benefit from perpetual sunlight most of the time; and the big benefit is near zero gravity, so we can make huge, light-weight structures."

Tad frowned. "How big?"

"How much power do you want? A concentration dish a kilometer in diameter can mass just a dozen tonnes but receives 2,500 kilowatts of sunlight."

Tad laughed. "That's enough for 25 people, and how would you ever build and steer such a thing!"

"We'd build it on Venice Mons at 5 degrees south, progressively. For example, we'd start with a big, open tower structure 20 meters across and 300 meters high and build a hemispherical mirror 500 meters across—"

"You'd start with about 600 kilowatts of power? That's enough for 6 people, and how much work will the tower take!"

"The tower can be built robotically. The dish would be of extremely thin mylar—like a solar sail—stretched over a thin hemispherical mesh structure. It'd mass maybe a tonne and would be steerable, to track the sun on top of the tower. Venice Mons already has sunlight 70% of the day and as the seasons advance in the southern hemisphere, in a few years it'll have sunlight 100% of the time."

"And you'll be lucky to get 300 kilowatts of electricity; our panels are only 50% efficient under ideal circumstances."

Wicahpi-Luta shook his head. "There's a better way; set up a secondary mirror to reflect the concentrated sunlight back through a hole in the center of the reflector, then reflect it down the middle of the tower to a molten salt reservoir in a building at the base of the tower. The intense sunlight heats the salt and a heat exchanger transfers the heat to a working fluid—nitrogen or helium gas, or possibly ammonia—which spins a turbine, then goes to a heat sink. That could be radiators spread out on the surface of Miranda or an ammonia-water reservoir underground. Either way, with a cryogenic heat sink, the conversion to electricity is over eighty percent efficient. But that's not the end; that's just the beginning, because your robots keep adding panels to the hemispherical reflector, making its diameter bigger and bigger. Periodically you jack up the tower higher and add another section to it. You also add to the molten salt target and add a second turbine. In about five years you reach the maximum size of the dish—4 kilometers in diameter, on a tower two kilometers high—and you can now capture 40,000 kilowatts of sunlight and generate 32,000 kilowatts of electricity, enough for about 320 people. The reflector and other mirrors might mass 100 tonnes, but in Miranda's gravity the weight will be less than a tonne, so the tower does not have to be very robust. If we make the robotic team and its human support team larger—about a dozen people—they could build one such tower every three years. That's roughly the rate at which our population will increase by immigration."

"Are you saying we could support our carriers and industrial sector—everything—with solar power?" asked Susan, surprised.

Wicahpi-Luta nodded. "We think so. Of course, in 30 years or so, fusion power may be cheap enough so we can use it instead."

"And that's about the time the seasons change and the sun heads for the northern hemisphere," noted Tad. "At that point, Venice Mons would move into 42 years of almost continuous darkness."

"Agreed," said Wicahpi-Luta. "But it would probably be possible by then to build a tower on a mountain in the northern hemisphere—Genoa Mons, for example—and transfer the solar dish to it, whole or in pieces."

"So, we'd move them all." Tad was startled by that idea. "Let's say by then Miranda has 3,000 people and needed ten solar dishes, each 4 kilometers across. That's . . . well, it sounds utterly crazy."

"Maybe because you're a geologist and not an engineer," replied Wicahpi-Luta. "The design is being steadily refined, and so far there are no unsurmountable obstacles. Automated construction is the biggest challenge; we'll need Martech to develop some pretty powerful software. But if they do, systems like these will revolutionize solar power on Phobos, Ceres, Callisto, even the moon."

"When will the design be ready?" asked Susan.

"We'll have something for the Council's consideration in a few months."

Tad nodded ever so slightly. "Interesting possibility."

Susan smiled at Wicahpi-Luta with a smile, as if to say, "That's the best you'll get out of him" and Wicahpi-Luta smiled back knowingly. Perhaps Tad had made a bit of progress.

"It's exactly as we thought," said Jamison Rideout, standing underneath the newly landed *Dorado* and facing north, up Columbia Vallis, toward a huge, dark, cave mouth.

"Well, not exactly," replied Andy Jordan, their chief geologist. "I am puzzled by the fact that this vallis is 500 meters wide and 600 meters deep, but the cave mouth is 250 wide and about 120 meters high. If the vallis was cut by running water that came out of the cave, why isn't the cave the same width as the vallis?"

“It may have to do with the fact that the cave is cut through ice bedrock and this vallis is cut through the ice-lava deposits of the planitia,” suggested Chen Jiaying. The expedition’s chief science officer. “The water poured out of Veles Patera, ten kilometers north of here; filled up the 2-kilometer crater immediately north of here, which iced over; it broke out of the crater, flowed over a low spot in the rim, and carved a vallis in the ice bedrock; it filled the depression here with thousands of cubic kilometers of water over some decades, creating Anupa Planitia; the constant flow of water excavated the vallis wider and deeper; it froze over on top, making a water-lava tube; it froze over here, too, but the slow water flow preserved a wider passage; eventually the water drained out and the roof collapsed here, but the tube was narrower and the roof was so thick, it stayed intact.”

“Well, we’ll see whether it’s intact,” replied Jamison. “We can speculate about the width of the vallis versus the tube later.” He turned around to see whether the rest of the geology party had egressed from the *Dorado.* They were coming out right then. “Let’s go.”

Jamison Rideout stepped forward with an eager, determined step. After six months on Triton, he had adjusted well to its gravity, just 8% as much as Earth’s and half the gravity of the moon, which allowed a careful walk or a rapid leaping lope. Tritonian valleys—to be precise, fossae, sulci, and valles—were named for sacred rivers on the Earth, and this one was named for the Columbia River of the northwestern United States, sacred to the many tribes that dwelt on its banks, and pretty special to Jamison as well, who was from Hanford. It was one of the reasons they had set down there rather than at Jordan Vallis, which had erupted water lava into Anupa Planitia from another patera fifty kilometers to the east.

A moment later the ranger caught up with them and slowed. It was a nuclear powered surface vehicle—modified for Triton specifically—capable of transporting three comfortably and many more in an emergency. They had landed a mere hundred meters short of the cave opening, and with the ranger's headlights they could now see inside some distance, until the lights disappeared into the vastness of the tube.

It was eerie to pass under the overhang and entered the underground space. Two hundred fifty meters was eight hundred feet; the opening was huge, and half that high as well. It would carry a mighty torrent of water, but the water did not have to be moving very fast; just fast enough to prevent freezing. The side walls glistened a bright translucent white or a glassy shine. The ceiling had occasional icicles—water lava stalagmites—and the floor was covered with rough, broken shards of ice that had either fallen from the top or had frozen on the flowing water and been dropped when the water drained away. The rover turned on a powerful searchlight on its roof and panned it so they could see both sides, but when the light was pointed straight ahead, the reflection was so distant and dim that they couldn't make out anything.

"Damn, this is big!" exclaimed Andy. "It's wider than Marius!"

"There are bigger lava tubes on the moon, though and maybe on Mars," said Jiaying. "I've been in a pretty big tube on Arsia Mons."

"Water ice, even at cryogenic temperatures, can bend and sag low slowly, so really wide structures can't exist here," said Jamison. "How safe is this place?"

"Triton has earthquakes, and there would have been plenty when Veles Patera was erupting," replied Jiaying. "This thing survived them. So it should be pretty safe."

"Sally, are you getting all of this?" Jamison said, speaking to the ranger driver.

"Oh yes, and the cameras are picking up the reflections from distant walls," she replied.

"We're computer enhancing as we go. We still have a good communications link, too,"

"We're all watching up here," added Rahmatullah Khan. He was on Proteus in the *Carina,* where the entire crew was eating supper. The live broadcast was riding a laser beam to the Seron and to Mars, also.

They continued forward slowly, stopping to pick up samples with the vehicle's arm—the ice was clouded with organics, because Triton's internal ocean had bionts, or very primitive life forms—and sometimes driving around piles of debris. Otherwise they were mostly silent, awestruck by the size of their discovery.

Then, after 350 meters, the tube suddenly opened up. "My God, we've reached Columbia A!" said Jiaying. They stopped and the rover panned its light to the right, the left, and even upward. Looking upward with the rover's cameras, they could see a ceiling faintly, way over their heads. But when they panned to the left or the right, the reflection was so faint and so distant, it was difficult to recognize anything. "What do we have, Sally?" Jamison asked.

There was a pause. "You won't believe it," she replied. "I've turned on the radar because the headlights and the spotlight are too weak for an immediate answer. They can photograph, but they can't estimate distances. Hold on."

They all stood in silence for nearly a minute while the computer analyzed the radar data. In that time, the ranger continued forward several hundred meters and drove in a circle in order to create a three-dimensional radar image. "Here you go," Sally finally said, and a three-dimensional radar image may suddenly popped onto the screen. "My God, the cavern is circular; it's most of the crater!" said Jiaying.

"There are several collapse areas; I think I count six of them," said Sally. "They go all the way up to the ceiling. They're frozen in place, so I think they would have been collapses into the lake when the ice crust had partially formed. Maybe the lake was filling and draining."

"Are you saying they're supporting the roof?" asked Jamison.

"That's what the radar seems to be showing. They connect to the ceiling. Do you see the long one at 10 o'clock? That one runs from the wall 300 meters toward the center of the cavern. That must be holding up a lot of weight!"

"How thick's the roof?" asked Andy.

"Three or four hundred meters of ice, hard as concrete at these temperatures! But in Tritonian gravity, the weight is equivalent to 20 or 30 meters of ice only."

"How many square meters is this place? Ask the computer, please. How high is the cavern?"

"The ceiling in a few spots is 300 meters above the original flat floor, but in those areas there are debris mounds up to 50 or 75 meters high. The collapses seemed to have helped create a natural arch to the ceiling! The computer estimates the floor area—based on the radar image, ignoring debris piles, but excluding pillars supporting the ceiling—is about 2.5 million square meters."

"That's incredible," said Jiaying.

"Three times the area of the Cathedral enclosures on Titan," said Jamison. "At 200 square meters per person, that's enough for 12,500 people."

"At one level! We could put fifty levels in there and use up only half the headroom!" exclaimed Rahmatullah on the *Carina.*

"That would generate a lot of heat and weaken the ceiling," said Jamison.

“We’d install support pillars every 100 or 150 meters,” replied Rahmatullah.

“How would we study the structural integrity of the ceiling?”

“There are quite advanced techniques developed on the moon for that purpose.”

“Interesting.” Jamison looked around at the darkness. He lened forward to look out the front window. His eyes had adjusted somewhat and he could see the ceiling faintly, over 200 meters overhead, and one wall 300 or 400 meters to the left. It gave him a dim sense of the immensity of the place. “Andy, is the cryovolcanism here completely dead?”

“Yes, near as we can tell, the hot spot has migrated 25 kilometers farther northeast, thanks to polar wander. This cryovolcanic event was twenty million years ago.”

“Is there still geothermal power potential here?”

“With deep drilling, I’m sure there is. Certainly if we drill forty kilometers northeast of here at the edge of Kanaloa Patera, we’ll hit plenty of heat.”

“To light this whole place, we’ll need about 1,000 megawatts.”

“Kanaloa Patera is pretty active. I think it could supply that much,” said Andy.

“So, Titan or Enceladus?” asked Jamison. “I think we just found our Titan, and our Enceladus doesn’t have geothermal heat.”

“Proteus is cold and dead, and too dark for solar,” agreed Jiaying.

“Rahmatullah.what do you think? The Seron is heading for Proteus, a year from now.”

There was a pause. “You’ve been on Triton for six months, so it’s time for the expedition to reunite. That usually means that the *Dorado* comes here. But we have the 50-meter cylinder just about complete. We plan to pressurize it next week. So that project is finished.”

“The engineers haven’t built the rotating inner drum.”

“That’s true. What I’m thinking is that we can transfer some of the hydroponic equipment from the U-75 to the mini-carrier, deflate the U-75, and bring it to Triton. We can set it up in the cave and base the expedition there for the next year. There’s really nothing we have to do on Proteus. When the Seron arrives, it arrives as a complete base.”

“How long will it take to build a rotating drum here for some open space?”

“I think we can build something that’s rotating in a year. It’d make a good complement to a caravel. In fact, if we can build two rotating drums, we could leave crew at Columbia Outpost without a caravel. The caravel could travel around the moon while a crew continued working at Columbia.”

“You realize Mercedes is hearing all this, and I am sure she has objections,” said Jiaying.

“This conversation is being broadcast, but it’ll be over an hour before the Seron receives it,” replied Jamison. “We have time to think this through. Triton is unique and its geology is incredibly dynamic; incredibly fascinating and important. Pluto’s is similar, but it’ll be several years before the Chinese get there. Where geology is concerned, the Neptunian system consists of an inaccessible planet without a solid surface, Triton, and a little dead debris. This is the place to be.”

“And it has a source of energy,” noted Rahmatullah. “That frees us from dependence on fission reactors.”

“There is one problem,” said Jiaying. “It’s retrograde, so Triton can’t be used for expeditions dipping into the Neptunian atmosphere to recover Helium-3, and it can’t easily be used to launch missions to other moons.”

“That’s what Proteus is for,” replied Jamison. “The Neptunian system is going to have two boroughs. It has to have two."

"If we can convince Mercedes," said Jiaying.

Jamison shook his head. "No, Neptunia has to have two boroughs. There's no way around it."

On the *Seron,* the exploration of Columbia lava tube and Columbia A crater's cavern occurred at suppertime and most of the nearly thousand people on board watched the whole thing on big screen tv. Mercedes Patel watched and listened with growing alarm, then she pulled out her communicator to summon her cabinet and headed to the conference room. Everyone arrived within seconds of each other.

"Rideout is at it again," said Jeremy, "He was determined to take both caravels to Triton. He explored quite a few areas on Triton, but he did not need to explore an obscure rille. He did that because it was named for his home river and because he had to find something that would call the entire plan into question. He has wanted to settle Triton all along."

"We shouldn't agree to it," echoed Ridwan Sistani, their navigator. "Proteus is going to be the big borough, not Triton. I suppose it will be a borough eventually, but only when we're ready."

"We can't land Seron on Triton, can we?" asked Mercedes.

"It is theoretically possible; its four engine clusters generate enough thrust," replied Ridwan. "But if we had one engine problem, everyone would be dead. The Seron was designed to land on bodies with less than one percent gravity and Triton has 8%."

"The Seron would have to be rebuilt, too. Triton's gravity would make all the floors feel substantially tilted," noted Fred Klass.

"So, we're going to Proteus; that's it," said Mercedes. "I like the idea of a huge underground outpost on Triton. That's very attractive. But not now. Maybe in a few years we can start on something like that."

"That's what I'd say," agreed Fred. "Their comparison with Cathedral is misleading. Titan has to excavate each section of Cathedral, so it has time to accumulate the oxygen, nickel-steel, artificial soil, plastics, lights, and the power to use the section. But this cavern . . . if it's 52 million square meters and an average of 200 meters high, that's 480 million cubic meters of oxygen and nitrogen gas. At 0.4 kilos per cubic meter, that's over 200,000 tonnes of gas! It'll take us a decade to make that much, a decade to generate enough electricity to light and heat the space, a decade or more to inspect and reinforce the ceiling—which is higher up than most tall buildings on Earth!—it's a great project, but not one we're pursuing any time soon."

"What did they say it'd accommodate; 12,000 people? We'll be lucky to reach that number in several decades, if ever. It's not clear what the point of so many people in the Neptune system would be." Mercedes shook her head.

"It's an opportunity for the twenty-second century," exclaimed Ridwan.

"Okay, I'll tell them to postpone any action until we arrive," said Mercedes. "Thanks, everyone."

Her chiefs of staff rose and left her office, leaving Mercedes to ponder her exact words. She scribbled talking points, then finally hit record. "Your discovery today is absolutely fascinating, Jamison. Columbia tube and cavern are extraordinary, and constitute an extraordinary opportunity for Neptunia in the coming decade. Our decision here is that your team return to Proteus for an exchange of personnel, as scheduled, then return to Columbia. Focus on evaluating the power potential of Kaneloa Patera, so we know whether it can provide the outpost with its energy. Investigate the availability of nickel-iron, chondrite, and stony meteorite; we'll need them when we decide to build. We need time to plan Columbia Phase 1. Considering Seron's size, it has to go to Proteus, so Phase 1 will be for a small geologically oriented outpost. Right now, we need Phase 0; the details to make sure the Columbia site will work out. That's all we want the *Dorado* to do. So plan to fly back to Proteus in a week or two and plan for the Dorado only to return to Columbia a month after that. Thanks, Jamison. Bye."

She crossed her fingers and hit send. It would be at least two hours before she received a reply. Jamison guessed, accurately, that he'd hear back from Mercedes about 2 ½ hours after the egress ended, so he asked Jiaying, Rahmatmullah, Andy, and Barry to stand by. As soon as he received Mercedes's reply, he called them together. Barry Adler and Rahmatullah were in the *Carina* on Proteus, so they were connected via video.

"I'm very disappointed," said Rahmatullah. "We've taken the radar and video data, enhanced the video so we can see the interior clearly, and begun to map the tube, the cavern, and the tube leading into the cavern from the patera. The engineering for reinforcing lava tubes on the moon is quite mature and well developed, and the properties of cryogenic ice are very well known thanks to the work on Titan."

"And there's a strong magnetic anomaly about forty kilometers east of Columbia," added Andy. "It's got to be a large nickel-iron body, so we have plenty of metal."

"We'll need it," continued Rahmatullah. "In this gravity, 300 meters of cryogenic ice has the weight of 25 meters under terrestrial gravity. The cavern's roof has collapsed in spots where the unsupported span exceeded 550 meters. In those spots, over time the roof bent under its weight until it rested on the collapse piles. On the moon, the gravity is higher but basalt is stronger. If we install steel pillars every 400 meters and connect them with a steel ceiling plate, the ceiling will be secure. On the moon they build four pillars in a square with the ceiling plate on top, then jack them up and extend the pillars, and all that work is done robotically with minimal supervision."

"Then what?" asked Jamison. "Install insulation and lights?"

"Basically."

"But how long will it take to terraform the entire interior?" asked Jiaying.

"Oh, decades! But that's fine. We can start with the exterior tube, 250 meters wide, 250 meters long, and 125 meters high. The ceiling there will be easy to secure and require little reinforcement. You realize if we can convince them to land the Seron here, it could be rolled on wheels straight into the tube? There's plenty of room!"

"And such a landing is possible," added Barry, their navigator. "The Seron's chemical rockets have a 25% surplus in thrust. But if they are worried about losing an engine and crashing—and I'd worry about that—I'd strip the Seron down to a minimum mass, leave as much in Triton orbit as possible, reduce its mass about 25 or 30%, and land that. The rest could be shuttled down later."

"They'll never agree to that," said Jamison. "Back to Mercedes's message."

"They're jealous of us," said Jiaying.

"No; they don't trust us," replied Rahmatullah. "They have a mission plan, we're supposed to go along, and we're changing it instead. But we're here, they aren't. We have the ground truth."

"This is the place for us to set up an outpost," exclaimed Andy, insistently. "We've explored all over Triton and sampled all its terrains. We've explored all over Proteus, too. Nereid and the smaller moons are fairly predictable, and while they will have surprises, they won't offer a better place to set up an outpost."

"And we're tired of confined interiors," said Jamison. "We need something bigger, gravitied, open, and green."

"I have an idea about that, too," said Rahmatullah. "Our 50-meter drum is just about enclosed; the floor and walls are in place and the roof is ready to be installed and welded in place. Most of the metal for the rotating inner drum has been processed, and the magnets to suspend the rotating inner drum are manufactured. The total mass is 150 tonnes. We could fly all 150 tonnes to Triton in three flights, 50 tonnes each time. The incomplete drum, minus its roof, masses about 50 tonnes and we could maneuver it onto the roof of the *Carina* and secure it there. Its weight on Triton will be a bit over 4 tonnes and I think we could engineer a crane to get it off the *Carina*."

"So, we could bring the drum here?"

"Exactly, and install it in the lava tube. The Seron has no need for the drum; it is a huge drum all by itself, twice the diameter and three times as high! On Triton, we would not need to build an inner rotating drum because the caravels provide us plenty of rotating gravity already, so we could weld together the second drum and set it up independently to double our pressurized open space. They'd be quite usable under Tritonian gravity."

"So, we have an entire plan!" said Jamison, laughing. "But no permission, so we have to persuade Mercedes. If we're unanimous about this, I think we need a joint communication to her. Shall we do that?" He looked around; Jiaying and Andy nodded, as did Barry and Rahmatullah on the *Carina.* "Good. Let's not say anything about moving the drum, but Barry, you point out that Proteus spaceport is set up and that we'll be there and standing by when they arrive. But say nothing about moving the Seron to Triton; that's a battle for a later time. Rahmatullah, stress that the tube entrance can be set up easily based on lunar lava tube technology, but nothing about moving the drum; we'll raise that issue in a few days. Andy, you stress that we've already spotted a nickel-iron source and we'll immediately start the search for chondrite and stony meteorites. Jiaying, you stress that we've already got detailed satellite imaging on Kaneloa Patera and will start our study of its geothermal potential immediately. I'll make the opening comments, alright?"

They all nodded. "Great." Jamison asked his AI to set up a recording, and then they recorded their plea. In three minutes, it was on its way on a beam of coherent light to the Seron, which was approaching the orbit of Saturn.

Mercedes was not pleased. It was getting late, but she summoned her advisors anyway.

Fred was disgusted. "Jamison has all of them under his thumb."

"They aren't thinking the big picture!" echoed Jeremy. "We've got an entire system to explore, and they're focusing on one little patch of Triton!"

"Don't they understand that we need to set up one outpost at a time?" said Ridwan. "We can't land Seron on Triton."

"They are talking about setting up one outpost at a time; just the wrong one," said Mercedes.

“You aren’t thinking about supporting them, are you?” asked Kwesi, their Director of Health and Education. “Because this gets into issues of chain of command, of the perceived strength of your position, and Jamison’s role in Neptunia, once we are all united.”

“I think he’s thinking about declaring sovereignty,” said Fred.

“You’ve never trusted Jamison Rideout, Fred; I know that.”

“Well, do you?”

“Yes and no.” Mercedes thought a moment while the others stared at their boss. “Is Proteus Spaceport ready?”

Ridwan nodded. “They didn’t have to do much. They have their reactors set up, they have been filling tanks with hydrogen and oxygen, and they’ve set up a landing pad for the Seron. Their primary mission is exploration of the system, to maximize the legitimacy of our claim.”

“Or Rideout’s,” injected Fred.

Mercedes’s eyes flashed anger at that comment. “Never mind. How long, to characterize the geothermal capacity of Kaneloa and study local resources?”

“A few months,” replied Jeremy. “Detailed study of the cavern, the seismic integrity of the roof, and such will take them a few weeks, with supercomputer work done here or at Martech.”

“Where do the geologists want to be, Jeremy?”

He shrugged. “Triton, plus missions to other moons, of course.”

“Of course. Fred, Rahmatullah alluded to the work done in Marius Rille’s lava tube. How much will that work help us understand Columbia Cavern?”

Fred nodded. “A lot, as will the work on Cathedral. There are a lot of automated systems we could set up to secure the ceiling, especially in the tube leading into the cavern, where the tube is narrower and lower. The entrance tunnel is only a little lower and wider than Cathedral."

"An interesting engineering challenge?"

Fred had to smile at that. "Of course. I'm sure Rahmatullah won't be able to sleep tonight, thinking about the possibilities."

"I suspect that, too. Our geologists are providing a lot of support for the Triton science and the engineering effort to build the drum, which will give them some open space on Proteus. Could they build a drum at Columbia?"

"If they have a big tunnel to move around, even in their suits, they may not need one!" said Jeremy. "Having a place of your own is as important as having open space with breathable air. They won't have to worry about radiation."

"I bet they could move the drum, anyway," said Fred, scratching his chin. "We don't need it. Once we arrive at Proteus, it's a waste of effort. Some of our engineers were helping out because the aerostat and Peregrine projects didn't require all their time and they needed a break. But it bored them because it was a temporary project."

"I sensed that." Mercedes looked at the others. "I think the issue isn't chain of command and possible insubordination. I think it's flexibility in the overall mission plan and trusting the folks on the ground. Jamison's heads of staff are smart, independent thinking professionals and they all support this decision. We have what appears to be a perfect location for a Triton outpost. Let them nail that down, and if it appears perfect, let them set up a drum there and start building a permanent location. Because of the tunnel, a caravel can be rolled inside and families can live on Triton with complete safety, so we can post geologists and engineers there with families, without any trouble. Triton is a huge world that will require a century of detailed study; it's a second Pluto. The Chinese plan for Pluto is to land the carrier permanently on one of the small moons, and set up outposts—eventually, homemade carriers—on both Pluto and Charon. That makes sense. And something like that makes sense for Neptune, too. We need a base of operations on a prograde moon in order to send Peregrines down to the aerostats collecting Helium-3, and we need a microgravity base of operations with hydrogen and oxygen to send and receive interplanetary flights. Proteus fills both of those roles. And we need a base of operations on Triton, even though it's in a retrograde orbit, because it's Triton."

"Mercedes, if you do this, you may open the door to them pushing you around further," warned Fred.

"No, what I will propose is a bit different from what Jamison and Rahmatullah want. They can't take both caravels to Columbia until we are sure the roof of the entrance tunnel is safe and that nickel-iron, chondrite, and stony meteorite resources have been confirmed. A good sense of Kaneloa's geothermal capacity is important, too. That'll take them maybe two months. If none of those conditions are met, we don't want an outpost there anyway, and we'll return to the standard mission plan. If those conditions are met, a change in the mission plan is definitely warranted and we can thank them for their diligence."

21.

Fusion and Fission

March, 2084

Marshall Elliott was both surprised and pleased to see that a videomail from Chief Minister Irina Mukhamadova had arrived overnight. He had met her on the Earth some twenty years ago, but after sixteen years commanding the human population in Venus orbit, eight years as elected head of state, she looked a bit tired.

“Good sol, Marshall,” she began. “Greetings from Magellan Station. I wanted to let you know that we just signed an agreement with the European and Indian space agencies whereby they will pay for two essential modifications of the basic Nike nuclear shuttle design. The first is a methane production unit from the Venus atmosphere; the aerostat’s existing air processing unit requires considerably more modification than expected. The second is air-breathing capability using atmospheric carbon dioxide, which will allow the Nike to dock to the aerostat for up to two hours while cargo is transferred robotically and the Nike is refueled. It will also allow the Nike to climb and accelerate before switching to internal methane propellant. We’re still trying to figure out how to carry out the extensive modifications to the aerostat’s air processing units. It may be extremely difficult to complete robotically and it may necessitate sending a whole new aerostat.

“So let your engineering team know. I’m sure they’ll be glad to hear. I’m sorry this took so long; five months have passed since the space exploration conference when the Nike project was formally begun!

“All the news here is good. As you probably know, a big fleet just left Earth for Venus and Mars. Most are doing a Venus flyby and heading on to Mars, arriving in October and

November, but two vehicles are stopping to drop off 380 and carry 90 people to Mars and some from there on to Earth. Our population will grow from 300 to 600.

"We also just signed an agreement with Ceres for them to send us a C-200 carrier in 2086. It'll depart with almost 3 million tonnes of water, 10,000 tonnes of metals, 50,000 tonnes of methane, and 6,000 tonnes of nitrogen. It'll arrive in 2088 with less than a half million tonnes of water, having converted the rest into hydrogen and oxygen propellant over two years to get the carrier here. We'll move ecology into the five sixths that is empty, and eventually it'll all be empty and we'll expand housing into it as well. We are cleared to grow by 300 people every two years and a carrier can comfortably accommodate 1,200 to 1,400, so we'll need a new carrier in 2088! We figure we'll import another carrier in the mid to late 90s and keep growing, if we can arrange the financial subsidy to continue expanding our exploration of Venus.

"I hear good things about the development of Enceladus and the continued expansion of Cathedral. You're doing great things out there; keep up the good work! And keep in touch. Bye."

Marshall had to smile as Irina's face faded from his screen. He had always appreciated her precision and wry humor. He hit reply. "Thanks, Irina, I'm glad to hear about all the great things you are doing. The shots of the volcanic eruption from your Scout 5 robotic rover were absolutely incredible, and Scout 4's climb up Mount Maxwell is fascinating to watch. Analyses from Venus's continental rocks keep pouring in and tell us the whole complex and sad history of the death of a habitable world; quite a warning to Earth, if the powers that be can't get it together. I follow every issue of the *Journal of Venus Studies.* Yes, we're doing well up here. Work on the carrier for Enceladus has already begun; we've shipped two dozen engineers from Titan and a hundred robots and they're assembling and welding as fast as sheet nickel steel can be produced.

It can be fairly thin sheet steel because the carrier will be inside an ice shell 15 meters thick, so the whole thing is going up pretty fast. We will have a functioning Nike in 15 months and plan to start test flights right away. So things are humming along, here. Thanks for the call with the good news. Ciao."

He hit send, then forwarded the videomail to Oscar Pereira, momentarily reflecting how it could be difficult to add newly arriving captains like Pereira into the existing administrative structure, which perhaps explained the difficulties Marshall had had with him. "Hey Oscar, here's some good news from Irina Mukhamadova about some modifications to the Nike design that Europe and India are funding so it works better in the Venus atmosphere. It sounds like they are modifying the air breathing design we're using with the Saturn atmosphere. I suggest you contact them for the details and let me know; I'm curious. Thanks. Bye." He hit send, pleased that Oscar would then have to report back to him about something.

The transport decelerated from supersonic speeds to a slow roll into Uzboi Station over a ten minute period. Helmut put down his work because the deceleration was unpleasant and took surprisingly long. When it rolled into Uzboi Station and stopped, he felt a sigh of relief. Hyperloops were frightening things to ride; the speed at which the countryside blurred by was unbelievable.

"What did you think?" he said to Ted Bukowski and Lin Changying. They had been sitting in the transport several meters away, but he hadn't wanted to bother them and they hadn't wanted to bother him.

"Amazing," said Changying. "They have a hyperloop between Beijing and Shanghai—all underground—and you can't tell how fast you are going because you can't see the tunnel walls at all, except as a blur. But here you can see boulders a dozen meters away, crater rims a few hundred meters away, and hills a few kilometers away; and even the hills are a blur! It's really unbelievable."

"And frightening, to consider if the transport ever derailed," added Ted.

"Oh, don't say that!" replied Changying.

"The Martech engineers say that should be impossible. We've still got 250 kilometers of chaotic terrain where the highway requires straightening, and once that's done next year, Uzboi will be 90 minutes from Aurorae. Even now, 3 hours to cover 1650 kilometers is absolutely unbelievable."

"Will you get complaints from the Central Highlands?" asked Ted.

"Oh, I already have! But a hyperloop skate started operating between Cassini and Dawes last week and the 2,300 kilometer trip is now six hours. The highway improvements will take three years and then the trip will be 2 hours and a quarter. So they already have experienced a huge improvement. Dawes to Meridiani will start in a few months and it'll be 5 hours initially. The chaotic terrain by Aram is the worst section to upgrade, but it'll be done in 5 years, at which point Meridiani will be a 3 hour trip from Aurorae and Dawes 5 hours, with a bit over 2 hours more to get to Cassini. That'll be a true revolution."

"It will," said Ted. "Thank you for inviting us to witness the nuclear explosion, by the way."

"Delighted. It seemed to me that we needed national representatives along. I'm glad you were able to come to Uzboi."

“We were very pleased to be invited,” replied Changying. “I’ve always wanted to see this place.”

“It’s a fascinating borough. I want to thank both of you for your central contributions to the Space Exploration conference and now to the initiative. Having the United States and China working together cooperatively has made all the difference. It has taken most of the negativity out of the process. I am sure we will continue to have bumps on the road, but the road is much smoother now.”

“It’s our pleasure,” replied Changying, looking at Ted. “We have developed a good working relationship.”

“I’m glad to hear it. Have either of you heard anything that would suggest the underground explosion will generate diplomatic resistance? I gather from our Foreign Minister that trouble is unlikely.”

“That’s my impression as well,” said Ted. “I think most terrestrial nations have accepted that Mars is a sovereignty and has a right to do this, especially since you are another planet and there is no radioactivity or other problems that will affect them.”

“And that nuclear weapons are a small danger to Earth, compared to diverting an asteroid; and several nations now have that capability,” added Changying. “We’ll be sure to release statements afterward about the importance of this effort for the future of Mars.”

“Thank you. I look forward to seeing both of you morrowsol at the control facility, then.”

“Welcome back to Proteus,” Rahmatullah Khan said to Jamison Rideout. The latter had descended the caravel’s elevator to the ground level, where an airlock and connection to the other caravel had been set up.

"Thanks. It's about time; almost three additional months!"

"I know; late March rather than early January. Let's not talk here, come to my office."

"Agreed," said Jamison. The two of them turned to the pressure tunnel and floated down it toward the *Carina,* greeting people as they went. Quite a crowd had turned out for the reunion of the two ships. "Everyone looks happy."

"We're glad to see the rest of the team, after nine months. Some marital separations are finally over, and there's the anticipation of seeing a new place."

"You'll like Columbia. Is everything packed?"

"Pretty much. We've installed the crane on the roof of the *Carina* so it can lift the partially completed drum onto the roof of the *Dorado.* Then we'll transfer the crane and lift the rest of the cargo onto the roof of the *Carina.* We have all the hydrogen ready for transfer to the fuel tanks and the gaseous core engines in orbit have finally checked out."

"I heard. I'm glad the anomaly has been fixed. But we'll take both along, to be sure. What about the U-75?"

"We'll leave it here, along with the soil we created and the plants. It can be tended robotically until the Seron arrives. They don't need it and it's more mass than we can move easily. We'll have a lot more space at Columbia anyway once the first drum is closed up, which will take a bit over a month."

"Good, I'm looking forward to some open space with breathable air! Columbia is big, but in a space suit you can't explore it very easily, and in the dark you can't see much."

"Once we set up a couple dozen floodlights, it'll be much better."

They turned and entered the vertical tunnel to the base of the *Carina.* There, they turned ninety degrees and entered centrifugal gravity. It was a short walk to Rahmatullah's office. "Well, at least Mercedes came around."

"Did she?" replied Jamison. "All she did is put her stamp on our plan in order to steal the accomplishment. What did she think, that I was stupid? I've commanded three expeditions to the asteroid belt! I wasn't planning to set up an outpost at Columbia if the tube was unstable, if there were no meteoritic resources nearby, or if there was no geothermal power. I wouldn't have come back here right away; I would have waited at least a month to confirm those things in at least preliminary fashion. Instead, we had to jump through three extra hoops."

"I'm glad we have a good, solid estimate of the power potential of Kaneloa."

"Do we? We know that the water-magma body is 500 to 1,000 meters down and can generate 100 megawatts for at least twenty years. That's enough for only one tenth the cavern. But there's a lot of 'hot rock'—hot, relatively speaking—and there's a lot of it, and if we drill down 4 or 5 kilometers there's an infinite amount of heat for our purposes. We have a big fat report. But we knew the basics already when we landed in January! As for nickel-iron, the magnetic anomaly told us there was plenty. As for chondrite and stony meteorites, Triton's crust is several percent of them everywhere. So what else is new?"

"The folks on the Seron need hard data to plan, Jamison. Now they can. They're part of this effort, too. They're providing us with backup."

"I know, but we're at the cutting edge, not them. We need to be calling the shots; we need to lead and they need to follow."

"So, do you want to be Chief Minister? You aren't."

“I know I’m not! I just expect a bit more . . . accommodation.”

“I was surprised Mercedes agreed to transport the *Carina* and both drums to Columbia so quickly and easily.”

“She’s not dumb; there’s no reason for the *Carina* to stay here, and the drums are not needed here, anyway. So, do you want to know the rest of the plan for this year?”

Rahmatullah smiled. “Do I have any say?”

“Of course; you have to tell me whether it’s feasible or not, because it involves the engineers! Four goals: first, we set up and pressurize drum 1; second, we assemble and pressurize drum 2; third, we modify the geothermal technology on Titan and set up a 25 megawatt well, turbine, and generator; fourth, we finish exploring within 100 kilometers of Columbia and send the *Dorado* to Larissa in November, in plenty of time for a preliminary exploration before it returns to Proteus in January.”

“Another moon? That’s ambitious. We can certainly pressurize both drums. We can get the ecology set up in the first drum and some of the second drum, but maybe not all of it; that depends on how fast the geologists can get us chondrite and stony meteorite. We can probably drill a well by then—the geologists will have to do that—and the engineers can set up a simple turbine and generator in eight months, but whether we can be producing power by the end of the year, I don’t know. And we’ll have no way to get the power here.”

“No, you’ll have a way, because we’ll clear a good ice road and set up two robotic tankers that can haul liquid oxygen and hydrogen here from Kaneloa. We’ll set up a small tank farm here, too.”

“So, you don’t want to abandon Columbia? You want to have a life support system and power supply ready to go, if both caravels leave."

"Exactly. The low gee will be a problem after six months, so we'll need to get a rotating carrier-like drum going next year. But I want to be able to leave a small party here when the two caravels return to Proteus."

Rahmatullah thought a moment, then nodded. "I think we can do that. What if Mercedes objects?"

"Let me handle that."

"No, Jamison, let me talk to Fred. If I can persuade him this is good engineering work for my team to do, he'll persuade Mercedes."

"Alright, let's give that a try."

Anand looked around the room at the members of the Urania Council. "I think we have a consensus," he said, as Wicahpi-luta closed the presentation. "It's a brilliant plan."

"Elegant," added Vahid.

"If no one minds, I'd put Wicahpi-Luta in charge," exclaimed Adla Ndung'u, who was in charge of engineering and construction.

"Sure; it's his baby," said Anand. "Thanks for the presentation, Wicahpi-luta. Can we expect a report in a month?"

"Yes, definitely, with a revised timeline." He nodded to the Council to show gratitude as well as express some of his bent up excitement. Then he headed for the door. Vahid came along right behind him.

"That was great!" he said, once they were outside.

“Thanks!” Wicahpi-Luta and Vahid did a hand slap. “I can’t believe it!”

“Believe it! It’s a sound piece of engineering, with every significant detail nailed down; one of the best presentations we’ve had in some time! I’m so happy for you, my friend!”

“Thanks! Now I just have to do it!”

“You will. We can talk more later; I’d better get back to the meeting. There’s still a lot on the agenda.”

“Okay. Thanks, Vahid, for your suggestions, and for the confidence you gave me. I’m really appreciative.”

“It’s nothing. Ciao.”

“Ciao.” Wicahpi-Luta turned away and almost danced down the hallway. He couldn’t believe it! The solar collector project was his! Three months of detailed work to produce an extensive engineering plan had paid off. Now he had to negotiate with Adla about the members of the team. Some of the people he wanted would be hard to obtain.

He hurried down the spiral ramp and out onto the square. Most people were still eating supper. Esther and Miranda saw him coming and waved. He hurried over and Esther could see the joy in his face.

“They said yes!”

“More than that; Adla put me in charge!”

“Really! Congratulations! And still months short of age 30!”

“I know, I guess I’m a professional now!” He laughed; Esther stood and they kissed. Then he sat.

“Get yourself some supper before they run out.”

"Good idea." Wicahpi-Luta stood, but just then Tad Lind, sitting at a table nearby, said, "So, you're building your solar collector?"

"Yes, a team is, but they asked me to be in charge. Phase 1 is a 500 meter collector with a molten salt generator and the timeline is six months. It'll make only 400 kilowatts, but in phase 2 we'll increase the collector to 1,000 meters in diameter over the next six months. After that, once the construction is automated, a team of three will be able to keep it going."

"So, the idea really works."

"Well, I hope so! Adla was behind it all the way, and she's an incredible engineer."

"She is." Tad hesitated a moment, then extended his hand. "Congratulations, Wicahpi-Luta. It's quite an achievement."

"Thanks, Tad."

Helmut arrived early to the Polar Vaporization Building—they had decided not to refer to nuking the poles in the official name—to watch the preparation and countdown. Uzboi seemed like a safe spot, after the near disastrous trashing of Borealis Station; at 27 degrees south, it was 3,700 kilometers from the South Pole. By the time he had greeted the scientists, Ted and Changying had arrived, as well as the Indian and European representatives.

"As you can see, we have a lot of cameras ready to go," said Wilhelm Steiner, who was in charge of the Nuclear Engineering Program. He pointed to a long, dim tunnel with lights at the end. "That's the actual bomb. It's implanted at the base of the carbon dioxide cap about 700 meters below the surface, in the center of the permanent cap. The tunnel is 5 kilometers long and angles downward from the surface. The bomb itself is 10 meters long and 4 meters in diameter.

You can see the power cable extending the length of the tunnel. It runs 100 kilometers to the end of the metal highway, where it connects to the power cable running all the way here, to Uzboi. We've been charging the bomb's capacitors for several hours."

"What'll happen to the power cable?" asked Ted.

"It'll be vaporized, but we don't know how much of it will be destroyed. We hope only 5 or 10 kilometers. We plan to start on another tunnel in a month or two about 25 kilometers away and hope to set off a second bomb in three months. We think we can do four bombs every southern summer."

"How powerful?" asked Changying.

"It's a gigaton. That's 1,000 megatons, and the largest bomb ever set off on Earth was 50 megatons, so this is 20 times bigger. The fifty megaton bomb destroyed everything within 60 kilometers, would have caused third degree burns to anyone within 100 kilometers, and broke some windows 900 kilometers away. The resulting earthquake was magnitude 5. Since this is going off underground there should be much less surface destruction, though the crater will collapse and the fireball will reach up into the atmosphere. The earthquake will be much more severe, but there's nothing within a thousand kilometers to be effected."

"How much will it thicken the atmosphere?" asked Ted.

"Not much!" replied Wilhelm. "It will be detectable, but it'll be small; less than a hundredth of a millibar, maybe. But as we accelerate the effort and use larger and larger bombs, we'll vaporize more and more carbon dioxide each time. In ten years we might manage to push the average pressure up by a millibar."

"And increase the circulation of water," added Helmut. "Especially as the greenhouse gasses increase, the temperature will begin to go up. In a generation, the result should be quite significant."

"We're thinking long term," agreed Wilhelm. He pointed to the chairs. "Please be seated. The countdown has a few minutes left."

Helmut nodded and sat in a chair in the viewing area, with the others next to him. In addition to the camera in the tunnel, there were three cameras situated on hills 5, 10, and 20 kilometers away from ground zero and two satellite cameras. They would have plenty to look at!

They sat nervously, in silence, watching the screens and the countdown. When it reached zero, there was a brilliant flash in the tunnel, then a split second later, that screen went blank. They turned their attention to the other three screens, which showed the ground leap upward and a fireball emerge, followed by an explosion of gas from all of the ground around the cameras as the dry ice snow instantly evaporated into the air. Then all the surface cameras went out as the gale force winds of expanding gas, followed by the shock wave, hit. They turned to the orbital views, where a mushroom cloud began to rise about a huge area of dust and gas extending outward a hundred kilometers in every direction.

"Mars has just started to enter a new estival," whispered Helmut, awestruck.

Plot Summary

Characters to focus on: Ted (Danforth), Changying; Helmut (Lind); Oskar; Rideout (Patel, Khan); Will and Ethel; Esther, Wicahpi-Luta (Lind);

Plots: Space exploration conference; Neptune issues; NASA/Chinese competition; nuking the poles; expansion of Aurorae, immigration, Central Highlands;

Ted, Will talk about space conference, early November; Will becomes the permanent chair of them
Vahid talks to Tad about his attitudes

Vernal Equinox: Mar. 4, 2083; nuking North Pole begins

Late Sept. 2083: Central Highlands boroughs (David Hamm, Dawes; Amina Omeroglu, Cassini; Meridianai; Thymiamata; Kalgoorlie; Elliott) meet to plan coordination

Nov: Marshall confronts Oscar Pereira over Enceladus plans and realizes he has been pushing Titan too hard; Interagency conference a success and leads to Space Exploration Initiative

Dec: Ted and Changying are "caught" on the beach by Will and Mike; Kristof visits Aram;

Jan/Feb 2084: Ceres: Plans for larger carriers with water and metals; plan for larger Prometheus, hypersonic transport develops further; Solar power controversy on Miranda; Rideout upsets Mercedes Patel and people fear he plans to declare independence;

Autumnal Equinox: March 20, 2084, followed by underground gigaton explosion

March 2084: Hyperloop service to Uzboi begins; Central Highlands people mad

April 2084: First fusion engine firing on Deimos; Kuiper and Pluto leadership met. Visionaries. They want their vehicles called "arks"; Ted talks to the Kuiper mission leader candidates and fights with Danforth over the best choice; Sirikit calls Bill because she and Charlie just visited Aram and Bill asks for help

May 2084: Planning begins for Mars 50th, Feb. 28, 2086; Lunar mass driver files for bankruptcy; Mariusville and Swiftville develop well

Progress of 500-tonne, 250 megawatt fusion plant for outer planets.

Sept. 2084: 500-meter collector finished; both drums set up and pressurized at Columbia; progress on geothermal is slow, but the reactor can be cranked up from 25 mw to 125 mw and the extra power stored as LOX/LH_2.

October: *Dorado* heads to Galatea and then to Larissa.

Nov. 2084: First wave of arrivals for new columbiad arrive via Venus (10,000 or so?); US Presidential election elects a Trump type

Saturn sends out a group of spytors

Jan. 2085: Venus sends two down to the aerostat for several months to make upgrades.

Autumnal Equinox: Mar. 20, 2084

Mars-Ceres opposition: 2084.209 = March 17, 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

Mars-Jupiter-Neptune flight possible

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 (Carrier for Pluto to Earth)

Mars-Ceres opposition: May 31, 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

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

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

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

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

Started volume 6, June 15, 2016; stopped in October; resumed 6 Feb. 2017; resumed again, June 2018