SKYLARK OF SPACE: THRESHOLD

A Modern Reimagining of the 1928 Public-Domain Novel

by Jeremy Salsburg

The Threshold Reimagining Series

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Title Page

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* * *

Dedication

For everyone who looked up and thought: *not yet, but soon.*

* * *

Epigraph

“The universe is not only queerer than we suppose, but queerer than we can suppose.”

— J.B.S. Haldane, Possible Worlds (1927)

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About the Author

Jeremy Salsburg writes from Utah.

The Skylark Threshold

ACT I — IGNITION

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Chapter 1 — “Anomaly”

The fume hood was making that sound again.

Nate Seaton leaned back from the deposition chamber’s viewport and listened. A low, intermittent rattle — not the blower motor, not the exhaust ducting. Something in the mounting bracket, probably. He’d asked facilities about it twice. They’d nodded and written it down and done nothing, because it was 11:47 on a Tuesday night in the Portland State materials science building, and the people who fixed things had gone home six hours ago.

He pushed his hair back and returned to the viewport. Inside the magnetron sputtering chamber, the latest MoS2 film was cooling on its titanium substrate, the pale gold sheen of a good crystalline deposit catching the halogen work lamp. Batch 47-C. Copper-doped, like the last forty-six. Thermoelectric characterization in the morning.

Except this batch was wrong. He already knew it.

The copper feedstock had arrived from the supplier three days ago with a certification sheet that didn’t match his purchase order. He’d ordered natural-abundance copper sputtering targets — 69.17% Cu-63, 30.83% Cu-65, the standard isotopic ratio you got from any supplier who wasn’t doing something exotic. What arrived was labeled 72.8/27.2. A small difference. A few percentage points. The kind of error that happened when a specialty isotope lab mislabeled an outgoing shipment and somebody in receiving didn’t cross-check.

He should have sent it back. He should have filed a non-conformance report and waited two weeks for replacements. But his DARPA Young Faculty Award expired in eight weeks, and he had twelve more deposition runs on his timeline, and the films he was making weren't weapons or drugs or medical implants — they were thermoelectric test coupons, bench-scale research samples that would be characterized and published and forgotten by everyone except the eleven people worldwide who cared about transition metal dichalcogenide thermoelectrics.

So he'd loaded the wrong copper and run the deposition anyway, because the isotope ratio shouldn't matter for thermoelectric performance, because the Seebeck coefficient depended on band structure, not on nuclear mass, and because Nate Seaton was two months from unemployment and not inclined to waste a day.

The film cooled to room temperature. He vented the chamber, pulled the substrate, and mounted it in the four-point probe station for a quick resistivity check. Normal. He set up the Seebeck measurement rig — a hot side and a cold side, a voltage measurement, the most basic thermoelectric test there was. He clamped the sample, set the temperature differential, and started the data acquisition.

The voltage reading was strange. Not the thermoelectric voltage he expected — something else. A DC offset that shouldn't be there, drifting slowly, as if the film were generating charge from nowhere. He checked his connections. Swapped leads. Same drift. He frowned, adjusted the hot-side temperature up by ten degrees, and watched.

The sample moved.

Not much. A twitch. The kind of motion you'd attribute to thermal expansion if you weren't looking directly at it, or to a vibration in the building if the building were vibrating, which it wasn't. But Nate was looking directly at it, and the sample had shifted laterally on its mount by perhaps half a millimeter, in a direction that had nothing to do with the thermal gradient.

He stared at it. Adjusted the current up.

The sample moved again. Definitively. It slid two millimeters across the glass slide under the probe tips, pulling itself free of two of the four contacts.

“What the hell,” Nate said, to no one.

He reclamped it. This time he used the spring-loaded sample holder, the one meant for brittle ceramics that might fracture under probe pressure. He set the current to the standard characterization level and increased it in steps, watching the film through the magnifying lens mounted above the station.

At 2.3 amps, the sample broke free of the spring clamps and shot off the end of the bench.

It hit the fume hood sash hard enough to crack the tempered glass.

Nate did not move for perhaps thirty seconds. He stood with his hand on the current supply dial, the magnifying lens still swung into position over an empty sample holder, and listened to the fume hood rattle — this time from the impact, not from the mounting bracket.

Then he walked to the fume hood and looked at the crack. A radial star pattern, the kind you got from a point impact. Beneath it, on the fume hood’s interior work surface, the sample sat face-down. A thin film on a titanium substrate, maybe eight grams total. It had crossed a meter of open air and cracked tempered glass.

He picked it up. It was warm. Not hot — warm, like a stone that had been sitting in sunlight.

His hands were steady. That was the thing about Nate — the shaking came later. In the moment, he was the version of himself that reran experiments. The version that had run batch 46 forty-six times because the forty-sixth showed a 0.3% deviation in Seebeck coefficient that he could not explain and refused to ignore. That version of Nate did not shake. That version looked at a cracked fume hood and saw a data point.

He went back to the bench. Prepared another sample from the same batch — 47-C, the wrong copper, the film that should have been unremarkable. This time he mounted it in a heavier fixture, a steel block with set screws, the kind of mount you'd use for a sample you expected to try to escape.

He applied current. Slowly, watching the fixture. At 1.5 amps, the fixture began to slide across the bench surface. Not the sample — the fixture. The whole steel block, 200 grams, moving as if nudged by an invisible hand. A thin film was pushing a block that outweighed it twenty-five to one.

Nate put his hand on the block to hold it still. He could feel the force — steady, continuous, pressing against his palm. He held it and increased the current with his other hand. 2 amps. 2.5. The force grew. At 3 amps, holding the block required effort. At 3.5, the sample tore free of the set screws with a metallic ping and launched itself across the lab.

It hit the far wall. A hard, flat crack — stone hitting concrete. He walked to the wall. The sample had embedded itself half a centimeter into the drywall, the titanium substrate punched in like a thrown knife, the film side facing outward, glinting gold under the fluorescent lights. The hole was clean-edged. Fractured, not melted. A kinetic impact from an object the size of a postage stamp and the weight of two paperclips.

He pulled it free. The burn scar on his left forearm — the old one from a grad-school crucible accident — itched the way it did when adrenaline was running. He ignored it.

He went back to the sputtering chamber, pulled a third substrate from the batch, and set up the measurement properly this time. The vacuum test cell: a small bell jar, a mechanical roughing pump, a calibrated force sensor on a pendulum mount. He'd built this rig two years ago for measuring thermal expansion coefficients. Crude but honest — anything that pushed the pendulum would register on the optical encoder. He bolted the sample to the pendulum arm so it couldn't launch itself anywhere.

He pumped the bell jar down to 10^-3 torr. Applied current to the sample through the vacuum feedthroughs.

The pendulum deflected.

He read the force: 0.4 newtons. From a 1 cm^2 film at 2.3 amps. That was — he did the math on the back of a lab notebook page, his handwriting tight and careful — roughly 40 kilonewtons per square meter if you scaled linearly. Which was insane. That was more thrust density than a solid rocket booster. From a film thinner than a human hair.

He increased the current. The force increased. Linearly. Proportional to current, proportional to film area. Direction: normal to the film surface. Perfectly, axially, repeatably normal. No exhaust. No particles in the residual gas analyzer. No electromagnetic emissions on the spectrum analyzer he wheeled over from the next bench. No detectable anything coming out of the film except force.

Nate sat down on the lab stool. His laptop was open on the bench beside him, the data acquisition software plotting thrust versus current in a clean straight line that meant either the most important physics result in a century or a systematic measurement error he hadn't found yet.

He checked the force sensor calibration. Correct. He checked the current measurement. Correct. He swapped the sample orientation — the force reversed direction. He rotated it ninety degrees — the force followed. Always normal to the film surface.

He made a larger sample. 4 cm^2, from the same batch. Pumped down, applied current. The force scaled exactly with area. 1.6 newtons.

The fume hood rattled. Outside the window, Portland was dark and wet, the streetlights on Broadway making orange smears on the glass. Nate could see his own reflection — a lean figure hunched forward, wire-frame glasses catching the light, flannel shirt untucked. He did not look like a man on the edge of anything. He looked like a grad student who’d forgotten to go home.

He ran it again. Smaller sample, lower current, every parameter logged. Same result. He ran it four more times. The data points fell on the same line every time, as obedient as gravity.

Then Nate did what scientists do when the data is too good: he tried to break it.

He increased the temperature. The force held steady up to 350 C, then began to drop. At 400, it fell sharply — efficiency collapsing like a switch being thrown. Above 420, the film itself started to degrade, the surface color shifting from gold to a dull brown as the copper atoms migrated through the lattice. He backed the temperature down and the force recovered, but not completely. Some damage had been done. Lesson: 400 C was a cliff, and the cliff had teeth.

He changed the vacuum level. The force was identical at 10^-3 torr and 10^-6 torr. He backfilled with nitrogen to atmospheric pressure. The force was still there, unchanged within measurement error. The effect didn’t care about the surrounding gas. It cared about the film, the current, and nothing else.

He disconnected the current leads and tried to make the film produce force by heating it, by bending it, by illuminating it with a laser pointer, by yelling at it. Nothing. Only current — flowing charge — triggered the effect. The coupling was electromagnetic, driven by the oscillating charge carriers in the lattice. No current, no force.

By 2 AM he had a parameter map: force versus current, force versus area, force versus temperature, force versus pressure, force versus orientation. Every relationship was clean. Every curve was repeatable. The effect was real, controllable, and — once you had the right film — as reliable as an electric motor.

His hands were shaking now. The delayed reaction, arriving on schedule.

At 2:14 AM, Nate picked up his phone and scrolled to a contact he hadn't called in three months. Martin Crane. Grad school at Oregon State, seven years back, back when Nate was a first-year PhD student and Martin was finishing his master's in aerospace structures before his commission came through. They'd shared a lab bench and a terrible apartment in Corvallis and an argument about whether SpaceX would ever land a booster that Martin won and Nate still disputed on technical grounds.

Martin picked up on the fourth ring, his voice thick with sleep. "Nate. It's two in the morning."

"I know."

"Someone better be dead."

"No one's dead." Nate looked at the crack in the fume hood. "Martin, I need you to come to my lab."

"Now?"

"Tomorrow. First thing. And don't — don't tell anyone I called."

A pause. The sound of Martin sitting up in bed, the rustle of sheets, the background quiet of a house in Lake Oswego where a man who ran a successful energy company slept on a reasonable schedule. "Nate. What happened?"

Nate stared at the data on his laptop. The line. The beautiful, impossible, terrifying line.

“I found something.”

* * *

Chapter 2 — “Verification”

Seventy-two hours later, the lab smelled like ozone and Martin Crane’s coffee.

Martin had arrived at 7 AM Thursday morning in a Rivian R1T that cost more than Nate’s annual salary, wearing a quarter-zip pullover and the expression of a man who’d driven an hour through Portland traffic to humor a friend who might be having a breakdown. By 7:45 he was no longer humoring anyone. By noon he’d canceled his Friday meetings. By Thursday evening he’d had a vacuum chamber, a set of calibrated piezoelectric force sensors, a thermal imaging camera, and a Faraday cage delivered from three different suppliers on overnight rush orders, and the two of them were rebuilding the measurement rig from scratch.

“From the top,” Martin said. He was standing at the whiteboard Nate had wheeled into the lab, a dry-erase marker in one hand and a legal pad in the other. Martin Crane took notes on legal pads. He organized them in folders with color-coded tabs. Nate found this both admirable and faintly alien. “What do we know and what do we think we know.”

Nate pointed to the sputtering chamber. “The host lattice is MoS2 — molybdenum disulfide. Standard transition metal dichalcogenide, nothing exotic. I dope it with copper during deposition. Co-sputtering from a copper target while the MoS2 goes down. The copper substitutes at specific lattice sites — about 3.2 atomic percent, that’s the sweet spot I’ve been optimizing for thermoelectric work.”

“And the contaminated batch?”

“The copper target came in at 72.8% Cu-63, 27.2% Cu-65. Natural abundance is 69/31. Small shift. I used it anyway because I didn’t think it would matter for thermoelectrics.”

“But it matters for this.”

“It matters for this.”

Martin wrote on the whiteboard: *Cu-63/65 ratio: 72.8/27.2. Critical parameter*. He underlined it twice. “Walk me through the measurement protocol.”

Nate walked him through it. The vacuum bell jar, the pendulum force sensor, the optical encoder. Martin listened without interrupting, then said, “Your force sensor has — what, 10 millinewton resolution?”

“About that.”

“We’re going to do better.” Martin opened his laptop and pulled up a supplier catalog. “Kistler 9256C1 three-axis force plate. Range up to 250 newtons, resolution 0.01 newtons. I can have one here Saturday.”

“That’s a twenty-thousand-dollar instrument.”

“Nate.” Martin looked at him over the laptop screen with the calm, level expression of a man who deployed utility-scale battery installations for a living and understood what money was for. “If this is real, twenty thousand dollars is a rounding error. If it’s not real, I’ll write it off.”

The force plate arrived Saturday. So did the thermal camera, a FLIR A700, and the Faraday cage components — copper mesh panels that Martin bolted together himself with a cordless drill, his hands quick and precise, the hands of someone who’d spent his twenties building airframes.

By Sunday morning they had the rig assembled. The sample sat on the force plate inside the vacuum chamber, which sat inside the Faraday cage. Current feedthroughs, voltage taps, three thermocouples on the sample, the thermal camera shooting through a zinc selenide window. Every signal cable was shielded and grounded. Martin had drawn the grounding diagram himself and checked it twice.

“Ready?” Nate said.

“Go.”

Nate brought the current up slowly. 0.5 amps. 1.0. 1.5. On the force plate readout, the Z-axis — normal to the film — climbed in lockstep. 0.08 newtons. 0.17 newtons. 0.26 newtons.

“Linear,” Martin said quietly.

“It’s been linear every time.”

2.0 amps. 0.34 newtons. 2.3 amps — the level that had cracked the fume hood — 0.39 newtons. Martin was writing numbers on the legal pad, his handwriting suddenly less neat than usual.

“X and Y axes?” Martin asked.

“Zero. Within noise.” Nate pointed to the readout. The lateral force channels showed nothing — millinewton-level fluctuations. All the force was axial. All of it normal to the film surface.

“Thermals?”

“Surface temp is 68 C at this current. Well below anything interesting.”

Martin stared at the numbers. “Take it higher.”

Nate pushed the current to 5 amps. The force climbed to 0.85 newtons. The sample surface temperature rose to 140 C. Still linear. Still axial. Still no electromagnetic emissions on the spectrum analyzer, no particles on the residual gas analyzer, no detectable exhaust or recoil products of any kind.

“Now turn it off,” Martin said.

Nate cut the current. The force dropped to zero in less than a millisecond. Clean. No residual. No hysteresis.

Martin set down his pen. He walked to the window and looked out at the Portland State campus, gray and damp in the November light. He stood there for perhaps a minute. Then he turned around.

“Force proportional to current. Proportional to area. Direction normal to the film surface. No exhaust. No detectable radiation. No reaction products.” He ticked each point on his fingers. “Nate, do you know what this means for propulsion?”

“I’ve been trying not to think about it.”

“Well, think about it.” Martin came back to the whiteboard. He was in his element now — the builder, the systems engineer, the man who turned physics into vehicles. “Thrust-to-power ratio. You’re getting 0.85 newtons from — what’s the input power?”

“About 14 watts at 5 amps.”

“0.85 newtons per 14 watts. That’s 0.06 newtons per watt.” Martin wrote it on the board. “For comparison. An ion thruster does about 0.06 newtons per kilowatt. You’re beating an ion engine by a factor of a thousand.”

“The comparison isn’t quite — “

“I know it’s not apples to apples. But the delta-V math doesn’t care about the comparison. It cares about thrust and power and time.” Martin was writing fast now, equations appearing on the whiteboard in the blocky handwriting of an engineer who’d been doing back-of-envelope calculations for twenty years. “If you scale this to a square meter of film. Same current density. You’d get — roughly 40 kilonewtons. Per square meter.”

“At about 1.2 megawatts of electrical input per square meter,” Nate said. “The power draw is enormous.”

“The power draw is a solvable problem. A compact reactor gives you megawatts in a package you can fly.” Martin tapped the whiteboard with the marker. “Nate. Ten square meters of this stuff, powered by a reactor, gives you a vehicle with a thrust-to-weight ratio greater than one. No propellant. No reaction mass. You can hover. You can fly to orbit. You can fly to the Moon.”

They looked at each other. The lab was quiet. The fume hood had stopped rattling — Nate had switched it off to reduce vibration during the measurement. Outside, a campus bus hissed past on Broadway.

“How much copper does the film consume?” Martin asked.

“I don’t know yet. The films I’ve tested are still producing thrust after hours of operation. But the copper dopant concentration has to be decreasing — the atoms are participating in whatever coupling process generates the force. I need to measure the depletion rate.”

“Failure modes?”

“One thermal runaway. A film overheated during an early test — I was pushing current without adequate monitoring. It fractured and released copper vapor into the chamber. The pieces went in random directions.”

Martin’s eyes narrowed. “Random directions at what force?”

“Same force-to-area ratio as the intact film. Just — fragmented. Shrapnel, essentially.”

“So if a panel fractures under power on a vehicle, you’ve got pieces of a thruster flying around at whatever thrust level they were operating at.”

“Yes.”

Martin wrote on the whiteboard: *THERMAL MANAGEMENT = PRIMARY ENGINEERING CONSTRAINT*. He underlined it three times. "What's the upper temperature limit?"

"I haven't mapped it fully. But the film I overheated was around 430 Celsius when it failed. The copper dopant sites became mobile — thermal diffusion destroys the lattice geometry."

"Hard ceiling?"

"I'd guess 400 C for safe operation. I need more data."

Martin capped the marker. He leaned against the whiteboard, arms crossed, and looked at Nate with an expression that was equal parts exhilaration and dread. "I'll fund whatever you need. Equipment, materials, labor, facility space. Whatever."

"Martin — "

"But." He held up a hand. "We need to understand the failure modes before we understand the applications. We need to map every parameter. Temperature limits. Lifetime. Scaling behavior. Isotope sensitivity. What happens when the film degrades. What happens in atmosphere versus vacuum. Everything."

"That's what I was planning to — "

"And we need security. This lab is on a university campus with open network access and no physical security worth the name. If this is what we think it is, we need to control who knows about it."

Nate felt something shift in his chest — the familiar tension between the part of him that believed science should be open and the part that understood Martin was right. "Okay."

"How many people know?"

"You. Me. That's it."

"Your postdoc?"

“Vanessa? No. She wasn’t here for the original accident, and I’ve been running these tests after hours.”

“Keep it that way. For now.” Martin picked up his keys from the bench. “I’ll start setting up a dedicated facility. Off campus. Somewhere with real security and real power supply. We’ll move the critical work there as soon as it’s ready.”

“Martin.”

Martin stopped at the door.

“Thank you.”

Martin looked at him for a moment. The calm, level expression softened into something warmer — the face of a friend who’d shared a terrible apartment in Corvallis and never lost the thread. “Don’t thank me yet. Buy me breakfast. It’s Sunday and I missed church, which Laura will remind me about for a week.”

They went to a diner on Hawthorne that Nate liked because it served breakfast all day and didn’t judge the state of his flannel shirts. Over eggs and coffee, Martin pulled out the legal pad and started sketching vehicle architectures. Cylindrical hull, thrust panels on articulated mounts, radiator arrays for thermal management. His pen moved in clean, confident lines.

Nate watched him draw and thought about the film in the vacuum chamber, sitting in the dark lab, inert and unremarkable and capable of something that no object on Earth had ever done before.

His phone buzzed. A text from Vanessa Almeida: *Saw lights in the lab when I biked past at 6am. You sleeping there again? Also I need the sputtering chamber Monday at 9.*

He texted back: *Chamber’s yours at 9. And no, I’m not sleeping in the lab.*

He did not mention that he'd barely slept at all.

* * *

Monday morning. Nate arrived at 8:30 to find Vanessa already in the lab, her dark curly hair tied back, her face wearing the expression of someone who'd found the Faraday cage.

"So," she said, standing in the middle of the lab with her arms crossed and her eyebrows raised. She pointed at the copper mesh enclosure, the vacuum chamber with its forest of feedthroughs, the Kistler force plate that cost more than the department's annual equipment budget. "Want to tell me what's going on?"

Nate set his coffee down. He'd been rehearsing this moment for three days, trying to decide how much to tell her and how to frame it. Vanessa Almeida was smart, direct, and completely intolerant of being managed. She was also his postdoc, his closest collaborator, and the person most likely to notice that something extraordinary was happening in the lab she used every day.

"Close the door," he said.

She closed it. Then she leaned against the bench and waited.

"I found something," Nate said. "Last Tuesday. The batch with the wrong copper isotope ratio."

"The mislabeled targets? I saw your note about it."

"The films from that batch produce directed force when current is applied. No propellant. No exhaust. Force proportional to current and area, directed normal to the film surface."

Vanessa's expression did not change for a long moment. Then she uncrossed her arms and walked to the vacuum chamber. She looked at the force plate through the viewport, the sample mount, the wiring. She looked at the data acquisition computer, where Nate's measurement files were still open.

"Show me," she said.

He showed her. He ran the entire measurement protocol — sample on the force plate, chamber pumped down, current ramped in steps, data logged. Vanessa watched the numbers climb on the screen and said nothing until the test was complete and the current was off.

"Run it again," she said.

He ran it again.

"Now flip the sample and run it again."

He flipped it. The force reversed.

Vanessa pulled the stool over, sat down, and spent twenty minutes scrolling through his data files. She opened the residual gas analyzer logs, the spectrum analyzer sweeps, the thermal camera footage. She did all of this in silence, her face the mask of intense concentration that Nate had learned, over eighteen months of working with her, meant she was integrating information across multiple domains simultaneously.

Finally she looked up. "Your error bars are tight."

"I know."

"Your controls are clean."

"Martin helped me redesign the rig. Full Faraday shielding, calibrated force plate, triple-checked grounding."

"Martin Crane was here?"

"He's funding the next phase."

Vanessa's eyes widened slightly. She knew who Martin was — Nate had mentioned him occasionally, the grad-school friend who'd made real money in clean energy. "How much does he know?"

“Everything I know.”

“Which is?”

“That it works. That it scales. That the isotope ratio is critical. That the thermal ceiling is somewhere around 400 C.” Nate met her eyes. “And that I have no idea why it works.”

“The isotope ratio,” Vanessa said. “72.8/27.2. That’s not natural abundance.”

“No. The natural ratio doesn’t produce the effect. I tested it — the standard-copper films show nothing. Zero force.”

“So it’s a lattice resonance. The different nuclear masses change the phonon spectrum, and at this specific ratio…” She trailed off, her hands moving in the way they did when she was thinking spatially, feeling the shape of an idea. “There’s a phonon mode at that ratio that doesn’t exist at natural abundance. And it couples to — what? Not photons. Not phonons externally. Something quantum-mechanical that produces real momentum transfer.”

“That’s where I am,” Nate said. “I have the what. I don’t have the why.”

Vanessa stared at the vacuum chamber. “Nate, if this is real — “

“It’s real. I’ve run it forty-three times.”

“If this is real, the theory behind it is a Nobel Prize. And the engineering is…” She didn’t finish the sentence. She didn’t need to.

“I know.”

She stood up. Smoothed her hair back. Took a breath. “What do you need from me?”

“I need the sputtering chamber for the next three weeks, twenty-four/seven. I need your process expertise to scale the deposition to larger substrates. And I need you to keep this completely quiet.”

“From the department?”

“From everyone.”

Vanessa studied him for a moment, her skepticism visible — the slight tightening around her eyes, the angle of her chin. “I have conditions.”

“Name them.”

“I’m not a technician. If I’m in on this, I’m a researcher. My name goes on everything. And when the theory paper comes — and there will be a theory paper, Nate, because if you sit on this it’ll eat you alive — I’m a co-author.”

“Done.”

“And you tell me everything. Not just the parts you think I need. Everything.”

Nate nodded. It wasn’t a hard promise to make. He’d been alone with this for five days and the weight of it was already more than he could carry.

“Then let’s get to work,” Vanessa said. “Starting with mapping that isotope sensitivity curve properly. Because if 72.8/27.2 is the magic number, I want to know how wide the window is and what happens at the edges.”

She was already pulling on nitrile gloves, moving to the sputtering chamber with the focused efficiency that had made her the best postdoc he’d ever worked with. Vanessa Almeida had come to his group eighteen months ago from MIT with a PhD in thin-film deposition, a deep skepticism about faculty who oversold their results, and a poster of Mae Jemison on her apartment wall. She ran the lab on Python scripts and sheer will, and she challenged Nate when he was wrong with a directness that he found uncomfortable and essential in roughly equal measure.

She’d earned co-authorship a dozen times over before this discovery. What she was going to earn now was something neither of them could yet quantify.

Nate watched her configure the sputtering parameters for the first isotope sensitivity run and felt something unclench in his chest. He was no longer alone with it. That helped.

But the data still glowed on the screen behind him — force versus current, straight as a ruler — and it still meant what it meant. And he still had no theory for why.

He needed a theorist.

* * *

Chapter 3 — "The Breach"

The email from Portland State IT arrived on a Wednesday, eleven days after the anomaly.

Nate almost missed it. It landed in the middle of a thread about parking permit renewals and a departmental announcement about holiday office closures, the kind of institutional noise he filtered automatically. But the subject line snagged his attention: *Security Incident — Seaton Lab Network — Action Required*.

He opened it at the lab bench, his coffee going cold beside him. The message was from the university's Information Security Office, written in the clipped, impersonal language of people trained to describe breaches without causing panic. An anomalous pattern of outbound data transfer had been detected from the subnet serving the materials science building. The traffic originated from a machine registered to Dr. Seaton's lab. The pattern was consistent with automated data exfiltration. The activity had begun eight days ago — three days before the anomaly — and continued for approximately 72 hours before the monitoring system flagged it.

Nate read it twice. Then he walked to the lab workstation — the Dell tower under the bench that ran the data acquisition software and stored his experimental logs — and looked at it as though it might tell him something. It hummed quietly, fans spinning, doing whatever it did when no one was watching.

Eight days ago. Three days before the crucible cracked the fume hood. Someone had been inside his network, copying his data, before he even knew there was something worth stealing.

He called the ISO office. The analyst who answered was cautious, procedural. Yes, the exfiltration appeared to target research data files. Yes, the volume was significant — several gigabytes over the 72-hour period, which was consistent with pulling down entire directory trees. No, they could not yet identify the destination; the data had been routed through multiple anonymizing relays. They were working with the FBI's Portland field office and would be in touch.

Nate hung up. He stood in his lab and thought about what was on that machine. His experimental logs — every deposition run, every characterization result, every parameter sweep. LabArchives files going back eighteen months. Force measurements. Thermal profiles. Scaling data. The careful, documented arc of a discovery that went from "equipment failure" to "this changes everything" in six days of experimental work.

He opened the file explorer on the workstation and started cataloging what was stored there. The sputtering run logs — all of them, including the contaminated batch. The four-point probe data. The Seebeck measurements. The force-versus-current curves from the bell jar tests. The thermal camera footage. The spectrum analyzer sweeps showing no electromagnetic emissions. Vanessa's isotope sensitivity measurements from the past week, plotted on graphs with the axes unlabeled because Nate was paranoid enough to leave the variable names off his digital plots.

The good news: the isotope ratio was not in the digital records. He'd recorded the supplier's certificate of analysis in his physical notebook — the Moleskine that lived in his backpack — and when he'd run the isotope sensitivity curve with Vanessa, he'd entered the Cu-63 fraction values into the sputtering controller manually, without saving them to the log files. The subsequent measurements were on a different machine, Martin’s laptop, at Martin’s house. The exfiltration had captured the what but not the why. Whoever had his data knew that something unusual was happening in his films. They didn’t know the key that made it happen.

The bad news: someone was looking. Someone had been looking before he’d even known there was something to find.

He opened his email client and scrolled back through the past two weeks of messages. Had he written anything to anyone about the isotope ratio? He’d emailed Vanessa — but those messages referenced only “the batch 47 parameter sweep,” without specifying what the parameter was. He’d texted Martin, but on Martin’s encrypted Signal thread, not through university email. He’d spoken to Anya Patel on a video call, but she didn’t have the specific number — he’d given her the general concept of a mixed-isotope lattice without stating the ratio.

The Moleskine was in his backpack. The backpack was in his apartment. The ratio was on page forty-three, written in blue ink, circled twice: *Cu-63/65: 72.8/27.2 — supplier COA mismatch — KEEP THIS NUMBER.*

He needed to keep that notebook secure. And he needed to tell Martin.

He called Martin.

* * *

Twelve hundred miles east and a world away, Dr. Marc DuQuesne sat in his glass-walled office on the eighth floor of Vanguard Strategic’s Tysons Corner campus and read Nate Seaton’s raw data on a 32-inch monitor.

The office was clean. DuQuesne kept it that way — minimal furniture, no personal photographs, a single bookshelf organized by subject and then by date of publication. The only concession to personality was a framed periodic table on the wall behind his desk, the 1969 IUPAC standard version, which he'd bought at auction because it was the edition his grandfather had used to teach high school chemistry in Baton Rouge.

The data had arrived that morning via Vanguard's technical intelligence division. A data package from a university lab in Portland. Routine collection — one of dozens of academic research targets that Vanguard's cyber operations team monitored for potentially strategic developments. The AI-driven triage system had flagged it for anomalous force measurements in a materials science context. DuQuesne was the senior physicist in the company's black-project R&D group; anything the system flagged in his domain came to him.

He'd opened it expecting noise. University labs produced noise at industrial scale — artifacts, miscalibrations, wishful thinking dressed up as data. He'd looked at dozens of these flags over the past year. None had survived ten minutes of scrutiny.

This one survived.

DuQuesne scrolled through the data files with the systematic patience of a man who'd spent a decade at Los Alamos learning to distinguish signal from noise in inertial confinement fusion diagnostics. The force measurements were clean — unusually clean for a university lab. The scaling was linear. The thermal profiles made sense. The control experiments were present and properly structured. And the phenomenon described was, if the data were trustworthy, the most significant physics result since the discovery of the Higgs boson.

Directed force. No propellant. No exhaust. Proportional to current and area. From a copper-doped transition metal dichalcogenide film.

DuQuesne pulled up his own knowledge base. TMD films. Copper doping. Thermoelectric applications. He knew the field — not as well as whoever Dr. Nathan Seaton was, but well enough to recognize that the experimental setup was standard except for the copper isotope contamination. The data package mentioned a supplier error. Different isotope ratio. That was where the trail went cold: the specific ratio wasn't in the digital files. The researcher had been smart enough — or lucky enough — to record the critical parameter somewhere else.

He leaned back in his chair. The Tysons Corner campus spread below his window, glass and steel and manicured landscaping, the architecture of a defense contractor that preferred to look like a tech company. In the parking lot, his Tesla Model S sat beside Brookings's Cadillac Escalade. That proximity was the geometry of his working life: his science adjacent to someone else's ambitions, close enough to share a parking lot but not a worldview.

DuQuesne opened a new analysis file and began reverse-engineering the catalyst requirements from the incomplete data.

He worked methodically, the way he'd been trained at Los Alamos — start with what you know, enumerate what you don't, quantify the gap. What he knew: the host lattice was MoS2, deposited by magnetron sputtering at 300 C substrate temperature. The copper dopant concentration was 3.2 atomic percent, co-sputtered from a separate target. The adhesion layer was titanium nitride on a Ti-6Al-4V substrate. All of this was explicit in the deposition run logs.

What he also knew: the force measurements were clean, linear, and reproducible. Thrust proportional to current density. Thrust proportional to area. Thrust direction normal to the film surface. No detectable emissions of any kind — no photons, no particles, no thermal signature beyond ohmic heating.

He pulled up the thermal camera data from Seaton's logs. The film heated under current — that was expected, any resistive material would — but the heating rate was lower than pure ohmic dissipation would predict. Roughly 60-70% of the input power became heat. The rest went somewhere else. To thrust work, presumably, but the mechanism was opaque.

DuQuesne opened his computational toolkit — a VASP density functional theory package he'd used extensively at Los Alamos for modeling high-pressure materials. He built a supercell of copper-doped MoS2 with the known doping concentration and began calculating the phonon dispersion relation as a function of Cu-63/Cu-65 isotope ratio.

The calculation was straightforward in principle. Different isotopic masses produced different zero-point vibrational amplitudes in the lattice, which shifted the phonon mode frequencies. At natural copper abundance — 69.17% Cu-63, 30.83% Cu-65 — the phonon spectrum showed a set of modes characteristic of the doped lattice. As he varied the ratio in his model, the modes shifted. Some moved up in frequency, some moved down, some split into doublets.

The problem was that he didn't know what resonance to look for. The data told him that something happened at some ratio. It didn't tell him what frequency was relevant or what physical coupling produced the force.

DuQuesne ran the full calculation. It took four hours on the workstation in his office, producing a landscape — a multidimensional map of phonon mode frequencies versus isotope ratio. There were thousands of modes. Any one of them could be the relevant one, or none of them, or a combination. The landscape was rich, complex, and utterly unhelpful without a theoretical framework to tell him which peak mattered.

He tried a different approach. The force-to-power ratio from Seaton's data implied a specific energy conversion efficiency. If he assumed the thrust mechanism was some form of vacuum coupling — the only hypothesis that didn't violate conservation laws — then the resonant frequency had to match a peak in the virtual photon pair-production spectrum for the lattice geometry. He could calculate that spectrum from the lattice constants and the symmetry properties.

The calculation was more speculative. It required assumptions about the vacuum-matter coupling that went beyond established physics. DuQuesne made those assumptions carefully, flagging each one in his notes, constructing a chain of inference that he could test when he had hardware.

The result: a predicted resonance in the 4-5 terahertz range, which corresponded to a phonon mode that appeared in a narrow window of isotope ratios. But the window was vague — somewhere between 70% and 75% Cu-63, with insufficient precision to pick the exact value. The calculation was pointing him in a direction, not giving him coordinates.

DuQuesne stared at the landscape on his monitor for a long time. He could narrow the search experimentally — make films at five or six ratios in that window and test each one. But that required enriched copper at specific ratios, which required isotope separation, which required time.

Time was the one resource Brookings didn't like spending.

He picked up his phone and called Brookings.

"I need to see you. In person."

"My office or yours?"

"Yours."

* * *

Russell Brookings's office was on the ninth floor, one up from DuQuesne's, with a view that was marginally better and furniture that was conspicuously more expensive. The desk was walnut. The chair was leather. On the wall behind it, framed photographs showed Brookings with three former directors of central intelligence, two secretaries of defense, and a senator who sat on the Armed Services Committee. The photographs were arranged chronologically, like a career timeline rendered in handshakes.

Brookings himself was behind the desk, silver-haired, fit, wearing a suit that cost what DuQuesne's car payment cost. He listened without interrupting as DuQuesne laid out the data. Force measurements. Scaling behavior. The implications for propulsion, for energy, for the entire defense-industrial base that Vanguard Strategic served and fed upon.

When DuQuesne finished, Brookings was quiet for a moment. Then he asked: "How confident are you in the data?"

"The measurements are clean. The researcher — Seaton — is methodical. His protocol is rigorous. I'd stake my professional reputation that the phenomenon is real."

"Can you replicate it?"

"Not yet. There's a critical parameter missing from the exfiltrated data — the copper isotope ratio. Without it, I can build the structure but I can't guarantee the effect."

"Can you figure out the ratio?"

“Possibly. Through systematic experimental search. Twelve to twenty weeks if I had the right facility and staff.”

Brookings considered this. His face had the practiced stillness of a man who’d spent twenty years in intelligence operations learning to process information without displaying his conclusions. “What are the applications?”

“Propulsion. Any vehicle class, any scale. Air, space, surface, subsurface. No propellant means no reaction mass, which means no Tsiolkovsky constraint. You could build a vehicle that accelerates continuously for as long as the power supply holds and the films last.”

“Weapons?”

“The thrust mechanism itself isn’t a weapon. But a vehicle with this performance envelope is a weapons delivery platform that makes hypersonic missiles look like ox carts. And the films could be configured as kinetic accelerators — linear arrays that launch projectiles.”

Brookings’s expression did not change, but something in his posture shifted. The faint forward lean of interest. “How hard would it be to classify?”

“Difficult, now. Seaton has published data — thermoelectric papers, nothing about the anomaly yet, but his lab logs are his proof of independent development. If he publishes the force measurements before a secrecy order is filed, classification becomes a legal battle rather than an administrative action.”

“And if he doesn’t publish?”

“Then you have a window. But it’s narrow. Seaton is a university researcher. Publishing is what they do.”

Brookings stood and walked to the window. He looked out at the Northern Virginia landscape — the Beltway traffic, the glass towers of contractors and consultants, the machinery of the national security state spread across the horizon like a second city. “What do you need?”

“A clean-room facility. Sputtering equipment. Isotope-enriched copper in a range of ratios — I’ll need to do a parametric search. Computational support. Two to three technicians with appropriate clearances.”

“Where?”

“Our facility at Groom Lake. It’s already set up for classified materials work. And it’s quiet.”

Brookings turned from the window. “You’ll have it. Budget is not a constraint. Timeline is.”

“I understand.”

“Marc.” Brookings’s voice was even, conversational, the voice of a man delivering instructions that would be obeyed. “This technology, in the wrong hands, destabilizes everything. Every treaty, every balance of power, every assumption about force projection. Whoever controls it first controls the next century.”

“I understand that as well.”

“Then you understand why Dr. Seaton’s garage-science approach is not just reckless — it’s dangerous. This belongs in a program. With proper security. Proper oversight. Proper control.”

DuQuesne met his eyes. He understood what Brookings meant by “proper control.” He understood that Vanguard’s clients — the “sovereign bidders” who retained the company’s strategic services — were not exclusively, or even primarily, the United States government. He understood all of this, and he accepted it, because Brookings was offering him a physics revolution, and the price of the revolution was Brookings.

“Give me six months and a clean-room,” DuQuesne said. “I’ll give you something that makes hypersonics obsolete.”

Brookings smiled. It was a thin smile, professional, the expression of a transaction completed. “You’ll have it in two weeks.”

DuQuesne walked back to his office. He sat at his desk and looked at Nate Seaton’s data on the monitor — the clean straight line of force versus current, the work of a careful scientist who did not yet know he had company.

He began drafting a list of equipment requirements for the Groom Lake facility.

* * *

Chapter 4 — “Theory”

Nate needed a physicist. Not a materials scientist — he was that. Not an engineer — Martin was that. He needed someone who could look at the data and tell him what was happening at the quantum level. Why a specific arrangement of copper atoms in a molybdenum disulfide lattice, when current flowed through it, produced directed force from nothing visible.

He needed a theorist. Specifically, he needed someone who worked at the intersection of quantum field theory and condensed matter physics, someone who understood both the vacuum and the lattice, someone who could bridge the gap between what the film did and why.

He found Anya Patel through a chain of two connections — a colleague at NIST who’d collaborated with a postdoc at MIT who worked in Patel’s group. Dr. Anya Patel: tenured professor, quantum vacuum dynamics, author of a textbook on Casimir effects that Nate had read in grad school and understood about sixty percent of. Brilliant. He’d emailed her posing as a colleague with a “hypothetical” question about momentum transfer in structured vacuum boundaries.

She’d replied in four hours, which meant she was either bored or intrigued. He suspected the latter.

Now she was on his phone screen, a video call, her face lit by the yellow light of what appeared to be a cluttered MIT office at nine PM Eastern. Tall, angular, with an expression of perpetual distraction — the face of someone whose attention was always partly elsewhere, running calculations in some back room of her mind.

“Your hypothetical,” Anya said, adjusting her position in her chair. There was chalk dust on her sweater. “Let me make sure I have the premises. A crystalline thin film with a specific dopant arrangement. Under current, it produces directional force normal to the surface. No exhaust, no radiation, no detectable reaction products. Force proportional to current and area.”

“That’s the hypothetical.”

“It’s a very specific hypothetical, Dr. Seaton.”

“Nate.”

“Nate. Most hypotheticals don’t come with a force-to-current ratio measured to three significant figures.”

He said nothing. She studied him through the screen.

“All right,” she said. “Let’s take your hypothetical at face value. A structured boundary that produces directional momentum transfer from the vacuum. This is not, actually, as impossible as it sounds.”

“It’s not?”

“The Casimir effect is real. Two conducting plates in vacuum experience a measurable force because the boundary conditions they impose on the quantum vacuum exclude certain electromagnetic modes between the plates. The energy density between the plates is lower than outside, which produces a net force pushing them together. This is established physics, measured to high precision.”

“But the Casimir effect is attractive. Between the plates.”

“In the standard parallel-plate geometry, yes. But the force depends on the boundary conditions. Change the geometry, change the material properties, and you change the force. There are theoretical configurations — metamaterial boundaries, for instance — where the Casimir effect becomes repulsive or directional. None of these have been demonstrated at useful force levels. But the principle is sound.”

Nate leaned forward. “So you’re saying a thin film could, in principle, couple to the vacuum in a way that produces directed force?”

“I’m saying the vacuum is not empty, and its interaction with material boundaries is well-established physics. Your hypothetical” — she stressed the word with a faint, knowing smile — “describes a material that happens to couple exceptionally well. The question is mechanism. What specific mode of the vacuum is coupling to your lattice?”

She pulled a tablet into frame and began writing equations with a stylus, her handwriting the spidery, rapid script of someone who thought faster than they could write. “The copper isotope ratio you described — 72.8 to 27.2. Mixed isotopes in a lattice produce a phonon spectrum that depends on the mass distribution. At this particular ratio, you’d get a specific set of phonon modes that don’t exist at the natural ratio.”

“I’ve mapped the phonon spectrum computationally. There are hundreds of modes.”

“Yes, but you’re looking for a mode that resonates with a vacuum fluctuation frequency. Not just any vacuum mode — a specific one.” She wrote a frequency on the tablet, circled it. “The quantum vacuum has structure at every energy scale, but the electromagnetic vacuum — virtual photon pairs — has a spectral density that increases with the cube of frequency. Your film would need to couple at a frequency where the phonon mode matches a virtual photon pair-production resonance.”

“Which frequency?”

“That depends on the lattice constants and the dopant geometry. But if I take your force-to-power ratio and work backward…” She wrote for perhaps two minutes, filling the tablet screen with equations. Then she looked up. “Approximately 4.7 terahertz. That’s in the far-infrared. And it’s a frequency that corresponds to a known peak in the vacuum spectral density for virtual photon pairs in a MoS2-type lattice with broken inversion symmetry."

Nate's hand was trembling slightly. He pressed it flat against his desk. "So the copper dopant breaks the symmetry."

"The copper at 3.2 atomic percent, at the specific isotope ratio, creates a lattice geometry that breaks inversion symmetry in exactly the right way to produce a phonon mode at 4.7 terahertz. That phonon mode drives coherent oscillation of the charge carriers. And the oscillating charges couple to virtual photon pairs at that resonance frequency, biasing the pair production asymmetrically across the film boundary."

"Biasing it how?"

"Think of the virtual photon pairs as appearing and disappearing everywhere in the vacuum, all the time. Normally, they're symmetric — equal momentum in every direction. Zero net force. But your film's boundary condition, at resonance, preferentially absorbs virtual photons approaching from one side and transmits those approaching from the other. The net effect is a momentum flux through the film. The film accelerates. The vacuum absorbs the equal-and-opposite momentum, distributed across a volume of spacetime that grows with the light-speed delay. Conservation of momentum is satisfied. It's just satisfied in a very nonlocal way."

Nate sat back. The theory was elegant — not simple, but elegant in the way that correct theories often were, connecting things that seemed unrelated and making them necessary. Phonons. Virtual photons. Vacuum symmetry breaking. Each piece was known physics. The combination was new.

"What are the constraints?" he asked.

"Several." Anya held up fingers. "Temperature. The phonon mode is a lattice vibration. Heat the lattice enough and thermal noise drowns out the coherent mode. I'd predict a sharp efficiency cliff somewhere around — let me calculate — " She wrote more equations. "Around 400 Celsius. Above that, the coupling dephases rapidly."

"We measured the ceiling at roughly 400," Nate said, and then caught himself.

Anya looked at him over the tablet. "We?"

A pause. "Hypothetically."

"Mm." She continued without pressing it. "Second constraint: the current density must be high enough to drive the charge-carrier oscillation at the resonance frequency. Below a threshold current, the oscillation is incoherent and no net force is produced. Above the threshold, force scales linearly with current — which is exactly what your hypothetical predicts."

"Third constraint?"

"Isotope ratio. The phonon mode is sensitive to the mass distribution. Natural abundance is close but not close enough — the mode is detuned by roughly 0.3 terahertz, which puts it off-resonance with the vacuum coupling. At 72.8/27.2, the mode sits directly on the peak."

"How narrow is the window?"

"Narrow. I'd estimate plus or minus 0.5 percentage points on the Cu-63 fraction. Outside that window, the coupling collapses."

Nate wrote this down in his Moleskine: *72.3-73.3 / 26.7-27.7. Target: 72.8/27.2.* This was the number that mattered. This was the number that was not in his digital files. He underlined it.

"Maximum thrust density?" he asked.

"Theoretically, the coupling saturates when the virtual photon flux through the film reaches the pair-production limit for that resonance. I'd estimate… around 50 kilonewtons per square meter. Above that, you'd need a different resonance — a higher-frequency mode, which would require a different lattice entirely."

Nate's own measurements had given him roughly 40 kN/m^2 at the highest current he'd tested. The theoretical ceiling was close but not yet reached. Headroom.

"And the power draw?" he asked.

"The electrical energy drives the charge-carrier oscillation. Most of the input power ends up as waste heat — the lattice absorbs it through phonon scattering of the non-resonant modes. I'd estimate 60 to 70 percent of input power becomes heat. The rest goes to thrust work and maintaining the coherent phonon state."

"That matches our — that matches the hypothetical measurements."

Anya set down her stylus. She looked at him through the screen with an expression he couldn't entirely read — part fascination, part something darker. "Nate. Can I ask you something outside the hypothetical?"

"Go ahead."

"If this were real — if someone had actually built a material that coupled to the quantum vacuum at these efficiency levels — it wouldn't just be a propulsion technology. The same coupling mechanism, in a different lattice geometry, could extract energy from the vacuum directly. Not momentum. Energy. The vacuum contains approximately 10^113 joules per cubic meter of energy density. Even coupling to an infinitesimal fraction of that, at the efficiencies we're discussing…"

She trailed off. Her hands were still on the tablet, but she wasn't writing anymore.

“What would it mean?” Nate asked.

“It would mean the energy problem is solved. Not mitigated. Not managed. Solved. Permanently. For every civilization that ever discovers this coupling.”

The call went silent. Nate could hear the faint hum of Anya’s office HVAC, the distant sound of traffic on Massachusetts Avenue. He could see the periodic table poster on her wall, the chalk equations on the blackboard behind her, the architecture of a life spent thinking about the vacuum.

“That’s a big hypothetical,” he said.

“Yes,” Anya said. “It is.”

They talked for another hour. Nate took eleven pages of notes in the Moleskine, his handwriting getting smaller and more cramped as the ideas compressed. The theoretical framework was coming together: a coherent, testable, falsifiable model that explained every observation and predicted the constraints he’d already measured. Anya was building the math in real time, her mind moving with the speed and precision that had earned her tenure at MIT before forty.

During that hour, Nate started calling them S-films in his notes — shorthand for “Seaton-effect films,” a name that embarrassed him slightly but that stuck because it was short and because Vanessa had already started using it. The effect needed a name. The films needed a name. You couldn’t work with something that was just “the anomaly” or “the copper thing” forever. S-films. Two syllables. Enough to carry the weight of what they were.

Anya walked him through the mathematical formalism — the Lagrangian that described the coupling between the lattice phonon field and the quantum vacuum’s electromagnetic modes. It was dense mathematics, tensor algebra and second quantization, but the physical picture was clear: the S-film created a one-way gate for virtual photon momentum. Momentum flowed in one direction through the film. The film moved. The vacuum absorbed the recoil, distributed across a spacetime volume that expanded at light speed. Conservation of momentum was maintained, but the “other half” of the momentum was, for all practical purposes, gone — dispersed into the fabric of space itself.

“It’s elegant,” Nate said. “It’s so elegant it makes me nervous.”

“Nature is not obligated to be inelegant for your comfort,” Anya said. “But I share the nervousness. This mechanism — if it’s real — it’s not something anyone predicted. It was discovered by accident. Which means the theoretical landscape is much richer than we understood. There may be other couplings, other resonances, other effects we haven’t imagined.”

“Other doorways.”

“If you want to be poetic about it. Yes.”

When they hung up, Nate sat in his darkened lab and read through his notes by the blue glow of the laptop screen. Outside, it had started raining again — the steady, patient rain of Portland in November, the kind that lasted for days and made the city feel like it existed inside a cloud. The theory was beautiful. The implications were terrifying. And somewhere in the back of his mind, a thought was forming that he didn’t want to examine yet: if the same coupling could extract energy, then the films weren’t just a propulsion technology. They were a bridge to something much larger. And the bridge went in only one direction.

He closed the Moleskine and held it in his hands. A black notebook with a rubber band closure, $12.99 from Powell’s Books on Burnside, containing the isotope ratio, the theoretical framework, and eleven pages of equations that described a new branch of physics. The most valuable object on Earth, probably, and it fit in his back pocket.

His phone buzzed. Anya, texting.

Nate. I’ve been thinking about your hypothetical. If what you described were real, it would also mean that the vacuum coupling is frequency-dependent. Different resonance frequencies give different effects — momentum transfer, energy extraction, maybe others. Your films are tuned to one frequency. But someone with the right lattice engineering could tune to many. This isn’t a discovery. It’s a doorway.

He stared at the message. Then he put the phone face-down on the bench, pushed his hair back, and went to find Vanessa. There was work to do.

* * *

Chapter 5 — “Money and Metal”

Martin Crane’s day started at 5:15 AM, the way every day started: alarm, gym in the garage, shower, coffee, and forty-five minutes at his desk before anyone else in the house was awake. The desk was in a room Laura called “the office” and Martin called “the office” and which was, in practice, the nerve center of three overlapping operations: Crane Energy Systems, which deployed utility-scale batteries from Portland to Sacramento; Cascade Aerospace LLC, the shell company he’d incorporated six days after seeing Nate’s data; and the thing that Cascade Aerospace existed to build, which did not yet have a name.

His desk was organized the way Martin organized everything — clean surface, labeled folders, a single legal pad centered in front of the keyboard. The legal pad was the fourth one he’d filled since Thursday. He was building a program.

The first page listed personnel. Nate Seaton, principal investigator. Vanessa Almeida, materials and process. Martin Crane, program management, structures, and funding. Below these, a question mark and a name: *Dorothy Vaneman?* He’d circled it twice.

The second page listed facilities. Portland State lab — compromised, to be abandoned. Replacement: a leased hangar at the Portland-Hillsboro Airport industrial park, Building 7-C, 4,200 square feet, concrete floor, three-phase power, roll-up doors. He’d signed the lease through a real estate LLC that was a subsidiary of a holding company that was owned by Cascade Aerospace. Three layers of corporate separation between the hangar and his name. It wouldn’t survive a serious investigation, but it didn’t need to survive forever. It needed to survive long enough.

The third page listed equipment. Sputtering system — ordered from a manufacturer in Minnesota, $380,000, delivery in three weeks. Vacuum pumps, power supplies, thermal instrumentation, cleanroom enclosure — another $220,000 from various suppliers. Force measurement rigs, data acquisition systems, computing hardware — $95,000. Security systems — cameras, alarms, electronic access control, RF shielding — $110,000, installed by a firm that Martin had vetted through a contact at the Air Force Research Laboratory, a firm that did security for classified government facilities and didn't ask questions about commercial clients who paid in full upfront.

Total capital expenditure so far: $805,000. Plus the lease, the insurance, the shell company formation, and Rebecca Tran's retainer, which was $25,000 per month and worth every penny. Martin was funding all of it from personal accounts and a line of credit against his Crane Energy equity. He could sustain this for perhaps eighteen months before it started to affect his ability to run his actual business. After that, he'd need outside capital or revenue, and the only revenue this project would ever produce was a fundamental transformation of human civilization, which was hard to put on a balance sheet.

Before Laura came down, he had two calls to make. The first was to Rebecca Tran.

He'd found her through a referral chain: his corporate attorney knew a regulatory attorney who knew a woman in D.C. who specialized in space law. "Space law" was a field that, five years ago, employed maybe sixty people in the entire country. Today it was busier, thanks to SpaceX and Blue Origin and the various startups that were mining the regulatory framework for loopholes. Rebecca Tran had been at the FAA's Office of Commercial Space Transportation before going private, and she'd written the commentary on ITAR regulations that the rest of the field cited.

She answered her phone at 6:15 AM Eastern, which told Martin she was either a fellow early riser or a chronic insomniac. “Rebecca Tran.”

“Ms. Tran. My name is Martin Crane. I run Crane Energy Systems in Portland. I was referred by David Chen at Stoel Rives.”

“David mentioned you might call. Something about export controls.”

“ITAR. Launch licensing. Potentially nuclear regulatory issues. And I need all of it done quietly, quickly, and in a way that can withstand hostile scrutiny.”

A brief silence. When she spoke again, the politeness had sharpened into something more focused. “Mr. Crane, the combination of ITAR, launch licensing, and nuclear regulation is not something that comes up in casual business development. What exactly are you building?”

“I’ll tell you everything in person. But I need to know first: can you handle a client with national security implications who may need to move faster than the regulatory framework was designed to allow?”

“That’s what I do.”

“Good. My retainer offer is $25,000 per month. Non-refundable, billed against hours at your standard rate, with a six-month minimum commitment.”

Another silence, shorter this time. “I’ll clear my Thursday afternoon. Come to my Portland office.”

Martin ended the call and made a note on the legal pad: *Tran — Thursday 2pm. Bring NDA.*

Then he heard Laura moving upstairs. The creak of the bedroom floor, the sound of the shower starting. She'd be down in twenty minutes. He had twenty minutes to make his second call — the one he'd been putting off.

He picked up his phone and scrolled to Dorothy Vaneman's contact.

Dorothy answered on the second ring, which surprised him — it was 5:45 AM, and the Dorothy he'd known at Boeing was not a morning person. But the Dorothy he'd known at Boeing had been a young engineer on the 777X structures team. The Dorothy who answered the phone was a JPL mission systems engineer on sabbatical, which meant she kept whatever hours suited her and was probably already working.

"Martin Crane," she said. Her voice was neutral, calibrated — the voice of someone who evaluated people by their work and hadn't yet decided what work Martin was asking about. "It's been a while."

"Three years."

"Four. We talked at the AIAA conference in San Diego. You told me you were going to electrify the Pacific Northwest, and I told you to call me when you had something interesting."

"I have something interesting."

A pause. He could hear her thinking — the particular quality of silence that Dorothy produced when she was assembling information. "This isn't about batteries."

"No."

"And you're calling me at 5:45 AM, which means it's time-sensitive."

"It is."

"I'm listening."

Martin told her. Not everything — not yet. He told her enough: a new propulsion technology, private development, early stage, extremely sensitive. He needed a mission systems architect. Someone who could design a vehicle from the propulsion up. Someone who understood thermal management, power budgets, structural mass allocations, guidance and navigation, life support integration, and the thousand other things that separated a laboratory demonstration from a machine that could fly.

“You’re describing a spacecraft,” Dorothy said.

“Yes.”

“Powered by what?”

“That’s the part I need to tell you in person.”

Another pause. Longer this time. “Where are you?”

“Portland. I can send a car, or you can drive — you’re on sabbatical in Portland, right?”

“How did you know that?”

“I asked around.”

“You’ve been planning to call me.”

“For about a week.”

“And you’re just now getting to it?”

“I had to build the lab first.”

She laughed. It was a short sound, surprised out of her, and it cut off quickly. “Send me the address. I’ll be there this afternoon.”

* * *

Dorothy Vaneman arrived at the Hillsboro hangar at 2:15 PM, driving a ten-year-old Subaru with a Caltech sticker on the rear window and a cargo area full of running shoes and technical papers. She was shorter than Martin remembered, but that was because the last time he'd seen her she'd been standing on a raised platform inspecting a wing spar. She wore cargo pants, boots, and a fleece jacket, and her black hair was in a braid that looked like it had been done quickly and forgotten about.

She walked into the hangar and stopped. The space was half-empty — the sputtering system hadn't arrived yet, and the cleanroom enclosure was still being assembled by a crew of two contractors who'd signed NDAs that Rebecca Tran had described as "aggressive." But the force-measurement rig was set up, and Nate was running a demonstration.

"Dorothy Vaneman," Martin said. "Dr. Nathan Seaton."

Nate looked up from the vacuum chamber. He was wearing his usual uniform — flannel shirt, jeans, trail runners — and his hair needed cutting. He pushed it back and extended a hand. "Martin says you're the best mission systems engineer he's ever worked with."

"Martin has good taste." Dorothy shook his hand, then looked past him at the vacuum chamber. "Show me."

Nate showed her. The same protocol: sample on the force plate, chamber pumped down, current ramped. Force climbing in lockstep. Linear. Axial. No exhaust.

Dorothy watched the numbers. She didn't speak during the test. When Nate cut the current and the force dropped to zero, she walked to the whiteboard where Martin had drawn the force-versus-current line and stood in front of it for a full minute.

"Thrust-to-power ratio," she said.

“About 0.06 newtons per watt at the current levels we’ve tested,” Nate said.

“Temperature ceiling?”

“400 C. Sharp cliff above that.”

“Waste heat fraction?”

“Sixty to seventy percent of input power.”

Dorothy turned around. Her face was composed, but her hands were moving — fingertips touching, separating, touching again, the gesture of someone building a system in her head. “You want to build a vehicle.”

“Yes,” Martin said.

“How big?”

“Big enough to carry a crew. Big enough to reach orbit.”

“Crew of how many?”

“Two, initially.”

Dorothy looked at the force plate reading, then at the whiteboard, then at Martin. “The thermal management problem is going to eat you alive.”

“I know.”

“Your radiators need to reject seven megawatts at full thrust for a flight-scale vehicle. In vacuum, radiative cooling only. That means large-area, high-temperature radiators. Sodium heat pipes, probably. Operating at five hundred to seven hundred Celsius to get the Stefan-Boltzmann rejection rate high enough. Deployable panels, because you can’t launch with forty-eight square meters of radiator extended into the airflow.”

Martin was writing. Dorothy was pacing now, her hands active, building the vehicle in the air in front of her.

“Power source. You need five megawatts electrical, minimum. Solar won’t do it — you’d need a hectare of panels. It has to be nuclear. Compact fission. There are a few candidates. Terrestrial Energy’s molten-salt design, maybe — they’ve been talking about space applications.”

“I’ve already started that conversation,” Martin said.

Dorothy stopped pacing and looked at him. “You have.”

“Their IMSR-Space Variant. Twenty-five megawatt thermal, five megawatt electric, forty-two hundred kilograms. Canadian startup, which means export paperwork, but Rebecca Tran is on it.”

“Who’s Rebecca Tran?”

“Our space-law attorney.”

Dorothy’s eyebrows rose. “You have a space-law attorney.”

“I have a space-law attorney, a shell company, a leased hangar, and a security budget larger than my first-year revenue at Crane Energy. What I don’t have is someone who can design the vehicle. That’s why you’re here.”

Dorothy studied him for a long moment. Her eyes — dark, sharp, missing nothing — moved between Martin and Nate and the equipment and the hangar space, integrating everything into a single assessment. Martin had seen that look before, years ago, when Dorothy had walked onto the 777X factory floor for the first time and within an hour had identified a tolerance stack-up that would have caused a wing-body join failure at limit load. She saw systems. She saw the connections between things that other people saw as separate.

“The safety case,” she said. “For a crewed first flight on a new propulsion system with no flight heritage. What’s your approach?”

“We don’t have one yet. That’s another reason you’re here.”

“Because the safety case doesn’t exist, and you know it doesn’t exist, and you’re going to fly anyway.”

Martin said nothing.

“I’m not saying I won’t help,” Dorothy said. “I’m saying I see the gap. And if I’m designing this vehicle, the safety case is mine, and you don’t fly until I say you fly.”

“Agreed.”

“Then show me the rest of the data. All of it. And I want to talk to your theorist — whoever told you why this works.”

Nate said, “That would be a professor at MIT named Anya Patel. I’ll arrange a call.”

“Good.” Dorothy pulled a notebook from her cargo pants — a green hardcover, engineering-ruled. She uncapped a pen. “What are you calling this thing?”

Martin and Nate looked at each other. They hadn’t named it. They’d been calling it “the vehicle” and “the project” and, once, in a moment of late-night exhaustion, “the thing that’s going to get us all arrested.”

“We’ll figure it out,” Martin said.

Dorothy was already writing. She wrote for ten minutes without stopping, filling pages with box diagrams and arrows and numbers, her pen moving with the quick, confident strokes of someone who’d spent seven years designing mission systems for vehicles that flew to Mars and beyond. Martin watched her work and felt something he hadn’t felt since the first time he’d seen Nate’s data: certainty. Not that it would work — there were a thousand ways it could fail. Certainty that it was worth trying.

*   *   *

That evening, after Dorothy had left with a USB drive full of data and a list of questions that ran to four pages, Martin sat in his home office and reviewed the security report from the consultant he'd hired.

The consultant's name was Jim Harrell. Former FBI, now private. Martin had found him through a contact at AFRL — a colonel he'd served with who owed him a favor. Harrell's report was three pages long and matter-of-fact: the hangar's security was adequate for commercial purposes but insufficient for a program with intelligence-community interest. He recommended upgraded electronic access control, interior and exterior camera coverage with offsite backup, RF monitoring for signals intelligence collection, and a counter-surveillance sweep of the facility and the surrounding parking areas.

The last page of the report was the one that made Martin set down his coffee.

Harrell had conducted the counter-surveillance sweep that morning, as part of his initial assessment. He'd found a vehicle in the industrial park's visitor lot — a rented gray Chevrolet Malibu with tinted windows — that had been parked in the same spot for three consecutive days. The vehicle's registration traced to a rental company that was a known front for contractor vehicle pools used by the intelligence community. Inside the car, visible through the windshield, was a directional antenna consistent with signals collection equipment.

Someone was watching the hangar. Had been watching it for at least three days. Before Dorothy arrived, before Nate moved equipment in, before the sign on the door said anything other than "7-C — Cascade Aerospace LLC."

Martin read the report a second time. Then he picked up his phone and called Harrell.

“The car in the lot,” he said. “How concerned should I be?”

“Concerned enough to upgrade your security posture today. Not concerned enough to relocate. They’re watching, not acting. If they wanted to act, they wouldn’t be sitting in a rental car in a public parking lot.”

“Who are they?”

“I can’t confirm yet. The rental front is associated with several contractors. Give me forty-eight hours and I’ll have a better picture.”

Martin hung up. He stared at the phone in his hand, then out the window at the dark street, the rain, the ordinary suburban quiet of Lake Oswego at night. Laura was in the living room, reading. He could hear the faint sound of her turning pages.

Someone was watching already. The project was three weeks old and someone was watching already.

He went downstairs. Laura looked up from her book — a novel, something with a blue cover. She had reading glasses on, the ones she said made her look like a librarian. Martin thought they made her look like the smartest person in the room, which she usually was.

“You look worried,” she said.

“I’m always worried.”

“You’re extra worried. Is this about the project?”

She called it “the project” because Martin hadn’t told her what it was. He’d told her he was investing in a technology startup, that Nate was involved, that it would require significant capital and time. She’d accepted this because Laura accepted what Martin told her and trusted him to fill in the details when the details were ready. But she wasn’t stupid, and she knew when her husband's worry was the normal worry of a man running two businesses and the abnormal worry of a man keeping a secret.

"There might be some security concerns," Martin said carefully.

Laura took off her reading glasses. "Martin."

"It's being handled."

"That's not what I asked."

He sat down on the couch beside her. She waited. Laura was good at waiting — it was a teacher's skill, the ability to hold silence until the other person filled it. Martin was good at silence too, but Laura was better.

"The technology we're developing has national security implications," he said. "I can't tell you more than that yet. But I will. Soon."

"National security implications."

"Yes."

Laura studied his face for a long time. Then she put her hand on his and squeezed once. "Be careful."

"I will."

"Be more careful than you think you need to be."

"I will."

She went back to her book. Martin went back upstairs and wrote on the legal pad: *Upgrade security. Accelerate timeline. Brief Dorothy on threat landscape.*

Below that, he wrote: *Call Rebecca Tran — ITAR framework, pre-patent filings, regulatory strategy.*

Below that, he wrote: *Someone is watching.*

He underlined it once, then closed the pad and turned off the light.

* * *

Chapter 6 — “Parallel Tracks”

The film on DuQuesne’s test rig twitched, rippled, and went still.

He checked the force readout. A blip — 0.08 newtons, lasted 200 milliseconds, then gone. Noise, or the ghost of something real. He’d been seeing ghosts for three weeks. Brief, inconsistent thrust events that appeared at random current levels and vanished before he could characterize them. The films were doing something, but the something was incoherent — a stuttering, arrhythmic pulse instead of the clean linear response that Seaton’s data showed.

DuQuesne noted the reading in his log, stripped the film from its substrate, and placed it in the reject bin. It was the fourteenth rejection this week. The bin was getting full.

He stood and stretched. The Groom Lake facility was austere — prefab buildings on a concrete pad, surrounded by desert and razor wire, the kind of place that existed in the gap between official and unofficial, where things could happen without paperwork. His lab occupied Building C, a 3,000-square-foot space that Brookings had outfitted in ten days: a sputtering system from a defense contractor in Virginia, vacuum equipment, power supplies, and a test rig that was, in every measurable way, superior to what Seaton had at Portland State.

The equipment wasn’t the problem. The problem was the isotope ratio.

DuQuesne had been running a parametric search — systematic variation of the Cu-63/Cu-65 ratio across the range of physically plausible values. He’d purchased enriched copper at five different ratios from a supplier that Brookings’s procurement team had arranged: 65/35, 68/32, 70/30, 73/27, and 75/25. Each ratio went through the full deposition process. Each film was tested under identical conditions.

The 70/30 and 73/27 films showed the ghosts — brief, inconsistent thrust events that suggested he was near the coupling resonance but not on it. The others showed nothing. He was circling the target but couldn’t find the center.

The problem was resolution. His isotope ratios came in 2-3 percentage-point steps, dictated by what the supplier could produce on short notice. The resonance window, if the theory was right, might be less than a percent wide. He could be straddling it, one film too low and the next too high, the sweet spot falling in the gap between his samples.

He needed finer resolution. He needed a 71/29 and a 72/28 and a 73.5/26.5. He needed the supplier to do custom isotope separation at half-point intervals, which would take weeks and cost a fortune. Brookings would authorize the cost. The weeks were the problem.

DuQuesne walked out of Building C into the Nevada morning. The desert stretched in every direction, flat and lunar, the heat already building though it was barely 9 AM. In the distance, the dry lake bed shimmered. A security contractor in a dusty Hilux cruised the perimeter fence, unhurried.

He pulled out his phone and dialed a number from memory. Brookings answered immediately.

“Progress,” Brookings said. Not a question — an instruction.

“Partial coupling events at two isotope ratios, but inconsistent. I’m in the neighborhood of the resonance but not on it. I need finer isotope resolution — half-point intervals between 70 and 75 percent Cu-63. Custom enrichment order.”

“Timeline?”

“Four weeks for the enrichment. One week for deposition and testing after that.”

“Unacceptable. What’s the bottleneck?”

“Physics. You can’t hurry isotope separation.”

“I can hurry procurement. Our primary source can expedite if I authorize the premium. Two weeks.”

“Two weeks is better. But Marc — I need you to understand something. The isotope search is physics. It’s not something you can throw money at to make it go faster. You can throw money at procurement, at logistics, at personnel. You can’t throw money at whether a phonon mode resonates. I’ll have the answer when the films tell me the answer.”

There was a pause on the line. DuQuesne could hear the faint ambient sound of Brookings’s ninth-floor office — the hum of the HVAC, the distant murmur of the Tysons Corner campus going about its business of connecting government needs to private capabilities. When Brookings spoke again, his voice carried the note of forced patience that meant the conversation was being recorded and he was performing for the record.

“Understood. What about the Seaton data? Anything else useful?”

DuQuesne hesitated. He’d gone through Seaton’s exfiltrated data with the thoroughness of a man who’d spent a career reading other people’s results — looking for the numbers between the numbers, the calibration constants, the instrument settings that might contain a hidden parameter. He’d found nothing. The isotope ratio was simply absent from the digital record.

“The data gives me the effect but not the key,” DuQuesne said. “Seaton recorded the critical parameter somewhere else. Physical notebook, most likely.”

A pause. “We could obtain the notebook.”

“How?”

“Physical collection. His apartment, his office, his person. It’s a notebook, Marc. It’s not Fort Knox.”

DuQuesne looked at the desert. The heat was making the distant mountains waver. “That’s an escalation.”

“We’ve already escalated. The cyber operation was an escalation. The surveillance in Portland is an escalation. Every day we don’t have working films is a day Seaton gets further ahead. He’s got a team now — three people, a facility, funding. He’s building something.”

“How do you know that?”

“Because I’m doing my job. You do yours.”

DuQuesne didn’t respond immediately. He was thinking about Seaton’s data — the clean lines, the careful controls, the work of a scientist who ran experiments properly. He’d read Seaton’s published papers, too. Unremarkable thermoelectric work, competent but not flashy. The man was a grinder, not a visionary. He’d stumbled onto the discovery by accident, through a supplier error, and his response had been to measure it. Forty-seven times.

DuQuesne respected that. In a different world, he’d have emailed Seaton and proposed a collaboration.

This was not a different world. This was the world where Brookings’s voice on a secure phone carried the subtext of resources and consequences, where the gap between “research collaboration” and “intelligence operation” was a distinction that Vanguard’s business model had been designed to blur.

“I’ll get you the ratio,” DuQuesne said. “Through the experimental search, not through a break-in. Give me the expedited enrichment order and I’ll have it in three weeks.”

“You’ll have the enrichment. You’ll also have the option of the notebook. I’ll keep both tracks open.” A pause. “Marc, I need you to understand the operational context. We have signals intelligence indicating that Seaton has recruited additional personnel. At least two, possibly three. He’s leased a facility outside the university — industrial space near the Portland airport. He’s spending money from a source we haven’t yet identified. He’s building something.”

“He’s building a test program. It’s what any competent experimentalist would do.”

“He may be building more than a test program. The facility he’s leased has aircraft-hangar dimensions. He’s ordered equipment consistent with scaling up from laboratory to production. And his new recruit — a Crane Energy executive named Martin Crane — has a background in aerospace structures and the financial resources to fund rapid hardware development.”

DuQuesne absorbed this. He recognized the feeling in his chest — the specific discomfort of knowing more about a situation than he wanted to know. “Brookings. If Seaton is building a vehicle, that changes the timeline.”

“It does.”

“And it changes the risk profile. A laboratory curiosity is one thing. A flying demonstrator is another. If he puts this technology in the air — or in orbit — before we have working films, the classification option disappears.”

“Yes.”

“Then let me work. Get me the enriched copper. Let me find the ratio the right way, through physics. And don’t” — he chose his words with care — “don’t do anything to Seaton’s program that makes it harder for me to do my job."

"I'll keep all options open," Brookings said. It was not the same thing as agreement.

Brookings hung up. DuQuesne stood in the heat for another minute, the sun pressing on his shoulders, the desert empty in every direction. Then he went back inside.

* * *

He spent the rest of the day troubleshooting. It was what he was good at — what he'd always been good at, even before Los Alamos, even before MIT. Growing up in Baton Rouge, the son of a high school chemistry teacher and a woman who managed a Piggly Wiggly, he'd been the kid who took apart the VCR and the microwave and the family car's alternator, not to break them but to understand the gap between how they were supposed to work and how they actually worked. The gap was where the science lived.

His grandfather, the chemistry teacher, had given him the periodic table that now hung in his office. Had told him, in the laconic French-Creole way of old Louisiana, that understanding a thing was not the same as controlling it, and that a man who confused the two would always be surprised by the results. DuQuesne thought about that advice more often than he'd expected to when he left academia for Vanguard. The confusion between understanding and control was, in many ways, the company's business model.

The inconsistent thrust events were, in their own way, informative. They told him the coupling existed in this region of parameter space — the films were trying to resonate, catching the edge of the resonance and losing it. He could characterize the failures systematically and use them to triangulate the optimum.

He set up a new measurement protocol. Instead of testing each film at a single current level, he swept the current continuously while monitoring force, temperature, and the phonon spectrum via Raman spectroscopy. The Raman probe gave him real-time information about the lattice vibration frequencies, which meant he could watch the phonon modes shift as the film heated under current and correlate those shifts with the thrust events.

The results were revealing. The thrust ghosts appeared when a specific Raman peak — at 4.71 THz, close to where theory predicted the vacuum coupling resonance — crossed a threshold intensity. The peak was present in both the 70/30 and 73/27 films, but it was weak and unstable, flickering in and out as thermal fluctuations shifted the lattice spacing.

At the correct isotope ratio, DuQuesne calculated, that peak would be strong and stable — a dominant mode that locked onto the vacuum resonance and stayed there. At his current ratios, it was a candle in a draft.

He wrote up his analysis in the meticulous, formal style he'd developed at Los Alamos — every assumption stated, every inference labeled, every data point cited. He was not a man who guessed. He was a man who knew what he didn't know and quantified the gap.

The gap was approximately 1.5 percentage points of Cu-63. He needed to be at 72 or 73, not at 70 or 75. The enrichment order would give him films at 71, 71.5, 72, 72.5, 73, 73.5, and 74. One of those would hit the resonance. Maybe two, if the window was wider than he calculated.

Three weeks. Maybe two, if Brookings could push the supplier.

DuQuesne sat alone in Building C as the Nevada sun went down, the desert cooling around him with the abruptness of dry climates. He opened his laptop and navigated to arxiv.org, checking the day's new submissions in condensed matter and quantum field theory. A habit, daily, the way other people checked the news. He was looking for anyone else approaching this territory — anyone whose theoretical work might intersect with what Seaton had found and he was chasing.

Nothing today. The field was quiet. Two people in the world knew what copper-doped MoS2 films could do under the right conditions, and they were working on opposite sides of a wall that neither of them had built.

DuQuesne closed the laptop and poured himself a coffee from the French press he kept on the workbench. It was his one luxury at Groom Lake — good coffee, beans from a roaster in Alexandria that he had shipped monthly. Brookings had questioned the expense once, in the early days, and DuQuesne had looked at him with the polite, level gaze that he used when he wanted someone to reconsider their position without the embarrassment of being told to reconsider it. Brookings had not mentioned the coffee again.

He stood at the window of Building C and drank. The desert was darkening, the mountains going purple, the sky layering itself in bands of orange and indigo. Beautiful, in the empty way of places that had no interest in being observed. He thought about Seaton — not about the rivalry, not about the data, but about the man himself. A university researcher making $85,000 a year, working in a building with a broken fume hood, who had accidentally discovered the most significant physics phenomenon since the photoelectric effect. And whose response had been to measure it. Carefully, repeatedly, correctly.

DuQuesne respected that more than he could say aloud. In a different world — a world without Brookings, without Vanguard, without the machinery of national security grinding toward whatever it was going to grind toward — he would have sent Seaton an email. *Dr. Seaton, I read your data with great interest. I believe I can contribute to the theoretical framework. May I visit your lab?*

But this was the world he lived in. And in this world, he had already received stolen data, was building a classified replication program, and was three weeks from asking his employer to authorize a more aggressive intelligence operation against a fellow scientist.

Incremental compromise. Each step defensible in isolation. The sequence carrying him somewhere he hadn't planned to go.

He looked at his latest failed film sitting in the reject bin. Fourteen failures this week, each one a step closer to an answer that would make all the steps after it more consequential.

"There's a parameter I don't have," he said to the empty lab. The words sounded different spoken aloud — more certain, more frustrated, more like a promise to himself.

He picked up the secure phone and called his isotope supplier.

* * *

Chapter 7 — “Intrusion”

Nate knew something was wrong before he opened the hangar door.

The security panel was green — all clear, no alerts. The lock accepted his code without hesitation. The cameras, when he checked the app on his phone, showed empty hallways and an undisturbed lab floor. Everything was exactly as he’d left it at midnight, seven hours ago.

Except the door. The strike plate on the personnel door — the smaller door beside the main roll-up — had a faint scratch near the bolt housing. A thin, bright line in the brushed steel, like someone had inserted a tool and withdrawn it. Fresh. The scratch hadn’t been there yesterday. He was sure of this because Nate Seaton noticed surfaces — textures, finishes, the way light hit things. It was a materials scientist’s reflex, and it had served him well in a career spent examining films measured in micrometers.

He called Martin.

Martin arrived in twenty minutes and brought Jim Harrell, who arrived in thirty-five. Harrell walked the facility with the unhurried thoroughness of someone who’d processed crime scenes for the FBI. He found the scratch on the strike plate. He found a second mark on the data room door — a standard commercial lock that had been picked or bypassed, not forced. He found that the backup hard drives in the data room had been removed from their cradle, the dust pattern disturbed, and placed back in a slightly different orientation.

“Cloned,” Harrell said. “Pulled the drives, imaged them, put them back. Professional job. Alarm was bypassed — probably RF spoofed the door sensors. Cameras are on a local loop; they likely overwrote the relevant frames."

"What about the notebooks?" Nate asked. His voice was flat. The cold, controlled flat of a man holding down fury.

Harrell walked to the secure cabinet where the research notebooks were stored — Nate's Moleskines, the lab records, the handwritten data that didn't exist in digital form. The cabinet's lock was mechanical, a combination dial. Harrell examined it.

"Opened and relocked. There are tool marks on the dial housing consistent with a manipulation attack. Takes about four minutes for someone who's practiced."

"So they had the notebooks."

"They had access. Whether they photographed every page or just the pages that interested them, I can't tell. But assume they got everything."

Nate sat down on the lab stool. The hangar was quiet. The sputtering system hummed in its standby mode. The cleanroom enclosure glowed with its UV sterilization lamps. Everything was exactly as it should be, except that it wasn't, because someone had come in the night and taken what they needed and left no trace except a scratch on a door.

He pressed his hands flat on his knees. The shaking had started — the delayed reaction that always came after the moment of calm. His hands trembled against the fabric of his jeans, and he let them, because there was no one to be steady for right now. The fume hood at Portland State had been one thing — an accident, a surprise, an anomaly. This was something else. This was someone reaching into his work and taking it, the way you'd take a wallet from a coat hanging on a chair. Practiced. Routine. Not even particularly careful about hiding it.

“The isotope ratio,” Nate said. “It’s in the notebooks. Every measurement I took. The sensitivity curve. The optimum value. All of it.”

Martin’s face was still. The dangerous kind of still — the expression he wore when his control instinct was running calculations, building frameworks, assessing threat levels. “Then whoever did this now has working parameters.”

“They have everything they need to make functional films. The isotope ratio, the deposition conditions, the doping levels. The temperature sensitivity data. Vanessa’s yield optimization notes. Everything.”

“What about the S-film samples?” Dorothy asked. She’d arrived during Harrell’s walkthrough and been listening in silence, her green notebook open in her hands, her expression the focused calm of someone who processed crisis the way she processed everything — systematically. “Are the physical films here?”

“No.” Nate almost smiled. Almost. “I keep the working samples in a safe in my apartment. Combination lock, bolted to the floor. Paranoia.”

“Not paranoia if they’re actually watching you,” Harrell said from across the hangar, where he was photographing the tool marks on the notebook cabinet.

Dorothy looked at Nate. “How long before they have working films?”

Nate calculated. He ran the timeline in his head the way he’d run it for his own team: procure enriched copper at the specified ratio, set up sputtering, deposit the first test film, characterize it, iterate on the process parameters. “If they already had the infrastructure — sputtering equipment, enriched copper at the right ratio — then days for a first test. A week to confirm the effect. Two weeks for reliable, flight-quality production.”

“And if they already had partial replication? If they were working toward this and just needed the missing parameter?”

“Then less. Maybe days.”

“And if they’re Vanguard Strategic,” Martin said quietly, “they have the infrastructure, the budget, and the personnel. They have a facility that’s already set up for classified materials work. They probably have enriched copper in stock, or can get it faster than we can.”

Harrell looked up from his photography. “What makes you say Vanguard?”

“The surveillance car you found last week. The rental front you traced. The cyber intrusion on Nate’s lab network at Portland State — the TTPs match known private intelligence contractors. And Vanguard has a physicist named Marc DuQuesne who was at Los Alamos doing high-energy-density physics until three years ago. If anyone outside our team could look at Nate’s data and understand what it means, it’s him.”

Nate felt something cold settle in his stomach. He’d looked up DuQuesne after Martin first mentioned him — a quick Google search that turned up a sparse professional trail. Publications in inertial confinement fusion and high-energy-density physics, all before a sudden silence three years ago. A LinkedIn profile that listed Vanguard Strategic as “private sector R&D,” which told you nothing and everything simultaneously. The man was brilliant, by all accounts. And he was working for people whose idea of “technology transfer” involved break-ins and surveillance.

The three of them stood in the hangar and let that settle. The morning light came through the skylights and fell on the sputtering chamber, the force measurement rig, the rolls of copper foil waiting for deposition — all the material evidence of a project that was no longer secret.

Martin spoke first, his voice clipped and level, the officer's voice that surfaced under pressure. "We have maybe three months before whoever did this has working films, a power source, and enough engineering to build something that flies. We need to be in orbit by then."

Dorothy looked at him. "Three months. From a lab bench to orbital flight. On a propulsion system with no flight heritage, a thermal management architecture we haven't tested at scale, a nuclear reactor we haven't bought yet, and a vehicle we haven't designed."

"I didn't say it would be easy."

"You said it like it was a schedule item."

"It is a schedule item. Everything is a schedule item. The question is whether the physics allows it."

Dorothy walked to the whiteboard. She picked up a marker and began drawing — not a vehicle sketch, but a trade tree. A decision diagram, branching at every major engineering choice, with constraints and requirements propagated through the branches like a nervous system.

"Thermal management," she said, writing. "The films produce 1.7 megawatts of waste heat per panel at rated thrust. Four panels, 7 megawatts total. Radiative cooling in vacuum follows Stefan-Boltzmann — radiated power goes as temperature to the fourth. That means your radiators need to run hot. Sodium heat pipes, 500 to 700 C operating range, 48 square meters of radiating area minimum. That's six deployable panels, each 2 by 4 meters. Folded for launch, deployed in orbit."

She drew the radiator configuration — panels extending from the hull like wings, angled to avoid shadowing each other. Her lines were precise, almost architectural.

“Power supply. Five megawatts electric from a compact reactor. The Terrestrial Energy IMSR is the right technology. Molten salt, passive safety, integrated shielding. Forty-two hundred kilograms. That’s your single heaviest component.”

“I’ve been working the procurement,” Martin said. “They can deliver a flight-configured unit in ten weeks. The export paperwork through ITAR is the bottleneck — Rebecca’s pushing it.”

“Structural mass budget.” Dorothy wrote numbers. “Hull: aluminum-lithium alloy, 4 millimeter thickness, 3.2 meter diameter, 12 meters long. That’s roughly 8,000 kilograms for the pressure vessel. Reactor and shielding, 4,200. S-film panels and gimbals, 600. Radiators, 1,200. Thrust structure, 800. Life support, 500. Avionics and comms, 300. Crew and personal equipment, 200. Margins and fasteners, 700.”

She added it up. “Approximately 16,500 kilograms dry mass. Add consumables — water, oxygen, food, CO2 scrubbers, copper feedstock — another 3,500. Launch mass roughly 20,000 kilograms.”

Martin was frowning. “That’s light. Very light for a crewed orbital vehicle.”

“It’s light because there’s no propellant. No oxidizer, no fuel tanks, no turbo-machinery, no plumbing for a conventional propulsion system. All of that mass goes away. The S-films replace it with electrical input and thermal management. The mass budget shifts entirely.”

“What about the reactor mass? And the radiators? Those are propulsion support systems.”

“They are. And they’re heavy. But they’re lighter than the propellant you’d need for equivalent delta-V from a chemical system. By a factor of…” Dorothy wrote the comparison. “By a factor of about fifty.”

Silence. That number sat in the air.

“Twenty thousand kilograms to orbit,” Martin said. “With continuous thrust afterward.”

“With continuous thrust limited by copper feedstock, thermal management, and reactor fuel life. The copper is the binding constraint for missions beyond a few days. But for an orbital demonstration — up, around, back down — copper consumption is minimal.”

“Then we need to talk about crew.” Martin looked at Nate. “The original plan was robotic. First flight unmanned. Get the data, prove the concept, iterate.”

Nate shook his head. “That was before the break-in. If we send it up unmanned and someone jams the command link or spoofs the guidance, we lose the vehicle. If we’re on board, we can manage the systems, respond to anomalies, and make decisions in real time. And we can broadcast on open channels — make the flight a public fact that can’t be disappeared.”

“You want to fly on the first orbital test of an unproven propulsion system.”

“Yes.”

Dorothy set down the marker. She turned to face Nate with an expression that was not angry, not dismissive, but absolutely, unmistakably serious. “The failure modes of this vehicle include thermal runaway of the S-film panels, which produces uncontrolled thrust from fragmented film. Reactor coolant leak, which introduces radioactive salt into the vehicle interior. Loss of thermal management, which means either shut down thrust or destroy the films. Structural failure from asymmetric thrust. And all the standard failure modes of crewed spaceflight — decompression, fire, loss of life support. You have no abort system. No escape pod. No launch escape tower. If something goes wrong above 40 kilometers, you are dead.”

“I know.”

“You know intellectually. You don’t know the way someone who’s designed safety-critical flight systems knows. The failure tree for this vehicle has branches I haven’t even mapped yet.”

“Then map them. And design around them. That’s what I’m asking you to do.”

Dorothy looked at Martin. Martin met her eyes and said nothing, which was its own kind of answer.

“Vanessa,” Dorothy said, turning back. “What does she say?”

Vanessa was in the cleanroom, processing the next batch of films. She’d heard the news about the break-in through the intercom and had said, over the speaker, in a tone that could have cut glass: “This is a terrible idea and you’re going to get yourselves killed, and if you don’t let me finish this deposition run right now I’m going to fail these films on purpose.”

“She objects,” Nate said. “Strongly.”

“She’s right to object.”

“She is. And I’m going with anyway.”

Dorothy picked up the marker again. She turned back to the whiteboard and added a new branch to the trade tree: *CREW — 2 persons. Nate Seaton, pilot. Martin Crane, flight engineer. Life support: 5-day minimum. EVA capability: 2 suits.*

“If you’re going to do something stupid,” she said, writing, “you should at least do it with a proper engineering plan.”

Vanessa’s voice came from the cleanroom, where she’d been monitoring a deposition run through the entire conversation. “For the record, I still object. To the crewed flight. To the timeline. To all of it.”

“Noted,” Nate said.

“And ignored.”

“Not ignored. Heard, respected, and overruled.”

“That’s the same thing as ignored with better manners.” There was a pause, and then the sound of Vanessa pulling off nitrile gloves. She emerged from the cleanroom, her curly hair escaping its tie, her face wearing the expression that meant she’d been thinking about something for hours and was ready to deliver her conclusion. “I know why you want to go crewed. I understand the argument about control and communication. But you’re making the decision based on threat assessment, not engineering readiness. And threat assessment is not my field. Engineering readiness is. And the engineering is not ready.”

“What would make it ready?” Dorothy asked.

“Three unmanned test flights. Suborbital, orbital, orbital with return. Instrumented, telemetered, data-reviewed between each flight. That’s what any responsible development program would require.”

“That’s six months,” Martin said.

“That’s how long it takes to not kill the pilot.”

Silence. The word “kill” sat in the air with a weight that equations didn’t have.

“Vanessa,” Nate said, and his voice was gentle in a way that it rarely was — the voice of someone who knew he was asking too much and couldn’t afford not to ask. “If we take six months, there will be two ships in orbit. One of them will be ours. The other one will belong to people who break into labs and steal research and might have very different ideas about what to do with this technology. I’d rather be up there in a vehicle that’s 90% ready than down here watching someone else fly the 100% version.”

Vanessa looked at him for a long time. Then she said, “If you die up there, I’m the one who has to explain it. To the world, to your parents, to everyone. You understand that?”

“I do.”

“Then build the damn thing right. Both of you.” She looked at Dorothy. “Every safety margin you can get, you get. Every redundancy. Every backup. You don’t cut a single corner because the schedule is tight.”

“I don’t cut corners,” Dorothy said.

“Good. Then we’ll get along.” Vanessa went back into the cleanroom. The sound of fresh gloves snapping on was her final word on the subject.

The next four hours were the most intense design session of Martin’s life. Dorothy drove it — she was a machine, a system for converting constraints into architecture, her pen never stopping, her questions relentless. She started with the propulsion system and worked forward, building the vehicle the way you built any complex system: from the thing that made it go to the thing that kept the crew alive.

“Gimbal response time on the S-film panels,” she said. “How fast can you repoint?”

“The stepper motors give us about 0.3 seconds for a 5-degree change,” Nate said.

“Too slow for atmospheric flight. You’ll need active damping on the control loop or the vehicle will oscillate during the high-dynamic-pressure phase of ascent. What’s the structural load path from the S-film mounts to the hull?”

“Direct bolted connections through the aft thrust structure frame.”

“Show me the frame design.”

Nate pulled up Martin’s structural sketches. Dorothy studied them for ten seconds, then took the marker and redrew them. Her version had gussets where Martin’s had flat plates, distributed load paths where his had point connections, and a mass savings of 40 kilograms from removing material that wasn’t carrying load.

She moved to the reactor. Shielding geometry — she sketched the shadow cone, calculated the solid angle subtended by the crew compartment, verified the radiation dose rate at the forward bulkhead. “Eight centimeters of tungsten-borated polyethylene composite. That gives you roughly four orders of magnitude attenuation for the gamma spectrum from the FLiBe salt. Dose rate at the crew station: approximately 0.5 milliSievert per hour at full power. Acceptable for a five-day mission. Not acceptable for anything longer.”

Life support. Cabin pressure at 70 kPa, nitrogen-oxygen mix at 75/25 — lower pressure than sea level but adequate for crew function and simplifying the pressure vessel design. CO2 scrubbing via lithium hydroxide canisters. Water storage. Food. Waste management — she spent twenty minutes on waste management, because in a sealed pressure vessel at 70 kPa, everything that the crew exhaled, excreted, or perspired stayed inside the vehicle until someone managed it.

“Viewports,” she said. “You need at least two. Sapphire, 15 centimeters diameter, fused to the hull with a graded ceramic-metal seal. Sapphire because glass can’t take the thermal cycling — cold side of the orbit you’ll be below minus 100 C on the hull exterior.”

Nate was taking notes in his Moleskine. Martin was filling legal pad pages. Dorothy was drawing on the whiteboard with both hands — marker in the right, eraser in the left, building and revising simultaneously.

By 9 PM they had a vehicle. On the whiteboard, in Dorothy's precise hand, a cylinder took shape: 12 meters long, 3.2 meters in diameter, with forward crew compartment, mid-section equipment bay, aft reactor housing, and a cruciform array of S-film panels on gimbal mounts at the stern. Radiator panels folded against the hull for launch, deploying outward like the petals of an angular flower.

Martin looked at it and felt the builder's vertigo — the moment when something went from possible to real, when the whiteboard stopped being a sketch and became a plan with a bill of materials and a schedule.

“One more thing,” he said. “We need a name.”

Dorothy looked at the vehicle she'd drawn. She looked at it the way she looked at everything — systemically, completely, every piece in relation to every other. “Skylark,” she said. “Old test-pilot tradition. Prototypes get named after birds.”

“Skylark,” Martin repeated. The word felt right in his mouth. Small, unassuming, fast.

He picked up his phone and called Rebecca Tran. “I need to buy a reactor.”

* * *

Chapter 8 — “The Clock”

Three months.

Ninety-one days from the break-in to the moment that Nate Seaton intended to be sitting in a metal cylinder, burning through the atmosphere on a thrust that no engine had ever produced, heading for an orbit that no private citizen had ever reached.

They started on Day 1. They didn’t stop.

* * *

Day 3. The sputtering chamber.

Nate and Vanessa stood in the cleanroom enclosure, gowned and gloved, watching the thirteenth deposition run of the week spin down. The vacuum chamber’s viewport showed the familiar gold sheen of a MoS2 film, this one a full-scale flight panel — 0.5 square meters on a titanium-alloy substrate.

“Temperature profile’s drifting,” Vanessa said, pointing at the monitor. The substrate temperature during deposition was supposed to hold at 300 C for optimal crystalline growth. It had crept to 307 during the copper co-sputtering phase.

“That’s within spec.”

“Barely. And it’s trending. The heater controller is overshooting on the PID loop. I’ve been tweaking the gains but I can’t get it to settle.”

“What’s the failure rate at 307?”

Vanessa pulled up the statistics. They’d deposited thirty-two full-scale films in three weeks. Thirteen had failed quality testing —

dead zones where the copper dopant distribution was non-uniform, producing areas of no thrust. A 40% failure rate.

“Unacceptable,” Vanessa said, in the tone she used when she was about to solve something. “The non-uniformity is spatial — it’s worse at the edges of the film. That tells me the sputtering flux isn’t uniform across the target. The copper target is eroding preferentially at the center, changing the local flux distribution.”

“Can you compensate?”

“I have an idea.” She pulled her notebook from the pocket of her gown. The notebook was a chaos of sketches, equations, and to-do lists, the polar opposite of Dorothy’s precise engineering hand. “If I modulate the substrate temperature during deposition — a cyclic profile, 295 to 305 C with a 10-minute period — it should cause the copper atoms to migrate locally during the cold phases and lock in during the hot phases. It’s an annealing trick. I used something similar in my PhD work for bismuth telluride films.”

“Will it work?”

“It’ll take three runs to find out. I also want to add in-situ X-ray diffraction monitoring. We can watch the lattice form in real time and adjust the sputtering power if we see the dopant distribution going off.”

She was already configuring the XRD system, moving with the focused energy that made her the best experimentalist Nate had ever worked with. Her contribution was going to be the thing that made the mission possible — not the theory, not the design, but the process. The ability to make functional films reliably and repeatably, at a rate that could keep up with the build schedule.

By Day 10, Vanessa’s process modifications had dropped the failure rate to 15%. Nate watched her work and felt the specific gratitude of a scientist who knew he couldn’t have done it alone.

*   *   *

Day 18. The reactor.

Martin stood in the parking lot of the Hillsboro hangar and watched a flatbed truck back through the roll-up doors. On the truck, in a custom-built shipping cradle that had cost $40,000 to fabricate, sat a cylinder the size of a compact car, wrapped in thermal blankets and surrounded by radiation monitors.

The Terrestrial Energy IMSR-Space Variant. Twenty-five megawatt thermal, five megawatt electric. Forty-two hundred kilograms of reactor, shielding, turbine, and control systems. The most compact nuclear power plant ever built for space application.

It had come from Ontario, Canada, by air freight to a bonded warehouse in Seattle, then by ground transport to Portland. The export paperwork — a Technology Assistance Agreement through the State Department's Directorate of Defense Trade Controls, an NRC import license for special nuclear material, a Canadian Nuclear Safety Commission export permit, and a transportation security plan approved by the Department of Energy — had taken Rebecca Tran six weeks of continuous effort. She'd slept in her office twice. She described the regulatory process as "a Kafkaesque nightmare with billable hours."

The bill for the reactor itself: $4.2 million. Martin had paid it from a Crane Energy line of credit, the single largest purchase in the company's history, recorded in the books as "prototype thermal management system for utility-scale application." His accountant had raised an eyebrow but said nothing. Martin paid his accountant well enough to buy silence.

Dorothy was in the hangar, directing the unloading. She'd designed the reactor integration — the mounting frame, the shielding geometry, the coolant connections, the electrical bus from the Brayton turbine to the S-film panels. On her workstation, a CAD model showed the reactor nestled in the aft section of the Skylark hull, surrounded by tungsten-borated polyethylene composite shielding that formed a shadow cone, blocking radiation toward the crew compartment while allowing it to radiate freely in other directions.

“It’s beautiful,” Nate said, standing beside Dorothy as the reactor was lowered from the truck by a rented crane. “In a terrifying way.”

“Beautiful is not my criterion,” Dorothy said. “Functional is my criterion. And we won’t know if it’s functional until we’ve completed the integration test sequence, which starts tomorrow and runs for twelve days. During which time nobody sleeps more than six hours.”

She said this as a statement of fact, not a complaint. Dorothy Vaneman did not complain. She identified constraints, designed around them, and executed. Sleep was a constraint. Six hours was the design margin.

* * *

Day 35. The vehicle.

The Skylark took shape in the hangar like an animal growing bones. The hull came first — five sections of aluminum-lithium alloy, each roughly 2.5 meters long and 3.2 meters in diameter, rolled and welded by a specialty fabricator in Tacoma who thought he was building a pressure vessel for an underwater research submersible. Martin had given him drawings, specifications, and a non-disclosure agreement. The welder, a sixty-year-old craftsman named Ray who’d built submarine pressure hulls for the Navy for thirty years before retiring to private work, had looked at the drawings, looked at Martin, and said, “This isn’t for underwater.”

“No,” Martin had said.

“I don’t need to know what it’s for.”

“No.”

“But the welds will be X-ray inspected. My shop, my standards.”

“Agreed.”

Ray’s welds were works of art. Nate had watched the X-ray films when they came back from the inspection lab — each weld joint a clean, continuous line of fused metal, no porosity, no incomplete penetration, no undercut. The kind of welds that kept submarines alive at crush depth and that would, in a few weeks, keep two men alive in vacuum. Ray had delivered the sections on schedule, collected his payment, and asked no further questions. Martin paid a premium for silence, and Ray had spent a career in environments where silence was a professional skill.

The hull sections arrived and were assembled in the hangar, forming a cylinder 12 meters long and 3.2 meters in diameter. The join protocol was Martin’s design: circumferential butt welds with backing rings, friction stir welded by a portable unit they’d rented from a shipbuilding contractor in Seattle. Each joint was tested — helium leak check to 10^-9 atm-cc/s, proof pressure test to 1.5 times operating pressure, X-ray inspection of every centimeter of weld line.

Inside, Dorothy supervised the installation of frames, bulkheads, wire runs, plumbing, and the thousand components that turned a metal tube into a habitable vehicle. She worked eighteen-hour days, moving between the CAD station and the hangar floor with the fluid efficiency of someone who’d spent seven years at JPL doing exactly this — turning designs into hardware, paper into metal, calculations into machines that went to Mars. Her green notebook filled with pages of installation sequences, torque specifications, cable routing diagrams, and a running punch list of items that needed attention, each one checked off in her precise hand as it was completed.

Martin handled procurement. His phone was a weapon — he wielded it in meetings, in the car, at dinner, at 5:15 AM before the gym. Components flowed into the hangar: avionics from a Crane Energy satellite subsidiary, life support modules from a supplier who also served the ISS program, EVA suits from Collins Aerospace (two units, modified for the Skylark's airlock dimensions, $800,000 each). He tracked everything on a master schedule that occupied one wall of his office, a grid of tasks, dependencies, and deadlines that he updated every evening and that, increasingly, showed red.

The S-film panels were the critical path. Nate and Vanessa produced them one at a time, eighteen hours per panel in the sputtering chamber, each one tested and characterized before acceptance. The four flight panels — each 2.4 square meters, mounted on two-axis gimbals with stepper motor drives — took five weeks to manufacture, including three rejections and restarts. By Day 50, all four panels were in the hangar, mounted on their gimbal rigs, tested individually, and ready for integration.

Nate stood in front of them and felt the vertigo of scale. In his lab at Portland State, the effect had been a curiosity — a 1 cm^2 film producing fractions of a newton. Here, four panels totaling 9.6 square meters could produce nearly half a million newtons of thrust. Enough to lift a 70-ton vehicle off the ground and push it to orbit in minutes.

He reached out and touched the nearest panel's surface. It was warm — residual heat from the last test. The gold sheen of the MoS2 film caught the hangar lights. It looked like metal. It behaved like nothing else on Earth.

*　*　*

Day 52. Dorothy’s whiteboard.

The vehicle name had stuck. *Skylark* was written on the hull in small, neat letters — Dorothy’s handwriting, applied with a paint pen during a brief ceremony that consisted of her writing the name and saying, “There.” Martin had wanted something more formal. Dorothy had said formality was for vehicles that had flown.

On the whiteboard, the engineering trade tree had grown into a forest. Every system, every interface, every failure mode mapped and mitigated — or not, with red flags marking the gaps they couldn’t close.

The thermal management system was the tallest tree. Six radiator panels, each 2 meters by 4 meters, using sodium heat pipes that transferred heat from the S-film substrates to the radiating surfaces. The panels folded against the hull for atmospheric flight and deployed on hydraulic hinges in orbit. Dorothy had tested the deployment mechanism eleven times. It worked nine times. That was a 20% failure rate on a component that, if it failed, meant the vehicle could not sustain thrust.

“I need two more weeks on the radiators,” Dorothy said.

“We don’t have two more weeks,” Martin said.

“Then we have a 20% chance of a deployment failure.”

“What happens on deployment failure?”

“If one panel fails to deploy, we lose 17% of our thermal rejection capacity. Maximum sustainable thrust drops to about 80%. If two panels fail, we’re at 60% capacity and can only sustain 50% thrust. If three or more fail…” She let the implication hang.

“Can we deploy manually? EVA?”

“Yes. If you want to send someone outside the hull during atmospheric transit to unfold a radiator panel while the vehicle is accelerating at half a g.”

Martin looked at Nate. Nate looked at the whiteboard. Neither of them said what they were both thinking, which was that in three months they had built a spacecraft from scratch with a team of four people and a budget that wouldn’t buy a single rocket engine from a conventional supplier, and that every shortcut they’d taken was a crack in the foundation, and that they were going to fly it anyway.

“The radiators deploy after we clear the atmosphere,” Nate said. “If one fails, I’ll EVA in orbit to fix it.”

“You have twelve hours of EVA training from a YouTube series and a swimming pool,” Dorothy said.

“Fourteen hours. I did the advanced module.”

Dorothy’s expression did not change. She picked up her pen and wrote on the whiteboard, beneath the radiator failure branch: *Contingency: EVA repair. Probability of success: moderate. Note: pilot’s EVA training is inadequate.*

“Noted,” Nate said.

* * *

Day 61. The heat-pipe radiators.

The breakthrough came from Nate and Vanessa, working a problem that was supposed to be Dorothy’s.

Dorothy had been taken — but that was later. At Day 61, she was still here, still driving the build, still the center of the engineering effort. The heat-pipe radiators were her design, and they worked, but the thermal bus that connected the S-film panels to the radiator headers had a pressure drop problem. The pumped NaK coolant loop couldn’t deliver enough flow rate at the available pump pressure to keep all four S-film panels below 380 C at full thrust simultaneously.

Nate and Vanessa attacked it from the materials side. Nate redesigned the thermal interface between the S-film substrates and the coolant channels, using a graded copper-diamond composite that improved thermal conductivity by 40%. Vanessa optimized the NaK flow distribution by adding passive flow-balancing orifices at each panel inlet — a plumbing trick she’d learned from a paper on nuclear fuel rod cooling.

The combined effect was enough. Bench testing showed all four panels stabilized at 370 C at full thrust, with 10 degrees of margin below the 380 C warning threshold.

Dorothy reviewed the data and said, “That’s not how I would have done it.”

“Is it right?” Nate asked.

“It’s right. And it’s better than my original design in one respect — the passive orifices don’t depend on the pump. If the pump degrades, the flow balance self-adjusts.” She made a note in her green notebook. “Good work.”

It was the highest praise Dorothy Vaneman offered.

* * *

Day 72. Intercut: Nevada.

In Building C at the Groom Lake facility, DuQuesne stood before a test rig and watched a 0.5 square meter S-film panel produce 22 kilonewtons of thrust for forty-five consecutive seconds before the thermal monitoring system shut it down at 385 C.

The panel glowed in the infrared camera feed — a bright, even bloom of waste heat dissipating through the substrate. On the force readout, a clean plateau: 22.3 kN, steady to within 0.5%, for the entire 45-second run. No oscillation, no drift, no ghosts. Just power, converted to force, through a mechanism that a month ago he couldn't replicate and now could.

He'd found the ratio. 72.8/27.2. The fourth sample in his fine-grained isotope series, right where his theoretical analysis had predicted the resonance should peak. The first test film at that ratio had produced clean, consistent, linear thrust from the moment current was applied. No stuttering. No incoherence. The phonon mode at 4.71 THz had locked onto the vacuum coupling and stayed there, stable as a crystal oscillator.

DuQuesne had stood in the lab at 3 AM on the night of the first successful test and felt something he hadn't felt since his early years at Los Alamos — the specific, private exaltation of watching the universe do something no one had seen before. He'd run it three more times, each run cleaner than the last, the data falling on Seaton's published curves with the fidelity of independent confirmation. It was real. It was his hands that had made it. And the fact that Seaton's hands had made it first didn't diminish the achievement — it confirmed it.

He'd reported the result to Brookings within the hour. Brookings's response had been immediate and specific: fast-track vehicle construction. DuQuesne's vehicle — designated "Condor" in Vanguard's project management system — had been in preliminary design for weeks, awaiting confirmation of the propulsion technology. Now the design went to fabrication.

The Condor design reflected its parentage. Where Skylark was a cylinder designed by an engineer who built Mars rovers, Condor was a platform designed by a defense contractor who built weapon systems. Twenty meters long, 4.5 meters in diameter, 140,000 kilograms at launch. Six S-film panels totaling 18 square meters — nearly double Skylark's thrust capacity. Armored hull with 2 centimeters of ceramic-steel laminate. Military-grade avionics sourced from a satellite reconnaissance program. Individual crew berths for three, with a pressurized volume nearly four times Skylark's cramped quarters.

And, over DuQuesne's explicit objection, a kinetic rail gun mounted on a dorsal hardpoint.

He'd fought the weapon in two meetings, a written memo, and a hallway conversation that had gone quiet enough to make the passing security guard slow his pace. "The weapon compromises the thermal budget," DuQuesne had told Brookings, laying his analysis on the walnut desk. "The rail gun's S-film accelerator draws 800 kilowatts per shot and produces 200 kilowatts of waste heat during the capacitor recharge cycle. That heat competes directly with the propulsion panels for radiator capacity. It adds 800 kilograms of mass. And it transforms this vehicle from a technology demonstrator into a military platform, which invites a military response from people with far more experience at military responses than we have."

"The weapon stays," Brookings had said. "It's not a weapon. It's a contingency."

"Contingency for what?"

Brookings had looked at him with the patient, empty expression that DuQuesne had come to recognize as his way of communicating that a decision was final. "For the possibility that Dr. Seaton's team doesn't respond to reason."

DuQuesne had not argued further. He'd learned, over three years at Vanguard, that there were arguments you could win and arguments you could survive, and that the difference between them was Brookings's tone of voice. This was a survive argument.

The Condor build was proceeding at a pace that made Skylark's three-month sprint look leisurely. Vanguard had resources that Martin Crane could not match: fabrication facilities with classified manufacturing equipment, supply chains that moved through government procurement channels without the bottleneck of commercial purchasing, engineers with security clearances who didn't need to be briefed through NDAs. The hull was being fabricated in sections at a Vanguard facility in Virginia and shipped to Groom Lake for assembly — three C-17 cargo flights from Langley Air Force Base, authorized through channels that Brookings maintained like a gardener maintaining hedgerows. The reactor — a modified naval design, heavier and less elegant than Skylark's IMSR but more powerful at 40 megawatt thermal — had been on-site since before DuQuesne achieved replication, a $12 million bet on his eventual success.

Brookings had also assigned crew. DuQuesne would fly as mission scientist and chief engineer. A Vanguard security operator named Perkins would handle "contingencies" — a euphemism DuQuesne chose not to examine closely. And an Air Force pilot named Cole had been "volunteered" through a classified personnel exchange that gave Cole orders to report to a facility he'd never heard of, to fly a vehicle that didn't exist in any database he could access, for a mission whose objectives would be briefed en route.

DuQuesne had met Cole briefly — compact, sharp-eyed, professional, the posture of a man who followed orders because following orders was what he'd spent a career learning to do well. He'd looked at DuQuesne with the polite wariness of someone who recognized the smell of a classified program and was reserving judgment until he understood the shape of it.

DuQuesne supervised the build with the same systematic thoroughness he brought to everything. But he was troubled.

The thermal management system was marginal. His radiator array — designed by Vanguard's thermal engineering team to a schedule that Brookings had imposed and DuQuesne had protested — provided approximately 12 megawatts of rejection capacity against a full-thrust thermal load of roughly 13 megawatts. An 8% shortfall. At full thrust, the S-film panels would slowly accumulate heat, the substrate temperatures climbing perhaps 3 degrees Celsius per minute. In twenty minutes, they'd reach the 380 C warning threshold. Then he'd have to throttle back to 40% for at least 10 minutes to cool the panels back to operational range.

Twenty minutes on, ten minutes off. An effective duty cycle of two-thirds. A vehicle with nearly double Skylark's thrust capacity that could only sustain two-thirds of it.

It was a design flaw that he'd flagged in the first review and that the Vanguard engineering team had dismissed because fixing it would require larger radiators — six more square meters of radiating area — which would delay the schedule by four weeks, which Brookings would not accept. DuQuesne had written the dissenting analysis and filed it in the project record. The record went into a classified database. The radiators stayed undersized.

DuQuesne knew what Dorothy Vaneman would have said. He'd read her published work — the JPL mission design papers, the thermal management architectures for the Europa Clipper subsystems. He could almost hear her voice, the voice of a systems engineer who understood that every shortcut in thermal design was a loan taken out against the laws of thermodynamics, and thermodynamics always collected: *The thermal ceiling is the entire game. Everything else is commentary.*

She was right. But she was in Portland, working for the other side, and he was here, building a vehicle that was faster than Skylark and less reliable, and the clock was ticking for both of them.

* * *

Day 78. The control van.

Vanessa Almeida had spent twelve hours turning a rented cargo van into a mission control center. The van sat in the parking lot of the Hillsboro hangar, and inside it she'd installed three monitors, a rack-mount server, two radio transceivers — X-band and VHF — and a data link to Skylark's onboard telemetry system. Cable runs went through a hole she'd drilled in the van floor, across the parking lot in buried conduit, and into the hangar through a weatherproof junction box.

The server ran her custom flight monitoring software — a Python application she'd written in four nights, building on code she'd originally developed for monitoring sputtering chamber parameters. It ingested telemetry from Skylark's avionics, displayed real-time system status on the three monitors, and logged everything to local storage. No cloud. No network connection. Air-gapped, the way everything was now.

She tested the radio link. Nate was inside the vehicle, seated in the left acceleration couch — the pilot's position, a term that made her want to laugh and cry simultaneously, because Nate had precisely zero hours of flight training and was going to fly a nuclear-powered spacecraft into orbit — and she could hear his breathing on the VHF channel, the sound of a man getting used to the confined space that would be his world for five days or until something broke, whichever came first.

“Telemetry check,” she said into the microphone. “Give me a power-on sequence for the flight computer.”

“Copy.” Nate’s voice on the radio, professional, controlled. He was practicing, she realized. Practicing being a pilot. Practicing the language, the cadence, the emotional register of someone who flew things for a living. She thought about the Mae Jemison poster on her apartment wall and the dying succulent and the fact that she was mission control for a flight that would either change the world or kill her best friend.

“Flight computer is online,” Nate said. “All four S-film panels reporting nominal. Reactor in standby. Radiators stowed. Cabin pressure 70 kPa.”

“Copy all. Telemetry is clean on my end.” She paused. “Nate.”

“Yeah?”

“Don’t die.”

“That’s the plan.”

“It’s a bad plan. It’s a two-word plan. Plans should have more words.”

“Dorothy’s plan has plenty of words. I’ve read it. It’s very thorough.”

“Dorothy’s plan has sixteen pages of contingency procedures and not one of them covers what to do if the pilot forgets to breathe because he’s too busy staring at the data.”

“I’ll breathe. I promise.”

She let it go. There was nothing more to say that wouldn’t be the kind of thing you said when you were afraid, and she’d decided weeks ago that fear was a luxury the mission didn't have room for. She had a job. The job was to be the voice in their ears, the eyes on the data, the connection to the ground. She would do the job until it was done.

*   *   *

Day 83. Rebecca Tran's office.

Martin sat across from Rebecca Tran at her desk in downtown Portland — a corner office in a high-rise, the kind of office that told you its occupant billed at rates that started at four figures per hour. The desk was clean. The chair was good. Behind her, through floor-to-ceiling windows, the Willamette River caught afternoon light.

Rebecca was small, sharp-featured, and wearing a blazer that cost more than Nate's monthly rent. She had reading glasses perched on her head, forgotten there, which made her look slightly less intimidating than she actually was. She was studying a document on her screen with the focused intensity of a raptor watching a field mouse.

"The FAA denied the launch license," she said.

"I know."

"The denial was on four grounds. Unlicensed nuclear power source. No prior launch history. No range safety system. No environmental review." She looked at him over the invisible reading glasses on her head. "Any one of those grounds is sufficient. Four together is the FAA saying 'no' in a way that's designed to withstand an appeal."

"Can we appeal?"

"We can. It would take six to eight months. By then, everyone in Washington will know what you're building, and the classification hammer will have fallen."

"So we launch without a license."

Rebecca was quiet for a moment. She took the reading glasses off her head and placed them on the desk with a precision that suggested she was buying time to formulate a response that was legally accurate, practically useful, and would not end her career.

"Launching a vehicle into orbit from US soil without an FAA license is a federal crime," she said. "51 USC 509. Penalties up to $100,000 per violation per day. Potential imprisonment."

"I understand."

"Launching a nuclear reactor without NRC authorization compounds the exposure substantially. And the ITAR implications of operating an unlicensed space vehicle with technology that falls under the Munitions List — "

"Rebecca. I understand the legal exposure. I'm asking you what happens after we launch."

She studied him. Martin Crane, sitting in her client chair, wearing the calm expression of a man who'd already made his decision and was consulting his lawyer out of courtesy rather than uncertainty. She'd been Rebecca Tran's client for six weeks, and in that time she'd watched him commit financial resources, personal relationships, and now his freedom to a project that either justified every risk or didn't, with no middle ground.

"After you launch," she said, "the calculus changes. If the technology works — publicly, demonstrably, on open radio frequencies so the whole world can hear — then prosecuting you becomes a political decision, not a legal one. The government would be jailing the people who just demonstrated the most significant technological breakthrough in history. That's a hard case to bring."

“And if it doesn’t work?”

“Then you’re a rich guy who illegally launched a nuclear reactor into the sky over Oregon and will spend the next decade in federal prison explaining why.” She paused. “I’m advising you not to do this.”

“Noted.”

“And I’m going to prepare the post-flight legal strategy as if you’re going to do it anyway.”

“Thank you, Rebecca.”

She opened a new file on her screen. “You should also know that I’ve filed provisional patent applications covering the S-film technology, the vehicle architecture, and the thrust-vectoring system. And I’ve prepared a voluntary ITAR disclosure that we’ll file simultaneously with the launch — not before, because filing before would trigger a review period during which they could issue a secrecy order. Filing simultaneously means the information is in the public record before anyone can classify it.”

“That’s aggressive.”

“That’s the job.”

* * *

Day 87. Eastern Oregon.

The Skylark sat on a concrete pad that Martin had hired a contractor to pour three weeks ago, on a tract of Crane-owned land in the high desert east of Bend. The land had been part of a failed wind-farm project that Martin had acquired for pennies in a bankruptcy sale. It was flat, remote, and served by a single gravel road that dead-ended at a locked gate with a Crane Energy sign. No neighbors. No flight paths. No witnesses except the sagebrush and the sky.

The vehicle had been transported on two flatbed trucks — hull and reactor on one, radiator panels and S-film arrays on the second — shrouded in tarps, making the four-hour drive from Hillsboro in the pre-dawn dark. Dorothy had supervised the loading and unloading, checking the mounting brackets and tie-downs at every stop. She'd ridden in the cab of the lead truck, her green notebook on her lap, making entries every thirty minutes: vibration levels, ambient temperature, road conditions. The S-film panels were sensitive to shock. The reactor, despite being a rugged piece of nuclear engineering, had coolant fittings that could loosen under sustained vibration. Dorothy tracked everything because Dorothy trusted nothing that hadn't been measured.

On-site assembly took four days. The hull was lowered onto its landing legs — four reinforced steel pipes with welded footpads, the most brutally simple component of the entire vehicle, designed in an afternoon by Martin, who'd said, "It only needs to hold the weight once, going up. Coming down is a different problem." The reactor was mated to the hull through a bolted flange joint that Dorothy tightened to precisely 180 newton-meters per bolt, checked with a calibrated torque wrench. The S-film panels were installed on their gimbals, connected to the power bus, and tested individually — each one producing its characteristic thrust pulse against the hold-down restraints, the concrete pad groaning slightly under the asymmetric load.

The Skylark looked, Dorothy said, like an industrial boiler that had been in a fight with an antenna farm. Nate thought it looked like the future, but he kept that thought to himself because Dorothy did not appreciate poetry about engineering.

Twelve meters long. A cylinder, brushed aluminum-lithium alloy catching the high-desert sun, bristling with radiator panels folded against the hull like the wings of a sleeping bat, S-film panels on their gimbal mounts visible at the stern as dark, gold-sheened rectangles. The reactor housing was a subtle bulge amidships, marked only by the radiation warning placards that Dorothy had insisted on, even though the reactor was cold and the only people for miles were the four of them and a security guard Martin had hired to watch the gate.

Nate stood in front of it in the cool desert morning and let himself feel it: the reality of a thing he'd built. Three months ago he'd been a materials scientist with a broken fume hood and a funding deadline. Now he was looking at a spacecraft. The word felt too large and too small simultaneously, like holding a telescope backward. He reached out and put his hand on the hull. The aluminum was cold from the desert night, smooth under his fingertips, and underneath it — inside the metal skin he could feel warming in the morning sun — was a reactor that could power a small city, a set of films that could push this cylinder to orbit, and two seats for two people who were about to commit several federal crimes in the name of science.

His phone rang. Unknown number. He almost didn't answer — he'd been getting spam calls all week, the consequence of his number being in various databases that various people were mining for various reasons. But something made him swipe.

"Dr. Seaton." The voice was distorted — digitally processed, flattened into something that could have been anyone or no one. Male, maybe. Or female, processed down. Impossible to tell. "You should stop building. This is your only warning."

The line went dead.

Nate stood with the phone pressed to his ear, the dial tone buzzing, the desert wind pushing against him with the cold, dry insistence of a high-altitude morning. The Skylark sat on its pad behind him, catching the first sunlight, the radiator panels throwing geometric shadows on the concrete. In the distance, a hawk circled over the sagebrush, riding thermals, doing what birds did — flying because the physics allowed it and because nothing could stop it.

He lowered the phone. He looked at the call log: UNKNOWN, 0:00:08 duration. Eight seconds. Enough to deliver a threat, not enough to trace.

He looked at the vehicle. He looked at the sky.

Then he walked to the control van where Vanessa was calibrating the telemetry uplink, and said, “We need to talk about the launch timeline. I want to move it up.”

Vanessa looked at him. She saw something in his face — the set of his jaw, the tension around his eyes, the way he was holding his phone like he wanted to throw it into the desert.

“What happened?”

“Someone called. Told me to stop building.”

“Vanguard?”

“Probably. Doesn’t matter. What matters is they know where we are. And they know we’re close.”

Vanessa turned back to her monitors. She was quiet for a long time — thirty seconds, maybe a minute — and when she spoke, her voice was steady in the way that it got when she’d made a decision and the decision cost her something.

“The S-film panels are at 85% of target qualification. The reactor coolant loop hasn’t completed its full-duration endurance test. The radiator deployment mechanism has a 10% failure probability on two of the six panels. The flight computer has a known glitch in the attitude determination software that Dorothy was planning to fix this week." She paused. "None of that matters to you right now."

"It matters. It all matters. But so does being first."

"I know." She pulled up the mission timeline on her center monitor. Launch minus four days had been the plan. "How much do you want to move it up?"

"How fast can you be ready?"

"The systems will be as ready as they're going to be in 48 hours. After that, it's diminishing returns."

"Then 48 hours." Nate looked at the monitor, at the timeline, at the names listed under crew: *N. Seaton, M. Crane.* His name. Martin's name. In 48 hours, those names would either be in history books or in obituaries. Both possibilities felt equally real and equally distant, the way the desert made everything look both close and far away at the same time.

"Call Martin," Vanessa said. "Tell him. And Nate?"

"Yeah?"

"When you get up there, you broadcast on every frequency you can reach. You tell the whole world what you've got. You make it so public, so loud, so undeniable that nobody can make it disappear." She met his eyes. "That's your real safety system. Not the radiators, not the reactor, not the hull. The fact that everybody's watching."

"I will."

"Good." She went back to the telemetry calibration. "Now let me work. I have 48 hours to get mission control ready for the most important flight in human history, and I haven't slept since Tuesday."

*   *   *

Chapter 9 — “Threat Assessment”

The phone call changed Martin’s posture before it changed anything else.

He sat in the security office at the Hillsboro hangar at six in the morning, watching playback from the parking lot cameras, and he felt his shoulders draw up and his jaw set the way they used to set at Bagram when the threat brief changed color. Nate had played the recording twice for him, the distorted voice flat and unhurried: *Dr. Seaton. You should stop building. This is your only warning.* Martin had listened with his hands folded on the desk, asked two questions, made a list, and started working the list.

The list was short. The list was expensive.

First: people. He called Jim Torrance, a private security consultant he’d used to vet warehouse personnel for Crane Energy’s battery deployments in rural Oregon. Torrance had been an Army CID agent, then Blackwater for two miserable years he never discussed, then a one-man firm in Bend. Martin told him the situation in broad strokes and asked for a four-person team inside the building and two roving outside, twenty-four seven.

“For how long?” Torrance asked.

“Until I say stop.”

“That’s a burn rate of about forty thousand a week, Martin.”

“I know what it costs.”

Second: the facility itself. The Hillsboro hangar had been adequate for lab work. It was not adequate for anything that attracted professional opposition. Martin spent the morning making calls, and by noon he had a lease agreement drafted for Hangar 7 at Portland International

Airport’s Air National Guard annex — a decommissioned F-15 maintenance bay that the 142nd Wing had vacated when they consolidated to the south ramp. It had reinforced doors, a perimeter fence, military-grade wiring, and a concrete apron big enough to park three semis. The lease ran through a Crane Energy subsidiary called Cascade Aerospace LLC, which Rebecca Tran had incorporated six weeks ago for exactly this kind of contingency.

He also called Laura. He didn’t tell her about the phone call — not the content, not the voice, not the distortion that suggested someone who knew how to disguise a phone signal. He told her the project was entering a new phase and that he’d be spending more time at the facility. She asked if everything was all right. He said yes. It was the first lie he’d told her since they’d started dating, and it sat in his chest like a stone.

Third: legal counsel. Rebecca Tran answered on the second ring, even though it was barely seven in the morning. Martin had noticed that about her — she kept the hours of someone who expected the world to generate emergencies at inconvenient times.

Her voice on the phone was measured, as always. “I need you to listen to me for five minutes without making a decision.”

“Go ahead.”

“We should file provisional patents this week. Not because we want to commercialize — because patents create a public record that’s timestamped and notarized. If someone classifies this technology later, the patent filing proves we had it first and that it was in civilian hands. It establishes priority and civilian provenance simultaneously.”

Martin leaned back in his chair. Through the office window, he could see Vanessa and two technicians packing S-film substrates into foam-lined crates for the move. “What about ITAR?”

“That’s the other thing. We prepare a voluntary disclosure to the Directorate of Defense Trade Controls. Not a full technical package — a notice that we’ve developed a propulsion technology with potential defense applications and that we’re making the government aware proactively. The goal is to get ahead of classification. If we disclose voluntarily, we look like responsible actors. If they discover us through surveillance or a leak, we look like criminals.”

“We might be criminals regardless.”

“We might. But the optics matter. Right now, we’re a private research team that discovered something extraordinary and is cooperating with the regulatory framework. That’s a story Rebecca Tran can tell a judge. The alternative story — that we hid a breakthrough propulsion technology in a leased hangar while a defense contractor tried to steal it — that story doesn’t have a happy ending for anyone.”

Martin told her to draft both filings. Then he picked up his personal phone and made the calls he’d been putting off.

He still had contacts from his Air Force years. Not many — six years as an engineering officer at Wright-Patterson didn’t build the kind of network that combat pilots accumulated — but he’d worked with people at Air Force Research Lab who’d moved up or sideways. He called three of them. Colonel Diaz at AFRL’s Aerospace Systems Directorate, who listened for ninety seconds and said, “Martin, are you having a breakdown?” He called Sarah Wendt, a civilian program manager at NASA Headquarters who’d been at Boeing when he was there, who said, “Send me the data and I’ll take a look, but I’m not promising anything.” And he called a number he hadn’t dialed in four years, a major general’s aide at Kirtland, and got a voicemail he didn’t leave a message on.

That was Monday.

Tuesday, Martin drove to the Air National Guard annex and walked through Hangar 7 himself. The building was cavernous — two hundred feet long, eighty wide, sixty to the roof trusses. The floor was smooth epoxy over concrete, scored with the marks of fighter jet landing gear that had been rolled across it for thirty years. Overhead, banks of high-intensity work lights hung from tracks that could be repositioned to illuminate any part of the floor. Along the walls, built-in compressed air lines and electrical conduits ran at regular intervals. The hangar smelled like jet fuel and metal and industrial cleaner, even months after the last F-15 had left.

It was not a lab. It was a workshop. Martin felt more at home here than he had in the Hillsboro facility. This was a place where things got built.

He walked the perimeter, checking the doors (four: one main rolling door for vehicle access, one personnel door on each side, one office entrance in the back), the windows (none on the ground floor, clerestory windows high up that could be blacked out with paint or foil), and the electrical panel (480-volt three-phase, enough to run the deposition chamber and the test rig simultaneously). The security gate at the perimeter was chain-link topped with razor wire — military surplus, adequate for deterrence, useless against a determined team but better than the Hillsboro facility's commercial lock system.

By Wednesday, the team was moving in. Martin supervised the transfer personally, standing on the concrete apron in a rain jacket, directing the flatbed trucks through the gate while Torrance's people swept the building for surveillance devices — radio frequency, acoustic, and visual. They found none, which meant either the building was clean or the opposition was better than the detection equipment. Martin chose to assume the latter and had Torrance set up a schedule for weekly sweeps.

The deposition chamber went in first, lowered off a flatbed by a rented crane and settled onto foundation bolts that the technicians had anchored into the hangar floor the day before. Then the test rig components. Then the workbenches, the instrumentation racks, the filing cabinets with Dorothy's drawings, the break room furniture, the cots. They were building a world inside these walls — a self-contained ecosystem of manufacturing and testing and living that would carry them from raw materials to a flyable spacecraft.

Nate arrived Thursday morning looking like he hadn't slept. He probably hadn't. He walked the length of the hangar, hands in his jacket pockets, taking in the new space with the careful attention of a man assessing a tool. He stopped at the far end where the S-film fabrication chamber — a hulking vacuum deposition system the size of a delivery van — sat on its new foundation bolts, its vacuum pumps already cycling to base pressure.

"We need to do a full-scale static test," Nate said. "Before we move to integration."

"Dorothy's been designing the test rig."

"I know. I want to be there."

Martin almost said something about the security brief, about the phone call, about the fact that Nate should be sleeping instead of standing in a hangar at seven in the morning with circles under his eyes that looked like bruises. He almost said that the first order of business should be rest, then security, then planning, then testing — the orderly sequence that Martin's operational instincts demanded.

But Nate's expression was the one Martin recognized from grad school — the one that meant he was going to do the thing regardless of what anyone said, so you could either help or get out of the way. It was the expression Nate had worn the night he'd called from the lab at two in the morning and said, *Martin, I need you to see something.*

"Saturday," Martin said. "Dorothy says the panel will be ready Saturday."

* * *

Dorothy Vaneman ran the static test like she ran everything: with a checklist, a timeline, and the serene focus of someone who had sent robots to Mars and knew that the universe did not care about your schedule.

The test rig was bolted to the hangar floor at the east end, a steel frame that held a single full-scale S-film panel — 2.4 square meters of copper-doped MoS2 on a titanium substrate, mounted on a two-axis gimbal identical to the flight hardware. Behind the panel, a bank of four calibrated load cells measured thrust. To the sides, thermal imaging cameras tracked surface temperature across twelve zones. A Faraday cage surrounded the entire assembly, wired to RF monitors that would detect any electromagnetic emission above the noise floor.

Dorothy stood at the control station — a folding table with three laptops and a UPS — and read from a laminated card in her hand. She wore safety glasses and hearing protection around her neck. Her braid hung over one shoulder.

"Test conductor is Vaneman. Test director is Crane. Principal investigator is Seaton. Time is oh-eight-forty-two local, fourteenth of September. Ambient temperature twenty-one C, humidity forty-eight percent. Test article is panel Alpha-Three, serial number SF-dash-twenty-six. Thrust axis vertical, gimbal locked to zero-zero."

She looked up. Nate was at the instrumentation rack, Vanessa beside him. Martin stood ten meters back, arms crossed. Torrance's people were outside. The hangar doors were closed and locked.

"Power supply status."

"Online," Vanessa said. "Five megawatt bus is stable. Coolant loop is circulating. Flow rate twelve point three liters per minute."

"Instrumentation status."

"Load cells calibrated and zeroed. Thermal cameras recording. Accelerometers active. RF monitors clean."

Dorothy checked each item on her card, initialing in grease pencil. Then she set the card down and put on her hearing protection. Everyone else did the same.

"Panel Alpha-Three, power sequence initiating. Ten percent rated current in three, two, one. Mark."

Vanessa moved the slider on the power control interface. The panel hummed — a low, pervasive vibration that Martin felt in his sternum more than heard through the ear protection. The load cells twitched.

"Thrust reading twenty-two point six kilonewtons," Nate read from the display. "Steady. Temperature zones one through twelve all nominal. Hottest zone is seven, reading one-forty-one Celsius."

"Twenty percent."

The hum deepened. Martin watched the thermal display — a mosaic of cool blues and warming greens — and felt the floor vibrate through his boots.

"Forty-four point eight kN. Temp zone seven at one-ninety-two."

"Forty percent."

The sound changed. It was no longer a hum. It was a presence — a physical pressure in the air, a vibration that wanted to be in your teeth and your fingertips. The load cell display climbed steadily. The thermal cameras shifted from green to yellow to amber.

“Eighty-nine point three kN. Zone seven at two-sixty-eight. Zone four at two-fifty-one. All zones below three hundred.”

“Sixty percent.”

Now Martin could see it. The panel, bathed in the harsh overhead lights, had taken on a dull red undertone — not glowing, not yet, but the surface heat was enough to make the air above it shimmer. The test rig groaned. The foundation bolts held. The thrust readings climbed past a hundred kilonewtons, past a hundred and ten.

“One-eighteen point nine kN. Zone seven at three-twenty-two. Approaching caution band.”

“Eighty percent,” Dorothy said. Her voice was level. Her eyes moved between the thermal display and the load cells in a steady rhythm.

The panel glowed. There was no other word for it. A deep cherry-red suffused the lower third of the surface, spreading upward like a tide. The heat-pipe radiator on the back face was working at capacity — Martin could see its own thermal signature blooming on the IR camera, a bright orange rectangle pumping heat away from the film as fast as the sodium inside could carry it. The sound was now a deep thrumming that he felt in his spine.

“One-fifty-seven point two kN. Zone seven at three-sixty-one. Zone four at three-forty-eight. Zones two and eleven entering caution band. All zones below four hundred.”

“Full rated power. One hundred percent.”

Vanessa pushed the slider to its stop. The panel blazed. The cherry-red became orange at the edges, and the radiator behind it screamed heat into the hangar air. Sweat broke across Martin's forehead from fifteen meters away. The thrust reading climbed, steadied, held.

"One-ninety-two point seven kilonewtons," Nate read. He looked up from the display. His eyes were wide. "Predicted was two-oh-eight. That's within eight percent."

"Zone seven at three-eighty-nine," Vanessa called. "Approaching thermal limit."

"Hold for ten seconds at rated power," Dorothy said. She watched the clock on her laptop. The seconds were the longest Martin had experienced outside of a war zone. Eight. Nine. Ten.

"Power to zero. Emergency coolant flush."

The hum died. The glow faded. The radiator continued to pour heat, and the coolant pumps whined as they drove chilled fluid through the panel substrate. Slowly, the thermal display cooled from angry reds through amber to green.

Dorothy pulled off her hearing protection. "Test complete. Duration at full rated power: ten seconds. Peak thrust: one hundred ninety-two point seven kilonewtons. Peak temperature: three hundred eighty-nine Celsius in zone seven. No thermal exceedances. No film damage detected on visual inspection."

She looked at Martin. Her expression hadn't changed, but her hands — always her most honest feature — were trembling slightly at her sides.

"It works," she said. "The engineering is sound. But that thermal signature is enormous. Any infrared satellite that happens to be looking at Portland is going to see a very interesting hot spot on the east side of the airport."

Martin nodded. He'd already thought about this. The test had run for less than ninety seconds total, with ten seconds at full power. He didn't think it was long enough to trigger automated satellite alerts. He hoped.

"Start integration planning," he told Dorothy. "I want the vehicle framework laid out by end of next week. Load-bearing structure, panel mounts, thermal bus routing, everything."

"And the reactor?"

"I'm working on it."

He turned and walked to the hangar's small office, closed the door, and sat at the desk. His phone showed a missed call from a number with a 505 area code. Kirtland Air Force Base. He'd left no message, but someone had called back.

He dialed.

The phone rang twice. A woman's voice answered — not the aide, someone more senior. Clipped, precise.

"Mr. Crane. This is Major General Whitfield. I've seen your data." A pause. "Don't file anything yet. I'm coming to Portland."

* * *

Chapter 10 — “General Interests”

Major General Karen Whitfield arrived at Hangar 7 on a Tuesday morning in an unmarked Suburban driven by a staff sergeant who stayed in the car. She wore civilian clothes — dark slacks, a gray blazer, sensible flats — and carried a leather portfolio under one arm. No stars, no uniform, no entourage. But she moved through the security checkpoint at the gate with the economy of someone who had been walking into controlled spaces for thirty years and expected every door to open.

Nate met her at the hangar’s side entrance. He’d been up since four, running the slides Dorothy had prepared, rehearsing explanations of the quantum vacuum coupling mechanism until the words felt flat and mechanical in his mouth. He’d showered, put on his cleanest flannel shirt, and tried to decide whether wearing his glasses or his contacts would make him look more credible. He’d settled on the glasses. Scientists wore glasses.

“Dr. Seaton.” Whitfield’s handshake was brief and firm. Her eyes were already past him, scanning the hangar interior — the vacuum deposition chamber, the test rig, the skeletal frame of what would become the vehicle’s structural bus, the organized chaos of crate stacks and workbenches and bundled cable runs. She took it in the way a pilot reads instruments: all at once, prioritized by relevance.

“General Whitfield. Thank you for coming.”

“Show me everything.”

Martin and Dorothy were waiting at the briefing table — a repurposed conference table from Crane Energy’s Portland office, set up in the hangar’s enclosed meeting room. Nate had printed the slides, twelve copies, because Whitfield had specified no electronic devices in the briefing. Her phone was locked in the Suburban’s glove box. Martin’s phone was in a Faraday bag on the shelf.

Nate began with the physics. He walked Whitfield through the S-film effect from first principles: the copper-doped TMD lattice, the isotope requirement, the quantum vacuum coupling mechanism. He used the metaphors he’d refined over months — the vacuum as a sea of paired particles, the film as a membrane that biased their symmetry, the current as the energy source that drove the bias.

Whitfield listened without interrupting. She took notes in a small notebook with a mechanical pencil, writing in a cramped, precise hand. When Nate reached the thermal limits — the 400-degree ceiling, the cliff-edge efficiency drop — she asked her first question.

“What’s the failure mode above the ceiling?”

“Copper migration in the lattice. The dopant atoms become mobile enough to diffuse out of their substitutional sites. The crystal geometry that produces the coupling effect is destroyed. It’s irreversible — the film has to be replaced.”

“How fast?”

“Minutes. At four-twenty Celsius, the lattice geometry degrades beyond recovery in three to five minutes. At four-fifty, it’s seconds.”

Whitfield wrote something and drew a box around it. “Continue.”

Nate showed her the test data — bench measurements, parametric sweeps, the full-scale static fire from the previous week. He pulled up the force-balance curves on the printed handouts and walked her through the measurement protocol: direct force from calibrated load cells, accelerometer cross-check, and the energy audit that closed electrical input against thrust work and waste heat to within four percent.

Whitfield studied the data with the focus of someone who had a PhD in electrical engineering and had spent a career evaluating claims from people who wanted her money. She ran her finger down the thermal profile plot — the curve that showed how panel temperature rose under sustained thrust — and tapped a point near the inflection.

“What’s this deviation at seventy percent power? The temperature slope changes.”

Nate leaned in. “Phase transition in the NaK coolant loop. The sodium-potassium eutectic has a specific heat anomaly near two-forty Celsius — it’s a known property of the alloy. The thermal bus absorbs a burst of heat at that point, which briefly flattens the panel temperature rise. It’s transient. Doesn’t affect steady-state performance.”

“But it masks the true heating rate during ramp-up. You could overshoot the thermal limit if you power through that transition too quickly.”

Nate blinked. She was right. It was a subtlety that Dorothy had already flagged in her thermal management notes but that he hadn’t expected a visiting general to catch from a printed plot.

“We have a ramp-rate limit in the control software,” he said. “Power increase capped at five percent per second through the two-forty regime.”

Whitfield nodded and wrote something else. “Good. Continue.”

Dorothy took over for the vehicle architecture briefing. She stood at the whiteboard and laid out the cylinder-and-panel design with the precision of someone who had briefed NASA review boards and knew that every number had to survive scrutiny. The hull — aluminum-lithium alloy, 3.2 meters in diameter, twelve meters long. The reactor in the aft section with its shadow shielding geometry. The four S-film panels on their gimbal mounts in a cruciform arrangement. The six deployable radiator panels, folded for launch, unfolding in orbit like petals to reject the seven megawatts of waste heat that full thrust produced.

Dorothy drew the thermal bus routing on the whiteboard — the NaK loop that connected panel substrates to radiator headers, the flow rates, the pressure margins. She drew the life support schematic: LiOH canisters for CO2 scrubbing, high-pressure oxygen tanks, the condensate recovery system. She put numbers on everything. Mass budgets. Power budgets. Thermal budgets. Time budgets.

Whitfield asked seven more questions during Dorothy's portion. All of them were good. Two of them — about asymmetric thermal loading during thrust vectoring and about radiation shielding geometry for the reactor — were questions Nate hadn't thought of until she asked them. A third question, about the failure cascade if a single radiator panel failed to deploy, led to a ten-minute back-and-forth between Whitfield and Dorothy that sounded less like a briefing and more like two engineers working a problem together. Nate watched them and thought: *if things were different, these two would build a hell of a program together.*

When Dorothy finished, Whitfield set down her pencil and looked at the three of them across the table. Her expression was unreadable.

"I have a few things to say. Some of them you'll like. Some of them you won't."

Martin leaned forward slightly. Nate pushed his glasses up.

"First: the physics is real. I've had two people at my directorate review the theoretical framework you sent — without context, attributed to a hypothetical. Both came back with the same assessment. The math is consistent with known QFT. The experimental results, if accurate, are consistent with the math. I believe you've built what you say you've built."

She paused.

"Second: you need to understand what happens when this becomes visible. And I mean visible to the bureaucracy, not to me. I'm giving you a courtesy by being here in civilian clothes without filing a trip report. The moment this crosses an official desk — a DARPA program manager, a Senate staffer, an NRO analyst who spots your thermal signature on a satellite pass — it enters a classification review. And that review has one likely outcome. This becomes a Special Access Program. Your lab becomes a SCIF. Your people get polygraphed. Your publication rights disappear."

"We understand that," Martin said.

"I don't think you do. Not fully. Because I'm not talking about inconvenience. I'm talking about the legal authority of the United States government to declare this technology born classified under the Atomic Energy Act — the reactor alone gives them a hook — and to prosecute anyone who disseminates it." She looked at Nate. "Including you, Dr. Seaton. Including anyone you've talked to."

The hangar was quiet. Somewhere, a coolant pump cycled on and hummed.

"My offer is this," Whitfield said. "Work with us. I can bring this under AFRL's research umbrella. Proper funding — not Martin's checking account, proper funding. Facilities at Kirtland or Wright-Patt. Security that doesn't sleep in a van outside your door. Acceleration — I have people who can help with the reactor integration, the thermal management, the flight test program. We can have a demonstrator in orbit in six months with the full weight of the Air Force behind it."

"And the catch," Nate said.

"The catch is that it becomes ours. Not personally — institutionally. You'd be the principal investigators. You'd publish, eventually, after classification review. But the technology, the vehicle, the IP — it goes into a SAP. You lose autonomous control."

Nate looked at Martin. Martin's face was still, his jaw set in the way that meant he was running scenarios — options branching, contingencies stacking, probabilities being assessed at a speed that Nate had learned not to interrupt. Dorothy sat with her hands flat on the table, watching Whitfield with the evaluative stillness of an engineer measuring a load.

The silence lasted five seconds. It felt longer.

"General," Nate said. "I appreciate the honesty. More than you know. But no."

He said it and felt the weight of it settle on him like a physical thing. He was declining the protection of the United States Air Force. He was declining funding, facilities, security, expertise. He was declining the rational choice, and he knew it, and he said no anyway because the alternative — handing the S-film technology to an institution that would lock it in a vault and parcel it out on a need-to-know basis for decades — felt worse than the risk.

Whitfield didn't blink. "I expected that answer. I'd have given the same one at your age." She closed her portfolio. "But I need you to hear one more thing. You are not the only people who will find out about this technology. And the next visitors might not ask."

"We know about Vanguard," Martin said.

A flicker crossed Whitfield's face — surprise, quickly controlled. She was good at controlling her expression, but she wasn't perfect, and in that half-second Nate saw something that looked like reassessment. She had come expecting enthusiastic amateurs. She was leaving having met people who knew the threat landscape and had chosen to operate in it anyway.

“Then you know more than I expected. And you know why I’m concerned.” She stood, and when she stood she carried the room the way senior officers always did — not through volume or gesture but through the simple assumption of authority that three decades of command had made reflexive. “I’m not going to stop you. I don’t have the authority, and frankly, I don’t have the inclination. But I’m going to be watching. And when this goes sideways — not if, when — I want to be in a position to help. That means I need to know how to reach you. And it means I need you to call me before you do something that puts me in a position where helping becomes impossible.”

She handed Martin a card. Plain white, no letterhead, just a phone number handwritten in the same cramped script she’d used for her notes.

“My personal cell. Not my office line. Not my aide’s line. Mine.”

Martin took the card and put it in his wallet without looking at it.

She extended her hand. Nate shook it — her grip was firm, brief, professional. Martin shook it the same way. Dorothy did not. She sat at the table with her hands flat and looked at Whitfield with an expression that Nate couldn’t read, and Whitfield looked back at her for a beat, and something passed between them that Nate recognized as the mutual evaluation of two people who were very good at their jobs and who disagreed about what that meant.

“Thank you for the briefing, Dr. Seaton. It was one of the more remarkable mornings of my career.”

She left the way she’d come — through the side door, into the Suburban, gone. No escort, no paperwork, no visible trace that a two-star general had spent ninety minutes in a leased hangar at PDX reviewing the most significant propulsion breakthrough in human history.

Nate exhaled. His hands were shaking. He shoved them in his pockets and leaned against the table and tried to decide whether what he'd just done was principled or stupid. The two options felt uncomfortably similar.

Martin stood at the window, watching the Suburban's taillights disappear through the security gate. His posture was rigid, controlled, the posture of a man who had just turned down a lifeline and was already calculating the cost.

"She's right, you know," Dorothy said.

The words dropped into the room like a tool onto a hard floor. Martin turned. Nate turned. Dorothy hadn't moved. She sat in her chair with her hands flat on the table, her braid over one shoulder, her face carrying the focused neutrality that Nate was learning meant she had something to say and intended to say it completely.

"About what?" Martin said.

"About taking the deal. We're building a spacecraft in a rented building with a security team that costs forty thousand a week and a reactor we haven't legally imported yet. She's offering us the infrastructure of the United States Air Force. Test ranges. Flight surgeons. Recovery assets. Thermal vacuum chambers we couldn't buy if we sold everything Martin owns." Dorothy's voice was level, analytical, the voice of someone reading off a trade study. "The risk calculus favors her offer."

"The risk calculus also includes losing control of the most important discovery since — since fire, Dorothy. Since the wheel. You want to hand that to the Pentagon?"

"I want to fly a vehicle that doesn't kill its crew. I want a test program that has range safety officers who've done this before, and medical staff who know what decompression does to a human body, and a recovery team that's more than Vanessa with a cell phone in a van." She paused. Her hands, flat on the table, were very still. "I've flown missions, Martin. Not personally — I've designed mission systems for vehicles that flew to other planets. And every one of those missions had a safety case that would fill this room. We have Dorothy Vaneman's notebook and a prayer."

"Dorothy—"

"I'm not finished." Her voice didn't rise. It didn't need to. "I also know what happens when you hand technology to the government. I worked at JPL for seven years. I watched a Mars sample return mission get delayed by eleven years because three different offices couldn't agree on the landing site selection process. I watched a flight-ready instrument get pulled from a Europa mission because a congressional staffer decided the budget was too high. I know what institutions do to innovation. I know why you said no."

She stood, gathering her printed slides into a neat stack and squaring the edges.

"You're probably right to say no. But you should say it with your eyes open about what it costs. Because the bill is going to come due, and it's going to come due in ways you haven't priced yet."

She walked back to her workstation. Martin watched her go. His face was tight. Nate watched both of them and felt the first real fracture in the team — not a break, not a rupture, but a hairline crack in the concrete of consensus that he could feel the way you feel a change in air pressure before a storm.

"She's not wrong," Nate said quietly.

"She's not right either." Martin pulled out his phone from the Faraday bag. His face had reset to operational mode — the emotions filed, the tasks queued, the machine running again. "We build our ship.

We fly our ship. And we do it before Vanguard does it for us."

*   *   *

Whitfield's Suburban pulled onto the airport access road and turned south toward I-205. She sat in the back seat with her portfolio open, reviewing her notes. The staff sergeant drove in silence. He knew when not to talk.

She took out her phone and dialed a number from memory. It rang once.

"It's Whitfield."

A pause while the other end responded.

"It's real. The physics is sound, the hardware is functional, and they're further along than any briefing I've seen from the primes. They have a full-scale panel producing sustained thrust and a vehicle architecture that's… aggressive but not insane."

Another pause.

"No. They declined. Politely. And I don't recommend forcing the issue — not yet. Seaton is principled and stubborn. Crane has money and lawyers. Pushing them underground makes this harder, not easier."

She looked out the window at the gray Oregon sky.

"There's something else. They're going to try to fly it. I'd estimate three months, maybe less. And they're not the only ones. If Vanguard has what I think they have, we're looking at two unauthorized spacecraft launches from US soil inside the next quarter." She paused. "Yes. I think we need to have a very quiet conversation with the National Security Advisor. Before someone louder does."

She hung up and closed her portfolio. Her face, in the window’s reflection, was the face of someone doing math she didn’t like the answer to.

* * *

Chapter 11 — “Supply Chain”

The copper was the problem. It was always the copper.

Nate sat at his workbench in Hangar 7 at eleven at night, staring at a spreadsheet that told him something he already knew. The hangar was quiet — the kind of quiet that only came after the technicians left, when the overhead lights dimmed to their nighttime setting and the only sounds were the vacuum pumps maintaining idle pressure in the deposition chamber and the distant hum of the building’s HVAC. He liked working late. The quiet helped him think, and right now thinking was the only tool he had for a problem that money and effort couldn’t solve.

The spreadsheet laid it out. They had enough enriched copper for the initial film set — four panels, 2.4 square meters each, requiring about 1.5 kilograms of isotope-enriched copper at the 72.8/27.2 Cu-63/Cu-65 ratio. They had that, sourced from a small lot he’d originally ordered for his thermoelectric research at Portland State, before the world had changed. They also had three kilograms of reserve feedstock for in-flight resurfacing, ordered through ORNL’s isotope program six weeks ago.

Four and a half kilograms total. It sounded like nothing — a couple of bags of sugar. Nate could hold the entire supply of the most important material on Earth in both hands. And the math was unforgiving: each S-film panel consumed approximately fifteen grams of enriched copper per hour at full thrust. Four panels at full thrust burned sixty grams per hour. Their 3-kilogram reserve gave them fifty hours of full-thrust operation, plus whatever life remained in the initial films. After that, the films thinned, the crystal geometry degraded, and the thrust dropped to zero.

Fifty hours. To fly to orbit, perform whatever mission they intended, and return. Fifty hours of the only fuel that mattered.

What they didn't have was a supply chain.

Natural copper was 69.17% Cu-63 and 30.83% Cu-65. A 3.6-percentage-point shift in the lighter isotope didn't sound like much. He'd had the same thought himself, months ago, when the isotope ratio first emerged as the critical variable — *how hard can it be to shift a number by three and a half percent?* The answer turned out to be: very hard. Because isotopes of the same element are chemically identical. They have the same electron configuration, the same bonding behavior, the same place on the periodic table. The only difference is mass — Cu-63 has thirty-four neutrons, Cu-65 has thirty-six. Separating them requires exploiting that tiny mass difference through physical processes: spinning them in centrifuges, deflecting them in electromagnetic fields, or exciting them with precisely tuned lasers. Every method was slow, expensive, and available at only a handful of facilities worldwide.

ORNL in Oak Ridge, Tennessee — the facility that had been enriching isotopes since the Manhattan Project, using calutrons that were conceptual descendants of the machines that had separated uranium-235 eighty years ago. Rosatom's isotope division in Russia, which was theoretically capable but practically inaccessible due to export controls and the particular geopolitical climate of 2026. A laser separation startup in British Columbia that Nate had found through a chain of academic contacts, which could produce gram quantities on multi-week timescales.

That was the list. Three facilities on the planet. There was no other list.

He pulled up the ORNL order status page for the third time that day. The interface was federal-government vintage: blue hyperlinks, gray backgrounds, the aesthetic of a system last redesigned when Clinton was president. His order — 5 kg of copper enriched to 72.8% Cu-63, order number ISO-2026-4471 — showed a status he hadn't seen before.

UNDER REVIEW.

Not processing. Not shipped. Not backordered. Under review.

He called ORNL's isotope sales office the next morning. The woman who answered was polite, well-trained, and uninformative.

"Dr. Seaton, your order has been flagged for additional review. I'm not able to share the specifics of the review process, but I can tell you it's being handled by our compliance division."

"Can you tell me who flagged it?"

"I'm not able to share that information."

"Can you tell me what the review criteria are?"

"The isotope program has standard review protocols for orders that fall outside normal academic or industrial use parameters. Your order quantity is within our standard range, but the specific isotope and enrichment level triggered an automatic review."

"Copper isotope enrichment is flagged?"

"Certain isotope requests generate automatic review. I'm not able to be more specific than that. You'll receive notification when the review is complete."

Nate hung up and stared at his phone. Certain isotope requests. He wondered if that was new, or if copper enrichment had always been on someone's watch list and he'd simply never ordered enough to notice. He wondered if someone at Vanguard had made a call.

He told Martin, who said three words: "Backup sources. Now."

That afternoon, Nate called the BC startup — Meridian Isotopes, run by a former UBC professor named Alan Chen who had developed a laser separation process that could handle small batches of metallic isotopes. Chen was enthusiastic when Nate described the quantity.

“Five kilograms of enriched copper? At what ratio?”

“Seventy-two-point-eight percent Cu-63, balance Cu-65.”

“That’s doable. My throughput on copper is about two hundred grams per week. So we’re looking at… twenty-five weeks for five kilos.”

“I need it in six.”

A long pause. “Dr. Seaton, I have one laser system. It processes one element at a time. The physics doesn’t compress.”

“What if I fund a second system?”

“The capital cost of a AVLIS unit is about three hundred thousand dollars. Lead time on the optics is eight weeks.”

Nate looked at Martin across the hangar. Martin was on the phone with a structural steel supplier, negotiating delivery of the vehicle frame components. Nate did the math. Three hundred thousand dollars was a rounding error in what Martin had already spent. But eight weeks for the optics, then another six to twelve weeks for enrichment — that was four to five months. They didn’t have four months.

“Start with what you can do now,” Nate told Chen. “Two hundred grams a week. We’ll take everything you can produce. I’ll wire the deposit today.”

He hung up and sat for a minute, staring at the spreadsheet. Two hundred grams a week from Meridian. Five kilograms from ORNL if the review cleared. A finite, fragile supply of a material that the entire project depended on, sourced from two facilities in two countries, neither of which he fully controlled. One phone call from the right person at the DoE could shut down ORNL's isotope sales. One export control ruling from Ottawa could freeze Meridian's shipments. The supply chain wasn't a chain at all — it was a thread, and it was fraying.

He thought about DuQuesne's supply situation. Vanguard had Brookings, and Brookings had intelligence community connections that could smooth procurement through channels Nate couldn't even see. If DuQuesne needed enriched copper, he probably had it already — sourced through a front company, shipped through a classified logistics network, invisible to the normal regulatory apparatus. The asymmetry made Nate's stomach turn. He was playing by rules that the other side had never acknowledged.

He closed the spreadsheet, rubbed his eyes, and walked to Vanessa's workstation. She was bent over the sputtering chamber's control panel, adjusting deposition parameters on a test sample. The chamber's viewport glowed with the violet haze of argon plasma — she was running a calibration batch, optimizing the MoS2 base layer thickness that the copper doping would later be deposited into. The X-ray diffraction monitor beside her displayed real-time crystal structure data as a waterfall of bright peaks against a dark background.

She looked up as he approached, reading his face the way she always did — fast, accurate, unsentimental.

"ORNL is stalling?" she asked.

"Flagged for review. Which means someone's paying attention to copper isotope orders, which means we can't rely on them."

"Damn." She pulled off her nitrile gloves and leaned against the chamber's housing. Her expression was the one Nate thought of as her problem-solving face — brow furrowed, lips slightly pursed, eyes focused on something internal. It was the expression she wore when the data was bad but the physics was still there, waiting to be approached from a different angle.

“I’ve been thinking about this,” she said.

“About ORNL?”

“About the isotope ratio. About why it has to be exactly 72.8/27.2. And whether it actually has to be.”

Nate waited. He’d learned in eighteen months of working with Vanessa that she arrived at conclusions through a path that was not always obvious but was almost always worth following.

“The ratio matters because of the phonon mode,” she said. “The mixed-isotope lattice produces a specific collective vibration at that ratio — the one that constructively interferes with the virtual photon resonance. At the natural ratio, the phonon mode is detuned. Coherent coupling collapses.”

“Right.”

“But the deposition temperature also affects phonon behavior. If I raise the substrate temperature during the copper co-sputtering phase — say, from three hundred to three-forty Celsius — I change the thermal population of phonon modes in the growing film. That shifts the effective phonon frequency.”

Nate saw where she was going. “You’re saying you can compensate for an imperfect isotope ratio by adjusting the deposition conditions.”

“Not fully. But partially. If I model the phonon spectrum as a function of both isotope ratio and substrate temperature, there should be a region in that parameter space where a lower enrichment — say, seventy-one percent Cu-63 instead of seventy-two-point-eight — still produces coherent coupling. The efficiency will be lower. Maybe significantly lower. But non-zero.”

“How much lower?”

“I need to run the models. And then I need to test it. Give me a week.”

Nate gave her a week. She took five days.

He watched her work during those five days the way a manager watches a key employee — with the particular mix of reliance and guilt that comes from knowing someone is carrying more than their share. Vanessa set up a parameter sweep: twelve test samples, each deposited with a different combination of isotope ratio and substrate temperature. She used the small batch of natural-abundance copper they had on hand — no enrichment needed for the low end of the sweep — and borrowed a few grams of the precious enriched stock for the calibration points at the high end. Each sample took six hours in the sputtering chamber. She ran them two at a time, sleeping in two-hour blocks on the break room cot while the depositions ran, checking the in-situ XRD monitor at each phase transition.

Nate offered to spell her. She declined. “You’ll change a parameter,” she said, not unkindly. “This is my experiment. I need to be the one who knows every variable.”

She was right. He went back to his own work — preparing the sputtering targets from the enriched copper stock, a delicate process of vacuum melting and pressing that turned precious granules into smooth, dense discs ready for the magnetron. Each target consumed about fifty grams. He had enough for eight. Eight chances to make four flight panels, assuming the current yield rate of eighty-five percent held. The margin was thin enough to taste.

The results came at midnight on a Thursday, Vanessa’s voice on the phone pulling Nate out of a dead sleep on the cot he’d set up in the hangar's break room.

"Seventy-one percent Cu-63, deposited at three-thirty-five C, gives me about sixty percent of the coupling efficiency of the optimal ratio at standard deposition temperature."

Nate sat up, rubbing his eyes. His neck ached from the thin cot mattress. "Sixty percent."

"Sixty percent of optimal. Which means sixty percent of the thrust per unit area, or — equivalently — we'd need about forty percent more panel area to get the same total thrust. But here's the thing." Her voice had the particular energy that Nate recognized — the sound of someone who had found something and couldn't quite believe it, and needed to tell someone who would understand why it mattered. "Natural copper is already sixty-nine-point-two percent Cu-63. To get to seventy-one, we need a much smaller enrichment step. Any centrifuge cascade or AVLIS system can do that in a fraction of the time and cost of getting to seventy-two-point-eight."

"So if ORNL falls through entirely, we could build with barely-enriched copper and accept the performance hit."

"Yes. It's not as good. The thermal margins get tighter because you need more panel area, which means more waste heat per unit of thrust. But it's a backup plan that doesn't depend on a single supplier for a niche product. And there's something else." He could hear her moving — pacing, probably, the way she paced when she was thinking out loud. "The substrate temperature compensation doesn't just work for the isotope ratio. It also affects film lifetime. The higher deposition temperature produces a slightly different crystal grain structure — larger grains, fewer boundaries. The copper depletion that limits film lifetime happens preferentially at grain boundaries. Larger grains means slower depletion. I haven't quantified it yet, but the films deposited at three-thirty-five might last significantly longer than the ones deposited at standard three hundred."

Nate's brain caught up. "You're saying the backup process might actually produce longer-lasting films?"

"At lower thrust, yes. Sixty percent of the thrust, but potentially twice the operational lifetime per film. The total impulse — thrust times time — might be comparable to the optimal films. Maybe better."

He sat on the edge of the cot in the dark break room and felt something shift in his understanding of the problem. Not a solution — they still needed the optimal-ratio copper for the flight panels — but a new dimension. A degree of freedom that hadn't existed an hour ago. Vanessa had done what good scientists do: she'd found the knob that nobody else knew was turnable, and when she turned it, it opened a door.

"Vanessa."

"Yeah?"

"This is your paper. When we can publish again, this is yours. First author, sole author, whatever you want."

A pause. "I'd settle for getting our actual ORNL order approved. Have you checked the status today?"

He hadn't. He pulled up the status page on his phone, the federal-vintage interface loading slowly over the hangar's cellular connection. Order ISO-2026-4471. Status: UNDER REVIEW. The same two words that had been staring at him for two weeks.

Someone, somewhere, had decided that copper isotope enrichment was interesting enough to look at twice. Interesting enough to hold in bureaucratic limbo while the days ticked by and the window closed.

The question was whether that someone worked for the Department of Energy's compliance division, following a standard protocol that had been triggered by an unusual order. Or whether the flag had been planted by someone in a glass-walled office in Tysons Corner who knew exactly what enriched copper was for and wanted to make sure Nate Seaton couldn't get any more of it.

He set down his phone and lay back on the cot and stared at the ceiling and did not sleep for a long time.

* * *

Chapter 12 — “Cyber”

Martin was in a meeting with his Crane Energy COO when the call came. It was a Tuesday, bright and cool, the kind of fall Portland morning that made you forget it would rain for the next seven months. He’d carved out two hours to deal with his actual company — the one that employed four hundred people and deployed battery systems across three states — because the bills didn’t stop coming because he’d decided to build a spaceship on the side.

His COO, a competent woman named Priya Mehta who deserved a boss who was more present, was walking him through Q3 projections when his phone buzzed with a 503 number he didn’t recognize.

“Martin Crane.”

“Mr. Crane, this is David Park, your IT director. We have a situation.”

Priya saw something change in Martin’s face and stopped mid-sentence.

“Go ahead,” Martin said.

“At approximately six-fifteen this morning, our primary file server in the Portland data center encrypted itself. Every engineering file on the E-drive — project specs, deployment records, customer contracts, the works. We’re looking at a ransomware payload. The demand came in at six-forty via an encrypted email to our general inbox. Two million dollars in Bitcoin. Seventy-two-hour timer.”

Martin stood up from the conference table. “Have you isolated the affected systems?”

“We pulled the server off the network at six-twenty-two. But the encryption was already complete by then. It ran fast — this wasn’t commodity ransomware. The encryption routine targeted specific file types. Engineering files. CAD, PDFs, spreadsheets. It left the operating system and applications intact."

"Backups?"

"Nightly backups to the offsite NAS are intact. We can restore from last night's image. But Martin — there's something else. The ransomware got in through a phishing email to one of our field engineers three days ago. The payload sat dormant for seventy-two hours before activating. During that time, our SIEM shows unusual outbound traffic patterns. Small packets, encrypted, going to an IP address in Latvia."

Martin's chest went cold. Not for the engineering files — those were recoverable. For the other traffic. The small packets. Three days of dormant access to the Crane Energy network, which was supposed to be entirely separate from the Skylark project's systems at Hangar 7.

Supposed to be.

"David, I need you to do something and I need you to do it right now. Check every USB device that's been connected to both the Crane Energy network and any system at the Hillsboro or PDX facility. Every thumb drive, every external hard drive, every goddamn phone charger. I want a log."

A pause. "Martin, what facility at PDX?"

"Just do it. And don't restore from backup yet. I want a forensic image of the encrypted server before we touch anything."

He hung up and looked at Priya. "Cancel my afternoon. Something's come up."

He called a cybersecurity firm out of Seattle — CrowdStrike had a regional team that could be on-site in four hours. He gave them a retainer number that made Priya's eyebrows rise when she overheard it, and he told them to bring their best incident response people.

Then he drove to Hangar 7 at fifteen miles above the speed limit and locked himself in the office with Nate.

“Tell me about the air gap,” Martin said.

Nate looked up from his laptop. “What about it?”

“Between our systems here and Crane Energy’s network. Tell me exactly how air-gapped we are.”

Nate’s face changed. He understood the question. “The deposition control system and the test data acquisition system are standalone. No network connection. No Wi-Fi. Data comes off on USB drives that we format before use.”

“And those USB drives. Where do they go?”

“Into my laptop. Which is on the local network here for file sharing between workstations. But that network isn’t connected to the internet. We have a separate machine for email and web access, and it’s on a different—” He stopped. “Martin. What happened?”

“Crane Energy got hit with ransomware this morning. The payload was dormant for three days before it activated. During those three days, something was exfiltrating data to an external server.”

“Jesus.”

“The question is whether anything on the Crane Energy network has touched anything in this building. A USB drive that went both places. A laptop that connected to both networks. Anything.”

They spent the next four hours tracing every device. It was painstaking, paranoid work — checking connection logs, interviewing technicians, physically inspecting USB drives for write-access timestamps. By three in the afternoon, they’d found it.

A 64-gigabyte Samsung thumb drive that Vanessa had used to transfer deposition parameter files from her Crane Energy email — where they'd been sent by a substrate supplier — to the fabrication control workstation. The drive had connected to Priya's executive assistant's computer (which had network access to the compromised file server) four days ago, then connected to the fabrication workstation here in the hangar two days ago. The air gap had a bridge, and the bridge was a three-inch piece of black plastic with a USB-A connector.

Martin held the drive in his palm and stared at it. Vanessa stood across the workbench from him, pale.

"I formatted it before I used it here," she said. "I always format—"

"A format doesn't remove firmware-level payloads," Martin said. His voice was flat, controlled. "If the malware rewrote the drive's firmware while it was on the Crane Energy network, a format wouldn't touch it. It would re-infect any machine it connected to."

"Do we know that happened?" Nate asked.

"We don't know that it didn't."

The CrowdStrike team arrived at four. Martin gave them access to everything — the compromised Samsung drive, the fabrication workstation, every machine in the hangar. They worked through the night. Martin watched them the way he watched structural tests: with the focused attention of someone who needed to understand the failure mode before he could build around it.

At two in the morning, the lead analyst — a young woman with a shaved head and the flat affect of someone who spent her professional life looking at other people's worst days — came to Martin with preliminary findings.

"The Samsung drive was compromised. Firmware-level implant. When it connected to the fabrication workstation, it deployed a secondary payload — not ransomware, something quieter. A data-collection agent that inventoried local files and staged them for exfiltration."

"Staged how? There's no network connection on that machine."

"It wrote the staged data to a hidden partition on the USB drive. The next time the drive connected to a networked machine, the payload would have transmitted. We don't think that second step happened — the drive came here and stayed here. But the inventory and staging were complete. We're looking at what was staged."

"What was staged?"

She glanced at her tablet. "Deposition control logs. Temperature profiles. Process parameter files. And a set of images — looks like photographs of a notebook."

Nate went rigid. "What notebook?"

"I can show you the staged files."

She showed them. The images were photographs of pages from Nate's Moleskine — the handwritten lab notebook he kept at his Portland State office, the one with the isotope ratio and the initial deposition parameters. Someone had photographed those pages and stored the images on a Crane Energy server, probably weeks ago, as a backup data path. And the USB implant had found them and flagged them for exfiltration.

The images were clear. Readable. The isotope ratio — 72.8/27.2 — was visible in Nate's handwriting on the third page.

"They already have this," Nate said. His voice was hollow. "The break-in at Hillsboro. They got this from the break-in."

"Maybe," the analyst said. "But this was a second collection attempt on the same data. Which means either they didn't get clean copies the first time, or this is a different group, or this is the same group being thorough.”

Martin sat down. He put his hands flat on the desk and looked at the wood grain — scarred, old, government surplus — and thought about the implications. Thought the way he’d been trained to think at Wright-Patterson, where threat analysis was a core competency and the first rule was: don’t react to the attack you see. React to the attack you don’t see.

The ransomware attack on Crane Energy was a smokescreen. Loud, visible, attention-grabbing — every IT person in the company focused on the encrypted files and the Bitcoin demand while the real operation ran silently underneath. The quiet exfiltration of Skylark project data through a supply chain compromise — a compromised USB device that bridged the air gap between the corporate network and the project systems. The tactics — firmware-level USB implant, dormant payload, targeted file selection — were not the work of an opportunistic criminal group. They were the work of a well-resourced intelligence operation with specific collection requirements. Someone had tasked this operation. Someone had defined the target files. Someone had known that a USB drive would cross between the two networks, or had engineered the conditions that made it likely.

The sophistication was chilling. Not because it was beyond what Martin had imagined — he’d worked adjacent to intelligence operations in the Air Force and knew what was possible — but because it meant the opposition had invested significant resources and operational planning into penetrating his facility. This wasn’t a casual data theft. This was a campaign.

He knew whose. The attribution didn’t matter legally, but it mattered to him. It told him who he was playing against, and it told him the stakes were not what he had assumed.

“Can you tell me who did this?” he asked.

“Attribution takes time. But the TTPs — tactics, techniques, procedures — the firmware implant technique matches a known toolset associated with a private contractor group. We’ve seen it in defense industry intrusions before. I can give you more in seventy-two hours.”

“Give me everything you find. And I want a complete security rebuild. Every machine in this building gets reimaged or replaced. New USB policy — nothing external connects to anything without being forensically scanned first. New network architecture. New everything.”

The analyst nodded and went back to work.

Martin sat alone in the office. The hangar was quiet except for the hum of the fabrication chamber’s vacuum pumps, running their eternal background cycle. Through the window, he could see Dorothy’s workstation, where the vehicle structural drawings were pinned to a corkboard in neat rows. Dorothy, who kept building through every crisis with the calm of someone who had learned at JPL that the universe was hostile and that the only response was better engineering.

He thought about the Suburban, the unmarked car, Whitfield’s steady voice: *The next visitors might not ask.*

The opposition was more capable than he’d assumed. More aggressive. More patient. They’d run a three-day dormant operation through his own company to breach an air-gapped facility. They had the resources of an intelligence operation and the persistence of an institutional actor. And they now had — or soon would have — every technical detail of the S-film deposition process.

Martin pulled up a spreadsheet on his laptop. The vehicle integration timeline. Twelve weeks to a flyable spacecraft, if everything went right. If the reactor arrived on time. If the thermal management system worked. If no one got arrested, or kidnapped, or killed.

He shortened the timeline by two weeks and started reworking the critical path.

The reactor arrived from Canada on Thursday. It came on a specialized transport truck through the Blaine border crossing at four in the morning, under paperwork that described it as a “thermal processing research apparatus.” Rebecca Tran had filed the export documentation with both Canadian Nuclear Safety Commission and the US NRC. The Canadian paperwork was approved. The American paperwork was pending. Rebecca said it would be fine. Martin noticed she didn’t say it would be legal.

The truck backed into the hangar at seven AM, and the driver — a taciturn man from Terrestrial Energy’s logistics team who had driven nuclear fuel casks for twenty years and treated the reactor with the respectful indifference of someone who had long ago made peace with the things he transported — guided the unloading with hand signals and a minimum of words. The crane lowered the shipping cradle to the hangar floor. The driver signed the delivery form, shook Martin’s hand, and left.

The reactor was beautiful and terrifying. An integral molten-salt reactor, cylindrical, about two meters tall and a meter and a half in diameter, wrapped in a thermal jacket that made it look like an oversized water heater. The shielding — tungsten-borated polyethylene, eight centimeters thick — added another fifteen hundred kilograms. Total mass: forty-two hundred kilos. It sat on the hangar floor in its shipping cradle, and Martin stood in front of it and felt the same thing he’d felt the first time he’d seen a jet engine at Wright-Patterson: the awareness of enormous energy held in a precise container, waiting.

He put his hand on the shielding jacket. It was cool to the touch — the fuel salt was solid at room temperature, inert, safe as a block of glass until someone heated it past 459 degrees Celsius and the fission chain reaction could sustain itself. Inside this cylinder, once activated, the uranium-235 dissolved in fluoride salt would generate twenty-five megawatts of thermal power — enough to warm a small town, channeled through a Brayton turbine into five megawatts of electricity, feeding the S-film panels that would push them into orbit.

Dorothy began integration that afternoon. She worked with two technicians Martin had hired — both with aerospace backgrounds, both under NDAs that Rebecca had written with prosecutorial intensity — and the reactor went into the aft section of the vehicle frame like it had been designed for it. Which it had. Dorothy's structural drawings were precise to the millimeter. The mounting bolts aligned. The coolant penetrations matched. The shielding geometry — the shadow cone that protected the crew compartment from the reactor's radiation while leaving the aft and lateral directions open — was exact.

Dorothy worked in silence, communicating with the technicians through hand signals and the occasional terse direction. Her braid hung over one shoulder. Her hands moved with the authority of someone who had designed the space these components occupied and knew that everything would fit.

Martin watched the integration from across the hangar and tried not to think about the CrowdStrike report that had arrived that morning. The second intrusion — the quiet one, the data collection — had been active for three weeks before the ransomware hit. Three weeks of inventorying files, staging data, waiting for the USB bridge to carry it out. Three weeks during which someone had been reading over their shoulder.

He wondered what else they’d taken. He wondered what was still running that the forensic team hadn’t found yet.

He pushed the thought down, checked his spreadsheet, and went back to work.

* * *

Chapter 13 — “The Paper”

Nate wrote the paper in four days. Not the experiment — the theory.

He wrote it in the break room of Hangar 7, on his 2019 MacBook Pro, in the LaTeX editor he’d used for every publication since his second year of grad school. The title was bland by design: “Coherent Momentum Transfer via Asymmetric Virtual Photon Pair Production in Copper-Doped Transition Metal Dichalcogenide Films: A Theoretical Framework.” Thirty-two pages, sixty-seven equations, four figures. No experimental data. No isotope ratios. No deposition parameters. Just the math.

The math was beautiful. Nate had always been an experimentalist first — he ran the experiment forty-seven times because the forty-sixth had a deviation he couldn’t explain — but the theoretical framework had emerged from his conversations with Anya Patel and from three months of working with the effect daily, testing its boundaries, mapping its behavior. He understood the physics now in a way that went beyond equations, into the kind of intuitive grasp that let him know when something was right the way a musician knows when a chord resolves.

The paper started from first principles: the Casimir effect, the known physics of virtual particle pair production in the quantum vacuum. It built through the specific case of a crystalline boundary condition that broke the symmetry of pair production, showed how the momentum transfer was real and calculable, derived the relationship between current density and thrust, and predicted the thermal sensitivity from lattice dynamics. Every prediction was something Nate had already verified in the lab. But the paper presented them as predictions, not measurements. Let other people verify them. That was the point.

He told Martin on a Wednesday. Martin's response was immediate and emphatic.

"No."

"Martin—"

"No. You're going to publish a roadmap for building a reactionless drive — sorry, a momentum-transfer drive — in a peer-reviewed journal that anyone on Earth can download for free. While we're building an illegal spacecraft in a hangar forty feet from where you're sitting. While a defense contractor is actively trying to steal our work. No."

"It's not a roadmap. There's no recipe. The theory tells you that the effect is possible and gives you the math to predict its behavior. It doesn't tell you how to make a film that works. That's the isotope ratio, the deposition parameters, the crystal orientation — none of that is in the paper."

"DuQuesne will read it. He'll fill in every gap."

"DuQuesne already has working films. The break-in and the cyber operation gave him everything he needed. This paper doesn't help him. What it does is make the underlying physics public, which means the government can't classify the theory. You can't classify what's already published."

Martin stood with his arms crossed, leaning against the office doorframe. His jaw was set. His voice was quiet, which was always more dangerous than when it was loud.

"And if the publication draws attention? If some DoE analyst reads it and makes a call? If it triggers the exact classification review Whitfield warned us about?"

"That review is coming anyway. Whitfield told us herself — it's a matter of when, not if. This way, the theoretical foundation is already in the public record. They can classify the engineering, the hardware, the films. They can't unring the bell of a peer-reviewed paper in PRL."

Dorothy, who had been listening from her workstation, spoke without looking up from her structural calculations. "He's right about the classification dynamics. Wrong about the timing."

Both men looked at her.

"Publishing now, while we're three months from flight, puts a spotlight on exactly the wrong things at exactly the wrong time. Wait until we're in orbit. Publish from space. Then the paper and the demonstration happen simultaneously, and neither can be suppressed."

It was a good argument. Nate heard it, weighed it, and rejected it. The problem with waiting was that waiting assumed they'd make it to orbit. If they didn't — if Vanguard moved faster, if the government intervened, if some accident ended the project — the theory needed to be in the world. It was bigger than the vehicle. It was bigger than the race.

"I'm submitting tomorrow," Nate said. "I wanted you to know, not to ask permission."

The room was very quiet. The hum of the deposition chamber's vacuum pumps filled the silence the way background noise fills a room where people have stopped talking but haven't stopped thinking.

Martin stared at him for a long moment. His expression moved through something — anger, assessment, resignation — and settled on the flat operational neutrality that was Martin's version of acceptance. He uncrossed his arms, let out a breath through his nose, and walked away.

The conversation was over. The disagreement was not. Nate could feel it settle into the air between them, a pressure differential that would persist for weeks — through the submission, the review, the publication, and the firestorm that followed. Martin would not bring it up again. He would also not forget it. The next time Nate made a unilateral decision, Martin would remember this one, and the calculus of trust between them would carry the weight.

* * *

Physical Review Letters had a review turnaround that averaged six weeks. Nate's paper came back in eleven days. Two referees. One recommended publication with minor revisions. The other — Nate suspected it was someone at CERN, based on the notation style — wrote a three-page response that was half objection and half excitement, questioning the vacuum momentum-transfer mechanism on thermodynamic grounds but acknowledging that the mathematical framework was self-consistent and made testable predictions. The referee recommended publication contingent on a revised discussion section addressing the entropy implications.

Nate revised in two days. The paper published online on a Thursday afternoon.

By Friday morning, it was everywhere.

The first wave was physics Twitter. A postdoc at Stanford posted the abstract with the comment: "Either this is the most important paper in propulsion physics since Tsiolkovsky or it's the most elaborate crank submission that somehow got through PRL review. Reading now." That post got four thousand likes in three hours. By noon, the physics subreddit had three competing threads dissecting the equations. By evening, a group at Caltech had posted a preprint arguing that Nate's vacuum coupling mechanism violated the quantum interest conjecture, and a group at Cambridge had posted a response arguing that it didn't.

The media found it Saturday. A science journalist at *Ars Technica* published a long-form article under the headline: “Portland Physicist Claims Theoretical Basis for Propellantless Thrust — And the Math Checks Out.” The article was careful, nuanced, and extensively quoted skeptics. It didn’t matter. By Sunday, the story had mutated through aggregation into “Scientist Claims Reactionless Drive Possible” — which was a mischaracterization that Nate couldn’t correct because correcting it would require revealing experimental details he was trying to protect.

His phone rang constantly. He stopped answering numbers he didn’t recognize, then stopped answering numbers he did recognize because half of his Portland State colleagues were calling to ask if he’d lost his mind. His departmental email filled with messages from journalists, physicists, cranks, DoD contractors, venture capitalists, and one from a man in New Mexico who claimed to have built a similar device in 1987 and enclosed a photo of what appeared to be a modified microwave oven.

On Monday, a reporter from the *New York Times* science section reached him through his Portland State office number. She was smart, prepared, and genuinely interested in the physics. Nate talked to her for twenty minutes, carefully staying within the bounds of the published theory, and was pleased with the conversation until she asked the question he’d been dreading.

“Dr. Seaton, has anyone built a working prototype based on these principles?”

“The paper describes a theoretical framework. Building a device that tests the predictions would require significant materials science work. Specific crystalline geometries, very precise material compositions, high current densities. It’s not a weekend project.”

“But is anyone working on it? Are you?”

“I’m a materials scientist. I work with thin films. The paper represents a theoretical departure from my usual experimental work.”

“Dr. Seaton, I should tell you — I’ve spoken with three physicists who reviewed your paper independently, and all three said the same thing. The theoretical framework is so specific in its predictions, so precisely testable, that it reads like someone describing an experiment they’ve already run. One of them said, and I’m quoting, ‘This paper was written by someone who has held a working device in his hands.’”

Nate’s grip tightened on the phone. “That’s a generous interpretation. I’d say the specificity comes from a thorough analysis of the underlying quantum field theory.”

“Of course.” The reporter paused. “I’ll be running the piece Wednesday. If you’d like to comment further, you have my email.”

He hung up and sat in the break room with a coffee that had gone cold and watched the metrics climb on his PRL author dashboard. Twelve thousand downloads. The most-read paper in the journal that month. Eighty-seven citations already, from preprints that had been posted in the five days since publication. His hands trembled, but not from the coffee.

Martin hadn’t spoken to him about anything except operational matters since the paper went live. The silence between them on the subject was a wall that Nate could feel every time they were in the same room. Martin thought the publication was reckless. Nate thought it was necessary. Neither of them was wrong, and the argument they weren’t having was louder than the one they’d had.

* * *

In Tysons Corner, Virginia, DuQuesne read the paper in his office with the door closed.

He read it twice. The first time, fast, for the structure and the conclusions. The second time, slowly, with a pen, annotating the margins. When he finished, he set the pen down and looked out the window at the parking lot and the Virginia oaks beyond it and did not move for several minutes.

The framework was elegant. Nate Seaton had taken a physical effect that DuQuesne had struggled to theorize from the hardware side — working backward from observed thrust to hypothesized mechanism — and had built it forward from quantum field theory. The vacuum coupling resonance, the isotope-dependent phonon mode, the thermal sensitivity as a lattice-dynamics prediction rather than an empirical limit — it was all there, clean and rigorous and exactly right.

DuQuesne had spent six months building films that worked without fully understanding why. He'd approached the problem as an experimentalist — methodical, systematic, guided by data rather than theory. He'd mapped the parameter space through brute-force testing: hundreds of films, each with slightly different deposition conditions, each tested for thrust output and thermal stability and lifetime. It had worked. His films produced thrust. But the optimization had been empirical, a black-box process of tweaking inputs until the outputs improved, without a clear model of why certain parameters mattered.

The paper told him why. It filled gaps in his own thinking that he hadn't known were gaps until they were filled. The phonon-mode analysis on page sixteen — the explanation of why the isotope ratio created a specific collective vibration that coupled to the vacuum — that alone was worth more to DuQuesne than six months of parameter sweeps. He could feel his understanding of the effect deepening as he processed the equations, the way a map comes into focus when you realize you've been holding it upside down.

He felt, simultaneously, admiration and something close to envy. Nate Seaton had done what DuQuesne had not been able to do: he'd seen the phenomenon from both sides, experiment and theory, and married them in a framework that was both predictive and beautiful. DuQuesne was a better experimentalist. Nate was a better physicist. The distinction mattered.

He also realized, with a colder part of his mind, what Nate had done strategically. The publication made classification of the theoretical framework nearly impossible. The physics was now in the public domain, available to every physicist in the world. The engineering remained secret, but the foundation was exposed. Nate had pulled the rug out from under any attempt to black-hole the discovery by making the most important part of it free.

It was brilliant. It was reckless. It was exactly what DuQuesne would have expected from a man who trusted his own judgment too much and other people's institutions too little.

He picked up his desk phone and dialed Brookings's extension.

"Have you seen the paper?"

"I've seen the headlines," Brookings said. His voice was tight.

"Read the paper, not the headlines. The theoretical framework is now public knowledge. Any effort to classify the underlying physics of our program has to contend with a peer-reviewed publication in the world's most prestigious physics letters journal. Seaton has complicated our position significantly."

"He's also drawn a very large arrow pointing at himself. And at us."

“At the technology. Not at either team specifically. The paper is pure theory.”

“My clients don’t see a distinction between theoretical and operational when it comes to press coverage. I’ve had three calls this morning from people who are not happy.”

“Your clients should consider that Seaton just made our parallel program’s existence slightly more defensible in the long run. If the physics is public, we can claim independent development more credibly.”

A pause. “That’s not the read I need from you, Marc. I need a timeline. Can you fly before the attention this paper generates reaches the wrong desks?”

DuQuesne looked at his annotated copy of the paper. The thermal sensitivity prediction on page twenty-three — he could use that. It explained a parameter he’d been tuning empirically. With the theoretical framework, he could optimize his deposition process faster. Nate’s paper would accelerate Condor’s timeline by weeks.

The irony was exquisite.

“Accelerated timeline,” DuQuesne said. “Six to eight weeks.”

He hung up and turned back to the paper.

* * *

The call from the Senate came through Rebecca Tran on a Thursday.

Nate was in the hangar, helping Vanessa calibrate a new sputtering target, when Rebecca’s name appeared on his phone.

“A staffer from the Senate Armed Services Committee just contacted my office,” Rebecca said without preamble. “They’d like you to brief the committee in closed session. Next week.”

Nate set down the calibration tool. “Brief them on what?”

“The paper. The propulsion implications. The staffer said the committee has ‘questions about the national security dimensions of the published research.’ Those were her exact words.”

“Is this optional?”

“Technically, yes. A briefing request is not a subpoena. But declining an invitation from SASC to discuss a technology with obvious defense applications sends a message you don’t want to send. It says you have something to hide.”

“I do have something to hide.”

“You have engineering details to protect. That’s different. The theory is published. You go in, you discuss the theory, you answer questions about the physics, and you do not discuss hardware, isotope ratios, or the vehicle in the hangar. I’ll be sitting next to you the entire time. If a question crosses a line, I’ll intercept it.”

Nate looked across the hangar at the vehicle taking shape — the cylindrical hull sections bolted to Dorothy’s structural frame, the reactor visible through an open access panel, the gimbal mounts waiting for the S-film panels that were still being fabricated. Three months of work. Millions of Martin’s dollars. Four people’s lives pointed at the sky.

“When?” he asked.

“Tuesday.”

* * *

Chapter 14 — "Testimony"

Rebecca Tran coached him on the flight from Portland to Dulles. She sat in the aisle seat of economy class with a legal pad on the tray table and walked him through the rules of engagement with the patience of someone who had prepared witnesses for congressional testimony before and knew that scientists were the hardest to prepare because they wanted to answer questions truthfully and completely, which was the last thing you wanted to do in front of a Senate committee.

"The theory is published. It's public. You can discuss anything that's in the paper. You cannot discuss hardware, experimental data, isotope ratios, deposition parameters, vehicle design, Martin Crane's funding, or the existence of any physical device. If a question approaches any of those topics, you pivot to the published theoretical framework. If a question directly asks about hardware, you say 'my paper describes a theoretical framework' and stop talking."

"What if they ask whether I've built something?"

"You say that your published research is in thin-film deposition and that the theoretical paper represents a departure from your usual experimental work. Both of which are true."

"That's evasive."

"That's accurate. There's a difference." She looked at him over her reading glasses — the ones she used as a prop, looking over them at people when she wanted them to feel examined. "Nate. Listen to me. You are not under oath. This is a briefing, not a deposition. You have no legal obligation to volunteer information beyond the scope of the published paper. You have a significant legal obligation not to disclose information that could be construed as classified under ITAR or the

Atomic Energy Act. If you tell the Senate Armed Services Committee that you've built a nuclear-powered spacecraft in an Oregon hangar, you will be arrested before you reach the parking garage."

Nate looked out the window at the clouds over the Rockies. "Understood."

"One more thing. There will be a senator on that committee who is connected to Vanguard. Keller, from Virginia. His questions will be designed to trigger classification. He wants you to say enough to give the DoD legal cover to seize the technology. Do not give him what he wants."

Nate had never been to Washington, D.C. The city felt like a movie set — monumental architecture populated by people in expensive clothes walking at exactly the speed that communicated importance without appearing hurried. Rebecca navigated the security checkpoints and the hallways of the Hart Building with the comfort of someone who had done this many times, and Nate followed her like a graduate student following his advisor to a conference — aware that the protocol was clear to everyone except him.

The room itself was small and windowless. A curved dais held seven chairs for senators; a table below faced it with two chairs and two microphones. A court reporter sat in the corner. Two staffers with laptops flanked the dais. The walls were paneled in a wood that wanted to be mahogany but wasn't.

Four senators were present. Nate knew two by sight — Senator Jacqueline Herrera of New Mexico, the committee chair, who had a reputation for technical literacy earned through twenty years overseeing Sandia and Los Alamos in her home state; and Senator Bob Keller of Virginia, whose office was walking distance from Vanguard Strategic's Tysons Corner campus. The other two Nate didn't recognize. Rebecca had briefed him: Senator Tanaka of Hawaii, a former Navy captain, and Senator Marsh of Montana, who sat on both Armed Services and Commerce.

“Dr. Seaton,” Herrera began, “thank you for accepting our invitation. This is a closed session. The proceedings are classified at the SECRET level. Your testimony is covered by your existing security clearance from your DARPA-funded work.”

Nate hadn’t known he had a security clearance from his DARPA work. He’d signed forms. He supposed one of them had been a clearance application. Rebecca’s hand rested lightly on his forearm under the table. He took the cue and said simply, “Thank you, Senator.”

“You’ve published a paper in Physical Review Letters describing a theoretical mechanism for directed momentum transfer using quantum vacuum coupling. In simple terms, propulsion without propellant. Is that a fair summary?”

“With a qualification, Senator. The mechanism I describe does not violate conservation of momentum. The quantum vacuum serves as the reaction mass. The term ‘reactionless’ that’s been used in media coverage is inaccurate. It’s more like an extremely efficient drive that uses the vacuum itself as propellant — an infinite propellant mass that you don’t have to carry.”

“That’s a meaningful distinction for physicists. For this committee, the relevant question is: does the theoretical framework you’ve published have practical engineering applications for propulsion?”

“Yes.”

“Has anyone, to your knowledge, built a device based on these principles?”

Rebecca’s hand pressed his forearm. Nate kept his expression neutral. “My paper describes a theoretical framework. I’m aware of experimental efforts to investigate quantum vacuum effects, but I'm not in a position to discuss specific hardware implementations."

"Are you yourself conducting experimental work related to this framework?"

"I'm a materials scientist, Senator. My published research is in thin-film deposition. The theoretical paper represents a departure from my usual work, and it was motivated by intellectual curiosity about an unusual class of thin films. I'm continuing to study the materials science aspects."

It was true. Every word was true. And every word was crafted to deflect without lying, because Rebecca had spent four hours on the flight from Portland coaching him on exactly this distinction.

Senator Keller leaned forward. He was a large man with silver hair and the kind of face that photographed well at fundraisers. "Dr. Seaton, I want to be direct. We have reason to believe that the technology described in your paper is of significant interest to entities outside the academic community. Are you aware of any private-sector efforts to develop propulsion systems based on quantum vacuum coupling?"

"I'm not aware of any specific efforts, Senator."

"Have you been contacted by any defense contractors regarding your research?"

"I've received a number of inquiries since the paper published. I haven't responded to any from defense contractors."

"Have you been contacted by foreign entities?"

"I've received emails from physicists at institutions worldwide. None of those contacts involved anything beyond scientific discussion."

Keller's expression didn't change, but something shifted behind his eyes. He was asking questions he already knew the answers to, and

Nate's careful responses were confirming that Nate was being careful. Which told Keller something by itself.

"Dr. Seaton, this committee has a responsibility to assess whether technologies with potential defense applications are adequately protected. Your paper describes a theoretical basis for a propulsion system that, if realized, would represent a transformation in military aerospace capability. Are you confident that the publication of this framework doesn't compromise national security?"

Rebecca spoke before Nate could. "Senator, my client published a theoretical physics paper in a peer-reviewed journal. The paper contains no engineering specifications, no material recipes, and no classified information. The theoretical framework describes physics that is, by definition, discoverable by any competent physicist. My client chose to publish rather than let the discovery occur overseas without American priority."

"I appreciate that, Ms. Tran. But the question stands."

Nate looked at Keller. He thought about the hangar, the vehicle, the S-films, the reactor. He thought about DuQuesne in Tysons Corner reading his paper and filling in the gaps. He thought about the phone call. *You should stop building.*

"Senator, I believe that the physics I've described belongs in the public domain. It describes a fundamental interaction between matter and the quantum vacuum. Attempting to classify a fundamental physical phenomenon would be like attempting to classify gravity. The engineering applications — which I have not published — are a separate matter."

Keller sat back. His expression was flat, controlled, the expression of a man who had asked his questions and received answers that confirmed what he already suspected. Nate could see him filing information — not the words Nate had said, but the words Nate had carefully not said.

Senator Tanaka went next. He was a compact man with a Navy captain's bearing and questions that were precise in a different way from Keller's — not political but technical.

"Dr. Seaton, your paper predicts a maximum thrust density of approximately fifty kilonewtons per square meter. Can you walk us through the limiting factor?"

Nate relaxed slightly. This was physics, not politics. "The limit is thermal. The crystalline structure that produces the coupling effect degrades above approximately four hundred degrees Celsius. At higher current densities, ohmic heating in the film exceeds the ability of any practical cooling system to remove waste heat. Fifty kilonewtons per square meter represents the approximate equilibrium point where thrust work and waste heat balance against the cooling capacity of state-of-the-art heat-pipe radiators."

"And the power requirement?"

"Approximately one-point-two megawatts of electrical input per square meter at maximum thrust density. The energy source is a significant engineering constraint. You need a compact, high-output power supply. Chemical batteries are inadequate by orders of magnitude. Solar arrays could work in principle but the area required would be enormous."

"What about nuclear?"

Rebecca's hand pressed his forearm again. Nate caught himself. "Nuclear power sources could theoretically provide the necessary power density. But I should note that my paper doesn't address power sources. That's an engineering question, not a physics question."

Tanaka nodded, apparently satisfied. Senator Marsh, a rangy woman from Montana who looked like she'd rather be on a horse, asked about economic implications — who would benefit, who would lose, what the impact on the existing aerospace industry might be. Nate deflected to "speculative at this stage," which was true. Marsh pressed: "But surely you've thought about it." Nate said, "I've thought about a lot of things, Senator. Most of them keep me up at night."

A brief laugh from the room. Even Keller's mouth twitched.

Herrera asked the final question. Nate suspected she'd been saving it, the way a good examiner saves the hardest question for when the witness is tired and has let his guard drop.

"Dr. Seaton, in your professional judgment, how long before someone builds a working device based on the principles in your paper?"

Nate hesitated. The honest answer was that two working devices already existed, or nearly existed, in hangars on opposite sides of the country. The answer he gave was carefully constructed, each word chosen: "The engineering challenges are significant. The materials science alone — achieving the specific crystalline geometries the theory requires — would take a well-funded team several years to solve. The theoretical framework is necessary but not sufficient."

Several years. He said it and felt the lie in his teeth. Not a lie, technically. A well-funded team starting from scratch would need years. But two teams that had started months ago, with stolen data and private fortunes, were weeks away. The distinction between what he said and what he knew filled the room like a pressure differential.

Herrera looked at him for a moment longer than necessary. Her eyes were sharp, appraising, and he had the uncomfortable feeling that she heard both what he'd said and what he hadn't.

She nodded, wrote something in her notebook, and closed the session.

* * *

Rebecca walked Nate out through the basement corridor toward the elevator bank. Her heels clicked on the marble floor. Nate's hands were in his pockets. He felt drained, the way he used to feel after qualifying exams — the bone-deep fatigue of performing under scrutiny for an hour and a half.

They turned a corner and Nate nearly walked into a man standing in the hallway.

The man was mid-fifties, silver-haired, fit in a way that suggested personal training rather than athletics. He wore a tailored suit that matched the building's aesthetic perfectly. His face was pleasant, forgettable, the kind of face that belonged in lobbying firms and golf courses and the kinds of restaurants where you needed a reservation three weeks out.

"Dr. Seaton." The man extended a hand. "I don't think we've met. My name is Brookings. I'm with Vanguard Strategic."

Nate didn't take the hand. Beside him, Rebecca went very still.

Brookings lowered his hand without visible offense. "Interesting testimony. I caught the parts that were available on the committee's internal feed. You're a careful speaker for a scientist."

"This isn't an appropriate conversation," Rebecca said.

"It's a hallway, Ms. Tran. People have conversations in hallways." Brookings's smile didn't reach his eyes. "Dr. Seaton, I want you to know something. The technology you described in your paper — the theoretical framework — is already under active development at a properly secured facility. Your contribution to the scientific literature has been noted and appreciated. But the practical implementation of these principles is proceeding under appropriate oversight, by people with the resources and the mandate to do it responsibly.”

Nate’s mouth was dry. The corridor felt narrower than it was.

“What I’m saying,” Brookings continued, “is that the race you think you’re running is already over. You published a paper. That’s your legacy. The rest is being handled.”

“My client has nothing further to discuss outside of official channels.” Rebecca stepped forward, physically placing herself between Nate and Brookings. She was a foot shorter than either man. She looked up at Brookings with an expression that Nate had seen her use on contract disputes — the expression of someone who had read every regulation and found the one you’d missed.

Brookings held his position for a beat, then stepped aside. “Of course. Give my regards to Mr. Crane.”

He walked away down the corridor, unhurried. His footsteps were nearly silent on the marble.

Rebecca gripped Nate’s elbow and steered him toward the elevator. Her hand was tight, her nails pressing through his jacket sleeve. Her face was pale, but her stride was steady — the deliberate pace of someone who would not give anyone watching the hallway cameras the satisfaction of seeing her rush.

“Don’t say anything until we’re outside the building.”

They walked in silence. Through the basement corridor, up the elevator, through the lobby security checkpoint where they retrieved their phones, out through the double glass doors into October sunlight. The Capitol dome rose white against a blue sky that Nate barely registered. A tour group passed on the sidewalk, a guide explaining the building's architecture in a cheerful voice that belonged to a different universe.

Rebecca steered him to a bench near the building's south entrance, away from foot traffic. She sat, crossed her legs, and took three measured breaths before speaking.

"He knew about Martin," Nate said.

"He knows everything. That's what he just told you. He wasn't there by accident. He waited in that corridor because he knew the hearing schedule, which means he has a source on the committee — almost certainly Keller's office. He knew you'd come out that way. And he wanted you to see his face and hear his voice and understand that he operates in this building as comfortably as you operate in a lab."

"And what he said about the technology being under development—"

"He told you Vanguard has working technology. He told you they're building. And he told you by implication that they have government cover — 'appropriate oversight' was the phrase. Whether that's true or strategic embellishment, I can't tell you. But the message was clear: stand down."

Nate looked at the sidewalk. A pigeon pecked at a dropped pretzel near a trash can. The ordinariness of the scene — a bird, a piece of bread, a bench in the sun — felt surreal against the conversation he'd just had.

"Rebecca. What do we do?"

She looked at him. Behind her reading glasses, her eyes were steady. "We do exactly what we were doing before. You go home. You build your vehicle. And you launch before they can stop you. Because that man in the hallway just told you something important: they're not ready to move against you openly. If they were, you'd have been served papers, not speeches. Brookings was trying to scare you into quitting. Which means they're not confident they can stop you legally. Not yet."

Nate pulled out his phone. His hands were steady, which surprised him. The adrenaline had done something useful: it had burned away the fatigue and left clarity. Cold, sharp clarity, the kind he usually only felt at two in the morning in the lab when an experiment was working and the data was clean and the world had shrunk to a bench and a screen and a phenomenon that demanded explanation.

He called Martin from the departures terminal at Reagan National. It was three in the afternoon, which meant noon in Portland.

"Martin. Listen to me. They have working films. They're building a ship. Vanguard is further along than we thought. Brookings told me to my face, in the hallway of the Hart Building, that the 'practical implementation' is already underway at a 'properly secured facility.'"

Silence on the line. Then: "How confident are you?"

"He was bragging, Martin. He wasn't bluffing. He walked up to me after my testimony and told me the race is over."

More silence. Nate could hear the sounds of the hangar — the whine of the vacuum pump, the clatter of a wrench on metal.

"Then we speed up," Martin said. "Come home. We have work to do."

* * *

Chapter 15 — “Abduction”

Dorothy Vaneman kept a routine because routines were the scaffolding of competence. She ran at five-thirty in the morning, four miles along the Willamette River on the Eastbank Esplanade, regardless of weather. She showered, dressed, ate steel-cut oatmeal with blueberries at the kitchen counter of her sabbatical apartment on SE Hawthorne, and drove to the hangar by seven-fifteen. She worked until eight or nine at night, drove home, read one chapter of whatever book was on her nightstand (currently a history of the Voyager program), and slept. The routine had carried her through seven years at JPL and two Mars landing campaigns and a broken engagement she did not discuss. It would carry her through this.

On a Tuesday morning in late October, the routine broke.

She finished her run at six-twelve, eight minutes later than usual because a stitch in her side had forced her to walk for two blocks near OMSI. She walked the last hundred meters to her apartment building, cooling down, keys in her right hand, phone in her left. The street was quiet. A delivery van was parked on the far side, engine running. She noted it without concern — the coffee shop two doors down received deliveries at odd hours.

She reached the building’s front entrance, a glass-and-steel door with a keypad. She punched in the code.

Someone stepped beside her. A man, average height, wearing a fleece pullover and jeans. He looked like a tech worker heading to an early meeting. He smiled.

“Morning,” he said.

Dorothy opened the door. As she stepped through, she felt a hand on her upper arm — not rough, but firm — and then something pressed against her neck. It was cold and smooth. There was a hiss.

The world went gray at the edges. Her legs lost coherence. She tried to pull away, to shout, but her muscles were disconnecting from her intentions one by one, like breakers tripping in sequence. The man caught her as she sagged. Another person appeared — she couldn't focus enough to see clearly — and they moved her toward the delivery van. The side door was open. The interior was carpeted and clean.

Her last clear thought before the gray became black was an observation, clinical and detached: the sedation was fast-acting and probably midazolam-based, given the amnestic properties. She wouldn't remember the next few minutes. She filed the thought away anyway, because that was what she did.

* * *

She woke in a room.

No windows. Fluorescent lighting, the industrial kind that buzzed at a frequency she could identify as 120 hertz from the flicker rate on her peripheral vision. Concrete floor, painted gray. Walls that might be concrete behind drywall. A cot with a thin mattress and two wool blankets. A door, steel, closed. A table and a chair. A chemical toilet behind a privacy screen.

She sat up slowly. Her head ached. Her mouth was dry, with a chemical aftertaste that confirmed the midazolam hypothesis. She still wore her running clothes. Her phone was gone. Her keys were gone. Her watch — a cheap Timex she'd owned for fifteen years — was still on her wrist. It read 10:47 AM, which meant she'd been unconscious for approximately four and a half hours.

She stood, steadied herself against the cot, and began to observe.

The door had no handle on the inside. The walls were smooth — no fixtures, no outlets, no features that could be pried loose. The fluorescent fixture was recessed and covered by a wire cage. The table was bolted to the floor. The chair was not. The chemical toilet was a portable unit, commercial grade, the kind used at construction sites. The blankets were wool, heavy, without zippers or buttons.

She checked herself for injury. None. No soreness beyond the stitch she'd had during her run and a mild headache from the sedation. Whoever had taken her had been careful.

She sat in the chair and placed her hands flat on the table and began counting breaths.

At 11:23, by her watch, the door opened.

The man who entered was tall, lean, sharp-featured. Dark hair graying at the temples. He wore a pressed button-down shirt and clean shoes that looked wrong against the concrete floor. He moved with a deliberateness that Dorothy recognized from academic settings — the careful physical language of someone who controlled their environment through precision rather than force.

He carried a tray with a bottle of water, a wrapped sandwich, and an apple. He set the tray on the table.

"Ms. Vaneman. I'm Dr. Marc DuQuesne."

Dorothy looked at him. She didn't touch the tray.

"I owe you an apology," DuQuesne said. He pulled a folding chair from against the wall and sat across from her. His posture was upright, composed. "The method of your transportation was not my preference. I argued for a more civilized approach. I was overruled.”

“Where am I?”

“A research facility in the southwestern United States. That’s as specific as I can be.”

“Why am I here?”

DuQuesne folded his hands. His expression was — and this was what struck Dorothy most, what she would remember later — genuinely regretful. Not a performance of regret. The real thing, in the eyes of a man who knew exactly what he had authorized and was uncomfortable with the knowledge.

“You are the most capable mission systems engineer I’m aware of who has hands-on experience with the Seaton-effect propulsion architecture. I need your expertise to solve an engineering problem that is, at present, beyond my team’s capability. And the timeline does not permit a conventional recruitment approach.”

Dorothy’s hands were flat on the table. She did not move them. “You kidnapped me to solve a thermal management problem.”

DuQuesne’s eyebrows rose — a fractional movement, controlled. “You’ve deduced the nature of the problem.”

“You built a vehicle with S-film panels. You pushed the thrust-to-area ratio too hard, or your radiator capacity is undersized, or both. Your films are hitting the thermal ceiling under sustained operation and you can’t figure out how to sustain full thrust without destroying them.”

She said it flatly, without emphasis. She said it because letting him know that she could see his problem from the outside was more valuable than pretending ignorance. It established something: she was not a hostage to be stored. She was a resource, and she knew her value.

DuQuesne was quiet for a moment. Then he nodded.

“Our vehicle — code-named Condor — has six S-film panels, total active area eighteen square meters. Maximum rated thrust approximately nine hundred kilonewtons. The radiator array provides approximately twelve megawatts of thermal rejection capacity. The full-thrust thermal load is approximately thirteen megawatts.”

“You’re a megawatt short.”

“At sustained full thrust, the film substrates reach three-eighty Celsius in approximately twenty minutes. We have to throttle to forty percent for at least ten minutes to cool back to operational baseline. It’s a duty-cycle constraint that effectively limits our sustained thrust to about two-thirds of rated.”

“That’s not a thermal management problem. That’s a design problem. You undersized your radiators because you were in a hurry.”

“I undersized the radiators because the mass budget was fixed by the vehicle structure that was already fabricated when we discovered the thermal shortfall. Adding radiator area means adding mass, which means redesigning the structural bus, which means six to eight weeks we don’t have.”

Dorothy looked at him. His eyes were steady, dark, intent. She could see the scientist behind the polished surface — the man who had looked at a physics problem and found it intolerable that he couldn’t solve it. She understood that instinct. She had the same one.

She could also see the solution. It had come to her in the time it took him to describe the parameters — a back-of-the-envelope insight about using the vehicle’s structural mass as a thermal capacitor, pulsing the heat bus to store energy in the hull during thrust phases and radiating it during coast phases. It was elegant. It was the kind of trick that required deep intuition about thermal dynamics in the way a jazz musician had intuition about rhythm. She could see it as clearly as she could see the man sitting across from her.

She would not give it to him.

“No,” she said.

“Ms. Vaneman—”

“You kidnapped me from my home. You drugged me. You brought me to a facility I can’t leave. You are asking me to help you build a weapon — because that’s what Condor is, Dr. DuQuesne, don’t tell me it isn’t — that will be used against the people I work with. No.”

DuQuesne held her gaze. His expression didn’t change. He was, she thought, genuinely sorry. And it didn’t matter.

“I understand,” he said. He said it with the formality that she was beginning to recognize as his default mode — the Southern politeness that served as both courtesy and armor. “The offer remains open. In the meantime, you’ll be treated well. If you need anything — books, clothing, medical attention — ask the guard outside the door.”

He stood, collected his folding chair, and walked to the door. His movements were precise, unhurried. Everything about him was controlled. She wondered what he looked like when the control slipped.

“Dr. DuQuesne.”

He turned.

“I will remember everything about this facility. Every sound, every smell, every footstep pattern, every shift change. The HVAC cycles at eighteen-minute intervals. The guard rotation is every eight hours. The machinery I can hear through the walls is a magnetron sputtering system on an eighteen-hour deposition cycle. You’re fabricating S-films here.” She paused. “When I leave — and I will leave — I will give a very detailed statement to very interested people. The kind of people who take kidnapping seriously even when the kidnapper has a PhD and good manners."

DuQuesne looked at her for a long moment. His expression shifted — not the regret from before but something more complicated, something that might have been respect or might have been the recognition that he had brought into his facility a person who was paying closer attention than he had anticipated.

"I know," he said. And left.

The door closed. The lock engaged — an electronic bolt, she noted, not mechanical. Battery-backed, probably, with a fail-secure design. She filed that detail with the others.

She unwrapped the sandwich. Turkey and swiss on wheat, from a deli, not a vending machine. She ate it methodically, because her body needed fuel and sentiment was not a reason to refuse it. She drank the water. She ate the apple.

Then she sat on the cot and began constructing a mental map of the facility from every piece of data she had gathered: the duration of the drive from the airlock to her room (forty-seven seconds at walking pace, approximately forty meters), the number of doors she had heard open and close during DuQuesne's visit (three, including hers), the direction of the machinery noise (south-southeast, consistent with a fabrication bay on the same level), the faint vibration through the floor that suggested heavy equipment or generators below.

She thought about the thermal management problem DuQuesne had described. Twelve megawatts of rejection capacity against thirteen megawatts of thermal load. A one-megawatt shortfall. She thought about the structural mass of a twenty-meter vehicle with ceramic-steel composite armor — enormous thermal inertia, probably on the order of several hundred megajoules per degree Celsius of temperature rise. She thought about pulse-duration modulation of the thermal bus, using the hull as a heat battery.

The solution assembled itself in her mind with the clean inevitability of a proof. She could see it. She could draw it. She could calculate the duty cycle extension to within five percent accuracy.

She would not give it to him. Not because she didn't understand the consequences of Condor's thermal failure — she understood them perfectly, and they included the deaths of three people — but because giving it to him meant helping him build the weapon that would be pointed at the people she worked with. At Nate. At Martin. At the vehicle she had designed.

She lay back on the cot and stared at the ceiling and began planning how to escape.

* * *

In Portland, the absence took three hours to register.

Nate arrived at Hangar 7 at seven-thirty and noticed Dorothy's workstation was dark. Unusual but not alarming — she'd been averaging twelve-hour days and sometimes came in late after a particularly brutal evening session. He worked until ten, then texted her. No response. He called. Voicemail.

At eleven, he told Martin.

Martin called Dorothy's phone. Voicemail. He called her landlord, who confirmed she hadn't been seen leaving the building that morning. He called Torrance, who dispatched a man to her apartment. The man reported back in thirty minutes: the apartment was locked, the lights were off, her car was in its parking space. Her morning running shoes were not in the rack by the door.

Martin stood in the center of the hangar, phone in his hand, very still. Nate watched him and felt the temperature of the room change.

“She went for a run,” Martin said. “She runs every morning. Between five-thirty and six-fifteen.”

“Maybe she went somewhere after.”

“Dorothy doesn’t go somewhere after. Dorothy runs, showers, eats oatmeal, and comes to work. Every day. For the entire time I’ve known her.”

“So what are you saying?”

Martin looked at him. His face had settled into the expression Nate recognized from the worst moments — not fear, not anger, but the cold operational focus of someone who had crossed from hoping for the best into planning for the worst.

“I’m saying she was taken. Between her run and this building. Probably at or near her apartment.”

“Taken by who?”

“Who do you think?”

They called the police. They filed a missing persons report. They told the officer enough to explain why Dorothy Vaneman might be a target — a researcher with valuable expertise, possible corporate espionage angle — without revealing anything about the S-film technology or the vehicle currently occupying three-quarters of the hangar behind a locked door.

The police were professional and slow. Missing adults who had been gone for less than twenty-four hours did not trigger urgent response protocols. The officer took notes and said someone would follow up.

Martin waited until the police left. Then he walked to his office, closed the door, and sat for five minutes in silence. When he came out, his expression had not changed, but something behind it had.

“Nate. Listen to me.”

Nate listened.

“Vanguard took her. There’s no ransom demand because they don’t want money. They want her expertise. DuQuesne’s vehicle has a thermal problem he can’t solve, and Dorothy is the person on Earth most qualified to solve it. They took her to make her work for them.”

“We don’t know that. It could be—”

“It’s not anything else. And it means two things. One: Dorothy is alive and will stay alive as long as she’s useful to them. Two: we can’t get her back by asking. We can’t get her back by calling the FBI, because by the time the FBI takes this seriously, Vanguard will have sanitized whatever facility she’s at. The only way we get Dorothy back is to change the equation. Make Vanguard’s position untenable.”

“How?”

Martin’s jaw tightened. He looked through the office window at the vehicle — the hull sections joined now, the reactor integrated, the thermal bus half-plumbed, the S-film panels curing in their deposition trays.

“We launch. We launch in two weeks. We get in orbit, we broadcast what we’ve done, and we make the whole world look at us. And then we get her back.”

“Two weeks? Martin, the thermal management system isn’t tested. The life support isn’t integrated. We haven’t done a single flight test—”

“Then we work faster.”

Nate opened his mouth to argue. Then he closed it. Because Martin's face — the cold focus, the set jaw, the flat eyes — was the face of a man who had already made the decision and was now executing it, and arguing with that face was arguing with a wall.

He thought of Dorothy in the hangar, her hands moving over structural drawings, her braid over one shoulder, her voice saying *the risk calculus favors her offer* about Whitfield's deal. He thought of her precision, her competence, her absolute refusal to be anything other than exactly who she was.

"Two weeks," Nate said.

* * *

Dorothy, alone in her room, sat on the cot with her back against the wall and began to catalog.

The guard outside changed every eight hours — she could hear the footsteps and the brief exchange of words through the door. The facility hummed with HVAC at a frequency that suggested large-scale climate control, consistent with a building designed for sensitive equipment. When the door opened, the corridor beyond was lit by the same industrial fluorescents and the air carried a faint chemical smell — solvents, or perhaps the ozone trace of high-vacuum equipment.

She could hear, very faintly, the whine of machinery through the walls. Not constant — periodic, in cycles of roughly eighteen hours. Consistent with a magnetron sputtering system running film deposition batches.

She was in a clean room facility. A film fabrication plant. She was inside Condor's manufacturing complex.

She filed every detail. She would remember.

* * *

Chapter 16 — “Forced March”

The next fourteen days were the hardest of Nate’s life.

He slept on the cot in the break room, when he slept at all. Time collapsed into a tunnel of tasks, each one feeding the next, each one critical, each one threatening to fail. The vehicle had been on a three-month integration timeline. Martin had compressed it to two weeks. The gap between those numbers was filled with human effort — with Nate and Vanessa and Martin and the two technicians working eighteen-hour shifts, with decisions made fast and sometimes wrong and corrected on the fly, with the relentless ticking awareness that Dorothy was gone and every hour they spent was an hour she spent in a concrete room.

The thermal management system was the centerpiece of the final integration. Dorothy had designed it on paper — six deployable radiator panels, each two meters by four, using sodium heat pipes, with a pumped NaK thermal bus connecting the S-film substrates to the radiator headers. The design was elegant, thoroughly analyzed, and about sixty percent built when she was taken.

Nate and Vanessa finished it.

They worked from Dorothy’s drawings, which were precise enough to build from but assumed an engineer of her caliber would be interpreting them. Nate was not that engineer. He was a materials scientist. He understood thermal dynamics at the molecular level — heat flow through crystal lattices, phonon transport, blackbody radiation — but the macro-scale systems engineering of a spacecraft thermal bus was Dorothy’s domain, not his.

He learned. He learned the way he learned everything: by running into the wall, backing up, examining the wall, and finding the crack he could exploit.

The heat-pipe radiators themselves were straightforward — sodium sealed in stainless steel tubes, wicked with sintered metal for capillary pumping. The working principle was simple: liquid sodium at the hot end evaporated, the vapor traveled to the cooler radiating surface, condensed, and wicked back. No moving parts, no pumps, no failure modes beyond structural breach. Nate had the technicians assemble them from components Dorothy had pre-ordered, following her drawings exactly.

The NaK thermal bus was harder. Sodium-potassium eutectic — liquid at room temperature, an excellent heat transfer fluid, and horrifyingly reactive with both water and air. Working with NaK required inert atmosphere handling, leak-proof fittings, and the focused attention of someone who understood that a spill would catch fire and burn through floor grating. Vanessa, whose lab skills included handling reactive materials, took the lead. She plumbed the thermal bus in a nitrogen-purged glove tent, wearing a face shield and Nomex gloves, connecting each fitting with the deliberate care of someone defusing ordnance.

The radiator deployment mechanism was the part that nearly broke them.

Dorothy’s design called for spring-loaded hinges with pyrotechnic pin-pullers — the same mechanism used on satellite solar arrays. The panels would fold flat against the hull for launch, then deploy when the pins fired, unfolding like petals. Simple in concept. Torturous in execution, because pyrotechnic mechanisms are one-shot devices that either work or don’t, and testing them means destroying them.

They built six deployment mechanisms. They tested two. Both worked. They installed the remaining four, untested, and Nate lay awake at two in the morning staring at the ceiling of the break room and thinking about the two they hadn't tested and the statistical implications of a sample size of two.

Martin handled everything outside the vehicle.

The legal nightmare was considerable. Launching an unlicensed nuclear-powered vehicle from US soil required an FAA launch license (denied), NRC authorization for the reactor (not applied for), presidential approval under NSPM-20 for space nuclear launch (laughable), and environmental review under NEPA (which alone could take years). Rebecca Tran had filed the FAA application knowing it would be denied — the denial created a paper trail showing they'd tried, which she argued would support a good-faith defense later. She also prepared a thick file of legal memoranda arguing that the technology's strategic significance made prosecution politically untenable.

"None of this will keep you out of prison if the political winds blow wrong," she told Martin on the phone, her voice carrying the bone-dry tone of a lawyer who had done her job and was now doing her client the courtesy of honest assessment. "What might keep you out of prison is succeeding so spectacularly that putting you in prison would be more embarrassing than letting you go."

"I understand the strategy," Martin said.

"I need you to understand it in your bones, Martin. Because the moment you light that reactor and leave the ground, you've committed at least four federal felonies. You, personally. And Nate. And anyone else on board."

"I understand."

He also understood something Rebecca didn’t say, because it wasn’t her job to say it: that if they succeeded, they would change the world so fundamentally that the felonies would become footnotes. And if they failed, the felonies would be the least of their problems.

Martin accepted that he was going with Nate.

He told Laura on day three of the forced march. He drove home at midnight — the first time he’d left the hangar in three days — and found her in the kitchen grading papers, a cup of tea gone cold beside her laptop. She looked up when he came in and he saw her clock the flight suit draped over his arm, the one he’d brought home to check the fit, and something shifted in her face.

“You’re going up in it,” she said. Not a question.

“Dorothy’s gone. Someone has to manage the systems. Nate can’t do it alone.”

“Martin.” She set down her red pen. Her voice was level, the way it got when she was working very hard to keep it level. “You’re an engineer. You’re not an astronaut. You’re not a pilot. You build battery installations. And you want to ride a nuclear reactor into space in something you built in a garage.”

“A hangar.”

“Don’t.”

He sat down across from her at the kitchen table. The table was covered with student lab reports about chemical reactions — baking soda volcanos, elephant toothpaste. The ordinariness of it hurt.

“Laura. If I don’t go, Nate goes alone. And if Nate goes alone in a vehicle with systems he can’t monitor from the pilot seat, he dies. The reactor coolant loop needs manual attention. The thermal bus has to be managed. The guidance computer has a known glitch in its attitude-hold mode that requires a human workaround. Dorothy designed all of this for a two-person crew. One person can't fly it."

"Then don't fly it. Wait. Get Dorothy back first, then fly."

"We can't get Dorothy back from the ground. Vanguard has her at a black site. The FBI will take weeks to act on a kidnapping complaint against a defense contractor with ties to the intelligence community. Weeks we don't have, because every day we wait is a day they get closer to launching Condor." He reached across the table and took her hand. Her fingers were cold. "The only way to change the game is to be in orbit. Once we're up there, everything changes. The world sees us. The technology is undeniable. And Vanguard's position — hiding Dorothy, building weapons, operating outside the law — becomes untenable."

Laura looked at their hands on the table. Her thumb moved against his knuckles. She didn't speak for a long time.

"When?"

"Eleven days."

"And you'll come back."

It wasn't a question. It was an instruction. Martin squeezed her hand.

"I'll come back."

She squeezed back, hard, and then let go and picked up her red pen and went back to grading papers, and Martin understood that this was how she processed things that were too large to process — by returning to the work in front of her, the way he returned to his spreadsheets, the way Nate returned to his experiments. They were all the same animal, in the end.

He drove back to the hangar at one in the morning with the flight suit on the passenger seat and the taste of the tea Laura had made him still on his lips.

Vanessa would stay on the ground. She'd run mission control from the hangar — or rather, from a control van that Martin had outfitted with X-band comms equipment, a redundant data link, and enough processing power to monitor telemetry in real-time. The van would be parked at the launch site in eastern Oregon, half a mile from the pad. She'd protested — briefly, fiercely, and then not at all, because she understood the logic and because she was the only person who could run the ground systems and because somebody had to be here to carry the work forward if the launch went wrong.

The launch site. Martin owned a tract of rangeland in Harney County, southeast Oregon — twelve hundred acres of high desert that he'd bought five years ago as a potential site for a utility-scale solar installation that never materialized. It was flat, dry, remote, and two hundred miles from the nearest city of consequence. He'd had a construction crew pour a concrete pad there two weeks ago, thirty meters square and half a meter thick, told them it was a foundation for an agricultural equipment shed. They'd believed him because nobody builds a spacecraft in rural Oregon.

On day ten, the vehicle was loaded onto a flatbed trailer at two in the morning. Martin drove the lead vehicle. A Torrance security escort followed in two SUVs. They took I-84 east to Pendleton, then south on US-395 through the empty dark of the Oregon interior, through John Day and Burns and out onto the rangeland where the only lights were the stars and their own headlamps. The Skylark, shrouded in tarps, looked on the flatbed like what it wasn't — an industrial cylinder, a boiler, a pipe section. The S-film panels were packed separately in foam-lined crates.

They reached the site at dawn. The concrete pad gleamed in the early light, incongruous against the sagebrush — a perfect gray square in an ocean of brown and sage-green that stretched to every horizon. The sky was enormous, the kind of sky that only the high desert produced, a dome of pale blue so vast it made the ground feel like a floor rather than a landscape. Nate stepped out of the cab into air that smelled like dust and juniper and cold rock, and looked up, and felt the distance between where he stood and where he was about to go like a physical gap in his chest.

The next three days were integration — the phase that separates engineers from theorists, the phase where every drawing becomes a weld and every specification becomes a torque setting and every assumption meets reality. The S-film panels were uncrated with the care of religious artifacts, each one inspected under portable lights for microcracking or delamination before being mounted on its gimbal. The gimbals were aligned with a laser tracker that Nate had borrowed — permanently, he suspected — from his Portland State laboratory. Each panel was connected to the thermal bus through stainless steel flex lines that Vanessa had fabricated in the hangar, each fitting torqued to the specification in Dorothy's drawings and then leak-tested with helium at 150% of operating pressure.

The landing legs — reinforced steel pipe with pad feet, designed by Dorothy, fabricated in a Portland welding shop by a man who thought he was building supports for a grain silo — were bolted to the aft thrust structure. Martin checked each bolt personally, running the torque wrench himself, because the landing legs were the last thing between the vehicle and the ground and he was not going to trust that to a technician he'd known for eight weeks.

The vehicle stood upright for the first time on day twelve, supported by a temporary scaffold made of rented construction framework. Twelve meters of cylinder and radiator and panel bristling against the desert sky. It looked crude. It looked wrong — too rough, too industrial, too much like something that belonged in a refinery rather than on a launch pad. The hull was unpainted aluminum alloy marked with Dorothy's inspection stickers and Vanessa's calibration tags and Martin's structural stamps, and none of them matched and none of them were pretty and all of them were necessary.

Nate stood fifty meters away and looked at it and felt something he hadn't expected: pride. Not the pride of achievement — they hadn't achieved anything yet — but the pride of effort, of seeing three months of sleepless nights and impossible decisions and stolen knowledge and pure stubbornness standing upright in the desert, defying the horizon.

Vanessa ran the final pre-flight diagnostics from the control van. She went through Dorothy's checklist, which Dorothy had written with the thoroughness of someone who had learned at JPL that the checklist was the only thing standing between you and the void. Every system was tested. Every sensor was read. Every valve was cycled. Every circuit was checked against its design current. Every thermal sensor was calibrated against a portable ice-point reference. The process took fourteen hours, and Vanessa did not take a break longer than five minutes during any of it.

Some of the results were good. Some were marginal. The reactor came online cleanly, its molten salt reaching operating temperature in four hours, the Brayton turbine spooling up and delivering 5.1 megawatts of electrical power to the bus. The S-film panels responded to low-power test signals, producing measurable thrust that jittered the vehicle against its scaffold. The guidance computer — modified commercial spacecraft avionics from a Crane Energy satellite subsidiary — initialized without errors and acquired GPS lock.

The life support was simplified to the point of austerity. CO2 scrubbing: fifteen lithium hydroxide canisters, enough for five days. Oxygen: 120 kilograms in composite tanks. Water: 180 liters. Food: thirty MREs and fifteen freeze-dried meals. Two modified Collins Aerospace EVA suits, hurriedly procured through a contact of Martin’s at a cost that would have funded Nate’s DARPA research for three years.

There was no flight surgeon. No recovery team. No range safety officer. No mission control beyond Vanessa in a van with a satellite uplink.

On day thirteen, with the Skylark standing on its legs on the concrete pad and the November desert wind pushing dust against the hull, a Torrance security man spotted something in the sky.

“Drone,” he said, pointing east. “Small, commercial-class. Maybe a DJI Mavic or similar. Range about three kilometers, altitude maybe five hundred feet.”

Martin raised binoculars. The drone was a dark speck against the pale sky, holding position. Watching.

“Vanguard?” Nate asked.

“Or a rancher who’s curious about the activity on his neighbor’s land. Or the FAA, or the NRO, or a journalist.” Martin lowered the binoculars. “Doesn’t matter. If they know we’re here, the clock just got shorter.”

“We’re already at launch minus thirty-six hours.”

“Then we launch in thirty-six hours.” Martin turned to the van. “Vanessa. Start the countdown checklist.”

Nate looked at the Skylark. In the flat desert light, it did not look like a spacecraft. It looked like what it was: a cylinder bristling with radiator fins and film panels, sitting on legs that were really just reinforced steel pipe, built in three months by five people who had no business building a spacecraft. The hull was unpainted aluminum alloy, marked with Dorothy's hand-labeled inspection stickers and Vanessa's calibration tags and Martin's structural load stamps. It was crude. It was real. It was about to carry two human beings into space or kill them trying.

He put his hand on the hull. The metal was cold in the November air. He could feel the faint vibration of the reactor through the skin, a heartbeat that had been running for three days and would need to run for many more.

"Okay," he said, to nobody. To the ship. To the sky.

* * *

Chapter 17 — “Launch”

Nate woke at 3:47 AM to the alarm on his phone and lay on his cot in the back of the equipment trailer for thirty seconds, staring at the ceiling, knowing that everything in his life now had a dividing line and this was it.

He dressed in the flight suit Martin had procured — a modified pressure garment from Collins Aerospace, bright orange, with a soft helmet and visor that connected to the vehicle’s oxygen supply. The suit was designed for commercial suborbital flights, rated for short-duration vacuum exposure but not for EVA. It was what they had. He pulled on the boots, sealed the wrist rings, and walked out into the desert dark.

The Skylark stood on the pad in a pool of floodlight, the only illumination for miles. Beyond the light, the high desert was absolute black, the Milky Way arcing overhead with a clarity that Portland’s light pollution never allowed. The air was cold — maybe two degrees above freezing — and it smelled of sage and dust and, faintly, the ozone tang of the reactor’s power conditioning equipment.

Martin was already at the vehicle, checking something on the aft thrust structure with a flashlight. He wore his own flight suit, the same orange, the same ill-fitting civilian-astronaut look. He turned when he heard Nate’s boots on the concrete.

“Reactor’s been at operating temp for eighteen hours. Coolant loop is stable. Guidance computer is locked on GPS and star tracker. Wind at surface is six knots from the northwest, forecast to stay below ten through mid-morning.”

“Film panels?”

“Tested at five percent power an hour ago. All four responded. Thrust readings are within two percent of static-fire numbers.”

“Thermal bus?”

“NaK loop is circulating. Inlet temp is sixty-two Celsius. All six radiator deployment pins show continuity.”

Martin rattled off the numbers the way he rattled off everything — clipped, sequential, controlled. But Nate had known him for fifteen years and could hear the thing underneath the numbers: the same fear that Nate felt, pushed down to where it couldn’t interfere with the checklist but not gone. Never gone.

They walked to the control van. Vanessa was inside, headset on, three monitors glowing with telemetry displays. She looked up as they entered. Her face was drawn, her dark curls pulled back tighter than usual, her expression the one Nate recognized from late nights in the Portland State lab — the focus that left no room for anything else.

“T-minus two hours by the timeline,” she said. “Weather is go. Airspace — well, we don’t have clearance for airspace, so that’s moot. NORAD is going to see you. Every radar installation on the west coast is going to see you. Every satellite in LEO is going to see your thermal signature. You understand that.”

“We understand it,” Martin said.

“The FAA denial is on record. Rebecca has the legal filings queued. The moment you clear the atmosphere, I’m transmitting the public notification packet — your names, the technology description, the open-frequency broadcast script. It goes to AP, Reuters, and NASA Public Affairs simultaneously.”

“Good.”

Vanessa looked at Nate. Something moved in her expression — not the professional focus but the thing behind it, the thing she kept walled off during work hours. “Nate.”

“Yeah.”

“Don’t die.”

He almost laughed. Almost. “Working on it.”

She turned back to her monitors. “Begin crew ingress checklist at T-minus sixty minutes. I’ll run you through it over comms.”

* * *

They climbed the temporary scaffold to the crew hatch at T-minus fifty-two minutes. The hatch was midway up the vehicle, a circular opening in the hull that led to the flight deck — the forward 2.5 meters of the cylinder, a cramped space with two acceleration couches, instrument panels, two sapphire viewports each fifteen centimeters in diameter, and the manual flight controls that Nate had practiced on exactly six times during ground simulations.

Martin entered first, sliding into the right-hand couch. Nate followed, taking the left — the pilot position, by default, because someone had to be in the pilot seat and Nate had insisted on being the one to fly the vehicle he’d made possible. He settled into the couch, felt the harness tighten across his chest and thighs as he buckled in, and looked at the instrument panel.

The panel was a compromise between aerospace engineering and startup pragmatism. The primary flight display was a ruggedized tablet running Dorothy’s custom guidance software, mounted in a vibration-dampened cradle. Flanking it were analog gauges for reactor temperature, coolant pressure, cabin pressure, and oxygen flow — because Dorothy had insisted on analog backups and Dorothy was always right about redundancy. Below the tablet, a row of physical toggle switches controlled the S-film panels: ARM, POWER, VECTOR. Each panel had its own set. Sixteen switches total.

Nate’s hands were shaking. He pressed them flat against his thighs and took three breaths.

“Vanessa, this is Skylark. Crew ingress complete. Starting pre-power checklist.”

“Copy, Skylark. Pre-power checklist is on your tablet, page one. Call each item.”

They worked through the checklist. It took twenty-three minutes. Each item was a switch thrown, a gauge read, a sensor confirmed. Martin’s voice on the right was steady, mechanical, the voice of a man running a procedure because procedures were what kept you alive when your hands wanted to shake.

“Reactor power,” Nate read from the list. “Confirm electrical bus at five megawatts.”

Martin checked the gauge. “Bus reads four-point-nine-eight megawatts. Nominal.”

“S-film panels. Arm panel one.”

Martin flipped the toggle. A green indicator lit on the panel. “Panel one armed.”

“Arm panel two.”

“Panel two armed.”

“Arm panel three.”

“Panel three armed.”

“Arm panel four.”

“Panel four armed.”

“Vanessa, Skylark. All four panels armed. Pre-power checklist complete. Ready for power-up sequence.”

“Copy, Skylark. Power-up sequence is authorized. T-minus twelve minutes. You are go for S-film power-up.”

Nate looked at Martin. Martin looked back. In the dim green light of the instrument panel, Martin’s face was calm. Not relaxed — calm the way steel is calm, holding its shape under load.

“Ready?” Nate asked.

“Go.”

Nate flipped the first POWER toggle. Panel one came alive. Through the hull, he felt it — the vibration, deep and pervasive, the same vibration he’d felt the first time a film sample had accelerated off his bench and punched through the fume hood. But now it was enormous, a presence that filled the vehicle and resonated in his bones.

He powered the remaining three panels in sequence. The vibration built. The vehicle hummed. The acceleration couches trembled.

“All panels powered. Thrust at five percent. Load cells show… twenty-four point one kilonewtons combined.”

“Copy, Skylark. Twenty-four-point-one kN at five percent. That’s consistent. You are go for ramp-up.”

“Increasing to twenty percent.”

The hum deepened. Nate watched the thrust readout climb. Forty-eight. Sixty. Ninety-six kilonewtons. At twenty percent, the vehicle was producing nearly ten tons of force against the landing legs and the concrete pad. The legs groaned. Dust swirled in the floodlights visible through the viewports.

“Twenty percent. Ninety-six kN. Thermal baseline nominal. NaK loop inlet at eighty-one Celsius.”

“Copy. You are go for launch power. T-minus three minutes.”

Nate put his hands on the thrust control — a physical lever, not a slider, because Dorothy had insisted that the most critical input should be something you gripped, not something you brushed. His left hand held the lever. His right hand rested on the vector control — a joystick that adjusted the gimbal angles of all four panels simultaneously.

“Vanessa.”

“Go ahead.”

“If something goes wrong — if we don’t make it — the data files are on the encrypted drive in the safe at Martin’s house. Password is the first line of the abstract of my first published paper, no spaces. Everything’s there. The films, the process, the theory. Make sure it gets to the right people.”

A pause. “Copy that, Nate.”

“Skylark, this is Vanessa. T-minus sixty seconds. Final go/no-go. Flight systems.”

“Go,” Martin said.

“Propulsion.”

“Go,” Nate said.

“Thermal.”

“Go.”

“Guidance.”

“Go.”

“Comms.”

“Go.”

“Skylark is go for launch. T-minus thirty seconds.”

Nate looked through the viewport. The desert was still dark. The floodlights made a small bright island in an ocean of black. Somewhere to the east, the sky was beginning to lighten — a thin line of gray along the horizon. Dawn.

“Twenty seconds.”

He gripped the thrust lever.

“Ten seconds.”

His heart was hammering. His hands were steady. The contradiction didn’t register.

“Five. Four. Three. Two. One. Skylark, you are go.”

Nate pushed the lever forward.

The S-films ramped from twenty percent to full power in 1.8 seconds. The thrust hit him like a wall. Four hundred and eighty kilonewtons — roughly fifty tons of force — slammed him into the acceleration couch. The vehicle leapt off the pad. There was no gentle rise, no stately hover. The Skylark threw itself at the sky with a violence that compressed Nate’s vision and drove the air from his lungs.

The vibration was enormous. The hull sang. Through the viewport, the floodlights dropped away, then the concrete pad, then the flat expanse of desert, all of it shrinking with a speed that his brain refused to process. The acceleration was 0.7 g on top of gravity — a total of 1.7 g pressing him into the couch. Manageable, barely. He could breathe. He could see the instruments. He could move his hands.

The thrust vectoring was imprecise. He’d known it would be — Dorothy’s notes had warned that atmospheric flight with gimbal-mounted panels was “adequate for ascent, problematic for precision maneuvering.” The vehicle yawed right almost immediately, a six-degree deviation that Nate corrected with the joystick, overcorrected,

corrected again. The Skylark’s response was sluggish, delayed by the 0.3-second gimbal lag. It felt like driving a truck on ice.

“Altitude one thousand meters. Velocity two-sixty meters per second. Trajectory offset four degrees east.” Martin read the numbers from the guidance display, his voice compressed by the g-load but steady. “Correct left two degrees.”

Nate nudged the joystick. The vehicle responded, slowly. The ground dropped away.

“Five thousand meters. Velocity six-twenty. Temperature zone seven at one-ninety Celsius. Thermal nominal.”

The sky outside the viewport was changing. The black of pre-dawn was giving way to deep blue, and the blue was darkening at the edges as they climbed. The acceleration pressed on. Nate’s vision narrowed to the instruments and the vector display and the narrow slice of sky visible through the sapphire port.

“Ten thousand meters. Velocity nine-forty. Beginning upper-atmosphere phase. Air density dropping. Vector response improving.”

It was true. As the air thinned, the vehicle’s behavior smoothed. The buffeting from aerodynamic effects faded. The gimbal corrections became cleaner, more responsive, the lag less consequential without atmospheric drag forces fighting the panels.

“Twenty thousand meters. Velocity fourteen-sixty. Sky darkening. Temperature zone seven at two-forty-two.”

The vibration was changing too. The deep roar of atmospheric passage gave way to a cleaner hum — the pure thrumming of S-film panels pushing against the vacuum, the sound Nate had heard in a thousand bench tests but never like this, never at this power, never with his body riding the wavefront.

“Forty thousand meters. Velocity twenty-one-hundred. Radiator deployment zone. Deploying radiators.”

Martin hit the pyrotechnic pin-pullers. Six sharp cracks sounded through the hull — Nate felt each one as a jolt. Through the side viewport, he saw the radiator panels unfold, catching sunlight as they swung to their deployed positions. All six deployed. The thermal indicators showed an immediate drop in panel temperatures as the heat-pipe radiators began dumping waste heat into space.

“All radiators deployed. Thermal margin restored. Temperature zone seven dropping through two-thirty.”

“Sixty thousand meters. Velocity twenty-six hundred. Entering mesosphere. Sky is black.”

Nate looked through the viewport. The sky was black. Stars appeared — not the slow emergence of a clear night but the sudden revelation of a sky that had always been full of stars, hidden by the thin blue veil of atmosphere that they were leaving behind. Below, the curve of the Earth was becoming visible — a luminous arc where atmosphere met space, glowing with the sunrise that was spreading across eastern Oregon.

He was in space. Not yet orbit — they were still accelerating, climbing, and the orbital insertion would require another twenty minutes of thrust and a carefully timed trajectory correction. But he was above the atmosphere, in the black, with the stars.

“Vanessa.” His voice cracked. He cleared his throat. “Skylark is above the Karman line. Altitude sixty-three kilometers and climbing. All systems nominal.”

“Copy, Skylark.” Vanessa’s voice on the comms was thin, distant already, laced with static from the growing distance. But he could hear it — the tremor she was controlling. “You’re looking good from here.

Telemetry is clean. Continue on ascent profile."

The minutes that followed were the strangest of Nate's life. The acceleration continued, pressing him into the couch, but the silence outside was absolute — no wind, no engine roar, just the vibration of the S-films transmitted through the hull. The Earth fell away below them, and the stars above burned with a steadiness that no atmosphere could touch.

Martin called out numbers. Altitude. Velocity. Orbital parameters. The guidance computer plotted their trajectory — an elliptical path that would become a stable low-Earth orbit with one more correction burn at apogee. The reactor hummed. The thermal bus circulated. The radiators glowed, visible through the side viewport as dark shapes edged with the deep red of their operating temperature.

"Orbital insertion burn in four minutes," Martin said. "Maneuvering to insertion attitude."

Nate adjusted the vector control. The Skylark rotated, slowly, pivoting on its center of mass. The stars wheeled in the viewport. The Earth swung into view through the lower port — blue and white and vast, the Pacific Northwest hidden under a bank of clouds, the Cascades a jagged line of white peaks catching the morning sun.

"Attitude achieved. Burn in sixty seconds."

"Standing by."

"Thirty seconds."

Nate gripped the thrust lever. The routine of numbers and checklists had absorbed the terror, pushed it down to a place where it couldn't reach the controls. He was operating on procedure and training and the muscle memory of six ground simulations and the bone-deep stubbornness that made him run an experiment forty-seven times. He was terrified. He was functional. The contradiction was, he was learning, what spaceflight felt like.

“Ten seconds. Five. Mark.”

He pushed the lever. Full thrust. The acceleration slammed back. The hull sang.

Sixty seconds of burn. The velocity climbed. The orbital display showed their elliptical path circularizing — the apogee holding steady as the perigee rose, the two values converging toward a circular orbit at 340 kilometers.

“Orbital insertion complete,” Martin said. His voice was strange — hushed, almost reverent. “Circular orbit achieved. Three-forty kilometers, inclination fifty-one-point-six degrees. Velocity seven-point-six-nine kilometers per second.”

Nate cut the thrust.

The silence that followed was the loudest thing he’d ever heard.

The vibration stopped. The g-forces vanished. His body lifted against the harness, weightless, and the straps were the only thing keeping him in the couch. A pen floated up from the instrument panel tray and drifted across his field of vision. Dust motes, liberated from every surface, hung in the cabin air like tiny stars.

He was in orbit.

He looked through the viewport. The Earth stretched below him, impossibly large, impossibly beautiful, the terminator line dividing day from night in a crisp arc. Clouds swirled in patterns he recognized from weather satellite images but had never seen with his own eyes. The Pacific Ocean was a blue deeper than any color he’d ever seen in a lab.

“Martin.”

“Yeah.”

“We did it.”

Martin unbuckled one hand and reached across the gap between the couches. Nate took his hand. They held it for a moment — two men in pressure suits, floating, gripping each other's hands in a vehicle they'd built in three months, in orbit around a planet that didn't know they were here yet.

Then Martin let go and turned to the comms panel.

"Let's tell them."

Nate activated the X-band transmitter and tuned to the open frequency he'd pre-selected — a maritime distress channel that any ground station could receive. He took a breath.

"This is Dr. Nathan Seaton aboard the vehicle Skylark, broadcasting on open frequency from low Earth orbit. Skylark is a privately built spacecraft powered by Seaton-effect film propulsion, as described in my recent publication in Physical Review Letters. We launched from the United States this morning and achieved stable orbit at approximately oh-six-forty-five Pacific time. I am accompanied by Martin Crane. We are in good health. All systems are functional. This broadcast is being transmitted to confirm the practical viability of quantum vacuum momentum transfer as a propulsion technology. Skylark out."

He released the transmit button. The signal was away, spreading outward at the speed of light — to ground stations, to receivers, to antennas that would pick it up and feed it to people who would feed it to other people until the whole world knew.

"Nate. Martin." Vanessa's voice on the comms, crackling now, the signal fading as their orbit carried them east. "You have company."

Martin pulled up the radar display. At the edge of detection range — a blip, climbing. Fast.

“Something just launched from southern Nevada,” Vanessa said. “Thermal signature is off the charts. It’s heading for orbit.”

Nate stared at the radar blip. Southern Nevada. Groom Lake. Condor.

He looked at Martin. Martin’s face, in the blue light of the instrument displays, had gone still.

“DuQuesne,” Nate said.

The blip climbed. The display updated. Trajectory: ascending. Intercept course.

They were not alone up here.

Chapter 18 — “Orbit”

The nausea hit before the wonder did.

Nate’s stomach floated up into his chest cavity — that was how it felt, a wrongness so fundamental his body had no category for it. He gripped the edge of the instrument panel and watched his knuckles go white against the aluminum rail, and for a long stupid moment the only thought in his head was that he was going to vomit into a spacecraft he’d spent three months building and there was no good way to clean it up.

“Breathe through your nose,” Martin said from the right-hand couch, his voice flat and controlled in the way that meant he was fighting the same battle. “Slow. In for four, out for four.”

Nate breathed. The cabin smelled like hot metal and outgassing polymer and the faint ozone tang of overworked electronics. Through the forward viewport — fifteen centimeters of synthetic sapphire, the most expensive window he’d ever looked through — the Earth’s limb burned electric blue against the black.

He breathed again and the nausea retreated to a manageable throb.

“Guidance computer,” he said. His voice came out rough. He swallowed and tried again. “Guidance computer shows us in a — ” He squinted at the display. The numbers were jumping. “Martin, does that look right to you?”

Martin unclipped his harness and floated — actually floated, his body lifting off the couch with a dreamlike slowness that made Nate’s inner ear scream — and pulled himself hand-over-hand to the navigation panel. His sandy hair drifted up from his forehead like he was underwater.

“Perigee one-sixty-two kilometers, apogee four-eighteen,” Martin read. “Inclination thirty-one point six degrees. Eccentricity point zero-one-eight.” He paused. “That’s not circular.”

“No.”

“We need to circularize or we’ll be dipping into upper atmosphere on every pass.”

“I know.”

The guidance computer chose that moment to freeze. The screen held its last frame for two seconds, then filled with hash — random characters scrolling too fast to read. Martin tapped the reset. Nothing. He held the power button for five seconds, released it. The screen went dark, then came back to a boot logo.

“It’s rebooting,” Martin said.

“Radiation hit, probably. The hardening on that unit was rated for LEO, not for the Van Allen passage we just punched through.” Nate rubbed his eyes behind his glasses. “How long to reboot?”

“Ninety seconds for POST. Another sixty for the nav stack to reload ephemeris data.”

“I can’t wait two and a half minutes.” Nate was already reaching for the equipment locker under his couch. He pulled out a battered HP scientific calculator and a spiral-bound booklet — Keplerian orbital elements, printed from JPL’s Horizons database three days before launch. The pages were dog-eared and coffee-stained. “Give me our current position and velocity from the star trackers.”

Martin floated back to the attitude panel and read off numbers: right ascension, declination, angular rates. The star trackers, at least, were working — two wide-field cameras matching the star field outside against an onboard catalog, giving them orientation to five arcseconds.

Not position directly, but Nate could work backward from the orbital elements they'd planned and the elapsed time since engine cutoff.

He punched numbers into the calculator. His fingers were shaking — adrenaline, not cold, though the cabin was cooler than it should have been. The Vis-viva equation first: velocity as a function of position and semi-major axis. Then the circularization burn: how much delta-V to raise the perigee from 162 to something safe, say 350 kilometers.

"Delta-V for circularization at apogee: one hundred fourteen meters per second," he said after three minutes of punching keys and checking his work twice. "Burn duration at — " He did the thrust calculation. Three S-film panels at full power, one at sixty percent. Total thrust approximately four hundred ten kilonewtons against their mass of roughly sixty-nine thousand kilograms. Acceleration: 5.9 meters per second squared, call it 0.6g. "Nineteen seconds. Prograde at apogee."

"When's apogee?"

Nate checked his numbers. "Forty-one minutes."

"The guidance computer will be back up by then."

"And it might crash again the next time a cosmic ray sneezes at it. I want the backup solution ready." He tore a page from the back of the booklet and started writing the burn parameters in block letters. Thrust vector: prograde. Start time: T plus forty-one minutes twelve seconds from engine cutoff. Duration: nineteen seconds. Orientation: the ship's long axis aligned with the velocity vector, S-film panels firing aft.

Martin watched him write and said nothing for a moment. Then: "We're in orbit, Nate."

Nate looked up. Martin's face was doing something complicated — control fighting with an emotion that wanted out.

"Yeah," Nate said. "We are."

They stared at each other in the floating cabin of a ship that shouldn't exist, two hundred kilometers above the Pacific Ocean, and for exactly one second neither of them was an engineer. Then the moment passed and they went back to work, because the ship was marginal and the work was not optional.

*   *   *

The diagnostics took twenty minutes they didn't really have. Nate worked through the subsystems methodically while Martin prepped the circularization burn, cross-checking Nate's hand calculations against the guidance computer, which had come back online and was — for now — behaving.

S-film Array One: nominal. Operating temperature 340 degrees Celsius, well within the 400-degree ceiling. Thrust output tracking commanded value within two percent.

S-film Array Two: nominal. Same story.

S-film Array Three: thermal fault. The temperature sensors on the panel's upper quadrant were reading 375 degrees at sixty percent power — fifteen degrees below the cliff where copper atoms started migrating and the whole panel died. At full power it would overheat in minutes. Nate pulled up the telemetry history and saw the problem: a coolant distribution tube on the NaK thermal bus had partially kinked during the launch vibration. Flow to the upper quadrant of Panel Three was reduced by about forty percent. The panel could operate, but only at reduced power. Sixty percent was the safe ceiling.

“Can we fix it?” Martin asked.

"Not from in here. The thermal bus is external. We'd need an EVA, and we'd need to straighten a sodium-potassium tube that's running at three hundred degrees Celsius." He shook his head. "We fly with three and three-fifths panels."

S-film Array Four: nominal.

Reactor: the molten-salt core was humming at rated power, 25 megawatts thermal, the Brayton turbine spinning up 5 megawatts electric. Beautiful. The most reliable system on the ship, which made sense — Terrestrial Energy had been building these for a decade, even if they'd never put one in a spacecraft before. But the coolant loop. Nate pulled up the primary salt level indicator and watched it for sixty seconds. It dropped 0.2 milliliters while he watched.

"The leak is real," he said. "Fifty mils a day, roughly. We've got a reserve container with twenty liters of FLiBe salt. That gives us…"

"Four hundred days," Martin said. "Not the binding constraint."

"No, but it makes me nervous. If the leak rate increases — "

"Then we deal with it then. What about life support?"

Nate checked the CO2 scrubber panel. The current canister had been online for three hours and was reading fifty-eight percent remaining capacity. Projected consumption rate: one canister per twenty hours for two crew at current metabolic output. That was faster than the nominal twenty-four-hour figure. Elevated breathing rate from the launch stress, probably. He hoped it would settle.

"Fifteen canisters," he said. "At current burn rate, that's twelve and a half days. If we calm down and our CO2 output drops to nominal, fifteen days."

"Mission plan was five days."

"Mission plan was a lot of things."

Martin didn't respond to that. He was looking at the oxygen tanks, the water gauge, the food locker inventory. Running the numbers silently, the way he always did — dependencies, timelines, critical path. When he finished, his face was the same controlled mask it had been all morning, which told Nate that the numbers were not good but not fatal.

"We can talk about it after the burn," Martin said. "Twenty-six minutes to apogee."

* * *

The circularization burn was anticlimactic in the best possible way. Nineteen seconds of gentle acceleration — the g-force pushing Nate back into his couch at a fraction of what the launch had delivered — and then silence. The guidance computer confirmed the new orbit: 348 by 356 kilometers, nearly circular, eccentricity less than 0.001.

For thirty seconds after the burn, Nate just looked.

The viewport framed a section of Earth that stretched from the Horn of Africa to the Arabian Peninsula. He could see the Red Sea as an actual red-tinged gash between the continents — not red, really, more a milky turquoise that shifted to deep blue at the margins, but he understood why the ancients had named it. The deserts of Saudi Arabia and the Sahara were variations on a single color: tan fading to white where sandstorms smeared the surface. The Indian Ocean was a blue so saturated it looked synthetic, like a color that didn't exist in nature, except this was nature, this was the planet, and the blue was real and the thin bright arc of atmosphere at the limb was heartbreakingly thin.

He had seen photographs. Every astronaut who came back said the same thing: photographs lie. They compress the palette, flatten the depth, eliminate the sensation of motion — the Earth turning below at seven and a half kilometers per second, a stately, inexorable rotation that made the landscape scroll like a camera pan in a film about gods. Photographs did not convey the scale. A screen could not contain the curvature. Only the eye, with its wide field and its depth perception and its connection to a brain that understood size, could grasp that the thing below them was a world.

Martin was looking too. Neither spoke. It was the last moment of pure wonder they would have for a long time.

Nate unclipped his harness and floated to the communications panel. He'd been thinking about this since before launch. Since the night Martin had said, "We're going to be criminals the moment we leave the ground," and Nate had replied, "Then we need witnesses."

He tuned the X-band transmitter to 8.1 gigahertz — a standard deep-space downlink frequency, one that every tracking station on Earth would be listening to. He keyed the mic.

"This is Dr. Nathan Seaton aboard the spacecraft Skylark, broadcasting on an open frequency from low Earth orbit. Current orbital parameters: three hundred and fifty-two kilometer circular orbit, thirty-one point six degree inclination. Skylark is a privately built spacecraft powered by Seaton-effect film propulsion — the quantum vacuum momentum-transfer drive described in my Physical Review Letters paper of February 2027. The vehicle is nuclear-powered and crewed by myself and Martin Crane. We launched from eastern Oregon approximately two hours ago. We are declaring our position and the nature of our technology as a matter of public record."

He paused. The words he'd rehearsed in his head sounded smaller than he'd wanted. He pressed on.

"The theoretical physics underlying this propulsion system has been published and is in the public domain. The engineering implementation was developed privately with no government funding. We are transmitting our telemetry data on this channel, unencrypted. We ask that any station receiving this signal relay it to NASA, the FAA, and major news organizations."

He released the mic and sat back. The transmit indicator glowed green. Across the planet, somewhere, a dish antenna was catching those words at the speed of light.

"You forgot to say 'over and out,'" Martin said.

"I never say 'over and out.' Nobody says 'over and out.' It's redundant."

"The press is going to love you."

Nate snorted. Through the viewport, the west coast of Africa was sliding into view, sunlight catching the Sahara in a sheet of pale gold. He thought about Vanessa down in the control van in eastern Oregon, probably on her fourth cup of coffee, monitoring their telemetry feed on a setup of laptops and SDR receivers that looked like a college radio station. He thought about Rebecca Tran in her Portland office, preparing for the phone calls that were about to overwhelm her switchboard. He thought about his parents in Eugene, who he hadn't told, who were about to find out from CNN.

The radio crackled. "Skylark, this is Goldstone. We copy your transmission. Uh — stand by." A long pause. Then a different voice, older, with the clipped cadence of someone who'd spent a career talking to spacecraft: "Skylark, Goldstone. We have you on DSN track. Your telemetry stream is being received. You should know that your broadcast has been picked up by at least six other stations and is currently being rebroadcast on open channels. You are — you are being heard."

“Copy, Goldstone,” Nate said. “Skylark copies. Thank you.”

He looked at Martin. Martin looked back. Outside, the world turned beneath them, blue and white and unconcerned.

“Now check the radar,” Martin said.

* * *

Nate had been avoiding the radar display the way a patient avoids test results. He pulled it up on the main screen and stared at the returns.

Low Earth orbit was cluttered — thousands of tracked objects, from the International Space Station to spent rocket stages to fragments of debris, all moving at various velocities and inclinations. The display filtered most of it out, showing only objects within a hundred kilometers and on converging trajectories. One return stood out.

It was below them and climbing fast. The radar return was strong — big object, metallic, accelerating. No transponder signal, no IFF code. But the signature was consistent with a vehicle about twenty meters long, matching the published intercept parameters that the US Space Force catalogued for every tracked object.

Except this one wasn’t in any catalog. It had launched from the Nevada desert about forty minutes after Skylark, and it was climbing with a thrust profile that could only mean one thing.

“That’s Condor,” Nate said.

Martin leaned over the display. “Altitude?”

“One-eighty and climbing. Acceleration — ” Nate watched the track update. “Sustained acceleration, about point-six-five g. He’s burning hard.”

“Closing rate?”

Nate ran the intercept geometry. Two ships in dissimilar orbits, one climbing to match the other. “He’ll match our altitude in about ninety minutes. But he’ll be in a different orbital plane — his inclination is off by at least ten degrees. To actually rendezvous, he’ll need a plane change, and that’s expensive.”

“DuQuesne knows that.”

“DuQuesne knows everything we know. He has the same physics.” Nate stared at the climbing dot. “He’s bigger. Six panels to our three and change. More thrust, more power. If he closes the plane-change angle and gets within maneuvering distance — “

“We can’t outrun him in orbit,” Martin said. The sentence was flat and final, a structural engineer identifying a load that exceeded the design margin.

The radio chimed — an incoming hail on VHF, the short-range ship-to-ship frequency. Nate stared at the blinking indicator. He did not answer it. Not yet.

Instead, he keyed the X-band uplink and called the control van.

“Vanessa. You seeing this?”

The response came four seconds later — the round-trip to eastern Oregon via satellite relay. Vanessa Almeida’s voice was tight, controlled, carrying the careful neutrality of someone managing six emergencies at once. “We see it. Something launched from southern Nevada approximately forty minutes after you. Tracking data is preliminary but consistent with an S-film signature — high sustained thrust, no chemical exhaust plume. NORAD has it catalogued as an unidentified object. Nate, whatever it is, it’s big and it’s heading your way.”

“It’s Condor,” Nate said. “DuQuesne’s ship. Vanguard built it.”

A pause. Then Vanessa: “How sure are you?”

“Where else is it coming from, Vanessa? Southern Nevada, S-film propulsion, launched right after us? It’s DuQuesne.”

“Copy.” Another pause. “Nate — they’re hailing you on VHF. We’re picking up the signal.”

“I know. I haven’t answered.”

“Your call.” Vanessa’s voice softened half a degree. “But you should know — the UN Security Council just convened an emergency session. Three governments have issued statements. CNN is running live coverage. The whole world is watching, and they’re about to see a second ship.” She paused. “Whatever you do next, do it knowing that.”

Nate looked at Martin. Martin’s jaw was set, his eyes on the radar return. The green dot climbed steadily, closing the distance between desert floor and sky.

“Answer the hail,” Martin said quietly. “Let’s hear what he wants.”

Nate reached for the VHF panel and stopped. Through the viewport, he could see the faint glow of a thermal bloom below and to the south — radiators at operational temperature, visible as a point of orange light against the dark earth.

Condor was climbing toward them. And DuQuesne had Dorothy.

Nate pressed the VHF receive button and waited.

* * *

Chapter 19 — “Condor”

The launch had been ugly.

DuQuesne sat in the commander’s couch and reviewed the damage reports while Condor climbed through two hundred kilometers, and the word that kept presenting itself was *ugly*. The ground crew had completed fueling eighteen minutes behind schedule. The pre-launch checklist, designed for a methodical two-hour process, had been compressed to forty minutes on Brookings’s direct order when Skylark’s thermal bloom appeared on the Nevada facility’s infrared surveillance network. Three items had been skipped. DuQuesne did not like skipping items.

The reactor was nominal — that, at least, was solid. The naval-derived core had been running for six weeks of ground tests and it performed as advertised: forty megawatts thermal, eight electric, the kind of reliable that came from a lineage of machines designed to operate under an ocean for twenty years without maintenance. The Brayton turbine was smooth. Power distribution was clean.

The S-films were another matter. Panels One through Five were operational, producing rated thrust at commanded power. Panel Six had a deposition flaw that DuQuesne had identified during ground testing and accepted as tolerable — a dead zone in the lower third, reducing effective area by about fifteen percent. He’d planned to resurface it in orbit. That plan now seemed quaint.

Thermal management. DuQuesne pulled up the thermal bus display and watched the numbers with the careful attention of a man monitoring his own vital signs. Average panel temperature: 355 degrees Celsius at current thrust. That was ten minutes into the burn. The trend line was climbing at 1.2 degrees per minute. Simple arithmetic: in twenty minutes, the panels would be at 379. The 380-degree threshold — efficiency cliff. By twenty-five minutes, 385. By thirty, irreversible copper migration and panel death.

He had twenty minutes of full thrust before the physics killed his propulsion system.

The hack he'd engineered was serviceable. When panel temperatures reached 375, he would throttle to forty percent for ten to twelve minutes, allowing the undersized radiators to drag the thermal load back down. Then full thrust again. Twenty on, ten off. It gave him two-thirds of his rated performance, which was still formidable — Condor could produce roughly six hundred kilonewtons on a sustained basis, against Skylark's four hundred with its damaged panel.

But it was inelegant, and it introduced a vulnerability. During the cooling phases, his acceleration dropped to 0.25g. If Skylark ran during one of those windows, every minute of DuQuesne's downtime was distance that Condor could not recover.

He should have solved this on the ground. He should have had six months instead of three. He should have had Dorothy Vaneman designing his thermal architecture instead of sitting in a locked compartment three meters behind him.

"We're tracking Skylark on radar," Cole said from the pilot's station. Lieutenant James Cole, USAF, officially on temporary duty to a classified program he'd been told was a technology demonstrator flight. Cole was neat, competent, and beginning to ask questions that DuQuesne did not want to answer. "Bearing zero-four-five, elevation forty-two degrees, range one-sixty-eight kilometers and closing. They circularized about twenty minutes ago. Three-fifty-klick orbit, nearly circular."

“Thank you, Lieutenant.” DuQuesne kept his voice measured. Southern formality — the Baton Rouge that never left, no matter how many years he spent in Virginia or Nevada. “What’s our intercept geometry?”

“Their inclination is thirty-one-point-six. Ours is twenty-eight-point-nine. The plane-change delta-V to match is about two hundred meters per second, which we can handle, but timing matters — we need to execute at the node. I’d recommend matching altitude first, then plane-change at the ascending node in approximately forty minutes.”

“Very good.” DuQuesne made a mental note: Cole was sharp. Cole was also starting to wonder why a technology demonstrator was rendezvousing with a vehicle he’d never been briefed on.

Perkins sat at the operations station behind them, saying nothing. Perkins rarely said anything unless he was issuing instructions or acknowledging them. He was built like a man whose body was a piece of equipment he maintained rigorously, and his face had the neutral affect of someone for whom situations were problems to be managed, not experienced. He wore a headset with a discrete channel to a communications package that DuQuesne was not supposed to know about — a tight-beam transmitter pointed at a relay satellite, linking directly to Brookings’s office in Tysons Corner.

DuQuesne knew about it because he’d designed the ship’s electrical system and recognized the power draw.

“Mr. Perkins,” DuQuesne said, “I’m going to hail Skylark. I want to establish communication before we close to maneuvering distance.”

Perkins looked at him. “Your call, Doctor. Mission orders are to intercept, compel compliance, and recover the vehicle and crew.”

“I’m aware of the mission orders.”

“Lethal force is authorized as last resort.”

“I’m aware of that as well.” DuQuesne held Perkins’s gaze for a precisely calibrated moment — long enough to assert authority, short enough to avoid escalation. “I intend to resolve this through dialogue. Dr. Seaton is a reasonable man.”

“He launched an illegal nuclear spacecraft and is broadcasting classified technology parameters on an open frequency.”

“Which is precisely why compelling his cooperation is more productive than destroying his vehicle.” DuQuesne turned back to the communications panel. “Lieutenant Cole, please maintain our current approach profile. I’ll be on VHF.”

He tuned the radio and composed himself. The words mattered. Seaton was a scientist; he would respond to precision and respect. Brookings wanted a hammer; DuQuesne intended to offer a handshake.

“Dr. Seaton. This is Dr. Marc DuQuesne aboard the research vessel Condor. I’m requesting you match orbit for a discussion about the safe management of this technology.”

He released the transmit key and waited. Silence. Ten seconds. Twenty.

Then Nate Seaton’s voice, slightly distorted by the VHF link, carrying an edge that DuQuesne recognized as controlled fury: “Marc. Let Dorothy go.”

DuQuesne’s hand stopped halfway to the transmit button. He felt something cold settle into his chest, behind his sternum, like a coin dropped into still water.

Seaton knew. Seaton knew that Dorothy Vaneman was aboard Condor. Which meant Seaton knew about the kidnapping — not just that she was missing, but where she was. How? DuQuesne’s mind ran the permutations: a leak in Brookings's organization, a signal from Dorothy herself, a deduction from the evidence. It didn't matter. What mattered was that the conversation he'd planned — the reasonable, collegial appeal to shared scientific interest — was dead on arrival. Seaton wasn't going to discuss safe management of technology with the man whose organization had abducted his colleague.

"I see," DuQuesne said, off-mic.

Behind him, Perkins shifted in his couch. "He knows about the woman?"

"Evidently."

"That changes the calculus."

"It changes nothing about the physics, Mr. Perkins. We still need to close the distance. We still need to match orbits. And Dr. Seaton still needs to come to a rational assessment of his situation."

DuQuesne keyed the mic again. "Dr. Seaton. Ms. Vaneman is aboard Condor. She is safe and unharmed. I understand your concern. But the situation we're both in — two spacecraft in low Earth orbit, both flying technology that every government on Earth wants to control — that situation requires cooperation, not confrontation."

Silence again. Longer this time. DuQuesne could picture Seaton on the other end: wire-frame glasses, that tic of pushing dark hair back from his forehead, the quiet stubbornness that DuQuesne had recognized from reading every paper the man had ever published.

"You stole our research," Seaton said. "You broke into our facility. You kidnapped a member of my team. And now you're following me into orbit with a ship that's — what, twice the size of mine? What exactly does 'cooperation' look like from your end, Marc?"

“It looks like both of us landing safely and having this conversation in a room with attorneys present.”

“I have an attorney. She filed an FAA launch application that was denied. We’re past attorneys.”

Perkins leaned forward and tapped DuQuesne’s shoulder. “Tell him to match orbit and prepare for docking inspection. If he refuses — “

DuQuesne pulled off his headset and turned to face Perkins. When he spoke, his voice was quiet and carried the particular stillness that people who knew him recognized as the precursor to an immovable position.

“Mr. Perkins. I am conducting this communication. You will not interrupt. If you have tactical suggestions, write them down and I will read them at my convenience.”

Perkins’s expression did not change. He sat back. But DuQuesne noticed his right hand drift to the operations console, where a screen he hadn’t activated before now displayed a targeting interface — a weapons system DuQuesne had argued against at every design review and had been overruled on at every one.

The kinetic rail gun. A two-meter tube lined with S-film accelerator material, fed by a capacitor bank that drew from the main power bus. Fifty-gram steel slugs at three kilometers per second. Forty rounds. Effective engagement envelope: under fifty kilometers. They were closing on fifty kilometers now.

“Mr. Perkins,” DuQuesne said. “Stand down from that console.”

“I’m running diagnostics, Doctor. Standard procedure.”

“There is no standard procedure for this. There is no procedure at all. We are three men in a spacecraft that has never flown before, three hundred kilometers above the ground. I will not authorize weapons activation."

Perkins looked at him with eyes that held no particular emotion. "You don't need to authorize it, Doctor. My rules of engagement come from Mr. Brookings."

DuQuesne felt the cold coin in his chest settle deeper. He had known this was possible. He had known it from the moment Brookings ordered the rail gun installed over his objections, from the moment Perkins was assigned to the crew rather than a second engineer. He had known it and he had launched anyway, because the alternative was watching from the ground while Brookings sent someone else.

The rationalization tasted familiar. It always did.

"Lieutenant Cole," DuQuesne said, keeping his voice level. "Please note the time and the following: I am formally protesting any weapons activation absent an imminent threat to this vessel. Log it."

Cole's eyes moved between DuQuesne and Perkins. DuQuesne could see the pieces clicking together in the pilot's mind — the briefing that didn't match the mission, the civilian security operator who outranked the mission commander, the weapons system on what was supposed to be a research flight.

"Logged," Cole said. Then, carefully: "Doctor DuQuesne, I'd like to understand the tactical situation. Who is aboard the other ship and why are we intercepting them?"

"Dr. Nathan Seaton and Martin Crane. They built an S-film spacecraft independently. We are — " DuQuesne chose his words. "We are directed to bring them into a controlled landing."

"Directed by whom?"

"Vanguard Strategic, under a government-adjacent security authority."

“Government-adjacent.” Cole repeated the phrase like he was tasting it. “Sir, I’m active-duty Air Force. My orders came through Space Command. I was told this was a classified technology demonstrator flight. Nobody mentioned an intercept.”

“I understand, Lieutenant. And I will give you a complete briefing as soon as the immediate situation is resolved.”

“I’d like that briefing now.”

“I’d like many things, Lieutenant. Right now I need you to fly the approach profile and not touch anything Perkins asks you to touch without my authorization. Can you do that?”

Cole held his gaze for a long moment. Then: “Yes, sir.”

DuQuesne turned back to the communications panel. Through the forward viewport, he could see Skylark — a bright point of light against the star field, its radiator panels catching sunlight, an improbable cylinder that two men had built in a hangar in Portland. He felt an emotion he recognized as admiration and suppressed it, because admiration was a luxury he could not afford.

The thermal display chimed. Eighteen minutes at full thrust. Panel temperatures averaging 370 degrees, climbing. Two minutes to the first mandatory throttle-down.

DuQuesne keyed the mic one more time. “Dr. Seaton. I want you to understand that I have limited control over the situation aboard this vessel. There are parties involved whose priorities are not the same as mine. I am asking you — as one scientist to another — to slow down and let us find a solution that doesn’t end with someone getting hurt.”

Seaton’s response was immediate. “Then let Dorothy go, Marc. That’s the solution. Everything else is conversation.”

DuQuesne closed his eyes. Opened them. The thermal alarm was sixty seconds from triggering.

“I’ll see what I can do,” he said, and throttled back to forty percent as the heat began to eat his ship alive.

* * *

The cooling cycle took twelve minutes. DuQuesne sat in the dimmer cabin — reduced electrical load during throttle-down — and reviewed the tactical display that he’d never wanted and now couldn’t ignore.

Condor’s approach to Skylark was following a standard Hohmann-like intercept, modified for the continuous thrust that S-films provided. Cole had shaped their trajectory to match Skylark’s orbital altitude within the next forty minutes, with the plane-change maneuver to follow at the ascending node. Once matched, they’d be in the same orbit, same velocity, closing the lateral distance at whatever rate DuQuesne chose.

And then what?

Brookings’s orders were clear: intercept, compel compliance, recover. The escalation ladder ran from radio demands to close approach to warning shots to — the phrase in Brookings’s briefing document had been “disabling fire.” DuQuesne had read it in the SCIF in Nevada, sitting across from Brookings’s smooth, camera-ready face, and had felt the first true vertigo of his incremental descent.

Disabling fire. Against a pressurized spacecraft with two humans aboard. A single kinetic slug through the hull would decompress the cabin in seconds.

DuQuesne had told himself he would manage it. That his presence aboard would moderate the worst outcomes. That Perkins, whatever his instructions, would respond to a reasonable voice. That Seaton, faced with the reality of Condor's superior capability, would see the logic of compliance.

He had told himself these things because the alternative was admitting that he had boarded a weapons platform designed to threaten civilians, and that his presence was not a moderating influence but a fig leaf.

The thermal display showed panel temperatures dropping through 360. Almost ready for the next thrust cycle.

Dorothy Vaneman was in the aft compartment, behind a locked hatch. She'd been confined there since before launch — Brookings's last-minute order, delivered with the smooth insistence of a man who never raised his voice because he never needed to. "Insurance," Brookings had said. "Dr. Seaton has a personal attachment. Leverage is a tool, not a threat."

DuQuesne had put Dorothy on this ship. Not directly — he hadn't given the order, hadn't known until twelve hours before launch that she'd been transferred from the ground facility. But he had created the conditions. He had identified her as valuable. He had told Brookings that Condor's thermal problems needed an expert of her caliber. And Brookings, who understood leverage the way DuQuesne understood quantum coupling, had drawn the obvious conclusion.

He thought about his office in Tysons Corner, the glass walls that looked out onto a landscaped courtyard where Vanguard employees ate lunch on benches. He'd hung his Los Alamos certificate on the wall behind his desk — not the PhD, the certificate of service. Seven years at the Lab, working on inertial confinement fusion, pushing the boundary of what plasma physics could achieve. He’d been good. Better than good. He’d had papers in Physical Review, invited talks at APS meetings, a reputation among the small community of people who understood high-energy-density physics.

He’d left because they wanted to use his work to improve weapons yields rather than develop energy applications. A principled stand. He’d told himself that. Vanguard had offered a clean room, a budget, and the promise that his work would have real-world applications beyond the weapons labs. The clean room was in Nevada, the budget came from sources Brookings never fully disclosed, and the real-world applications turned out to be the same weapons applications he’d rejected at Los Alamos, but with better cafeteria coffee and a private-sector salary.

Incremental compromise. Each step locally rational. The sequence indefensible.

He pulled up his personal archive on the flight computer — a folder of files he’d copied from his office before launch, against Brookings’s explicit instructions. His own research notes. His own theoretical work. He’d spent the past three years developing a framework for quantum vacuum coupling that paralleled Nate Seaton’s published work, approaching the same physics from a different mathematical direction. DuQuesne’s framework was more complete in some ways — he’d solved the thermal coupling equations that Seaton’s paper had left as an exercise for the reader. In other ways, Seaton was ahead — the experimental validation, the materials science intuition that DuQuesne’s theoretical approach couldn’t replace.

Together, they could advance the field by a decade in a year. Instead, they were chasing each other around the Earth in machines that each had built without the other’s best work.

The waste of it. That was what gnawed at DuQuesne more than the moral compromise, more than the kidnapping, more than Perkins and his rail gun. The colossal, inexcusable waste of two brilliant research programs that should have been one.

“Doctor,” Cole said. “Temperatures are at three-forty-five. Ready for full thrust on your command.”

“Full thrust,” DuQuesne said. The S-films spun up and the acceleration pressed him gently into the couch, and Condor resumed its climb toward a ship it was designed to threaten, crewed by a man DuQuesne respected, carrying a prisoner DuQuesne had created.

The cold coin behind his sternum felt like it had been there all his life.

* * *

Chapter 20 — "Evasion"

The slug passed five hundred meters off their port side at three kilometers per second, and neither Nate nor Martin saw it. What they saw was the radar return — a tiny blip that appeared on the display for exactly one frame, moving too fast for the tracking algorithm to tag, and then gone into the void. What they heard was Vanessa, her voice tight with something Nate had never heard from her before, relaying data from a ground-based radar station that had caught the event.

"Skylark, I'm reading a kinetic track from Condor's bearing. A projectile, small, very fast. It passed within five hundred meters of your position."

Nate stared at the radar display. His mind was doing arithmetic it did not want to do: fifty grams of steel at three thousand meters per second carried two hundred and twenty-five kilojoules of kinetic energy. A rifle bullet carried about two thousand joules. This was a hundred times that, moving three times faster, in a vacuum where there was no air resistance to slow it down. If it hit the hull — four millimeters of aluminum-lithium alloy — it would punch through both sides of the pressure vessel and keep going, leaving two holes the size of a fist and a cabin that decompressed in about nine seconds.

"They shot at us," Martin said. His voice was the quietest Nate had ever heard it.

"Warning shot." Nate's own voice sounded strange to him — detached, analytical, as if the part of his brain that was terrified had been temporarily disconnected from the part that was speaking. "Five hundred meters. If they wanted to hit us at this range, they would have."

"At this range. What about at five?"

Nate didn't answer. He was staring at his hands on the console, watching them tremble with a fine, rapid vibration that he could not will away. A graduate student in materials science did not get shot at. A postdoc running thin-film deposition experiments did not get shot at. A man who had published a paper in Physical Review Letters and testified before the Senate Armed Services Committee did not get shot at. These were the categories his life was supposed to fit into, and they had all failed simultaneously, replaced by a single new category: target.

He forced his hands flat on the console. Breathe. Think.

"Vanessa," he said into the X-band mic. "We've been fired on. Kinetic projectile from Condor, warning shot, five hundred meters miss. Log it. Broadcast it. I want the world to know that Vanguard Strategic just fired a weapon in orbit."

The twenty-second delay felt interminable. Then Vanessa's voice, tight: "Copy. Logging and broadcasting. Nate, DSN Goldstone is relaying everything in real time. The networks already have it. You need to — " Static. " — decide fast."

He knew. He knew he needed to decide fast because Condor was twenty-two kilometers away and closing. The plane-change maneuver had brought DuQuesne into their orbital plane. Relative velocity was being bled off with each of Condor's thrust cycles — twenty minutes of burn, ten of cooling, the thermal constraint pulsing like a heartbeat. Nate had been watching the pattern for two hours. He knew it better than DuQuesne probably wanted him to.

"Nate." Martin's hand was on his arm. "We need to decide. Right now."

Nate looked at the tactical display — a word he'd never thought he'd apply to anything he was involved with. Two dots, twenty-two kilometers apart, orbiting Earth at seven and a half kilometers per second in a ballet of thrust and drift. Condor was converging at about two hundred meters per second relative. In two hours, maybe less, they'd be in close proximity. And Condor had a weapon.

The options were brutally simple.

They could comply. Match orbit, accept whatever DuQuesne — or Perkins, or Brookings — demanded. Land. The technology would be seized. Classified. Controlled. Everything Nate had published, everything he'd testified to, rendered moot by the physical possession of both ships by people whose first instinct was to lock everything away. And Dorothy would remain in Vanguard's custody.

They could go higher. Boost to a higher orbit, buying time. But Condor was faster on the straights — more panels, more thrust. A higher orbit just meant a longer chase that Condor would eventually win. DuQuesne's thermal limitation was a constraint, not a crippler. He could still sustain two-thirds of his rated thrust indefinitely.

Or they could run. Not into a different orbit. Not back to Earth. Out.

The Moon. The thought arrived in Nate's mind with the clarity of a circuit closing. Two hundred and forty thousand miles. Three hundred and eighty-four thousand kilometers. Skylark could reach it in — he ran the numbers — about ten hours at a reasonable thrust profile. A lunar flyby would give them a gravitational slingshot, bending their trajectory, adding velocity without spending copper. And every time DuQuesne had to throttle down for his ten-minute cooling cycle, Skylark would gain distance. Not much. Maybe a few kilometers per cycle. But over a ten-hour transit, that was sixty kilometers of accumulated advantage, and at lunar distance the geometry would start to matter.

"The Moon," Nate said.

Martin looked at him. Then at the navigation display. Then back at Nate.

“The Moon,” Martin repeated.

“Lunar flyby. Gravity assist. Slingshot us onto an outbound trajectory. DuQuesne can follow, but his thermal constraint means he can’t match our sustained acceleration. We gain distance on every cooling cycle. By the time we round the Moon, we’re far enough ahead that his intercept geometry falls apart.”

“And then what? We’re heading into deep space with consumables for five days.”

“We’re heading away from the people shooting at us.”

Martin’s jaw worked. Nate could see him running the same calculation — not the orbital mechanics, but the human math. The risk assessment that weighed certain capture against possible survival. Martin was a builder. He liked controlled outcomes. This was not a controlled outcome. This was a leap into the dark, literally, with a leaking reactor and a broken S-film array and enough food for four more days.

“Run the trajectory,” Martin said.

Nate was already pulling up the navigation software. The guidance computer had stabilized — no more crashes since the circularization burn, the radiation environment in their current orbit being gentler than the Van Allen belts they’d punched through on the way up. He entered the parameters: current position, current velocity, target — the Moon’s position ten hours from now, accounting for its orbital motion.

The transfer orbit was not elegant. They weren’t starting from a nice circular parking orbit with a clean trans-lunar injection burn. They were in a 350-kilometer orbit with a ship that could produce variable thrust, aiming for a moving target. The software churned through the

Lambert problem and spat out a solution: a sustained burn of approximately 3,200 meters per second delta-V over the next ninety minutes, shaping their orbit from circular LEO to a high-elliptical trajectory with a perigee near current altitude and an apogee that intersected the Moon’s orbital distance.

But the software assumed four functional panels. Nate adjusted: three panels at full power, one at sixty percent. New burn time: one hundred and twelve minutes. Copper consumption for the burn: one hundred and twelve grams from each full panel, sixty-seven from the damaged one, call it four hundred grams total. They had four and a half kilograms of enriched copper aboard. The burn would consume less than ten percent of their reserves. That was fine.

The thermal budget was tighter. One hundred and twelve minutes of sustained thrust meant one hundred and twelve minutes of waste heat pumping into the radiators. Total thermal load with the reduced panel: approximately six megawatts. Radiator capacity with all six panels deployed: nine megawatts. Margin of thirty-three percent. Sustainable, but the cabin would get warm and the radiators would be glowing orange against the black of space.

“Trajectory is viable,” Nate said. “Burn starts in — ” He checked the phasing. They needed to fire prograde at a specific point in their orbit to shape the departure angle. “Fourteen minutes. Duration one-twelve. We’ll cross lunar distance in approximately ten and a half hours. Closest approach two hundred kilometers above the surface.”

“Two hundred kilometers is tight.”

“Two hundred is what the math gives us if we want maximum slingshot benefit with minimum fuel expenditure. We can widen it to five hundred if you want margin.”

Martin thought for three seconds. “Two hundred. We need the speed.”

Nate nodded and began programming the burn parameters into the guidance computer, with the handwritten backup on a torn page from his Keplerian booklet, because he trusted his pencil more than the radiation-addled flight computer.

The radio crackled. DuQuesne’s voice, unreadable: “Dr. Seaton. That warning was not fired on my authority. I want you to know that.”

“Noted,” Nate said. He did not key the mic again.

* * *

Fourteen minutes felt like fourteen hours. Nate ran the numbers twice more, checked the thermal bus status, verified the gimbal angles on all four panels. Martin monitored the radar. Condor was at eighteen kilometers and still closing, but the geometry was about to change radically.

“Burn in thirty seconds,” Nate said. “Vanessa, if you’re still listening, we’re executing a trans-lunar injection. Repeat: trans-lunar injection. We are leaving Earth orbit.”

Vanessa’s response came through heavy static — they were approaching the terminator, and the control van’s uplink was marginal. “Copy TLI. Nate — ” A burst of noise. ” — be careful.”

“That’s the plan. Skylark out.”

He armed the S-film arrays. The status board showed green on One, Two, and Four. Panel Three showed amber — sixty percent, the thermal fault glaring at him like a bad grade. Good enough.

“Firing,” Nate said, and pressed the execute button.

The acceleration came like a hand pressing on his chest. Not violent — 0.55g, comfortable by launch standards — but sustained, inexorable, building over seconds into a steady pressure that pushed him deep into the couch. The S-films were invisible in their operation: no flame, no roar, no exhaust. The only sound was a faint electromagnetic hum from the power distribution bus and the whisper of the NaK coolant pumps cycling heat to the radiators.

Through the aft cameras, the radiator panels glowed. Not cherry-red like the ground tests — more a deep orange, the color of a kiln, heat radiating into vacuum at the rate of nine megawatts across forty-eight square meters of sodium heat pipe. Beautiful and terrifying. That glow was the only thing standing between them and S-film panels that cooked themselves to death.

The cabin temperature climbed. Eighteen degrees. Twenty. Twenty-two. The hull was a thermal conductor — heat from the aft section migrated forward through the aluminum-lithium structure, warming the crew compartment despite the insulation layers. Nate's flight suit stuck to his back with sweat. The instruments fogged at the edges of their displays, moisture condensing on glass surfaces that were slightly cooler than the ambient air.

Martin monitored the thermal bus with the attention of a man tending a furnace. Every thirty seconds he read the numbers aloud — a pilot's habit, Nate realized, inherited from his Air Force years, the rhythm of a cockpit where silence meant missed data. "Panel One: three-forty-two. Panel Two: three-thirty-eight. Panel Three: three-seventy-one at sixty percent. Panel Four: three-thirty-nine. Radiator average: five-eighty. NaK flow: eleven-point-nine liters per minute. All nominal."

The numbers were a liturgy. They kept the fear at bay.

Condor’s radar return began to shift. Not immediately — both ships were moving at orbital velocity, and the departure burn was initially aligned with their orbital motion. But over minutes, Skylark’s trajectory curved upward, diverging from the circular orbit like a ball leaving a track. Altitude climbed: 380 kilometers. 420. 500. The Earth began to recede.

DuQuesne would see it on his own radar. He would understand immediately what it meant. The question was whether he would follow, and whether he could.

“He’s adjusting,” Martin said, watching the display. “Condor is rolling to match our departure vector. He’s going to follow.”

“He’ll try. Watch his thrust cycle.”

They watched. Condor’s acceleration signature — visible on radar as a change in closing rate — held steady for sixteen more minutes, then dropped. The throttle-down. DuQuesne’s panels were hitting their thermal limit, and he had to back off to forty percent while the radiators fought to reject the accumulated heat.

During those ten minutes of reduced thrust, Skylark’s relative advantage was stark. At full thrust, both ships were accelerating at roughly 0.6g. During DuQuesne’s cooling phase, Skylark maintained 0.55g while Condor dropped to 0.25g. The velocity difference accumulated: every cooling cycle, Skylark gained roughly 1.8 kilometers per second of delta-V advantage.

It wasn’t much per cycle. But over a ten-hour transit, with DuQuesne’s cycling at approximately thirty-minute intervals, Skylark would execute twenty cooling-phase advantages. Thirty-six kilometers per second total. More than enough to open a decisive gap.

The Moon grew in the forward viewport. Not visibly, not yet — at this distance it was still a bright disc, no larger than a thumbnail at arm’s length. But on the navigation display, the lunar distance ticked down: 380,000 kilometers. 370,000. 360,000.

The burn was steady and the ship was holding. Nate allowed himself to breathe.

He thought about what they were doing and the scale of it nearly stopped him. No human had traveled this far from Earth since Apollo 17, more than fifty years ago. Three men on top of a Saturn V, the product of ten years and twenty billion dollars and the focused will of a superpower. Nate and Martin were doing it in a cylinder they'd built in a hangar with a team of four, funded by one man's battery-company fortune, powered by a reactor from a Canadian startup and propulsion physics that had been discovered by accident five months ago.

It was either the most audacious thing anyone had ever done, or the most reckless. Probably both.

The communications delay grew. Vanessa's voice, when they could hear it, came from farther and farther away — the signal weakening, the delay lengthening. By six hours into the transit, the one-way lag was over a second. Real-time conversation was becoming call-and-response, each exchange punctuated by silences that grew longer as the kilometers accumulated. Nate started composing his thoughts before keying the mic, the way you composed a letter rather than speaking a conversation.

* * *

Three hours into the translunar coast, they ate. It was a miserable meal — MREs consumed in the fading acceleration, beef stew and crackers that tasted like cardboard and salt. Nate squeezed the stew from its pouch and caught a floating glob of it with his mouth when the acceleration dipped during a course correction.

“Supplies,” Martin said, chewing methodically. He’d pulled up the inventory list on his tablet. “We have food for four more days at three meals. Two more days if we drop to two.”

“Then we drop to two.”

“Water: one-sixty liters remaining. Consumption at two-point-five liters per person per day, that’s thirty-two days for two people. Better if we ration to two liters.”

“Fine.”

“CO2 scrubbers: thirteen canisters remaining. At current consumption, eight days. If our breathing rate settles, maybe nine.”

“CO2 is the binding constraint.”

“CO2 is the binding constraint. O2 is not a concern — we have plenty. Reactor coolant leak is steady at fifty mils a day. Enriched copper: four-point-one kilos remaining after the TLI burn. That’s approximately sixty-eight hours of full thrust, or longer at reduced power.”

Nate put his MRE down. “Sixty-eight hours of thrust. We might need all of that and more. The slingshot will give us velocity without spending copper, but we’ll need to maneuver. Corrections, braking, whatever comes next.”

“Whatever comes next.” Martin looked at him. “What does come next, Nate? We slingshot around the Moon. We’re heading… where? We have nine days of air. We’re leaving Earth. We can’t land on the Moon. We can’t get to Mars — that’s a six-month transit. Where are we going?”

Nate didn’t answer immediately. He looked through the viewport at the star field — brighter and steadier than any stars he’d seen from Earth, because there was no atmosphere between him and them. He thought about the orbital mechanics of their trajectory, the parabolic arc that the lunar slingshot would bend into something else, and the fact that “somewhere away from Condor” was not a destination.

“I don’t know,” he said. “But I know we’re alive and we’re free and DuQuesne isn’t shooting at us anymore. So I’ll take nine days of not-knowing over zero days of being captured.”

Martin held his gaze. Whatever he saw there — stubbornness, conviction, fear, all three — he seemed to accept.

“Then let’s make the nine days count,” he said, and went back to the supply inventory, pencil in hand, making the numbers work the way he always did: precisely, without sentiment, because sentiment did not extend the consumables timeline.

* * *

Chapter 21 — “Slingshot”

The Moon filled the viewport and Nate forgot how to breathe.

He had seen photographs all his life. He’d stared at high-resolution mosaics from Lunar Reconnaissance Orbiter, zoomed into individual craters, traced the rilles and maria with the comfortable familiarity of an armchair explorer. He thought he knew what the Moon looked like.

He did not know what the Moon looked like.

It was an expanse — the word was wrong, too small, everything was too small — of gray and white and deep shadow that stretched beyond the edges of the viewport and kept going. The terminator line cut across the surface in a razor edge, dividing sunlit desolation from absolute black. Craters overlapped craters, their rims casting shadows that pooled like ink. The surface was close enough that he could see texture: boulders, ridgelines, the subtle color shifts between highland feldspars and basaltic mare. No atmosphere softened anything. Every edge was knife-sharp. Every shadow was total.

Two hundred kilometers. At their current velocity — just under two kilometers per second relative to the surface — the Moon was scrolling beneath them like a landscape seen from an aircraft, except there was no aircraft and no air and the landscape was four and a half billion years old and nobody had ever seen it from this angle at this speed.

“Coming up on periapse in ninety seconds,” Martin said. His voice had the clipped quality it took on under stress, but there was something underneath it — the same thing Nate was feeling, the awe that leaked through the cracks in professionalism. “Gimbal angles set. Thrust sequence loaded.”

The slingshot maneuver was not a passive event. A pure gravity assist — flying past the Moon on an unpowered trajectory — would bend their path and add some velocity, the gift of momentum that Newton and Kepler had described three centuries ago. But it wouldn't be enough. The geometry of their approach, hastily computed during the translunar coast, needed an active component: a precisely timed thrust burn at periapse, the point of closest approach, where the Moon's gravity pulled hardest and every kilonewton of thrust got maximum leverage.

The burn profile was loaded into the guidance computer and backed up on Nate's paper, because the computer had glitched twice more during the transit and he no longer trusted it with his life. The sequence: all three functional panels at full power, the damaged Panel Three at sixty percent, firing in a carefully calculated direction — not straight behind them, but angled twenty-two degrees below their velocity vector, using the thrust to simultaneously accelerate and bend their trajectory outward, away from the Earth-Moon system and out of the ecliptic plane.

Why out of the ecliptic? Because Condor would follow. And a trajectory that stayed in the plane of the planets was predictable — DuQuesne could compute the intercept geometry and use his superior thrust-on-paper to close the gap over days. A trajectory that left the ecliptic plane made the intercept problem three-dimensional, harder to solve, harder to execute. Every degree of inclination Skylark gained was a degree DuQuesne had to spend fuel matching.

“Sixty seconds,” Martin said.

Nate checked the thermal displays. The panels had been cooling during the final approach — they'd throttled down for the last forty minutes, letting lunar gravity do the work, and the S-films were sitting at a comfortable 310 degrees. They had headroom. They'd need it.

“Thirty seconds.”

Through the viewport, the crater Tycho slid past — a young impact scar with bright rays splashed across the southern highlands, its central peak catching sunlight like a beacon. Nate thought, absurdly, of his mother’s geology textbooks, the diagrams of impact craters he’d stared at as a child. He was looking at one now, from two hundred kilometers, in a ship he’d built in a hangar in Portland.

“Ten seconds. Five. Execute.”

Nate pressed the button. The S-films kicked in at full power and the acceleration slammed him back into the couch — 0.55g, the same as the TLI burn, but it felt harder after ten hours of freefall. His body had gotten used to floating in the forty minutes since the last course correction. Now gravity was back, false gravity, the product of four panels pushing against the quantum vacuum, and the ship groaned.

The groan was bad.

Structural loads. The thrust was asymmetric — three panels at full power, one at sixty percent — and the bending moment on the hull was at the edge of the design envelope. Dorothy would have told him exactly how far at the edge, would have quoted the stress analysis from memory. Dorothy wasn’t here.

Thermal alarms shrieked.

Panel Three — the damaged one, the panel with the kinked coolant line that had been running hot since launch — was spiking. The reduced flow to its upper quadrant meant that section couldn’t reject heat fast enough at sixty percent power. Under the sustained burn, temperatures climbed: 380. 385. The copper atoms in that section of film were starting to migrate, the crystal lattice degrading in real time.

“Panel Three is redlining,” Martin said, unnecessarily. The alarm was shrieking.

“I see it.” Nate’s fingers were on the power controls. He could throttle Panel Three down to forty percent, which would save the film but reduce their total thrust by another ten percent. Or he could shut it down entirely and fly on three panels, which was asymmetric as hell and would require recomputing the entire burn profile on the fly.

Or he could ride it out. The burn was scheduled for eighty-four seconds. They were twenty seconds in. If Panel Three survived for another sixty-four seconds —

The temperature display hit 395 and jumped. 401. The thermal protection cutoff was set at 390, but Nate had overridden it during the pre-burn setup because he’d known the panel would spike and he’d decided, with the cold calculation of a man who had no good options, that he’d rather risk one panel than compromise the entire maneuver.

412 degrees. The copper was migrating. The film was dying.

At the forty-second mark, Panel Three failed. Not gradually — catastrophically. The upper quadrant fractured along crystal grain boundaries, and the intact segments produced a chaotic burst of uncontrolled thrust that kicked the ship sideways. The gimbal mount screamed as the panel tried to thrust in four directions at once. Nate killed power to Panel Three and the chaos stopped, replaced by a sullen silence from the aft section.

Three panels. Forty-two seconds left in the burn.

“Recomputing,” Nate said, and he was already doing it, pencil and calculator in hands that were shaking with adrenaline while the Moon scrolled beneath them and the burn profile was now wrong — the thrust vector had shifted because Panel Three was dead, and the remaining three panels in their cruciform arrangement produced thrust that didn’t pass through the center of mass.

Martin didn't wait for the math. He was out of his couch, floating in the reduced acceleration, pulling open the access panel behind the pilot seats. The gimbal controls were there — manual overrides, mechanical linkages that connected to the S-film panel mounts through the hull. He'd helped Dorothy design them. He knew their limits.

"I can adjust the gimbal angles mechanically," Martin said. "Panels One and Four need to cant inward by about three degrees each to move the thrust vector back toward centerline. Two stays where it is."

"How are you going to — "

"There are manual adjustment screws on the gimbal frames. They're meant for ground alignment, not in-flight adjustment, but they'll turn." He was already reaching into the access panel, his hands working by feel in the cramped space behind the instrument rack. "Keep the burn going. I'll compensate."

Nate kept the burn going. Three panels at full power, producing roughly 360 kilonewtons of thrust, enough to maintain 0.52g of acceleration — less than planned, which meant the burn needed to run longer to achieve the same delta-V, which meant more copper consumed and more time at thermal load and a trajectory that was already diverging from the computed optimum.

He watched the navigation display. The intended post-slingshot trajectory was a gentle curve up and out, leaving the Moon's sphere of influence on a hyperbolic path that would take them sunward at first, then — as the Sun's gravity curved them — outward, climbing above the ecliptic plane. The actual trajectory, with reduced thrust and a late start to the correction, was flatter. Less climb. Less ecliptic departure. DuQuesne would have an easier intercept.

Behind him, Martin grunted. A mechanical sound — metal on metal, a wrench turning in a confined space. "Got One adjusted.

Working on Four."

"Hurry."

"I'm hurrying as fast as mechanical engineering allows."

Thirty seconds later, the thrust vector shifted. Nate felt it as a subtle change in the direction of the acceleration — the couch pressure shifted from centered to slightly left, then back to centered as Martin got the second panel aligned. The navigation display updated: trajectory correction, not perfect, but closer to the planned path.

The burn ended at one hundred and six seconds — twenty-two seconds longer than planned to compensate for the lost panel. Nate killed the arrays and the silence of space rushed back in, broken only by the ticking of cooling metal and the hum of the life support fans.

"Post-burn assessment," Nate said, his voice hoarse.

"Panel Three is dead," Martin reported, emerging from the access panel with grease on his hands and a scrape across one knuckle that was beading blood in little spheres that floated off his skin. "The upper quadrant fractured. Lower quadrant might be salvageable — the film looks intact on the sensor data — but the gimbal mount took a lateral shock when the panel went asymmetric. I wouldn't trust it to hold rated thrust. Call it a partial — maybe thirty percent capacity if we're lucky."

"So we have three panels and a maybe."

"Three panels and a maybe." Martin floated back to the couch, trailing a smear of blood from his scraped knuckle. In microgravity, the blood didn't drip — it formed a thin, wavering trail of red spheres that hung in the air like a string of tiny Christmas ornaments. Nate watched one drift toward the instrument panel and caught it on his sleeve before it could contaminate the electronics.

"Your hand," Nate said.

“It’s a scrape. Worry about the ship.”

Nate pulled up the navigation display and studied their new trajectory. The slingshot had worked — they were leaving the Moon’s sphere of influence at a velocity of 3.4 kilometers per second relative to the Earth-Moon barycenter, heading outward at an angle of nineteen degrees above the ecliptic plane. Not the twenty-six degrees he’d planned, but enough to complicate DuQuesne’s intercept geometry.

Their velocity relative to the Sun was climbing. They were heading out of the Earth’s gravitational well on a trajectory that, if unpowered, would carry them to a maximum solar distance of roughly 1.4 AU before the Sun pulled them back. With thrust, they could go farther. How much farther depended on the copper they had left.

“Condor?” Nate asked.

Martin checked the radar. Condor’s return was faint at this range — they’d opened a gap during the slingshot — but still visible, a determined dot rounding the Moon approximately forty minutes behind them. DuQuesne had clearly followed, executing his own slingshot, but his thermal cycling had cost him during the approach. Every ten-minute cooling phase while the Moon’s gravity was pulling hardest was momentum he didn’t get back.

“Forty minutes behind. He’s rounding the far side now — we’ll lose radar contact for about ten minutes while the Moon blocks the signal. When he comes back around, we’ll know his post-slingshot velocity.”

“He’ll be slower,” Nate said. “He had to throttle down twice during the approach. Each cooldown cycle during the closest lunar approach cost him significant slingshot benefit.”

“He’ll be slower. But he’s not giving up.”

No. DuQuesne wouldn't give up. The man who had left Los Alamos over a disagreement about weapons research and then taken a job with Vanguard Strategic because they offered him a clean room and a budget — that man would not give up. He would run the numbers, accept the tactical disadvantage, and keep coming, because somewhere inside the calculus of leverage and control there was a physicist who wanted to see what was out there as badly as Nate did.

Communications with Earth were degrading. The X-band dish was pointed at the receding Moon, which meant it wasn't pointed at Earth, and reorienting it would take a manual slew that Nate didn't want to spend time on. He did it anyway — twenty minutes of careful repositioning, the dish stepping in one-degree increments while Martin called out the signal-strength readings, hunting for the thread of Vanessa's carrier signal like fishermen in fog.

They found it. Barely. The signal was twelve decibels above the noise floor — enough for intermittent voice, not enough for reliable data. The one-way delay was 1.4 seconds and climbing as they pulled away from the Earth-Moon system.

"Skylark, Skylark, this is Almeida." Vanessa's voice was ghostly, compressed by the codec into a thin approximation of itself. "We copy your post-slingshot trajectory. DSN has you on track. The Secretary of Defense held a press conference. He called the launch 'an act of reckless endangerment.' The UN Security Council is debating." A crackle. "Nate, the whole world is watching. CNN, BBC, NHK, Al Jazeera. Your broadcast from orbit has been viewed four hundred million times. People are in the streets. Not protests — more like vigils. They're watching the sky."

Nate pressed the transmit key and held it. "Vanessa. Tell the world we're alive. We're past the Moon, heading outbound. We have damage but we’re flying. We’ll be in touch when we can. Take care of yourself.”

He released the key. The acknowledgment, if it came, would arrive 1.4 seconds later, then another 1.4 for Vanessa’s reply — nearly three seconds of round-trip silence. Before it arrived, the signal dissolved into static. The Moon’s limb was cutting the line of sight. Vanessa’s voice broke into fragments: “…tracking you… Condor also… be careful… we’ll be…”

Static.

They were on their own.

Nate slewed the dish back to its default position and stared through the viewport. Behind them, the Moon was a shrinking grey disc, the Earth a smaller blue one beside it. He could still cover both with his outstretched hand. In a few hours, he’d be able to cover them with his thumb. In a few days, they’d be indistinguishable from the stars.

He thought about his apartment in Portland. The single-speed bike chained to the rack on the porch. The lab at Portland State, the fume hood with the patch where the crucible had punched through. The Moleskine notebook with the isotope ratio scrawled on page forty-seven. All of it on the blue dot behind him, receding at 3.4 kilometers per second.

Martin broke the silence. “We should inventory the damage from the slingshot. The hull took some stress during the asymmetric thrust. I want to check the frame junctions.”

Work. The universal solvent for existential dread. Nate nodded and they began the post-maneuver inspection, moving through the cabin with flashlights and a torque wrench, checking every bolted joint and welded seam for signs of the bending loads they’d imposed on a hull that had been designed for symmetric flight.

They found two frame junctions where the bolts had shifted — not failed, but loaded beyond their preload torque, the hull flexing during the asymmetric burn. Martin tightened them and made a note: monitor every twelve hours. If the bolts walked again, they had a fatigue problem. The reactor compartment seal was intact. The coolant leak continued its steady drip, fifty milliliters a day. Nate topped off the reservoir and logged the consumption. Eighteen-point-nine liters remaining. The one number that didn't keep him awake.

Nate stared at the star field through the viewport and thought about copper. Four point one kilograms at the start of the TLI burn. Minus four hundred grams for the translunar transit. Minus roughly two hundred sixty grams for the slingshot burn. Remaining: approximately three point four four kilograms of enriched copper.

At full thrust on three panels, consumption was forty-five grams per hour. Seventy-six hours of thrust. About three days, if they burned continuously.

At reduced thrust — economizing, coasting, burning only when needed — they could stretch that to maybe eleven days. After that, the copper was gone, the panels were inert, and they were ballistic. A rock in space, moving in whatever direction the last burn had pointed them, with no way to change course, slow down, or stop.

Wherever they were in eleven days, that was where they stayed.

The Moon slid behind them, its gray face turning away like a door closing. Ahead was the black. Nate checked the CO2 scrubber panel — twelve canisters remaining, eight days for two crew at current consumption — and began to plan for a future measured in numbers that kept getting smaller.

* * *

Chapter 22 — "Deep"

On the fourth day, the Sun became small.

Nate noticed it while replacing the CO2 scrubber canister — a task that had become a ritual, performed every nineteen hours now that their breathing rate had settled to something closer to normal. He was pulling the spent canister from its housing, the lithium hydroxide inside fully converted to lithium carbonate, inert and useless, when he glanced through the forward viewport and stopped.

The Sun was still the brightest object in the sky. But it was no longer the Sun he knew. It had lost the overwhelming presence it had at Earth's distance — the glare that dominated every outdoor moment, the heat that you felt on your skin, the thing that anchored the day. Out here, beyond the Moon's orbit and accelerating outward at a steady 0.15g on reduced thrust, the Sun was a fierce point of light in a black field. Bright enough to hurt if you stared, but small. Diminished. A lamp viewed from across a parking lot instead of across a room.

He snapped the fresh canister into the housing. Nine remaining. At one canister per nineteen hours for two crew, that was seven days and three hours of breathable air.

"Sun's getting small," he said.

Martin looked up from the engineering console, where he'd been monitoring the reactor coolant leak. "We're at point-oh-four AU. About six million kilometers from Earth. The Sun's apparent diameter is — " He paused, did the math. "About thirty arcminutes, same as from Earth. It shouldn't look smaller yet."

"It feels smaller."

"That's psychology, not optics."

Nate supposed it was. But the cold was not psychology. They'd reduced reactor output to conserve the primary coolant salt — the slow leak had consumed a liter in four days, and while they still had nineteen liters of reserve, Nate's paranoia about the leak rate increasing had driven them to drop electrical generation from five megawatts to three. The Brayton turbine spun at reduced speed, producing less electricity, which meant less heat for the cabin. The thermostat read 14 degrees Celsius. They wore their flight suits zipped to the collar and slept in the emergency thermal bags that Collins Aerospace had supplied with the EVA suits — silver-coated Mylar that crinkled with every movement and made sleep a negotiation between warmth and annoyance.

The cold was manageable. They learned its rhythms: colder when the ship rotated to shade the cabin from the Sun, warmer during the brief thrust corrections when the reactor output increased to power the S-films. They slept in shifts — one always awake, monitoring the systems, listening for the subtle changes in sound that signaled a pump struggling or a fan bearing wearing or a seal losing its grip. The ship spoke to them in a language of hums and clicks and ticks, and they were learning to interpret it the way sailors learn the voice of a hull in heavy weather.

The hygiene situation deteriorated predictably. No shower — the water budget didn't allow it. Sponge baths with dampened cloths, which they rationed to every third day. The cabin air recycler handled odor to a point, but the activated charcoal filters were designed for a five-day mission and were saturating. By day four, the cabin smelled like what it was: a sealed box containing two sweating humans, their food waste, and the chemical byproducts of a dozen laboring systems.

The silence was harder.

In orbit, there had been radio chatter — Goldstone, Vanessa, the background crackle of a planet full of transmitters. During the translunar coast, Vanessa’s voice had been their tether to Earth, delayed by seconds, fragmented, but present. Now, at six million kilometers, the one-way light delay was twenty seconds. A question took twenty seconds to reach Earth and the answer took twenty seconds to return. Conversation became a series of monologues separated by long pauses that filled with the hum of life support fans and the faint tick of cooling metal.

They spoke to Vanessa once every four hours, when the X-band antenna could be pointed at Earth without conflicting with the thermal radiator configuration. Martin had worked out the antenna scheduling with his usual precision: four minutes of communication, then the dish swiveled back to its default position, and they were alone again.

The last communication had been three hours ago. Vanessa’s voice, tinny and thin across twenty light-seconds: “The UN Security Council passed a resolution calling for both ships to return to Earth. The US and Russia abstained. China voted for. The resolution has no enforcement mechanism. The Secretary-General issued a statement calling the Skylark flight ‘the most significant event in the history of human exploration’ and asking for calm. Nate — CNN has your parents on. Your mom is…” A burst of static. “…handling it well. Your dad looked like he wanted to build you a better ship.”

Nate had smiled at that. His father, a geology professor at the University of Oregon, had spent thirty years studying rocks that didn’t move and would be utterly horrified at the idea of his son riding a homemade nuclear reactor into deep space. His mother, a literature professor, would be horrified in a more articulate way.

“Vanessa,” Nate had replied, timing his words carefully to fit the communication window. “Tell my parents I’m fine. Tell them the ship is holding. Tell them I’ll call when I can.” He paused. “How’s the press?”

Twenty seconds later: “The press is insane. Rebecca is managing it. She’s given four statements today. The FAA has formally referred the case to the Department of Justice. Nobody expects an indictment while you’re still in space — the optics are too bad. Vanguard’s stock dropped eighteen percent yesterday on the kidnapping reports. Brookings issued a statement calling it ‘competitive intelligence-gathering.’ Nate, the world knows about Dorothy.”

Dorothy. Nate had told Vanessa to go public with the kidnapping — not the details, not the methods, but the fact. Dorothy Vaneman, a member of the Skylark team, was being held by Vanguard Strategic aboard the vessel Condor. Let the world chew on that while the lawyers figured out jurisdiction in space.

* * *

On the fifth day, they ran out of food.

Not completely — they had two MREs and four packets of freeze-dried meals remaining, which represented roughly three days of eating at the reduced schedule of two meals per day they’d been following since the slingshot. But the variety had collapsed. The beef stew was gone. The chicken and rice was gone. What remained was vegetable lasagna (which Nate had eaten enough of to last a lifetime), peanut butter crackers, and something labeled “Southwest Beef and Black Beans” that tasted like cumin-flavored salt.

They ate the peanut butter crackers for dinner, floating in the cabin with the lights dimmed to save power, and did not talk about the food.

Instead, they talked about radiation.

Martin had positioned two of the six radiator panels — the ones not currently needed for thermal management, since they were on reduced thrust — as impromptu shielding on the sunward side of the hull. The sodium-filled heat pipes added about five grams per square centimeter of mass between the Sun and the crew, which was better than the hull's four millimeters of aluminum-lithium alone. But galactic cosmic rays — the high-energy protons and heavy nuclei that permeated interplanetary space — came from all directions, and no amount of radiator repositioning could block them all.

The onboard dosimeters read 47 millisieverts accumulated since launch. Five days. That was roughly ten millisieverts per day, compared to the two-and-a-half millisieverts per year that a person got on the ground. They were absorbing a year's background radiation every six hours.

"At this rate," Martin said, his pencil scratching numbers on a notepad that was getting full, "we'll hit two hundred millisieverts in about sixteen days total. That's the NASA thirty-day limit for low-Earth orbit. Not immediately dangerous, but not something you shrug off. Long-term cancer risk increases measurably above one hundred."

"We're already above one hundred."

"We're already above one hundred."

Nate stared at the dosimeter reading. 47 mSv. An invisible tax being levied on their cells, breaking DNA strands with silent cosmic bullets that passed through the hull like it wasn't there. Nothing they could do about it except reduce exposure time, which meant getting back to Earth, which meant solving the problem of Condor and trajectory and copper reserves and CO_2 scrubbers and all the other numbers that kept shrinking.

“Let’s work the problem,” Nate said.

They ate first — the daily ritual that had replaced meals as a concept. They no longer chose what to eat. They opened the next item in the rotation and consumed it with the mechanical efficiency of machines refueling. Today it was vegetable lasagna, which Nate had hated since day two and which now tasted like nothing at all. His body was burning fifteen hundred calories a day and receiving fifteen hundred calories a day, a zero-sum equation that left no surplus for pleasure.

The silence during meals was different from other silences. In the lab, silence meant concentration. In the hearing room, silence meant calculation. Here, in a cabin that smelled like recycled air and lithium hydroxide and the particular staleness of two unwashed humans in a closed space, silence meant something else. It meant the absence of anyone to talk to except each other, and the growing awareness that they had said everything there was to say about the immediate situation, and that the unsaid things — fear, regret, the slow dawning recognition that they might actually die out here — occupied the spaces between words like pressure in an unpressurized hull.

Martin folded his MRE packaging into a precise square and stowed it in the waste container. Even garbage management was engineered: the container was sealed against the cabin atmosphere to prevent off-gassing from decomposing food. Every system on the ship, no matter how mundane, was a system that could fail.

They worked the problem. Nate on the navigation computer, Martin on the consumables spreadsheet, both of them approaching the same question from different directions: *what do we do now?*

The navigation problem was ugly. They were heading out of the ecliptic plane at 4.2 kilometers per second, their trajectory an elongated curve that would carry them to about 0.15 AU above the ecliptic at its highest point before the Sun's gravity pulled them back down. Their distance from Earth was increasing: six million kilometers and growing. Return to Earth required reversing their velocity and heading back — a maneuver that would consume roughly 2.5 kilograms of their 3.4 kilograms of remaining copper, leaving them with 0.9 kilograms for arrival maneuvering. Tight. Possible. But it meant flying back into range of whatever military assets the US government had by then positioned to intercept them, and back into Condor's reach.

Condor was still behind them. Radar showed DuQuesne at a steady distance of roughly 40,000 kilometers — he'd settled into a long-range pursuit, matching Skylark's general trajectory but not closing aggressively. His thermal cycling continued: twenty-minute bursts of full thrust followed by ten-minute cooldowns, a pattern as regular as breathing. He was conserving his own resources, biding time, waiting for Skylark's consumables to force a decision.

It was, Nate admitted, a rational strategy. DuQuesne didn't need to catch them. He just needed to wait until they had to come back.

"Unless we don't come back," Nate said, thinking aloud.

Martin's pencil stopped. "Explain."

"If we turn around, we're flying into DuQuesne and the US military. If we keep going, we run out of air in seven days. The only way the math works is if someone gives us supplies."

"Nobody is out here, Nate."

"DuQuesne is out here."

The silence that followed was the most loaded Nate had experienced since the moment the crucible had punched through the fume hood in his lab, five months and a lifetime ago. Martin's face did something complex — recognition, rejection, then a reluctant return to recognition.

"You want to negotiate with the man who kidnapped Dorothy."

"I want to negotiate with the man who has forty days of food, twenty days of CO2 scrubbers, and a thermal management problem I think Dorothy can solve."

"Dorothy is his prisoner."

"Dorothy is his leverage. And leverage is only useful if you have something to trade. We have something he needs."

Martin turned back to his notepad. He did not say yes and he did not say no. He wrote numbers, columns of them, the way he always did when the variables exceeded his ability to decide by instinct.

Nate let him work and turned back to the navigation display. Condor was out there, forty thousand kilometers behind, a green dot on a black screen. Patient. Waiting.

He wondered what DuQuesne was doing right now. The same thing, probably — staring at displays, running numbers, calculating how much time he had before the systems that kept him alive ran out or broke down. They were both scientists, both engineers, both trapped in machines of their own making. The only difference was that DuQuesne had chosen to carry a weapon and Nate had chosen to carry a postdoc.

He thought about Vanessa, alone in the control van in eastern Oregon, managing a global media crisis and a data relay operation from a setup that looked like a college radio station. She'd stayed because someone had to, and because she was the kind of person who finished what she started. He owed her more than he could calculate. He owed Martin more. He owed Dorothy everything, and she was on the wrong ship.

Not for much longer, if he could help it.

*   *   *

The comm chimed at 0200 ship time.

Nate was asleep, or trying to be — floating in his thermal bag in the dimmed cabin, anchored to the couch by a bungee cord, his body exhausted and his mind refusing to stop running the consumables arithmetic. The chime pulled him out of a half-dream in which he was back in his lab at Portland State, running a deposition cycle, and the vacuum chamber was leaking, and no matter how many times he tightened the fittings the pressure kept climbing —

He was at the communications panel before the second chime, his thermal bag trailing behind him like a silver cape.

The signal was on VHF. Ship-to-ship. Condor.

DuQuesne's voice was different from the last time they'd spoken. The controlled Southern formality was still there, but underneath it — in the pacing, in the slight roughness of a throat that had been talking too much or not enough — was something Nate recognized. Fatigue. And something else. Something that sounded, improbably, like honesty.

"Dr. Seaton. I apologize for the hour. I've been debating whether to make this transmission for the last twelve hours, and I've concluded that further delay serves neither of us."

Nate waited.

"I have your colleague, Dorothy Vaneman, aboard this vessel. She was transferred to Condor before launch on orders from my superiors at Vanguard Strategic. She is alive, unharmed, and has been provided with adequate food, water, and living space. She has declined to cooperate with my engineering team and I have respected that decision."

A pause. Nate could hear DuQuesne breathing. The VHF signal was clear — at forty thousand kilometers, the transmission was strong.

"Dr. Seaton, my ship has a problem I cannot solve. The primary cooling loop that manages heat rejection from the S-film arrays is degrading. The NaK eutectic fluid is breaking down under sustained thermal cycling — a problem I did not anticipate because I did not have time to perform adequate endurance testing before launch. At the current degradation rate, I will lose effective cooling within forty-eight hours. When that happens, my S-films will overheat and fracture within minutes of activation. I will have no propulsion."

Another pause.

"I will be stranded in deep space with three crew members, one of whom is aboard against her will. I have supplies for approximately fourteen days. After that — " He stopped. When he spoke again, the formality had cracked. "After that, we die out here. All four of us."

Nate pressed the transmit key. "All four of you."

"Yes. Ms. Vaneman included."

Martin was awake now, floating beside Nate, reading the conversation in Nate's expression. Nate met his eyes and saw the same thing he felt: the terrible arithmetic of leverage and survival, the recognition that DuQuesne's crisis was also their opportunity, and the sick knowledge that using someone's impending death as a bargaining chip was the kind of thing Brookings would do.

"What are you proposing, Marc?" Nate asked.

"Dorothy's safe return to Skylark in exchange for technical assistance with the cooling system. I'll provide supplies — food, water, CO2 scrubber canisters, medical supplies. Enough for two weeks. You solve my cooling problem. I solve your consumables crisis."

"And after that?"

"After that, we both go home. Separately. Whatever happens on the ground, happens on the ground."

Nate looked at Martin. Martin's jaw was tight, his eyes narrow, doing the math. Twenty CO2 scrubber canisters from Condor would extend their air supply from seven days to roughly twenty-five. Food for fourteen days. Water. Medical supplies. Everything they needed to survive long enough to plan a return trajectory.

And Dorothy.

"I need time," Nate said.

"You have it," DuQuesne replied. "But not forty-eight hours of it."

The VHF went quiet. Nate floated in the dim cabin, looking at Martin, and neither of them spoke for a long time.

* * *

Chapter 23 — “Negotiation”

The cooling loop display told DuQuesne everything he needed to know, and none of it was good.

He floated in front of the engineering panel in the blue-white glow of Condor’s instrument lights, his shirt sleeves rolled to the elbows, and watched the numbers degrade with the steady precision of a clock running backward. Primary NaK coolant flow rate: 9.2 liters per minute, down from the design specification of 12. The sodium-potassium eutectic was not leaking — the loop was sealed — but the fluid itself was changing. Sustained thermal cycling between 300 and 550 degrees Celsius, repeated hundreds of times over five days, had degraded the eutectic composition. Oxide contamination from trace exposure to the loop’s steel piping was raising the viscosity. The pump, designed for a fluid with the consistency of water, was now pushing something closer to warm honey.

The effect cascaded. Higher viscosity meant lower flow rate. Lower flow rate meant less heat transported from the S-film substrates to the radiator headers. Less heat transported meant higher panel temperatures at any given thrust level. Higher temperatures meant more thermal stress on the pipe joints, which meant more oxide generation, which meant higher viscosity.

A positive feedback loop. DuQuesne had recognized it on day three and spent eighteen hours trying to break it — flushing the system with fresh NaK from the reserve tank, adjusting pump speeds, modifying the duty cycle to reduce peak temperatures. Each intervention bought a few hours. The trend continued.

Forty-six hours. That was his estimate. In forty-six hours, the flow rate would drop below the minimum threshold for effective cooling, and the S-film panels would begin accumulating heat faster than the radiators could reject it. At that point, he could still operate — for a while — at dramatically reduced thrust, perhaps fifteen or twenty percent of rated capacity. But the degradation would continue. Within a week, the loop would be functionally dead, and Condor would be an unpowered hull drifting in an orbit that intersected nothing.

He had told Seaton forty-eight hours because round numbers were easier for non-engineers, and because the two-hour margin might matter.

“Dr. DuQuesne.” Cole’s voice from the flight deck. “Ms. Vaneman is requesting to speak with you.”

DuQuesne pushed away from the engineering panel and pulled himself through the connecting corridor to the aft compartment. Condor’s interior was more spacious than Skylark’s — the advantage of a twenty-meter hull — with individual berths, a proper galley, and a compartment that had been converted into Dorothy Vaneman’s involuntary quarters. The hatch had a mechanical lock on the outside. DuQuesne had added a second lock after Perkins suggested restraints, because DuQuesne was determined that however far he had fallen, he would not reach that particular depth.

He opened the hatch. Dorothy floated inside, her black hair in a braid that was starting to fray at the edges after five days without a proper mirror, her face composed in the expression DuQuesne had come to recognize as her default: evaluating, categorizing, filing information for later use.

She had been watching. From her compartment, she could hear the engineering alarms. She could feel the changes in acceleration as DuQuesne modified the thrust profile. She could smell the faint metallic tang that crept through the ventilation when the NaK loop ran hot. She had been assembling a picture of Condor's deterioration with the same systematic attention she'd brought to every engineering problem in her career.

"Your coolant is dying," she said.

"Yes."

"The oxide contamination is thermal-cycle-driven. Your loop materials aren't rated for the temperature differential you're imposing. You're using 316L stainless for the piping, aren't you?"

DuQuesne's eyebrows rose slightly. She'd deduced the pipe material from the smell of the oxide products. "316L, yes. It was what we had in the timeframe."

"You needed Hastelloy-N, or at minimum Inconel 625. The chromium oxide from 316L poisons NaK at these temperatures. You'd have caught it in a six-month test program." She said this without satisfaction. It was a statement of engineering fact, delivered with the same precision she'd use to read a pressure gauge.

"We did not have six months."

"No. You were too busy building weapons and kidnapping people."

DuQuesne absorbed this. He had learned, over five days of brief exchanges with Dorothy, that she did not waste words on emotion she didn't mean. When she said something barbed, she meant the barb.

"I've contacted Dr. Seaton," he said. "I've proposed an exchange: your return to Skylark in exchange for technical assistance with the cooling system."

Dorothy's expression shifted by a fraction — the tightening around her eyes that DuQuesne had catalogued as her tell for surprise she didn't want to show.

“You’re letting me go.”

“I’m proposing a trade.”

“Because you need me.”

“Because I need someone who can solve this problem, and you are the best thermal systems engineer within forty thousand kilometers. Also because holding you against your will is — ” He paused, choosing the word with care. “Unconscionable. It has been unconscionable since the beginning. I should have refused when Brookings ordered your transfer.”

“Why didn’t you?”

The question was simple and the answer was complex and DuQuesne owed her the truth, or as much of it as he understood.

“Because I told myself that my presence aboard this ship would moderate the worst outcomes. That I could control the situation. That having you here — even involuntarily — was safer for you than being left at the ground facility under Brookings’s direct authority.” He met her eyes. “These are rationalizations. I know that. Each one felt reasonable at the time. The sequence is indefensible.”

Dorothy studied him for a long moment. DuQuesne had the sense — not for the first time — that she was running a diagnostic on him, checking his outputs against his inputs, looking for inconsistencies.

“You’re losing control of your own mission,” she said.

“I lost control of my own mission the moment Perkins powered up that rail gun.”

“Perkins takes orders from Brookings.”

“Perkins takes orders from whoever is paying. Brookings is paying. I am not.”

“What are Brookings’s current orders?”

DuQuesne hesitated. Then: “Bring back Seaton’s ship and crew, or bring back nothing.”

“Or bring back nothing.” Dorothy let the phrase hang. “That means ‘destroy Skylark if you can’t capture it.’”

“Yes.”

“And you’re proposing to give me back to the ship Perkins has orders to destroy.”

“I’m proposing to fix my cooling system so that Condor survives, provide Skylark with supplies so that Seaton survives, and bring everyone home alive. Brookings’s orders were predicated on a world where he had control. He doesn’t. Not out here. Not anymore.”

“And Perkins?”

DuQuesne’s face did not change, but something behind his eyes tightened. “Perkins is a problem I will manage.”

“You said that about this mission.”

“Yes. I did.”

Another silence. Dorothy’s hands moved — her most expressive feature, DuQuesne had noticed, always in motion when her mind was working. She spread her fingers, brought them together, tapped her thumb against her palm. Problem-solving in gesture form.

“I can fix your cooling,” she said. “Not permanently — you’d need to rebuild the loop with the right alloys for that. But I can give you a workaround that extends your operational window long enough to get home.”

“How?”

“Your hull. Condor is a hundred and forty thousand kilograms. Most of that is structure and shielding — steel and ceramic laminate.

Steel has a specific heat capacity of about five hundred joules per kilogram per kelvin. If you pulse the thermal bus to dump excess heat into the hull mass during thrust periods, then radiate it out through the hull surface during cooling phases, you're using the entire ship as a thermal capacitor."

DuQuesne's mind raced through the calculation. One hundred and forty thousand kilograms of steel equivalent at five hundred joules per kilogram per kelvin — a one-degree temperature rise absorbed seventy megajoules. The excess thermal load was roughly one megawatt — the gap between the full-thrust heat generation and the radiator rejection capacity. Seventy seconds to raise the hull temperature one degree. In a twenty-minute thrust window, that was a seventeen-degree rise. Manageable. The hull could handle fifty degrees of thermal cycling without structural issues. That bought them nearly an hour of continuous thrust before the hull reached its cycling limit.

"That extends the duty cycle," he said. "Thirty-five minutes at full thrust instead of twenty."

"With an eight-minute cooling phase instead of ten, because you're now radiating from both the radiators and the hull surface. Your effective sustained thrust goes from sixty-seven percent of rated to roughly eighty-two percent."

"That's — " DuQuesne stopped himself from saying *elegant*, because he was not in a position to offer compliments. "That's workable."

"It's a hack. Like everything else on this ship." Dorothy's voice was flat. "But it'll get you home. Assuming the pipe fittings hold, the valves don't leak, and you don't push the hull past its thermal cycling limit. Steel fatigues under repeated heating and cooling. You'll want to keep the temperature swing under fifty degrees per cycle, which means shorter thrust windows if the hull starts showing stress."

"I understand the limitations."

"Do you? Because the people who built this ship understood the limitations of a lot of things and pushed past them anyway, and that's why you're in this situation. Your films are overheating because your radiators are undersized because your build schedule was too aggressive because Brookings wanted a weapon in orbit before Seaton could establish a public presence. Every failure on this ship traces back to a decision that prioritized speed over engineering margin."

The words were delivered without anger. That was what made them devastating. Dorothy Vaneman did not accuse; she diagnosed. And the diagnosis was accurate, and DuQuesne knew it, and the knowledge settled into the space between them like a load-bearing element that neither could remove.

DuQuesne nodded. He looked at the floating woman in the compartment that had been her prison for five days, and he felt the full weight of what he had done settle onto him — not incrementally, not gradually, but all at once, like a debt called in.

"I'll negotiate the transfer with Seaton," he said. "Your crossing to Skylark, in exchange for the cooling solution and supply transfer."

"I'll give Seaton the solution after I'm aboard Skylark. Not before."

"Understood."

"And Marc."

He paused at the hatch.

"If Perkins interferes, I will not come back. And you will not get the fix. Make sure he understands that."

DuQuesne nodded. He sealed the hatch behind him — the lock felt different this time, heavier — and pulled himself forward to deal with Perkins.

* * *

Perkins was at the operations console, exactly where he always was, his face carrying its habitual expression of professional neutrality. The tight-beam transmitter icon on his console was active. He'd been communicating with Brookings.

"Mr. Perkins," DuQuesne said. "I'm transferring Dorothy Vaneman to Skylark."

Perkins didn't look up immediately. He finished what he was reading on his console — instructions from Brookings, DuQuesne assumed — then turned with the unhurried movement of a man who did not recognize urgency in other people's voices.

"No," Perkins said.

"It's not a request."

"My orders — "

"Your orders from Mr. Brookings are based on a tactical situation that no longer exists. Our cooling system is failing. Without Ms. Vaneman's technical assistance, delivered through a cooperative exchange with Skylark, this ship will lose propulsion within forty-six hours. At that point, your orders become irrelevant, because we will all be dead in two weeks."

Perkins considered this. DuQuesne could see the assessment running behind the flat eyes: mission parameters, chain of command, self-preservation. Perkins was not stupid. He was not even, in

DuQuesne's estimation, malicious. He was a tool — a precision instrument designed to execute instructions with maximum efficiency and minimum friction. The problem with precision instruments was that they did exactly what they were designed to do, regardless of context.

"Mr. Brookings's most recent instructions," Perkins said, "are to retain all assets and return to Earth for recovery. Ms. Vaneman is an asset."

"Ms. Vaneman is a human being, and if she remains aboard a disabled ship, she is a dead human being. As are we all."

"The cooling problem can be resolved without Seaton's involvement."

"It cannot. I have spent eighteen hours attempting exactly that. The solution Ms. Vaneman has proposed requires physical modifications to Skylark's radiator configuration and a coordinated data exchange between both ships. It requires cooperation."

"Then she cooperates from here."

"She won't."

"She'll cooperate if instructed."

DuQuesne felt the cold behind his sternum flare into something hotter — a brief, dangerous surge of anger that he controlled by habit and will. When he spoke, his voice was quieter than before, which was, by the rules of his particular psychology, the more dangerous register.

"Mr. Perkins. I am the mission commander. I am a scientist with thirty years of education and fifteen years of field experience. I am telling you, with the full authority of that expertise, that the woman in that compartment is the only person within fifty million kilometers who can save this ship. I am going to transfer her to Skylark, where she will solve both ships' problems, and I am going to do it whether you agree or not. Your options are to assist, to stand aside, or to attempt to prevent me, in which case Lieutenant Cole and I will restrain you and proceed anyway."

He turned to Cole, who was floating near the flight deck hatch, watching the exchange with the careful alertness of a man recalculating his allegiances. "Lieutenant. Your assessment?"

Cole looked at Perkins. Looked at DuQuesne. Something settled in his face — not quite resolution, but the adjacent thing: the recognition that the ambiguity he'd been living in for five days had reached its boundary.

"I agree with Dr. DuQuesne," Cole said. "The ship's survival takes priority over asset retention. If Mr. Perkins disagrees, I'll support the mission commander."

Perkins looked from one to the other. DuQuesne watched him perform the calculation: two against one, in a confined space, millions of kilometers from any authority that could enforce a chain of command. Brookings's instructions, however clear, could not project force through a radio signal.

"I'll stand aside," Perkins said. "But I'm logging this, and my report to Mr. Brookings will reflect that the mission commander deviated from operational directives."

"Log whatever you like," DuQuesne said.

Perkins turned back to his console. His fingers moved on the keyboard — composing the report, presumably, or transmitting an update to Brookings. DuQuesne watched him and understood, with the analytical clarity that was both his gift and his curse, that this confrontation was not resolved. It was deferred. Perkins had stood aside because the tactical math favored compliance, not because his orders had changed. When the math shifted — when the ship was repaired, when the immediate survival crisis was past — Perkins would return to his default programming. Brookings's instrument, following Brookings's agenda, in a place beyond any law's reach.

DuQuesne filed this understanding away and moved to the supply bay. "Now help me load the supply crates for transfer."

* * *

Nate's answer came four hours later, during a scheduled communication window when both ships oriented their X-band dishes at each other instead of at Earth. The signal was clear — forty thousand kilometers was nothing for an eight-gigahertz transmitter.

"Marc. We accept the exchange. Dorothy crosses to Skylark first. Once she's aboard and the hatch is sealed, she'll talk you through the cooling fix by radio. We'll match velocity for supply transfer afterward. No close approach until Dorothy is safe."

DuQuesne keyed his mic. "Agreed. I propose we match velocity at one hundred meters separation. EVA transfer for Dorothy, then EVA for supply crates. I have twenty LiOH canisters, forty MREs, fifty liters of water, and a medical kit. They're yours."

"One hundred meters." A pause. "That's a long EVA in deep space."

"It is. I'll escort Ms. Vaneman to our airlock and she'll cross on a tether."

"What about Perkins?"

DuQuesne glanced at Perkins, who was floating at his console with the rigid composure of a man who had lost a power struggle and was annotating the fact for later use.

“Mr. Perkins has been informed of the plan and will not interfere.”

“Forgive me if I don’t find that fully reassuring.”

“I understand. I give you my word, Dr. Seaton. Whatever that’s worth to you.”

A longer pause. Then Seaton: “We’ll begin matching maneuvers in six hours. Skylark out.”

DuQuesne closed the channel and went to tell Dorothy that she was going home.

* * *

Chapter 24 — “Rendezvous”

The suit smelled like someone else’s sweat and machine oil and a chemical she couldn’t identify — some kind of sealant or lubricant used during assembly, baked into the fabric lining by years of storage in an environment that had never been designed for long-term gear preservation.

Dorothy pulled the lower torso assembly up over her hips and locked the waist ring, feeling the hard-shell segments settle against her body with the impersonal precision of equipment designed for an average male frame. The suit was a modified Collins Aerospace orbital EVA unit — one of three Condor carried — and it was too big for her. The gloves bunched at the fingertips. The boots had two centimeters of dead space at the toes. The helmet ring sat slightly too high on her shoulders.

She had twenty minutes to adapt, because in twenty minutes she was going to step through an airlock into hard vacuum and cross a hundred meters of nothing to a ship she’d helped design but never boarded.

DuQuesne floated at the airlock inner hatch, watching her with the careful attention he brought to everything. His expression was its usual controlled mask, but she’d been studying him for six days and she could read the variations: the slight tension around his mouth was concern, and the way his eyes tracked her hands as she checked the suit seals was the focus of a man who wanted this to go right for reasons that had moved beyond self-interest.

“Oxygen is full,” she said, reading the HUD display projected on the helmet’s inner surface. “Suit pressure at thirty-five kPa. CO2 at zero-point-two percent. Battery at one hundred. Comms check."

"I hear you clearly," DuQuesne said through his own headset, monitoring from outside the suit. "Radio check with Skylark."

She keyed the suit radio. "Skylark, this is Vaneman. Comms check."

Nate's voice came through immediately — the ships were close now, the VHF signal strong. "Copy, Dorothy. We hear you. How's the suit?"

"Too big. It'll do." She checked the tether attachment at her waist ring. The tether was fifty meters of braided Kevlar line with a spring-loaded reel — not long enough to span the full hundred meters between the ships. DuQuesne had rigged an extension: another fifty-meter length of climbing-grade dynamic rope, clipped to the Kevlar tether with a locking carabiner.

A hundred meters of line. In a spacesuit she'd never worn. Between two ships drifting in formation eight million kilometers from Earth.

She had performed exactly zero EVAs in her career. Her training consisted of watching NASA EVA footage, reading the Collins suit manual three times in the last four hours, and a five-minute pressurization test in the airlock. She was a mission systems engineer who designed spacecraft for other people to fly. The closest she'd come to walking in space was a neutral buoyancy pool at JSC during a JPL cross-training exercise, wearing a suit that had been fitted to her body by technicians who'd spent an hour getting the sizing right.

This suit had been fitted by DuQuesne in ten minutes, using shims cut from packing foam.

"Dr. Vaneman." DuQuesne's voice was formal. The gravity of the moment demanded it. "The procedure is straightforward. I'll depressurize the airlock. You open the outer hatch. You push off toward Skylark at approximately one meter per second — gently, do not push hard, the tether will manage your trajectory. Keep your body oriented toward Skylark, face forward. Do not spin. If you begin to rotate, use the tether as a damper — grip it and let the tension arrest the spin. Mr. Crane is at Skylark's airlock. He'll reel you in on his end."

"I understand." Her voice was steady. She noticed this and was distantly impressed with herself, because her heart rate was one hundred and forty beats per minute and her hands — her expressive, always-moving hands — were clenched inside the too-big gloves.

The inner hatch opened. Perkins floated into the airlock bay.

He was calm — he was always calm, it was the defining characteristic that made him effective and frightening in equal measure. He held a modified flare gun in his right hand, pointed at the deck, the kind of casually professional weapons handling that said *I am not threatening you, I am simply armed*. The distinction was a matter of angle.

"Dr. DuQuesne. I can't let her leave."

DuQuesne turned to face him. In the confined airlock bay, the three of them formed an uncomfortable triangle: Dorothy in her oversized suit, DuQuesne in shirt sleeves with his burned hand wrapped in gauze, Perkins with his flare gun and his flat expression.

"We discussed this, Mr. Perkins."

"I'm acting on updated instructions from Mr. Brookings. Ms. Vaneman remains aboard. The supply transfer can proceed, but the asset stays."

Asset. Dorothy heard the word and felt something cold and precise crystallize in her chest. Not fear — she had been afraid for six days and the fear had burned down to a hard residue that no longer controlled her.

What she felt was clarity. She was an asset in a spreadsheet, a line item in a cost-benefit analysis being conducted by a man in a glass office in Virginia who had never met her and would never face consequences for what happened to her.

Cole appeared at the inner hatch behind Perkins. He was not armed, but his posture — shoulders squared, feet braced against the hatch frame — was that of a man who had chosen a side.

“Mr. Perkins,” Cole said. “Stand down.”

“Lieutenant, this isn’t your call.”

“It is. I’m an active-duty officer and this is an unauthorized detention of a civilian. Whatever your instructions from Mr. Brookings, they don’t override federal law.”

“We’re eight million kilometers from federal law.”

“Then we’re eight million kilometers from Mr. Brookings, too. And I’m here and he’s not.”

Perkins looked from Cole to DuQuesne to Dorothy. The calculation ran behind his eyes — the same calculation Dorothy had watched DuQuesne describe: assets, leverage, tactical advantage. Two against one. The flare gun was a single-shot weapon, useful for intimidation, less useful against two opponents in a confined space.

“Brookings will hear about this,” Perkins said.

“Brookings can hear anything he likes,” DuQuesne said. “Ms. Vaneman is leaving.”

Perkins lowered the flare gun. He stepped back from the airlock bay. The movement was deliberate, unhurried — the retreat of a man conserving his position for a future engagement, not conceding the war.

Dorothy exhaled. The suit’s CO2 scrubber registered the spike.

“One more thing.” DuQuesne reached into his pocket and withdrew a small USB drive, sealed in a plastic bag. He clipped it to her suit’s chest utility loop. “My experimental logs. All of them. The film deposition parameters, the test results, the isotope procurement records. Everything Vanguard has, minus the weapons specifications. Give it to Seaton.”

Dorothy stared at the small plastic bag. “Why?”

“Because the data should be with someone who will publish it. I should have reached that conclusion months ago.”

She looked at him — the sharp features, the gray temples, the eyes that missed nothing — and for a moment she saw him clearly: a man who had taken each step in a logical sequence that led him to an indefensible place, and who was now taking the only step back that was available to him. Not redemption. Not atonement. Just a data transfer, because he was, underneath everything, a scientist, and scientists published.

“Thank you, Marc.”

“Don’t thank me. I put you here.”

“Yes. You did.” She turned toward the airlock. “Open the hatch.”

* * *

The airlock depressurized in forty-five seconds. Dorothy watched the pressure gauge drop — 35 kPa, 20, 10, 5, trace — and felt the suit stiffen around her as it took the full pressure differential, the hard-shell segments becoming rigid, the gloves inflating into awkward semi-curved shapes that made gripping the tether more difficult.

The outer hatch opened.

She had expected darkness. What she saw was light — light everywhere, the Sun blazing from her left, the stars dense and unwavering in every direction, and directly ahead, a hundred meters away, the shape of *Skylark*.

The ship looked different from how she'd imagined it during the months of design and build. Smaller, for one thing — twelve meters was nothing against the infinite backdrop. The radiator panels caught the sunlight and threw it back in sheets of orange-gold. The hull was a cylinder of aluminum-lithium alloy, scarred already by micrometeorite pitting and thermal stress marks, the landing legs folded against the lower hull like a sleeping insect's limbs. She could see the S-film panel mounts in their cruciform arrangement at the aft end — three panels dark and stowed, one mount empty where Panel Three had been before it failed.

It was crude. It was beautiful. She'd drawn the first sketch of that hull on a whiteboard in a Portland hangar, five months ago, and now it was hanging in space, holding two human beings alive, and it was waiting for her.

She gripped the hatch frame and looked down.

Down was a meaningless word. There was no down. Below her boots was the same void that surrounded her in every direction — a black so total that her eyes ached trying to focus on it. No ground. No horizon. No reference frame except the two ships and the tether and the stars. The Sun threw her shadow onto the hull of Condor behind her, a distorted figure in an oversized suit, and beyond the shadow the hull curved away into darkness.

Eight million kilometers from Earth. The distance hit her in a way the numbers on a display never had. She was standing at the edge of an airlock and below her was not the ocean, not the atmosphere, not anything she had a category for. Below her was space. Not the word. The thing itself. Vacuum and radiation and the absolute zero of the cosmic microwave background, and the only things keeping her alive were the twenty-three layers of fabric and ceramic and polymer between her skin and eternity.

Her breathing was loud in the helmet. Too loud. One hundred and fifty beats per minute.

“Dorothy.” Nate’s voice in her ear, calm, grounding. “I can see you. You’re at the hatch. Take your time.”

She took her time. She breathed. In for four, out for four, the way she’d trained herself on rock climbing walls when the exposure got bad and her hands wanted to freeze. The suit’s life support hissed gently, feeding her oxygen, scrubbing her exhalations, keeping her in a bubble of warmth and air that was impossibly thin against the void.

She checked the tether. The first fifty-meter length was clipped to the reel at her waist; the second fifty-meter extension was secured to a hard point inside the airlock, the locking carabiner visible. She tugged it. Solid.

“I’m stepping out,” she said.

She pushed off.

Gently — she remembered DuQuesne’s instruction — one meter per second, no more. Her boots left the airlock rim and she was floating, the tether unspooling behind her with a faint vibration she could feel through the waist ring. Condor’s hull receded. Slowly. One meter per second was walking pace, the speed of a person crossing a room, but out here, with no walls and no floor and nothing between her and the Sun, it felt like standing still and watching the universe rotate around her.

The tether sang. A low, thrumming note transmitted through the Kevlar braids — the vibration of a hundred meters of line in vacuum, carrying no sound but conveying tension through her suit like a tuning fork pressed to her hip. She could feel the slight drag as the reel played out, the resistance calibrated to keep her trajectory straight.

Twenty meters. She was a fifth of the way across. Condor was behind her now, a dark bulk that blocked the stars in a rectangular silhouette. Ahead, Skylark glinted in the sunlight. Between them: nothing. A hundred meters of nothing. No air, no friction, no sound, no net, no rescue if the tether broke.

She did not think about the tether breaking.

At thirty meters, she made the mistake of looking to her right.

The Sun was there. The visor's gold coating dimmed it to a bearable disc, but her eyes registered the distance — ninety-three million miles of vacuum between her suit and the surface of a star, and nothing in between. No atmosphere, no magnetic field, no ozone layer. Just the visor coating and the fabric layers and the void. The suit's external temperature sensor, visible on the HUD, read minus 173 Celsius on her shadow side and plus 121 on the sunlit side. A temperature differential of nearly three hundred degrees across the width of her body. The suit managed it. The suit was managing everything. If the suit stopped managing, she would have about fifteen seconds of consciousness.

She looked away from the Sun. She looked at Skylark. She kept moving.

Forty meters. Halfway. She was in the center of the gap, equidistant from both ships, suspended in void. The Sun hit her visor and she dimmed it with a glove tap on the side control. The gold coating reduced the glare but cast the world in amber, like looking through old glass. She could see the details of Skylark's hull now — the access panels, the viewport frames, the deployment hinges of the radiator panels, the hand-holds she'd specified in the design that she'd never expected to use herself.

A hand-hold. She’d put hand-holds on the hull. Martin had asked why, and she’d said, “Because someone might need them,” and Martin had added them to the build sheet without further discussion. She could see them now — small aluminum rungs, twelve of them, spaced along the hull from the aft section to the airlock hatch amidships. For her. Not designed for her, not imagined for her, but waiting.

Sixty meters. Seventy. The tether’s Kevlar section ran out and she felt the transition to the dynamic rope extension — a slight give, a springiness that made her trajectory oscillate gently. She gripped the tether and damped the oscillation, her too-big gloves wrapping around the rope with a firmness that surprised her. Her hands knew what to do, even inside gloves that didn’t fit. She was a climber. She understood ropes and tension and the physics of a body in motion on a line.

Eighty meters. She could see the airlock hatch — open, lit from inside, a warm rectangle of yellow light in the cold hull. A figure in the hatch: Martin, in a suit that fit him better than hers fit her, his visor up, his face visible. He was paying out a line from Skylark’s side — a secondary tether, a safety backup, because Martin never trusted a single system for anything.

Ninety meters. She reached for the secondary tether. Her gloved hand closed around it — a solid, physical grip, something to hold, something connected to the ship she’d designed and the people who’d built it. Martin pulled. She floated the last ten meters in a smooth arc, the tether gathering behind her, and her boots touched the airlock rim.

She grabbed the hand-hold — the one she’d specified, five months ago, on a whiteboard in Portland — and pulled herself inside. Her hands were shaking. Her whole body was shaking, the adrenaline of the crossing hitting her now that the void was behind her and the walls of the airlock were around her.

Martin cycled the outer hatch closed. The repressurization hiss filled her helmet. Pressure climbed: 10 kPa. 20. 30. 35.

The inner hatch opened.

Nate was there, floating in the cabin that smelled like recycled air and instant coffee and unwashed humans and lithium hydroxide. He looked thinner than the last time she'd seen him, his cheekbones sharper, his dark hair floating in the microgravity. His glasses were slightly crooked. There was a quality to his expression that she'd never seen in the months of working together — a nakedness, a relief so profound it had stripped away the controlled precision he usually wore.

He reached for her hand and pulled her through the hatch. His grip was firm and slightly desperate — the grip of a man who had been imagining this moment for six days and was only now allowing himself to believe it was real. She felt the warmth of his fingers through the suit glove, the first human contact she'd chosen in a week, and something released inside her chest that she had not known she was holding.

For a moment they were both floating, tethered to nothing but each other, in a cabin the size of a minivan eight million kilometers from anyone else. The ship smelled like recycled air and stale food and lithium hydroxide, and it was the most welcome smell of her life.

"Hey," he said. His voice was rough.

"Hey." She managed a smile. It felt unfamiliar on her face, like a muscle she hadn't used in days. "Your radiators are wrong."

He laughed — a short, surprised sound, almost a bark. "I know they're wrong. We did the best we could without you."

"I can see that." She was already looking past him at the engineering displays, her mind shifting from survival to analysis with the reflexive speed of a systems engineer encountering a new problem set. The thermal bus data was on the main screen. The coolant flow rates, the panel temperatures, the radiator performance curves. She could see the compromises they'd made — sensible compromises, given the constraints, but suboptimal in ways that she itched to fix.

"I can fix that," she said. "But first — DuQuesne's cooling problem. If Condor dies out here, three people die with it."

The smile faded from Nate's face. He looked at Martin, who had followed through the airlock and was removing his helmet with the methodical care of an engineer who takes care of his equipment.

"We'll talk about it," Nate said.

"We'll talk about it now," Dorothy said.

* * *

Chapter 25 — “Repair”

The argument lasted twelve minutes.

Nate timed it, not intentionally but because the mission clock on the main display was the largest number in his field of vision and his mind, trained by months of time-critical decisions, catalogued the duration automatically. Twelve minutes of three people floating in a cabin that was too small for one disagreement, let alone the two that were actually happening.

The first disagreement was about whether to help DuQuesne at all.

“He kidnapped you,” Martin said. His voice was at its quietest, which was its most dangerous register. “His organization shot at us. His security man has orders to destroy this ship. And you want us to save his cooling system.”

“His security man has orders from Brookings,” Dorothy said. “DuQuesne defied those orders to let me go. Cole sided with DuQuesne. Perkins is one man in a three-person crew, and two of them have decided he’s wrong.”

“Perkins has access to a rail gun.”

“Which DuQuesne controls the power feed to. He can disable it.”

“Can. Will he?”

Dorothy didn’t answer that immediately. She was at the engineering panel, scrolling through Skylark’s thermal bus data with the focused speed of someone catching up on a week of work, her hands moving on the controls with an authority that made the panel look like it had been waiting for her.

Nate watched the argument and felt the familiar pull of a decision that would define something — not just the outcome, not just the mission, but who they were. The practical case for helping DuQuesne was strong: the supplies he'd promised, the reduced threat of a cooperating rather than desperate adversary, the simple fact that letting three people die when you could prevent it was a line Nate did not want to cross. The practical case against was also strong: Condor was a weapons platform, Perkins was unpredictable, and every calorie of assistance they provided to DuQuesne was a resource that could be turned against them.

But the decision wasn't practical. Not really. It was moral, and Nate had discovered something about himself during five days in deep space that he hadn't known in the lab or the hearing room or the hangar: his moral instincts, for better or worse, were not negotiable. They operated below the level of calculation. He didn't decide not to let people die. He just couldn't.

"We help them," Nate said.

Martin turned to him. The look on his face was not surprise — Martin had known Nate long enough to predict this — but a kind of resigned recognition, the expression of a man watching his friend do the exact thing he expected and feared.

"We help them," Martin repeated.

"We're not going to let three people die because one of them is an asshole."

Martin stared at him for three seconds. Then something shifted — a micro-expression, the tightening of his jaw relaxing by a fraction, the acceptance of a course that his instincts resisted but his values could not reject.

"Fine," Martin said. "But we do it on our terms. Dorothy gives the cooling solution by radio, from here, after the supply crates are aboard. DuQuesne doesn't come within twenty meters of our airlock. And if

Perkins touches that rail gun, we burn every gram of copper we have getting away."

"Agreed," Nate said.

Dorothy was already sketching on Skylark's tablet — a ruggedized Samsung that had been aboard since launch, smeared with fingerprints and floating cracker crumbs. Her stylus moved in fast, precise strokes: a schematic of Condor's thermal bus, reproduced from memory after six days of captivity during which she'd assembled the ship's engineering architecture from sound, smell, and DuQuesne's reluctant technical disclosures.

"The fix is conceptually simple," she said, not looking up. "Condor's NaK coolant loop is degrading because the pipe material is wrong. I can't fix the material. What I can do is change the way the loop operates."

She held up the tablet. The schematic showed Condor's thermal bus: a pumped loop of sodium-potassium eutectic running from the S-film panel substrates, through the reactor heat exchanger, to the radiator headers, and back. A closed circuit, simple in concept, failing in execution because the steel pipes were contaminating the fluid.

"The current operating mode is continuous — the pump runs at constant speed, the fluid circulates at constant flow rate, the heat rejection is steady-state. That's the textbook approach, and it's wrong for this situation, because the contaminated fluid gets worse the more you circulate it. Every pass through the hot sections generates more oxide, which raises viscosity, which reduces flow, which raises temperatures, which generates more oxide."

She drew a second schematic: the same loop, but with valves — manual valves, the kind Condor carried as spares — inserted at two points. The valves divided the loop into three segments: the S-film panel section, the reactor section, and the radiator section.

“You isolate the segments. During a thrust phase, you run the S-film section at full flow but valve off the radiator section. Heat accumulates in the hull mass — the structural steel absorbs it. I calculated this on the crossing: the hull can absorb twenty minutes of excess heat with a temperature rise of less than fifteen degrees.”

“Then you valve off the S-film section, open the radiator section, and dump the stored heat. The radiators are oversized for the hull’s thermal mass alone — they’ll pull the temperature back down in eight to ten minutes. Then you swap back.”

“The key is that during each phase, only half the loop is circulating. The contaminated fluid spends half the time at rest, which means half the oxide generation rate. It won’t fix the underlying problem, but it will slow the degradation enough to get home.”

She set the tablet down. “I’ll need to talk DuQuesne through the valve installation. It requires cutting into the loop and inserting manual gate valves at two positions. He’ll need to drain the affected sections first and refill with fresh NaK from his reserve. It’s a four-hour job in microgravity.”

Nate looked at the schematic. The engineering was clean — not elegant in the way of a purpose-built solution, but effective in the way of a field repair made with available materials under time pressure. Dorothy’s gift: she saw the system as a whole, every component in relation to every other, and she could restructure the relationships to route around a failure.

“How do we know he’ll actually do it right?” Martin asked.

“Because DuQuesne is a competent engineer who wants to live. He’ll follow my instructions because the alternative is dying in the dark.”

*   *   *

The supply transfer happened first.

DuQuesne loaded four crates into Condor’s airlock and depressurized. Cole, in an EVA suit, pushed each crate across the hundred-meter gap on a tether line, where Martin — suited up again, still using the handholds Dorothy had designed — caught them and muscled them through Skylark’s airlock.

Nate watched from the flight deck, monitoring the radar for any sign of Condor’s weapons activation, his hand near the S-film power controls. Nothing. The rail gun’s targeting radar remained dormant. Perkins, whatever his intentions, was standing down.

The crates came aboard one by one. Nate inventoried them as Martin passed them through the inner hatch, and the numbers — the beautiful, life-giving numbers — accumulated on his notepad:

Twenty LiOH canisters. At one canister per nineteen hours for three crew, that was approximately five and a half days per canister — no. Wait. Three crew now, not two. The consumption rate was higher. He recalculated: one canister per twelve hours for three crew. Twenty canisters: ten days. Plus their remaining nine: fourteen and a half days total. Not abundant, but not desperate.

Forty MREs. At two meals per day for three people, that was about six and a half days. Add their remaining four freeze-dried meals: seven days.

Fifty liters of water. Added to their remaining one hundred forty: one hundred ninety liters. At two liters per person per day for three crew: thirty-one days.

A medical kit: bandages, antiseptic, antibiotics, a suture set, four vials of injectable morphine, two EpiPens, a blood pressure cuff, a pulse oximeter. The supplies of a ship that had expected to need a field hospital.

Nate set the pencil down and stared at the numbers. They were not comfortable. They were not generous. But they were enough. Enough to survive for two weeks, which was enough to plan and execute a return trajectory to Earth. The existential crisis of five days — the countdown of scrubber canisters, the rationing of crackers — had been replaced by a problem with a solution. Tight, but solvable.

He keyed the radio. “Marc. Supplies received. Thank you.”

“You’re welcome.” DuQuesne’s voice carried a tension that Nate recognized: the man was waiting for the other half of the deal. “I’m ready for the cooling procedure whenever Ms. Vaneman is available.”

Nate looked at Dorothy, who was already at the communications panel with her tablet in one hand and the suit radio headset in the other. She met his eyes and nodded.

“Go ahead, Dorothy,” Nate said.

*   *   *

The repair took five hours, not four.

Dorothy talked DuQuesne through it step by step, her voice steady and precise on the VHF link, each instruction delivered in the language of a systems engineer communicating with a competent peer: specific, quantified, leaving nothing to interpretation.

“The first valve goes at the junction between the S-film header and the main trunk line. You’re looking for a ninety-degree elbow fitting approximately one-point-two meters from the Panel One substrate mount. There should be a service union — a bolted flange — at that joint. That's where you cut in."

DuQuesne's voice came back, measured: "I see the union. Flange diameter is — " A pause. "Eight centimeters. Six-bolt pattern."

"Good. Unbolt the flange. You'll lose a small amount of NaK — have a containment bag ready, the fluid is liquid at ambient temperature in the engineering bay. Once the flange is open, you'll see the loop interior. It should be dark gray with oxide buildup."

"It's dark gray. Almost black in some areas."

"That's consistent with what I expected. Insert the gate valve body between the flange faces. The valve stem should orient perpendicular to the flow direction, with the handle accessible from the main corridor side."

Nate listened to the exchange and marveled at its quality. Two engineers, separated by forty kilometers of vacuum, performing surgery on a spacecraft's circulatory system through voice instructions and sketched diagrams transmitted as photographs. Dorothy drew each step on the tablet, photographed it, transmitted the image on the data channel. DuQuesne acknowledged, executed, reported. The rhythm was call-and-response, the cadence of people who trusted the process if not each other.

Martin monitored the supply inventory. Nate monitored the radar. The two ships drifted in loose formation, five kilometers apart now — Cole had widened the gap after the supply transfer, a gesture of good faith or caution, Nate wasn't sure which.

At the three-hour mark, DuQuesne hit a problem. The second valve installation required draining the radiator section of the loop, and the drain procedure released a burst of NaK vapor into the engineering bay.

Sodium-potassium was reactive with water — including the water vapor in the air — and the vapor ignited on contact with the cabin atmosphere, producing a brief but intense flash of white light and a shower of caustic sodium hydroxide particles.

“Fire in the engineering bay,” DuQuesne reported, his voice carrying the absolute calm of a man who had trained himself never to panic. “Small. NaK vapor ignition. Extinguished with CO2 bottle. No structural damage. Minor chemical burn on my left hand — I was not wearing gloves for the valve work. Continuing.”

Dorothy closed her eyes for two seconds. When she opened them, her voice was unchanged. “Acknowledged. Marc, from this point on, wear gloves. The next drain step will produce more vapor. Seal the engineering bay from the crew compartment and operate in a depressurized environment if possible — NaK won’t ignite without atmosphere.”

“Understood. Depressurizing the engineering bay now.”

The repair continued. DuQuesne worked in a partially depressurized compartment, wearing an EVA suit for the remaining steps, his burned hand wrapped in gauze inside the glove. Cole assisted from the crew side of the sealed hatch, passing tools through an improvised airlock made from a cargo bag and duct tape.

At the five-hour mark, both valves were installed.

“Testing,” DuQuesne said. “Cycling the valves. Flow rate through the S-film segment at full pump speed — ” A pause. “Eleven-point-eight liters per minute. Nearly nominal.”

“That’s because you’re only pushing fluid through half the loop,” Dorothy said. “The resistance is halved. Your pump can deliver near-rated flow to each segment independently, even with the degraded fluid.”

“Now the radiator segment.” Valve sounds. “Flow rate: eleven-point-four. Also near-nominal.”

“Good. Now test the thermal capacitor mode. Run the S-film segment at full flow for twenty minutes with the radiator segment valved off. Monitor hull temperature at the thermal sensor nearest the engineering bay.”

They waited. Twenty minutes of silence on the radio while DuQuesne ran the test. Nate floated in Skylark’s cabin, eating a lukewarm MRE — chicken fajita, vastly better than the vegetable lasagna he’d been subsisting on — and watched the clock.

“Test complete,” DuQuesne said. “Hull temperature rose four-point-three degrees over twenty minutes. I’m now switching to radiator mode.” Valve sounds. “Radiator section flowing. Hull temperature is — declining. The radiators are pulling it down.”

“Rate of decline?”

“About zero-point-six degrees per minute.”

“That gives you a recovery time of roughly seven minutes. So your cycle is twenty minutes thrust, seven minutes radiate. Effective sustained thrust: seventy-four percent of rated. Better than your old cycle, and the fluid degradation rate should drop by about half.”

Silence. Then DuQuesne’s voice, stripped of formality: “It works.”

“Yes,” Dorothy said. “It works.”

“Thank you, Dr. Vaneman.”

Dorothy set the tablet down. Her hands were still for the first time in five hours. Nate realized, watching her, that she had just saved the lives of three people aboard the ship that had held her prisoner, and she had done it with the same focused precision she brought to every engineering problem. No hesitation. No satisfaction. Just the work, and the work was done.

“You’re welcome, Dr. DuQuesne,” she said. “Don’t make me regret it.”

* * *

Dorothy turned to Skylark’s problems next, and Nate learned what he’d been missing.

She started with the radiator configuration. The six panels had been deployed in a symmetric pattern — three on each side of the hull, evenly spaced, radiating heat into space. It was the obvious arrangement, the one Nate and Martin had come up with during the frantic build, and it worked. But it wasted capacity.

“The problem is view factor,” Dorothy said, pulling up a thermal model on the navigation computer — repurposed, since they weren’t navigating at the moment. “Each radiator panel can see the panels next to it. That means they’re radiating at each other, not just at space. You’re losing about fifteen percent of your rejection capacity to inter-panel thermal coupling.”

“We knew that,” Nate said. “We didn’t have time to optimize.”

“I know. Here’s the fix.” She sketched on the tablet: the six panels rearranged asymmetrically, three on the sunward side (where they also served as radiation shielding, a dual purpose Martin had already improvised), two on the anti-sunward side, and one deployed at a forty-five-degree cant from the hull axis. “This configuration eliminates the worst view-factor losses and improves net rejection by about thirty percent. It also puts more shielding mass between the Sun and the crew.”

“Can we reposition the panels from inside?”

“The gimbal mounts have manual repositioning capability. It’s the same adjustment screws Martin used during the slingshot, plus a lockout pin on each radiator hinge that sets the deployment angle.”

Martin was already opening the access panels. The work took two hours — physically demanding in microgravity, requiring Martin to reach into the hull interstices and manipulate hardware that was designed for ground adjustment, not in-flight reconfiguration. Dorothy directed, Nate assisted, and by the end the thermal bus display showed the improvement in real time: average radiator surface temperature dropped by eight degrees, which meant more margin between the waste heat load and the radiator capacity.

Then she turned to Panel Three.

The upper quadrant was dead — fractured during the slingshot burn, the copper dopant atoms scattered through the ruined lattice like seeds on salted earth. But the lower quadrant, Dorothy confirmed by examining the sensor data, was intact. The film was undamaged. The gimbal mount had taken a lateral shock but was not structurally compromised — Martin’s post-slingshot inspection had been conservative.

“I can bring the lower quadrant back online at about thirty percent of a full panel’s capacity,” Dorothy said. “The trick is isolating the power feed. Right now, the control circuit sends power to the entire panel — upper and lower quadrants together. If I splice the power bus to feed only the lower quadrant, it’ll produce thrust from half the panel area at the same current density. That’s roughly thirty percent of a full panel, accounting for edge losses.”

“How do you splice a power bus in flight?”

Dorothy held up two items from the equipment locker: a pair of wire cutters and a roll of kapton tape. “With these, and very steady hands.”

Nate watched her work. She opened the access panel to the S-film power distribution board — a dense array of high-current copper bus bars and circuit breakers that carried the enormous current load from the reactor’s output to the four panel feeds. She identified the Panel Three feed, traced it to the branch point where it split between upper and lower quadrants, and cut the upper quadrant feed.

“Insulate,” she said, wrapping the cut ends in kapton tape with the precise movements of a surgeon closing. “Now re-route the power to the lower quadrant only.” She used a jumper cable from the spares kit to bypass the branch point, sending full rated current to the surviving film.

“Test,” she said. “Panel Three, twenty percent power.”

Nate brought the panel up. The status display flickered — the control software didn’t understand the modified configuration — and then stabilized. Panel Three: active. Thrust output: twenty-eight percent of rated. Temperature: 340 degrees. Within limits.

“Welcome back, Panel Three,” Nate said.

Dorothy allowed herself a small smile. “You now have three panels at full capacity and one at thirty percent. Total thrust: approximately eighty percent of original design. With the improved radiator configuration, you can sustain that indefinitely without thermal issues.”

Martin had been quiet during the work, watching Dorothy with an expression Nate recognized from the Boeing years Martin sometimes talked about — the look of an engineer watching a colleague operate at a level he respected deeply enough to stay out of the way.

“Good to have you back, Dorothy,” Martin said.

“Good to be back.” She pushed off from the access panel and floated to the navigation display. The trajectory data was still on-screen:

their outbound path, the residual velocity from the slingshot, the slow curve of solar gravity pulling them along an arc that led to nothing.

“Where are we going?” she asked.

Nate looked at the display. The question he’d been avoiding for five days, the question that had no answer, because they’d run without a destination and now they were in deep space with an eighty-percent spacecraft and a two-week consumable budget and no plan beyond survival.

“That’s the question,” he said. “Because right now, we’re heading nowhere. And ‘nowhere’ is very big.”

Dorothy studied the display for a long moment, her eyes tracing the trajectory curve, her hands resting on the console edge. Then she turned to look at Nate, and there was something in her expression — not concern, not calculation, but the particular intensity of a mission architect who has just been given a problem with no constraints except physics and will.

“Then we’d better figure out somewhere,” she said. “Because this ship is too good to waste on nowhere.”

* * *

Chapter 26 — “Signal”

Nate found it at 0347 ship time, on day seven, while looking for something else entirely.

He was running the navigation problem. The specific navigation problem — not the philosophical question of where they were going, but the engineering question of how to get back to Earth without flying into Condor’s weapons envelope. He’d been at the console for three hours, running trajectory simulations on the guidance computer, plotting fuel-optimal return paths that swung wide of DuQuesne’s projected position, looking for a geometry that used the remaining copper budget to bring them home on a trajectory that arrived at Earth’s sphere of influence from an unexpected direction.

The X-band dish was pointed at Earth for the data relay — Vanessa’s last uplink had included updated ephemeris data for the inner planets, solar wind measurements from the ACE satellite, and a terse message from Rebecca Tran that said, “The DOJ is not pursuing charges while you are in space. Get back before they change their minds.” Between data packets, the receiver scanned across its frequency range in a slow sweep, the way it was designed to — the default mode that kept it listening for signals even when it wasn’t specifically communicating.

Nate had the receiver output on a secondary display, running as a waterfall plot: frequency on the vertical axis, time on the horizontal, signal strength as color. Mostly it was blue — the cold noise floor of deep space, the cosmic microwave background hiss, the faint whisper of Jupiter’s magnetosphere and the Sun’s radio emissions. Occasionally a bright line appeared at the X-band frequencies when they caught a sideband of a terrestrial transmitter bounced off nothing in particular.

At 0347, a mark appeared on the waterfall that didn't belong.

It was faint — barely above the noise floor, a thin line of pale green against the blue, at a frequency of 6.834 gigahertz. It held steady for eight seconds, faded, then returned. Held for twelve seconds. Faded. Returned.

Nate stared at it.

6.834 gigahertz was not a standard allocation. It wasn't in the ITU frequency plan for space research, Earth exploration, or fixed satellite service. It wasn't a known harmonic of any standard communications frequency. It was nobody's sideband.

He almost dismissed it. Equipment artifact — a mixing product from the receiver's local oscillator, or a harmonic of the ship's own electronics reflecting back into the antenna feed. He'd seen similar ghosts during the ground testing of the comms system, phantom signals that appeared when the receiver warmed up or when a particular combination of equipment was running simultaneously.

But this one had a pattern.

He watched it for five minutes. The signal appeared, held for a variable duration between six and twenty seconds, disappeared for a variable gap between four and fifteen seconds, then returned. The durations were not random. They were not regular, either — not a simple on-off-on-off cycle. There was structure.

Nate opened the spectrum analyzer — a software tool on the navigation computer that performed a Fourier transform on the raw receiver data, decomposing the signal into its frequency components. The analyzer confirmed what the waterfall showed: a carrier at 6.834 GHz, bandwidth approximately 200 hertz, with amplitude modulation at a rate of roughly 2 Hz.

Two hundred hertz of bandwidth. Extraordinarily narrow. A signal that narrow implied a transmitter with exceptional frequency stability — a clock of almost atomic precision, holding its output to a drift of less than one part in ten billion. No natural source produced a signal that narrow. Even pulsars, the most precise natural oscillators in the universe, had pulse profiles that spread across kilohertz or megahertz of bandwidth.

Nate's hands had stopped moving on the keyboard. He was aware of this in a distant way, the way you were aware of your breathing in a moment when breathing was not the important thing.

He checked the antenna pointing. The X-band dish was aimed at Earth — bearing 214 degrees azimuth, 12 degrees elevation in the ship's reference frame. The signal at 6.834 GHz was coming from a different direction. He could tell because the dish had a beam pattern — a cone of sensitivity centered on the pointing direction, with diminishing response off-axis. The signal's strength varied as the ship drifted slightly in attitude, and the variation was consistent with a source located roughly 40 degrees off the dish's boresight.

40 degrees off the Earth-pointing direction. He calculated the bearing: approximately 254 degrees azimuth, negative 8 degrees elevation. He checked the star field through the viewport. That bearing pointed away from the Sun, away from Earth, roughly toward the constellation Ophiuchus. There was nothing there. No known spacecraft, no planet, no catalogued radio source.

"Martin," Nate said.

The word came out wrong — too quiet, too controlled, the sound of a man keeping his voice steady because the alternative was letting it shake. Martin was asleep in his thermal bag, bungeed to the aft couch, his breathing the slow rhythm of exhaustion. He didn't stir.

“Martin.” Louder.

Martin’s eyes opened. Twelve years of friendship had taught him to read Nate’s voice, and what he read brought him fully awake in under a second. He unclipped the bungee and floated to the navigation console.

“What is it?”

Nate pointed at the waterfall display. “Signal. Six-point-eight-three-four gigahertz. Two hundred hertz bandwidth. Amplitude modulated. It’s not from Earth.”

Martin looked at the display. He looked at the spectrum analyzer. He looked at the antenna pointing data.

“Equipment malfunction,” he said. The words were immediate, reflexive — the engineer’s first instinct, because equipment malfunctions were common and extraordinary signals from deep space were not, and the probability calculus favored the mundane by a factor of roughly a billion.

“That’s what I thought. But look at the modulation pattern.”

He’d been recording the signal since he first noticed it — the computer automatically logged all receiver data. He pulled up the modulation envelope: a waveform showing the signal’s amplitude over time, the on-off pattern rendered as peaks and valleys.

The pattern was not random. And it was not the simple periodic cycling of equipment interference. It was sequential — a series of bursts with varying durations, separated by varying gaps, and the sequence was repeating. Nate had watched it cycle through twice while waiting for Martin to wake.

He laid the two cycles side by side on the display. They were identical. The same sequence of burst durations, the same gap timings, repeating with a period of approximately four minutes.

“A repeating, structured sequence,” Martin said. “That’s not noise.”

“No.”

“Could be a satellite. Some kind of beacon or timing signal.”

“At six-point-eight-three-four gigahertz? That’s not a standard frequency for anything. And the bearing is wrong — it’s not coming from Earth orbit, it’s coming from — ” Nate checked his calculations. “It’s coming from ahead of us. Roughly along our trajectory, maybe fifteen degrees off.”

Martin’s face changed. Not dramatically — Martin did not do dramatic. But the controlled competence shifted into something sharper, the look of an engineer encountering data that didn’t fit the model.

“Run diagnostics,” he said. “Cycle the receiver. Switch to the backup antenna feed. If the signal persists on both feeds, it’s external. If it disappears on one, it’s internal.”

Nate ran the diagnostics. He powered down the primary receiver chain, waited thirty seconds, powered it back up. The signal was there, unchanged. He switched from the main dish feed to the backup omnidirectional antenna — a small helical unit mounted on the hull for emergency communications. The signal was there, weaker by about 15 dB — consistent with the omni’s lower gain — but at the same frequency, the same modulation, the same pattern.

“It’s external,” Nate said. “It’s real.”

“Wake Dorothy.”

* * *

Dorothy analyzed the signal for forty-five minutes before she spoke.

She sat at the navigation console, headphones on — they'd routed the receiver's audio output through a demodulator, converting the amplitude modulation into audible tones — and listened with the focused stillness that Nate had learned to recognize as her deepest concentration. Her hands were uncharacteristically still. She did not sketch. She did not touch the tablet. She listened.

The signal, demodulated, was a sequence of tones: short bursts and longer bursts, separated by silences, cycling through a pattern that repeated every four minutes and twelve seconds. Nate had been thinking of it in terms of on-off durations, but Dorothy heard something he hadn't.

"Count the bursts in each group," she said.

Nate counted. The sequence began with two short bursts. A gap. Three bursts. A gap. Five bursts. A gap. Seven bursts. A longer gap. Eleven bursts. A longer gap. Thirteen bursts. A very long gap. Then the sequence repeated.

Two. Three. Five. Seven. Eleven. Thirteen.

The first six prime numbers.

Nate felt the floor drop out from under him. Not physically — there was no floor, they were floating in microgravity — but the sensation was physical, a vertigo that had nothing to do with the inner ear and everything to do with the mind confronting something it had no category for. The room tilted. The stars outside the viewport looked different. Everything looked different.

"Primes," Martin said. He'd been counting too.

“Primes,” Dorothy confirmed. “But that’s not all. Listen to the gaps.”

Nate listened. The gaps between burst groups were not uniform. After the group of two, the gap was short. After three, slightly longer. After five, longer still. The gap duration was proportional to — he did the math — the square root of the preceding prime.

“The gap durations encode a mathematical relationship,” Dorothy said. “If the burst count is p, the gap duration is proportional to the square root of p. That’s a mathematical grammar. It’s saying: I know what prime numbers are, and I know what square roots are, and I can combine them into a structured signal. It’s not a message. It’s a proof of concept. It’s saying — “

She stopped. Her hands moved again, a sudden flurry of gesture, and her voice when she continued was the same precise, controlled tone she always used, but Nate could hear the tremor underneath.

“It’s saying: I was built by someone who understands mathematics.”

The cabin was silent except for the hum of life support and the faint, repeating tone of the signal in the headphones: two, three, five, seven, eleven, thirteen. Two, three, five, seven, eleven, thirteen.

“Where is it coming from?” Dorothy asked.

Nate pulled up the bearing data. They’d been tracking the signal for over an hour now, and as the ship drifted in attitude, the signal strength varied — strong when the dish was closer to the source bearing, weaker when it drifted away. By fitting a curve to the signal strength versus antenna pointing, he could estimate the source direction to within about two degrees.

Bearing: 251 degrees azimuth, negative 6 degrees elevation in ship coordinates. He converted to ecliptic coordinates using the star tracker data, then plotted the bearing as a line extending from their current position into space.

The line pointed ahead of them, roughly along their trajectory but displaced by about fifteen degrees. At their current velocity and heading, the closest approach to the bearing line would occur in approximately six days — they would pass within roughly 0.01 AU of whatever was out there. Ten thousand kilometers.

“The source is a point,” Nate said. “Not diffuse — the signal strength doesn’t change with dish orientation in a way that suggests an extended source. It’s coming from one spot. And that spot is — ” He ran the range estimation. The signal strength at their receiver, given the dish’s known sensitivity and the assumed power of any reasonable transmitter, implied a source somewhere between 0.2 and 0.4 AU away. Forty-five million kilometers, give or take.

“Roughly point-three AU ahead of us,” he said. “Along our trajectory.”

“What’s out there?” Martin asked. His voice was the quietest Nate had ever heard it. Quieter than when they were shot at. Quieter than when they discussed the consumables crisis. The quiet of a man encountering a load that exceeded every design margin he’d ever calculated.

Nate checked the ephemeris data — the catalogue of known objects in the solar system, updated by Vanessa’s last data relay. At the coordinates indicated by the signal bearing, there was nothing. No asteroid, no comet, no spacecraft, no debris. The region was between the orbits of Mars and Jupiter, in the inner asteroid belt, but no catalogued body was near the signal’s apparent position.

“Nothing catalogued,” Nate said. “Nothing known.”

The three of them floated in the cabin, surrounded by the hum and hiss of a ship keeping them alive, and looked at the waterfall display where the thin green line repeated its message: two, three, five, seven, eleven, thirteen.

Nobody spoke for a long time. The signal cycled through its sequence twice more while they watched — the primes counting out in their ancient order, the gaps encoding their square roots, the pattern as patient and inhuman as the ticking of a clock in an empty house.

Nate’s scientific training pushed back against the vertigo. Extraordinary claims require extraordinary evidence. A structured signal was not proof of anything except structure. Nature produced structure — crystals, pulsars, the Fibonacci spirals of a sunflower. He needed to eliminate the natural explanations before he could entertain the unnatural ones.

“Alternatives,” he said, forcing himself into the discipline. “What else could produce this?”

“Pulsar,” Martin offered.

“Pulsars emit broadband. This is two hundred hertz. And pulsars don’t encode prime number sequences.”

“Interstellar scintillation. Some natural source being modulated by the interstellar medium.”

“The modulation is too regular. Scintillation produces stochastic variation, not repeating mathematical sequences. And the bandwidth is orders of magnitude too narrow.”

“A classified military satellite that we don’t know about.”

“At six-point-eight-three-four gigahertz, off the ecliptic plane, in a direction where there are no known orbits? And broadcasting prime numbers?”

“I’m trying to be thorough.”

“I know. Keep going.”

“Reflection. Our own transmitter bouncing off something.”

“We’re not transmitting at six-point-eight-three-four. And the signal is too strong for a passive reflection at this range — the power levels imply an active transmitter.”

Martin ran out of alternatives. Dorothy had not offered any. She was staring at the waterfall display with the expression Nate had seen her wear exactly once before: at the whiteboard in the Portland hangar, when Nate had first shown her the S-film thrust data and she’d understood what it meant. The expression of a mind rearranging its model of what was possible.

“We need to tell Vanessa,” Dorothy said.

“We need to tell DuQuesne,” Nate said.

Martin turned sharply. “No.”

“Martin — “

“We do not share this with the man who shot at us.”

“The man who shot at us has the same receiver architecture we do. If we can detect this signal, so can he. It’s a matter of time before his instruments pick it up — if they haven’t already. We can share it proactively and maintain a cooperative relationship, or we can say nothing and let him discover it independently, at which point we have no influence over what he does with the information.”

“What can he do with it? He’s forty thousand kilometers behind us with a failing cooling system.”

“He’s forty thousand kilometers behind us with a functioning cooling system, thanks to Dorothy. He can maneuver. He can approach the source. And he has a weapons system.” Nate met Martin’s eyes. “If there's something out there, I want us to be the ones who arrive first, with DuQuesne as a cooperative partner, not as a rival racing to beat us."

Dorothy said nothing. She was staring at the waterfall display, her hands resting on the console edge, her face unreadable. Nate watched her and recognized the expression: it was the face of a mission architect looking at a mission that had just changed in ways she couldn't yet quantify.

Martin's jaw worked. The calculation behind his eyes was visible — risk, benefit, control, trust, the entire framework of decision-making that governed his life compressed into a single evaluation. Nate waited. He did not argue further. He had made his case and Martin would reach his own conclusion.

"Fine," Martin said. "Tell him. But on an open channel. If we're sharing this, we're sharing it with everyone."

Nate turned to the X-band transmitter and tuned it to the open frequency he'd used for his original orbital broadcast. The same frequency that every tracking station on Earth was monitoring, the frequency that had carried his declaration from low Earth orbit to a world that was still trying to process what had happened.

He keyed the mic. His hand was steady now. The tremor from earlier — from the moment of vertigo when the primes had resolved in his mind — had been replaced by something else. Not calm. Purpose. The feeling of standing at a threshold and choosing to step through, knowing that the door only opened one way.

He thought about the lab in Portland. The crucible punching through the fume hood. The moment everything changed, alone with his instruments and a result that should have been impossible. This was the second time. The first had changed what he understood about physics. This one was going to change what everyone understood about everything.

He pressed the transmit button.

"This is Dr. Nathan Seaton aboard the spacecraft Skylark, transmitting on an open frequency. We have detected an anomalous signal at six-point-eight-three-four gigahertz, originating from a point source approximately zero-point-three astronomical units ahead of our current trajectory. The signal exhibits a repeating modulation pattern encoding the first six prime numbers, with gap durations proportional to the square root of each prime. The signal is narrow-band — approximately two hundred hertz — with exceptional frequency stability. We have confirmed its external origin through multiple antenna feeds and receiver diagnostics."

He paused. The words he was about to say would change everything. Not the physics of the S-film effect, not the politics of the launch, not the chase or the kidnapping or the rail gun. Everything else. Everything after.

"We assess the signal as artificial in origin. We do not believe it is of human manufacture. We are transmitting the raw signal data on this channel for independent analysis."

He released the transmit key. In approximately twenty-seven minutes — the current one-way light delay to Earth — those words would reach a planet of eight billion people.

Martin was looking at him with an expression Nate couldn't read. Dorothy was looking at the waterfall display.

"Six days," Nate said, and his voice was not steady, and he did not try to make it steady. "At current velocity, we'll pass within ten thousand kilometers of whatever is generating that signal. In six days."

The thin green line pulsed on the display. Two. Three. Five. Seven. Eleven. Thirteen.

Something was out there. Something had been out there for a long time, transmitting a message that said, in the universal language of mathematics: I am here. I am not natural. Come and find me.

And they were heading straight for it, in a ship held together by field repairs and determination, with two weeks of air and a trail of enemies behind them, falling toward something that made every human problem — the chase, the politics, the consumables — feel as small as the Sun looked from out here.

Nate stared at the stars through the viewport and felt the universe shift on its axis. Whatever they found in six days would be the beginning of something he couldn't imagine. And the human problems — Condor, Perkins, the copper budget, the CO2 canisters — they wouldn't go away. They never went away. You carried them with you into the unknown, because that was what it meant to be human: to haul your limitations into the face of the infinite and keep working the problem anyway.

He reached for his calculator and began plotting the approach trajectory.

Chapter 27 — “Disclosure”

The signal was there again. Nate watched it pulse on the spectrogram display, a thin vertical line at 6.834 GHz repeating its patient arithmetic: two, three, five, seven, eleven, thirteen. Gap. Two, three, five, seven, eleven, thirteen, seventeen. Gap. The nested grammar building on itself, each cycle adding the next prime like a teacher waiting for the student to recognize the pattern.

He had been watching it for nine hours. The signal-to-noise ratio had improved by four decibels since yesterday. Whatever was broadcasting was getting closer, or they were getting closer to it. Both, really. At their current velocity, the geometry was collapsing at roughly forty kilometers per second.

Martin was asleep in the port acceleration couch, strapped in loosely, one arm floating free. He slept like he was angry about it, jaw clenched, breath shallow. Five days of rationed food and recycled air had carved new lines into his face. They both looked older than they had at launch. Launch had been seventeen days ago. It felt like a year.

Nate pulled up the navigation display and overlaid the signal bearing against their trajectory. The intersection point had barely moved since yesterday: 0.31 AU ahead, five degrees above the ecliptic plane, close enough to their course that a minor correction burn would bring them within a thousand kilometers of the source. The copper cost would be negligible. Eight grams, maybe ten. They could afford it.

The question was whether to spend it alone.

He floated back from the instrument panel and looked out the starboard viewport. Five kilometers away, Condor was a dull glint against the star field, visible only because Nate knew where to look. The bigger ship had matched their coast velocity after the resupply exchange and settled into a loose formation that neither crew had formally agreed to and neither had broken. An armistice measured in distance rather than words.

DuQuesne had been quiet for two days. After the cooling repair and the supply transfer, their communications had dwindled to terse navigational updates. Skylark, this is Condor, no course changes planned. Condor, Skylark, acknowledged. The formality of strangers on a shared highway.

Nate rubbed his eyes. The cabin air tasted stale, a faint metallic edge from the reactor compartment’s shadow shield that the scrubbers never quite caught. He needed to change the LiOH canister in another four hours. He needed to eat something. He needed to decide.

The argument for keeping the signal to himself was obvious. Condor had weapons. Condor had Perkins, who took orders from a man in Tysons Corner whose primary interest in any discovery would be its leverage value. Sharing the signal meant sharing the destination, and sharing the destination meant arriving at whatever was out there with an armed ship crewed by a security contractor whose orders were to secure and control.

The argument for sharing was simpler and, Nate thought, stronger. If they found something — something genuinely not of this world — and only Skylark’s instruments recorded it, the data would be contested forever. Equipment malfunction. Cosmic-ray artifacts. Wishful thinking. The same dismissals that had greeted the S-film paper, magnified by the strangeness of the claim. But if Condor’s independent instruments confirmed the same signal from the same source, that was corroboration. That was science. Two data sets from two rival teams, cross-checked against each other like the measurement protocols he had designed back in the Portland lab.

He thought of Vanessa, back on Earth, managing the data relay with a composure that still surprised him. She would tell him to publish. She always told him to publish. Secrecy is for people who are afraid of being wrong, she had said once, and he had quoted it in the PRL paper's acknowledgments.

Nate unclipped his tablet from its velcro mount and composed a message. Text only — the bandwidth through the X-band link barely supported voice anymore, and he wanted precision.

He read it twice, changed one word, then opened the VHF channel.

"Condor, this is Skylark. I'm transmitting a data package on the inter-ship link. I need you to look at something."

Forty seconds of silence. Then DuQuesne's voice, careful and clipped: "Skylark, Condor. Standing by to receive."

Nate sent the file: nine hours of spectrogram data, the Fourier analysis Dorothy had run, the prime-number decomposition, the bearing calculations, the trajectory intersection geometry. Everything.

He waited. Three minutes. Four. The signal pulsed on his screen. Two, three, five, seven.

"Dr. Seaton." DuQuesne's formality was back, the Louisiana courtesy that meant he was processing something larger than the words could hold. "I am looking at your spectrogram. I would like to point our dish at the indicated bearing and run an independent measurement. Is that acceptable to you?"

"That's why I sent it, Marc."

Another pause. Nate could hear, faintly, the background hum of Condor's systems through the open channel. Then DuQuesne's voice again, stripped of control for just a moment: "Give me twenty minutes."

Martin woke during the wait, blinking into the cabin's fluorescent half-light. He saw Nate's face and unstrapped. "What."

"I shared the signal data with DuQuesne."

Martin's expression went through surprise, anger, and calculation in the span of two seconds, settling on a flat stillness that Nate recognized as his command mode. "Why."

"Because if we find something out there and we're the only witnesses, nobody will believe us. If DuQuesne's instruments confirm it independently, that's corroboration."

"And if Perkins decides whatever we find belongs to Vanguard?"

"Then we deal with that when it happens. But right now we're two ships in deep space running out of copper and food, and there's something ahead of us that shouldn't exist. I'd rather have a witness I don't trust than no witness at all."

Martin stared at him. The calculation was still running behind his eyes — threat assessment, resource allocation, the decision tree branching into futures he couldn't control. Then he exhaled slowly through his nose, the way he did when he was letting go of something he'd been gripping.

"Fine. Your call. But we document everything. Every transmission, every data exchange, every course correction. Timestamped, checksummed, stored on both the local drive and a backup."

"Already started."

The VHF crackled. "Skylark, Condor." DuQuesne's voice was different now. The composure was still there but something had cracked underneath it, like ice over moving water. "I have confirmed the signal on our arrays. Same frequency, same modulation structure, same bearing. Our spectral analysis matches yours within instrument error."

Nate looked at Martin. Martin looked back.

“Dr. Seaton,” DuQuesne said, and now the crack was wider, “do you understand what this means?”

“I’m starting to.”

“I would like to propose a joint course correction to optimize our approach to the signal source. Both ships, coordinated burn, minimum copper expenditure.”

Martin shook his head sharply, but Nate held up a hand. “Send your proposed trajectory. We’ll run it independently and compare.”

“Transmitting now. And Dr. Seaton — thank you for sharing this.”

The channel closed. Martin was already pulling up the navigation software, his anger redirected into the mathematics where it could be useful. Nate floated to the comms panel and composed a second message, this one for Earth. It would take nearly three minutes to reach Vanessa at the current distance, and another three for any reply to come back, but the message itself was simple.

He transmitted the full signal data set on an open channel. Not encrypted. Not restricted. Broadcast on the standard deep-space frequency that every radio telescope on Earth was monitoring.

“Vanessa, this is Nate. I’m sending you something. Share it with everyone.” He paused, aware that the next words would be heard by anyone listening, that they would become part of the public record of whatever happened next. “We’ve detected a structured signal from a point source approximately 0.3 AU ahead of our current position. It’s artificial. We’re going to take a look.”

He released the transmit key. On his spectrogram display, the signal pulsed. Two, three, five, seven, eleven.

Martin looked up from the navigation screen. “His trajectory checks out. Copper cost is eleven grams for us, fourteen for him. Arrival in six days.”

“Then we go.”

“We go.” Martin entered the correction parameters. “And Nate? When we get there, I’m not letting Perkins within a hundred meters of whatever it is.”

“Agreed.”

The VHF was quiet. Somewhere behind them, ninety million kilometers away, Nate’s broadcast was crawling toward Earth at the speed of light. By the time Vanessa heard it, by the time the world’s radio telescopes swung toward the indicated bearing, by the time the UN Security Council added a new agenda item and the cable news networks found their graphics templates for ALIEN SIGNAL DETECTED — by the time any of that happened, Skylark and Condor would have been falling toward the source for hours.

Nate strapped into his couch and watched the signal pulse. The primes climbed higher, patient and precise, like a hand extended across an unimaginable distance, waiting.

* * *

Dorothy emerged from the aft equipment bay wiping NaK residue off her hands with a rag that had been white two weeks ago. She had been adjusting the thermal bus flow rates, a task that required lying prone in a space designed for equipment, not people, with her face six inches from piping that carried liquid metal at three hundred degrees. She did it every forty-eight hours now, fine-tuning the balance between the S-film panels and the radiators the way a pilot trims an aircraft in turbulent air. The system was stable but not forgiving. Leave it alone too long and the temperatures drifted, the margins shrank, and options disappeared.

“You told him,” she said, reading the comms log on the main display.

“I told him.”

She nodded once, the way she did when a calculation confirmed what she already expected. “Good. What did Martin say?”

“He’s not happy. But he ran the numbers.”

Dorothy pulled herself into the navigator’s seat and studied the trajectory overlay. She had been the one to identify the prime-number structure in the signal modulation, sitting at this same panel three days ago with her reading glasses perched on her head, pencil in her teeth, scribbling Fourier coefficients on the back of an MRE wrapper. The moment she had found the pattern, her hands had gone still — the only time Nate had ever seen her stop moving while she was thinking.

“Six days,” she said now. “I want to run a full diagnostic on all three active arrays before we get there. If we need to maneuver at close range, I want to know exactly what we have.”

“Agreed.”

“And I want to talk to DuQuesne about his sensor complement. Condor’s dish is bigger than ours. If we coordinate our measurements, we can triangulate the source geometry during approach — get a size estimate before visual range.”

Nate watched her work. She had been aboard Skylark for six days now, and in that time she had improved the radiator performance by thirty percent, restarted the damaged S-film array at eighty percent capacity, reorganized the equipment bay for access, and established a maintenance schedule that she enforced with the quiet authority of someone who had spent seven years keeping Mars rovers alive across a twenty-minute communications delay. She had also, without discussion, taken the navigator’s seat as her station, and neither Nate nor Martin had thought to object.

She caught him looking and raised an eyebrow. “What?”

“Nothing. I’ll set up the DuQuesne call.”

On Earth, the signal data was arriving. Nate imagined Vanessa in the control van — which by now was probably a commandeered conference room at Crane Energy, surrounded by agency liaisons and reporters and lawyers — pulling up the spectrogram, running her own analysis, confirming what she saw.

He imagined the radio telescopes turning, one by one, great dishes pivoting against the sky. The Allen Telescope Array. Arecibo’s replacement. The Square Kilometer Array in Australia. All of them listening for a sound that had been there all along, waiting for someone to notice.

Perkins, aboard Condor, made his own call. The tight-beam channel to Brookings was a pencil of microwave energy aimed at a specific relay satellite, narrow enough to be undetectable by Skylark’s instruments at five kilometers. The message was brief and encrypted. The reply, when it came eight minutes later, was briefer.

Secure whatever you find. By any means.

Perkins read it, deleted it, and went back to monitoring the inter-ship channel with the patient attentiveness of a man who had been waiting for orders and now had them.

*   *   *

Chapter 28 — “Approach”

Dorothy watched the signal grow.

Not literally — the spectrogram looked the same as it had for days, the thin line pulsing its primes with mechanical patience. But the numbers around it were changing. Signal strength climbing by two decibels per day. The bearing estimate tightening from a cone of uncertainty to something approaching a vector. And their velocity, the great ballistic trajectory that had carried them past the Moon and into the dark, slowly bending as the correction burn took hold and aimed them at a point in empty space where something waited.

She ran the sensor fusion for the fifth time that morning, combining Skylark’s X-band dish data with Condor’s measurements transmitted every six hours per their agreement. The triangulation was converging. The source was a point object, or close enough — unresolved at their current distance, which meant it was smaller than a few hundred meters across. Small, then. Not a ship, not a station, not the vast slow wheel of science-fiction imagination. Something compact, precise, functional.

The size bothered her less than the orbit. She had plotted it against the JPL ephemeris data stored in Skylark’s navigation computer. The object was at 2.3 AU from the Sun, inclined twelve degrees from the ecliptic, in an orbit that did not match any known asteroid group, any cataloged debris, any natural object in the database. Someone had put it there. And the orbit was stable — not the slowly decaying path of something thrown, but a carefully chosen trajectory that would persist for millennia without correction.

She told Nate and Martin what she found during the morning systems check, the three of them floating in the forward cabin with squeeze-bulb coffee that tasted like the plastic it was stored in.

“It’s been there a long time,” she said. “The orbit stability implies either active station-keeping, which we’d see as thrust signatures, or a very precise initial placement. I’m not seeing any thrust signatures.”

“How long is a long time?” Martin asked.

“Micrometeorite accumulation rates in the asteroid belt are roughly known. If the object has a surface, and if that surface shows pitting consistent with its environment, we could estimate exposure time when we get close enough for imaging. But from the orbit alone — at least thousands of years. Possibly much longer.”

Martin set his coffee down carefully, velcroing it to the panel. “Thousands of years.”

“At least.”

The number sat in the cabin between them, too large to hold and too important to put down. Dorothy knew the feeling — she had built spacecraft systems for a decade, designed missions to worlds millions of kilometers away, and the distances had always been comprehensible because they were expressed in engineering terms. Delta-V budgets, signal-delay calculations, thermal radiator sizing. But thousands of years was not an engineering number. It was an abyss.

Nate broke the silence. “What can we learn during approach?”

Dorothy pulled up her tablet. “Spectroscopy first. Once we’re within fifty thousand kilometers, the optical telescope should resolve it. I want albedo, composition if the spectral library can match it, and rotation state. If it’s tumbling, that tells us it’s inert. If it’s attitude-stabilized, that tells us something is still working.”

“The beacon is still working,” Nate said.

“Right. So at least one system is active. But a two-watt transmitter is different from an attitude control system. I want to know how much of it is alive.”

“And then?”

“And then we decide how close to get. I don’t want to approach to less than ten kilometers without a full risk assessment.”

Martin nodded. This was the Dorothy he had recruited — the JPL mission architect who had once spent three months designing a fault-tree analysis for a rover wheel motor. She would not rush. She would not guess.

The days passed in a rhythm of measurement and maintenance. Dorothy ran the diagnostic cycle on the three active S-film arrays, finding one gimbal actuator with a sluggish response that she traced to a loose connector and fixed in twenty minutes. She pressure-tested the reactor coolant loop and confirmed the slow leak had stabilized — the fitting that Martin had retorqued during the deep-space coast phase was holding, though the reserve salt container was down to thirty percent. She inventoried consumables with the specificity that had kept robotic missions alive when the margin was measured in watts and grams.

The inventory was not encouraging.

Enriched copper: 2.1 kilograms remaining, plus 0.8 kilograms of natural-abundance copper that could be used at reduced efficiency. At full thrust on three panels, they consumed roughly forty-five grams per hour. That gave them approximately sixty-five hours of full thrust, or somewhat more on reduced power. The deceleration to approach the signal source would cost twelve hours. The return trajectory to Earth — a long, looping path that Martin had sketched on the navigation display — would require at minimum forty hours of thrust, assuming optimal timing and gravity assists.

Sixty-five minus twelve was fifty-three. The minimum to get home was forty. The margin was thirteen hours. At forty-five grams per hour, that was 585 grams. Less than six hundred grams of copper standing between reaching Earth and being stranded in a heliocentric orbit that no rescue mission could reach.

Dorothy wrote the numbers on a piece of paper torn from the back of the maintenance manual and taped it to the instrument panel where all three of them could see it. She did not annotate it. The math spoke for itself.

“There’s a scenario,” Martin said that evening, studying the paper, “where we decelerate for the approach, find nothing useful, and don’t have enough copper to get home.”

“Yes,” Dorothy said.

“And you want to do it anyway.”

“I want us to understand the decision we’re making.” She pointed to the number on the paper. “Thirteen hours of margin at full thrust. That’s our entire cushion. If we find nothing at the source, if there’s nothing we can use, we burn that margin on the return and arrive at Earth on fumes. Any delay, any unplanned maneuver, any equipment failure that costs us thrust — and we’re short.”

“Point of no return,” Nate said from the pilot’s seat.

“Exactly. We pass it in about thirty-six hours. After that, the deceleration burn is committed and the copper is spent. We can still abort now, skip the approach, and head home with a comfortable margin.” She looked at both of them. “I’m not arguing for that. But I want it on the table.”

Martin studied the numbers again. Dorothy watched him run the calculation she already knew he was running: the probability that whatever was generating the signal had something useful against the probability that it didn't, multiplied by the consequences of each outcome. He was a builder, a systems thinker, a man who managed risk by controlling variables. And the variables here were beyond his control.

"DuQuesne?" Martin asked.

"Similar situation, worse margin," Dorothy said. "His copper reserves are lower and his thermal duty cycle eats more per hour. He's running the same math on Condor. He hasn't said anything about turning back."

"He wouldn't."

"No."

DuQuesne's voice on the comms that afternoon was clinical. "Dr. Vaneman, I've been reviewing your spectral analysis from yesterday. I'd like to propose a coordinated observation schedule — your optical telescope for imaging while our dish provides ranging data. The combination should give us a three-dimensional fix by day four."

Dorothy toggled the VHF. "Agreed. Transmitting our telescope pointing schedule now. We should also discuss approach velocities. I want to be below fifty meters per second relative at closest approach."

"Concur. I'm computing a deceleration profile for Condor. We should synchronize burns to conserve copper on both ships."

"I'll send our burn parameters. DuQuesne — your cooling system. How is it holding?"

A pause that was too short to be hesitation and too long to be nothing. "Adequate. Your pulsed thermal capacitor design is performing within parameters. I can sustain sixty percent continuous thrust for the deceleration.”

“That’s all we need.”

Dorothy closed the channel and turned to Nate, who had been listening from the pilot’s seat. “He’s lying,” she said. “Adequate means marginal. His thermal system is holding but he’s nursing it.”

“Can he make the approach?”

“Yes. Can he make the approach and get home? That depends on what we find.”

On the fourth day, they had their first image.

Dorothy called Nate and Martin to the navigation station at 0347 ship time, her voice flat and careful in the way it got when she was controlling something bigger than words. The optical telescope — a modified commercial unit with a twenty-centimeter aperture, bolted to Skylark’s hull and boresighted with the X-band dish — had accumulated enough photons over a six-hour integration to resolve the source against the star field.

It was dark. Angular. Catching sunlight along one edge in a line too straight to be natural. The image was grainy, the resolution limited by distance and the telescope’s modest aperture, but the shape was clear: a geometric solid, faceted, with flat surfaces meeting at defined edges. Not a boulder. Not a fragment. A made thing.

Martin said nothing. Nate said nothing. Dorothy watched them look at it and felt the same thing she saw on their faces — a vertigo that had nothing to do with microgravity. The knowledge that the universe had just become a different place, larger and more populated than the one they had woken up in that morning, and that there was no going back from seeing this.

She saved the image with a timestamp, made two backup copies, and composed a transmission for Earth. Then she pulled up the approach trajectory and started planning the deceleration burn.

“Thirty-two hours to point of no return,” she said. “Do we go?”

Nate looked at the image on the screen. The angular shape, dark against the stars, patient as the signal it broadcast. “We go.”

Martin looked at the copper inventory taped to the panel. Thirteen hours of margin, measured in grams of enriched metal that had been mined and separated and deposited and flown across a hundred million kilometers of vacuum to bring them to this moment.

“We go,” he said.

Dorothy entered the burn parameters. In thirty-two hours, the decision would be made in copper and momentum, irrevocable as gravity. She found, to her surprise, that she was not afraid. She was, for the first time since boarding Condor as a prisoner, exactly where she needed to be.

* * *

Chapter 29 — “Artifact”

Nate saw it through the forward viewport at a range of twelve kilometers, and his first thought was geometry.

The object was an octahedron — eight triangular faces meeting at six vertices, the Platonic solid that filled space most efficiently among the regular polyhedra. Forty meters across, give or take. Dark, the surface color of aged steel or weathered titanium, catching the distant Sun along its edges in razor lines of reflected light. It rotated slowly, one revolution every eight minutes or so, a lazy tumble that might have been deliberate or might have been the accumulated nudge of millennia of solar radiation pressure.

Dorothy had been right about the pitting. Even at this distance, the telescope showed the surface scarred by micrometeorite impacts — tiny craters overlapping in a pattern that said old, old, old. And over the pitting, a fine dust, the carbonaceous residue of the asteroid belt, settling into the geometry’s recesses like snow in the cracks of a granite wall.

The beacon signal was loud now. The spectrogram display was saturated, the prime-number sequence clear and sharp, each pulse a small thunder in the radio spectrum. Dorothy had calculated the transmitter power: roughly two watts, broadcast omnidirectionally. A whisper by human standards. But a whisper that had been speaking for a very long time.

“Condor, Skylark. We have visual. Confirm?”

DuQuesne’s voice came back immediately, the Louisiana formality thinner than usual, the vowels clipped short. “Confirmed. Optical and radar. Forty-two meters on the long axis. Radar cross-section is consistent with a metallic body. No active emissions except the beacon.”

“We’re matching rotation for close approach. Proposed minimum distance: five hundred meters for initial survey.”

“Concur. Condor will hold at one kilometer and provide overwatch.”

Overwatch. A military word. Nate let it go. He brought Skylark in slowly, one-second thrust pulses on the attitude thrusters Dorothy had rigged from the reduced-capacity fourth array. The big ship moved like it was pushing through water, the response lag making every correction an exercise in patience. Three kilometers. Two. One. Five hundred meters.

At five hundred meters, the octahedron filled the viewport. Nate could see individual impact craters now, some of them centimeters across, bright against the dark surface where the underlying material was exposed. He could see the edges — perfect, machined-sharp where the dust had not accumulated, the faces meeting at angles that his eye read as deliberate, intentional, designed. And on one face, near the midpoint of one edge: an opening. Circular, roughly two meters in diameter, dark against the dark surface.

“There,” Dorothy said from the navigator’s seat. She had the telescope on maximum magnification, the image stabilized by software she had written on her tablet during the approach. “Circular opening, two meters, clean edges. Not impact damage — the geometry is too regular. It’s an access point.”

“Or a vent, or a sensor port, or a wound that healed in a shape we interpret as designed,” Martin said from behind them.

“Possible. But the edges show no deformation, no fracture pattern. If it was damage, it was damage that happened to produce a perfect circle. I think it’s a door.”

Nate stared at the opening. It was black, not the black of shadow but the black of depth — a hole into an interior that the Sun's light did not reach. He felt a pressure in his chest that was not fear exactly, and not excitement exactly, but something older than both, a recognition that the next few hours would divide his life into before and after.

"I'm going over there," he said.

"Not alone," Martin said.

"DuQuesne should come." Nate heard himself say it and recognized the logic even as it formed. "Two ships, two witnesses, two sets of instruments. Whatever we find in there, it needs to be corroborated."

Martin's jaw tightened. "Nate —"

"I know. But this is bigger than the rivalry. This is bigger than Vanguard. If DuQuesne and I both document what's inside, neither side can suppress it."

"And if Perkins comes along?"

"He doesn't. DuQuesne, Cole, and whoever DuQuesne trusts. Not Perkins."

Dorothy turned from the telescope. "I'll manage Skylark while you're out. Martin handles comms and recording. Every instrument we have stays pointed at that thing, and every byte goes to the backup drives in real time."

She looked at Nate. Something passed between them that was not a word or a gesture but an understanding, the kind built over days of shared problem-solving in a cabin the size of a delivery van, where you learned the rhythm of someone's thinking before you learned their middle name. Be careful. I will. Come back. I will.

Nate keyed the VHF. “DuQuesne. Joint EVA. You and me. Your ship holds at one kilometer, mine at five hundred meters. We go in through the opening and document everything we find. Agreed?”

The pause was longer than signal delay could account for. Nate imagined DuQuesne in Condor’s cabin, calculating — not the orbital mechanics but the human ones. The risk of leaving Perkins alone with the ship. The risk of entering an alien structure with a man he had pursued across the solar system. The certainty that this was the moment his career, his choices, his Faustian bargain with Vanguard had been pointing toward.

“Agreed,” DuQuesne said. “I will suit up and EVA to your position. Cole will manage Condor. Perkins will be… supervised.”

“Copy. We’ll have a tether line ready.”

The suiting-up took forty minutes. Nate’s EVA suit was a modified Collins Aerospace unit, commercial-grade, designed for low-Earth-orbit construction work and adapted for deep space with additional thermal layers and a radiation dosimeter that Dorothy had wired into the wrist display. It fit poorly — too tight across the shoulders, too loose at the hips — and the gloves reduced his manual dexterity to something approximating winter mittens. He ran through the checklist Dorothy had written on a laminated card velcroed to his forearm. Pressure: nominal. O2 flow: nominal. Communications: check. Helmet light: check. Tether: secured.

Martin helped him into the airlock. “Document everything. Touch nothing you don’t have to. If anything activates, back out.”

“I know.”

“And Nate?” Martin gripped his shoulder, the pressure transmitted through the suit layers into something that felt like the handshake at the start of a long journey. “Whatever happens in there, we have the copper to get home. Dorothy and I checked."

It was a lie, or close enough. The margin was thin. But Nate appreciated the intent, and he squeezed Martin's hand through the glove and sealed the helmet.

The airlock cycled. The outer hatch opened on vacuum.

Deep space was not like the orbital EVAs he had watched on video feeds, the blue marble filling half the sky, the sense of height and falling. There was no down here. There was no up. There was the Sun, a fierce bright point forty-five minutes old by the time its light reached them, and the stars, thick and steady without atmosphere to make them twinkle, and the octahedron, dark and enormous from this range, and nothing else. No frame of reference, no horizon, no ground. Just the geometry of the object and the geometry of the void.

DuQuesne crossed from Condor on a tether line Cole had rigged between the ships, a hundred-meter traverse through absolute nothing. Nate watched him approach — a white figure against the black, moving with the slow deliberation of a man who understood that momentum in vacuum was unforgiving. DuQuesne's suit was better than his: military-spec, properly fitted, with integrated maneuvering thrusters on the backpack unit. He crossed the gap in four minutes and arrested his approach with a precise counter-thrust that brought him to a halt two meters from Skylark's hull.

They looked at each other through their faceplates. DuQuesne's face was sharp in the helmet light, the premature gray at his temples silver-white, his expression stripped of the courteous control that was his default setting. Underneath it Nate saw what he had not expected: wonder. Pure, unmediated wonder, the face of a physicist in the presence of a thing that should not exist.

DuQuesne extended a gloved hand. "Dr. Seaton."

Nate took it. The grip was firm through double layers of suit material, a handshake that meant more than either of them could have articulated. It was not forgiveness for the stolen data, the pursuit, the kidnapping. It was not trust. It was recognition — two men who had spent their lives trying to understand the universe, standing at the edge of something that proved the universe was larger than either of them had imagined.

“Marc.” Nate released the hand. “Ready?”

“I have been ready for this my entire life.”

They crossed to the octahedron on tether lines, using the maneuvering thrusters on DuQuesne’s suit pack and the portable cold-gas unit Nate wore on his belt. The surface came up slowly, the scale deceptive in the absence of atmosphere. What had looked smooth from five hundred meters was rough at ten — the micrometeorite pitting a landscape of tiny craters, the dust a gray-brown film that puffed away in slow-motion clouds where their tethers brushed the surface. Nate reached out and touched the metal. Through the glove he felt nothing, but the suit sensors reported surface temperature: minus one hundred sixty degrees Celsius. Cold as the space it sat in, dead as the vacuum around it.

Except for the beacon. Somewhere inside this cold geometry, a device was drawing power from a source that had not depleted in millennia and using it to broadcast a patient arithmetic into the dark.

The opening was on the face below them — or above them, or beside them; direction had no meaning here. They oriented to it using helmet lamps, the beams cutting white cones through the dust motes their approach had raised. The circle was precise: two meters in diameter, the edges sharp, the surface inside the opening smooth and free of the pitting that covered the exterior. Protected from micrometeorites by its recession into the structure.

“I’m reading no atmosphere inside,” DuQuesne said, his wrist-mounted instrument panel illuminated by the helmet light. “No radiation above background. No electromagnetic emissions except the beacon signal, which is stronger here. Thermal gradient: the interior is slightly warmer than the surface. Minus one hundred forty degrees.”

“Twenty degrees warmer. Heat source.”

“Small one. But yes.”

They looked at each other. Then Nate oriented himself feet-first and pushed gently into the opening.

The interior was a corridor. Smooth walls, the same dark metal as the exterior but untouched by the deep-space weathering. His helmet lamp revealed surfaces that caught the light with a faint iridescence, like oil on water — a material property he had never seen in any metal or ceramic. The corridor was round, matching the opening’s diameter, and it ran straight into the structure for roughly four meters before opening into a larger space.

DuQuesne followed. Their breathing was loud in the suit comms, the only sound in a place that had been silent for longer than human civilization had existed.

The chamber was octagonal, echoing the outer geometry. Eight meters across, the walls covered in geometric markings — not text, Dorothy had predicted, and she was right. They were patterns: interconnected lines and nodes, like circuit diagrams or crystallographic projections, etched into the surface with a precision that Nate’s trained eye read as sub-micron. The patterns covered every wall from floor level to the ceiling four meters above, unbroken except where corridors opened into the six radial passages.

“Are you recording?” Nate asked.

“Everything. Video, thermal, spectral. My suit is logging all sensor channels.” DuQuesne was turning slowly, his helmet lamp sweeping the chamber, and Nate could hear in his breathing the same awe that was tightening his own chest. “The wall markings. They’re not decorative. Look at the connectivity — these are schematics. Functional diagrams.”

Nate looked. DuQuesne was right. The patterns had the topology of engineering drawings — components connected by pathways, nodes that repeated in variations suggesting related but distinct functions. He could not read them — the symbology was nothing he recognized — but the structure was familiar because it was universal. Any civilization that built complex systems would need to diagram them, and the logic of diagramming was constrained by the logic of the systems themselves.

“Six radial corridors,” DuQuesne said. “Modular layout. Each one probably leads to a subsystem.”

“The beacon power source should be in one of them. And maybe something else.”

They explored methodically, each corridor in turn, documenting every surface, every junction, every device-shaped object in its mounting cradle. The chambers at the ends of the radial corridors were smaller — three meters across, functional, each containing equipment of varying size and form. Some were clearly damaged, surfaces buckled or cracked by impacts that had penetrated the outer hull millennia ago. Some were intact but inert, dark shapes that gave no reading on any instrument.

The fourth corridor was different. DuQuesne saw it first: a faint warmth on the thermal display, a device in its cradle that was not at ambient temperature but at minus eighty degrees. Warmer than the structure around it by sixty degrees. Warmer meant active. Warmer meant power.

They stood in front of it. The device was compact — roughly sixty centimeters by forty by thirty, seated in a cradle of the same dark metal with physical couplings visible at four points. Its surface was smooth, featureless except for a series of fine lines that might have been seams or might have been interfaces. And it was warm.

“The beacon power source,” Nate said.

“No.” DuQuesne pointed to a much smaller device in the corner of the chamber, a thing the size of a bread loaf, connected by a single conduit to the wall. “That is the beacon power source. Two watts output. This — ” he gestured to the larger device, “this is something else.”

Nate looked at the larger device and felt the primes pulsing in his memory: two, three, five, seven. A beacon to draw attention. And beside the beacon, a gift.

“Dorothy,” he said into the comms. “I need you to look at something.”

* * *

Chapter 30 — “Power”

Dorothy studied the images for forty minutes before she spoke.

She was floating in the navigator’s seat, tablet propped on her knees, flipping between the high-resolution photographs Nate had transmitted from inside the artifact and the spectral data DuQuesne had collected with his suit instruments. Martin was at the comms panel, relaying everything to Earth in real time, the transmission crawling toward Vanessa and the waiting world at the speed of light.

The device in the cradle. Sixty centimeters by forty by thirty. Eighty kilograms, according to DuQuesne’s suit-mounted mass estimator. Surface temperature minus eighty degrees Celsius — sixty degrees warmer than the surrounding structure, warm enough to suggest internal activity, cold enough to suggest dormancy. The physical couplings at four points: two that resembled power connections, two that resembled data interfaces, though the analogy was imperfect and Dorothy knew it was her human pattern-matching imposing categories on alien design.

But she could not help the pattern-matching, and the pattern she saw was familiar. Not in the specifics — the materials, the geometry, the construction were all beyond anything in her experience — but in the logic. This was a modular component designed to be installed and removed. The cradle held it. The couplings connected it to the larger system. The form factor was consistent with a unit that could be carried, transported, swapped out. A power supply, replaceable and portable, the way a battery pack was replaceable and portable. The engineering logic was universal because the physics was universal: energy sources served systems, and systems needed to be maintained, and maintenance required modularity.

“Nate,” she said into the VHF. “The coupling interfaces on the lower two points. Can you get me a close-up of the contact surfaces?”

A minute passed. The image appeared on her tablet: high-resolution, lit by helmet lamp, showing a surface where the device met the cradle. Two concentric rings of a slightly different metal, separated by a gap filled with a crystalline material — clear, faceted, catching the light.

“Electrical contacts,” Dorothy said. “The concentric ring geometry is a coaxial power interface. The crystalline spacer is an insulator. This is a power output device.”

“How do you know it’s output and not input?” Martin asked from behind her.

“The contact area. The outer ring is larger than the inner ring by a factor of roughly three. In any high-power electrical connection, the return path — the ground — is larger than the hot conductor, to minimize resistance and heating. If this device were receiving power, the design priority would be the input conductor, not the return. The larger outer ring is the return. Power flows out.”

“That’s a lot of inference from a photograph.”

“It’s engineering. The physics is the same here as it is in Portland.” She zoomed in on the crystalline insulator. “Nate, I want to see the other two coupling points. The ones I think are data interfaces.”

More images. The upper two couplings were different: smaller, finer, with a multi-contact pattern that reminded her of a fiber-optic connector — multiple pathways, precisely aligned, designed for information rather than power. One of them showed signs of damage: a hairline crack across the contact face, the kind of fracture pattern that came from thermal cycling or micrometeorite-induced vibration transmitted through the structure.

“The upper-right data coupling is damaged,” she said. “That might be why the device is dormant. It could be waiting for a handshake signal that the damaged interface can’t deliver.”

“Or it could be dormant because it has been turned off,” DuQuesne said on the shared channel, his voice carrying the measured quality of a man being very careful with his conclusions. “Dr. Vaneman, I am looking at the cradle mechanism. There is a manual release — or what I believe is a manual release. A lever, approximately fifteen centimeters, recessed into the cradle frame. It has two positions.”

“Which position is it in now?”

“I would describe it as… up. If there is an up.”

“And the other position would be down. Marc, don’t touch it yet.” She pulled up the thermal data again. “Here’s what I think we’re looking at. The device is a power source. It’s modular, designed to be installed and removed. The lever controls either the physical coupling — seating the contacts — or the device’s operational state. Possibly both. The device is currently installed but inactive. The lever may be an on-off switch, or it may be a lock-release.”

“How do we determine which?”

Dorothy closed her eyes and let the problem fill her. This was what she did — what she had done for every rover landing, every orbital insertion, every moment when a machine built by human hands met the reality of another world and the only thing between success and a billion-dollar debris field was the quality of the engineering inference. She thought about power systems. She thought about modularity. She thought about a civilization that had built a beacon and placed it in a stable orbit and left it running for thousands of years with a power source that still worked.

“We don’t touch the lever,” she said. “Not first. First, I want Nate to disconnect the damaged data coupling. If the damage is preventing initialization, removing the damaged connector might allow the device to default to a standalone mode. Power output without data handshake.”

“That’s a guess,” Martin said.

“It’s an inference. Earth-designed modular power systems have standalone modes. If your generator can’t talk to the grid controller, it still generates — it just doesn’t synchronize. If this device was designed with the same philosophy, disconnecting the broken interface should allow it to operate independently.”

“And if it wasn’t designed with the same philosophy?”

“Then disconnecting the interface does nothing, and we’ve learned something about how it works by the absence of response. Either way, we’re gathering data.”

Nate’s voice came through the helmet comms, steady and slightly amused in the way he got when someone else’s engineering matched his own instinct. “Dorothy, you’re telling me to unplug it and plug it back in.”

“I’m telling you to remove the damaged connection and see what happens. Standard troubleshooting protocol. You’d do the same thing with a thermal sensor in the lab.”

“Copy. DuQuesne, can you hold a light on the upper-right coupling while I work?”

“Ready.”

Dorothy listened to the sounds of the EVA: breathing, suit fabric against alien metal, the click of tool attachments being swapped on gloved fingers. She watched through Nate’s helmet camera as his hands — clumsy in the EVA gloves, but patient — reached for the damaged data coupling. The crystalline connector was held in place by a friction fit, the kind of interface that required alignment rather than force. Nate grasped it with the tips of his gloved fingers and rotated it counterclockwise. A quarter turn. Half. The connector came free with a sensation he described as a soft click transmitted through the glove.

Nothing happened.

“No change,” DuQuesne reported, reading his instruments. “Surface temperature stable. No electromagnetic emissions.”

“All right,” Dorothy said. “Now the lever.”

“I thought you said not to touch the lever.”

“I said not first. We’ve eliminated one variable. Now we try the next one. Marc, describe the lever mechanism to me again. Material, resistance, range of motion.”

DuQuesne leaned in. “The lever is the same dark metal as the cradle. It moves in a single axis, approximately thirty degrees of arc. Current position appears to be the upper stop. Resistance is — ” he pushed gently, then harder, “moderate. It moves. There’s a detent at the lower position. I can feel it through the glove.”

“A detent means two stable states. That’s a switch, not a release. Nate, I want both of you to be in physical contact with the cradle, not the device, when Marc moves the lever. If the device activates and there’s any energy release, I want you braced against the structure, not floating free.”

They positioned themselves. Dorothy watched through the helmet cameras, one eye on the telemetry display where the device’s thermal signature glowed like a small ember in the cold structure.

“Marc,” she said. “Move the lever to the lower position.”

DuQuesne placed his gloved hand on the lever and pushed. The mechanism moved smoothly, a controlled arc of thirty degrees that ended in a distinct click — the detent engaging, the lever locking into its new position.

For two seconds, nothing happened.

Then the thermal signature on Dorothy's display began to change. The device's surface temperature climbed: minus eighty, minus seventy, minus fifty, minus twenty, zero, plus ten, plus twenty. The rate was controlled, a steady thermal ramp that spoke of a system warming up according to a designed protocol, not an uncontrolled reaction.

"I'm reading a temperature increase," DuQuesne said, his voice tight with the effort of remaining clinical. "Surface now at thirty degrees. Thirty-five. Stabilizing at approximately forty degrees Celsius."

"Electromagnetic?"

"Yes. Low-level emissions across a broad spectrum. The pattern is — I cannot characterize it. It's not like anything in my experience."

Dorothy pulled up the power-contact data from Nate's helmet camera. The concentric ring interface at the lower coupling point was showing a voltage. She could see it in the faint luminescence of the crystalline insulator, which had begun to glow with a pale blue-white light — not bright, but visible, steady, the kind of light that came from a material responding to an electric field.

"Nate. I need you to put a voltmeter across the lower power contacts."

He had the suit's multitool, a field-service device with basic electrical measurement capability that Dorothy had insisted on including in the EVA kit over Martin's objection that they wouldn't need it. It was not a precision instrument. It had a voltage range up to a thousand volts DC and an accuracy of five percent. It was enough.

Nate touched the probes to the concentric ring contacts. The display flickered, settled, and showed a number.

“Eight hundred and forty volts DC,” he said. “Stable.”

“Current capacity?”

“I can’t measure that without a load. But Dorothy — eight hundred forty volts. That’s in the range of our main bus.”

“I know.” She was already thinking about the interface. Skylark’s main power bus ran at eight hundred volts DC, fed by the reactor’s turbine generator through a power conditioning unit. The match was not perfect but it was close enough to be workable with a simple voltage regulator. Whether the coincidence was meaningful — whether the device was somehow calibrated to be compatible with human electrical systems, or whether eight hundred volts was simply a natural point in the efficiency curve of the underlying physics — was a question for another decade.

“Marc, what’s the output impedance? Can you estimate from the thermal behavior?”

DuQuesne understood immediately. “The device is radiating approximately five hundred watts of waste heat at the current state. If the conversion efficiency is similar to what we see in S-film systems — sixty to seventy percent of input to useful work — then the power throughput is in the range of one to two kilowatts. But that is at idle. The device is warm, not hot. It may be throttled.”

“Or it may be at full output and it’s just that efficient.”

“That is the other possibility. And frankly, the more exciting one.”

Dorothy let the data settle in her mind. A device the size of a large microwave oven, producing at least a kilowatt of electrical power with five hundred watts of waste heat, operating at room temperature, consuming no visible fuel. If this was idle — if the device could be loaded and would respond by increasing output — then the implications were beyond anything the S-film effect had suggested. This was not a better battery or a better reactor. This was a direct tap into the quantum vacuum energy that Nate had theorized and that S-films exploited crudely for momentum transfer, engineered to a level of refinement that made their best work look like rubbing sticks together.

"I want to bring it to Skylark," she said.

"We haven't tested —"

"I know what we haven't tested. We haven't tested load response, thermal stability under load, failure modes, or a dozen other things that I would normally spend six months characterizing before I connected an unknown power source to a crewed spacecraft. But we have thirteen hours of thrust margin and a hundred-million-kilometer trip home, and if this device can power our S-films directly, we don't need the copper reserve for the reactor and we don't need the reactor for the S-films. We need to know if it works under load, and the only way to test that is to connect it to something and draw power."

Silence on the channel. Then Martin's voice, quiet: "She's right."

"Remove the device from the cradle," Dorothy said. "Both power couplings and the remaining data connector. Marc, I want you to document the cradle interface geometry in detail — measurements, photographs, material readings. We'll need that for the connection adapter."

"Dr. Vaneman." DuQuesne's voice carried something that was not quite admiration and not quite deference, but a recognition of authority that Dorothy heard and accepted without comment. "You realize what you are proposing. You are proposing to connect an alien power source to a human spacecraft and use it to fly home."

“Yes.”

“Then let us be thorough.”

The disconnection took an hour. The device came free from its cradle with the same clean modularity that Dorothy had predicted — the couplings disengaging smoothly, the physical mounts releasing when Nate rotated them a quarter turn. The device itself was dense, eighty kilograms of material packed into a volume that should have weighed less, the surface warm against his gloves, the faint glow of the power contacts dimming as the couplings separated.

They carried it through the corridor and out the circular opening, two men in spacesuits cradling something that had waited in the dark for longer than Rome had stood. Nate held one end and DuQuesne held the other, and they moved with the care of people carrying a newborn, which in a sense they were.

Back on Skylark, Dorothy worked.

She built the adapter in the equipment bay using components scavenged from the reactor’s power conditioning unit — bus bars, voltage regulators, thermal sensors, a breakaway disconnect that would sever the connection in milliseconds if the voltage or current exceeded safe parameters. The work was precise and physical: cutting wire, crimping terminals, bolting copper bus bars to aluminum brackets, testing each connection with the multitool before moving to the next.

Martin handed her tools and held components in place. Nate monitored from the flight deck, one eye on the comms and one on the radar display where Condor held station at a kilometer. DuQuesne had returned to his ship, the joint EVA over, but he remained on the open VHF channel, listening, occasionally offering a suggestion that Dorothy accepted or rejected on its merits without regard for its source.

The adapter took three hours to build. Dorothy tested it with the reactor output first — confirming that her breakaway disconnect worked, that the voltage regulation was clean, that the thermal sensors were calibrated. Then she disconnected the reactor feed and connected the artifact device.

“Here we go,” she said. “Nate, I want you on the main bus display. Martin, thermal monitoring. If the panel temperatures go above three hundred on any array, we shut down immediately.”

She engaged the adapter.

The device responded to the load like a generator responding to demand. The voltage held at eight hundred forty volts. The current climbed as the S-film arrays drew power — ten amps, fifty, a hundred. The device’s surface temperature rose from forty to forty-five degrees. The waste heat increased proportionally but modestly. At a hundred amps, the power output was eighty-four kilowatts — more than enough for one S-film panel at full thrust, more than the reactor’s electrical output on a good day.

But the device was not straining. The temperature rise was linear and shallow. The voltage was rock-steady. Whatever governed the device’s output had the character of a system operating well within its design envelope, the way a car engine sounded at highway speed: loaded but not working hard.

Dorothy increased the load. Two panels online. The current climbed to three hundred amps. Two hundred fifty-two kilowatts. Surface temperature: fifty degrees. Waste heat: perhaps a kilowatt. The efficiency was absurd — better than ninety-nine percent, a number that would have been nonsensical for any human technology.

“Three panels,” she said.

Nate brought the third array online. The current climbed. Five hundred amps. Four hundred twenty kilowatts. The device's surface warmed to fifty-five degrees and held.

"Full thrust on three panels," Dorothy said, watching the numbers with an intensity that she could feel in her jaw, her hands, the tight muscles across her shoulders. "Nate, open the fourth array. Eighty percent, as rated."

The fourth panel — the damaged one she had restarted — came online at reduced capacity. The total draw crossed five hundred kilowatts. The device supplied it without complaint. Its surface temperature stabilized at fifty-eight degrees Celsius. One kilowatt of waste heat from a device producing half a megawatt of useful power.

Martin said it first. "That's enough to get home."

"That's enough to get home three times over," Dorothy said. She was staring at the power readings, and her hands — the most expressive part of her, the hands that talked when she was working through a problem — were completely still. "We don't need the copper reserve for the reactor's electrical output anymore. The artifact powers the S-films directly. All the copper goes to film maintenance and thrust. Our margin just went from thirteen hours to… " She ran the number in her head. "Over eighty hours. Assuming the device sustains this output."

"What happens if it doesn't?" Martin asked.

"Then we switch back to the reactor and we're where we were before. The breakaway disconnect works in both directions. But Martin — look at the stability. Look at the thermal profile. This device has been operating for thousands of years on a two-watt trickle to power a beacon. We just asked it for half a megawatt and it barely noticed. I don't think it's going to fail."

She was right, and she knew it, and the knowing was not arrogance but the accumulated judgment of a decade spent trusting instruments and physics in places where human intuition was not enough. The device worked. It worked the way well-engineered things worked — cleanly, reliably, with margins that spoke of a design philosophy that over-built rather than optimized for minimum cost.

“DuQuesne,” she said into the VHF. “The device is powering Skylark’s S-films at full capacity. Our copper margin has increased to approximately eighty hours of thrust. That is sufficient for the return to Earth with substantial reserve.”

DuQuesne’s response was quiet, and in the quiet was a complex calculation: the knowledge that the device was on Skylark, not Condor; that his ship would make the return on its own diminished reserves; that the prize — if it was a prize, if that was the right word for something this large — was not in his hands.

“Understood,” he said. “Condor has sufficient reserves for an independent return trajectory, assuming standard deceleration profile. Dr. Vaneman — thank you.”

“We’ll share the data. All of it. Every measurement, every image, every reading from inside the artifact. Both ships get the full record.”

“That is… more than I expected.”

“It’s what the data deserves. Skylark out.”

Dorothy turned to the adapter interface she had built, checked each connection one more time, and then began planning the return trajectory. Behind her, through the aft viewport, the octahedral artifact turned slowly in the sunlight, its beacon pulsing its patient primes into the dark, its purpose — if it had a purpose beyond being found — still unknown but no longer unreachable.

They left two hours later, the artifact extensively documented, its position logged in four independent navigation systems, its signal frequency and modulation recorded for every radio telescope on Earth to confirm. They took the power device. They left everything else. It would be there when humanity came back.

And humanity would come back.

* * *

Chapter 31 — “Confrontation”

The call came as Nate was running the outbound trajectory calculations.

They had been under thrust for two hours, the artifact shrinking behind them, Skylark’s three functional S-film panels and the restored fourth drawing power from the alien device with a steadiness that still made Dorothy check the readouts every ten minutes. Condor was thirty kilometers to starboard, matching their acceleration on its own reactor power, DuQuesne nursing the thermal duty cycle that Dorothy’s pulsed-capacitor design kept functional.

“Skylark, Condor.” Cole’s voice, not DuQuesne’s. The Air Force pilot sounded wrong — clipped past his usual professional crispness, the words arriving too fast. “We have a situation aboard.”

Nate grabbed the VHF handset. “Condor, go ahead.”

“Perkins has armed the rail gun and is demanding that Dr. DuQuesne hand over the artifact power device. He says his orders from Brookings supersede DuQuesne’s operational authority. DuQuesne refused. Perkins is — Perkins has a sidearm. Not the flare gun from before. A pistol. He must have had it stowed somewhere we didn’t check.”

Martin was already at the radar display, pulling up Condor’s position and vector. Dorothy moved to the S-film control panel without being asked.

“Where is DuQuesne now?” Nate asked.

“Engineering bay. He’s between Perkins and the weapons system power feed. Perkins is in the crew compartment. I’m in the cockpit. The hatch between cockpit and crew compartment is open. I can see

Perkins."

"Is DuQuesne armed?"

"Negative. He has a wrench."

The rail gun. Nate remembered the kinetic warning shot from orbit — a steel slug at three kilometers per second passing five hundred meters from Skylark. At their current range, thirty kilometers, Condor's targeting system could put a slug through Skylark's hull with enough precision to choose which compartment it hit. The weapon was designed for exactly this kind of engagement: two co-moving spacecraft, close enough for radar lock, closing geometry that made evasion a question of acceleration rather than distance.

"Cole, can Perkins fire the rail gun from the crew compartment?"

"Negative. The fire-control system is in the cockpit. But if he gets past DuQuesne and reaches the engineering bay, he can power the weapon from the S-film bus directly. DuQuesne is standing in front of the power junction."

"With a wrench."

"With a wrench."

Nate looked at Dorothy. She was already running the numbers, her face carrying the expression he had learned to associate with worst-case analysis: calm, focused, the way she got when the margins disappeared and the only option was precision.

"If Condor fires on us," she said, "at this range, we have approximately eight seconds between radar detection of the slug and impact. I can initiate a lateral thrust burn in four seconds. It won't dodge the slug — not at three klicks per second — but it will change our cross-section. He'd be shooting at a moving target."

"That's not a plan, that's a prayer."

“I know. Nate, talk to him.”

Nate keyed the VHF to the open inter-ship frequency, the one Perkins would be monitoring. “Perkins. This is Seaton on Skylark. I know you’re listening. I want to talk.”

Static. Then a voice he had heard only once before, during the resupply EVA — flat, professional, uninterested in negotiation. “Dr. Seaton. This doesn’t concern you. This is a matter of operational authority aboard this vessel.”

“You’re pointing a weapon at my ship. That concerns me.”

“The weapon isn’t pointed at your ship. Yet. The device you took from the artifact is the property of the United States government, recovered during a sanctioned operation under the authority of —”

“Under the authority of a private defense contractor whose VP of Strategic Programs ordered a kidnapping and authorized lethal force against civilians. That’s not the US government, Perkins. That’s a man in a suit in Tysons Corner who wants to own something he can’t build.”

“My orders are valid.”

“Your orders are from Brookings. Not from the Air Force, not from the DoD, not from anyone in the actual chain of command. Cole knows this. DuQuesne knows this. You’re the only one on that ship who’s pretending otherwise.”

Silence. Nate could hear Perkins breathing, or thought he could — it might have been his own pulse in his ears. Behind him, Martin was plotting evasive trajectories on the navigation computer, his fingers moving with the quiet economy of a man preparing for the worst while hoping for the best.

DuQuesne’s voice cut in, distant, transmitted through Cole’s open mic from the engineering bay. “Perkins. Stand down. The device stays on Skylark. We return to Earth. This ends without anyone getting hurt."

"Dr. DuQuesne, you are relieved of operational authority per —"

"Per nothing. There is no protocol for this. There is no field manual for first contact with alien technology in deep space. There is me, and you, and a decision about what kind of man you are."

"I'm the kind of man who follows orders."

"Then follow mine. I'm the mission commander. My order is: stand down."

What happened next came through Cole's open mic in fragments — sounds without video, a story assembled from noise. A grunt of effort. The clang of metal on metal. A shout that was DuQuesne's voice, sharp with pain. The particular flat crack of a body hitting a bulkhead in microgravity — no weight behind it but all the momentum, the collision of two masses in a space where there was no floor to anchor against and no friction to stop the tumble.

"He's moving," Cole said, his voice tight. "Perkins is moving toward engineering. DuQuesne — DuQuesne is down. He's floating. He's not moving."

Nate felt something cold settle in his chest. "Cole. Can you get to Perkins?"

"I'm unstrapping now. The — he's at the hatch. He's going through."

More sounds. A yell that was Cole's. The wet thud of a fist hitting flesh through a flight suit. In microgravity, a fight was not what the movies showed — no bracing, no leverage, no way to plant a foot and throw a punch with the full weight of a body behind it. It was grappling, clumsy and desperate, two men clinging to each other and to any handhold they could reach, every action producing an equal and opposite reaction that sent them tumbling through the compartment.

Cole was younger, fitter, trained for high-G environments if not for hand-to-hand combat. Perkins was thicker, experienced, a man who had fought in places where the rules were more practical than principled. But Perkins was fighting in a space he was not designed for, against a man who had spent his career strapped into cockpits where the proprioception of three-dimensional movement was second nature.

The sounds went on for ninety seconds that lasted a year.

Then Cole's voice, breathless: "He's restrained. I used the cargo straps. He's — he got me once, good one, my left eye is swelling. But he's secured."

"DuQuesne?"

A pause. "He's conscious. Breathing's bad. I think Perkins hit him in the ribs with something — maybe the wrench. He's holding his side and he's not moving much."

Dorothy was already pulling up the medical database on her tablet. "Cole, listen to me. I need you to assess DuQuesne. Is his breathing shallow and rapid? Is there crepitus — a crackling sensation — when you press gently on his rib cage? Is he coughing? Any blood?"

Cole relayed questions. DuQuesne's answers came back in fragments, his voice thinner than Nate had ever heard it, the Southern courtesy reduced to bare syllables. Breathing hurts. Left side. Yes, something shifts when I inhale. No blood.

"Broken ribs," Dorothy said, her voice carrying the flat authority of someone delivering a diagnosis from a million kilometers. "At least two, possibly three, on the left side. The risk is pneumothorax — if a broken rib end punctures the lung, air leaks into the chest cavity and the lung collapses. In microgravity, the air distribution is different than on Earth, which is actually slightly protective, but it's still dangerous. Cole, I need you to immobilize his torso. Use a flight suit as a compression wrap. Tight enough to limit rib movement, not so tight he can't breathe. And get him analgesics — there should be a medical kit aboard."

"Copy. I — there's a lot happening over here."

"I know. One thing at a time. Secure Perkins first. Then DuQuesne. Then call me back."

She closed the channel and turned to Nate. Her face was steady but her hands were moving, the fingers of her right hand pressing against her left palm in a rhythmic pattern that he recognized as her thinking habit, the body's need to process what the mind was working through.

"If he develops a pneumothorax," she said quietly, "we can't treat it. Not here. Not without a chest tube, which we don't have, and training, which none of us have. He needs to get to a hospital."

"How long?"

"If the ribs are stable and the lung stays intact, he can manage for weeks with pain management and restricted activity. If a rib shifts and the lung gets punctured — hours to days, depending on the severity. In microgravity, the presentation will be different. The air pocket won't collect at the top of the chest the way it does under gravity. It'll distribute. He might not show classic symptoms until it's already critical."

Nate stared at the radar display where Condor's icon pulsed, thirty kilometers away. Three people on that ship: one restrained, one injured, one trying to hold it together. "We need to get home."

"Yes. And fast."

The VHF crackled. DuQuesne's voice, painful and precise. "Dr. Seaton. I owe you… an explanation and an apology. The explanation will have to wait. The apology is this: I should have seen what Perkins was before I saw what Brookings was. That failure is mine.”

“Marc —”

“The device goes on Skylark. You fly it home. The world sees what we found. I’ll follow on Condor’s remaining power.”

“Your ribs —”

“Are broken, not fatal. Cole is competent. The ship is functional. Our return trajectory is longer than yours — Condor’s thermal duty cycle limits our sustained acceleration. But the math works. I will be approximately six days behind you.”

Nate looked at Martin, who was listening from the navigation station, his face unreadable. Then he looked at Dorothy, who gave a single nod.

“We’ll transmit continuous updates on our position and trajectory. If anything changes on your end — anything — you call us.”

“Understood. And Dr. Seaton?” A breath that cost him something. “When we get back… everything goes public. My account, unredacted. Vanguard, Brookings, the kidnapping, the weapons, the orders. All of it.”

“I’ll hold you to that.”

“I’m counting on it. DuQuesne out.”

The channel closed. Nate sat in the pilot’s seat and watched Condor’s radar icon begin to separate as Skylark’s superior acceleration — powered now by a device that had waited millennia for someone to find it — pulled them ahead. Thirty kilometers became forty. Fifty. Condor shrank from a glint in the viewport to a point on the radar to a data entry in the tracking log.

Martin broke the silence. “When we get back, everything changes.”

Nate thought about the device humming quietly in the equipment bay, about the artifact turning in the sunlight behind them, about the beacon still pulsing its primes into the void. About DuQuesne, broken-ribbed and honest for the first time, drifting in a ship he had built for the wrong reasons. About Dorothy, already recalculating their return trajectory with the intensity of someone who had decided that everyone was getting home alive.

"It already has," he said.

* * *

Chapter 32 — “Return”

The journey home took nineteen days.

With the artifact device powering the S-films, Skylark could sustain continuous thrust at a level the reactor alone had never managed. Dorothy calculated the optimal trajectory: a long, curving deceleration that bled off the outbound velocity they had accumulated during the flight from Earth, bent their path back toward the inner solar system, and brought them into Earth approach at a velocity that atmospheric reentry — or rather, the controlled descent that their S-films made possible — could handle. The math was elegant. The execution was a matter of patience.

For the first time since launch, they were not in crisis. The power device produced its half-megawatt with the reliability of a heartbeat, the surface temperature holding steady at fifty-eight degrees, the output voltage unwavering. The S-film panels drew what they needed and the device supplied it, and the copper that had been their most precious and dwindling resource was now needed only for film maintenance — the slow resurfacing cycle that replenished the dopant atoms consumed by thrust production. Dorothy estimated they had enough enriched copper for a hundred and twenty hours of full thrust. They needed fifty-three for the return. The margin was no longer measured in grams but in days.

Nate slept properly for the first time in three weeks. Eight hours, uninterrupted, in the starboard acceleration couch with the sleeping bag strapped over him and the cabin lights dimmed to the dull orange glow that Dorothy had set as the night cycle. He woke clearheaded and hungry, which was itself a novelty — the constant low-grade anxiety of the outbound flight had suppressed his appetite to the point where Martin had been monitoring his food intake and occasionally shoving an

MRE into his hands with the directive eat this, not a suggestion.

The days acquired a rhythm. Morning systems check: reactor, S-films, power device, thermal bus, life support, comms. Breakfast. Navigation update. The long middle hours filled with maintenance tasks, data analysis, and the slow work of documenting everything they had found.

The documentation was Dorothy’s insistence. She sat at the navigator’s station with her tablet and Nate’s laptop and the helmet-camera footage from the artifact EVA, and she built a record: photographs annotated with measurements, spectral data organized by location within the artifact, the power device’s operational parameters logged at fifteen-minute intervals, the mathematical analysis of the beacon signal refined and extended. She worked with the methodical intensity of someone building a case that would be examined by the entire world, because it would be.

Nate helped when she asked. The rest of the time he spent on the theory.

The power device operated on principles related to the S-film effect — that much was clear from the spectral emissions during operation, which showed the same quantum-vacuum coupling signatures that characterized S-film thrust production. But where S-films extracted momentum from the vacuum through a narrow resonance, the artifact device extracted energy across a broad spectrum. It was, as DuQuesne had said over comms, the difference between a flashlight and a fusion plant. The same physics, separated by generations of engineering refinement that Nate could not yet imagine, let alone replicate.

He filled the Moleskine notebook he had carried from Portland with calculations, diagrams, questions. The isotope requirement that constrained S-film production — was it a fundamental limit or an artifact of their crude manufacturing? The artifact device showed no isotopic sensitivity that they could measure. The thermal ceiling at four hundred degrees — was it a material limit or a physics limit? The artifact device ran at room temperature. Every constraint that had defined the boundaries of human S-film engineering appeared to be a manufacturing problem, not a physics problem. The universe allowed far more than they had learned to ask for.

He wrote this in the notebook and underlined it twice: The ceiling is ours, not nature's.

Communications with Earth improved daily as the distance shrank. Vanessa's voice on the X-band link progressed from a ghost arriving minutes after she spoke to a real-time conversation with a delay measured in seconds. The first time her voice came through clearly enough to carry emotion — a roughness that was not static but feeling — Nate had to leave the cockpit and float in the equipment bay for five minutes with his eyes closed.

The world they were returning to had changed. Vanessa's briefings sketched the outline in the shorthand of a woman managing a hundred simultaneous crises: the UN Security Council had passed a resolution (unanimous, for the first time in a decade) declaring the artifact a heritage of all humanity and calling for an international research framework. Vanguard Strategic's stock had been suspended, then delisted; the SEC and DOJ investigations were moving at a pace that suggested cooperation from inside the company. Brookings had been arrested at Dulles Airport attempting to board a flight to Dubai. The charges were federal: conspiracy, kidnapping, export-control violations, and a novel application of the Espionage Act that legal scholars were already arguing about.

General Whitfield had been promoted. She was now the senior military liaison to a hastily formed interagency task force on S-film technology and extraterrestrial artifacts, reporting to the National Security Advisor. Rebecca Tran, Martin’s lawyer, had negotiated a framework under which Skylark’s crew would cooperate with the task force in exchange for immunity from prosecution for the illegal launch and associated regulatory violations. The deal was complicated and fragile and entirely dependent on the crew actually returning safely, which added a dimension of urgency to the negotiations that Tran reportedly handled with her customary composure.

The signal data that Nate had broadcast on the open channel had done what he intended: made the discovery a public fact that no government or corporation could classify or suppress. Every radio telescope on Earth had confirmed the beacon signal within forty-eight hours of his broadcast. The mathematical structure was now the subject of more academic papers than Nate could read in a lifetime, published in a flurry of preprints and rapid-review articles that made the response to his original PRL paper look like a minor footnote.

And behind all of it, the question that no one could yet answer: who built it? When? Why? And was the beacon — with its patient prime-number arithmetic, its millennia-spanning persistence — an invitation?

Nate thought about these questions during the quiet hours of the coast phases, when the S-films were at reduced power and the cabin was dim and the stars filled the viewports with their cold, steady light. He did not have answers. He did not expect to have them in his lifetime. But the questions themselves had changed the shape of his thinking in ways he was only beginning to understand, the way a landscape looked different after you climbed high enough to see the horizon.

*   *   *

Martin talked to Laura.

The comms delay was down to forty seconds by day twelve of the return — long enough to make conversation unnatural, short enough to make it possible. They spoke every evening during the window when the DSN station in Goldstone had Skylark in view, twenty-minute sessions that Martin recorded on the local drive and listened to again during the night cycle when he could not sleep.

She told him about the reporters camped outside their house in Portland. About the Crane Energy board meeting where the directors had voted to support him unanimously, possibly because the company's stock had tripled on the news of the artifact. About the call she had gotten from the White House — not the National Security Advisor, not a military liaison, but the President's scheduler, asking when Martin would be available for a meeting. She had told the scheduler that her husband was currently in deep space and would call back.

Martin laughed at that, a real laugh, the first one in weeks, and the sound surprised him. He had forgotten what it felt like.

"Laura," he said during one of the calls, and the pause before her response was twenty seconds of silence that he filled with everything he could not say across a radio link monitored by a dozen agencies. "I'm sorry about the secrecy. I'm sorry about the danger. I'm sorry I didn't tell you how bad it was."

Her reply, when it arrived, was steady and warm and slightly angry, which was how she sounded when she loved him most. "You can be sorry when you're home. In person. Until then, fly the damn ship."

"I'm not the one flying it. Dorothy's flying it."

“Then tell Dorothy to fly the damn ship.”

“She can hear you.”

Dorothy, from the navigator’s station, raised a hand without looking up from her trajectory calculations. “Flying the damn ship.”

* * *

Nate and Dorothy did not talk about what was between them.

There was no dramatic scene, no declaration, no moment that a camera would have captured. There was instead a gradual closing of distance that happened in the margins of the work: a hand on a shoulder when passing in the equipment bay, a look held one second longer than navigation required, a conversation about radiator performance that drifted into a conversation about the artifact and then into silence, the comfortable kind, the kind that happened when two people were thinking the same thing and did not need to say it.

On day fifteen, Dorothy was in the equipment bay running the bi-daily thermal bus adjustment, and Nate brought her a squeeze-bulb of reconstituted coffee. She took it with her free hand, her other hand deep in the access panel where the NaK piping ran hot against her forearm through the insulated sleeve, and she looked at him with an expression he had not seen before — open, unguarded, the precision and the systems thinking set aside for a moment in favor of something simpler.

“Thank you,” she said, and it meant the coffee and it meant pulling her through the airlock after the EVA and it meant sharing the signal with DuQuesne and it meant the decision to go to the artifact and it meant everything else.

“You’re welcome,” he said, and it meant all of it back.

That was enough. There would be time for the rest. The one thing this journey had given them, finally, was time.

*   *   *

DuQuesne kept his word.

On day seven of the return — Condor six days behind Skylark and falling further back as the slower ship nursed its thermal limits — DuQuesne transmitted his account on an open channel. Unredacted. Unedited. The full record.

It began with the data theft. The compromised lab network, the exfiltrated experimental logs, the partial replication at the Groom Lake facility. It continued through the parallel build: Condor's construction, the weapons integration he had opposed and been overruled on, the mission parameters that Brookings had defined and DuQuesne had accepted. The kidnapping of Dorothy Vaneman — ordered by Brookings, facilitated by Perkins, enabled by DuQuesne's failure to intervene in time. The pursuit, the warning shot, the rules of engagement that authorized lethal force against civilians.

He held nothing back. Not the moments of complicity, not the rationalizations that had carried him from "responsible stewardship" to "accessory to kidnapping" in a sequence of steps that had each seemed locally defensible and were collectively indefensible. He named names. He cited dates. He attached copies of the encrypted communications between Condor and Vanguard's Tysons Corner campus, decrypted by Cole using authentication codes that DuQuesne had memorized.

The transmission was two hours long. Vanessa received it, verified its integrity, and released it simultaneously to every major news organization, the Department of Justice, the House and Senate intelligence committees, and the UN Security Council's ad hoc working group on S-film technology governance.

Within forty-eight hours, Vanguard Strategic's remaining board members had resigned. The company's government contracts were suspended pending review. Three senators who had received Vanguard PAC contributions issued statements of shock and calls for investigation. Brookings, in federal custody, declined to comment through his attorney.

DuQuesne, aboard Condor with broken ribs and a restrained security contractor and a pilot who had chosen the right side, watched the consequences of his honesty propagate at the speed of light. Cole brought him water and analgesics and the news updates that Vanessa relayed.

"How does it feel?" Cole asked.

DuQuesne considered. The pain in his ribs was a constant, a grinding ache that sharpened with every breath and made sleep a negotiation with his body's tolerance. The political consequences were beyond his control and therefore beyond his concern. The scientific consequences — the knowledge that the artifact existed, that its power device worked, that the S-film effect was a first step on a very long road — those he could not yet feel the edges of.

"It feels," he said carefully, "like the beginning of something. Which means the end of something else."

"Poetic."

"Southern."

* * *

Edwards Air Force Base. Day nineteen. 0741 Pacific time.

Skylark descended through the California morning like a building falling sideways, the S-film panels canted into the airstream at angles that Dorothy had calculated to provide both deceleration and lift, the radiator panels glowing cherry-red against the desert sky. The reactor was shut down — had been shut down for six hours, the artifact device carrying the full electrical load with the indifference of something designed for a task a thousand times larger. The thermal bloom was visible from the ground, a heat signature that every tracking station in the western hemisphere was watching.

Nate flew the descent manually. The flight computer could have handled it, but this was not a moment to delegate. He had his hands on the thrust controls, his eyes on the altitude and velocity displays, his feet on the pedals that adjusted the gimbal angles, and he brought the ship down the way he had brought it up — by feel and physics and a desperate unwillingness to let the machine be anything other than perfect.

The desert expanded beneath them. The runway at Edwards was a long gray stripe against the brown and tan of the Mojave, and beside it, the lakebed — miles of flat, hard clay, the place where the X-1 had landed and the Space Shuttle had landed and now something new and stranger was landing.

Skylark touched down at 0747, the landing legs absorbing the impact with a shudder that ran through the hull and into Nate’s spine. The S-films spun down. The radiators cooled. The artifact power device, as if sensing that the journey was over, reduced its output to idle — forty degrees, a few hundred watts, the same patient trickle that had kept the beacon running for millennia.

The silence, after nineteen days of machinery and atmosphere recyclers and the constant low hum of the S-films under power, was enormous.

Dorothy unbuckled first. She moved to the equipment bay and began the post-flight shutdown checklist she had written during the return, the procedures she had designed for a moment exactly like this one. Reactor to cold standby. Power device connections verified and safe. Thermal bus depressurized. Life support to external feed. She worked through the list with the same precision she had applied to everything since boarding Skylark, and if her hands shook slightly on the last item, neither Nate nor Martin commented.

Martin was on the radio. “Edwards tower, Skylark. We are down and safe. Three crew, all in good health. Requesting ground support and medical standby.”

“Skylark, Edwards tower. Copy all. Welcome home. Ground teams are rolling.”

Nate sat in the pilot’s seat and looked out the viewport. The desert stretched to the mountains, brown and old and ordinary. The sky was blue, the blue of an atmosphere, the blue of home. He had spent three weeks looking at stars through vacuum, and the sky was blue, and he had forgotten how beautiful that was.

The hatch opened. Sunlight fell through the opening like a solid thing, warm and heavy and real. Nate pulled himself out of the seat and floated toward the hatch — then caught himself. Not floating. The gravity was back. His legs were weak, his balance uncertain, the inner ear recalibrating after weeks of microgravity, but he was standing under a sky with a horizon and the ground was firm beneath his feet and he was home.

He climbed down the ladder that the ground crew had placed against the hull. The tarmac was warm through his boots. The air smelled like creosote and jet fuel and desert sage. There were people — dozens of them, hundreds maybe — behind a cordon line a hundred meters away. He saw cameras. He saw uniforms. He saw a woman in a civilian blazer with reading glasses perched on her head who was pushing through the cordon with the authority of someone who had paperwork that superseded every badge on the field. Rebecca Tran. Behind her, a younger woman with dark curly hair who was not pushing through the cordon because she was already through it, running, and Vanessa Almeida reached him first and hugged him hard enough that his weakened legs nearly buckled.

“You’re an idiot,” she said into his shoulder. “You’re an absolute idiot and you changed everything.”

“I had help.”

Dorothy descended next, then Martin. The ground crew surrounded Skylark with the organized urgency of people who had been briefed on what the ship contained and were trying very hard to follow protocols that did not yet exist for this situation. Medical teams moved in. Radiation monitors swept the hull.

General Whitfield was on the tarmac.

She stood apart from the crowd, in service dress blues with two stars on each shoulder, her posture as precise as the first time Nate had met her in the Portland hangar. She waited while the medical team checked his vitals and the security detail confirmed his identity and the cameras recorded everything. Then she walked to him, and her face carried an expression that Nate had not seen on her before — not the political sharpness, not the institutional calculation, but something quieter. Respect, maybe. Or recognition.

“Dr. Seaton.”

“General.”

“You launched an unlicensed nuclear vehicle from US soil, violated sovereign airspace of three nations during your ascent, failed to comply with NORAD directives, and returned with technology of extraterrestrial origin that has triggered every classification protocol the Department of Defense possesses.” She paused. “I told you the next visitors might not ask.”

“You did.”

“I was right. They didn’t.” She extended her hand. “Welcome back. The real work starts now.”

Nate shook her hand. Behind him, Skylark stood on the desert floor, a cylinder of aluminum and titanium and heat-pipe radiators, crude and functional and extraordinary, and inside it, the power device hummed at idle, warm and patient, waiting for whatever came next.

He looked up. The sky was blue. Somewhere beyond it, the artifact turned in the sunlight, its beacon pulsing its primes, its corridors empty and waiting. Somewhere behind the blue, DuQuesne was nursing broken ribs and a clear conscience and closing the distance home. Somewhere on the other side of the planet, telescopes were listening. Somewhere, people he had never met were looking at the same sky and understanding, for the first time, that it was not a ceiling but a door.

The real work starts now.

* * *

Epilogue — “Beacon”

Six months later. Geneva.

The building was glass and steel and compromise, a joint facility funded by twenty-three nations and administered by an organization that had not existed eight months ago. The International Deep Space Research Consortium occupied a campus on the western shore of Lake Geneva, between the UN complex and the CERN accelerator ring, the location chosen for its symbolism and its proximity to institutions that understood the scale of what was coming. The construction had been the fastest international building project in history, which meant it was still unfinished: exposed conduit in the hallways, temporary signage, the smell of fresh concrete and new carpet competing with the alpine air that came through the windows.

Nate’s office was on the third floor, overlooking the lake. It was too large for him — he had asked for something smaller, closer to the lab, and had been gently informed that the director of the Artifact Analysis Division did not work in a closet. He had filled the excess space with whiteboards, which were already covered in his handwriting: equations, diagrams, questions marked with stars, provisional answers marked with question marks. The Moleskine notebook from the flight was pinned open on a corkboard above his desk, the page that read The ceiling is ours, not nature’s visible to anyone who entered.

The morning had been meetings. The morning was always meetings. Budget allocation for the next quarter. Staffing requests from the materials science team. A teleconference with the JPL group building the remote-sensing package for the return mission to the artifact. A classified briefing on the latest signals analysis — the beacon’s mathematical grammar was yielding to study, slowly, and the working group thought there was a coordinate system embedded in the nested prime sequences. An address, maybe. A direction.

He took his lunch in the commissary, a space that was half cafeteria and half conference room, designed by someone who understood that the best science happened over bad coffee and good arguments. The food was Swiss-institutional, which meant it was better than it needed to be, and Nate ate a sandwich he did not taste while reading a preprint on his tablet — a new theoretical framework for broadband vacuum coupling that built on his PRL paper and extended it in directions he had not imagined.

The author was a postdoc at Caltech. She was twenty-six years old. She had never built an S-film in her life, and her math was better than his. He smiled at the paper and made a note to write to her.

DuQuesne found him in the corridor afterward, walking with the careful posture of a man whose ribs had healed but whose body remembered. He had arrived in Geneva three months ago, after the federal charges were resolved through a combination of cooperation, testimony, and the pragmatic recognition that one of the world's two experts on S-film propulsion was more useful in a laboratory than in a prison. His team occupied the floor below Nate's, working on the theoretical physics of vacuum energy extraction, trying to bridge the gap between S-films and the artifact device that sat in a clean room in the building's basement, still operating, still warm, still patient.

"The Caltech paper," DuQuesne said, falling into step beside him. He had a copy on his own tablet. "Her approach to the coupling efficiency problem is elegant. Possibly wrong, but elegant."

"I think she's right about the temperature dependence. The four-hundred-degree ceiling is a lattice-stability issue, not a coupling issue. If you can maintain the crystal geometry at higher temperatures —

better substrates, better dopant binding —”

“Then the ceiling lifts. Yes. I sent her a note this morning with some data from our Los Alamos-era high-temperature work. Declassified last week, finally.”

They walked together, the former rivals, through a building that existed because they had both built ships and flown them into the dark and brought back something that neither of them fully understood. Their relationship was not friendship. It was something more specific and more durable: the mutual recognition of competence, tested under conditions that burned away everything else. They argued about physics daily. They had not discussed the past since the day DuQuesne arrived, when he had stood in Nate’s office and said, without preamble: I owe you a debt I will repay in work.

Nate had accepted. There was nothing else to say.

Dorothy was in the engineering wing, which was the only part of the campus that was fully finished because she had refused to work in an unfinished laboratory. The space was large, clean, and filled with equipment that made the Portland hangar look like a garage sale: precision sputtering chambers, a dedicated isotope enrichment line, a thermal test facility, and in the center of it all, the skeleton of a ship.

Skylark II was still mostly blueprint and budget line, but the structural prototype — a ten-meter section of hull with integrated S-film mounts and a next-generation thermal management system — occupied the floor of the engineering bay like the spine of something that would eventually fly. Dorothy stood beside it, tablet in hand, talking to a structural engineer from the European Space Agency while simultaneously reviewing test data from the morning’s film-deposition run. Her reading glasses were perched on her head, forgotten. Her hands moved while she talked, describing shapes in the air that the engineer translated into notes on his own tablet.

She saw Nate in the doorway and the look she gave him was the same one from the equipment bay on Skylark, the day he had brought her coffee: open, unguarded, specific to him. They had not kept what was between them secret, exactly, but they had not performed it for the cameras either. It existed in the margins, as it always had — in the shared work, in the conversations that ran longer than necessary, in the quiet of the Geneva apartment they did not yet officially share.

“Hull section three passed thermal cycling this morning,” she said when he reached her. “Twelve hundred cycles, no delamination, no drift. The titanium-nitride adhesion layer is holding.”

“And the new film geometry?”

“Deposition run is in the chamber now. Results in four hours.” She looked at the structural prototype, the ribs and frames of a ship that would go further than Skylark had, stay longer, carry more. “We’ll have a flight-ready vehicle in eighteen months. Maybe less.”

“Where will it go?”

“The artifact, first. Proper survey, proper instruments, a team that has more than two hours to study a structure that’s been there for ten thousand years. After that…” She tilted her head toward the window, where the late afternoon light was turning the lake gold and the mountains were sharp against a sky that was already darkening toward evening. “After that, we follow the beacon.”

The coordinate system in the signal. The address embedded in the mathematics, still being decoded but coming clearer every week. A direction. A distance. A destination that someone had gone to the trouble of marking, the way a traveler marked a trail for those who came after.

Nate left Dorothy to her ship and walked back to his office. The sun was setting over the lake, the Alps silhouetted against a sky that shifted from blue to amber to the deep violet that preceded the stars. He stood at the window and waited.

The stars came out. Not all at once, not the way they appeared through Skylark’s viewport in the instant the sun passed behind the hull. Here they emerged gradually, the brightest first — Venus, low in the west, then Jupiter, then the familiar constellations assembling themselves against the darkening sky as the atmosphere thinned overhead and the ancient light came through.

He thought about the signal, pulsing in the dark. Two, three, five, seven, eleven. A hand extended. A door opened. An arithmetic that said: we are here, we were here, come and find us.

He thought about the device in the clean room, warm and patient, drawing energy from the vacuum the way a tree drew water from soil — effortlessly, continuously, tapping a reservoir so vast that ten thousand years of operation had not measurably diminished it.

He thought about DuQuesne, one floor below, running calculations. About Dorothy, in the engineering bay, building a ship. About Vanessa, back in Portland, running the S-film production line that would supply the fleet that was coming. About Martin, in Washington, negotiating the governance framework for a technology that would reshape every economy on Earth. About Cole, discharged with honors, finishing his aerospace engineering degree at Stanford on a scholarship named after the mission he had not asked to join. About Perkins, in federal custody, a footnote. About Brookings, in a different kind of custody, a cautionary tale.

He thought about the artifact, turning in the sunlight at 2.3 AU, its beacon pulsing, its corridors empty, its remaining devices waiting for the return visit that was now a matter of when, not if. Someone had built it and left it and trusted that the universe would eventually produce a species curious enough, stubborn enough, and desperate enough to find it. And the universe had. Just barely. By the margin of a contaminated copper sample and a grad student’s persistence and a friendship that funded an impossible machine and a rivalry that turned out to be the thing that made the discovery credible.

The stars were bright now, the Milky Way a faint band across the zenith, and Nate stood at the window and looked at them and felt the old pull, the one that had started in a Portland lab at 2 AM when a crucible went through the wall and the data on his laptop said the universe was larger than he thought.

The stars look different now. They look like addresses.