

Flybys and Foci

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1 Chapter 1: Funding

James Ballard stared at his screen intently. He tapped the left arrow key repeatedly and the image jiggled a few pixels to the left. Everyone else had gone home but James had long since lost track of the time. Though his office was only a few doors away, he had stayed here in the shared computer lab after helping one of his students with a tricky piece of code. Rolling his chair back, he carefully inspected the slide; now the graphs were out of alignment.

“No no no no,” he mumbled to himself as he undid the changes. He pushed his chair back again to study the subtle difference in layout when the door behind him opened, slamming into his chair.

“Professor Ballard, I’m so sorry!” squeaked a graduate student. “What are you still doing here?”

“I should be asking you the same thing,” replied James kindly. He spun around in his chair to face his student, then began merrily rolling around the cramped room straightening things up as he went. Tables clung to the perimeter of the windowless workspace, studded with computers, screens and the rare paper book.

“I wanted to make some last minute changes before my presentation tomorrow,” explained James as he gathered pens strewn on the connected desks and dropped them into a cup. “But Tess, you should be at home! You’re not the one going in front of the Science Advisory Board tomorrow, I am!”

Tess plucked an eraser hanging to a whiteboard and started wiping, cleaning the surface of equations and curved lines. “I was running a simulation and was waiting to see if it finished,” Tess replied. She finished wiping and tossed the eraser to the board. It gently arc through the air before being tugged in by the magnets embedded behind the wall. James, still seated, theatrically kicked his legs back and slid across the room playfully. He tapped a dark screen as he zipped by and the screen cheerfully lit up.

“Looks like your program crashed hours ago before finishing,” he said with a smile and a kind twinkle in his eye, “but don’t worry, we’ll work on it later this week. It’s not pressing.”

Slightly crestfallen, Tess nodded and turned to walk out as James stood up behind her and slung his bag over his shoulders. They continued together down the corridor and bounded down the stairs of the Institute building. Once outside, James bid farewell to Tess and headed towards his home in the quieter district of town. He half skipped half walked through the

streets, slowing briefly to watch several children playing in a park. It was getting late, but there were still kids outside enjoying the last few minutes of play before heading home. James smiled as he saw a young boy swinging off the playground equipment wildly into the air before tumbling back to the ground unharmed.

James looked up at the night sky. Jupiter shone brightly as always, its stormy bands tumbling and jostling with each other in a hypnotizing swirl of color. After aligning himself with the quiet street, James turned to the left an eighth of a turn. He held his fist out to the horizon and slowly moved it upwards one fist width at a time, counting as he went ¹. When he finished, he paused and stared at a point just above his thumb. There was nothing visible there, no planets, no moons, and no distant stars. But to James and many others, it was the most intriguing place in the whole universe.

Several hours later, James clung to a handhold on an early morning train. The vehicle whipped through excavated tunnels noisily, jolting suddenly as it curved around gentle corners. There were few other early morning commuters, but James was too excited and anxious to sit. He also found keeping balance on the hurtling train fun, like surfing on distant waves. Of course, he had no idea what surfing was actually like and had never seen an ocean before. Everything he knew about surfing came from a travel magazine he had once perused at the dentist.

“The *Einstein* lensing telescope will let us capture clear images of the target planet and provide evidence of intelligent extraterrestrial life,” James said out loud, rehearsing his lines to the nearly empty train car. He shook his head and gazed off at the ceiling. It was too formal, too heavy with bland words that would put the politicians on the Science Advisory Board to sleep. He struggled in his head to find the right words, fragments and phrases floating around before being dumped into a mental recycling bin. The train started to slow.

“This telescope will help us find aliens! Give us more money!” James burst out with a laugh as the doors opened. A woman raised her head to give James a brief stare before returning to her screen. He’d have to work on that some more.

With a final lurch that nearly threw James off balance, the train halted at the station. The door clanged open and he strode out towards a graffiti-clad sign labeled “Government Center.” Near the escalator a homeless man shook both arms at the morning commuters, one hand clutching a cup and the other a beat up phone for digital handouts. James ignored the vagabond and bounded up the stairs, his mind still wrestling with the right phrases for his pitch.

Once aboveground James spun around, briefly lost. Over his head stretched the thick glass dome that encased the city and shielded it from radiation. A web of metal beams supporting the glass criss-crossed over his head in a neat, tessellating pattern. It was still a Jovian night, when the sun was hidden but Jupiter hung overhead and basked the city in dim light as it sat in its fixed position. The streets around the center curved ever so gently, wrapping around the domed city in perfect circles. James found the correct street and headed off, bounding lightly in the low gravity towards the government building.

“Fourteen years ago radio telescopes picked up a signal from the Trappist-1 system, 40 light-years away. The signal contained complex....no...complicated patterns, suggesting they were created by an intelligent civilization,” James rehearsed as he took the stairs to the building three at a time. For more than two centuries, astronomers had been trying to find radio signals coming from an alien civilization. And somehow, James was lucky enough to be alive when they finally heard something. Or at least, thought they heard something. A great debate was raging about whether the signal really was coming from aliens or from something more mundane. Meanwhile, astronomers kept pointing their telescopes at the planet they suspected was the home to aliens, hoping to learn more.

James turned around to check he was heading up the correct stairs. The stairs rose up above the surrounding streets and led to the entrance of the government building. He scanned the skyline that was dotted with streetlights and buildings of varying sizes. It was a very clean and neat looking city, with most industries hidden in the tunnels that snaked underneath. Around him were apartment blocks, schools, and other public buildings. Space on the surface was quite limited, so anything that could be underground was built beneath the streets. His eye caught another flight of stairs to his far right, the one meant for visitors. Cursing to himself, James leapt back down in wild careening arcs.

He stole a look at his watch, wondering if he might be late. “Light from the target planet is warped by our sun’s gravity until it converges at a focal point,” he whispered to himself while waiting for his bag to get scanned at security. “The sun acts like a giant telescope lens, magnifying the light by a factor of 100 billion.” James tried saying the line again, placing emphasis on different words to best convey this astounding property.

It was like a cheat code built into the universe, a shortcut that could let humans spy on another civilization many light years away. Of course, this came with a catch. A telescope at the sun’s focal point could photograph a distant planet at a resolution of a few kilometers - enough to see oceans, forests, and possibly even cities and farms. But reaching the focal point was a long and treacherous journey. It sat 600 AU away from the sun, more than 100

times the distance between Earth and Jupiter. The trek would easily take decades for even the fastest spacecraft.

“You’re all clear, go ahead,” said the security guard lazily. With a wide yawn and a bored look he returned to his phone. James hurriedly thanked him and grabbed his bag, tossing it over his shoulder while zipping down the hall. His watch showed the Science Advisory Board would be convening in one minute.

“I hope they’re late,” James said out loud. He flew by the Feynman boardroom mid arc and kicked off a pillar to stop himself. Oil paintings of the colony’s original founders dotted the corridor, seeming to smirk at the professor’s hasty arrival. Pausing to straighten himself, James took a deep breath and pushed open the door.

The room was empty.

“Please adjust your seat backs and tray tables to their upright and locked positions. The pilot is beginning our descent towards *Lakhani* port.”

Professor Grace Mercer lifted her computer up, locked her table in place, and continued working. She clicked through windows of complicated schematics, dense software descriptions, and carefully laid out timetables. What had started as a “quick favor” four years ago was about to be a full time occupation. Pausing only to write a comment on a software planning sheet, she closed out her files and opened her email. Scrolling down she saw a note from her scientific counterpart and co-lead of the *Einstein* project:

Grace,

Please find attached the slides fro the morning presentation to sci advisory board. Will let you knwo how it goes. Safe flight to Callisto.

James Ballard

The email had nothing attached. Shaking her head with a slight grin, she scrolled further and saw another email from James with the presentation and a hastily typed out apology. Grace opened the file and skimmed over the presentation. Much of it was information she already knew, having been involved on and off with the telescope for the past few years. She paused on the page listing the budget. It was quite literally an astronomical number, the Achilles heel of the audacious project. Her heart had stopped when she saw the figure years ago but James had waved it off nonchalantly. As it turned out, spying on ET wasn’t cheap.

“Ma’am I’ve already asked you once. Please put your computer away we’re nearing the surface,” a stern looking flight attendant snapped at Grace.

“Oh I’m sorry, I didn’t realize!” Grace replied, feigning innocence. The flight attendant walked away. Only after he shot back another glance did Grace stow her laptop. The rocket awoke with an abrupt shaking as the engines underneath rumbled to life, slowing the craft’s descent. Grace turned her gaze towards the hardened plastic window and beamed out the window. Callisto, Jupiter’s second largest moon, came into view to greet her. The sprawling lights and domes of the burgeoning settlement grew rapidly in the window, a shimmering lighthouse in the pitched darkness. Jagged canyons littered with ancient craters stretched towards the horizon, like scars on the moon’s surface.

The sight of Callisto never failed to amaze her. It outshone all of the other moons of Jupiter, even the glistening white ice of Europa and her glowing, lonely research stations. The space stations that floated around Jupiter, one of which she was returning from a routine inspection of, also couldn’t quite compare to the size and natural grandeur of Callisto. Off in the distance was a pair of glowing lights and she felt a twinge of pride; it was a sleek set of nuclear reactors she had worked on. They had gone from design to operational in just two years, a record that she was proud to be a part of.

The engine lit up once again, sending bright blue flames lapping against the window. The rocket shuddered, an aging beast serving its last few flights before retirement. Grace laid her hand against the window and gazed out while thousand degree flames danced just inches from her fingers. The seasoned engineer smiled as she saw the landing legs extend beneath them and snap into place. With a final emphatic thump, the spacecraft touched down.

Grace let out a low, wistful sigh. It was a bittersweet moment. This would be her last flight as a project manager for Callisto Corp, the largest engineering conglomerate in the Jovian system. It was a senior role that let her advise the biggest engineering projects, from giant solar farms to orbiting fuel depots. She loved the job, the travel, and the endless parade of wondrous engineering feats she got to work on. Now she would remain on Callisto and be dedicated to the careful planning and assembly of *Einstein*, one of the greatest scientific projects ever embarked on. It was painful to leave her job but James’s insistence and steadfast belief that this would be the greatest discovery in history finally won her over. Perhaps she would take a trip to Ganymede after a big milestone. Or even a long flight to Mars or Earth when it was all over.

“Ladies and gentlemen, please remain in your seats. Our gate is currently occupied and we’re expecting to be sitting on the tarmac for another oh, half hour or so.” A collective

groan reverberated through the cabin. Grace chuckled to herself, reached down into her bag, and fished out her computer.

James turned around, lost and confused. He pulled out his phone and checked that he was in the right place. He was. Frantic, he backed out of the conference room. Was there an update he missed? A meeting change? Did he get the time wrong? Any of those were possible. His mind started racing. The feeling of a rat lost in a maze suddenly seized him. Down the corridor a custodian guided a fleet of cleaning robots. James took off towards him.

“Excuse me, do you know where the Science Advisory Board is meeting today?” he asked the man, nearly tripping over one of the robots.

“The science what now? There aren’t any meetings scheduled in this wing this morning. That’s why I’m here cleaning it,” replied the custodian, gesturing at his robots. James blinked aimlessly. Words were failing him. He rubbed his head in confusion, running his hand over his unruly hair.

“Do you know who heads that committee? I can maybe show you the way to their office,” asked the custodian without looking up. He continued calmly guiding the robots with his tablet.

“Um uh...Fremont. Senator Fremont,” stammered James. The custodian listed the directions to the senator’s office while James nervously bounced on the balls of his feet. He took off running before the janitor finished.

“Thanks so much!” he called over his shoulder, nearly steamrolling through a hapless robot. Up the stairs, two rights, and down the hall. Twice the professor thought he had gotten lost. Was it third door on the right? Or fourth on the left? The name placards flashed by. He skidded to a halt.

The light in Senator Fremont’s office was on. This was a good sign - she was probably inside and the meeting had been rescheduled. James paused outside the office and silently debated the best way to ask when the meeting was without sounding more flustered than he actually was. He knocked twice, the first time too softly and the second time too loudly, sending noisy echoes crashing through the quiet corridor.

“If you’re going to break down my door just open it and come in,” called Senator Fremont.

James meekly opened it and poked his head in.

“Professor Ballard, hello!” said Senator Fremont. The professor cracked the door open further and stepped in before gingerly closing it behind him.

“You need a bandage for your knuckles? You nearly smashed apart my door. It’s taxpayers like you that would be paying to fix it,” teased the senator. She was a middle-aged woman with short blonde hair, younger than James but who radiated experienced. In her early years the senator had been a tunneler, operating machinery to excavate tunnels connecting various domes across Callisto. The tunnels and the trains that ran through them were the backbone of Callisto’s infrastructure. From these blue collar roots, Senator Fremont had entered politics and risen to her current position.

“The meeting this morning downstairs, the Science Advisory meeting, has it been rescheduled?” bumbled James. Senator Fremont returned a confused look. “About the *Einstein* lensing telescope project,” he added.

“Professor Ballard, has nobody told you?” Senator Fremont asked with a concerned tone. James blinked back with a blank face.

“The project has been cancelled,” said the senator gravely, “your funding has been zeroed out.” James’s eyes widened and his mouth went dry. He could feel his knees start to give out.

“James!” exclaimed the senator. She ran to the opposite side of her desk where James was falling to the ground and helped him into a chair. Returning to her own seat, she shifted tablets around and took off her glasses.

“The senate passed a compromise budget two nights ago. The parties agreed to more military spending and more for infrastructure improvements,” Senator Fremont said matter-of-factly, “funding for the Institute will still be the same, but something had to give. The money for *Einstein* and a few other projects with...with less clear applications just isn’t there.” She ended her sentence carefully and looked at James with a diplomatic smile.

“But this could be the greatest discovery Callisto has ever made, the greatest discovery of all time!” James blurted in protest. Blood was beginning to rush back into his head.

“I don’t doubt the scientific merit of the project, but there isn’t enough money,” replied Senator Fremont, shaking her head slightly.

“Surely the cuts can come somewhere else? I thought our budget had already been guaranteed!” cried James.

“Well things have changed,” the senator said sternly. The polite smile had vanished and she began drumming her desk impatiently.

“But discovery is in our DNA! It’s what we do! Humans...humans need to explore and discover and wonder. We’re unlocking the mysteries of the universe!” James stammered. “The whole colony is a people of explorers. This is one of the most important things Callisto should be doing!”

Senator Fremont abruptly laid a hand out on her desk in front of James, signalling for him to stop. “I don’t want to hear any more of these soundbites,” she said sternly, “we’re a people of explorers alright, explorers looking for a pay day. People didn’t shoot themselves out past the asteroid belt for knowledge or discovery. They came to mine metals. To harvest helium. To make a living on this barren rock.”

“But the science budget is such a small part of the pie, a drop in the budget! Just one day of military spending could fund...”

“I don’t want to hear it,” repeated Senator Fremont. She locked her gaze on James with her steely eyes. “Telescope money doesn’t protect Jovian space from enemy fleets, the military does. For goodness sake professor look around you. There’s homelessness in the streets! The domes need repairs! The rails need repairs! If we don’t build mirrors there won’t be enough sunlight to grow food. You want people to starve so you can shoot your telescope out to nowhere and look for aliens? People can’t eat telescopes!”

James shrunk in his seat. He had largely averted politics but could see why people voted for Senator Fremont. She was tough and cared a lot about her electorate.

“We need funds to fix Callisto, so science gets cut but there’s still plenty of money for bullets?” James jabbed back. It was so silly to him, dumping money into an endless arms race. Senator Fremont’s eyes flashed and for a moment James thought he had gone too far. For a split second, the senator shut her eyes and breathed in slowly. When she reopened them, Senator Fremont looked back at James with a calm but firm expression.

“I love science and discovery, but how can I justify spending so much money in deep space when there’s so much to be done on the ground?” she asked James quietly.

James sat speechless, no response coming to mind. Silently, Senator Fremont lifted her

arm and gestured towards the door. Feeling humbled, James nodded his head, thanked the senator for her time, and slipped out of the office. He walked down a flight of stairs, sat down, and buried his head in his hands.

2 Chapter 2: Flux

Months later James sat at the head of a neatly polished glass table. Two seats down from him sat Grace, her feet resting on one of the curved magnesium table legs. Around the table sat another dozen professors and heads of the beleaguered *Einstein* project, their eyes fixed on the screen behind James.

“Did you consider advances in ion drive technology?” inquired James tersely.

The man at the front shook his head in dismay. “We’ve already considered the most cost efficient engines. We’re not expecting any drastic cost reductions, and with this cheaper engine we’re limited in how much mass we could carry to the focal point.”

“And that mass number is impossible,” chimed Parker, the telescope engineer sitting opposite Grace, “just the telescope weighs nearly that much, and then we’re not even talking about communication equipment, radiation shielding, the sunshade, a bunch of other essentials. We can’t make a real mission if that’s all the mass we can send.”

“What about this scenario,” offered an increasingly desperate James, “we assume the best ion drive technology at the cost of a cheaper engine, maybe get away with a mirror with half the mass.” Parker turned to James looking gobsmacked.

“We’ll make up for it with better software processing - that can be finished while the telescope is in transit,” James pushed on, “and we take the best possible gravity assist route. Where does that leave us?”

The room erupted into protests.

“We can’t just magic up better software!” huffed the software lead.

“What miracle mirror are you expecting from us?” snapped Parker. The eyes in the room turned towards Lisa, the head trajectory planner. She shook her head slowly and forlornly.

“My team looked at every scenario. There’s no gravity assist and no flyby that can get us out there on that budget. We’ll waste too much time mucking around the solar system trying to pick up speed and the mission will just take too long. Sorry James, the planets aren’t aligned for us,” sighed Lisa.

James drummed his hand impatiently against the table. These were not the answers he was hoping for. The last three months had been a roller coaster of emotions, or rather like

running through an endless maze. Every new path that seemed to open up funding had turned into a dead end. Their petition to the Science Advisory Board had been politely refuted and a collaboration with NASA axed by budget cuts on Earth. Like a desperate crew trying to keep a ship afloat they were throwing anything they could overboard to cut cost. The hope was that funding could be restored for a cheaper, slimmer mission. It was their last card to play and it was coming up short. A heavy fog of silence rolled into the room.

“James, I don’t think this is going to work,” Grace finally said. The words reverberated through the room like a fatal diagnosis given to a dying patient. “We can’t build a mission with this money, and the money might not be approved anyways.”

James looked down at his curled up fists as the room hung in silence. He shook gently from a mix of anger and crushing disappointment. The group of scientists and engineers looked solemnly at each other as their final card fell short. Finally, Grace stood up.

“Thank you all for your hard work. It’s been a long meeting and a long past several months. We’ll have to start shutting down the program, documenting the work, and wrapping things up,” Grace gave a half hearted shrug, “we tried our best.”

“The planets just weren’t aligned for us,” repeated Lisa. With sad sighs and gentle murmurs, the room emptied out. Only Grace and James remained. Grace slung her bag over her shoulder and headed for the door.

“Is that it then, Grace? You’ve given up?” James said, not lifting his head from the table. Grace slid her bag off and propped it on the table, resting her elbows on top of it.

“James, there’s nothing we can do. The money just isn’t there,” she said softly, “I’m trying to be pragmatic.” Her shoulders fell to her side in a sign of defeat.

“Thanks for everything. I’ll see you around campus...I’ll be lounging around a lot, there’s nothing else for me to do,” said James forlornly. The telescope he had been working on for years and the prospect of finding aliens with it now looked shattered beyond repair.

“Maybe someday, another generation will make it out there,” offered Grace. “Maybe they’ll find out if there really are aliens there.” James had dropped his head back into his hands and only shook his head mildly in response. As Grace turned again to leave the door, she heard a quiet whimpering from the room.

There was still much work to do. As Callisto passed into a double day, where both the

sun and a slice of Jupiter shone above, Grace pushed through her work. She had left her last job thinking she'd be spending much of her career nurturing a magnificent telescope to life. Instead, Grace took on the role of a funeral director, putting the last of the once lively project to rest. The work was carefully archived and documented and the engineers and coders who had toiled on the project began trickling off to their next jobs. The weeks melted away, slowly worn down by the necessary but dreary work. The silver lining was that she'd be returning to Callisto Corp.

Towards the end of the Callistan day, just before the sun was again set to slip below the horizon, Grace walked through the halls of the Institute. She watched gaggles of students traveling to class in packs. James had taken a leave of absence, but could sometimes be seen wandering around campus. Today she hadn't seen him. Stepping into her office entryway Grace waved hello to Dawn, her assistant.

"Grace, there's someone here to see you," Dawn replied, gesturing to a woman sitting patiently outside of her office door.

"I'm Lucy. Lucy Sodo. I'm an officer in the Navy." A graceful woman with dark hair neatly tucked into a bun stood up and gently bowed to Grace. "Why don't we sit down and chat for a little? I'm very interested in your work."

Perplexed, Grace nodded and opened the door to her office and welcomed Lucy in. It was a cramped office with scarcely space for a desk and two chairs - space was at a premium in the city. A screen on the wall played images of fish drifting around a kelp forest, surrounded by framed schematics of complex circuits. The two women walked into the neatly kept office and Grace moved to shut the door.

"And Professor Mercer, could you kindly ask your assistant to step out into the hall?" asked Lucy, "it's best if we're not overheard." Grace paused, taken aback. She wasn't quite sure what to make of this request.

"It's a confidential matter," said Lucy with a small smile. Grace nodded and stepped into the hall, hiding the confusion from her face.

"Dawn, could you please step out for a minute? Why don't you go for a coffee break," Grace called to her assistant in a wavering voice. Dawn, looking surprised, pushed her chair back from the computer and walked out. The two women finally sat down with the door shut, Grace nervously licking her lips. A pall of mystery hung in the room and Grace eyed the unexpected guest curiously.

“Sorry for the secrecy, my superiors wanted us to talk at a secure site but I felt this would be less mysterious,” said Lucy apologetically, turning to reach into her bag. For a moment Grace paused, wondering what would emerge from the gray and beat up backpack..

“Oh gosh, I didn’t mean to scare you,” Lucy said when she saw Grace’s frozen expression. Lucy pulled out an outdated and beat up tablet and placed it on the table. “Let me tell you more about myself. I work in the Advanced Naval Research Division. I’m an officer in the military but my business isn’t blowing up ships. I work on advanced technologies, and actually I graduated from the Institute.”

“You’re an engineer?” inquired Grace, curiosity replacing her receding apprehension.

“That’s right, I studied nuclear fusion engineering, just like you did,” replied Lucy cheerfully. “The reason I’m visiting is because we’re interested in funding *Einstein*.” Grace stared back, not sure if she had heard correctly. Lucy tilted her head curiously, as if wondering whether her words had travelled across the room properly.

“Why?” blurted a puzzled Grace, “there’s no military value in the telescope...It’s for taking pictures of a planet around another star, for looking for signs of an alien civilization...unless you think aliens are...coming?”

“Oh no no no, nothing like that Professor. There are really two pieces to this,” Lucy swiped her tablet open and pressed her palm against it, pulling up a complicated schematic, “The first is we have a new engine that we’d like to test.” She turned her tablet towards Grace, who pulled it in with growing curiosity.

Grace stared intently at the engineering diagram and her eyes ballooned open. Any lingering suspicion of Lucy was squeezed aside by pure, unbridled wonder. The plans before Grace were for a fantastic engine, leaps and bounds ahead of anything in the solar system. She scanned the specifications and her eyes popped even further from her skull. The engine’s efficiency handily dominated any competitor while its performance outclassed even the most advanced military drive. Grace looked up at Lucy, awestruck.

“This...this thing is real?” Grace blurted out.

“The *Sheridan* drive is quite classified and undergoing testing, but you’ve been given permission to know it exists,” said Lucy crisply as she spun the tablet back towards herself. Grace gaped at Lucy as if she was a time traveller revealing secrets from an advanced future. There was no other rocket engine like the *Sheridan* drive in the solar system.

“Why do you need our help? What does this have to do with *Einstein*?” Grace asked slowly. Her mouth continued to hang open slightly and her mind was racing. This drive was a long sought after holy grail, a practical nuclear fusion engine.

“Your team has some of the best engineers and system integrators. We could use your talent to help put a test spacecraft together.” Lucy replied smoothly. Grace blinked back wearing an unconvinced expression. Surely the Navy had plenty of resources to build a test ship, and there was no reason to stick a telescope on. Lucy seemed to read her face.

“The second reason is the big one. We want the image processing software that your team was developing. ” Grace sat silently, slowing taking in what she had heard.

“Think of it as a trade,” offered Lucy. “We’re building a new engine and you’re going to help us test it. In exchange for funding your telescope, we get the image processing software you develop.”

Grace kept looking at the tablet in Lucy’s hands, wishing to consume more about this fantastic drive. She stared at Lucy, not sure if this conversation was real or if this woman had appeared from her imagination. But doubts still lingered in her mind. There was part of the picture she didn’t understand

“I don’t see how our software could be useful to you...” Grace began cautiously. One of the trickiest parts of the project was writing image processing and reconstruction software for interpreting the images *Einstein* would beam back. It was a treacherous task, still filled with unknowns.

“Again there are some parts that are classified, but our engineers are confident that the image processing software you’ve been working on will be useful,” repeated Lucy evasively. “Our team has looked carefully at all of your publications and spoken with several former members of your team. There are some other details of this agreement - information sharing, funding, clearances - that I’d like to go over with you. Are you interested in hearing more?”

Grace opened her mouth to speak, her mind racing. It was such an unexpected turnaround. Just an hour ago *Einstein* had been relegated to the trash heap, dreams for another generation; Grace had already started studying the next project she was slated to work on at Callisto Corp. But something nagged at Grace. She and James were jointly in charge and she wasn’t sure how he’d react to the deal. But it was too good of a chance to pass over, a second (or fourth depending on how one counted) chance for their telescope to finally fly. Grace turned to Lucy.

“Tell me everything.”

Later that day James fell into his chair, the exuberance from a moment ago draining from him. He stared off blankly at the wall while his mind slowly processed the words that had just washed over him. Grace sat across her desk from him, arms crossed and struggling to look sympathetic.

“The military Grace, the military! Our telescope co-opted by the military!” James moaned. Grace stared back at him with a mix of exasperation and disbelief. Off to the side on the office wall, a fish swam lazily across the screen.

“Well we either follow Lucy’s terms or there’s no telescope, James,” Grace said patiently, explaining what she thought was obvious.

“Terms! It’s like we’re under her thumb! What next, they want *Einstein* to be fitted with missiles?” James replied, a palm now rubbing against tired forehead. He pushed himself further back in his chair, looking at the ceiling with anguish.

“Well that’s what they are, they’re terms of an agreement,” said Grace through gritted teeth, her arms crossing more deeply into her chest, “I’m not thrilled about it either. It’ll add a lot of costs and complications to development.” James’s hand had slipped over his eyes, which he rubbed relentlessly.

“What are her terms,” he said with disdain.

“Our workers will need security clearance, the software can’t be open source anymore and it’ll be owned by the military afterwards, and only Callisto citizens can work on the project,” Grace listed off in rapid succession, “and we’re providing comms and other systems to test their new engine.” She scratched her head trying to remember the other requirements Lucy had enumerated. There were so many different ones carrying impenetrable acronyms that it was hard to keep track.

“We’ll have regular meetings with Navy officials and there’s a list of engineering requirements we’ll have to meet too,” she finally finished.

“This is ridiculous,” James whispered back, now in danger of falling backwards in his chair. “We’re building a test platform for their shiny new toys and they’re pretending to be nice, letting us strap our telescope on for the ride.”

“And Lucy will be joining you and me as the third head of the project,” Grace slipped in

defeatedly. James snapped forward in his chair, his hands slapping on the desk between them as he fell towards her in the low gravity. He looked like he had been slapped in the face as he stammered for words.

“Too many cooks in the kitchen!” he finally burst out, “this is a peaceful mission for science! For discovery! Not some...some military exercise.” The fish on the screen turned and continued swimming through the kelp forest, oblivious to the shouting.

“James I don’t like it either!” replied a tired, exasperated Grace. “I’d rather be engineering than mucking around in red tape,” Grace said shaking her head. The flurry of regulations and requirements made her wonder if this project would be worth it. Part of her wondered whether it’d be best to return to Callisto Corp full time and give up on *Einstein*.

“Then you see my point!” expounded James determinedly. He sprung to his feet, nearly hitting his head against the ceiling. “We go back to that Lucy person, tell her that..that these terms are unworkable! We can’t build a telescope like this!” Grace tilted her head and shook it gently.

“James, it’s not like that,” she said with sadness and frustration. “We can’t just...not agree to what they want.”

“Or else what?” he replied back with wide eyes. Grace stared back with her mouth slightly open. She bent down and spoke slowly, like she was talking to a young child.

“Or else there is no *Einstein*,” she said quietly. For a moment she wasn’t sure why she was pushing so hard on this. James sat back down and looked down at his feet as if this was some new revelation to him. He looked out the window, drumming his fingers anxiously.

“What are they going to do with the image processing software?” he finally asked.

“Not a clue,” replied Grace. She leaned back into her chair and started spinning gently back and forth. It was a mystery to her too. Because of the way the sun bent and focused light, their telescope wouldn’t receive clean pictures of Trappist-1e. Instead the pictures of the planet would come back smeared around in a ring. It would take mind-numbingly sophisticated - and woefully undeveloped - software to pick out clear pictures from the distorted ring images. The two sat silently for a moment, both wordlessly wondering.

“The military, Grace. We’re going to be working for the military?” murmured James, still in disbelief. “And we still don’t have a clue what they’re going to do with our software!?” Grace continued staring out the window wrestling with her own reservations. She had done

work with the military while at Callisto Corp before. It made for a bureaucratic mess, and she had steered clear ever since. Continuing *Einstein* would be diving head first back into that quagmire.

“You don’t think there’s any other way we’ll get this funded, do you?” asked James half-heartedly, even though he already knew the answer. It was like a dream, a beautiful dream he had worked towards for years, was slowly being clouded over and corrupted. Grace let out a humorless laugh.

“Not a chance James, not a chance,” she replied. James stood up and began pacing. For several long moments he was silent. Finally, after the digital fish on the screen had done several more laps, he turned towards Grace with a sigh.

“Then for me the choice is clear. Not easy,” he interjected, “but clear.” A small smile was beginning to appear on his face again. Grace looked back at James, knowing that grand thoughts of discovering alien cities were again bubbling through his mind. His smile was always so terribly infectious. After pausing for a moment, she gave a small nod and smiled back.

3 Chapter 3: James

James awoke early in the morning. Like he often did these days, he blinked his eyes a few times and wondered if what had happened over the past few weeks was a dream. Methodically, James walked through the events of the last several fantastic weeks. The meeting with Grace. The meeting with Lucy. A guarantee of funding from the Navy. Once he had reassured himself that it all had really happened James smiled and pushed himself out of bed.

In the low gravity James vaulted up towards the ceiling as his covers swam through the air like an undulating sea monster. Even though he had grown up on Callisto and had never felt the gravity of another planet or moon, James never failed to enjoy the delights of living in low gravity. It must be so dull, he thought to himself, to be chained down by the pull of Earth, where the gravity was eight times stronger than that of his home.

After coraling his covers back into his bed James floated across the room and pulled out his phone. He hummed gently to himself as he swiped through notifications, read messages, and scrolled through news stories. James paused for a moment when he looked at his calendar - he had an important appointment today, one that came once a year. And given the recent weeks, it had come at an auspicious time.

Once dressed, James glided over to the kitchen in his studio. He lived alone, no spouse, no roommates, and no children. For the most part living alone and having never married didn't bother him - James had thrown his life into his work and had formed great bonds with people along the way. As he munched his way through breakfast James casually scrolled through a paper one of his colleagues had published, consuming the information as easily as he consumed his cereal.

It was a Saturday, and though James usually worked through weekends he decided to take a little time off. The last few weeks had been a whirl of meetings, negotiations, and finally hand shaking. He would have normally plunged straight into his work anyways but there would be time for that later - with their agreement with the Navy freshly sealed there would be plenty of work to do. In the meantime, James decided to focus on his appointment.

James finished breakfast and put away his dishes. Pausing briefly, he tapped out a few sentences of advice to a student who had messaged him with a question that morning. He glanced one more time at his phone before heading out of his apartment. Above him the sky lights of the dome were shining brightly. Callisto revolved around Jupiter every 17 days and moved between sunlight and darkness in the same period of time. Artificial lights

illuminated the city, creating the illusion of 24 hour day and night cycles. Of course, it was hard to pretend it was dark when the sun sometimes still hung overhead at “night.” But the citizens of Callisto had adapted, mostly in the form of thick blackout curtains.

Humming to himself again, James headed through the city. He lived in one of the many domes that made up the Callistan Republic. Like many professors, he chose to live in this particular dome because it housed the Institute where he worked. James charted a path to a flower shop several streets away and set off. He made a point to try and take a different route to the store each time he went. But over the years, it was getting harder to be original.

As he walked through the streets James couldn’t help but smile. He had barely slept the night Grace told him the Navy would fund *Einstein*, kept awake by the exhilarating prospect of seeing their beloved telescope fly. In the weeks since then James had slept only slightly more but the excitement and reality of what was happening had pushed him through. Meeting Lucy in person had put James at ease a little bit; he saw her as an academic, another graduate of the Institute. Sure, she was with the military now and working for the Navy. But people sometimes stray from their path, and James assured himself that the values instilled by the Institute must surely still be in her.

At the flower shop James cheerily greeted the owner. As he perused the flowers he stopped for a moment at a cluster of gray tulips. Sliding in closer to look, James read the label and confirmed his suspicion. The flowers were navy gray, grown to be the exact same color as the uniform of the Callisto Navy. He had seen a lot of that color lately - in meeting rooms, over video calls, and in the offices of different Navy officials. At a presentation last week James had stared out into a sea of endless gray while he explained how the sun’s gravity bent light from a faraway planet like a giant lens. He had expected a barrage of skeptical questions but the monochrome mass only asked a few polite technical questions about the image processing software the team was writing. Hardly the worst presentation James had given.

After another second gazing at the stoic looking flowers, James tore his eyes away. He picked a bunch of bright lilies with screaming reds and oranges and thanked the shopkeeper. Now singing gently to himself, James strode off towards the Institute. Even a few blocks away from campus James could see the Institute library standing proudly in the distance. As he neared the school more and more buildings came into view - the bioengineering laboratories, a set of domed telescopes, and an educational nuclear reactor.

The Institute had been founded in the early years of the Callistan Republic by a group of electrical engineers. For the first several years the school had a peculiarly narrow focus, churning out almost exclusively experts in circuit design and computer software. But as

Callisto grew the Institute grew with it, branching out into other subjects and becoming a research and teaching powerhouse renowned across the solar system. James's lucky ticket into the Institute had been when he was an aspiring graduate student many decades ago. At the time James had just graduated from undergrad but found himself working as a city maintenance worker changing light bulbs; he had been more interested in enjoying life than studying as a student. But James had a long running passion for computer algorithms and had written to a professor at the Institute whose papers he read between shifts. One lucky break led to another until James and the professor met, ultimately securing him a spot at the Institute.

James smiled slightly when he walked onto campus. He had lived much of his life here, having stayed for his postdoc and then remaining as a professor. The buzz of energy and discovery was always so palpable to James when he was at the Institute; even the sight of bleary-eyed students didn't dissuade him from this notion. Clutching the group of flowers in his hand, James began walking to a spot on campus that he often passed by but made a special visit to once a year.

As he walked through a grassy square James saw a group of three Naval officers, clad in their signature gray uniform. The sight of the officers wasn't unusual; a large part of the Institute's research was funded by the Navy and groups of representatives often came to visit. Flock of gray geese. It was the phrase that Professor Montlake, the same professor that brought James to the Institute many years ago, had coined for them. Professor Montlake was a brilliant scientist, a loving mentor, and a stubborn pacifist. When she wasn't researching Professor Montlake would take to the streets, joining students half or a third her age protesting against the money being wasted on the military. "We need more domes and more science, not more missiles," she often repeated to James.

But Professor's Montlake's pacifism had a deeper motivation than pragmatic fiscal responsibility. This far from the sun, out in the deep blackness of space, life was a rare and precious gem. Hundreds of millions of kilometers from Earth, the cradle of humanity, humans had built colonies on Mars, Callisto, and on asteroids that bobbed through space between the planets But the gremlins of radiation, empty vacuum, and sheer distance constantly threatened to erase these wisps of human civilizations back into lifeless rocks. Adding human violence to this poisonous concoction was downright insane to Professor Montlake.

Up ahead James saw his destination - an open clearing where the ground was paved with colored stones and where the paths of the Institute radiated away in all directions. Dozens of aluminum metal posts sprouted out of the ground, arranged in a neat spiral pattern with

a polished magnesium² placard mounted on each of them. Surrounding the memorial were two broad arches, perpendicular to each other and crossing at the top, that wrapped above the posts like the skeleton of a miniature dome. Carved on each of the placards was the name of the Institute's founders and most storied professors. With flowers in hand, James slowly walked to Professor Montlake's post.

Professor Montlake had taught and mentored James for five years, and after he earned his Ph.D she remained a dear friend to James. As a postdoc and new professor James would regularly meet Professor Montlake, talking for endless hours about how to help a struggling student or sidestep another research roadblock. Their conversations often digressed into long discussions about politics and the state of tensions that existed between Mars, Callisto, and the other nations of the solar system.

James stopped at the post with Professor Montlake's name. He got down on one knee until he was eye level with the placard and bowed his head. After pausing for a few seconds he looked up and read the words on the placard that he practically had memorized from all of his visits:

Professor Clementine Montlake

Professor Montlake is recognized for her dedication and service to the Callisto Institute of Technology³. Professor Montlake was responsible for the invention of the Montlake Communication Protocol (MCP), which revolutionized low power communications and greatly improved communication across vast distances of space. With her invention, spacecraft in deep space could communicate with each other and with the ground more easily and with less power.

"Only with peace can there be prosperity." -Professor Clementine Montlake

In truth, it was a bit of an exaggeration. Professor Montlake had hoped that her invention would revolutionize communication. At the heart of MCP was a digital signal processing algorithm that Professor Montlake's team had designed, a computer algorithm that could pick out the faintest radio signals from the background noise that filled space. It let ships transmit signals to each other while using less power, relying on the algorithm to pick out the low power signal. When Professor Montlake invented MCP, the ships that plied the solar system used great arrays of solar panels to generate electricity, which meant power was often in short supply.

Leaning further down, James softly placed the flowers at the foot of Professor Montlake's post. In the moon's low gravity the flowers fluttered to the ground slowly, almost hanging in the air. She had been proud of her invention, but it never caught on as widely as she had hoped. MCP needed a special antennae and other hardware to work, which many ships weren't outfitted with. In the end, the need for low power communications largely went away. Instead of giant wings of solar panels, new ships were designed with compact nuclear fission reactors that generated bountiful amounts of electricity. Instead of using Professor Montlake's special software and antennae, huge amounts of power could be dumped into traditional communication arrays. The sheer volume of having megawatts of power behind each transmission was enough to be heard across space.

James stood up, still looking down at the post engraved with his former mentor's name. Out of the corner of his eye he could see another flock of gray geese walking through campus. James shut his eyes again with a mixture of anger and sadness, wishing the gray uniforms would disappear. MCP was still used in some applications where ships had limited power. But the main use of Professor's Montlake invention was one that haunted her for the rest of her days.

Years after moving onto other projects Professor Montlake learned that the Callistan Navy had picked up MCP. She was devastated when she found out what they were using it for: guiding missiles. It was truly a perfect niche application for MCP. Missiles were still the best ways to shoot down other ships in space. But the wide array of sensors needed to track enemy ships couldn't be crammed onto a missile - only a fully outfitted military spacecraft could hold all of the equipment. This meant that when missiles were fired, the ships that launched them had to constantly beam tracking data to keep the missiles on course.

But beaming tracking data often gave away the positions of the ships that fired them. The Callistan Navy long struggled to find a way to guide its missiles without announcing to the enemy where its ships were. A young officer hit on the idea of using MCP - even if enemy ships were outfitted with the right equipment, the dribbles of power used to communicate with and guide missiles made it nearly impossible for enemy ships to hear. For the Callistan Navy it was a huge advancement - its ships could fire on enemy spacecraft with almost no warning, undetected until the final moment. Today, virtually all of the Callistan Navy's spacecraft used MCP to guide missiles to their targets.

Looking to the side, James saw that the Naval officers had left. He breathed out with a gentle sigh - today above all days he didn't want to see them on campus. Professor Montlake had been devastated when she learned what her invention was being used for. She had felt

foolish and betrayed; all of her calls for peace had been rendered moot by the work she unintentionally did for the Navy. James had watched Professor Montlake go from a vibrant, joyful woman to a downcast, hollow shell of her former self. She continued working at the Institute for several more years but became increasingly fearful that the military would again co-opt her work and use it for sinister purposes. The stranglehold that this fear had on her eventually choked off her creativity and energy for invention.

James stood and straightened himself up. He gripped the shiny gray placard on the post and once again bowed his head silently, like a reverend saying a prayer. Professor Clementine had passed away more than a decade ago, a sad broken woman. James often thought about his former mentor and passed by this spot as he hustled around campus and between meetings. Since her passing James had made a point to return to Professor Montlake's memorial each year and pay respect to the woman who had kickstarted James's career.

In his pocket James could feel his phone buzzing - even though it was a weekend he told his students to contact him any time of day they needed him, including weekends. James continued standing at Professor Montlake's memorial, reflecting on how the military had co-opted her invention and irreversibly shattered a lovely, joyful woman.

"I won't let it happen to me," whispered James. After another brief pause, James fished his phone out of his pocket and got to work⁴.

4 Chapter 4: Fire

Jupiter continued its march around the sun, bringing its spinning flock of moons with it. As the planet retreated from the sun in its orbit, the Jovian summer gave way to winter. For the inhabitants of the growing cities on Callisto this made little difference; the coming winter brought the temperature outside from lethally cold to even more lethally cold. Just as the temperature fluctuated, tensions between Callisto and the other nations of the solar system waxed and waned. Much of the outer solar system remained unclaimed and was tied into an impenetrable, overlapping web of territorial claims. Any jolt in the web could be felt across the system. But on Callisto the *Einstein* telescope slowly lurched forward, oblivious to the dangerous interplanetary chess match being played.

“And then you apply another convolution and the pixel should fall out,” James explained to Tess. He stood by a whiteboard littered with equations and fields of arrows. Tess, who was part of the small army of graduate students working on *Einstein*, stared back with her head slightly tilted.

“I understand that part,” she noted after a minute, “but our problem has been modeling the Gaussian soft edge filter; the model results have been crap.” James stepped back and stared intently. His eyes scanned around the whiteboard, looking for a solution he might have accidentally scrawled out. The past two years since funding was restored had seen many moments like this.

“It’s too easy for the filter to fall out of phase with the light that gets past the coronagraph,” she explained again after a minute. James nodded again; his thesis many orbits ago had been about this exact problem. But applying it into working software suddenly made the solution slippery and elusive. James glanced at his watch and shook his head. He was going to be late for his meeting but he wanted to stay and get actual work done.

“Tell you what, I have to run but you sleep on it and we’ll chat later,” sighed James, finally giving up.

“Professor Ballard, is this a meeting with Officer Sodo you’re going to?” inquired Tess softly. She looked nervous, like she was asking permission to engage in seditious acts.

“Yeah, Lucy will be there,” James replied absentmindedly. He looked around his chair for his phone while still pondering the problem on the board.

“Can you ask her...ask her what the Navy wants with our software?” Tess finally said

cautiously. James bumped his head against the bottom of the chair. Cursing gently he straightened up and slid his recovered phone into a pocket.

“I’ve been asking constantly the entire time, but all I get is Navy confidential mumbo jumbo,” James replied with a shrug. He sighed heavily out of pent up frustration. Tess looked crestfallen.

“Okay...it’s just...some of the other grad students and I have been talking. We want to know what we’re working on and what it’ll be used for,” Tess said. James shook his head sympathetically.

“I wish I knew too,” he finally said with a long pause, “I have to run, but I’ll try and weasel it out of Lucy this time.” Tess smiled appreciatively and bid James goodbye. He stole another look at his watch and hustled out the door through the halls of the Institute. As he rode up in a glass elevator he could see into the sleek, transparent conference room and caught Grace’s eye. She shook her head disapprovingly and he smiled, miming running to the room. After exiting the elevator James jogged to the room, waved to two passing engineers and slipped inside.

“To summarize, the telescope mirror passed this round of testing and we think everything is on track,” reported Parker. Parker was one of the few engineering heads still working on the project after it had been cancelled. Despite Grace and James’s best efforts, droves of engineers had left when *Einstein*’s funding was thrown into limbo.

“That’s excellent to hear, thank you Parker,” said James enthusiastically as he strode to his chair. He glanced over at Lucy with an annoyed look. She was staring at her phone, making no effort to feign interest. “The mirror is really one of the key parts of the whole mission,” he said slightly louder than necessary.

“Thank you James,” replied Parker, looking pleased but confused.

“Where’s our drive specialist? Lucy, that’s one of your people right?” asked James pointedly. Grace shifted nervously in her chair, jaw clenched.

“He couldn’t make it,” replied Lucy simply, barely glancing from her screen. Clearly visible bags hung beneath her eyes.

“Well, he usually can’t say much to us anyways,” said James, with a forced casual tone. Lucy lifted her head up, almost to say something, but just as quickly returned to her screen. Her furrowed eyebrows were bent into a deep “W” shape and she continued tapping away at

her screen. Grace looked between the two, feeling worn down by the unceasing friction that had built up over two years. The meeting soon ended and the various project leads filed out leaving only Grace, James, and Lucy.

“James, Lucy, are you coming? I think someone has the room after us. And James, remember we’re getting lunch with Tess,” called out Grace from the doorway. Grace had known Tess even longer than James had, ever since Tess was a young bright-eyed undergrad. Lucy remained glued to her phone while James hovered nearby, slowly packing and repacking his bag up. The two briefly glanced at each other. James exhaled sharply.

“Actually you go ahead, I’d just like to chat with Lucy,” he replied. Grace nodded and stepped outside, leaving just the two of them.

“Is there something you’d like to speak about, Professor Ballard?” inquired Lucy slowly. She finally put down her phone and stared at him, attentive but unfazed. He remained standing and leaned over towards her, as if sloppily trying to intimidate Lucy. The Navy officer stared back impassively.

“Lucy, I...we need to know more about what’s going on,” James said emphatically, “about the *Sheridan* drive, and what you’re doing with our software!” Frustration that had built up over the years came bubbling out. Lucy nodded her head softly, looking at the table.

“Professor Ballard, I’ve told you this for a long time. The Navy’s interest in the *Einstein* image processing software is strictly confidential,” Lucy continued. “As for the *Sheridan* drive, that’s highly classified and only my people can work on it.” James shook his head, unsatisfied with the answer.

“People have a right to know what they’re working on! And our whole mission is dependent on that drive! That’s our ticket to space! You can’t expect us to not know how the engine is doing?” pushed back James. Lucy nodded with restrained patience.

“I understand Professor, which is why I’m arranging for you and Grace to visit the Navy test site,” Lucy replied. “You won’t be able to see the drive, but we can discuss some of the details.” James gradually reeled himself back, like a slowly deflating balloon. The bottled up frustration in him was receding as quickly as it had erupted.

“Details about...both the drive and the software?” he asked tepidly, feeling embarrassed.

“I’ve been working on getting the right permissions for some time now,” Lucy continued, a tone of exhaustion evident in her voice. She looked up at James, blinking slowly and tiredly.

“Sorry, I should have told you earlier, but I wasn’t sure if I could get your visit cleared.”

“Oh...then... we really look forward to it,” he replied sheepishly.

A week later, Grace and James were sitting on a speeding train, gliding smoothly along the tracks. The train was quiet that morning, with a handful of other civilians flanked by dozens of uniformed officers. James flipped his hard plastic ID card that had been freshly printed over in his hand. A small digital version of him smiled back.

“Took only two years of working with them to see the base,” he remarked to Grace. She was staring out the window at images of playing cards flashing in the dark tunnel, an art display someone had installed⁵.

“And maybe it’ll be only a few more until we get to see the drive,” chuckled Grace before pausing for a moment to think. “Actually we might never see it...”

“I bet that drives you crazy,” replied James with a restrained laugh.

“What....oh haha,” Grace with a small smile. Truth be told, it did make her uneasy. The project had so many critical moving parts that had to work in sync with each other like a perfectly synchronized orchestra. Trusting the *Sheridan* drive, a black box that she had no control over and almost no knowledge of, didn’t sit well with her.

The train glided to a halt, jerking slightly and sending the marines standing around them stepping forward. Grace and James disembarked and their guide led them out of the station. Above them stretched the familiar criss crossing lattice of a dome, though this one was much smaller than the ones enclosing cities.

“All this money for a Navy site,” whistled James, looking dismayed but deeply impressed. “I bet we could have funded *Einstein* with half the money it took to build it.” Grace elbowed him in the ribs, a little sharper than she meant to. They walked quietly a few blocks while around them serious-looking officials waved and saluted crisply dressed soldiers. Grace noticed James smirking whenever he saw this. She resisted the urge to elbow him again.

“It’s good to see you, I’m glad you made it all the way out here okay,” Lucy said with a smile. Grace noticed the bags under Lucy’s eyes had gotten deeper and her voice seemed a bit faded. Her graying hair was tied in a loose bun that was at risk of falling apart.

“Good to see you too Lucy,” replied Grace. “We’re excited to be here and see the *Sheridan*

drive.”

“We won’t be able to go on a tour of it today, it’s on the test stand right now being fired,” said Lucy with a small sigh. She turned and led them into an elevator.

“But we will be going over its progress and some technical details,” she offered as the elevator opened on the fourth floor. Lucy waved off the escort and led them to her office. It was a cramped room, even smaller than Grace’s and jammed with furniture that threatened to overflow into the corridor. Lucy turned on a small screen as the three delicately arranged themselves in the room. With great difficulty James turned and closed the door.

“The *Sheridan* drive has had some teething problems,” Lucy said as she brought up a test schedule, “we’ve had trouble igniting the reaction and keeping it burning. My teams have been working almost constantly to get it fixed but we’re stretched thin.”

“Stretched thin?” asked James, “have you had funding troubles? We’re not really told of these things.”

“Some of my engineers have been pulled away, the Navy has a backlog of ships that need fixing,” said Lucy sadly, “and that takes higher priority than this apparently.”

“But will you still finish on schedule?” James implored, starting to worry.

“We think so. That’s what I wanted to share with you,” said Lucy. She flipped to the next slide and began to explain. A parade of charts, timelines, and proposed schedules paraded across the screen. An hour later the meeting was still going when Grace glanced out the window and gasped.

A shower of brilliant sparks was surging through the sky, raining dazzling color against the dark background. A sun suddenly erupted above the horizon in a burst of fire and basked the ground in its wicked blue and white light. What looked like shards of incandescent metal were spewing outwards, lazily falling down in sinister glowing arcs. Moments later a terrible groaning filled the tiny office as the ground shook angrily. Alarms blared.

“My god!” yelled Lucy, “the drive!”

James bent backwards to open the office door, hurriedly fumbling with the handle. The three piled out of the cramped room and followed Lucy to the exit. They rushed through the lobby, a symphony of sirens calling out to them. Air pressure loss warnings. Low oxygen warnings. Structural damage warnings. The incessant chimes all blended together into a

cacophonous roar. Through the door they stumbled into the streets that were filling with soldiers and workers. James felt water dripping from the sky and for a moment wondered if he was hallucinating.

“Well that’s awfully pretty...” he murmured, dropping to his knees. Water was falling through cracks in the glass dome, outside of which were what looked like billowing white clouds. Drones were spraying water on the dome in a struggling attempt to freeze the leaks shut. But in the tug of war between water and vacuum, the blackness of space yanked and pulled at the small bubble of air thinning beneath the dome. Perhaps this is what rain looked like. James’s vision blurred and he waved his hand up like a child caught in a sudden summer storm.

“James let’s go!” yelled Lucy, tugging at his arms. In her other arm she supported Grace who was fighting to stay standing. Hypoxia was beginning to take a toll, the lack of oxygen in the dome rendering them slow and confused. With great focus James stood up once again and forced himself forward, concentrating on each step down the street. They could feel a rush of cool air billowing up from the underground train station as they half stumbled half fell down the stairs. A soldier at the station rushed over, clasp oxygen masks onto each of them.

“The door is jammed!” he yelled sharply through his own mask. The soldier looked to be in his early twenties, alert but calm. “There’s another station five hundred meters away, think you can make it?” Lucy started coughing and gasping violently and fell on all fours. James and Grace stooped to help her but she waved them off.

“You make a dash for it,” Lucy cried out, waving vaguely at the wall, “I don’t know if I can get there.”

“Might not be time for us!” babbled Grace incoherently. Her eyes were watering and her face contorted with slow desperation. Even with the help of the oxygen mask, each breath was now a struggling gasp.

“We’ll go as a group. We’ll carry you,” offered another soldier who had been breathing deeply into a mask. He gasped again and inhaled sharply. Lucy lifted her head to protest but before any sound came out James hoisted her up, nearly tossing her in the air under the low gravity. The group began heaving up the stairs again in wavering steps. They had barely crossed the first few steps when James tripped and collapsed again, his ankle ghastly bent as the others fell on him.

“Agh!” he cried out. Even with the mask dribbling in oxygen, the stairs in front of James began swimming before him. Lucy gasped again and fell onto her hands. The air was thinning more rapidly now, oxygen being replaced by fear and panic. Like a cornered animal one of the soldiers fell backwards, his head snapping side to side looking for a way to escape. The world before Grace began to blur into an indistinct smear. The others had fallen into a tangled heap of weak limbs and gasping mouths when a light breeze passed over them.

Two rescuers emerged from behind the mangled doors. In one hand they each held an axe that had been used to bludgeon open the damaged entryway. With the other hand they waved the group towards safety. Grace smiled weakly and passed out.

“I’m glad your ankle is fine,” Grace said to James. He sat beneath an aging oak tree on campus with a tight cast around his ankle, serenely watching students walk in ones and twos to lab. A week had passed since rescuers had pulled them from the failing dome.

“I’m glad all our lungs are fine,” James replied with a smile. Grace took a seat next to him, resting on one of the thick roots.

“Lucy called today. She’s doing fine, and she wanted me to thank you for helping her in the dome,” said Grace. She paused briefly, then opened her mouth as if to say something, but nothing came out.

“That’s good... I’m starting to like Lucy,” James remarked offhandedly. “Even though she’s with the...you know...the military, she’s a good person, hardworking.” He paused for a moment, oblivious to Grace’s critical look.

“Is she still trying to meet the launch window?” asked James, plowing on. The accident had thrown their schedule into chaos, their chariot to the stars stalled in the repair shop. “It’s very kind of her to try, but I really don’t see it happening,” James continued calmly. A hint of sadness and longing clung to his voice but his face was steadfast and smiling. He waved lazily at a postdoc pushing a cart of electronics. It was a perfect day on Callisto, the clean air and dark sky even more flawless than usual.

“She’s trying to stay on schedule because the Navy wants that drive,” reminded Grace, emphasizing the last three words. Doubts floated through her mind and she wondered whether to vocalize them. Beside her, James was playing with a butterfly, smiling and laughing as if he had never seen one before. Behind the placid face, Grace knew that the

stress from the project was starting to impact James. He continued to stare off, not quite willing to accept the daunting challenges their project now faced.

“We’ll just have to keep pushing on,” said James determinedly. “We’ve had problems on our end, so this gives us more time to sort out the kinks.” Grace gave a weak smile. To her, they were more than just kinks; the image processing software was badly behind and large chunks needed to be completely rewritten. The mirror was progressing well, but then there were the communication issues, the power systems problems, the integration nightmare that still lay ahead. She looked over at James, who was continuing to smile.

The doubts about the project began to congeal in Grace’s mind into solid thoughts. The accident had blasted a hole in their schedule, and even if it hadn’t happened they were far from being on track. Now with the drive in shattered, smoldering pieces the problems that needed to be fixed threatened to overwhelm them. She was on the verge of vocalizing her reservations when a figure in the distance ran towards them. It was Tess.

“Professor Ballard! Professor Mercer!” Tess cried to her mentors as she bounded over. “How’ve you both been? When did you get out of the hospital?” Tess slowly skidded to a stop before them, her eyes wide with worry.

“We’re both okay!” James replied as he laughed. “We’re both okay! Tess tell me how your week has been. I’d love to hear.”

With a relieved smile, Tess sat down and began enumerating all of her recent research triumphs and challenges. Grace pushed her doubts back down a mental black hole.

5 Chapter 5: Farewell

More than a year after the accident Grace quietly walked through the halls of an Institute building. It was dark and shadowy, even as the sun was rising once more. Most of the researchers and engineers had already gone for the day but Grace remained, puzzling over an engineering detail. The team was mapping out how the *Sheridan* drive's reactor would power the rest of the spacecraft. But the accident a year ago had unleashed an avalanche of revisions to the drive's design from the Navy that had her team ripping up plans and starting over.

Adding to the frustration, her engineers had not been told about all of the revisions; she angrily replayed a meeting where she was told that the changes were *confidential* for now. It made for an almost impossible job: trying to design around an engine that she didn't have all the details for. The last year had been rough for everyone, with many of her best engineers quitting. Shaking her head, Grace turned a corner into one of the shared computer labs and saw Tess leaning over a cardboard box.

"Hi Tess," Grace said with a smile, flicking on the lights. Tess spun around looking surprised, then gave a small wave.

"You know as a postdoc, you're supposed to go home at a normal time now," Grace teased with a smile. She instinctively ran her hand through her wavy brown hair. It passed through streaks of pencil gray that had not been there when the project began.

"Professor Mercer! I was just finishing up...for good, actually," breathed out Tess with a sigh. Her whole body seemed to fall slightly. Though the lights remained on a sudden gray darkness permeated the room. Grace blinked rapidly, her body frozen as she stared through Tess.

"Oh...you're leaving?" she finally murmured. Grace dragged herself to a chair, spun the seat around and dropped herself in. Tess paused for a moment before grabbing a nearby chair. She meekly scooted towards Grace, who remained silent. Dark monitors in the room blinked cheerfully, standing out against the suddenly sullen mood.

"I'm starting a new job. I'm working on image recognition for automatic ground surveyors," Tess said quietly. She looked up at Grace, who was glumly rocking side to side in her chair.

"But why, Tess? Here, you're building a telescope to hunt for aliens! The furthest we've ever traveled to the stars! Why are you going to this...this mining company instead?" Grace

stared at Tess, her eyes filled with sadness. Before Tess spoke, Grace already had an inkling what the answer would be. Tess squirmed in her seat uncomfortably, not sure what to tell her long-time mentor.

“I...I can’t do this anymore Professor,” she finally stammered. A thick tear appeared in her eye. “I don’t know what I’m doing here, I’m not sure what we’re doing or why.” A heavy pause seized the room. Grace stopped her side to side motion and looked at Tess, giving her time to finish.

Tess breathed out slowly. “You say we’re hunting for aliens...but what if they’re not there? What if this doesn’t work? What if it’s...all just a waste of time?” Tess’s voice faded away and she stared forlornly at the wall.

“We don’t know, that’s what...that’s what makes discovery exciting and hard,” choked Grace, gesturing haphazardly. She hardly sounded convinced herself. Tess’s face hardened into a firm grimace as she fought back tears. She shook her head methodically, swinging it side to side.

“That sounds like what Professor Ballard would say,” Tess said with a tearful laugh. “I just...don’t know if I believe in this dream anymore. I’ve been working on this software for all these years, and I don’t even know what the Navy is going to do with it, if it’s ever going to be used to find aliens.” Grace moved her lips but no words came out. Tess was saying it all for her.

“All these grand ideas about science and discovery....like it’s some, some fairy tale,” continued Tess in a defeated voice. She was staring at the floor now, practically whispering. She looked up at Grace with tired, wide eyes. “Have you seen the Lewis paper?” Grace froze again as she felt an icy chill crawl down her back. She sighed again.

“Yeah, I’ve seen the Lewis paper. I was talking to James about it today,” Grace replied glumly. “He’s unconvinced,” she added, though she knew she did not need to.

“Of course he’s not convinced,” said Tess with another sad laugh. Her voice trailed off and she dropped her head, continuing to stare at the carpet. “They’re saying that there is no pattern in the signals, that it’s been analyzed wrong the whole time. That there are no aliens.”

Grace buried her face in her hands. Since the signal from Trappist 1-e was detected there had been an ongoing debate amongst scientist about its origins. The faint signal, carried delicately across all the empty space between the stars, had faded and returned many times

since it was discovered. The Lewis paper was just the latest in a string of publications that argued the signal had natural origins, and that the aliens they were chasing were a mirage. Like wildfire, the paper had been tearing through the *Einstein* team. Some of the scientists were despondent. Others were fiercely defensive.

“I’m sorry Professor Mercer, I’m really sorry,” choked out Tess, “you and Professor Ballard have been amazing mentors and I can’t thank you enough for everything. It’s just that I feel like I need to work on something...something more...”

“Something more real,” Grace finished for Tess. Tess nodded in return.

“No, I understand Tess,” replied Grace as she stood up and walked towards her. “You want to do some work that feels more real, that you feel like is helping Callisto and is making a difference. And you will be, mining is a really important industry.”

Tess also stood up from her chair and gave a small nod. She stepped forward and wrapped her arms around Grace.

“Thank you,” she whispered, tears now sliding down both of their faces.

“You’ll always have a place here if you choose to come back,” replied Grace. The two women released each other and Tess returned to straightening her things.

“Thank you Professor,” choked Tess and she turned to pick up her box.. “But I don’t think I’m coming back.”

Later that week Grace sat on the roof of the Institute library. It was near the middle of campus and stood proudly over the surrounding neighborhoods⁶. Callisto was facing away from the sun and the lights of the city were off. A true night, with only a half lit waxing Jupiter spoiling the darkness. She poured herself another glass of wine.

Off in the distance she could see the lights of *Lakhani* Port. Great blue and white pillars of flames rose through the night as the metal monsters that rode them climbed into the heavens. Even more spectacular were the rockets landing at port, their bottoms madly spewing out fire to cushion their fall. The port desperately needed new infrastructure to keep up with the acceleration in cargo movement. Its air traffic control system was horribly outdated and had nearly guided two rockets onto the same pad just weeks ago. Grace had been offered a

job to upgrade the software a few months back but had turned it down. She took a long sip from her glass and continued staring past the edge of the Callisto Institute of Technology, off into the real world.

She sighed deeply and thought about Tess. Tess would be starting work at her new job soon, writing code for robots that scoured the surface for precious resources. More iron, more magnesium, more of everything needed to keep Callisto growing. Behind her a door opened with a gentle thud. Feeling warm from the wine, Grace serenely turned around. It was James, a beer in one hand and a folding chair in another.

“I see you’ve found my favorite spot, Grace,” he said with his trademark smile. He unfolded his chair next to her and opened the beer. The scientist and the engineer clinked their drinks together and drank silently. Up above, Jupiter’s clouds continued to swirl methodically.

“Grace, I’ve had this thought for the past few months,” started James after a long pause. Grace had to resist rolling her eyes - that phrase usually was the prelude for another wild idea. Tonight, she had no appetite for such thoughts.

“The accident with the *Sheridan* drive...it’s odd right? Funny that it happened the day we visited,” began James in a conspiratorial tone. “Lucy doesn’t want us to know what our software is being used for, doesn’t want us to know about the drive. Do you think maybe...it wasn’t an accident?” Grace’s stomach started churning. She continued staring out into space, her mouth open and unable to form words.

“The damn thing blew up right in front of us. That wasn’t an accident,” she finally said curtly. James looked over at Grace, nodded to himself and settled back into his chair.

“Never mind I said that,” he mumbled, “just a thought.” The two continued to sit in heavy silence.

“Tess is leaving,” Grace finally stated. It was an expression of fact, with no emotion behind it. Next to her James sighed deeply. Tess had been as close to James as she had been with Grace. They sometimes joked they were Tess’s academic godparents.

“I tried to talk her out of it. She came by a few days ago to say goodbye, but I couldn’t get her to stay,” replied James. “Not sure if you knew, but some other postdocs - Cobe and Selene - they also planned on leaving. I had more luck talking them into staying.”

Grace snorted to herself. She wondered what would have happened had James not been so persuasive, so capable of inspiring others to believe they were a part of something greater.

James seemed to have mistook her snort for a laugh.

“I guess the last few months since the accident have been rough...people have been leaving left and right,” James continued.

“The rate of resignations was this high before the drive blew itself up,” deadpanned Grace. “People are all jumping ship.” She poured more wine into her glass. In the low gravity it flowed out much too slowly for her liking. Beside her James took a long drink from his beer.

“Then I wonder why people are leaving,” pondered James. Grace opened her mouth to reply but he continued. “I suppose the pay isn’t as good, and there’s other interesting things to do too...”

“It’s the work James, the work. How have you not realized it after all the years?” replied Grace sharply. Her glass was empty again. James continued staring off, slowly absorbing what she had said.

“We’ll be able to see the continents, rivers, maybe even cities if they really are there. We can study Trappist 1-e the same way we study earth, look at another planet’s weather patterns, plate tectonics. We’ll finally figure out if that signal is coming from an alien civilization. The greatest discovery in all of humanity! Grace, what could be more exciting than that?” James turned to Grace flashing his bright, boyish grin. Normally, that look of raw wonder and excitement made Grace smile. Tonight, she turned away and grimaced.

“Looking for aliens that might or might not be there isn’t enough. People look around and want to solve the problems in front of them, here on Callisto.” Grace replied. She continued staring off at *Lakhani* Port and watched the mesmerizing blue glare of an engine throttling down. It looked like a bright glowing star, swooping in to kiss the ground.

James’s smile dissipated away. Instead he looked at Grace with worry. “Grace do you still believe we’ll find something? I mean it’s....pretty clear the Lewis group had some flaws in their methodology but...sometimes I’m not sure if we’ll get back pictures of a dead, brown planet. But that uncertainty is...it’s kind of thrilling!” James blindly tipped his bottle to Grace with a smile and emptied it down his throat.

“I’m not sure anymore if it matters what’s there...or not there,” replied Grace. She kept on staring off at the distance. James’s quick smile receded again from his face.

“I know this takes patience, and frankly I don’t know if I’ll live to see those pictures. But it’s like building a cathedral right? We start the work, lay the foundation, and maybe another

generation gets to finish it!” orated James. “Even if there aren’t aliens...the scientific returns of this mission will be immense! People will be studying the data for decades!” He turned to Grace, looking pained. “But Grace...if what’s there doesn’t matter to you, then what are you working for?”

For a moment Grace contemplated the answer “I don’t know.” It was the easy answer, a succinct answer that captured the confusion and aimlessness and doubt she felt. Up above a blue light flared up, suddenly growing brighter as it coursed through the sky relentlessly and with unwavering purpose. Likely a military ship of Callisto, burning hot in a training exercise.

“I’m doing this for Callisto,” Grace finally said, though in the moment she didn’t know what it meant. Professor Ballard briefly smiled, looking content. But the flash of satisfaction was quickly replaced by confusion. Before he had time to ask what she meant, Grace had left.

Months later, Lucy stood at the back of a control room, looking out over a sea of monitors and headsets. At the front of the room a single enormous screen canvassed the wall of the closely guarded underground facility. The wide space was unnaturally quiet, with only the babble of engineers and technicians at their stations breaking the silence. Lucy clung to her mug of coffee; around her many others did the same as they pressed to stay alert in the early morning hour. A man in his forties in a crisp uniform and a buzz cut appeared next to Lucy.

“Big day huh,” he remarked, lifting his eyebrows.

“Wouldn’t be able to tell from the energy, Admiral Beacon” yawned back Lucy. The admiral gave a small laugh. The chatter had begun to die down and the eyes in the room that weren’t glued to monitors were turned to the front. An animated image of a small, seemingly insignificant spacecraft plied through the screen. Towards the top right a countdown steadily ticked down.

“Three, two, one, mark.”

A bright blue flame arose from the engine on the screen, almost cartoonish in its symmetry and steadiness. It had the air of an elementary animation project, thrown together by art students playing with a new software for the first time. The flat two dimensional image traced along pixelated golden lines that stretched to the ends of the screen. But across the Jovian system, the real life analog of the mundane picture roared to life. The engine

burned, first tentatively then steadily more and more viciously. The spacecraft hugged close to Jupiter in its orbit, hidden from prying eyes by the planet's sheer girth. As if afraid of being seen, the blue light from the engine extinguished itself almost as soon as it had erupted. An underwhelming chatter broke out in the room again, broken by a loud, lonely pair of clapping hands.

"You'd think they'd be more excited," chuckled Admiral Beacon to Lucy. He pulled his hands apart and set them on his hips, shaking his head disapprovingly at the room full of engineers. The admiral swept his look of disappointment across the rows of monitors then turned to Lucy, lifting up his eyebrows.

"There's still a long way to go and the accident has people cautious," replied Lucy steadily. She continued staring at the screen, clasping her mug without looking back. The admiral guffawed shamelessly, and several heads turned around at him.

"That was more than an year ago, we're past that. Lucy, this is the first flight test of the *Sheridan* drive. Your little robot workers should be smiling," smirked Admiral Beacon.

"We're a naturally cautious group," Lucy replied simply. "This was a small scale test, and there's a very long way to go." Inside she was more relieved than jubilant; in her business, many things accidentally ended up in a nuclear fireball. The test they had just pulled off was also just a small warmup compared to the full testing that would be done on *Einstein*. Lucy looked down and was disappointed to find her coffee mug empty.

"Well, we want things to go much faster. The *Sheridan* drive has been pushed to the highest priority," replied the admiral. Lucy blinked hard several times; she was straining to keep her eyes open.

"We're already pushing as hard as we can. My people can't move faster without more resources, more money," Lucy said, beginning to feel irritated by her superior.

"You're about to get your wish," the admiral said with a small smile. Lucy turned to him with a puzzled look on her face. The admiral's smile morphed into an insidious smirk. "We're killing *Einstein* and pushing all the funding to your team."

"What?!" blurt out Lucy. Her arms fell to her sides and the last drops of coffee went flying to the floor.

"You didn't hear it from me though, still hasn't been decided, plans are still classified," Admiral Beacon said in a mock whisper. "About damn time too. Playtime is over for the

scientists, time to get the real work done.”

“What they’re doing is real work,” retorted Lucy angrily. “We need their help with a test craft, we need their software.”

“Their software is finished enough for us to use, even if they can’t find their aliens with it,” replied the admiral brusquely. Lucy stared back at her dangerously misinformed superior, beginning to feel livid.

“We made a deal! We can’t renege on this! And they’re nowhere near finished with the software for it to be useful!” she yelled. A few of the engineers in the room monitoring the spacecraft turned around, looking concerned. Admiral Beacon looked back at them, a familiar snarling look of irritation crossing his face. He lowered his voice again in a clumsy attempt to remedy his lack of discretion.

“Then you better get your scientist friends to move faster,” he warned, “or else they’re getting the axe.”

6 Chapter 6: Faster

A few weeks after the *Sheridan* drive's secretive test, Jupiter finally reached the furthest point in its sweeping, elliptical orbit. The gas giant once again started to swing slightly inwards toward the sun, subtly warming its swirling clouds and collection of moons. But elsewhere in the solar system tensions flared up, hot and sudden. A dispute over an asteroid rich with precious metals sent military ships racing through the system in a mad stampede. Before Callistan ships could reach it, a Martian fleet stormed to the asteroid and wrapped it in a menacing web of bristling warships. Mars had been colonized decades before Callisto had been and was home to millions of resource hungry people. But for many on Callisto, the incident was a remote curiosity, a story barely worth a few inches of screen space.

"Parker, this all looks great. Thank you so much for going through this with me," Grace nodded appreciatively. The two sat in Grace's office with complicated engineering diagrams and timetables before them. A news notification buzzed on Grace's phone about the disputed asteroid but she swatted it away like a fly.

"Mirror integration is tricky, but I think we're on our way," replied Parker happily. Just like with James and Grace, the years working on the project were starting to show on Parker; small bald patches were cropping up in his once thick hair. The mirror work had been one of the high points of the project; the image processing software was still a wild, unruly beast by comparison.

"Best in the business, Parker. It's good that at least part of the project is on track. I'm starting to wonder how much the Navy will tolerate us being...so behind, and over budget." Grace said with a tired smile. The two had met on a research station on Europa, Grace as a visiting engineer during her postdoc years and Parker as a younger rotating base technician. While Grace had become a professor at the Institute, Parker worked in industry before being hired by the Institute to work on *Einstein*. They often joked about making another trip down to Europa together.

"Don't worry, a project that costs twice the budget is under budget by the Navy's standards," joked Parker with a laugh. He breathed out with a melancholy sigh, the smile fading away.

"Grace, there's something else I wanted to bring up," Parker said with a hint of sadness. Before he opened her mouth, Grace knew what Parker was going to say.

"You're leaving, aren't you?" Grace said quietly. She blinked sadly at her colleague, confidante, and friend of more than two decades. Parker nodded slowly.

“I wouldn’t be doing it if the mirror work wasn’t wrapping up. The rest of the team is good, they won’t have any trouble finishing it,” Parker said assuredly. “But I’ve been asked to work on the next generation of orbiting mirrors, for our farms. I’m planning on leaving in a few months, at the end of the year. It really feels like...the perfect project for me.

Grace leaned back in her chair and watched a digital fish on the wall bobbing in and out of the coral. It really was perfect for Parker. As Callisto grew, it needed ever more farms and greenhouses for food. Sunlight for the farms came from mirrors that dangled in space over Callisto, reflecting down sunlight like miniature suns.

“I understand, Parker,” replied Grace with a cheerless smile. She stared at him and felt a mixture of sadness, disappointment, and envy wrap around herself.

“You should come too,” said Parker, his eyes bright and wide. “They’re looking for a large-scale software integrator. You’re more than qualified for it. Actually, I already recommended you and the project head wants to talk.” Parker flipped his phone through his worn palms and started scrolling. He swiped around until he found the number. With another swipe and a buzz it appeared on Grace’s phone. Grace looked at Parker with wide, longing eyes. Before she could begin offering excuses, Parker stood up to go.

“I have to run Grace, but do consider it. It’ll be a good change of pace - maybe better than waiting decades for ET to wave hello,” said Parker with a gentle chuckle. He leaned in and the two embraced.

“Think about it, Grace,” Parker finally said when they broke off. As he walked out the door Grace returned to her chair and gazed out the small, claustrophobic window. Through the glass she thought she could see one of the orbiting mirrors, shimmering out like a jewel in the night. She flipped her phone over in her hand a few times, thoughts swishing through her head. Her hand drifted to the number Parker sent and she swiped her thumb up and down the screen, watching the icons bounce around. She dialed the number. As the dial tone rang Grace mindlessly fidgeted around on her phone, tugging and tapping on notifications. One of them caught her eye. A voice on the other end picked up.

That same week, James sat huddled under a table with three software engineers. They exchanged bored looks and impatient sighs while around them cacophonous sirens wailed wildly. Their pitch swung up and down in a hypnotic, repetitive whooping noise that drowned

out any other sounds. After nearly a minute, James finally swung out from under the table, opened his laptop and began scrolling while ignoring the angrily blaring sirens. Another engineer emerged cautiously from beneath the table just as the alarms suddenly ceased.

“Now that the bomb drill is over and we’re safe from the Martians, let’s get back to some real work,” huffed James impatiently. His ears were still ringing from the screeching sirens. With one hand he continued scrolling to the equation he was looking for while he used the other to tap his ear, as if trying to get water out.

“Let me pull up the exoplanet motion charts,” one of the engineers said, opening her laptop. As Trappist-1e orbited around its host star, *Einstein* would have to minutely change its position to keep the planet in sight. It meant absolutely delicate motions that demanded sophisticated software to lock and stay on target.

“Please do, unless the Navy decides we need to get under the table for our own safety again,” replied James without taking his eyes off the screen. The drills had started several months ago, once every two weeks. To James, this was far more often than his preferred frequency of zero. The engineer pulled up the charts and began updating James on how *Einstein* would use its array of ion thrusters and a complex target tracking algorithm to return pixels of the planet and not empty space. He listened without saying anything for twenty minutes, drinking in the information.

“And...how far along are you?” he finally asked. The drill had made James unusually irritable. The engineers exchanged looks at each other, each one trying to hide from responsibility.

“We...we haven’t started yet,” stammered the most senior of the three. James leaned in and tapped his ear, as if wondering if he had heard correctly.

“Haven’t started?” he repeated back.

“We have started, but our early versions wasn’t performing well. Then there was a change in the ion array and our code wasn’t built to handle that...” rambled another engineer. James held up a hand to stop him. With a deep breath James rubbed his hands into his face and shook his head.

“We need to stay on track,” James finally said. He gave a small smile but behind it there was a look of disappointment. Another engineer spoke up.

“But we’re already so far behind...I don’t see how we can get back to our baseline schedule,” she mumbled. Instantly she looked like she regretted saying it. James stood up and shook

his head slowly.

“We need to stay on track,” he repeated. The engineers nodded their heads.

“Now tell me what you need to get back on schedule,” James said, forcing a smile across his tired face.

Half an hour later, James stepped out of the meeting and walked down the main path through the Institute. He opened his phone and found an urgent text message from Lucy. His heart skipped a beat and he hurried off, walking aggressively to a spot on campus she had asked to meet. Moments before his mind had been bouncing with thoughts on tracking software and ion engine micro-adjustments. But now he raced off, his head running through what Lucy could want to talk about. Several minutes later he saw Lucy standing near a fountain. Its powerful jets of water gracefully leapt through the air before falling in a crashing roar.

“Lucy, what’s this about?” he yelled over the water, “and is this the best place to talk?”

“Where’s Grace?” Lucy replied. James could barely hear her over the water.

“She said she had some personal commitment, maybe a family thing?” James shouted back. Lucy shook her head, looking distraught.

“*Einstein* is about to be cancelled,” Lucy said in barely a whisper. James looked at her, unsure if he had heard right.

“*Einstein* is going to be cancelled unless you finish faster. You’re not supposed to know this but you need to push your team to finish as soon as possible,” Lucy said to James. She spoke slowly, making every word clear. “The Navy is thinking about killing the program and taking what you’ve already done.” James stood back from Lucy, the same fear that he had felt in Senator Fremont’s office washing over him. Behind him the water continued to dance noisily.

“But...why? We have...we have a deal!” James stammered back.

“They want the money to fund the *Sheridan* drive, and they think enough of the software is done,” Lucy replied, “The higher ups are starting to wonder if the whole telescope is worth funding.” James shook his head. He had to be mishearing something.

“You need to finish the telescope,” Lucy said, staring at James. “They won’t kill *Einstein* if the project is on track and under budget, it’ll raise too much suspicion. But you don’t know any of this. All you know is you need to finish *Einstein* faster if you want your telescope to

get launched.” James rubbed his eyes, his mind groggy and unresponsive. They were so far behind and he was already pushing his teams. He didn’t see how they could be going much faster. And who would be suspicious about their telescope? James felt his legs weaken and sick waves of dread reverberated through his stomach. It all felt too familiar, one of his worst nightmares coming true. Breathing slowly, James braced his arms on his knees and steadied himself. By the time James had opened his eyes again to ask, Lucy had disappeared.

7 Chapter 7: Grace

“Grace, you’re obviously very qualified for this position. I hope this isn’t too upfront, but when can you start?” the senior engineer asked Grace. Grace couldn’t help but smile a little at the offer.

“Could you give me a few days to think about it?” Grace finally replied. The man nodded affirmatively and thanked her for the time. He showed Grace to the door and she set off towards the underground train station. As she walked through the dome Grace couldn’t help but crane her neck around, staring at the hulking, monstrous machines swinging around her.

Unlike the residential domes, this dome was much more industrial and thoroughly working class. Instead of towering apartment blocks and sleek government buildings, this dome was packed with giant robotics arms and assembly lines. It felt like being in an open air factory; up above Grace could see Jupiter shining between the metal supports of the transparent ceiling. The dome was smaller than the ones most people lived in but still stretched a kilometer across. Grace finally stopped walking and let herself take in the humming factory around her. She decided to give herself a little extra time today.

Grace sighed deeply like a curator admiring a fine piece of art. It had been so long since she had seen real, living hardware like this; most of the work on *Einstein* was still just drawings, schematics, and plans. In one corner she watched crane operators swing huge lengths of metal beneath dangling wires. As the cranes turned, the hulking masses of metal suspended underneath reluctantly followed, like heads of cattle being herded. Turning her head slowly, she saw workers fold great glimmering sheets of reflective plastic into compact origami shapes. This far out in space, the sun didn’t shine brightly enough to nourish plant life. Instead, giant mirrors were lofted into space to reflect sunlight onto Callisto’s farms. Grace couldn’t help but grin at the enormity of it all. It was a huge infrastructure project, one of the largest that Callisto had undertaken. An audacious project that this new job would let her be a part of.

At the far end of the dome a large enclosure rose above the ground beneath the ceiling. It was shaped like a half cylinder lying flat on its side, more than two hundred meters long with one end up against the wall of the dome. Inside the gigantic airlock mirrors were carefully packaged into the nosecones of rockets. Piece by piece, the mirrors were launched into space and assembled together high above Callisto. Grace thought about wandering over to take a closer look. She didn’t have many chances to come out to this dome, and she could probably sneak in to see the rockets up close.

After a long pause, Grace finally tore herself away from the carefully orchestrated engineering circus going on around her. There was no way she'd be able to think straight about whether to leave the *Einstein* project with all of this around her. With one last glance, Grace reluctantly trudged the rest of the way to the station and descended down the stairs. She stood on the platform waiting as the train was unloaded; great bundles of metal parts that had been fabricated elsewhere on Callisto were rolled off, ready to be assembled into mirrors. For the most part, the underground trains that came to this remote dome were cargo carrying, with a space for a few passengers and workers. Grace squinted at the train, looking closely at the design of the wheel undercarriage. She walked up to a shift manager supervising the unloading.

"Hey, is this a Caltrain model 320?" Grace asked the man casually.

"You've got a good eye," the supervisor said cheerily, "one of the last of the 320's that Callisto Trains built. What gave it away?"

"Bo-Bo wheel arrangement was the big hint. Plus the square crew cabin windows⁷," Grace replied, "I worked at Callisto Corp for a while, so we were building trains that competed with these." The man nodded, looking impressed.

"Callisto Corp...it's such a huge engineering conglomerate. They do a lot of good work. You must have seen a lot of amazing things there," the supervisor said, still nodding.

"I started off in the fusion reactor department then went to the advisory division there," Grace explained, "so I rotated between a lot of different projects, helped make sure things were on track." The twinge of nostalgia for her old job that Grace had been feeling all day blossomed into a deep longing. A cheery dinging noise echoed through the platform, the last call for passengers to board. Grace bid farewell to the supervisor and boarded the train.

The train ride back to Grace's dome was about an hour long. She sat in an almost empty passenger train car; most people at the mirror assembly dome were still working, and there weren't exactly many people trekking out to the dome in the middle of the day for a job interview. A large map of the train system was plastered on the side of a wall next to Grace; even though she had the system memorized she loved sitting next to maps and studying them on every train ride.

The Callistan Republic was made up of dozens of domes, each of them plotted on the map along with faint traces of major craters, canyons, and other topographic features. The locations of all the domes had been carefully planned in advance following a master plan

laid out decades ago. The locations of future residential, agricultural, and industrial domes that had yet to be built were also all planned out, enough domes and living space for a population five times the current one. As she looked at the map, Grace mentally dropped pinpoints on other important sites around Callisto - fusion power plants, spaceports, and mining settlements. For the second time that day, Grace reflected on the audacity of it all. Out here, hundreds of millions of kilometers from their home planet, humanity had built a thriving nation on an otherwise barren rock. It was a testament to mankind's ingenuity and engineering prowess. It was also a grand project that Grace wasn't sure she was a part of anymore.

The train pulled into a stop under one of the residential domes. For a moment, Grace contemplated hopping off and wandering through this neighborhood she had never been in. It was an upscale area, and even had a small lake in the middle of the dome - perhaps the perfect place to contemplate why she was still working on *Einstein*. She had signed up to work on the telescope because of James's insistence but also because she saw it as the next big engineering challenge. Grace drummed her fingers against the window of the train. But what was the point of an engineering challenge if it wasn't helping Callisto? Making a tower of dried spaghetti was also an engineering challenge, but not a particularly fruitful one. Too lost in thought, Grace stayed onboard until after the doors had slammed shut and the train began accelerating away. Perhaps she'd see the lake another day.

Grace continued pondering her new job offer. Callisto's population was growing faster than expected, boosted by a steady flow of immigrants. The government had accelerated construction of new space mirrors and agricultural domes to stay ahead of the expected growth. A new generation of mirrors would soon be launched, and in her new job Grace would be managing the accelerated construction cadence. The job ticked all the right boxes and was just the type of engineering that she missed.

"Will *Einstein* still happen without me?" Grace asked out loud to the empty train car. She paused for a moment, not daring to say the words that had been floating through her mind.

"Does it matter if *Einstein* doesn't happen?" she blurted out. The unfilled seats on the train stared back at Grace noiselessly. She had wondered for a while if *Einstein* was just a vanity project, something to keep scientists placated and intellectual talent on Callisto. The train jostled slightly as it pulled into the next station. Grace saw several passengers waiting on the platform and again was tempted to get off for some wandering.

The domes that dotted the surface weren't the only inhabited spaces on Callisto. There was also an intricate network of tunnels and excavated areas beneath many of the domes. Besides

train stations these underground areas housed industries, storage tanks, and a handful of shops and restaurants. At this particular stop was one of the largest underground shopping malls on Callisto. It had once been a giant bomb shelter during the early days of the Callistan Republic but had since been retrofitted for cheerier purposes. For the second time, Grace stayed in her seat and watched the train pull out of the station.

Her day to day work was still very interesting, Grace admitted to herself. Designing the telescope and seeing its numerous pieces come together was still something she looked forward to in the morning. And the image processing software that was coming together was by itself an engineering artwork. Grace stared out the window again, wrapping her mind around a puzzle that had bothered her from day one. The Callistan Navy was awfully interested in *Einstein*. Maybe *Einstein* to them was just a testbed for their *Sheridan* drive. But there was still the image processing tech that Lucy had hinted the Navy was so keen to see finished.

The train finally pulled into Grace's station. She pushed aside her thoughts and tried to focus on the decision at hand: whether to stay on *Einstein* or leave. Being an engineer was what Grace had wanted to do for as long as she could remember. She had gone from being just one of hundreds of engineers designing wiring for fusion reactors to overseeing hundreds of other engineers. Engineering was about helping people, about building a place for humanity to live and prosper. It was just getting hard to see how *Einstein* was helping anyone other than people like James prosper.

When she got to her apartment, Grace pulled open her mailbox and found a postcard from one of her younger brothers. She had two younger brothers, a pair of twins that both worked in construction. They talked regularly but still sent each other physical mail, which today was a welcome distraction from the puzzle going through Grace's mind. She walked into her apartment, shut the door behind her, and plopped down onto the couch in her living room. The postcard was of a shipyard near *Lakhani* spaceport, where the Callistan Navy built ships to patrol the space around Jupiter. Grace admired the picture before turning to the opposite side and began reading:

Grace -

Hey big sis, hope you've been doing well! Construction has been booming down at the ports - tons of overtime shifts and not enough hands to take all of them. I don't know what the Navy is going to do with all the ships we're building for them but hey I'm not complaining. I read an article about that telescope you're working on. Pretty cool stuff! How long before you guys find aliens with that thing?

-Ace

The smile on Grace's face slowly rolled off. When would they find aliens? Would they find anything interesting on Trappist-1e at all? There was so much to do on Callisto - domes needed to be built, mirrors needed to be launched, communication systems needed to be upgraded. Her brothers were building ships for the Navy and assembling mirrors in orbit and what was she doing? Grace frisbee tossed the postcard toward her desk but missed; it skidded off and landed on the floor.

"Maybe I should leave," Grace said out loud to the empty apartment. After another minute, Grace rolled off the couch to pick up the postcard. It had landed with the picture of the Navy shipyard facing up, and as Grace stooped down to pick it up she paused and admired the sleek, partially built ship on it. It was part of the Wickes⁸ class, a smaller spacecraft designed mostly to patrol the space around Jupiter. Occasionally these ships were sent to escort larger spacecraft on long cruises to distant asteroids and other planets. Despite having a smaller population and economy than Mars, the Callistan Republic had a big advantage when it came to building spacecraft - gravity, or rather a lack of it. Callisto's small size and low gravity made it easy to build ships and infrastructure on the ground and send it into space.

"I'm working for the Navy too," she said, scooping up the postcard and sitting cross legged on the ground. She stared at the picture. The Navy was spending a huge sum of money on *Einstein* and of all the institutions on Callisto the Navy was by necessity one of the most pragmatic. This couldn't be just some vanity project. This wasn't about hunting for aliens or solving the mysteries of the universe. The Navy wouldn't be interested in that. There was another purpose to this, something closer, some other reason that *Einstein* was so important. Clearly they wanted to test the *Sheridan* drive and use their image processing algorithm. Grace just couldn't figure out for what.

"I'm not James, I'm not looking for aliens," Grace said to the postcard. She gripped it tightly, staring at the picture of the half completed spacecraft, "I'm working on *Einstein* for the same reason the Navy is. For Callisto."

Grace smiled to herself and ran the thoughts through her mind again. Yes, it made sense, it all made sense to her. Grace stood up and started straightening up her apartment. As she cleaned she ran the same logic through again. This wasn't about aliens, it was about Callisto. After an hour of dusting the same places over and over again. Grace plopped back onto her couch. She would still need a few days to decide whether to stay on *Einstein*. But it felt like a tipping point of sorts had been reached, that she had already started to settle

on one side of the argument swirling in her head. Grace reached for her phone, opened it, and saw a message from James. Her eyes widened as she read the message. Stopping only to read the message a second time, Grace stood up and ran towards the door.

8 Chapter 8: Fractures

“What exactly did Lucy say?” pressed Grace. “Are you sure you didn’t mishear her?” Grace and James sat in James’s office as he recounted his conversation with Lucy. Night was starting to fall in the city as the bright lights of the dome were slowly dimmed. James shook his head.

“I didn’t hear wrong. She said...she said we had to finish or *Einstein* would be dead,” James recounted. “That...that killing a project that was on track would look suspicious. But she didn’t say suspicious to who.” Grace paced around the room, her brain struggling to understand. Some of the pieces were floating together.

“We’re a weapons research project...” she said slowly.

“Yeah, I try not to remember,” mumbled James. “I guess the Navy will want to keep working with civilian engineers in the future. Binning a big project like this if it were on track would look bad, put a sour taste in a lot of mouths.”

“I’m sure that’s part of it...but it doesn’t...it doesn’t raise suspicion,” said Grace. The two sat in silence, again pondering what Lucy had said. James stared up at the ceiling of his office at a poster of Jupiter he had taped to the ceiling. Next to it was a poster of the Trappist-1 system, the solar system *Einstein* was set to one day take pictures of.

“If *Einstein* was behind schedule then it would make sense to kill it, it’s just the Navy saving cash,” he said thoughtfully. Grace nodded while staring at her shoes. She began spinning back and forth in her chair while she wrestled with her thoughts.

“But if the Navy pulled the plug while we were on track then it would look like...it would look like...oh...” Grace trailed off, her eyes starting to drift off. She gazed at the wall silently for several long seconds. James turned to look at Grace, staring intently as they tried to pick apart this puzzle.

“It would look like what?” he asked. His eyes were wide open, nearly jumping out of their sockets.

“It would look like a weapons program,” Grace said quietly. For several seconds, a loud silence echoed through the room.

“But it is a weapons program,” replied James with a confused look. He paused to think for a moment and drummed his fingers against his arm rest. Finally he softly spoke up. “canceling

would tell everyone it's done." Grace sat motionless for a second, then nodded slightly.

"That's brilliant," whispered James. "They let us finish the telescope and all of our work is a cover, it's a mission for science and the Navy happens to be kind enough to fund it."

"And if they kill a program that's behind schedule and over budget, no one wonders why," said Grace nodding. Like a ray of light, the rationale was methodically falling into place. "But ending a program that's on track announces exactly which parts were needed by the Navy and which parts it doesn't care about."

"So the only way we get *Einstein*..." said James slowly, the enormity of the task washing over him, "is to finish her, fast." The two sat in silence. Outside the city lights had dimmed to a mere afterglow, with only the streetlights illuminating the roads.

"We have to tell the team," said James, breaking the silence. He stood up suddenly as if to make the announcement in the next minute. The chair he was sitting in slid back and noisily crashed into a bookshelf.

"No, we have to think this through!" shouted Grace. She also stood up. "Did Lucy say anything else?" James paused for his moment, his mouth moving noiselessly as he recounted the meeting

"She said that I didn't know this, that all I knew was we needed to get *Einstein* finished." James said with his eyes closed, his face scrunched together from the effort of recalling Lucy's words. Grace stared back at James with an exasperated look. Her doubts about staying on the project bubbled up again but she pushed them aside. She would deal with that later.

"James we can't just run off and tell people this project is on the chopping block! We tell everyone this project will be cancelled...people will leave in droves! Lucy could lose her job over this! They'll find out she told us!" Grace said with an anguished look. James collapsed back into his chair and covered his eyes with his hands.

"No one will find out was Lucy told us, and even if the Navy does what's the problem?" challenged James.

"She...they...when Lucy told you this what was she like? How was she acting?" asked Grace. She had sat back down and resumed spinning side to side in her chair.

"She was...definitely being secretive, trying to keep this under wraps..." trailed off James. He rested his head in his hand, rubbing his temples thoughtfully. Grace shot back a look of

triumph.

“This must be something classified; we’re not supposed to know about this. Lucy is trying to protect us, trying to protect *Einstein* from being cancelled. We go around telling people we know the project could be killed and Lucy’s going to be in a world of trouble,” Grace said quickly. James looked back at her, trying to see a loophole or a way around her reasoning.

“You’re...right,” he forced out. After a long pause, he sat up again and turned to Grace, “I hate this but you’re right.” Grace smiled grimly and nodded. The two sat in silence, both absorbing the task that laid ahead. Innumerable problems remained to be solved and there was still a world of new ones that had yet to rear their heads.

“How was your family thing?” asked James casually, trying to lighten the mood. He had stood up and was reaching for a beer in his fridge.

“It wasn’t a family thing, it was an interview.” Grace said to her feet. James slowly turned around and looked at her.

“An interview to work on the orbital mirrors,” she finished. James looked like he had seen his table start doing backflips while engulfed in flames.

“Grace...” he started in a wavering voice.

“I’m not going to take the job,” she said simply. A look of joy and relief exploded onto James’s face and he began breathing normally again. Grace looked back with a slight smile. “I’m staying here, I’m doing this for Callisto. Now hand me a drink.”

James and Grace worked feverishly the next months, pushing their team along with them. Days bled into the nights while weeks bled steadily into the weekends until life was a constant blur of work. While the engineers on the ground plunged deeper into putting *Einstein* together they remained blithely unaware of the dangerous game that continued to be played out above their heads hundreds of millions of kilometers away. Like a game of Russian Roulette, each new incident and emergency threatened to blow the system apart.

“This is the *Keppler*, of the Callistan Navy. Please reply,” enunciated a radio officer. He was a young man, only a few years into adulthood. He clung to his headset and tensely awaited a reply; only static greeted him.

“Still nothing, Officer Kent?” asked the ship’s captain. Officer Kent shook his head, his bright green eyes drooping sadly. He stared at his radio set, as if willing a reply to come through and greet him.

“No sir, but I’ll keep trying,” Officer Kent replied determinedly. He’d been promoted to officer just weeks ago and was serving on the *Keppler* for the first time. The captain gave him a quick nod and strode to the center of the bridge where two other officers joined him. They were on a routine patrol high above Jupiter where only the small and forgotten moons plodded around in their lonely orbits. Officer Kent continued fiddling with his radio nervously but heard only different types of crackling. He looked up at the captain and officers and caught snippets of their conversation.

“Could be a trap...”

“It’s just like how they got the *Glennon*...”

“Prepare the missiles, I don’t want to be surprised...”

Growing more tense, Officer Kent continued flipping between channels. He heard static, meaningless clicking, and more static. For a moment he paused and then flipped back to the clicking. The captain floated over to him noiselessly.

“Son, you heard anything from them?” the captain asked patiently.

“No sir, just some clicking,” Officer Kent replied with a shaking head. The captain looked at the radio operator, less than half his age, and nodded slowly.

“We’re counting on you Kent. You’re going to have to tell us if that ship floating out there is trying to ask for help or another booby trap,” he said sternly.

“Yes Captain,” nodded back Officer Kent. He breathed out slowly and closed his eyes, forcing himself to focus. Again he went through the standard procedure, flipping between channels and listening with all his might. With a few keystrokes algorithms joined him and began parsing the radio waves, searching for a signal.

“Come on, come on,” he whispered to himself. Again he switched back to the clicking channel. The *Keppler* had picked up a derelict ship on radar, drifting well outside any normal trade lane. Normally the Callistan ship would have scooted up and boarded the ship to search for survivors. But these were far from normal times. Officer Kent stared at the wall and listened to the clicking pattern with every ounce of concentration, trying to will

some meaning out of it. He struggled to find some shining reason not to launch their missiles as the minutes grimly ticked on. Behind him the senior officers continued to debate.

“It’s just like the *Glennon*, they plant a dead ship, we sidle on up, and boom we all get blown to kingdom come.”

“How’d a bunch of terrorists get a ship to turn into a booby trap?”

“Probably some help from the boys in red if you ask me...”

“Last chance Kent, you got anything?” the captain asked again. Officer Kent looked back up, his bright green eyes shining sadly.

“No sir, just more clicking,” he replied crisply. The captain shook his head sadly.

“You’ll understand one day, but the best weapon is the one you never have to use,” the captain noted with a stoic look on his face. He looked off at distant console while still talking to Officer Kent, as if venting about a long work day to a therapist. “Higher ups want us to clear any ship without a transponder in case it’s another terrorist trap. Trigger happy dunces with their heads safely under a dome but...I follow my orders.” With another shake of his head the captain slowly floated off.

“Come on, come on baby,” repeated Officer Kent to the radio. Something was off. The clicking didn’t seem like noise; there was some pattern to it but the computer didn’t recognize it as any encoding. He breathed out slowly again and bored his eyes into the wall.

“It’s Morse code!” Officer Kent yelled out. The senior officers on the bridge and the captain spun around but Officer Kent had already started scribbling letters on a piece of paper. They crowded around his console like children watching their friend play a video game.

“It’s an S.O.S. call!” Officer Kent yelled triumphantly. He scanned his fingers over the characters and began nodding vigorously. “*Shelton* drive failure radio failure. Survivors send help.”

“Radio failure, but they’re still transmitting?” asked the executive officer.

“They’ve got some makeshift radio I think sir, they’re turning it on and off. That’s why it’s in Morse!” replied Officer Kent. His head felt warm but he knew that he was right.

“Look up the *Shelton*’s flight plan, how did it get out here?” barked the captain to another officer. Women and men raced throughout the deck, temporarily liberated from the burden

of firing their armaments. Officer Kent blinked rapidly at his console, praying there was a logical reason the Martian freighter had been thrown so far away from shipping lanes. The seconds passed like hours and Officer Kent's heart thumped relentlessly.

"We got it sir," a woman reported, "pulled up the flight plan and ran some simulations, we think the drive went dead on the outbound leg and got tossed out here by an accidental gravity flyby past Io. We're running the sims again but the story checks out." The captain nodded approvingly.

"Keep checking but I think it's safe to say it's not a terrorist trap and we don't need to use it as target practice. Nav, bring us in," called out the captain triumphantly. At his console, Officer Kent breathed a sigh of relief and hung his headset up on a rack, rubbing his bright red ears. The captain drifted over to him again.

"You did good son, you did good," the captain said with twinkling eyes.

Down on Callisto the distant tip toeing and delicate decisions happening aboard the Navy's ship barely garnered a news story. Grace and James continued working incessantly, throwing themselves into turning *Einstein* from a dream to reality. The weeks blurred into marathon sessions of work, with no weekends and few breaks to mark the passage of time. But the pressure inexorably spread to the rest of their teams. Several months into their new regimen Grace found herself staring at a table. She was in a meeting but couldn't remember what for; her mind had temporarily gone numb.

"Grace, Grace you okay?" an engineer asked. Grace blinked rapidly and shook her head. She turned to the engineer, who also had a matching set of bags under his eyes.

"Sorry Ulysses, I'm fine," Grace said unconvincingly. She reached for her cup but missed, her hand slapping uselessly against an empty patch of table. Blinking again, she pushed backward out of her chair and stood up. It was too sudden, and she instantly felt lightheaded and saw the conference room blurring before her.

"No, you're not okay," Ulysses said firmly. He got up and helped stabilize Grace. "You're pushing too hard, these last few months have been insane."

"Grace, what's going on," asked another engineer in the room. "You look like you haven't slept in weeks and you've looked that way for months. I mean we're all tired, but you

especially.” Grace rubbed her head. Things were starting to come back to her.

“Vega, we need to keep pushing,” she mumbled back semi-coherently. Her head was still throbbing. “Keep pushing and stay on schedule.”

“Grace, this is getting ridiculous,” Ulysses said sternly. He had been on the project for nearly six years; only a handful of people matched his tenure. “We can’t keep up this pace, morale is the lowest I’ve seen. You’re asking people to suddenly go into crazy mode but we don’t see why.” Grace sat down again and stared at her fists on the table. She was nearing a breaking point. The gap between timeline and reality had slowly begun to close but they were still far from being on schedule.

“Some of the people on my team...they’re thinking about leaving,” said Vega grimly. She looked from Ulysses to Grace. “The hours are impossible and none of us know why it’s like this. Is it the Navy? Have they been pushing this?”

“Yeah, it’s the Navy,” said Grace. For the past few months James and Grace had vaguely attributed the quickened pace to their benefactor’s impatience. But the explanation was beginning to grow tired and feel trite. People were starting to crack, unsatisfied by hearsay and rumors of budget cuts.

“Maybe James’s announcement will clear things up then,” dropped Ulysses casually. The blood drained from Grace’s face.

“James is making an announcement?” she said. Grace began standing up again slowly.

“Uh yeah...he called an all hands...” replied Ulysses uneasily. Grace had been too busy to check her email. “I think it’s happening right now actually.” Grace froze, staring at the wall. She quickly processed what this meant. The Navy would realize James and Grace knew their project was on the chopping block. They could very well trace it back to Lucy. Engineers would pile out the door, leaping off the sinking ship that their project was becoming.

“And where is this announcement taking place?” Grace asked slowly. Vega and Ulysses glanced nervously at each other and then at Grace. Vega told her. Grace nodded slowly, calmly walked to the door, and took off running.

Grace sprinted through the halls, leaping down a staircase and nearly landing on a table. Her breath was fast and ragged and her heart thumped painfully as she rushed to the door. Down the hall she could hear James’s voice echoing on a microphone. She burst into the room and saw hundreds of bodies, with James elevated on a makeshift stage.

“The Navy is plotting to kill this project. But even under the threat of cancellation, even under the threat of having our work cruelly ended we need to persevere!” his voice boomed out. “You’ve all put in so much work and sacrificed so much. And that’s something Professor Mercer and I are eternally grateful for.”

A few of the engineers near Grace turned to her and smiled appreciatively. Grace looked around wildly, staring at James as if by sheer willpower she could get him off the stage. A small ripple of applause rose from the crowd.

“I understand that these months have been hard, and I understand that many of you have family and other obligations you need to spend time with.” James said kindly. “And I understand that for some this lifestyle isn’t the one you want. If you need to leave the project, then I understand and I can’t thank you enough for what you’ve done.” James’s voice hardened and it reverberated out, thick with resolve. “But if you stay, you’ll get to be a part of history. Part of the team that first uncovers an alien planet, perhaps the first to ever discover an alien civilization. It will be the greatest discovery of the our time, perhaps of all time. These years and months of work will be remembered for centuries!”

Grace scanned through the crowd and saw a few shaking heads. But they were drowned out by the clapping hands and pumping fists that rose above the cheering crowd. Grace staggered back and looked up at the stage and saw James blasting the crowd with his trademark grin, his arms outstretched as he basked in the applause. Rather than sad resignation, the room was electrified with the sound of hardened resolve and endless enthusiasm. James caught Grace’s eye and smiled even wider.

9 Chapter 9: Lucy

A week later, Lucy sat in a cramped room before a panel of Navy officials, struggling not to look at the clock.

“Officer Sodo, even with the recent progress it’s getting harder to justify continued funding for *Einstein*,” a dark haired woman behind a metal bench said to Lucy. Lucy nodded respectfully from her chair in front of the wall of uniformed officers. She had been to plenty of these hearings but they always felt more like interrogations than meetings.

“Understood, Admiral Magnolia. But the image processing software the team is working on isn’t ready for the Navy to take over. Not yet,” Lucy replied stoically.

“Playtime is over for the scientists,” Admiral Beacon smirked from off to the side. He smiled tauntingly and shook his head, “there’s no reason to keep funding their toy, our guys can take it over from here. We got the *Sheridan* drive anyways, we don’t need what the scientists are cooking up.” Lucy tried her best to resist rolling her eyes. With all the practice she had, it wasn’t hard.

“Thank you, Admiral Beacon, but the discussion will be based on current progress and not whether you think it’s still playtime,” snapped back Admiral Magnolia. She was senior to Admiral Beacon, and Lucy couldn’t help but smile a little at her brusqueness.

“The engineers and scientists at the Institute have been working a tremendous amount lately; they’re nearly back onto the original schedule,” Lucy reminded the board, “And if we intend to continue working with the Institute, it’s important to preserve goodwill. Canceling *Einstein* could come back to cause trouble down the road.” The hearings were nearly over, but she felt this was worth reiterating. She’d been in this room for nearly three hours and couldn’t wait to get out.

“Thank you very much Lucy, and as always we appreciate the hard work you’ve put in leading this project,” Admiral Magnolia said unexcitedly. Lucy thought she caught an actual glimmer of genuine appreciation in her tone. It was hard convincing the funding board that *Einstein* was worth it, but Lucy suspected Admiral Magnolia was starting to see that this could be one of the biggest breakthroughs for the Navy in a generation. With a tired flourish, Admiral Magnolia dismissed the room and began swiping on her tablet.

Relieved, Lucy walked out of the room while trying not to look too eager to get out. It was almost evening and Lucy had been working for twelve days straight. She had made plans to

get dinner with Grace at a restaurant near the Institute in a few hours and decided to give herself the evening off. The two women had grown closer over the years while working on *Einstein*; they swapped stories from their respective years studying nuclear fusion engineering at the Institute and enjoyed each other's company. Stopping briefly at her home to change out of her uniform, Lucy soon headed to the Institute.

As the train glided towards her destination, Lucy pulled out her phone. She skimmed through the news but it was littered with the same types of stories - news of a local election and updates on various construction projects throughout Callisto. At the margins were brief pieces about more trouble in the solar system, more elbowing over unclaimed asteroids, more stick brandishing and threats of conflict. Lucy sighed and instead read messages from her adult son and daughter, one who worked for the civilian government and one who worked in engineering. She rarely saw her children but was immensely proud of both of them. The train gently slowed down and Lucy quietly stepped out towards the Institute.

Just as she had planned, Lucy still had a few hours before meeting Grace. Even though she was often on campus for meetings, it had been a while since Lucy had really taken in and enjoyed the scenery. She had spent two years here earning her Master's degree in fusion engineering, two years that she had loved dearly. Lucy had contemplated completing a doctorate like Grace, but halfway through her second year found her calling elsewhere. As she wandered around campus, Lucy found herself gravitating towards the library that stood proudly above the Institute.

Lucy stood on the outskirts of the library, looking upwards where she knew a stairwell snaked up the side of the building. Memories from her many nights working here flashed back and she stopped briefly, wondering whether to go inside. A thought flickered in the back of Lucy's head. Surely it wasn't still here. It must have been decades since they painted it. Lucy looked around the pond in front of the library, and for a moment contemplated sitting by the water and enjoying the company of the ducks that bobbed on its waters. Finally, curiosity got a hold of Lucy and she opened the door to the stairwell.

Once inside, Lucy found a ladder she knew was next to the staircase and gripped the bottom rung. The ladder was used for maintenance and ran continuously up to the roof. It sat in an open space next to the stairs that zig zagged up the side of the library, to the ninth floor. She paused for a moment and hesitated. It would look so silly if someone found her here, a Navy officer climbing a maintenance ladder next to a staircase inside the Institute library. But there was nothing really wrong with being here, and she could always pretend she was here exercising or just floating around. Gripping the ladder more tightly, Lucy kicked off the

bottom rung and started floating upwards.

In her early years Lucy hadn't been interested in politics or what went on in the wider world. She loved her country dearly, and became an engineer to help build Callisto. After a few years of work Lucy went to the Institute hoping to land a promotion and pivot into designing fusion power plants. By chance, she befriended a group of doctorate history students during her last year at the Institute.

After climbing a few meters Lucy paused and found what she was looking for - faded white lettering on the side of the staircase. It was painted on the outside edge of the staircase, where no one walking up and down could see. The only vantage point where the lettering was visible was from the ladder where Lucy was, where she and her friends had spent hours climbing and painting in the final few months before she graduated. The words in Lucy's handwriting read:

The story of the Callistan Republic begins on two planets, Earth and Mars.

Unsurprisingly, the history doctorates Lucy met were passionate about the founding of Callisto and how this lifeless, barren rock became the third largest oasis of humanity in the dark desert of space. One of them hatched the idea to write the history of their nation on the side of this staircase, a testimony to their home. Lucy and her friends spent months ascending and descending this ladder, lugging gallons of paint and dodging campus security. When they finished, they had written a history of Callisto along the edge of the entire staircase.

But next to her words Lucy found something that she and her friends hadn't left - a small mural of Earth and Mars, left by another student. It must have been painted by a younger student after she had graduated. Lucy looked upwards and could see splotches of color that looked like other murals. Lucy pushed off and continued scaling the ladder, eager to see what other murals and drawings were beside the words she and her friends had left behind.

The first humans on Callisto were sent by one of Earth's oldest space agencies in the middle of the twenty-first century. They built a tiny base manned by astronauts who shuttled between their home planet and the desolate moon. Just as Lucy had hoped, she found a small drawing of the original base, a small trio of domes that was now designated a national monument. Looking more closely, Lucy noticed the paint didn't look faded; either it had been painted recently or someone had been touching it up.

The base was the beginning of Callisto, but it was hardly much of a start. The astronauts were explorers, not colonists; astronauts rarely stayed and for decades Callisto was never

home to more than a dozen people. Lucy stopped at a larger, more detailed mural of Mars than the one at the bottom of the staircase. It was shaded a ruddy red, but with thin dark lines snaking across the surface. Unlike Callisto, Mars had truly been colonized by humans. Different groups from Earth laid claim to Mars, slicing up the Red Planet into different territories and soon nations. But while the colonists from Earth largely left behind the differences they had on their home planet, new divisions soon erupted.

Lucy heard a loud bang above and threw her head back to look. Someone had opened the door to the staircase, but the footsteps were growing quieter not louder. By now, she was far too curious about what other murals were here to care much about being seen. Lucy pulled herself up a few more rungs and was greeted by a fleet of painted ships. As the nations on Mars grew, the friction and tensions between them grew commensurately. One by one, the governments on Mars were transformed from fragile democracies into authoritarian states and military dictatorships as the drums of war beat louder. Life on Mars had always been difficult, and the challenges of staying alive and competing for resources made freedom and liberty secondary concerns.

In each of the half dozen Martian nations there were pro-democracy activists and thinkers who fought for a return to elected governments. These activists were a common thorn in the side of the Martian countries sliding towards despotism. Many of them fled Mars, either back to an Earth that had never truly been their home or to one of the backwater colonies springing up on large asteroids. The ones who stayed were finally expelled by their respective governments, along with their families and anything that tied them to Mars. The countries on Mars exiled their own citizens to Callisto, the most distant human settlement from Mars, where they would be too concerned about survival to agitate for democracy on Mars.

The banished Martians set off on a long journey to Callisto. When their fleet of spacecraft finally arrived, they were greeted with open arms by the astronauts living there. Lucy reached out and touched the words that one of her friends, who later became her husband, had written on the staircase:

The Callistan Republic was founded by pro-democracy Martian exiles and the astronauts that welcomed them on Callisto. The day is now commemorated as Founding Day.

Lucy couldn't help but laugh out loud when she read this. Her future husband had practically wanted to write a small book on this stair, explaining the intricacies of how the Callistan Republic was born and how its constitution was written. But Lucy had convinced him otherwise - that messy year long effort was best left in a history book and not here. One of the most difficult questions the founders grappled with was whether their new nation should

have a military. Many of the colonists had watch militaries covertly vacuumed up power on Mars, which was now devolving into a grisly civil war.

Ultimately, fears that the inferno on Mars would spread throughout the solar system motivated the Callistan Republic to build a military. Old spacecraft destined for the scrap heap were converted into makeshift warships. These rust buckets didn't stand much of a chance against the vessels Mars, which was soon engulfed in violence, was churning out but they were still better than nothing.

Lucy crouched down on the ladder, then like a grasshopper kicked out her legs and shot forward. In the low gravity of the moon, she flew upwards and nearly overshot the next mural and written message. There, next to the words one of her friends had carefully painted was a bar chart showing the exploding population of Callisto:

In its early years, the Callistan Republic grew rapidly from an isolated outpost to a large, permanent settlement.

The first few years were difficult for the new country and its people struggled to survive. What they called a republic was truly just a few hundred people, but Callisto grew as a base for mining asteroids and harvesting precious gases from Jupiter's clouds. For nearly three decades, the young democracy flourished and new domes were built to a carefully laid out master plan.

More slowly now, Lucy climbed up to the next panel. The ground beneath her was a small, just barely visible dark landing at the bottom of a long fall. But like most people on Callisto, Lucy wasn't afraid of heights; here gravity was so weak that a fall from seemingly outlandish heights was perfectly safe. Lucy let out an appreciative gasp when she saw the next mural - a beautiful map of the solar system, showing the orbits of Mars, Jupiter, and the Martian fleet that had nearly wiped out Callisto. Lucy had studied this map carefully when she joined the Navy and could tell the orbits were a near perfect copy of what was in her textbook.

The newly formed Mariner Valley Alliance (MVA) from Mars sent a fleet to annex Callisto, claiming it was a breakaway province and a colony of the MVA. The period when the fleet was on its way to Callisto became known as the "Year of Fear."

Lucy swallowed hard as she reread the words that she had written years ago. Learning about the Year of Fear from her friends was one of the reasons she had joined the Callistan Navy. After the Martian Civil War finally ground to an end, the Mariner Valley Alliance emerged as one of the victors. The Alliance had forcibly annexed several of its Martian neighbors and

now looked greedily at prosperous Callisto. History books were rewritten - instead of exiles, Callisto's founders were rebranded as colonists sent from Mars. The Callistan Republic was slandered as a renegade colony that had run away from her home country. Flush with victory, the Mariner Valley Alliance dispatched a fleet to forcibly annex Callisto.

The launch of the fleet caused a panic on Callisto. The Alliance's warships were far superior to Callisto's, and a battle in the space near Callisto could lead to the young republic's destruction. If the fleet reached Jupiter, some the Alliance's ships could easily slip past the Callistan Navy and annihilate the domes and spaceports that had been so painstakingly built. Some members of the Callistan Senate hatched a daring plan. Instead of waiting for the Alliance's fleet to arrive, they proposed sending Callisto's meager navy to intercept them in deep space.

The plan was fraught with risks. The bulk of Callisto's Navy would have to be dispatched, leaving the Republic almost defenseless. Intercepting the fleet would require a huge amount of fuel, and most of Callisto's ships would only just be able to confront the fleet and still have fuel to return home. Finally, there was the challenge of just tracking and being able to find the Alliance's fleet in the vast emptiness of deep space. It was the same game of cat and mouse that submariners had played for centuries, trying to detect their enemies in Earth's oceans without being seen themselves.

The chocolate soldiers of the Callistan Navy departed to meet the Alliance's fleet in deep space between Mars and Jupiter. Back at home, scientists and engineers worked to track the enemy ships.

Chocolate soldiers⁹. It was the derisive name given to the Callistan Navy by the Alliance, the tauntings of a military state towards what was effectively an army of civilian soldiers. But Callisto proudly embraced the label. While the two fleets sailed through space, a group of the Institute's professors and students worked tirelessly to track the approaching Alliance ships. New signal processing and detection algorithms were invented from scratch. The programs were loaded onto tracking satellites that had been clobbered together and hastily launched into space. For months the people of Callisto waited for the day that their fleet was supposed to intercept the enemy ships.

Lucy closed her eyes and imagined the terror that must have swept Callisto. Her dad had been on one of the Callistan ships sent into space. He had told stories of how they didn't know if they would ever find the Martian ships, or if they would stumble through space while Callisto was wiped out. But the scientists and engineers at home did their jobs right, and the Callistan Navy soon found the Martians right where they were supposed to be.

The Callistan Navy met the Alliance fleet in the space between Mars and Jupiter. The appearance of the Callistan Navy was a huge surprise to the Martians.

Now at the next mural, Lucy could see a drawing of the two fleets intersecting in space. She tilted her head and counted the ships. There were thirteen Callistan ships drawn but in reality only nine belonged to the Callistan Navy - the remaining were supply vessels or civilian ships hastily outfitted with missiles and radar. Even with these tin cans¹⁰, as the additional ships were affectionately called, the Callistan fleet was outnumbered three to one. A huge debate had been raged in whispers and behind closed doors about what to do once the Callistan fleet found the Martian ships. Some members of the Senate and the military lobbied hard for a sneak attack, a sudden strike that would preserve the element of surprise and wipe out the Alliance fleet.

But the president of Callisto had disagreed. He believed that violence would lead to more violence and that the destruction of the first fleet would only lead to the arrival of a second, more powerful force. Instead he ordered the Callistan Navy to send a warning to the Martians, hoping to scare them into returning to Mars. The Callistan ships used false radio signals and decoys to deceive the Martians into thinking that they were only the vanguard and that any day a second, much larger Callistan fleet would burst onto the scene.

Miraculously, it worked. Lucy couldn't help but do a small, celebratory fist pump on the ladder as she admired a mural of the Martian ships returning home. The sailors of the Callistan Navy returned home as heroes while the scientists and engineers on Callisto became celebrities.

The day the Martian fleet returned home is now celebrated as Callisto's Independence Day. The modern Callistan Navy's motto was also born out of the conflict: Strength in deterrence.

Strength in deterrence. Lucy smiled reading the words, the same words she had recited when she joined the Navy and gave an oath to protect her home world. Climbing this ladder and painting this memorial had given her best friends, a husband, and a sense of purpose in her life. Her passionate friends had taught her the full story of their little republic's beginnings as they painted this mural on the staircase. They would often spend hours at the roof of the library, marveling at the city around them and discussing its roots. After graduation Lucy signed up for the Navy and then began working in the Advanced Naval Research Division.

More quickly now, Lucy continued climbing up the staircase and reading the words she and her friends had left on the remaining stairs. Callisto had grown explosively after the Martian fleet turned back and soon expanded to Jupiter's other moons: research stations on Europa

and a small base on Ganymede. But Callisto was still home to the majority of humans around Jupiter, and the majority of people who lived out past Mars and the Asteroid Belt.

Finally, Lucy climbed past the last stair she and her friends had written on and floated upwards towards the roof. Turning to the side, she found a surprise - another staircase with white words painted on that she didn't remember. Someone had added to their memorial:

Since its founding, Callisto has preserved its proud democratic tradition. Today the Callistan Republic is the only democracy beyond Earth.

Lucy read the words slowly. Earth seemed like such a distant place, and she had never thought about the connection that Earth and Callisto had as the only places where people chose their leaders. Cautiously, Lucy pushed up on the hatch in the ceiling she knew led to the roof. It sprung open and Lucy pulled herself up before carefully shutting the hatch. She took a moment to admire the view around her, the Institute stretching before her below and Jupiter hanging above her in the sky.

It was a sad thing to contemplate. Mars was still governed by a patchwork of nations, either outright military dictatorships or strongmen hiding behind a facade of democracy. The small settlements on different asteroids were run by corporate governments or lawless anarchies. Democracies continued to thrive on Earth but Earth was such a faraway and remote planet to the people on Callisto. It was a healing planet, steadily recovering from the ravages of climate change. Water shortages had at one point become so grim that countries dynamited huge chunks of the Antarctic ice cap off to harvest freshwater, a practice that only accelerated sea level rise. The governments on Earth were now more concerned about fixing their world than expanding to other ones, and so Lucy rarely thought about the planet or her kindred democracies.

Lucy paced around the roof of the library and listened to the hum of ventilation machinery. Her feet wandered over to the ledge of the building, where she had often stood and admired Callisto while she was a student. The great contradiction of Callisto lay before her. From Lucy's vantage point looking down from the library it all looked so grand and permanent, like it was perfectly natural for the city beneath her to be there. The buildings, the trees, and the neatly arranged streets all looked so rooted and immovable. But when she looked up at the stars, the great slice of civilization diminished into a fragile outpost of humanity that the dark empty sky threatened to swallow up. It was hard for Lucy to juxtapose these extremes in her head: the engineering wonder that Callisto was and the fragility that permeated every piece of it.

Einstein was another way to protect Callisto, another small rock in the levee that kept destruction at bay. Lucy stared hard at the edge of the dome, where the glass ceiling curved downwards and was anchored to the moon's surface. Finding aliens with the telescope was of course never going to help protect Callisto. But for a moment, Lucy closed her eyes and imagined the breakthrough that would come once the telescope's software was adopted by the military. Some of the senior leadership didn't realize how much was left to be done, how much the Navy still needed James, Grace, and their brilliant team.

Lucy's mind fell back to more pedestrian thoughts: her dinner with Grace. She pulled out her phone to check the time. Lucy's knees shook and she felt like she'd been walloped by a speeding train. She had dreaded this moment, even though she knew it might happen. On her phone was a message from Admiral Magnolia:

Your security clearance has been revoked. Report to headquarters immediately.

10 Chapter 10: For Callisto

“She’s really coming together, isn’t she?” asked James incredulously a year later. Grace gave a small nod. Before them in a pristine clean room *Einstein* took shape while an army of technicians in gowns and masks worked around her. The task of carrying *Einstein* forward had passed from the scientists and engineers to these men and women delicately assembling her - welders, crane operators, bolt fasteners, electricians, and workers with a whole zoo of other titles. Grace leaned over the railing and stared at a wide cylinder hidden beneath a giant tarp - the *Sheridan* drive’s reactor waiting to be added on. She remained silent.

“Grace...you’re not still...mad at me are you?” broached James carefully. Grace pursed her lips, still staring at the mysterious, literal black box that was the beating heart of their telescope.

“You cost Lucy her job,” she finally said with a shaking head. Lucy was too kind to be angry at James but Grace wasn’t above that. She had seen the sadness in Lucy’s eyes at *Lakhani* Port as she boarded a ship to leave Callisto. Thinking about it made Grace bitter, but more so angry. She distracted herself by watching two figures wrap insulating foil around *Einstein*.

“We had to...I had to. People needed to know the truth. The project would have been killed if we hadn’t told people. Everyone has been so much more driven and passionate after finding out,” James said. Grace stayed silent for a minute. He was right; she could see people work with so much more conviction after James’s announcement. And her fear that the staff would leave in droves had turned out to be wrong. Their efforts had really been heroic; in the past year the project had almost miraculously been pushed back onto schedule.

“We could have just pushed people and...I don’t know, blamed it on the Navy,” murmured Grace. James shook his head sadly. In front of them a metal truss was gliding through the air, suspended from a slow moving crane.

“People had to know the truth,” he repeated softly. The truss halted for a moment, bobbing back and forth like a pendulum.

“Well the truth got Lucy fired! It destroyed her career! Do you ever think about that?” spat Grace. “I just...just wish there was a way that hadn’t happened to her.”

“She hasn’t been fired, she was sent to another project!” protested James. A few months

after James's announcement the Navy had quietly dismissed Lucy from her position and reassigned her to a different project. There were whispers that she had leaked secret information and had a conflict of interest on the project. Charges were never pressed but she was sent away anyways.

"To Europa, James, to Europa! It's a backwater there, there's no serious research going on for someone like Lucy!" cried Grace. "They're practically still researching how to get indoor plumbing down there!" James stammered for a few moments then fell silent. The truss on the crane had begun moving again.

"I hope you're happy James," said Grace darkly. She stormed out of the observation deck, leaving James alone to watch the workers tightening bolts.

That same week Lucy stared out a rattling window. A great white snowball emerged before her, growing larger and larger through the hardened plastic. Red and brown streaks ran across the surface of Europa in criss crossing patterns. It had been a long flight - her ship had taken the long way, spending several months on patrol and was only now descending down to Europa. Just barely visible in the distance was a small cluster of lights - the base that Lucy would call home for the next few months, or possibly longer.

Lucy sighed as the spacecraft shuddered, creaking gently as the rocket engine ignited to cushion their fall. Around her were grunts, soldiers doing a rotation on the European base until they could get a better assignment. In some ways they were also exiles like herself. Except for them this was a necessary step for promotion; no promotion laid in her future. She pressed her face against the window and watched the red flames of the engine undulate outside. As the ground came up closer, Lucy couldn't help but smile a little to herself. Europa was absolutely beautiful. Its steep white icy cliffs and ragged geography made it a magnet for tourists, hikers, and low gravity thrill seekers. Many decades ago it was also the site of the greatest discovery by Callistan scientists - aquatic life beneath its icy shell.

The rocket shook again on its final approach and four creaky landing legs reluctantly snapped open beneath them just in time. Lucy knew she wouldn't be making any big discoveries down here - her assigned project had none of the vitality or significance of the *Sheridan* drive. Compared to Callisto, Europa was fantastic for scientists and tourists but not the site of much civilization; her icy shifting surface was much more treacherous to build on. Given the moon's closer orbit to Jupiter, Europa's radiation levels were also far more lethal. It was

generally accepted that Callisto maintained bases on Europa largely to keep others away. Lucy stole one last glance out the rocket and sighed slightly. Self pity was unintuitive to her but she still felt a twinge of disappointment in being here. She picked up her bags and marched off the rocket with the others.

“Officer Sodo, welcome to Europa,” a young naval officer saluted to Lucy as she stepped off. Lucy gave a small nod and saluted back.

“Let me show you to your quarters,” the officer said. Lucy followed the her down a dimly lit flight of stairs. The inside of the base’s building was simple but neat - thoroughly working class. Instead of spacious glass domes the buildings were half buried in the snow and ice and connected by pressurized tunnels, a necessary precaution from the onslaught of Jupiter’s radiation. Lucy swept her eyes across the rooms and noticed the rough contours of the wall - probably prefabricated on Callisto then shipped down.

The two walked silently to the Lucy’s new room where she would be staying for an indefinite amount of time. There would still be chances to fly back to Callisto, see colleagues and old friends, but for now the Navy had assigned her here. As she walked through the halls she couldn’t shake the feeling that she was a bit of a prisoner, an officer in exile. Truth be told it had been coming for some time now; even before she leaked the Navy’s plans to James there were constant grumblings that she was shielding the scientists and their vanity project.

“This is your room madam, it’s not much but I hope you find it fitting,” the officer said to Lucy. She opened the door. It was larger than Lucy expected; the room had no frills but was as neatly kept as the rest of the base and pleasantly well lit. A beaten but functional plastic bookcase stood beside an aluminum chair paired with a matching desk. All very functional for a land even more inhospitable than Callisto.

“This will do, thank you,” said Lucy with a gentle smile. She dismissed the officer and opened a pocket of her bag. Carefully she unfolded a worn poster of Callisto and pinned it to the wall. Next to it, she hung up a second poster stylized as a vintage travel pamphlet. It had been designed near the turn of the millennium by Earth’s most storied space agencies. Beneath the different hues of black, purple, and maroon were the words “Planet hop from Trappist-1e. Voted best ‘hab zone’ vacation within 12 parsecs of Earth.” Lucy stepped back, admired her posters, and smiled¹¹.

Several weeks later a Callistan military ship mysteriously went silent near a disputed aster-

oid. The Mariner Valley Alliance, which claimed the asteroid, quickly issued a statement expressing condolences for the “tragic disappearance.” A fleet of Callistan ships was hurriedly dispatched to search for wreckage. But by the time they arrived more weeks had passed and they came up empty, the ship seemingly consumed by the impossibly wide expanse of space. An emergency meeting was called by the Callistan Senate and debates rang late into the night. But James had no time to contemplate a disappearing vessel. He stood in a wide cubicle farm with a serious look on his face. Normally calm under these circumstances, James had trouble standing still.

“Team one, status?” he asked a young software engineer. James’s eyes were tired from lack of sleep; so much of his energy had been poured into what was about to happen. The engineer nodded affirmative.

“Team two, ready?” he called, turning to a propulsion expert. She gave a wide thumbs up. With a serene nod, James flipped off a light switch. The room was plunged into darkness, broken only by the dim blue and orange lights emanating from buttons on computers. The quiet chatter in the room calmed down.

“Okay everyone, get under and stay quiet!” instructed James. There was a rustle as people ducked under chairs, tables, and hid behind racks of equipment. James climbed beneath a table and pulled his legs in, holding them tight against his chest in anticipation. He tried to slow his breathing as his heart raced ahead inside. The unmistakable pitter patter of footsteps approached and James bit down on his tongue anxiously to stay quiet. His legs began quaking in nervous anticipation. So much had gone into this moment, but there was still so much that could go wrong. The door cracked open and a figure slowly strode in.

Grasping the edge of the table with both hands James swung out from under and vaulted into the air.

“Surprise!” he yelled as an eruption of people burst forth from beneath their hiding spaces. The lights beamed on and streams of bright colored paper flowed through the air like fireworks. A visibly shaken Grace jerked her head up from the news story she had been intently reading when she walked in. She stumbled backwards as a chorus of “Happy Birthday” rang out. James pretended to direct the last few bars and turned to Grace with a wide smile.

“James, what is this?” Grace stammered while a grin crept onto her face.

“I thought the song made it obvious,” replied James, showing mock disappointment. He returned to his wide smile. “Just wanted to say happy birthday, and thank you for all

you've done on this project!" The scientists and engineers around the room echoed James, showering Grace with words of gratitude. All around, colorful banners and thank you notes hung from the ceiling.

"I...I don't know what to say..." said Grace, beaming widely.

"How about a toast?" offered James, who was already distributing glasses of champagne. He handed a glass to Grace and raised it up in the air.

"To peaceful discovery!" he cried cheerfully.

"To peaceful discovery!" echoed Grace. She paused for a moment. "And...for Callisto."

"And for Callisto," replied James with a deep nod. They lifted their glasses and drank cheerfully. Behind James an enormous cake was rolled forward by two postdocs. Grace walked into the room towards it, smiling uncontrollably. Looking down, she swished her glass.

"For Callisto," she whispered to herself as the cake was cut, too quietly for anyone to hear. James was happily pulling apart paper plates. She finally knew what these words meant, years after she had first blurted them out. The words kept her madly focused on pushing *Einstein* past the finish line and through all of the bitterness and anger she felt. Grace looked over at James, knowing that he would never understand.

11 Chapter 11: Flybys and Foci

“Sir, hold still. It’s hard to put your helmet on when you’re shaking like this,” the technician said to James. With a deep breath, he commanded his muscles to stop twitching with anticipation. It had been nearly a year since their birthday surprise for Grace, but soon there would be something even bigger to celebrate.

“Sorry, just a tad excited,” James replied breathlessly. The technician placed the helmet on and twisted it in place. It locked shut with a smart click.

“First time is always special,” came a voice over James’s earpiece. The voice was soon drowned out by the hissing of the airlock as oxygen slipped into vacuum. Even this far from the sun, James lifted up his arm to shield his eyes from the twinkling star. He trudged forward a few steps then bounded up, cautiously at first, then with more vigor. Despite living his whole life on Callisto, he had never walked out onto the surface before. Like a penguin just learning to waddle, he made his way up to a parked rover. With a nod and a wave to the driver he climbed aboard and they sped off, bouncing gently over the smoothed road.

The rover paused at the edge of a steep drop. Beyond the cliff and the thin plastic barrier that delineated it the landscape of Callisto yawned wide open. James smiled gleefully and made to get up but was caught; his seat belt was still fastened. Impatiently he clicked it off and delicately placed his boot on the ground. As he waddled slowly towards the cliff his eyes widened and he let out a low, long gasp.

Kilometers in the distance was a military spaceport. Even at this distance he could see the lattice trusses that criss-crossed up the side of the launch tower. Standing in the tower’s gentle embrace was a rocket glimmering in the dim sunlight. It was unremarkable, identical to the dozens of rockets that took off and landed each day on Callisto. But its top was unusually elongated, like an animal with its neck stretched strangely past what was normal. Inside sat *Einstein* in its metal and composite cocoon. Once freed from the gravity of Callisto it would burst forth and emerge into a butterfly with the power and force of a charging freight train.

“James, I was beginning to worry that you’d miss this,” said Lucy with a smile. She had returned to Callisto following her rotation on Europa, her position restored in time to oversee the final months of development.

“Well I had some second thoughts, in case the *Sheridan* drive got rowdy again,” joked James.

Behind Lucy another figure in a spacesuit waved clumsily at James.

“Grace, good to see you!” beamed James.

“I didn’t work on this project the whole time to miss the launch,” replied Grace. She couldn’t stop smiling. Their earpieces crackled and the small cadre of engineers and scientists hastily turned towards the launch tower.

“Engine chill is complete.”

“Launch director on countdown one, go for launch.”

“Vehicle is configured for flight.”

“T minus fifteen standby for terminal count.”

Quietly at first then louder and louder James chanted the countdown in his helmet. Beside him Grace gripped the guardrail tighter and she felt her heart almost pause, as if afraid that its miniscule beating would disturb the rocket and its treasured payload.

“Three...two...one.”

Unbounded by the launch clamps and barely held down by gravity the rocket sprung forth into the sky, moving with surprising swiftness. In hardly an eye blink it had cleared the tower as it rode upwards on a rollicking blue, monstrous flame. There was no sound and no rumble, only a brilliant metal machine leaping through the sky. A moment later the ground shook as the shock waves of launch rolled through where the group was standing. Grace’s gentle, awestruck smile broke into a wondrous beaming gaze. She tracked the rocket with her eyes as it elegantly soared away like an impossibly fast shooting star.

Grace turned to James, who smiled back with the greatest smile she had ever seen.

A few hours later the rocket that lofted *Einstein* into space ignited once more. It pushed the precious telescope out of Callisto’s gravity, beginning a gentle ten day fall towards Jupiter. Around Callisto, *Einstein* was bid farewell by thousands of dignitaries, fans, and the loving scientists and engineers that brought her to life. But as she swung by Jupiter the telescope was much more alone. Though the watchful eyes back on Callisto doted over her progress there was nothing they could do to help. *Einstein* swooped in, making her closest pass to the gas giant as the mighty *Sheridan* drive finally roared to life.

A dancing blue and ultraviolet flame poured out of the engine bell, creating a dazzling arc

of light that the largest telescopes on Callisto could just barely make out. The drive pushed up against *Einstein* and together the engine and telescope surged forward, whipping around the swarming clouds of Jupiter and out of the planet's gravity. But for the drive, it was more of a yawn than a roar. The *Sheridan* drive performed flawlessly but even this fine first test was a mere dress rehearsal for what it was capable of.

Einstein slumbered away in hibernation and again fell inwards. But now instead of towards Jupiter, king of the planets, she dove towards the sun, king of the solar system. For four years she coasted alone, occasionally pinging home to say hello to her watchful parents. In those years much changed; Grace and Parker visited Europa while James settled into full time teaching at the Institute. Their work on the cathedral was done and now they could only wait. Across the solar systems tensions continued to wax and wane. The Mariner Valley Alliance caught wind of the miraculous engine that powered *Einstein* through the cosmos. Declaring the telescope a front, they planned to dispatch a ship to chase her down and investigate. Cooler heads and a thick lathering of diplomacy aborted the scheme and *Einstein* was very much on her lonesome when she began her flyby of the sun.

Like a spinning skater, *Einstein* rotated around her axis as she coasted closer and closer to the sun. Finally the time came. It was opening night. The *Sheridan* drive burst to life, first slowly and cautiously then with more confidence it throttled up to a steady roar. Like a symphony the engine crescendoed from a tepid pianissimo to a churning forte as *Einstein* whipped around the sun, her brilliant natural cousin. The drive burned with a steadiness and stamina that seemed to defy its violent raw power. *Einstein*'s signals were eagerly awaited back at mission control. First for an hour then for two she kept up a stream of positive reports and indicators in the green. Finally, four days later the *Sheridan* drive fell silent. Its task was done and *Einstein* was left barreling through the dark loneliness of space.

Well before her drive had finished its fiery performance, *Einstein* was the fastest body in the solar system. The telescope screamed past Earth, past Mars in a matter of weeks. She brushed by Jupiter, briefly sending a cheery hello to mission control before continuing her relentless march through the outer solar system. As she crossed by planets and moons and the pockets of humanity that clung to them, *Einstein* brought both wonder and alarm. On Mars, a frantic government poured mounds of funding into replicating the secrets of the *Sheridan* drive. Meanwhile on Callisto, a vindicated military quietly pushed forward on plans to equip her fleets with the new engine.

As the decades wore on *Einstein* was largely forgotten. She became a historic relic, a test article of the past whose true purpose and true payload was forgotten except by those who

still eagerly awaited pictures of an alien planet. When she was still only halfway to her final destination James retired from the Institute and moved to a neighborhood even closer to campus. Grace finally made her trip to the inner solar system. But she found it too decadent, too tame, and she returned to work on Callisto.

On a quiet morning, James shuffled around the small garden that he had tended for nearly half a Jovian year. His knees had given out many years ago but the powered braces around his legs kept him going. He watered a collection of petunias and, as was habit, looked up at the sky. Jupiter was half full and the sun hung off in the distance, an unusually bright but far from overpowering star. Two students on their way to the Institute passed by; James lifted his good arm up to wave and his former students merrily waved back. He had just turned to return inside when he heard a voice.

“Professor Ballard.” He stopped and turned around.

“Tess! I haven’t seen you in weeks, not since our last dinner,” James said cheerily, the water spilling from his watering can. When he saw who was behind her he smiled even wider and set down the empty container. “And you’ve brought Grace! What a pleasant surprise!” Grace smiled back. Her hair was now white, but between the many wrinkles and dark spots on her face, lay the same gentle smile she had worn many decades ago.

“Professor Ballard, I wanted your help with something,” said Tess slyly. She was holding a plain, large envelope. Grace hovered behind her, struggling to contain her anticipation. James gave them a curious smile.

“Only if you stop calling me Professor, it’s James to you now!” he poked back. Tess opened the envelope and handed a stack of printed pictures to him. He stepped over his tomato patch and sat down on a stone bench.

“Wow, I didn’t know we printed pictures on Callisto!” he said with genuine surprise. He mock studied the first image intently. “I’m getting old, but I believe this is a circle.” Tess smiled even wider.

“It is, but why don’t you look at the second picture,” she replied. James nodded and shuffled the image on top to the back, revealing the second one. Suddenly his eyes turned wide with seriousness.

“It’s blue and green...a planet,” he gasped. He flipped to the next picture. It showed a blue body of water outlined by a green and brown coast.

“Oh my gosh, Tess, is this...” he trailed off as he flipped through the pictures. Each picture was an inset of the previous one, shown with more and more detail. He finally stopped at the last picture and stood back up, rendered speechless. It was blurry but showed a coastline with the water and land undulating back and forth. Near the middle the water made a sudden jump into land, a dark blue gash in the green landscape. But around the bay the land was gray and white, with the streaks radiating outwards in narrow lines. Unnaturally straight lines. James bent in closer and started shaking, then lifted his head slowly. A smile began to creep onto his face.

“Tess...Grace...,” he whispered, “is this what I think it is?” Tess finally burst out crying and she raised her fists with joy.

“Yes! We found them! *Einstein* found them! Aliens on Trappist 1-e! And they build cities!” she cried out with excitement. Beside her Grace leaned in and embraced James. After a long tearful pause he lifted his head again, a feeling of wild vindication and raw joy coursing through him.

“I wish Lucy was still around to see this,” he finally said with a sad smile. Lucy had passed away two years ago after decades of friendship with Grace and James. Grace nodded, and tears of sadness joined the ones already rolling down her cheeks.

“Me too,” Grace replied, “but at least she lived to see what she was working towards on the project.” Grace moved in and embraced James more tightly.

“And now so have we,” he whispered back.

12 Epilogue

Einstein continued coasting out further and further in space. She stayed along the focal line of the sun, scooping up more and more pixels of Trappist 1-e to beam back to Callisto. As the years went by supercomputers churned around the clock to process and interpret the images, revealing more details of the alien civilization to a spellbound humanity.

Out past Jupiter, lingering around Saturn, the *Reuben James*¹² quietly plied through space. The small ship flew the flag of the Callistan Navy and orbited silently around Mimas, a small icy moon. Onboard the ship a copy of *Einstein*'s image processing software, truly a cousin rather than a copy, hummed away. Pixels of a very different kind were run through the software as it teased out more and more detail with each pass.

"Definitely a military ship, of the Mariner Valley Alliance," read off Executive Officer Baker. "*Curiosity* class, more than three times our size," she added.

"With what certainty?" a man inquired. Officer Baker turned around to face the other officer.

"*Chamber Black* is reporting a 100% match with the enemy vessel database," she replied solemnly to the ship's weapons officer. She spoke clearly and crisply, the words rolling off in a clean staccato. She turned to a different man standing on deck.

"Captain Kent, this is the fourth intrusion in our zone of defense by a warship of the Mariner Valley Alliance," Officer Baker rattled off to the captain. The captain continued facing away from the two officers. He nodded slowly, taking in the information. With his left hand the captain ran his hair through his graying hair, the product of many decades serving the Callistan Navy.

"Any sign they've spotted us?" asked the captain, though he already knew the answer. With so much empty space between the two ships, it was nearly impossible for one to detect the other. Only with the help of *Chamber Black*, that miraculous image processing software developed from a decade of work, was the *Reuben James* able to peer out and detect her adversary.

"No indication sir, we're well out of range of their scopes," replied Officer Baker.

"Weapons Officer Greenwood, kindly spin up missiles one through five, and twenty through twenty-four,¹³" Captain Kent said calmly to a third person on the bridge. He continued staring at the wall, breathing in the gravity of the situation.

“Sir, it would be hasty to fire upon the Martians,” protested Officer Greenwood. Captain Kent spun around slowly and walked towards him, his sharp green eyes shining brightly.

“I have not made a decision, I’m merely keeping all of our options open,” he replied severely. The weapons officer bowed his head slightly and lifted his left arm up, where a screen was affixed. With his other hand he tapped in the commands and the enlisted soldiers on the ship began executing the captain’s order. In distant parts of the ships machinery whirred to life and the crew readied itself for the what was to come. A thick fog of anticipation and apprehension hung in the air.

“A lot of missiles,” remarked Officer Baker.

“Wouldn’t want to miss if it came to it,” Captain Kent said simply to her.

“Captain, I must advise against firing on the Martian ship. That would be a clear act of aggression, a start of a war,” warned Officer Greenwood. As he spoke he shot a threatening look of restrained tension towards Officer Baker. Captain Kent paced around and finally strode to the center of the ship’s bridge. He gestured to the two officers and the three crowded around a large table display at the center of the room.

“We’re already at war,” barked Officer Baker, “and Officer Greenwood, I invite you to recognize that reality.” She turned towards the weapons officer and pushed each syllable out like a hammer blow. She then shifted her gaze to the captain’s impassive face. “Mars blew up two Callistan ships over Mimas, and this ship is positioned near our base. Whether they’re spying or jamming we don’t know, but the point is they shouldn’t be here,” Officer Baker said forcefully.

“We’re not at war yet,” reminded Captain Kent sternly. “Tensions are high, but war hasn’t been declared.” This moment that he had feared for so long was appearing before them. It was another round of the game of Russian Roulette that had been played for decades. Only now, it was his turn to pull the trigger.

“And we haven’t confirmed those ships were destroyed by Mars!” protested Officer Greenwood, bringing his fist down sharply to the table, “We could be provoking war on inconclusive evidence!”

“Our intelligence tells us those ships were blown up by terrorists sponsored by the Mariner Valley Alliance,” retorted Officer Baker acidly. “Callistan ships don’t blow up on their own, Officer Greenwood.” Officer Greenwood looked anxiously from Officer Baker to the captain and nervously rubbed his arm. A beeping from the display interrupted the quarreling officers

and the three looked down at the screen. Blinking lights representing ships cruised smoothly across the sleek glass.

“The Martians are shifting orbit - they’re aligning their orbit to drop warheads on the base. It’s a classic hit and run!” diagnosed Officer Baker.

“It’s inconclusive...” replied Officer Greenwood slowly. The weapons officer bent in closely to examine the screen. “This doesn’t mean they’re about to drop bombs! We should send a report back to Callisto... await further orders then,” the weapons officer said, straightening himself. A tremor of fear reverberated through his voice. The danger felt in the room rose precipitously.

“President Fremont and the government are eighty light-minutes away, Officer Greenwood,” said Captain Kent with a shaking head, “we’re on our own on this. And I have orders from her to maintain the zone of defense, even if by force.”

“If there’s going to be a war, it’s best to have it on our terms,” growled Officer Baker. She turned to the captain. “Whatever happens we have got the *Sheridan* drive, *Chamber Black*. And they have not,” she enunciated. “But that’s only for now. We wait a few years on this war and our edge could be gone¹⁴. If it’s going to happen, it should happen here, and now.” Officer Greenwood shot another look of disdain and exasperation at Officer Baker. He leaned over the display with his arms outstretched and shook his head violently.

“With that thinking Russia would have been destroyed after the war. And it’s damn good we didn’t go down that route!” he said, snapping his head up.

“That was an ancient war!” scoffed Officer Baker¹⁵.

“Officer Baker, you do know what ship you’re on right?” murmured Captain Kent, managing a small smile. He had turned away from the bickering officers again to contemplate.

“We’re outnumbered out here, we can’t afford this kind of aggression!” protested Officer Greenwood.

“Numbers don’t matter,” scoffed Officer Baker, “the moment we fire, Callistan ships will be screaming through the solar system to reinforce us before the Martians can show up!”

“But there’s too much uncertainty!” cried out Officer Greenwood. “We could be starting a war unprovoked! For all we know this...this could be a trap; they could be luring us into firing first, make us out to be the aggressors!”

“The only way to be certain what the Martians are doing ends with a couple hundred dead civilians, our civilians, down there,” retorted Officer Baker. “The Martians are the aggressors, they’ve already shot first, and they’re preparing to attack. They’re over our base! They’re not here to say hello!”

“We don’t know if the Martians have shot yet! We can broadcast a warning! We can’t start shooting!” yelled back Officer Greenwood. The officers looked on the verge of wrestling each other to the ground. As the argument escalated, lights kept blinking across the screen. The Martian ship continued cruising closer towards the base on the moon’s icy surface. Captain Kent lifted an arm to silence the two and spun around. He wore an impassive look on his face hiding the turmoil and agony beneath.

“We can’t send a warning,” Captain Kent finally said. “And Officer Greenwood, I expect you to understand why.” The weapons officer closed his eyes and nodded solemnly. *Chamber Black* was perhaps the best kept secret of the Callistan Navy. Adapted from *Einstein’s* image processing software, it let the Navy see far deeper out into space than any enemy ship could. It was a tactical dream - to be able to see while remaining too far away to be seen. But a warning would shatter the veil of secrecy, revealing to the Martians that they could be spied on by Callistan ships too far away to be detected. Such a revelation would be a strategic catastrophe for Callisto. Captain Kent leaned over the table display and breathed in slowly.

“Officer Greenwood, open fire on the Martian ship. Shoot to kill.”

The Officer Greenwood stared at the captain, devastated, while Officer Baker grimly stood silent. With an unwavering, tight look on his face Officer Greenwood lifted his arm again and tapped the controls to fire. Dull thumps reverberated through the ship as missiles sprung out from their tubes. Their engines ignited into brilliant blue pouring flames that glowed brightly against the dark backdrop of space. Like a flock of angry birds they raced forward, diving towards their unsuspecting target.

As the missiles crossed the empty space to the Martian ship the captain and officers watched impassively, the lethal warheads reduced to small blinking lights on a screen. *Chamber Black* continued streaming back images of their prey, the Martians oblivious to the coming onslaught of hungry predators. Far too late, the engines on the Martian ship ignited in a great blue light. Like a swimmer belatedly becoming aware of shark infested waters the ship desperately tried to escape. Lights on the ship burst out, sparkles against the darkness as the Martian defenses fired. First one, then two, then three of the wave of incoming missiles were destroyed in a blaze of exploding, incandescent debris. But the vicious hunters pressed their attack, closing the distance to the ship.

The first missile soon arrived, whizzing by in a wide miss. Another one detonated prematurely close to the ship, spraying out glowing, splintering metal. But finally the missiles began striking home. One effortlessly punched straight through, leaving a ghastly hole in its wake before hurtling onwards. Another tore through the bridge, decapitating the ship and her commanders. Still the brave Martian ship continued, her engine burning like a wounded animal struggling to escape but unaware of its own anguish.

Finally a missile honed in on the ship's engine. In a great flash of white light the vessel was incinerated as the reactor meltdown, savagely shredded by the remorseless metal intruder. Where once a proud Martian ship had plodded through space there remained only a field of burning light and spinning debris.

Back on the *Reuben James*, the captain and two officers stood in silence on the bridge. Officer Baker had turned paper white while Officer Greenwood stood frozen over the screen, his face staring unblinking through it. The heavy significance of what they had done hung in the air like a noxious cloud. What minutes before had been a plan for an attack, the start of a hypothetical war, a dangerous but still unrealized future, was now stubbornly real. *Chamber Black* continued merrily spitting out images of what remained of the Martian ship, the computer oblivious to the parade of carnage. The glow of molten debris and exploding engine burst forth on the screen before gently fading into darkness. The lights on the screen representing missiles and the enemy vessel methodically blinked out until only a milky black remained.

Captain Kent exhaled slowly and wearily, barely moving. There was still an infinite number of possible futures that could play out before them, most of them grim. Officer Baker looked over at him, still white as snow, as if pleading for guidance. Officer Greenwood glanced over with wide, defeated eyes.

"The lights are going out all over the solar system," Captain Kent breathed out heavily. "We shall not see them lit again in our lifetimes."¹⁶

13 Author's notes

Notes

1. A common astronomer trick is to measure angular distances with a clenched fist. The width of a fist held at arm's length is approximately 10 degrees.
2. Magnesium is used to make Professor Montlake's placard, and magnesium is one of several metals found on Callisto's surface: [https://en.wikipedia.org/wiki/Callisto_\(moon\)#Composition](https://en.wikipedia.org/wiki/Callisto_(moon)#Composition)
3. Callisto Institute of Technology is sometimes shortened to Caltech. The label "The Institute" is a nickname sometimes used to refer to MIT in Cambridge, MA.
4. The chapters "James", "Grace", and "Lucy" are modeled after an episode of Avatar: The Last Airbender. The episode "Tales of Ba Sing Se" follows each of the main characters as they go about a separate adventure.
5. The playing cards that Grace sees in the tunnel to the Navy site are based on a real art display. Riders on the Link light rail in Seattle can see displays with playing cards in the tunnel around Beacon Hill station.
6. The library in the story is modeled after Milikan Library at Caltech in Pasadena, CA. Milikan Library is the tallest building at Caltech.
7. Square cockpit windows are one of the features that distinguish the Airbus A320 from the similar looking Boeing 737. The Boeing 737 cockpit windows have a diagonal cut in the bottom corner.
8. The *Wickes* class was a class of U.S. Navy destroyers, built from 1917-1921. They were succeeded by the *Clemson* class: https://en.wikipedia.org/wiki/Wickes-class_destroyer
9. *Chocolate soldiers* was a derogatory term the German army used to describe the Belgian army during the First World War. The implication was that the Belgians would not fight, and would melt away from the invading German army. In actuality, the Belgians fought like lions.
10. *Tin can* is a nickname for U.S. destroyers.
11. The poster that Lucy hung in her room on Europa was designed by NASA in 2016: <https://www.nasa.gov/feature/jpl/exotic-cosmic-locales-available-as-space-tourism-posters>
12. The *USS Reuben James* (DD245) was a U.S. Navy destroyer that served during WWII. She was the first U.S. ship sunk during the war, before the U.S. had officially entered. However, her sinking did not pull the

U.S. into the war: [https://en.wikipedia.org/wiki/USS_Reuben_James_\(DD-245\)](https://en.wikipedia.org/wiki/USS_Reuben_James_(DD-245))

13. The line “spin up missiles one through five, and twenty through twenty-four” is originally from the movie *Crimson Tide* (1995).
14. Officer Baker’s line “Whatever happens we have got the *Sheridan* drive, *Chamber Black*. And they have not” is an adaptation of a quote by the British author Hilaire Belloc (1898). “Whatever happens, we have got the Maxim gun, and they have not.” The Maxim gun was an early version of the machine gun, which Belloc felt assured Britain’s advantage in battle: https://en.wikiquote.org/wiki/Hilaire_Belloc
15. The war Officer Baker refers to as “ancient” is the Second World War.
16. The final line of the story is adapted from a line by British Foreign Secretary Sir Edward Grey on 3 August 1914, on the eve of the First World War: “The lamps are going out all over Europe, we shall not see them lit again in our life-time.” https://en.wikipedia.org/wiki/The_lamps_are_going_out