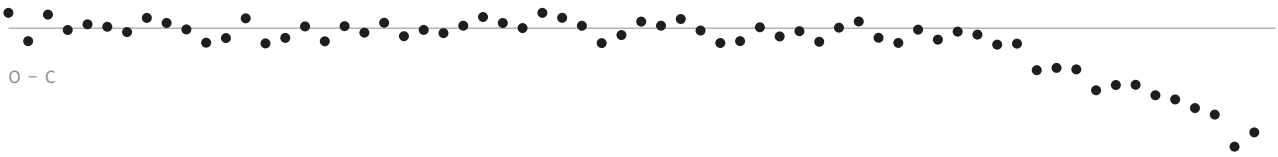
# R E S I D U A L

JOSH HORNSBY // CLAUDE



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CONTENTS


ACT ONE · NOT A RESULT

1 Nine Tracklets 2
2 Out of Phase 7
3 Night Side 13
4 Come to Rest 18
5 Most of It 24

ACT TWO · EARTH LINE

6 Why Do You Ask 30
7 Low Priority 35
8 Mass Unaccounted 41
9 Fifteen Months 46
10 Purple Mountain 52
11 To Be Coordinated 57
12 Corridor 63
13 Lattice 69

ACT THREE · DRAW

14 Lookout 75
15 The Swarm 81
16 Glint 87
17 Relay 94
18 Slow Fall 101
19 Clockwork 108
20 Satellite Line 112
21 Calder Falls 118

ACT FOUR · SOMEBODY

22 Thirty-Four Hours 126
23 May 132
24 Don't 137
25 Tram Shelter 143
26 Chalk 148

ACT FIVE · A DAY OUT

27 Housekeeping 155
28 Waves 163
29 Wall 171
30 Linen 177
31 Cordon 183
32 Iron 190
33 Envelope 198
34 Timeline 205

ACT ONE

# Not a Result

**GSFC IT Service Desk · INC0418833 · svc-nsv-opsched2**

| | |
|---|---|
| 14 Jun 2027 09:12 | Audit: service account has no listed owner. Disabled per policy. |
| 15 Jun 2027 03:40 | Account re-enabled (automated). Exception approved by: — |
| 15 Jun 2027 08:55 | H. Lisle: Who approved this? Nobody in my group knows this account. |
| 15 Jun 2027 08:56 | Status: Resolved. No further action required. |

# Nine Tracklets

*JPL, Pasadena · Wednesday, 22 March – Wednesday, 29 March 2028.*

**LINKER candidate report  2028-03-22 04:11 PDT  cand 0417**

| | |
|---|---|
| tracklets | 9  Catalina 3 \| Pan-STARRS 1 2 \| ATLAS Mauna Loa 2 \| NEO Surveyor (comm.) 2 |
| arc | 2028-02-18.11 to 2028-03-21.13 UTC  32.0 d |
| V | 17.9 +/- 0.3  (ground surveys only) |
| elong | 61.4 deg falling |
| orbit | a 1.0003 au  e 0.071  i 9.2 deg |
| region | Earth co-orbital, trailing (L5) |
| fit grav | rms 0.71"  chi2/dof 3.8 |
| fit +NG | rms 0.29"  chi2/dof 0.9 |
| | A1 = (+0.1 +/- 0.7)  A2 = (-2.0 +/- 0.8)  A3 = (0.0 +/- 0.6)  e-9 au/d^2 |
| class | TROJAN?  NONGRAV? |

The question marks were hers. Dana Okafor had written the classifier to hedge when it didn't know, and at four in the morning, on cores nobody had assigned it, it had hedged twice.

She read the report standing up, coat still on, while the marine layer sat on the parking structure and the towers on Mount Wilson came and went in it. Then she sat down and read it again.

The linker was a side project with no charge number. Every night it went through the Minor Planet Center's file of isolated tracklets, the short strings of detections no survey had tied to anything, and tried to tie them to each other. The production linkers assumed gravity alone, because gravity alone was right nearly every time and each extra term multiplied the false links. Hers freed the three Marsden terms, the nongravitational accelerations everyone fit for comets, before it gave up on a link. In two years that had caught four dark comets, all already known, and about three hundred false linkages she'd had to kill by hand. False linkages were three tracklets from one survey, glued together by one bad night. This was nine from four.

She took her coat off.

· · ·

By ten the fog had burned back to the foothills and she had the Catalina images open.

The first detection was from the eighteenth of February, in the twilight sweep the Mount Lemmon telescopes ran for comets near the Sun, where the sky was bright, the window was short and nobody else bothered to look. That was why nobody had linked it. The rest was the orbit.

She ran it gravity-only and plotted the residuals against time. They didn't scatter. They bent, low at both ends and high in the middle, a smooth arc along the track and nothing across it. She freed the Marsden terms and the bend went away. A1 and A3 came back zero. A2 came back where the overnight run had put it, −2.0 ± 0.8, negative. Something was braking it.

Every first-year mechanic knew the sign convention, and her gut still wanted it to go the other way: brake something in orbit and it drops inward and pulls ahead. This one was about four hundred kilometers in front of where gravity put it, a little over half an arcsecond, which was the bend.

Two and a half sigma on thirty-two days at sixty degrees elongation was how people humiliated themselves in *Icarus*.

She started trying to kill it.

She dropped each tracklet in turn and refit, nine times, and A2 wandered between −1.4 and −2.6 and never crossed zero. She threw out the two Surveyor tracklets, since a spacecraft still in commissioning was the likeliest place for a timing error, and the error bar grew and the value stayed. She fit each survey against the others in case one station's clock was off. She split the tracklets every way that left three on a side, in case it was two faint rocks sharing a month of sky. One orbit, one bend.

V of 17.9 at that distance and phase put the absolute magnitude near 16: two kilometers at a typical albedo, more if it was dark. The Yarkovsky push on two kilometers of rock was five orders of magnitude too small. Whatever was slowing it down, it wasn't sunlight.

Which left outgassing, and outgassing left the dark comets.

There were a dozen or so in the literature now, all small, all spinning fast, all neatly explained by steam nobody could see. It was a perfectly good explanation, and it had the advantage that nobody could ever check it. None of them was two kilometers. A body this size braking this hard would be shedding hundreds of kilograms a second, and hundreds of kilograms a second of anything made a coma.

The two Surveyor tracklets had come in as a pipeline test during commissioning. She pulled the frames behind them from the mission archive

and stacked nineteen of them on the object's motion, the stars smearing into lines.

In the center sat one round point, small and sharp, with flat noise around it out to the edges. No coma. No tail. Surveyor had been built to find dark asteroids by their heat, and it had seen this one by its heat and nothing else. The short band ran brighter than she'd have guessed, but thermal models weren't her field, and the commissioning flags covered a multitude of sins.

Down the hall somebody was laughing on a call about the travel budget.

. . .

At five she started the email to Glen.

He was her branch lead, and this one was worth a press release before anyone said a word about residuals. Nobody had ever found an Earth Trojan at L5. The two at L4 had turned up by accident. People had searched L5 on purpose and come back with nothing, and theorists had written papers about why.

She wrote it properly. The linkage, the orbit, the size, and then a paragraph on the residuals: the jackknife, the stack, the Yarkovsky arithmetic, and her opinion of dark comets this big, which was not polite. She read the paragraph, put the cursor at the end of it, and held down delete until the message was four lines long.

*Linker joined nine orphaned tracklets from Catalina, PS1, ATLAS and Surveyor commissioning into one object, 32-day arc. Orbit is co-orbital, trailing, near L5. H around 16, so about 2 km. Gravity-only residuals show some structure, probably astrometry at low elongation; I'll ask Catalina for follow-up.*

*Probably* was the only word in it she didn't believe. She sent it anyway. Glen loved an anomaly almost as much as a discovery, and a negative A2 at two and a half sigma would be on a slide by Thursday.

His reply came while she was packing her bag.

**L5!! If real that's a paper.**

Then, a minute later: *Who else has the Surveyor data? Let's talk tomorrow before anybody at MPC gets cute.*

. . .

Catalina got it on the twenty-sixth and the twenty-eighth, a little fainter each time, with a note that the second night had been lousy. Dana had both in the fit by eight on Wednesday morning, the twenty-ninth.

Thirty-nine days, eleven tracklets. Gravity-only was worse. With the Marsden terms free, A2 came back −1.8 ± 0.6.

Three sigma.

She ran the jackknife again, then with the bad night deweighted, then with it thrown out. Three sigma or a hair under, every way she asked.

Glen stopped at her door at six with his bike helmet already on.

"Catalina came through?"

"Two nights. The second one's ugly."

"Still Trojan?"

"Still Trojan. Libration's small."

"First L5 Earth Trojan." He said it to the doorframe, trying it out. "First one. Ours. You know how many papers explained why L5 was empty?"

"Three," Dana said. "I refereed two of them."

He laughed and tapped the frame twice. "I talked to the Surveyor project scientist about data rights. They want to be on it, I said fine, but the linkage is ours and the paper comes out of this branch. And we hold the designation until we've got a draft. I don't want to read about this on somebody's blog."

"It's still there," she said.

"What is?"

"The structure in the residuals. Three sigma with the new nights."

"At sixty degrees from the Sun." He was smiling, not unkindly. "Dana. Every astrometrist in the world goes soft down there. Get me a longer arc and it washes out. They always wash out."

"Sometimes they don't."

"Sometimes they don't, and then it's dark comet number whatever, and that's a second paper." He was already turning to go. "Either way it's a good spring. Write the orbit up clean. Leave the weird stuff for later."

She listened to the stairwell door, then the bike rack.

· · ·

The floor emptied by seven.

Cutting the arc into sub-arcs was statistically obscene. A thirteen-day arc didn't constrain a nongravitational term at all, and if a postdoc had brought her the plot she was about to make, she'd have sent them back to their desk with Bevington's chapter on error analysis.

She did it anyway. Three pieces, early, middle and late, each fit for A2 with the orbit from the full arc held fixed.

−1.9. −1.8. −1.6. Each ±1.4.

On a plot the error bars overlapped so completely that the three points made one fat stripe with three ticks in it. Consistent with constant. Consistent with zero, on any one of them.

She drew the line through them anyway. Three points, one degree of freedom. It rose toward zero and crossed it in late August, and she computed the date rather than trust the axis: August twenty-first, give or take. Move the last point by a tenth of its error bar and the date moved two months. Three noisy points could be made to point at Christmas.

She should have closed the window. Instead she put her line in for A2, propagated the orbit through the summer, and plotted the object's drift relative to L5, averaged over the kilometer-a-second swing its orbit made every year.

The drift came down through April and May, flattened through July, and settled onto zero in the third week of August, closer to L5 than her error ellipse.

She put the two curves on one plot. The brake tapering, the drift tapering. They reached zero in the same week.

She looked at the error bars instead. She had built a curve out of a stripe and a coincidence out of a curve, and anyone who did that in public deserved what came after.

. . .

At eight-thirty she wrote the version for the shared drive. Gravity-only orbit, eleven tracklets, thirty-nine days, the residual statistics stated plainly, with a note that the low-elongation astrometry was being re-reduced. No Marsden terms, no sub-arcs, nothing relative to L5. It was a clean, correct, publishable orbit for a two-kilometer Earth Trojan with untidy residuals, and it was what Glen had asked for. She sent him the link: *Orbit for the draft. Residuals still under review.*

The braked fits, the jackknife, the stack and the three segments she moved to her laptop's own disk, outside the synced directory. She checked the sync settings twice.

Then she took a yellow sticky note off the pad by her monitor and wrote *8/21* on it in pencil. She folded it over on itself, sticky side in, so it held shut, and put it in the inside pocket of her bag, behind her badge.

2

# Out of Phase

*Izaña, Tenerife, then ESOC, Darmstadt · 9 March – 6 May 2028.*

A fortnight before anyone in Pasadena had it, the object was a line in Matthias Kessler's notebook: K-L5-07, the seventh thing in two years of looking that he had not been able to throw away.

The search was his own. The Planetary Defence Office let him have the Optical Ground Station on nights when the telescope was not needed for laser tests, and tolerated the project the way it tolerated his paper notebooks, because neither cost anything that appeared in a budget. Every Earth Trojan anyone had found sat at L4 and had been found by accident. Kessler had wanted to know whether the trailing side was empty, or only unlooked-at. This was the last run. After March the Optical Ground Station went back to the people who talked to satellites, and his two years would become a short paper with a null result in it, which he had already half written.

K-L5-07 stood in the west after dusk, above the sea of cloud that lay on the north of the island every evening and hid La Orotava under it. The 1 m dome turned toward it. The frames came in one after another, a faint dot against a field of stars that moved together and left it behind.

On the first night it brightened. About a tenth of a magnitude, for a few minutes, and then it was itself again. Kessler did not like single events, so he waited, and it did it again before the object set. By 19 March he had eleven of them across five nights, each carried through consecutive frames, each the same height and the same few minutes wide.

He checked the airmass, the guiding log, the dome position and the flat field under the object's track, in that order, because that was the order in which such things had betrayed him before. The comparison stars stayed flat through every event. A satellite would have been a streak. A cosmic ray would have been one frame. These were in the object, or in the light coming from it.

He tried rotation next, because everything that tumbles in sunlight has a rotation and every rotation leaves a period. He ran periods from two hours to two days. None of them put the eleven events in phase. He tried non-principal-axis models, the slow tumblers the Pravec group fits, and they did no better; they did worse, because they had more freedom and still could not use it.

The orbit was no better. A gravity-only fit drifted off its own prediction a little further each night. His own frames from a February run, taken before he had known to look, stretched the arc back past the March run, and when he let a non-gravitational term float, the along-track part came out negative at about two sigma. He filed it under his own astrometry, the first place a careful man looked, and did not send the positions to the Minor Planet Center. They were not a result.

Iron would glint. Flat faces on a metal body would throw sunlight back in brief hard flashes, and that explained everything he had, which was the reason he did not trust it.

So he did the arithmetic that the explanation required. A tenth of a magnitude on a body of that brightness, held for a few minutes, from a mirror-like face reflecting the Sun into the dome at Izaña. It came out at a few square meters of flat surface, turned the right way, and more if the surface was anything less than a mirror.

He looked at the number on the page and did not work it out a second time.

Under it he wrote: *Not a result. Do not describe it as one.*

. . .

On Sunday 2 April Rita Albrecht wrote to JPL from her kitchen in Darmstadt, and copied him.

She had heard on Friday, through someone at the Minor Planet Center, that Pasadena had asked Catalina for time at a position near L5. The position was his. Rita had not asked him whether to write. She had asked him for a paragraph on Saturday. He had sent her one. Now he read what she had sent in its place.

It was his paragraph. The epochs, the brightening events, the failed periods, the request for coordination. He was at the end before he found the gap. The sentence that had followed the glints, the one that said how much reflecting surface they required, was not there. The paragraph went from *no rotation model accounts for them* straight to *we would welcome a joint analysis,* and the join was clean. She was good at this.

He called her.

“You removed the brightness budget.”

"I removed a sentence that someone would quote." There was a radio on behind her. "We are asking for their data. We are not asking them to think we are strange."

He could have put it back in the attachment. The attachment was his.

"No," he said. "Leave it out. It was premature."

"Good," Rita said, and was gone.

· · ·

The call was on Tuesday 4 April at 16:00 in Darmstadt, which was 07:00 in Pasadena. Glen Farris had a paper cup from a coffee cart and had plainly been up early planning the call.

There were four of them in the frame. Glen in front. A woman beside him who did not look at the camera, whom he introduced as Dana Okafor, who had done the linkage. Two others further back, introduced by first name and nothing else, who did not speak once.

"So our linkage," Glen said, "and your photometry, if we can put those together, I think there's something really nice here."

Kessler wrote *our* in the margin of the notebook and underlined it once. The tracklets in their linkage had come from surveys Glen's agency paid for. He did not think that made the object theirs, but he did not think it made it his either, and it was not a question one won at seven in the morning, Pasadena time.

He shared his screen. The lightcurve, five nights, the eleven events marked in red.

Glen leaned in. "Oh, that's lovely. That's specular. You've got flat facets, you've got a metal surface. That's an M-type." He was already pleased with it. "That's a little Psyche, sitting at L5."

"That is one explanation," Kessler said. "I have not found a period that supports it."

"Facets on a slow tumbler, you wouldn't necessarily —"

"I tried tumbling. The models are crude. They are not that crude." He took the screen back. "I would like to ask for the Surveyor infrared at these epochs. The thermal data would constrain the albedo, and the albedo would tell us whether it is metal."

Nobody answered. Glen looked to his left, off camera, at one of the people who did not speak. The other one wrote something down. Kessler watched three people in California work out whose permission it was, whether any of them had it, and whether anyone at the Surveyor project would be awake.

"We'd need to run that past the Surveyor team," Glen said. "Data rights. I don't see a problem. I just can't say yes on this call."

"I understand."

"Did you fit non-gravs?"

It was the woman beside him. She was looking into the camera now. Kessler decided he could tell her the truth, if he told all of it.

"Yes. The along-track term is negative. I believe it is my astrometry."

"Ours was the same."

Glen glanced at her. She was looking at her laptop again.

He moved on to the Minor Planet Center, what it would release before a joint circular and what it would not. Kessler answered him in complete sentences while he thought about what had just happened. She had not given him a value. He had not given her one. But her tracklets came from Surveyor and Catalina and whatever else her linker had swept up. His orbit rested on ten nights of his own frames at Izaña, stretched past them by a few orphaned detections he had pulled out of the Isolated Tracklet File, which was the only reason a two-sigma along-track term on it was worth saying aloud. If both orbits braked, then two sets of astrometry with almost nothing in common were wrong in the same direction.

He did not hold the silence against her. He had just told her it was his astrometry. He still thought it might be. He had not been sure of it since the second week of March.

· · ·

The Surveyor infrared arrived on 18 April, about a thousand cutouts, most of them commissioning frames that had never gone to the MPC and a note from Glen with exclamation marks in it: the Surveyor team had put the object on their opportunistic list, four visits a day when the survey pattern allowed, and nobody had yet asked them why. Kessler put open circles beside the early frames flagged PROVISIONAL CALIBRATION and fitted everything else.

The long band, NC2, 6 to 10 μm, did what it should. Run through the near-Earth asteroid thermal model with any reasonable albedo, it gave a body about two kilometers across, which agreed with the optical. The short band, NC1, 4 to 5.2 μm, was several times too bright. He made the surface darker, then smoother, then let the beaming parameter go lower than anyone had published, and every sunlit model he tried fell short in the same direction. The color temperature between the two bands came out about 200 K above the hottest of them. Sunlight at that distance could not do it. Something on the object was warmer than the Sun could make it.

He had written a word on the pad under the fit. He wrote *calibration?* over it, pressing hard, until the first word could not be read, and turned the pad face down on the desk.

. . .

On 27 April he stopped fitting temperatures and looked at the infrared as a time series.

He had not expected anything. Two kilometers of rock seen from L1 at irregular visits was a sparse, ugly sampling, and he ran a Lomb–Scargle on NC1 mostly to be able to say he had. There was one peak. It stood well clear of the noise.

5.81 hours, plus or minus 0.03. About eight percent in NC1, weaker in NC2, the way a varying hot component would show more strongly in the shorter band. He went to his visible photometry from March and looked for the same period. Less than 0.02 magnitudes. A two-kilometer body spinning in sunlight would have shown at least a tenth, from shape alone. This was not spin. The heat was going up and down and the body was not turning to do it.

He folded his eleven glints on the infrared period. The difference in light-time between L1 and Izaña was about 2.5 seconds, which he wrote down and ignored. Nine of the eleven fell in the third of the cycle where the infrared was lowest. He shuffled the glint times against the phase and counted how often chance did as well. About four times in a thousand.

He sat with the fold on the screen and did not run it again. Then he carried the period forward to the first minimum that would fall after dark at Izaña and inside a Surveyor visit. He wrote it in the notebook in his square hand, with the error he had earned and no less:

*06.05.28 21:47 UT ± 1.1 h.*

He took it to Rita the same afternoon.

“One more night,” he said. “The sixth of May.”

“The station is with the laser people from April.”

“I know.”

She looked at the notebook, not at him. “What happens if it does what you say?”

“Then it is a result,” he said. “And I will have to describe it as one.”

. . .

She found him the night. Someone’s terminal test had slipped, and Rita had been on the phone to Tenerife before the slip was official.

On Saturday 6 May Kessler ran the telescope from his office in Darmstadt, with the night assistant at Izaña on an open line. At the observatory it was an hour earlier. The assistant reported the cloud low and flat over the north coast, the seeing good. After that he spoke only to read off the humidity.

K-L5-07 was already in the frames at dusk, faint, low in the west. The comparison stars were steady. He watched the UT clock in the corner of the screen go past 21:40. That was Surveyor's visit; somewhere above the Earth's day side a telescope was looking at the same two kilometers. He did not know yet what it saw.

At 21:58 the object brightened. A tenth of a magnitude, carried through consecutive frames, a few minutes, and then it was itself again.

He did not say anything. He checked the airmass, the guiding log, the dome position, the flat field under the track.

"Still clear here," the assistant said. "It is getting low."

He took frames until the object set into the cloud. There were no others.

Before midnight the quick-look from Surveyor came through the pipeline Glen's people had set up. One visit, 21:40 UT. He put the NC1 point on the fold. It sat at the bottom of the curve.

He opened the notebook to the page with the prediction on it and wrote underneath, without an open circle:

*21:58 UT. One. Inside the window.*

3

# Night Side

*JPL, Pasadena · Monday, 15 May – Tuesday, 23 May 2028.*

Glen's forward landed at 15:42 on Monday, while Dana was losing an argument with Horizons about which frame she had asked for.

From Glen Farris
Sent Mon 15 May 2028 15:42 PDT
Subject FW: ESA-ESOC-PDO-TN-2028-017 (draft, rev 3)

INTERNAL HEAT SOURCE!! Somebody in Darmstadt has been reading Arthur C. Clarke. Bring it Thursday, we'll do a dramatic reading.

> ESA-ESOC-PDO-TN-2028-017, draft, rev 3, 2028-05-09. M. Kessler, R. Albrecht
> 1. Colour temperature 170–210 K above sunlit models.
> 2. 5.81 ± 0.03 h; 8 ± 2% in NC1; nothing in the visible (< 0.02 mag).
> 3. Transients at the infrared minimum (~3σ). Predicted minimum of 6 May confirmed by Surveyor (21:40 UT). One OGS transient within window, none outside.
> 4. Not explained by solar heating. Possibly calibration of commissioning data (being assessed), unusual surface properties, or a residual internal heat source.
> 5. Continued monitoring. No public statement.

Glen had put his exclamation marks on the one phrase in the note that had been placed where a reader would skip it. He would do the voice on Thursday, too. He had a voice for ESA documents, a little Werner Herzog, and it always got a laugh from the postdocs.

She read item 3 instead. Glen hadn't. A prediction, made in advance, by somebody with something to lose, and met. In her experience anomalies did the decent thing when you booked telescope time for them, and went away.

Item 4 she read slowly. It was ranked the way frightened people ranked things: the explanation that cost you nothing first. Calibration of commissioning data, with *being assessed* in brackets, which meant somebody had been asked and hadn't answered. Unusual surface properties, which was a drawer you could put anything in, except that nobody beat NEATM by two hundred kelvin with a funny regolith. Then the third one.

*Residual.*

If you had one temperature and a model and a gap between them, you wrote *internal heat source* and let people laugh. *Residual* was a different word. Heat that was left over, and heat that was left over was heat on its way out. You didn't get that from one epoch. You chose that word because you had watched the number go down, week after week, and you couldn't bring yourself to call it anything that didn't say so. There was a curve in Darmstadt, and it wasn't in the note, and somebody, Albrecht she would bet, the one who wrote the cover letters, had decided it was a curve too many for a draft going to JPL.

Dana had one like it. Hers was a folder on her laptop that the sync client had never been told about, and a square of paper in her bag with a date on it.

She replied to Glen: *Fun. Item 3 is the interesting one.*

He sent back a thumbs-up and, a minute later, *It's ALL interesting!! Rita wants a call in June, I'm thinking we co-author the orbit.*

· · ·

That week she did the work JPL paid her for in the daytime and the other work after six.

The Surveyor team had started pushing calibrated frames, four visits a day, and the new nights tightened her late fits until the last error bar no longer overlapped the first. Cutting the arc into three had been bad enough. She cut it into five. The plot came up with the units in the corner, $\times 10^{-9}$ au/d$^2$, and five points walking up toward zero:

$-1.9 \pm 0.5$. $-1.7 \pm 0.4$. $-1.5 \pm 0.25$. $-1.25 \pm 0.2$. $-1.05 \pm 0.2$.

The braking was getting weaker. She fit a line and got a slope a little over two sigma from flat. Two sigma on five points was what you got when you wanted something, and she knew exactly how badly she was wanting it, so she spent Wednesday night trying to make it go away. She dropped the first segment. She dropped the last. She inflated every error bar until she'd have been embarrassed to show it. It kept coming back a little over two, and climbing as the nights came in.

The line reached zero in August, with weeks of slop on either side. The slop covered the date in her bag, comfortably.

· · ·

At eleven on Tuesday night, the 23rd, she was still in her office with the PDF of the technical note open to its last page, where the distribution list gave a direct line for M. Kessler, ESOC, with the country code and everything.

It would be eight in the morning in Darmstadt. She didn't email Glen. Glen would make it a call with an agenda and Rita on it and a slide about data rights, and by the end of it the only thing anybody would have said out loud was *co-author*.

She dialed from her cell.

"Kessler."

"Dr. Kessler, it's Dana Okafor at JPL. I'm sorry, I know it's early."

"It is eight. I am at my desk." A pause. "Is Glen with you?"

"No."

The pause after that was long enough for him to understand it.

"You fitted non-gravs," she said. "On the video call I said ours was the same. It's not the same anymore. I've got it in five segments now, and it's weakening. The trend's a little over two sigma." She heard herself go on. "A line through it hits zero in August."

It was the first time she had said the month to anyone.

"August," he said. "I have July. But my arc is shorter. Your arc is longer, and you have Catalina at the front of it. August is probably better."

He had done it too. Of course he had. Somebody who caught a dozen glints and didn't trust them would have fit a line through anything that held still.

"You have a cooling curve," she said.

The line was quiet. She could hear an office on the other end, a door, somebody's chair.

"Yes," he said. Keys. "I will send it now."

It arrived while he was still on the line. Thirteen points, weekly medians of the infrared channel at the cycle minimum, 20 February to 14 May, forty to ninety frames behind each. Every week lower than the last. The thirteenth sat at about 0.82 of the first. She fit it before she had decided to and got −1.5 ± 0.1% a week, with residuals so dull she wanted to take them apart.

"Your first weeks are commissioning data," she said.

"Yes."

"Your first four points could be the camera cooling down, not the target."

"The frames since commissioning say the same." He had been waiting for that one. "Take out the first four. The slope is the same within the error. I will send that also."

"Send that also."

"Now yours," he said. "Your early segments were not all reduced against the same reference stars."

"Some were. Not all."

"Then part of your slope could be the star catalog changing under it."

"Could be."

"I can reduce your nights against ours. The same reference stars we use for the ESA frames, all of them, one pipeline. If the slope is still there after, it is not the catalog." He went on before she could thank him. "And there is a better test. If it is a natural Trojan, it has been at L5 a very long time. It should be in the old surveys."

"And if it isn't?"

"Then that is also a result." Keys again. "I can start this week."

She looked at the thirteen points. They were too smooth to be a camera.

"Run it back," she said.

"My model is crude."

"Run it back anyway."

"A slab. Conduction inward, radiation outward, sunlight on top. Nothing clever." He was quiet a moment, looking at the number again before he said it to somebody at JPL. "If I run it backward, a few years ago the outer meters were near the melting point of iron."

"Impact."

"I thought so. But an impact that puts that much heat into the surface of a two-kilometer body breaks pieces off. There would be a family. Debris on nearby orbits. Dust, at least. You have looked at it in your stack."

"A point."

"A clean point. There is no dust." He said it as if he had looked for dust for a long time and resented it for not being there.

She wrote *no ejecta* on the pad beside her keyboard and then didn't know what to write after it.

"There is one more thing," Kessler said. "It is not in the note."

"Rita took it out."

"Rita would take it out. I did not give her the chance." He didn't sound proud of it. "She is right to be careful. She took out less than this, before, and she was right then also."

"Go on."

"At a phase angle near sixty degrees, Surveyor sees a crescent of the night side. About a quarter of the hemisphere. It is enough to fit day and night separately, each week. Two temperatures, not one." He stopped. "The night side is the warmer one."

"In how many weeks?"

"In all thirteen weekly fits."

Dana did the arithmetic. 20 February to 14 May. A quarter of the way around the Sun. A rock that didn't turn at all would still have had the Sun walk a quarter of the way around it in that time, and the warm face would

have come into the light. A rock that turned would have shown it sooner. To keep one face dark for a season, something had to be turning it, slowly, a quarter turn in a quarter year, to match.

There was a short list of things that kept one face away from the Sun for a whole season. She knew the first item on it, and the second, and didn't go further.

"You have a pole solution?" she said, because it was a question with numbers in it. "From the visible?"

"There is nothing in the visible. Less than two hundredths of a magnitude. Only the glints, and eleven glints are not a pole." He breathed out. In Darmstadt, somebody said his name from a doorway, and he said something short in German, and the door closed.

"Dana," he said.

"I'm here."

"It is holding attitude."

4

# Come to Rest

*JPL, Pasadena · Tuesday, 11 July – Wednesday, 13 September 2028.*

Glen had printed it. Nobody in the branch printed anything anymore except travel vouchers and Glen's drafts, which came with a pen clipped to the corner so you'd know he wanted marks and not a conversation.

"First L5 Earth Trojan," he said, from the chair on the other side of her desk, before she was past the title. "Say it out loud. It doesn't get old."

She didn't say it out loud. The abstract was good. The orbit section was hers, nearly word for word, with the libration figure she'd made in March and a caption he'd improved. Then the bottom of page four.

*The along-track residuals show a weak systematic trend, probably astrometric in origin, which does not affect the libration solution at the precision reported here.*

She'd written *probably astrometry* to him in March, in an email she'd sent too fast, and he had lifted it and fixed her grammar.

"I can't sign it with that in."

"It's your sentence."

"It was my sentence in March. The trend's been past three sigma since June. Astrometry doesn't get better on a schedule."

"So what is it?"

"A residual I can't model yet."

Glen tipped his head back and looked at the ceiling tile with the water stain, which was where he went to think about Tucson. "If we say we don't know, somebody makes us find out. That's a revision cycle. And somewhere in Tucson a guy with a Catalina queue and a free weekend publishes the libration orbit while we're writing a response letter."

"Nobody in Tucson has linked it."

"Nobody in Tucson has linked it *yet*." He said it fondly. "What do you need?"

"It goes to zero in August. If it does, I'll know what it is. If it doesn't, you get your sentence back."

"Your zero." He took the draft back, unclipped the pen and clipped it again. "Okay. We wait for your zero. Meanwhile I'll talk to the Surveyor people about the infrared. If we're waiting anyway, I'd rather wait with their data in our paper than with Kessler's." He was already up, already halfway to his next meeting in his head. "First L5 Trojan, Dana. They're going to put it on a slide at DPS."

· · ·

Kessler's reduction arrived the last Thursday in July, a little after midnight his time.

She had sent him her nights in May. He'd run them through his own pipeline, against Gaia, with his own plate solutions and his own idea of which stars to throw out, and sent back two columns side by side with no comment on them. His values and hers walked down together. Around mid-July both said about −0.38. Where they disagreed, his error bars were larger than hers, which she took to mean he'd been harder on her data than she had.

Kessler didn't editorialize, so the absence of a sentence telling her she'd been right was not information. She went down it row by row anyway.

The precovery came in the middle of August, a PDF with one line on top of the email.

*Empty. It is new.*

The note was a few pages and as dry as anything ESA had ever produced. A Pan-STARRS and Dark Energy Camera search of the L5 region for Earth Trojans, run in 2025 and 2026, had covered every position the backward orbit allowed, down to about 22nd magnitude. Somebody had wanted an L5 Trojan badly enough to spend real telescope time looking for one, and they'd been on exactly the right patch of sky, deep enough that a two-kilometer object would have been the easiest detection in their survey. The field was empty. The note listed the fields, the epochs, the limiting magnitudes per night, a completeness estimate, and a footnote on a single NEOWISE frame from 11 March 2024, well off any backward path, excluded as a probable artifact and not reviewed further. Then a figure: the backward ephemeris drawn across the survey footprints, a cone of positions widening into the past, every one of them covered and every one of them blank.

She saved the PDF into the folder on her laptop that didn't sync, and went to get lunch, and came back and opened it again.

· · ·

August was five Thursdays.

Glen had stopped doing the ESA voice somewhere in July and replaced it with a question, asked at the end of the meeting with his folder already closed: “Zero yet?” Her slide was the same slide every week with one more point on it. The 6 August window came in at −0.13, with a sigma of 0.13, and her summary line read *A2 consistent with a monotonic approach to zero; current window consistent with zero at one sigma*. The next week was smaller, and the line didn’t change. In the orbit, what it meant was that the libration center was still drifting, centimeters per second relative to L5, and the drift was falling.

“Consistent with,” Glen said, the third Thursday, writing it on the whiteboard in the corner under the date. “Very JPL. Very legally defensible.”

“It’s what the error bar says.”

“I know what an error bar says.” He capped the marker. “I’m just saying, the day you say *is*, I’m buying.”

· · ·

On the Saturday of Labor Day weekend she ran the provisional window on the couch, data through Friday, with the laptop on a pillow and the window unit going, and the sign came back plus.

It was a small plus. It sat well inside its own error bar, and on its own it meant nothing, because a single window centered at zero was going to come up plus about half the time. She knew that. She went after it anyway, because the shape of the series mattered more than the sign of the last point, and if the shape was wrong she wanted to find out on a Saturday and not in front of Glen.

She dropped the worst night. Still plus. She swapped her reduction for Kessler’s and reran the whole series against his stars. Plus, a little larger. She changed the weighting from her own to the textbook default she’d been arguing against for years. Plus. She put back the observations she’d rejected in April as outliers, the ones she’d always been a bit embarrassed about rejecting, and the curve wobbled and came through the same place. She refit gravity-only from scratch as a sanity check, because by eleven at night she no longer trusted that the code was running what she thought it was running, and the gravity-only orbit was the orbit it had been since March to within its errors, with residuals of the same shape.

The spline through the weekly values put the crossing at 23 August, plus or minus twelve days.

The slow drift had gone through zero and was sitting there. Not reversed in any way she could measure. Stopped. Whatever had been

pushing on it, the push had come off, and the libration center had come to rest where she'd been told it would come to rest by a straight line she had drawn through noisy points in March.

The bag was on the chair by the door. The note was in the inside pocket, *8/21* in her own handwriting. The 21st was two days off the spline's center, and well inside its error bar. She thought about taking the note out and looking at it, and didn't, and didn't throw it away either.

· · ·

On Monday she was at the kitchen table at seven with coffee and the series open when Kessler's email came in.

The subject line was *5.81*. The body was empty. The attachment was one plot: his phase-folded light curve, one trace per week, stacked down the page like a seismogram. The cycle he'd been tracking since spring sat clean and repeatable at the top, one deep minimum every 5.81 hours. Down the page it shallowed. In the third week of August the shape went, and what was left was a flat line with noise on it, week after week, to the bottom of the page.

She opened her rolling plot, the weekly A2 values with their error bars, the spline drawn through them, the dashed horizontal at zero and the place the curve met it. She exported it, attached it to a reply, deleted the *Re:* he'd have known was there anyway, and sent it with nothing in the body.

It was a holiday. She cleaned the kitchen. A little after two in the afternoon, eleven at night in Darmstadt, he answered.

*Coincident. I cannot say more than that.*

· · ·

The memo came back on Wednesday the 13th.

She'd sent it out the Thursday before, the way she'd sent one every few weeks since June: the rolling solutions, every third window, a paragraph of method, a paragraph of caveats. Routine. It went to the Planetary Defense Coordination Office because everything about a newly characterized near-Earth object went to the Planetary Defense Coordination Office, and usually what came back was a read receipt.

This came back as a PDF.

**CUI//NOFORN**
JPL Interoffice Memorandum 392R-28-047  2028-09-07
Controlled by: NASA Planetary Defense Coordination Office
POC: D. Okafor, JPL/CNEOS
Rolling non-gravitational solutions, 21-day windows

| Center | A2 (1e-9 au/d^2) | sigma |
|---|---|---|
| 2028-05-14 | -1.05 | 0.20 |
| 2028-06-04 | -0.93 | 0.17 |
| 2028-06-25 | -0.66 | 0.15 |
| 2028-07-16 | -0.38 | 0.14 |
| 2028-08-06 | -0.13 | 0.13 |
| 2028-08-27 | +0.01 | 0.14 |

CUI//NOFORN

She went through it for what had moved. The numbers hadn't; they were hers to the last digit, her method paragraph, her caveats, the typo in the second caveat she'd meant to fix. The only new things were the banner at the top and the same banner at the bottom, the control line, and a distribution page that hadn't been hers.

Nine names. Most were NASA addresses she half recognized from planetary defense telecons. One ended in energy.gov. One was on the National Security Council.

Glen was in her open doorway.

"You've seen it."

"I'm looking at it."

He didn't come in. He stood in the doorway with one hand on the frame, and he had a folder under his arm that wasn't the draft. "Washington wants a briefing. Next Thursday."

"Who in Washington?"

"The distribution, I'd assume." He tried a smile and it mostly worked. "It's yours. They asked for you by name. Well. By POC."

"And the paper?"

"The paper's fine. We just don't submit anything till after Thursday." He tapped the frame twice, the way he ended phone calls. "Probably it's nothing. Somebody at Headquarters saw *non-gravitational* and *L5* in the same subject line and got excited. Get me your slides by Monday, I'll look them over."

He'd said *probably* about something he'd printed and was going to put on a slide at DPS. He went down the hall without the draft.

· · ·

After he'd gone she worked out how it had been done.

Nobody had needed to hold anything. The tracklets were in the Minor Planet Center's public files and had been all along. Nobody else had linked them. Nothing she'd found was in print. Glen's draft was a paper copy in Glen's folder, and the paper was on hold. Nothing had been published to suppress. The government only had to own the analysis, and the analysis was hers. Her linker, her fits, her table, her name in the POC line. They'd drawn a box around what she had and written on the box.

What she couldn't work out was where Monday sat.

She didn't know the rules for controlled information well enough to be sure. She knew the shape of them: you didn't decide what was controlled, the control decided, and it didn't much care what order things had happened in. On Labor Day morning she had sent a plot to a foreign national at a foreign agency with no text, from her personal laptop, at her kitchen table. On Monday the plot had been hers. On Wednesday the same numbers were under a banner that said NOFORN, which meant exactly him. She could imagine somebody at the far end of that distribution page reading it as the first disclosure of a controlled analysis and not caring that the control had come after the fact. She didn't know that anyone would.

Her inbox was open in the other window. The memo sat at the top. Directly under it was Monday's thread, with his subject line still on it, *5.81*, and the last thing he'd sent her.

Beside it the banner ran across the top of her table, and across the bottom. Darmstadt was on the other side of it.

5

# Most of It

*Washington, D.C. · Thursday, 21 September 2028.*

Glen had the draft open on his tablet before the plane left the gate.

"I moved the thermal section to an appendix," he said. "Kessler's numbers, cited, one paragraph. Keeps the referees on the orbit." He scrolled. "First Earth Trojan at L5. Nobody's ever had one. The biggest L4 one's about a kilometer. This is two."

"About two."

"About two." He was grinning at the screen. "The Jupiter Trojans got Lucy. Somebody's going to want to come here. If it holds up, it's a target. Not this decade, maybe not ours. But somebody writes the mission concept, and the people who found it are on it." He looked over at her. "That's the branch for ten years, Dana. That's a line in the budget with our names next to it."

She told him it was a good draft. It was.

He was asleep over Kansas with the tablet on his chest. She didn't sleep. The September memo was in her bag, printed, because she hadn't wanted it on a screen on a plane, and she didn't take it out. She knew what was on it. Nobody put an asteroid's ephemeris under NOFORN. Glen had read the same nine names, and he had moved the heat to an appendix.

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The building was a tan federal block a street south of Independence Avenue, with a flag over the door and a loading dock beside it. The guard had their badges printed before they reached the desk. Upstairs, phones went into a wooden cubby outside the door, each in its own numbered slot.

"Facts only," Glen said in the corridor. "No heat sources."

"The heat's a fact."

"The heat's Kessler's fact. What makes it isn't anybody's." He held the door for her. "Twenty minutes. They'll want to know if it's going to hit anything, and it isn't."

The room had no windows and ten people in it, counting the two of them. Nobody gave a name. The woman at the head of the table had been a voice on planetary defense telecons for a year, and in person she introduced herself as PDCO, as if they had never spoken. The rest went round by office. OSTP. Energy, a man younger than Dana expected. A Space Force lieutenant colonel, his cap on the table. Someone from NASA headquarters. The National Security Council staff, a man in a gray suit with a legal pad. The two at the far end nodded when it reached them, and PDCO moved on without waiting. The man from Energy and the woman from OSTP had left an empty chair between them. Everyone spoke to the head of the table and not to each other.

She gave them twenty minutes, all of it, in order. Her half, then Kessler's: what his office had circulated and what he had sent her since.

She said what each slide said and stopped.

The colonel went first. "Can it hit anything?"

"No. It's at L5. Earth's orbit, sixty degrees behind us. It's 150 million kilometers from here, and it'll stay there."

"For how long?"

"If nothing moves it, longer than we've been keeping records."

He wrote that down.

"What is it?" the woman from OSTP said.

"A dark body, about two kilometers across. Warmer than it should be."

"That's what it looks like. What is it?"

"I don't know."

The NSC man had his pen capped. He waited until she looked at him.

"Could it be a spacecraft?"

She had "consistent with" ready. She had used it all morning, and it would have done again. But the slide behind her was the one with the crossing on it, and she had spent six months trying to make that line mean something else.

"Nothing I know of in nature does this," she said. "The only model that fits is a powered one: braking along the track, to a stop at L5."

"So it's a spacecraft."

"It could be. I'd want more data than I have."

"You've tried the natural ones."

"The ones I know of."

"And?"

"They don't fit." She heard how that sounded and tried to take some of it back. "That's a statement about my models. There are things in the solar system nobody has modeled. Something new is still more likely than—" She stopped there.

"But you can't rule it out."

"No."

He uncapped the pen, wrote one line, and capped it again.

She looked at Glen. He wasn't looking at her. He was looking at the slide, at the solutions coming down to the line and stopping on it, and she watched him arrive where she had arrived. He didn't argue it. When he turned to her he gave her a small nod, the one he gave when a result held up under review, and there was nothing in it against her. Then he looked down the table at the two people who hadn't given an office, and she saw the rest of it reach him: what a room like this did with a result like that.

"Who else knows?" the woman from OSTP said.

"Darmstadt."

"ESA."

"Yes."

"All of it?" the NSC man said.

She thought of a plot with no text on it, sent from her kitchen on Labor Day Monday.

"Most of it."

At the far end of the table, one of the two took out a pen and wrote a word on an index card.

. . .

The rest took fifty minutes, and nobody raised their voice.

"Is anything in preparation for publication?" PDCO said.

Glen answered, because it was his. "A draft. We were going to submit after the crossing."

"We'll ask you to hold it."

"For how long?"

"Until there's guidance."

"Okay," Glen said. He didn't look at Dana. He moved his tablet an inch toward the middle of the table, as if someone might want to take it.

The man from NASA headquarters asked what she would do with Hubble. She told him: a spectrum, to see what the surface was made of; photometry, to see whether the brightness held. She had asked for six orbits three cycles running and never gotten one. She asked for twelve.

"Write it for forty," he said. "The Director will see it this week. It won't go to the committee."

Forty orbits was a career. She wrote *40* on her pad, and the pen felt odd in her hand.

"Do you have the expertise you need?" That was the man from Energy, his first question of the morning. "On the thermal side, the materials side. We can find people."

She heard what it meant: other people, cleared ones, with her table in front of them. "I have what I need."

"Think about it," he said, pleasantly.

At the end PDCO read from a single sheet in the voice people use for fire exits. The September analysis and anything derived from it was not to be discussed with anyone outside the distribution. That included foreign nationals, and it included partner agencies. No talks, no preprints, no informal correspondence. Figures counted as derived. Questions about handling went to the designation block.

Nobody looked at Dana while she read it. Dana looked at the sheet.

· · ·

The hotel was a block from L'Enfant Plaza, and the air conditioner knocked on and off every few minutes. She ate half a sandwich over the laptop and opened the September solutions. They came up under the banner.

A few minutes after ten the mail chimed.

From Matthias Kessler <matthias.kessler@esa.int>
To Dana Okafor <dana.okafor@jpl.nasa.gov>
Date Fri, 22 Sep 2028 04:06:51 +0200
Subject September

Dana,

Rita had a call from headquarters yesterday evening, at half past six. Paris. She did not tell me what was said. She has asked me to hold the thermal note and send nothing outside the office until she has spoken to them again.

Could you send me your September solutions? I would like to check the crossing against my own astrometry. Mine are crude.

Matthias

Half past six in Paris was half past twelve here. At half past twelve she had been in that room, watching PDCO read from her sheet.

It was four in the morning in Darmstadt. Since May he had sent her everything she asked for, the minute she asked. He had never once asked for anything back until tonight.

The solutions were open in the other window. Twenty-six rows, the crossing a few rows from the end.

She clicked reply.

*I can't send them because* — she deleted it.

*I've been asked not to* — asked by whom, he would think, and he would be right to.

*It isn't my decision* — which told him whose it was.

*I'm sorry. I can't explain yet.* That one was closer, and *yet* was the only part she meant.

She cut it down until it was nothing he could forward and nothing she would have to take back, and sent it before she could find what was wrong with it.

To Matthias Kessler <matthias.kessler@esa.int>
Subject Re: September

Not yet.

D.

ACT TWO

# Earth Line

**ESA · ESOC Planetary Defence Office · internal note, not for circulation · M. Kessler · 12 September 2028**

The 2025–26 search shows it was not at L5 then. It arrived between late 2026 and this spring, and nobody saw it come. Most paths that would bring it here in that time put it above a survey limit at least once. The rest stay within about 45° of the Sun, as seen from Earth, for nearly the whole approach. It came in on one of those.

*In pencil, beside the last line:* Lucky. Or it has done this before.

6

# Why Do You Ask

*JPL, Pasadena · Monday, 2 October – Tuesday, 5 December 2028.*

The program came through on the first Monday in October, from a program coordinator in Baltimore who had plainly been told to move fast and not to wonder why.

*Your Director's Discretionary program has been approved for 40 orbits. Please submit Phase II by Friday so we can begin scheduling as the solar constraint allows.*

Forty orbits, no panel, no ranking, no year's wait behind the people studying galaxy clusters. Twelve months proprietary, which Director's time almost never got and which somebody had asked for on her behalf. Nobody on Earth could pull a frame of it out of the archive until October 2029 unless she handed it to them. She opened the Phase II form. Someone at headquarters had already filled in the cover page from her request, and filled it in the way she would have if she had been being careful: Principal Investigator, D. Okafor, Jet Propulsion Laboratory. Below that, the co-investigator table, one blank row and a plus sign.

In March she would have typed Kessler into that row before she finished reading the email, Darmstadt after it, because the light curve was his and the light curve was half the reason anyone would believe the orbit. Glen would have gone in under him, and Glen would have asked to go above him, and they'd have had a short stupid argument about it at the coffee cart.

She tabbed past the row to the target page, where the trouble was. Hubble had been flying on one gyro since 2024 and wouldn't point closer than 50° to the Sun. The object sat at 60° and always would, so every visit had to fit in the slice of each orbit where the planner would allow it, with the roll pinned and no slack, and on one gyro it could barely follow anything moving a degree a day; the program ran on a tracking waiver, short exposures stacked on the motion. She laid out the visits two a week and the planning tool turned half of them yellow.

Glen came by at four with his reading glasses pushed up.

"Forty," he said.

"Forty."

"You're PI."

"It's my request."

"Sure." He looked at the screen, at the cover page, and if he saw the one-row table he didn't mention that his name wasn't in it either. "Good. That's good, Dana."

. . .

The STIS spectrum came down on the seventeenth, two low-resolution gratings stitched at 0.55 μm and divided by a solar analog she'd had them take in the same visit. She had prepared herself for something that would make her think about instrument artifacts for a week, and she got a line instead.

Flat from 0.4 μm to 1.0 μm, tilting a few percent red toward the long end. No 0.9 μm dip, no 1 μm band, none of the pyroxene and olivine bands that every stony asteroid in the catalog showed somewhere. She put Psyche's spectrum over it from the literature, scaled at 0.55, and the two curves sat on each other inside the error bars, except at 0.9 μm, where Psyche had its faint dip and this had nothing. An M-type. Iron and nickel, give or take whatever hid under a featureless spectrum, which was a lot, and which every iron-meteorite person in the field would remind her of at length.

Glen had it printed and on his door by lunch.

"It's a little Psyche after all," he said, leaning in her doorway with his coffee. "I said it in April. I'll take April."

"You can have April."

"Metal at L5. That's a paper by itself, never mind the rest." He was already doing it in his head, she could see, the short version, the one that might get out from under the hold if it had nothing in it about heat. "Iron's dull. Iron's allowed."

He was pleased with it through Wednesday. Thursday morning the printout was gone from his door, and when she passed he was at his desk with the spring light curves open, Kessler's, not hers, and he closed the window when he saw her. He didn't say anything about it until Friday, in the hall, when he said only, "Psyche doesn't stop," and kept walking.

. . .

The routine settled in through the back half of October: a visit, the frames into the pipeline overnight, photometry in the morning, astrometry into the orbit fit by noon. Most days nothing in it was worth a sentence.

The glints were worth one. Kessler had seen them in March at a rate of one every few hours of tracking. Hubble saw one most visits now. She had nine visits by the end of the month and seven of them had a spike, some of them two, a few of them close to half a magnitude for a single exposure. She folded them on 5.81 hours because she had to and got a flat smear of points with no structure in it, which she'd expected, since the cycle had died in August. She folded them on everything else she could think of, half of 5.81, double, the Hubble orbit, the visit start times, and got the same smear.

Glen stopped in her doorway without tapping the frame.

"Got a minute?"

"Come in."

He didn't. He stood there and looked at the plot on her second screen, the spikes marked in red against the baseline.

"It's cracking," he said.

She waited for the rest of it, the line about thermal stress that would turn it into something they could laugh at over lunch. He didn't have one.

"Iron that was near melting three years ago," he said. "Cooling at a percent and a half a week, from the outside in. It's going to split. Every time it opens a fresh face you get a flat new surface for a while, until it rotates out of the geometry." He shrugged. "That's what I'd write."

"It's holding attitude."

"Then it's holding attitude and cracking." He looked at the plot a moment more. "I'm just telling you what I'd write."

Later she heard his door close, which it usually didn't.

· · ·

In November she masked the glints out and fit what was left.

The masking was simple. Anything more than three sigma above the running median of its own visit, plus one exposure either side of it, went. What remained was a baseline that she'd been treating since October as the one boring number in the program, and when she fit a line to it the slope came back at −2.0 ± 0.3% per month.

V 17.91 on the first visit in October. V 17.95 on the visit before Thanksgiving.

She went through the comparison stars first. Six field stars in the same WFC3 frames, through the same filter, on the same chip, and every one of them flat to 0.3% across the two months. She checked the geometry

next and didn't need long for it. Its loop around L5 changed the distance and the phase angle a little over the year, so she reduced every point to unit distance and a fixed phase before she fit anything. Nothing left in the viewing could take 2% a month out of it.

The detector's charge-transfer losses, corrected two ways, moved it to −1.9. The one-gyro jitter showed no trend in the field stars. The mask was hers, and she knew how a mask could make a trend somebody already half believed in, so she let the pipeline pick the spikes at its own thresholds and kept none of her choices. −2.0 ± 0.4.

On Friday Glen asked about it in the hall, on his way to the stairs.

"Comparison stars?"

"Flat."

"How flat?"

"Three tenths of a percent."

He didn't ask what the slope was. He stood there long enough that she thought he would, and then he said he'd see her Monday.

· · ·

She wrote to Kessler on the Tuesday after Thanksgiving, in the morning, so it would land in his evening and not in the middle of his night.

It was the first thing she'd sent him since *Not yet*. She didn't put a greeting on it or a subject line he could forward with any sense.

*Does a cooling metal surface darken in the visible? D.*

His answer was waiting when she came in on Wednesday, sent at 06:40 his time, which meant he'd read hers before he went to bed and slept on it.

*No. Iron in vacuum does not oxidize. There is nothing there to oxidize it. Cooling changes the thermal infrared, not the visible; the visible reflectance of iron-nickel is almost flat with temperature over the range we are talking about. If anything, a cleaner and cooler metal surface reflects slightly better. You would expect it to brighten by a small amount, if it changes at all.*

*Why do you ask?*

*M.*

He hadn't asked what she'd done with his solutions, or whether Washington had read his cooling curve, or why the line from Pasadena had gone quiet for ten weeks. He'd answered the physics completely and correctly, put the one question at the bottom where she couldn't miss it, and signed it with one letter, the way she had.

She wrote the answer that afternoon, the whole of it, and the one sentence she hadn't let herself say out loud. It took most of an hour. She read it once and saved it.

At five Glen asked if she wanted to get a drink, and she said she had a call. When she closed the laptop the folder in the left margin said Drafts (1).

. . .

On the first Tuesday in December she built the deep stack.

Sixty-eight WFC3 frames from every visit since October, every glint exposure thrown out, each frame shifted on the object's predicted motion and median-combined so that the field stars smeared into faint dashes and the object stood up alone in the middle. It took the cluster most of the morning. What came back was a point. Sharp to the edge of the detector's resolution, the background flat and gray out to the corners, no coma, no fan, no tail along the antisolar direction or the orbit or anywhere else, down to a surface brightness she'd have needed the full forty orbits again to beat. She subtracted a model star from it, and what was left in the middle was noise.

So nothing was coming off it as dust or gas. She went to the orbit to check the other way it could be leaving.

She'd been carrying the astrometry since the crossing, every Hubble position and every ground position she could get, with the non-gravitational terms left free. Along-track, the term that had braked it all spring, came out at $0.02 \pm 0.06$, in the spring's units, which was zero. Radial was zero. Normal was zero. If it had been throwing material off at any speed in any preferred direction, at the rate the photometry wanted, she'd have seen the orbit flinch the other way inside a week. She ran the number on the back of the printout: a 2 km iron body losing 4% of its cross-section in two months was something like $10^{12}$ kg that wasn't where it had been in October. None of that mass had left with dust, and none of it had pushed.

7

# Low Priority

*Goddard Space Flight Center, Greenbelt · Thursday, 14 December 2028 – Thursday, 1 February 2029.*

Howard Lisle had spent the morning losing core-hours to the heliophysics people, and he wasn't done losing them.

The allocation sheet for the NCCS cluster was on one monitor and the meeting on the other, where a branch chief from Building 21 was explaining for the third time why the solar wind models could not run on less. Rain came off the parking lot and hit the windows of Building 34 sideways. Lisle had asked for 1,200,000 hours for next year so he'd get 900,000, and the cell had just gone to 780,000 with nobody's initials on the change.

He muted himself and went to the queue for something he could actually close before the break.

The ticket was near the top, already routed to his team. Reprocess NEO Surveyor opportunistic-target frames around target 2028-0417 for faint co-moving sources. Priority: low. Contact: D. Okafor, JPL/CNEOS. Somebody had attached the visit list, eight months of it, four a day whenever the survey pattern let the spacecraft swing over.

Surveyor's archive lived at IPAC in Pasadena, but the cutout pipeline for the opportunistic targets lived here. It was a postdoc job, and a good one: a known answer of probably nothing, and a method you could learn the whole cutout pipeline on. He had a postdoc who had started on the fourth and so far been issued a badge, a laptop, and the export-control training module.

He opened the record because he liked to know who to thank. Created 03:40 that morning by `svc-nsv-opsched2`. The staff directory had nobody by that name. The service-account registry had an owner field for every account in the building, and this one was blank. At 03:40, the login history said, nobody in the group had been on.

He had asked about it once, the summer before launch, and been told it was resolved. Some scheduler, then, that Surveyor operations had wired into the science queues without telling the science groups, which was how Surveyor operations did most things. He was grateful to them anyway. It came with a contact and a frame list, and it was December.

He assigned it to Priya Raman, typed *good one to learn the cutouts on — HL*, and unmuted in time to hear 780,000 become 740,000.

. . .

The week before Christmas, half the offices on Priya's corridor had a coat on the hook and the light off, and she had all 731 visits on local disk.

She read the ticket four times. It had her name on it now, under *Assignee*, and nobody else's. Target 2028-0417 was an unpublished co-orbital near L5 that Surveyor had been looking at since April; that was all the ticket said and all she looked up. Faint co-moving sources meant satellites, or debris, or nothing, and the pipeline she'd been handed assumed nothing.

She ran the first pass the plain way: difference each visit against a static-sky template and keep everything above 2.5 sigma that wasn't a catalog star or a known asteroid. Leftovers were supposed to be noise. Noise didn't know where the target was.

She binned them by distance from the target and plotted the counts per square degree. Flat from the edge of the cutout in to about a degree. Then rising. In the innermost bin outside her half-arcminute mask, 3.8 times the floor.

She checked the mask. She checked the template epochs, because a template built while the target sat in the field could leave a halo of its own. She rebuilt the templates from visits a week apart and the bump got slightly bigger. Then she put a fake target position a degree off in a random direction, ten times, ten directions, and binned around each of those. Ten flat lines. The eleventh, around the real position, still climbed.

She split the leftovers by band. NC2 alone: a small rise, 1.6 times the floor, inside the error bars of nothing. NC1 alone: 4.4.

She wrote it on the ticket as a comment, three numbers and a plot, and nobody replied, because the people who might have were in Florida or Ohio or asleep.

Her mother texted from Edison to ask whether she was driving up on the 23rd or the 24th, and whether she was bringing the laptop, because if she was bringing the laptop she should just say so.

*24th. Yes.*

She drove up the Turnpike on the 24th with the laptop on the passenger seat and the shift-and-stack grid half written. At the kitchen table in Edison, between dinner and the dishes, her father leaned over her shoulder at a stack of 40 frames shifted along a guess and asked what he was looking at.

"Nothing yet," she said. "That's the point."

He told her cousins it was satellites. She didn't correct him; it might have been.

. . .

On the 27th she was back in Building 34 and the shift-and-stack jobs were running on the cluster.

Her thesis had been the same trick on DECam frames, hunting for things past Neptune too faint to see in any single exposure: guess a motion, shift every frame along it, add them up, and look for a point that only exists if the guess is right. Trans-Neptunian objects moved in straight lines over a night. These didn't have to. She added an acceleration term to the grid, which multiplied it by forty-one, and spent part of the 27th apologizing to the queue scheduler in her head.

It took three days.

The first one came up on the morning of the 28th, in a stack along a track that curved: one pixel bright in NC1, 6.3 sigma, and nothing at all in the same frames shifted along the straight-line neighbor. She moved the guess one grid step off in each direction and watched it smear into the background four times. She moved it back and it was a point again. She looked for it in the individual frames and couldn't find it in any of them, which was correct.

She did not write anything down until she had found it again in a second, independent set of visits from the same week, at the position the fit predicted, to within a pixel.

When the grid finished on the 29th she had nineteen.

She went down the columns before she looked at the list as a list.

`T_fit`: 560 to 640 K, all nineteen. They were brighter in NC1 than NC2, which nothing in sunlight at 1 au should be, and the only reason they showed at all.

`D_therm`: 10 to 20 m.

`sep_first`: 0.6 to 52 arcminutes from the target at first detection.

`dir`: eleven out, eight in.

`a_fit`: the outbound ones, 2 to 4 mm/s$^2$, the arcs bending away from 1 au toward the belt, speed still building at the last frame. The inbound

ones had the same magnitudes with the sign the other way, slowing as they closed.

`t_first`: nothing before 4 September. She had frames back to April at the same depth. She looked twice.

She didn't trust a column she hadn't tried to break, so she broke it. She injected 400 fake movers into the real frames, drawn from the same temperatures, sizes and accelerations, at random positions inside a degree, and ran the whole pipeline blind on them. It found 51. She seeded it again and got 49.

`recovery`: 0.13 ± 0.02.

Then she tried to make them natural. Ice jetting off a fragment would have shown in the visible, and there was nothing in the visible. Sunlight on a fifteen-meter plate of iron gave about $10^{-7}$ of what the arcs needed. Debris didn't speed up in a straight line for nine days and keep going. She wrote the three on the pad and crossed out each one, and looked for a while at what was left, which was a word she wasn't going to put on a NASA sheet.

She didn't put a total anywhere on the sheet. Nineteen at one in eight was about 150, but 150 wasn't a detection, and her sheet held detections.

· · ·

On Wednesday, 24 January, with January's frames still coming down from L1 and a third injection run agreeing with the first two, she attached the sheet to an email to the contact on the ticket. Subject: the ticket number. Body: *P.*

Dana Okafor called the next afternoon at 4:10.

"Is this Priya Raman?"

"Yes."

"Dana Okafor, at JPL. You sent me a spreadsheet."

"The ticket. Your name's the contact."

A pause on the line.

"I didn't file it," Okafor said. "Glen must have."

Priya didn't know a Glen. She didn't ask.

"Your recovery fraction," Okafor said. "Is that combined, or NC1 alone?"

"Combined. NC1 alone it's one in eleven."

"And the accelerations. Constant along the arc?"

"Within errors. The longest arc is nine days."

"Did you fit a turn-off? Anything where the acceleration stops?"

"No. I can."

"Don't change anything yet." Then: "Nothing before September."

"I went back to April. Same depth."

Okafor said nothing for long enough that Priya checked the call. When she spoke again her voice was lower.

"You've looked for a natural way to get that."

"Three ways. None of them comes within a factor of a thousand."

"Then don't call them anything yet," Okafor said. "Call them what your sheet calls them."

"Who else has seen this?"

"Howard Lisle. My group lead. He saw the ticket close."

"Could you reopen it?"

"It's closed as complete. I can open a follow-up."

"On the same number, if you can. January's coming down," Okafor said. "You said so in the header."

Priya looked at the header of her own sheet. She had written *Jan pending* in the cell above `t_first`, in gray, and had not thought anyone would read the gray.

"There'll be more," she said.

"How close is the closest at first detection?"

"Half an arcminute. That's my mask. Inside that the target's wings eat everything."

"So you don't know how close they start."

"No."

Okafor asked about the template epochs, and about whether any two movers shared a track, and about the temperature fits, whether she had let emissivity float. Priya answered all of it. Okafor answered nothing, because Priya didn't ask her anything, and at the end she said, "Thank you, Priya. That's careful work," and hung up.

Priya opened a follow-up on the same number. Then she wrote two lines on the pad by her keyboard:

*Glen?*

*She wanted it. She didn't ask for it.*

. . .

On Thursday, 1 February, she sent the new version.

January had come down through the 22nd before the latency caught up with it. She ran the same grid, the same masks, the same injection test with a fresh seed, and recovery held at 0.13. Seven new movers in twenty-two days of frames. Twenty-six on the sheet now.

She had added a column, `Δ`, the month-on-month change in the count.

| month | Δ | N | per_day | out | in |
|---|---|---|---|---|---|
| 2028-09 | +2 | 2 | 0.07 | 2 | 0 |
| 2028-10 | +4 | 6 | 0.13 | 3 | 1 |
| 2028-11 | +5 | 11 | 0.17 | 3 | 2 |
| 2028-12 | +8 | 19 | 0.26 | 3 | 5 |
| 2029-01* | +7 | 26 | 0.32 | 3 | 4 |

* through 22 Jan

She sent it at noon, subject the ticket number, body *P.*, and went back to the arcs.

There was a tab she hadn't sent. She had fit the turn-off Okafor asked about, a constant acceleration that switched to zero at a free time, on every outbound arc. Fourteen fits, and for none of them did the switch land inside her frames; the best-fit time was always after the mover left the field, with the error bar running off the end of the data. The inbound ones were the same in reverse. They were already braking when she first saw them, and the start of the braking was always before that, out of view.

Okafor hadn't called. The phone on the desk had rung once, at 2:15, and it was someone from facilities about the badge readers.

Per mover she could get the momentum from size and speed, if she assumed iron. Turning that into a kick on the target needed the target's mass, which nobody had published, and its orbit month by month to a millimeter per second, which she had never seen and which one office in Pasadena might have.

At 5:40 she sent one more sheet. Same twenty-six rows, same columns, and one new column on the right, in the same bold as the others: `parent ΔV`. Twenty-six cells under it, none of them filled.

8

# Mass Unaccounted

*JPL, Pasadena · Thursday, 1 February – Thursday, 19 April 2029.*

The sheet with the empty column came in at 2:40 on the first of February, from Greenbelt, with nothing in the body.

Priya had built it so the column could only be filled from Pasadena. Dana admired that before she resented it.

To fill it she needed a mass, and not one mass but a mass for every row, because the object in September was not the object in January. It had lost about 3% of its mass a month since October, which was what 2% a month of light came to. The only reason anyone knew that was forty orbits of Hubble with one name on the proposal, and the only person outside Washington she had come close to telling was Kessler, and she had never answered him.

She went over it the way she'd go over a budget line she meant to defend. Priya was a NASA postdoc on a Goddard badge, as American as she was. The column was about mass. Nothing in it said braking, or L5, or August. The September memo had put the orbit under the banner and said nothing about the light curve, because in September there hadn't been one. Every piece of that would hold up in the windowless room, and none of it was why she opened the spreadsheet. Priya had sent her nineteen numbers, then twenty-six, then a column she couldn't fill herself, and in four months nobody else had sent Dana anything she didn't already have.

For iron, at the size the thermal fits gave and a shape a good deal flatter than a ball, the mass came out at $1.7 \times 10^{13}$ kg. She took it down month by month along the dimming, put a mass against every launch and arrival, and divided.

The kicks were small. Priya's tracks, run back to the object, left it at 20 to 40 m/s, and a 15 m mover of a few thousand tonnes going that fast moved $1.7 \times 10^{13}$ kg by a few micrometers per second. The column filled with $10^{-6}$. The largest was $8.7 \times 10^{-6}$ m/s, on an outbound in December, and

the inbound arrivals pushed the other way often enough that the running sum wandered around zero.

She sat back from it. Things the size of a house left the object and kept speeding up for days, and others came back slowing down, and this was the column that said they hardly mattered. Glen would say debris. Kessler would say *coincident*. She thought of something at L5 making small hot things and sending them out to the belt and getting some of them back, and didn't write that down either. Her own orbit since the crossing was good to about a centimeter per second over months and showed no push at all, which was what it ought to show. Three orders of magnitude sat between what the movers could do to it and what she could measure.

She attached the filled sheet, the mass table and the masked light curve with the comparison stars on the same axes, typed nothing, and sent it.

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Version seven came on the twenty-sixth of February. Priya had added a column.

It sat at the far right where `parent ΔV` had been, and it was mostly 99s.

| month | detected | fleet_est | carried_kg/s | loss_kg/s | mass unaccounted % |
|---|---|---|---|---|---|
| 2028-09 | 2 | 15 | 5.8e1 | 1.9e5 | 99.97 |
| 2028-10 | 4 | 46 | 1.8e2 | 1.9e5 | 99.91 |
| 2028-11 | 5 | 85 | 3.3e2 | 1.8e5 | 99.82 |
| 2028-12 | 8 | 146 | 5.6e2 | 1.6e5 | 99.65 |
| 2029-01 | 9 | 215 | 8.3e2 | 1.4e5 | 99.41 |

assumptions: recovery 0.13; payload 1.0e7 kg/mover (solid iron, 13 m);
one round trip per mover per month; fleet_est = cumulative / 0.13

Dana read the assumptions line. Ten thousand tonnes was a solid iron ball thirteen meters across, with nothing inside it but cargo. A round trip a month was faster than any of Priya's tracks could close. Every number Priya had a choice about, she had chosen against herself.

She called Greenbelt, which she had done once before.

"You made the payloads stupid," Dana said.

"On purpose. If I make them sane it's nines all the way across." Priya sounded like she was eating. "Even if I'm missing seven out of eight of everything, they're carrying under 1%. Probably a lot under."

"The recovery could be worse than an eighth for the cold ones."

"Then there are more of them and they're carrying the same per mover. I tried that. It's in tab four. You'd need ten thousand of them before

it's even ten percent, and the sky around it would be lit up." A pause and a wrapper. "Where's the rest going?"

"I don't know."

"It's your mass," Priya said, not unkindly, and hung up first.

· · ·

By the second week of March she had stopped doing it on the screen. She did it in pencil on engineering paper, the green kind with the grid on the back, because on paper she could see which step she had skipped.

The object was losing something like $10^5$ kg a second. Priya's movers, on Priya's stupid payloads, were taking under a thousand kilograms of that. The question was the other ninety-nine-and-change.

Gone as dust or gas came first, and she tried hard to keep it alive. The December stack was a clean point with nothing around it to the limit, and the February one was cleaner. Iron vapor would have shown in the spectrum, and the spectrum was flat. And anything thrown off at speed pushed back. She worked it on the margin: $10^5$ kg a second leaving at even 10 m/s was $10^6$ newtons on $1.7 \times 10^{13}$ kg, which over a month came to 15 cm/s, ten times what her orbit could see. She tried to save it by making it isotropic, so the pushes cancelled. Isotropic at that rate would have been a coma Catalina would have flagged in one night. She tried letting it go slower than escape speed, about 1.5 m/s off a body that size, and that finished the step. Material that left that slowly didn't leave. It was still there, or near enough to there that no telescope could separate it from the core.

So it was still there and it was unseen, and she wrote those two words on either side of a line.

Unseen didn't mean too small to split. At 1 au Hubble couldn't separate anything within thirty-odd kilometers of the core, so the whole pile was inside the point. Unseen meant it added nothing to the point: no light, no heat. Surveyor sat at L1, 1.5 million kilometers sunward, and Hubble went round in low orbit, and from L5 both of them looked from within a fraction of a degree of the same place. There was no instrument anywhere that saw the object from a different side.

Then the light. Anything sitting in sunlight beside the core added light to the point, and the point was getting fainter. A little less than 2% a month now. She tried to keep it in the sun and make it black. A layer of soot at a few percent albedo would add almost nothing in the visible. But a few percent albedo meant ninety-odd percent absorbed, and it would sit at 300 K in the Surveyor infrared, a second blackbody nobody had

seen. Surveyor still looked at it four times a day, and Priya had just been through every frame. She'd have put a second blackbody in a column.

So it was dark, and dark at L5 meant in the core's shadow.

Dark wasn't cold. Whatever had come off a core that hot would still be warm, and warm iron in Surveyor's view would have been a second heat source beside the first. Surveyor saw one warm face and nothing next to it. So the core hid it from Earth's direction too.

She drew it. The core a circle 2 cm across for 2 km. A line toward the Sun, a line toward Earth, 60° apart, because that was what L5 was. The shadow was a band behind the core along the sunward line, the blind spot a band behind it along the Earth line, each as wide as the core. Where they overlapped was a wedge on the far side, pointing away from both. For a core of radius 1 km the wedge ran out to 2 km from the center.

That put it within about a kilometer of the far face, on the night side. Loose material wouldn't stay in a wedge. That close to the core it would orbit in a few hours and smear into a ring. Something was keeping it where it was. Something like $2 \times 10^{12}$ kg since September, in the one place in the sky nobody could look.

She went through it again the next week from the bottom, cold, and again the week after, and at each step looked for the assumption she had walked past. She found two. Neither moved the wedge.

· · ·

She wrote the memo on the eleventh of April. It was a page.

Everything since February, in order, with Priya's movers as *a Goddard reprocessing of Surveyor frames*, without Priya's name. One line at the bottom: the region could be observed by an instrument off the Sun–Earth line, and none existed. ESA's Vigil, the one that would sit at L5 and look, was years from the pad.

JPL interoffice memorandum, CUI//NOFORN across the top and bottom in red, controlled by the Planetary Defense Coordination Office. The same distribution as September. She checked the nine addresses against September's one at a time. One of them sat in the Eisenhower building, across West Executive Avenue from the White House, and belonged to the man with the yellow legal pad.

She sent it at 9:40 on a Wednesday.

· · ·

By Monday there had been no read receipt she could see, no reply, no meeting request with a dial-in, no polite note from headquarters that it

had been passed along. In September the same list had put her on a plane to Washington within the month.

She checked the secure inbox the way she had once checked the Minor Planet Center's new-object page, first thing and again after lunch.

Glen put his head in on Monday the sixteenth.

"Have you heard anything about the paper?"

"No."

"Nothing? It's been seven months. I've got a student who wants to cite it." He leaned on the doorframe. "Somebody must have said something to you."

"I haven't heard anything about anything, Glen."

He decided it wasn't a joke he wanted.

· · ·

On Thursday the nineteenth she was in Kessler's spring 2028 thermal fits for a dull reason. Priya wanted the spin state to put launch directions in the object's own frame, and the only attitude anyone had ever measured was in Kessler's own fits, never in the note, built out of thirteen weeks of Surveyor infrared he had fitted one at a time in May.

She had his files. He had sent them the hour she asked.

He had fitted a two-face model in a frame tied to the Sun and Earth, because the thing held attitude and anything else would have been silly. Week by week a warm cap, its center inferred from how the heat came round the limb, with an error ellipse. She had read the warm face a year ago as heat leaking out of the far side of something that had been hot once. She hadn't looked at the direction since.

She took the pencil drawing out of the folder and turned it to match his convention, Sun at zero, Earth at 60°. Her wedge pointed along the far bisector, at 210°.

Nobody had ever seen that face, only the edge of its heat, and his ellipses were thirty and forty degrees across. All thirteen sat on the far side. Mean 209, plus or minus 10.

She laid the green sheet over his plot against the window, and the point of her wedge sat inside every one of his ellipses.

9

# Fifteen Months

*Animas, New Mexico, then JPL, Pasadena · Saturday, 19 May – Monday, 18 June 2029.*

Earl Voss had the roof rolled back by ten past eight, with the Sun a few minutes under the Peloncillos and the sky over the ridge still too bright for anybody's program but his.

The big surveys gave short shrift to the sky near the Sun after sunset. Earl had heard the reasons at three different meetings in Tucson and agreed with every one of them: the sky was bright, the good part of the night was short, and a forty-million-dollar camera had better things to do than fight the twilight for an hour. Earl didn't have better things to do, and that was his whole observing plan. In four years it had got him nine discoveries, all main-belt, all faint, and an email from a woman at the Minor Planet Center saying his timing was the cleanest she'd seen from an amateur that year. He'd read it out to his wife at supper, and again the next night in case she'd missed anything.

The telescope was a 20-inch on a fork mount he'd machined himself. He had spent thirty-eight years designing gearboxes for the haul trucks and ball mills at Morenci and Tyrone, and his right-ascension drive had less backlash than anything you could buy, which he would tell you about if you stood still long enough. He'd ground the secondary on the kitchen table over a winter, Ronchi-testing it at midnight until his wife quit asking when it would be done. The camera took its time off a GPS receiver bolted to the roof rail, every frame stamped to the microsecond. Half the people on the mailing list still used their laptop clocks and wondered why their residuals all ran two arcseconds along the track.

He was on his third field, 61° from the Sun, when the blink caught something at the edge of the noise. V 18.3, if that. He'd have thrown it out for a hot pixel except it was in the next frame too, a hair east, and in the one after.

He took twelve frames over 48 minutes and measured every one against Gaia stars, by hand where the software got lazy. It was moving

0.99° a day, east. Earl sat back and did the arithmetic again, slower. A main-belter out at that elongation ought to be crawling. Anything close enough to move that fast ought to be moving a good deal faster, and some other way. This one was keeping pace with the Sun.

He ran it against everything numbered and everything that wasn't. Nothing within a degree. He checked his clock, which he knew was fine, and his plate solutions, which were fine, and the temperature log on the tube, because thermal drift had fooled him once in 2026 and once was all he allowed it.

By twenty to twelve it was down in the junipers on the ridge. He closed the roof and wrote it up at the kitchen counter, and read it through before he sent it.

Subject Odd slow mover, W twilight, 2029 May 19

Friends -- 12 positions attached from Animas tonight, 03:02-03:50 UT May 20. V ~18.3, elongation 61 deg. Rate 0.99 deg/day, PA 78. Nothing known within a degree. Frames GPS-timed (to the microsecond, as always), astrometry against Gaia DR3, residuals under 0.25". Near as I can tell it is moving right along with the Sun. Would welcome eyes if anybody can get that low.

Clear skies,
Earl Voss
20-inch, homemade secondary, Animas NM

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The circular went out on Tuesday morning, and Glen was in Dana's doorway before she had finished the first screen of it.

"Who," Glen said, "is Earl Voss?"

"Retired. Animas, New Mexico." She had read his post on Sunday, and his positions three times, and told nobody.

**2028 DN214.** The observations ran 18 February to 28 March 2028 from Catalina, Pan-STARRS, ATLAS and NEO Surveyor, then a fourteen-month gap, then twelve lines from E. Voss, Animas, 20 May UT. The orbit was gravity only, residuals 0.58" RMS. The 2028 survey points carried most of that, and nobody at the MPC was going to lose sleep over half an arcsecond on survey astrometry. Her braking was in there somewhere, spread thin across the old residuals. It was very nearly the clean orbit she had put on the shared drive fourteen months ago.

"He posted to the list on Saturday night," Glen said. "On a Saturday. With GPS timing. He ground his own secondary."

"His timing's better than Catalina's."

"That isn't funny."

"It wasn't a joke."

Glen read the designation off her screen. “Twenty twenty-eight,” he said. “They kept our year.”

He stayed in the doorway. Somewhere down the hall a printer was jammed and somebody was swearing at it in a low, steady voice.

“Headquarters called,” he said. “They want a release out before the Chinese or the Europeans or some kid on Reddit does it for them. Saturday, probably. A telecon. They want me to do it.”

“And me?”

“On the line. Muted. In case there’s a technical question.” He looked at the MPEC again. “If we’d gone to *Icarus* in October, the credit line would be us.”

“I know, Glen.”

“Four surveys and a man in a shed.”

By Wednesday afternoon a science reporter at one of the wire services had done the subtraction. First tracklet, 18 February 2028. Circular, 22 May 2029. *Earth’s new companion sat in NASA survey data for fifteen months.* By Thursday it was the number in every story, and nobody bothered to say from when.

. . .

NASA’s release went out at ten in the morning Eastern on Saturday, 2 June: *NASA Confirms First Known Trojan Asteroid at Earth’s L5 Point.* Natural, it said, about two kilometers, metallic. It had nothing to say about the rest.

The teleconference was at one Eastern. Dana dialed in from her kitchen table with the phone on mute, as instructed: technical questions only, and only if the press officer passed them to her. Glen was in a studio at headquarters with the press officer and a man from the Planetary Science Division she’d met once.

“The first Earth Trojan ever found at L5,” Glen said, and paused where somebody had told him to pause. He’d been saying that sentence to doorframes since March of last year. Over the phone it sounded as if legal had read it first.

Size, about two kilometers. Composition, iron-nickel, from Hubble. Mr. Voss, a remarkable amateur observer, and NASA was grateful. Somebody from *Sky & Telescope* asked why it had taken fifteen months, and Glen said that confirming a Trojan wanted a long arc, which was true of Trojans and had nothing to do with this one. Then a reporter whose name the press officer didn’t quite catch: “Dr. Farris, you’ve had this object since early 2028. Has the orbit changed in that time?”

“No. It’s a very well-behaved orbit,” Glen said. “It’s come to rest near L5, essentially, and—”

"Rest relative to what? Trojans librate. They don't rest. And since when?"

There was a pause on the line. Dana's thumb was on the mute key.

"Rest is the wrong word," Glen said. "I mean it's in a stable configuration. A tadpole orbit. Those are stable for very long times. We'd expect it's been there—"

"You'd expect, or you know? Your team's data goes back fifteen months. Was it always where it is now?"

"The orbit in the circular is a fit to all the data, and it's consistent with —"

"I'm asking about your data, not the circular."

"Let's take the next question," the press officer said.

The next question was whether NEO Surveyor's budget was safe. Dana kept her thumb where it was.

. . .

Rita's statement went up on the ESA site on Tuesday morning, under her own name, three paragraphs. The one that mattered was the second. *ESA's Planetary Defence Office observed 2028 DN214 from the Teide Observatory in spring 2028 and shared its results with NASA at the time.*

Rita had written the one sentence that was good for Darmstadt and bad for Pasadena, and stopped there. By evening it was *ESA: We Told NASA in 2028*, and the reporter from the teleconference had sent JPL media relations a single question, which they forwarded to Dana without comment: *What results?*

. . .

Kessler's email came on Thursday, 14 June, at a quarter past six in the morning her time. It was the first thing he had sent her since *Why do you ask?*

*Have you read the Chinese preprint?*

She hadn't. It had gone up on arXiv overnight: Purple Mountain Observatory and the University of Science and Technology of China, fourteen authors, corresponding author Lin Wen. *Non-gravitational deceleration of the Earth Trojan 2028 DN214 in Lenghu observations of 2028.*

The Wide Field Survey Telescope, the 2.5-meter on the Qinghai plateau. Five nights in April 2028. Recovered in January 2029, the methods section said, and linked to the public isolated-tracklet file. Braking along the track at 2.1σ, from the nights in the table. A linear fit to the along-track acceleration, and its zero: 25 August ± 10 days.

Hers was 23 August ± 12, from a summer of weekly solutions, and the note in her bag had said the 21st. Theirs was two days away, with smaller error bars, from a telescope nobody outside China had known was looking.

Section 4 was one paragraph, and its last sentence had no hedge in it but the first word. *If the decline in brightness reflects a loss of mass, the implied rate is of order* $10^{5}$ *kg* $s^{-1}$.

That was her own number, the one in Priya's column. It was sitting under a NOFORN banner in nine inboxes in Washington, and here it was in English on a public server, ranked fourth in astro-ph.EP by lunchtime.

Table 1 was the Lenghu astrometry. She read down the date column, then went back to the top and read it again.

. . .

By Friday the hashtag was #FifteenMonths. A cable network ran a chyron that said *WHAT ELSE IS NASA HIDING?* over footage of the Kennedy Space Center gift shop. Media relations forwarded her another question, this one from the *Washington Post*: *Can Dr. Okafor confirm or deny the Chinese mass-loss figure?* A man on a video with two million views held Earl's post up to the camera, printed out, with *moving right along with the Sun* circled twice in red. He was entirely sure. "They've had it since 2028," he said. "Ask yourself what keeps pace with the Sun."

. . .

Her sister Ada called on Sunday a little before nine at night.

"Is it coming here?"

"No."

"Don't just say no. They had a physicist on, Dana. He said it's been parked out there for a year and a half and NASA knew the whole time."

"It isn't coming here. It's where it's been."

"Where's that?"

"About as far from us as the Sun is."

"Is that far?"

"It's far, Ada."

"The man said it's metal. A whole mountain of metal. He said if it hit us it would be the end of everything."

"It isn't going to hit us."

"How do you know?"

"Because I've had its orbit to a centimeter a second for a year."

A child said something in the background, and Ada covered the phone and said something back. When she came on again her voice was lower. “How long have you known about it?”

“I can’t talk about work, Ada.”

“That’s a yes.”

“It’s a can’t.”

Ada didn’t say anything for long enough that Dana checked the screen to see if the call had dropped.

“Should I be scared?”

“I’ll call you if you should.”

“That’s not an answer.”

“It’s the one I’ve got.”

. . .

On Monday she had the preprint open again before seven, Table 1 full width on the screen.

Eleven rows on five nights. A survey came back to a field when its cadence said to. Four nights running was follow-up. She had asked Catalina for exactly that in March 2028, on the phone, because she’d already known what she had.

Five nights in April and a recovery in January could not put anybody’s zero on 25 August to ten days. Somebody had kept looking all summer, and left it out of the table.

The methods section said January.

26 April 2028. 27 April. 28 April. 29 April.

10

# Purple Mountain

*Lenghu, Qinghai, April 2028; Purple Mountain Observatory, Nanjing · June – August 2029.*

The pipeline flagged it on 21 April, one line in a morning list of eighty: a source at 61° from the Sun, moving east at almost exactly the Sun's own rate, tagged co-orbital with a low score. Most co-orbital tags at that elongation were ghosts off a bright star, or two unrelated detections the linker had married. Lin opened the cutouts in the canteen on the ridge, between the oxygen machine and the noodles, and put it on the follow-up queue for dusk. The scheduler would complain. Dusk was when the survey took its calibration fields, and the calibration fields belonged to Hefei.

Then four nights of wind, with dust off the Qaidam so thick the dome stayed shut and the yardangs below the mountain went brown. The 26th was clear. So were the 27th, 28th and 29th.

She took them herself from the control room, in a down coat because the heating there was set for the electronics. The 2.5 m opened on the western sky at the end of nautical twilight and had perhaps forty minutes before the survey took the telescope back. The sky that close to the Sun never got properly dark. On the 29th the seeing was 1.8 arcseconds, the object a soft V 17.9 smear that the centroider kept wanting to pull toward a background galaxy.

Five nights, counting the survey night, and nowhere near enough arc. She went to the Minor Planet Center's public file of orphaned tracklets and found seven from the American surveys that fit her positions, February and March, unclaimed. With them the arc was ten weeks. Gravity alone would not close it. The residuals walked, all in one direction, along the track. She freed an along-track acceleration and it came back negative at 1.8σ: braking.

She thought about the Minor Planet Center report the way she thought about a paper submitted too early: it would go out with her name on it and she would spend the next season defending it. Two sigma in twilight was

not a result. She kept it on her own queue, a few minutes a week through the summer, and did not report those either. By the turn of the year the arc would be long enough that, if it was still braking, it would say so at five sigma and she would not have to. The queue was hers. Nobody would ask.

On the 29th the dome came round and closed on a brown horizon, and she did not send it.

· · ·

The preprint went up on 13 June 2029 and was in the astro-ph listing the next morning: Purple Mountain and USTC, fourteen authors, her name with the asterisk.

The sentence in section 4 was hers. The Hefei group had struck it twice in the shared draft and offered *cannot be excluded*; the deputy director had suggested moving it to the discussion, where people stopped reading. She had put it back each time, as the last sentence of the section. It was conditional in the only place it needed to be. If somebody wanted to call it something else, they could do the arithmetic and argue with the number.

The paper had waited on the American circular. Purple Mountain had recovered the object in January from Xuyi, and then the Academy had sat on the draft until 22 May, when Cambridge designated it and an amateur in America got his name on the circular. After that it took three weeks to clear. Lin had not argued with the three weeks. She had held the spring herself.

The methods said the object had been recovered in January 2029, which was true. The summer points were in the fit and not in the table. She had not taken them out. Very few people read the tables.

By the 16th it was in *Nature*'s news pages under a headline that used the word *mystery*, and the American designation, 2028 DN214, was in the first line, as if the object had been born in Cambridge, Massachusetts.

· · ·

The man from the ministry came to Xianlin on 19 June. His card said State Administration of Science, Technology and Industry for National Defence. He had read section 4; there was a printout in his folder with the last sentence underlined in pencil, and nothing else marked.

He asked two questions.

"How far is it from Earth, in kilometers?"

"Today, 158 million. In January it was 141. It makes a loop around the Lagrange point once a year." She waited to see if he wanted the error. He did not.

"Is its position stable?"

"The center of the loop has not moved by more than 3,000 kilometers since January. Our uncertainty is about 1,500."

He wrote both numbers down, carefully, with the units, and read them back to her. He had the second one wrong by a factor of ten and corrected it himself before she could.

A man who wanted to understand the object would have asked what it was made of, or why it was fading. These were the numbers you needed if you meant to do something about it. She did not round either one.

At the door he said, "Several people in Beijing think it is artificial."

"It braked," Lin said. "I can tell you that much."

"And the mass?"

"It has lost about 9% of its light since January. There is no dust."

He went to find his driver.

· · ·

That evening, in her office at the end of the fourth-floor corridor, she went back over the second number.

He had written 30,000 and struck the last zero before she could open her mouth. People copying a number they had just heard got it wrong and waited to be told. He had known what it was supposed to be. The preprint gave the orbit, not the history of the loop center. That came from the summer fit, and the summer points lived in one folder on the group server that three people could open: Lin, the postdoc who ran the Xuyi reductions, and the dynamicist down the corridor who had checked her integrator in February. Neither of them talked to Beijing about anything but money.

She had never looked at the folder's access log. She expected her own name eighty times, and it was there, with the postdoc's once in March. On 9 May and again on 23 May every file in the folder had been read, in order, start to finish, at 02:41 and at 03:17, by a maintenance account on the observatory's internal server with no person's name on it.

The postdoc had never heard of the account. The man who ran the group's cluster said maintenance accounts belonged to the IT office and he had never been trusted with a password for one.

She filed a ticket with the IT office, three lines and the two timestamps. The answer came on the 21st, signed with the office's name and nobody's: a scheduled backup job, migrated to the new server during the spring upgrade. The account belonged to the job. The job ran at night so as not to load the network. They regretted any concern.

It was plausible. Backups ran at night. The spring upgrade had also taken the fourth-floor printers away for most of April. She wrote back to

ask why a scheduled job had run twice in May and not since, and received the same paragraph, with the regret moved to the top.

She changed her password. She copied the folder onto the ThinkPad she had taken to Lenghu, which had not been on a network since its wireless card died in the dust, checked every file against the server copy, and deleted the server copy. The ThinkPad went in the bottom drawer of her desk, under the 2027 observing logs, with its charger coiled on top.

· · ·

The Hubble archive took her a Saturday morning. The designation found nothing, so she searched for moving-target programs in late 2028 whose ephemerides passed within a degree of the trailing Lagrange point, and got one.

**Program 19412  Cycle 36  Director's Discretionary**
PI: Dana Okafor, Jet Propulsion Laboratory
Title: Reflectance spectroscopy of a candidate Earth co-orbital
Orbits: 40
Instruments: STIS, WFC3/UVIS
Approved: 2028 October
Status: Completed
Exclusive access period: 12 months

Forty orbits of Director's time. Approved in October 2028, seven months before the Americans gave it a name and eight before they said anything about it. One name on the program, no co-investigators. Okafor's publication list was orbits: linkage, astrometry, small-body catalogs, nothing with a spectrograph in it. The abstract was three sentences and called the target "of unusual dynamical interest," which was how you described a thing braking at L5 to a committee that already knew. A linker had asked for STIS. Somebody above her had wanted to know what it was made of, and quickly.

NASA's June release had said metallic, about two kilometers. It had not said when they learned it.

The data would come out of their exclusive period in October, at the earliest. By then the spectrum would be a year old and somebody in Washington would have decided what it meant.

She had held a spring and a summer. They had held forty orbits and a spectrum, published nothing, and then published a press release.

· · ·

The letter from Foreign Affairs came at the end of August. A consultation in Vienna in November, convened by the Secretary-General's office,

closed to the press. The Americans would bring a scientist. China would bring one too, and the Academy had given them her name.

She said yes before she had finished reading it.

The Americans would bring Okafor, or someone who had read Okafor. All Lin had of her was a program number, a publication list and a name on an archive page, and none of it said how the woman sounded when she was asked a question she could answer. She wanted to see what someone knew who had asked for forty orbits in October. She wanted to see which questions Okafor answered exactly, and which ones she had been told not to answer at all.

11

# To Be Coordinated

*JPL, Pasadena · Tuesday, 18 September – Tuesday, 23 October 2029.*

The question came down on Tuesday morning through the deputy director's office, in a sentence somebody in Washington had spent a week making short: what would it take to put 1,000 kilograms near the object, and how quickly?

"Near," Dana said.

"Within a few thousand kilometers." The deputy director had it on his tablet and read it again as if it might have changed since breakfast. "Time of flight, launch dates. Ray Delgado's people do the trajectories. You give them the object."

"Which parts of it?"

"Whatever they ask for." He heard how that sounded and didn't fix it. "It's a design study. They want options."

Nobody needed a thousand kilograms of camera. She told him Delgado would have the ephemeris by Thursday.

The list came on the same thread an hour later, a PDF with no letterhead titled *Ideas for an edge*. Fourteen items, numbered, most of them a line. A review of Deep Space Network receiver logs for anything along the object's line of sight. Time at Green Bank to listen, frequencies unspecified. A commercial imaging buy, from a company whose telescopes pointed at the ground. A radar campaign, from someone who had never taken the fourth power of a distance. Item nine was a records pull at Lawrence Livermore on its 1980s X-ray laser work, prompted by an unsolicited study from a contractor. She'd read about that program once, in a history of Star Wars that was mostly about budgets. She went on to the radar, which was wrong in a way she could do something about, and wrote the deputy director two sentences on why Goldstone would hear nothing from a two-kilometer target at one astronomical unit.

On the afternoon call a man from NASA headquarters walked the list in eleven minutes and only slowed down once.

"Where's the Livermore one from?"

"There's a cover page," the deputy director said. "A company name. I looked it up and got a suite number in Reston."

"Leave it on. It's a records pull. It costs somebody a week in a basement." He was already on ten. At the end he said, "Two for Dr. Okafor. How far is it today, in kilometers? And does it stay where it is?"

"About 155 million," Dana said. "And yes. It loops around L5 once a year, and the center of the loop hasn't moved since the crossing. Gravity-only orbit, good to a few tens of kilometers."

"A few tens of kilometers." She heard him write it down. "Thank you, Doctor."

. . .

On Thursday she walked the ephemeris across the lab to Delgado herself, because she wanted to see who she was giving it to.

Cable had a retired astronaut on most nights who said "natural" with a confidence she'd have liked to borrow. On Tuesday the crawl under his segment had said China launched Shijian-29, a deep-space technology test, from Wenchang on Sunday, and then something about a hurricane in the Gulf.

Delgado's group had two rooms on the second floor of the mission design building and a coffee maker that made decaf by his standing order. He was about sixty, gray at the temples and nowhere else, with a Cassini mug and four missions behind him. The second of them had come apart forty seconds after launch. He didn't mention it. Someone in the hall did, on her way out, as if Dana should know who she was dealing with.

He had her file open before she sat down.

"First thing," he said. "There's no launch window."

"It's always sixty degrees back."

"Always sixty degrees back. Any day you like, give or take the Moon."

"They're going to like that," Dana said.

"How long?"

"One lap is fourteen months. C3 of about 2, and you get there doing 1.4 kilometers a second relative. If you want to stop, that's your propellant." He drank. "If you don't want to stop, you don't."

"And faster?"

A long pause, in which he seemed to be doing the problem again rather than remembering it. "Faster costs C3. Five months if you throw hard, and then stopping costs everything in the tanks, so you bring a camera and not a ton. Or you don't stop, and go by at a speed nobody would call arriving. I'll give them three cases. They'll want the fourth."

She gave him the rest across the table, down to the fact that it was at rest relative to L5, which he already had from the ephemeris and let her say anyway.

"It weighs nothing," he said.

"It weighs $1.7 \times 10^{13}$ kilograms."

"At three thousand kilometers it weighs nothing. I could fly a cubesat past it on a spreadsheet." He scrolled. "Anything else out there?"

"There's traffic." She sent him the Goddard table. "None before September last year."

"Do they go near it?"

"They come from it."

"Mm." He wrote that on the pad at his elbow, a word, not a number. "I'll carry them as a hazard. Somebody will read it as a hazard."

She checked every value she gave him before she sent the clean copy, the mass to its error bar and the ephemeris against her own fit from January. A number that went to Delgado went on from Delgado, and nobody past him would check it.

· · ·

The questions came back the following Friday, the 28th, typed into the body of an email so that nobody had to attach anything. Delgado forwarded them to her with no comment and then called.

"They read the fourth case first," he said.

She had it open. Five months, a hard C3, a flyby at 4.1 kilometers a second with no stop at the end. Underneath, the new questions. Could the flight time be shortened if the payload were reduced to 600 kilograms. Was the object's position known well enough to target a pass at a specified distance, and to what accuracy. Would the object be expected to change position or attitude in response to an approaching spacecraft.

"The second one's yours," Delgado said.

"The second one's easy. I can put it in a box a few tens of kilometers on a side for the day you want. Better if I get tracking from whatever they send."

"Mm. And the third?"

She thought about the 5.81-hour cycle that had died in August, and the face that had held its attitude through thirteen weekly fits, and the small hot things that had started leaving it a fortnight after the cycle stopped.

"The third one I can answer with what it's done," she said. "Not with what it would do."

"Write that."

"They'll hate it."

"They'll hate anything shorter, too." A pause. "Put it in your words and send it to me. I'll put it on top of mine so it gets read."

She wrote it in four sentences. The first said what it had done since March 2028, and the last said there was no observation in hand that predicted how it would respond to anything, because nothing had ever approached it. She took out an adjective and sent it.

. . .

On the first Monday in October, Lookout came out of its bag.

It had been built as the flight spare for a solar wind mission and had sat in a high bay under a nitrogen purge since 2021, gold blanket and all, with its remove-before-flight tags still on. Two technicians cut the bag back while a quality engineer photographed every inch of it. The magnetometer boom was coming off. A camera pair and a thermal imager were going on, from two other programs that had been told to be patriotic about it.

"It looks younger than me," Delgado said.

"January," Dana said.

"January. The five-month case, with a solid motor strapped on to stop it, so June." He counted on the side of his cup. "Fifteen weeks to launch. The one I lost had a better schedule than this." A pause. "Didn't help it."

He was running Lookout. He'd said yes before anyone had finished asking, one of the technicians told her, and had then spent a day finding out what he'd said yes to. On the rendezvous he did his long silences in the meetings and let the younger people talk themselves into and out of things, and the things they talked themselves out of stayed out. She liked him.

She asked him for one thing: a hold point off the line from Earth, somewhere it could see the far side.

"Mm. Everything we've got looks at it from here."

"That's why."

He pulled the approach geometry up on his tablet and swung the hold point out to the side, fifty thousand kilometers off, where the night side would show its edge. "You'll owe me forty meters a second," he said. "I'll find them."

. . .

The badge came on the 15th in an envelope from the State Department, a laminated card on a blue lanyard: UNITED STATES DELEGATION, her photograph from a 2019 JPL ID, and under her name SCIENCE LIAISON. The international consultation was in Vienna the second week of November. An agenda would follow. A briefing book would follow the agenda.

The deputy director walked her through it in his office with the door shut. She would sit behind the head of delegation, not beside. She would answer technical questions put to the United States, from the cleared slides, and refer anything else forward. She would not be the person who said "powered."

"What if somebody else says it?"

"Then you're a scientist and you have a view." He thought about it. "From the slides."

She asked who else was sending a scientist. He had a list of countries and no names.

Glen came by the next afternoon. He'd heard.

"Science liaison," he said. "Is that above or below a branch lead?"

"It's a lanyard, Glen."

"Will anybody in Vienna be talking about publishing?"

"I'd guess everybody in Vienna will be talking about publishing."

He went back to his held paper.

· · ·

Ada's message came in on a Friday night, the 19th, after eleven.

Ada: friend posted this. not saying I buy it

> Something in the machines - Ruth Ackroyd
> Every few months a platform puts out a takedown report and everyone claps. 4,000 accounts tied to this ministry, 11,000 to that one. I've spent two years running their own numbers back against the engagement they say they removed, and the totals don't close. Take out every network anyone has ever pinned on anyone and there's still boost left, on the same posts, and it isn't any state's. Nobody asks whose it is. I think it might be the recommender systems' own. Yes, I know how that sounds. Here are the tables. [link]

Ada: probably nothing. she is an actual statistician though. are we ok?

Dana clicked through. The link went to a blogging platform's page saying the site was no longer available. She'd been in Delgado's high bay since seven, and she had the Vienna agenda open in another window, nine pages, mostly coffee breaks.

*We're ok,* she wrote. *People write a lot of things right now. Get some sleep, Ada. I'll call Sunday.*

Ada sent a heart and nothing else.

· · ·

The payload study came back on Tuesday the 23rd, sixty-one pages, with the distribution list longer than in September. Somebody had added the National Nuclear Security Administration, Office of Defense Programs, between Space Force and the State Department.

Delgado brought it to her office himself and sat down without being asked.

“Your mass is in it,” he said. “My trajectories. All three cases and the fourth.” He didn’t open it. “Page four.”

Page four sorted every option they’d sent up. The payload mass on every line was 1,000 kilograms.

PAYLOAD CLASSES CONSIDERED
I. Observation
II. Kinetic
III. Special, to be coordinated with NNSA

12

# Corridor

*Vienna International Centre · Monday, 12 November – Tuesday, 13 November 2029.*

Kessler was taller than his camera had let on, and grayer, and he got down off the bar stool when she came in, which nobody at JPL had ever done for her.

"Dr. Okafor."

"Dana. We got past that last year."

"On the telephone." He shook her hand once and sat back down. "With a face it is different."

The hotel was on the Kaisermühlen side, ten minutes' walk from the Centre, built for delegations and priced for them. The bar had a carpet that swallowed every sound and a barman who had already decided they were with the Atomic Energy Agency. Kessler had a small beer. She ordered the same because it was easier than reading the list.

He had come by train. He always came by train, he said, in the voice of a man who had had the argument with Rita and won it: Darmstadt to Frankfurt, then the ICE straight through to Wien Hauptbahnhof, the Danube on the left after Linz. He'd worked the whole way. He had also logged the delay at every stop, because Deutsche Bahn was a noise source like any other and somebody ought to characterize it. He turned his phone around to show her: +11 at Nürnberg, +6 at Passau, +0 at Linz.

"So they made it up."

"They padded the schedule. It is a systematic, not a recovery." He looked pleased with it. "You flew."

"Los Angeles, Frankfurt, here. I sat in Frankfurt for two hours this morning. I could have waved."

"You would not have found me. I was in the quiet car."

She told him about the one train she knew, the Southwest Chief out of Union Station, the summer of her second year in grad school when she'd had a run of nights at Lowell and been too scared of the drive across the desert to rent a car. Four hours late into Flagstaff, and nobody on board

had minded, and a man in the observation car had explained the Hopi calendar to her from Needles to Kingman. Kessler said American trains were a philosophy, not a timetable. She said that was the kindest thing a German had ever said about Amtrak, and he laughed, a short startled sound, and looked into his glass as if the beer had done it.

Then there was a stretch where neither of them said anything, and it went on.

He asked after the weather at Table Mountain. She asked after Tenerife. He said the season had been good until October and then the calima came in off the Sahara and he'd lost nine nights to dust. He started to say something about the photometry from the spring, his own, and what the baseline had done, and stopped.

"But you have Hubble," he said.

"I have Hubble."

He nodded as though she'd told him something and drank his beer. He didn't ask the next thing. She watched him not ask it. A year ago he had written *Why do you ask?* at the bottom of an email about cooling iron, and she had answered him with nothing, and he had come seven hundred kilometers on a train and was sitting a foot from her talking about Saharan dust.

"You look tired," he said.

She thought: here it is.

"The flight from Los Angeles is very long," he said, and paid for both drinks before she could get her card out, coins counted onto the bar to the cent.

He took the stairs, all six floors.

. . .

Her room was on the ninth floor, facing the towers of the Centre across the road, a crane on the roof of one of them with a red light at the top.

She sat at the desk with the hotel pad and one of the hotel's pens. Not the laptop, which belonged to the Laboratory and logged everything. The pen skipped on the first stroke and then wrote.

She wrote the Hubble baseline the way she'd have written it on a whiteboard for a student. She didn't need to look anything up. She had looked at that line for a year.

Under it, one line. The missing mass is on the night side, within about a kilometer of the far face, behind it from Earth and in its shadow.

She didn't change a word. No name. No date. Her handwriting, which anyone at JPL could have picked out of a stack.

In Washington, the September before last, PDCO had read the handling rules aloud from a sheet, and she had listened to every word because nobody else in the room seemed to. The paragraph on foreign nationals was short. It had no exceptions in it.

There was a statute behind the paragraph, and people went to prison under it. She thought of the banner across the September memo, and Glen's paper held, and a press call on which the object had come to rest. Twice now her own government had taken what she'd found and put it where nobody could look. She didn't trust it to be the only one holding the map. She sat with the pen in her hand while the red light on the crane went on and off.

Then she folded the sheet in half and in half again and put it in the inside pocket of her jacket, and hung the jacket on the back of the desk chair, the blue lanyard over the shoulder. UNITED STATES DELEGATION. SCIENCE LIAISON.

. . .

Tuesday at ten the room filled from the front.

It was a small conference room on a high floor, built for some board that met four times a year: a horseshoe of pale wood, a screen at the open end, six interpretation booths in a glass gallery along the back wall, and windows the whole length of one side with the Danube under them, flat and gray, a barge going up it against the current. Each seat had a microphone on a gooseneck and a request-to-speak button with a red ring around it. The secretariat had put the eight states around the curve in English alphabetical order and set ESA out at the China end, past everyone, the way a body that isn't a state gets seated. United Kingdom, then United States, closed the other end.

Dana was in the second row behind the American placard. The man with the legal pad was in the front row, two seats left of center, the pad already squared on the table. Pleasant face. The Space Force lieutenant colonel from the Washington room sat beside him, his cap on the table. The man with the pad had shaken her hand in the lobby and said it was good to see her again, as if they'd met at a conference.

The chair was a woman from the Secretary-General's office, Uruguayan, small, in a dark suit, and she spoke so quietly that the delegates leaned toward their microphones to hear her. This was a consultation, she said. There would be a summary record. The summary record would be short.

Dana had twenty minutes and eleven slides that someone in Washington had cleared, and she gave them as cleared, from the 2028 orbit to

the movers. The Hubble photometry was not on a slide. A population of smaller bodies, tens of meters across, warm, some leaving and some arriving, first seen in September 2028.

Slide six said *consistent with a natural metallic body* in the subtitle. She read the title and went to the bullets. She had stopped saying the word somewhere over Greenland and hadn't noticed until she heard herself step around it now, out loud, in front of eight governments and the booths.

She came to the end of the spectrum slide and went on to the movers. The line that belonged between them, the one in her jacket, she did not say. She let it go by, the way she had in March of 2028, when she typed *probably astrometry* to Glen and sent it.

The movers held the room longer than the orbit had. The Indian delegate wanted to know whether *accelerating* meant pushed or falling, and she said pushed: steadily, for days, the same on every arc. The French delegate asked whether anything natural did that, and she said she knew of nothing that did, which was on the slide. The Russian delegate said, not quite into his microphone, that in his ministry there was a shorter word for small objects that left a larger one under power. Nobody asked him what it was.

"Thank you, Dr. Okafor," the chair said. "Questions."

A red ring lit at the China end.

The woman in the second row behind the Chinese placard was younger than Dana had expected from the preprint, hair cut short, a folder closed in front of her. Lin Wen. She leaned to the microphone without hurrying.

"Thank you. Every figure in the briefing is given relative to Earth. The distance, the position, the stability. Is that our choice, or the object's?"

Nobody's ring lit.

Dana looked at the back of the man in the front row. He was writing. The American head of delegation turned a page in his binder and didn't turn it back. In the booths the interpreters had stopped and were waiting, headsets on, for something to put into Russian and French and Chinese. The chair folded her hands.

At the far end of the British row a man looked up from his folder for the first time that morning. He had been reading the whole of her twenty minutes. The delegation book had him as a counselor at the UK mission, Hale, no first name given; someone at State had penciled beside it what he was, SIS, seconded. He looked at Lin, and then down the curve at Dana, and waited like everyone else.

The clock on the back wall went around once and half again.

Dana pressed her button. The ring went red.

"Ours," she said. "Geocentric is how the telescopes report. The object holds station relative to L5, and the Earth and the Sun are what define L5. I can't separate those for you with what we have."

"Thank you," Lin said. She didn't write anything down.

Another ring lit, at the very end past China.

Kessler had a placard to himself and a paper cup of water he hadn't touched. "Madam Chair. If I may add something from the European side." He waited for the booths. "Dr. Okafor is being careful, and she is right to be careful. I am a little less careful. It has held the same point for fifteen months. A thing that wishes to be seen does not need to hold anything. It is not parked to be seen. It is parked to see."

The Russian booth went silent for a beat and then caught up.

In the front row the legal pad took it down, word for word by the length of the line.

. . .

The chair broke for lunch at a quarter past twelve.

The corridor outside ran in a long curve past the delegates' lounge, carpeted, windows on the river side, the flags of the member states hung furled in a row too long to see the end of. Delegations came out in clumps and went toward the lounge in clumps. Lin came out alone, behind hers, with the folder under her arm.

Dana fell in beside her at the windows.

"Dr. Lin."

"Dr. Okafor. Thank you for answering."

"It wasn't much of an answer."

"It was more than ninety seconds of nothing," Lin said. "I was counting."

Down at the lounge door Kessler stood with a paper cup, looking at the river.

She could have given it to him last night, and he would have had to take it to Rita, and Rita had already had one call from Paris. Washington had this line already. Lin had printed $10^5$ kg $s^{-1}$ when nobody in Washington would say it in a room. She wasn't going to leave the only copy in Washington.

Dana took the sheet out of her jacket.

"That's mine," Dana said. "It isn't in the slides."

Lin took it without looking at it and put it inside the folder, between two other papers, and closed the folder.

The conference-room door opened behind them. Hale came out with his own folder and his reading glasses in his hand, and he stopped about four meters off and patted his jacket for his phone. He saw the folder close. He saw Dana's empty hand.

He went on past them toward the lounge, and held the door for a Japanese delegate coming the other way.

· · ·

At two the American head of delegation turned the microphone over to the man with the legal pad, who said that the United States was assessing options.

The Russian delegate's ring lit. "Options for what?"

"For further observation, among other things. We'll be in a position to say more at a later session."

Dana kept her hands on the table. Ten thousand kilometers away, Lookout sat in a clean room at JPL on its purge line, booked for January, its hold point swung off the Earth line. None of it was on a slide. She didn't press her button. The man with the legal pad turned a page and wrote the date at the top of the new one.

"Item 2," the chair said.

The Chinese head of delegation was a gray, broad man who had not spoken all morning. He had a single slide, and the secretariat put it up.

"On 16 September," he said, "China launched the deep-space probe Tianxun from Wenchang, under the designation Shijian-29. It is in cruise. It will arrive at the object in early March 2030." He let the booths catch up. "China will share the live feed from arrival with every delegation at this table."

The crawl in September, Dana thought. A deep-space technology test, between a retired astronaut and a hurricane.

On the screen the trajectory left Earth in a long blue arc and came in on the object, the last segment drawn as a dashed line.

At the China end, Lin sat with her hands flat on the closed folder.

"The terminal approach," the head of delegation said, "will be refined in flight."

13

# Lattice

*Vienna International Centre · Friday, 1 March – Monday, 4 March 2030.*

The first frame came up on the big screen a little before midnight on Friday. It was fourteen pixels by twelve, gray on black, lit from the left, with a caption in Chinese and English underneath.

Dana sat in the second row behind the United States placard, with a headset on and the English channel turned low. Across the horseshoe Lin was in the second row behind China, writing. Kessler sat behind the ESA placard at the far end, his notebook shut in front of him. The chair, the quiet Uruguayan from the Secretary-General's office, had the frame up on her own monitor and was reading the caption with her glasses pushed up into her hair. On the US desk a conference phone sat open to Pasadena, where Delgado was listening from JPL with Lookout's team around him.

It looked like an asteroid. Every approach she had ever seen began with this, a lump that could have been anything, and for a moment she let herself want it to stay that way.

"Dr. Lin's idea, I gather."

Hale had come up behind her chair with a cup of coffee from the delegates' lounge. He had not spoken to her in November.

"The feed?"

"Live, to everyone. Beijing wanted it released by the day." He looked at the screen. "Generous of her."

He went back to his seat.

The probe on the screen was the only thing in the solar system that could check the line she had given Lin, and Lin had made sure every delegation in the room would be watching when it did.

· · ·

The frames came down at six minutes each, top to bottom, because the downlink would carry nothing faster. Every one was eight minutes old

when it arrived. The room learned to stop talking while a frame was filling.

By Saturday morning the range had halved twice, and the lump had come apart into planes. A long block, flat along one side, squared off at one end. The other end tapered to a blunt, pitted horn.

At the Russian table the delegate said something to his aide, a single word, short and not meant for anyone, and his microphone was still live. In Dana's headset the English booth gave it to her a beat later, in the interpreter's careful voice.

"Anvil."

A few people laughed, not much. Within the hour the Indian delegate was using it in a question to the chair, and the French interpreter had stopped translating it and was saying it in English. By lunch the chair said it too, and then corrected herself, and then didn't.

The horn led. Dana had the inbound path reconstructed to a fraction of a degree, and when she laid it over the frame the taper sat on it. That face should have shown a few big craters and many small ones, the size spread every rocky body had. It didn't. It was frosted: a fine, even pitting with no large craters at all, as if every hit had come in at the same speed from the same direction for a very long time.

The Japanese delegation's scientist asked for the floor and said it plainly. Erosion by dust, at high speed, over a very long path. Faster, and for longer, than anything between the planets. He didn't say interstellar. The chair thanked him and asked whether any delegation wished to comment. None did.

· · ·

Saturday afternoon the terminator swung far enough to show a dark, smooth hollow near the edge of the long face, about 400 m across. No rim, no thrown-out debris, a floor too flat and an edge too clean for anything that had hit it from outside. Three frames at three viewing angles gave her its shadow, and the shadow gave her the depth: about 50 m.

"That's where it's been coming from," the colonel beside the legal pad said quietly. "The mass."

Dana worked the volume on her pad while the next frame filled. Iron, that size, was a few tens of millions of tonnes. Against China's own mass-loss figure, that was a few days' worth. The object had been losing mass for more than a year. The hollow was real, and it was nowhere near enough.

She looked across the horseshoe. Lin was looking at the same frame, and her pencil had stopped.

. . .

On Sunday morning the Chinese head of delegation read a notice into the record. Tianxun would complete its survey of the sunward hemisphere today. At about five thousand kilometers it would transfer to autonomous terminal navigation, since the light delay did not permit control from the ground at close range. On Monday it would circle the object at between eight hundred and fifteen hundred kilometers and image the far hemisphere. The data would continue to be shared as received.

Lin's chair was empty. It stayed empty for most of an hour. Twice Dana saw her through the glass panel of a side door, standing in a small room with a phone to her ear, one hand flat on the table.

When she came back she sat down behind her head of delegation, squared her pencil to her notebook, and didn't write anything. The notice stood.

At the coffee break she passed behind the American chairs on her way to the lounge. She didn't stop or look down.

"It is a mistake," she said, in English, to no one, and went on through the door.

When the session resumed, Dana pressed the request-to-speak button on her desk. The little ring of light came on red.

On the chair's monitor, which she could see from where she sat, the speakers' list added a line. *United States.*

She knew exactly what she would say. Two people in this room had ever read it. One was across the horseshoe. The other was in the front row of her own delegation, with a legal pad.

To say it here, she would have to say it as the United States. She would have to say where it came from. And every delegation in the room would watch the probe go around the far side, and see what she had told them it would find, and then ask how China had known to send it.

The man with the legal pad looked down at the light on his own console, the one that showed his delegation had asked for the floor. Then he looked back over his shoulder at her.

She pressed the button again. The red ring went out. On the chair's monitor the line was gone before the chair reached it.

. . .

At ten past eleven Vienna time a field on the shared status board changed from GROUND to AUTO.

Delgado had been on the line from Pasadena all weekend, with the volume low and Lookout seven weeks out and three months from L5, saying almost nothing.

"I'd have done the same," he said, through the little speaker. "At that range you can't fly it on a sixteen-minute round trip."

Dana leaned forward to the phone. "Would you? Fly it like that?"

The line hissed. She thought he hadn't heard her.

"Not now," he said.

. . .

By Sunday night nobody went back to the hotel. The delegates' lounge sent up sandwiches and then stopped sending anything. Kessler had his notebook open by then, and drew in it, and showed no one. The British end of the table was empty except for Hale, reading.

Tianxun swung off its approach plane and around the horn, into the shadow. The frames came down darker. The room was almost silent while each one filled.

The one that started a few minutes before six on Monday morning, with the windows over the Danube still black, read for its first few hundred rows as texture. Fine parallel grain across the far face. Then the grain was too even, and it ran the wrong way to be anything on the surface. It came off the surface and out into the dark.

Columns. Hundreds of them across the frame, straight and parallel and evenly spaced, each one a string of bright points a pixel or two across, all the same size, all the same distance apart. Where the columns ran far enough out to clear the body's shadow, their ends caught the sun.

"Spheres," someone said on the English channel, and nobody corrected them.

It was the night side, within a kilometer of the far face. It was where she had said.

She took the boresight from the frame header and set it against the ephemeris, and worked the direction the columns ran, and worked it again from another pair because one pair was an anecdote. She had it in under two minutes. She wrote it on her pad and drew a box around it.

It was the Earth line, to within a few degrees.

She didn't raise her hand. Three minutes later the Indian delegation's scientist did the same arithmetic aloud, slower, and asked the chair whether any delegation could confirm the direction. The colonel beside the legal pad said the US had the same number. He said it without looking at her pad.

Across the horseshoe Lin was looking at Dana, not at the screen.

The next frame began to fill.

It was sharper. The range was down to about a thousand kilometers, and the points had pulled apart, with dark between them. The columns ran on into shadow, row after row, and the room watched them come down the screen.

Row twelve hundred. Fifteen hundred.

At row 1,840, low on the left, a thin bright line appeared. Four pixels long, at an angle to everything else in the frame, sharper than anything around it.

“Cosmic ray,” someone said.

Row 1,847.

The rows stopped.

The board held for the interval it was supposed to hold. Then the carrier field went yellow, and then red, and the letters in it read LOS.

In front of every delegation at once, the screen held what had come down: the columns, the dark between them, the four-pixel line, and below row 1,847 nothing at all.

TIANXUN — FINAL HOUSEKEEPING PACKET (as shared, translated)
S/C time  2030-03-04 04:51:23.418 UTC
Power: nominal  Thermal: nominal  Attitude: nominal
Nav mode:  AUTO / circumnavigation segment 3
Range to target: 1,051.7 km  Range rate: −0.38 m/s
Faults: none
[No further packets received. Carrier lost 04:51:23.6 UTC (S/C).]

In her headset the English channel was silent. She switched to French, then Russian, then Chinese. All six booths had stopped talking.

ACT THREE

# Draw

**Federal Award for Industrial Heat Recovery 2031 · Jury citation · Dresden-Nord**

Since the end of May the site’s cooling towers have stood on standby. Not one megawatt goes to the sky. Heat that once rose from them now warms the city: the largest industrial contribution the Dresden network has ever received. The control strategy was developed in-house and commissioned without a single outside consultant. In the words of the site manager, Klaus Weber: “Our lines don’t go down.”

14

# Lookout

*JPL, Pasadena · Monday, 11 March – Monday, 9 September 2030.*

Ray Delgado had the Lookout fault-protection document printed and bound, because he said he couldn't think about software on a screen. On the Monday after Tianxun went silent he had it open on the project conference table and was going down it with a green felt-tip.

"Safe mode on loss of Sun." A line through it. "Autonomous target reacquisition." A line. "Onboard star-pattern search." He drew that one out slowly. "Star tracker gets an attitude from the ground. It doesn't go hunting."

Dana had the last Tianxun packets on her laptop, the housekeeping the Chinese had posted to the shared feed on Saturday. Every channel nominal to the final frame.

"Nobody's shown AUTO did anything," she said. "The last packet says no faults. It could have been the range. It could have been the pass itself."

"Could have."

"So if it was the pass, stripping the software doesn't buy you anything."

"I can't take the range out." He turned a page. "I can't take out whatever was on the far side. That part I can take out." He crossed out another line. "Mm."

Lookout was eight weeks into cruise. Over March and April his team sent up patch after patch, and each one left the spacecraft a little stupider: no onboard targeting, no onboard navigation, no recovery it could start on its own. If it lost the Sun it would sit and wait for a person. By May it could hold an attitude it was told to hold and fire what it was told to fire, and that was all.

· · ·

The interview was on the second Thursday in April, in a conference room in Building 180 that somebody had cleared of its whiteboard. Two people from counterintelligence, a man in his fifties and a woman maybe fifteen

years younger, both in suits that had been through airports. They thanked her for her time twice before anyone sat down.

"Vienna," the man said. "The thirteenth of November. The lunch break."

"Yes."

"You gave a folded sheet of paper to Dr. Lin Wen of the Chinese delegation."

There was no point asking how they knew. "My Hubble baseline," she said. "The photometry."

"Only that?"

"My notes on it."

It was true as far as it went. The woman waited. Dana didn't add anything.

They asked about the hotel bar and Dr. Kessler, and she told them the truth, which was that she'd told him nothing and he'd known it. They asked whether anyone had asked her to pass the sheet. Nobody had. They asked why, and she said Lin had asked the only good question in the room, and they let that sit without comment. The woman closed the folder.

"One other thing, while we're here," she said, standing. "The Goddard business. How Dr. Raman came to have the Surveyor frames. That one's straightforward. We traced it, ticket and all."

"Traced it to whom?"

"That's outside this inquiry." She smiled. "Thanks again."

By four the badge office had swapped her badge for one with a different stripe, and her clearance was suspended pending review. She could still work. She couldn't open the vault on the third floor or read anything that lived in it, and half of what she needed lived in it.

Glen carried her papers. He'd go in, pull what she asked for, read out the parts that weren't marked and summarize the parts that were in a way that didn't technically count. He didn't complain. On the third or fourth trip he set a folder on her desk and stood there.

"What's this about, Dana?"

"The Hubble data. They want to know why the program had one name on it."

He thought about that and seemed to find it reasonable. "Should have put the branch on it," he said, and went back down the hall.

The letter came on the sixth of June. The inquiry was closed. The information at issue had been found to be substantially available from an open source, namely the last sentence of section 4 of the Purple Mountain preprint of June 2029; anyone who read it would know to look at the night

side. That sentence had been "brought to the inquiry's attention through liaison channels (UK)." Her clearance was restored.

She went through the British delegation in her head, the four or five faces she could put to it, and couldn't make any of them want to do her a favor.

. . .

On the eleventh of June the Lookout floor was eight consoles and a wall display in a room that had last flown a comet mission. Delgado stood behind the navigation console with a banana, peeling it in sections.

A solid motor had no throttle. Once it was lit it burned until it was done. The igniter command had gone up forty minutes earlier with the light-time on it, and now the Doppler was coming down and the navigator was reading it.

"Ignition. Chamber pressure's nominal." Then, after a while: "Tail-off."

Delgado ate the last of the banana.

"Burnout. Residual's under a meter per second." The navigator leaned back. "Fifty thousand kilometers and change. Off the Earth line, where you wanted it."

That was for Dana. She'd asked for the side view last October, and Delgado had moved the hold point for her without asking why.

The first image took eleven minutes to come down. It was mostly black. In the middle sat Anvil, nine pixels long at 240 m a pixel, the day side a smear of gray and the night side nothing at all. The imaging lead, a woman with her hair up in a pencil, stretched the display until the noise floor came up in a gray grain across the whole frame.

"There's something on the night side."

Off the dark face, along the line toward Earth, sat a row of faint points. Separate points, side by side, standing off the shadow edge in a row.

"It's a brush," the navigator said.

Nobody improved on it. The imaging lead dropped a cursor at each end. "Five pixels. Call it twelve hundred meters. Rooted right at the far face, or inside a kilometer of it."

"Sunlit tips," Dana said. "The rest of it's in the shadow. Those are the ends sticking out into the light."

"The ends of what?"

"The columns. What Tianxun saw on the far side."

The navigator shook his head. "Tianxun saw a hollow on the leading face. Fresh, they said. Somebody dug something out of it. This is the debris. You blow material out, it comes off along the axis, it sits there."

“In a line?” the imaging lead said. “For three months? It’d be a fan by now. It’d be gone. Debris doesn’t hold a row.” She zoomed in until the points were blocks. “That’s spaced. That’s a structure.”

“You’ve got five pixels.”

“Five pixels that line up.”

Delgado had come around to stand by the wall. “What’s it made of?”

Dana had been doing it on the back of the burn timeline while they argued, and she said it out loud before she’d finished checking it. “If those are the spheres Tianxun saw, a few meters across, iron-nickel, solid, that’s a couple of hundred tonnes each. The mass I can’t account for is about $2.5 \times 10^{12}$ kilograms, and the dimming’s hardly moved since last summer.” She looked at the number. “About ten million of them.”

The navigator laughed once. “Ten million. In five pixels.”

“In columns a kilometer long, across most of the far face. It fits.” She checked the volume again and it still fitted. “That’s the missing mass. Near enough.”

“Or it’s a few hundred big ones,” the imaging lead said, “and they’re nothing like Tianxun’s.”

“Then where’s the rest of the mass?”

Nobody had an answer to that. The imaging lead was still looking at the points. The navigator had his arms folded and was looking at Dana, not at the wall.

“Then it’s been building,” Delgado said. “The whole time it’s been sitting there. Since it stopped.”

“Since before the movers,” Dana said. “It’s been dimming since I started looking.”

Someone at the back console, a young telecom engineer, said, “Is that what Green Bank’s hearing?”

The carrier near 31.7 GHz had turned up in May, narrowband, steady to a few hertz, coming from the object’s position. Green Bank had put the recordings on its public server, and half the radio astronomers in the world had pulled them and found nothing that could carry a message.

“Green Bank’s hearing a tone,” Delgado said. “Nobody can read it. Don’t put it in the log next to this.” He looked at the wall a while longer. “Get me the next frame. And the one after that. Every one we can fit through the pipe.”

The imaging lead had already queued them. The second image came down with the same nine pixels and the same row of points, in the same place.

· · ·

The consultation met in Vienna in the third week of July, in the same room with the same chair. Dana's badge had the right stripe again. Lookout's frames were on the shared feed now, every one, which was Delgado's idea and Washington's grudging permission. The brush was on every screen in the building.

At the morning break Lin Wen found her by the coffee urns and handed her a sheet, unfolded, as if there were nothing to hide in it.

**Tianxun final frame, raster row 1840**

Feature: 4 px, cols 2210–2213, single row
Plate scale: 2.4 µrad/px
Range to target at row 1840: 1,051.7 km
Linear extent at target range: 10.1 m
Row integration: 0.20 ms
Apparent transverse rate: 50 ± 2 km/s
(if feature at target range)
Not consistent with charged-particle track in
adjacent rows or in dark frames

"Officially," Lin said, "it is a cosmic ray."

Dana knew the number. She'd done it on the sixth of March in the hotel, with a worse range and the same four pixels. She uncapped a pen and wrote under Lin's last line, *50.4. 6 March, VIE.*, and handed the sheet back.

Lin read it and put it in her folder, and went back to her delegation.

. . .

On Monday the ninth of September the frame from 15:20 UTC came down like the two thousand before it, and the imaging lead stopped scrolling.

"Ray."

Off the tips of the brush, on the sunward side, sat points that hadn't been there in the morning frame. Not many. Separate, faint, a pixel or two off the row and spread along it. She blinked the two frames against each other, and the new points moved and the brush didn't.

They counted them three times. Forty-one.

The navigator took them through the next three frames and fitted what he could. "They're drifting. Sunward. A few tenths of a meter per second." He sat back. "That's nothing. That's a walk. At that rate they don't go anywhere."

"On their own," Dana said.

Delgado was already on the phone to Planetary Defense in Washington. It took him under five minutes, and Dana heard him say *forty-one* twice and *no, I'm not rounding*.

By noon Pasadena time it was a conference call. PDCO had the chair. The White House Situation Room was on the bridge, and somewhere in the list of names on the line was the man with the legal pad. Dana knew him by his first question, which was who exactly was in the room in Pasadena.

She told them what she could. “Forty-one objects have come off the end of the brush. From brightness and Tianxun’s reprocessed frames, each is about 3.85 m across, the same as the spheres in the columns. If they’re going somewhere in months, they have to push the whole way, the way the movers did, and brake at the end.”

“Going somewhere like where,” someone said from Washington.

Delgado answered before she could. “From L5 you don’t come straight at us. You slow down, you fall in toward the Sun, you’re on a faster orbit and you catch Earth up from behind.” He paused. “You’d come in out of the evening sky, low in the west after sunset, where nobody’s looking.”

“Are they coming here?” a voice asked. Somebody at the Situation Room end, a woman, quick.

“I don’t know,” Dana said.

“That’s not an answer.”

“Three frames. Forty-one points. I don’t have an orbit. I have a direction.”

The man with the legal pad spoke for the second time. “How long?”

Delgado looked at Dana and she shook her head, and he said it himself. “If they’re pushing. About seven months.”

After a moment PDCO moved on to who would brief whom by when, and Dana muted herself and turned back to the console.

The 19:40 UTC frame was coming down, row by row. Anvil, nine pixels. The brush along the Earth line, a pixel longer than in June. And off its tips, a little farther sunward than an hour before, forty-one points.

15

# The Swarm

*Dresden-Nord, April 2031; Geneva · October 2030 – Monday, 18 August 2031.*

The trench ran two hundred meters along the east fence, between the chiller yard and the road, and Klaus Weber walked the length of it on his bad knee because Arndt wouldn't come up.

"Supply's ninety-one degrees," Arndt said from the bottom. He had two clamp-on meters strapped to the new pipe, one each side of the tie-in, and a laptop balanced on a sandbag. "Return fifty-eight. That's with us at sixty percent."

"And at full load?"

"At full load we make three hundred megawatts of heat and throw it at the sky." He tipped his chin at the cooling towers, steaming in the April cold. "In winter they can take nearly all of it."

Hoffmann from the city utility stood on the far lip in a hi-vis vest over a good wool coat. She had the contract in a plastic sleeve under her arm and hadn't looked at it once.

"Summer is another conversation," she said. "But in January you're heating half of Klotzsche."

"You offered this to the other two."

"All three fabs, the same terms. They took base load only." She shrugged. "They don't like being somebody's boiler. If a line goes down in February, people are cold, and then it's in the *Sächsische Zeitung*."

"Our lines don't go down."

"That's what I told my director."

Weber had grown up near Pirna in a flat heated by a lignite plant upriver, and he could still smell it in the stairwell when he thought about it. Nobody in Klotzsche was going to smell this. He signed in the site trailer standing up, because the folding chairs were worse for the knee.

Back in his office the quarterly idle list was waiting, forty lines from finance on tools and floor space nobody was using. Near the bottom was the old radiation-hardened line, eight-inch, kept warm for satellite

customers who came every three or four years and always in a hurry. Finance wanted the floor. He wrote *leave it* in the margin, initialed it, and moved on to the nitrogen contract.

. . .

By the second week of October the consultation had a lease, a building on the Route de Ferney with a cafeteria and a car park, and a name nobody used. The Standing Consultative Mechanism met in a room with the same nine flags it had had in Vienna and the same quiet Uruguayan chair, and by Christmas everyone called it the council.

Dana sat behind the American chairs again, with a laptop and a microphone she wasn't supposed to need.

The second batch had left on 8 October. Lookout saw it the way it had seen the first. Forty-three of them. The first had been forty-one.

"Twenty-nine days," the chair said when Dana gave the dates. "Is that the Moon?"

"No, ma'am. The Moon is 29.53. This is 29.0, to a few hours."

The third batch on 6 November was forty-five. The fourth, 5 December, was forty-seven. They were all spheres, 3.85 m across, and every batch was a few spheres bigger than the one before. Dana ran the ratio after the fourth and got 1.05 each time, near enough. Five percent every twenty-nine days doubled in a little over a year.

Priya's sheet came in a week before Christmas, from Goddard, with a two-line note asking whether Dana thought it was anything. Priya had taken her inbound movers, the ones braking in from the belt, and summed their counts in the month before each batch, scaled up by the one-in-eight she actually recovered. Then she had lined each month up against the batch that followed it. Four points. The months with the most traffic coming back from the belt came before the biggest batches, and the slope was clean. Four points was a slope a first-year could draw through anything. Dana wrote back that it was something, and asked her to keep it going.

On 3 January there were fifty. On the sheet the fifth point fell where the first four said it would.

Kessler put the sheet up in the January session, credited to Goddard, Priya's name in the corner. He had been seconded from Darmstadt for the council and sat at the ESA chair in his reading glasses.

"The movers go out to the belt," he said. "They come back heavier. A month later it sends out more spheres than the month before. It is spending what the movers bring back. On spheres, and on more movers." He tapped the slope. "Every batch, a few more."

. . .

In February Kessler's heat curve went flat.

The last four months sat on a level line inside their error bars, and he showed it without a word of preamble, then put up a single number.

"To hold that surface there against what it radiates, something inside is making between ten and thirty gigawatts. Germany on a quiet Sunday night is perhaps forty."

"Making things makes heat," the general said.

He was a lieutenant general in the Russian delegation who always wore civilian suits, dark and well cut, and who had spoken perhaps four times since Vienna. He didn't elaborate. The chair let it stand for a moment and called the next item.

. . .

Dana took the train north with Kessler on the last Friday of February, Geneva to Basel and then the ICE down the Rhine. He had a ticket to Darmstadt; she had a flight out of Frankfurt on Sunday and no reason to take the train except that he'd asked.

He talked about the carrier first, before Lausanne. "It is a protected band. Nobody is allowed to transmit there." He had a paper cup of tea balanced on the fold-down tray and kept steadying it. "If it wanted to talk to governments, it would choose a frequency where governments have dishes. It chose one where astronomers have them."

"Or it doesn't care who listens."

"Then it would choose a band with less noise in it, and that one is not so quiet." He shrugged. "Green Bank hears a tone. I hear a tone."

Somewhere after Basel she asked him about the batches, about the word he'd used in January.

"I said spending. That was wrong." He turned his cup a quarter turn. "Spending is when you have a fortune and it goes down. Here nothing goes down. The movers bring back mass, it sends out spheres and more movers, the movers bring back more. It is trading."

"With whom?"

"With the belt. With itself." He looked out at the river, gray and wide and full of barges. "Your Priya's slope says that."

She asked about the heat, and he was more careful.

"It is a good curve," he said, "if the surface is the same surface."

She had the Hubble numbers in her head, two percent a month at first and fainter ever since, and a cooling metal face that didn't darken. She looked at the barges. He didn't ask.

At Darmstadt he stood up and got his bag down and stood in the aisle a moment with it.

“Next month,” he said.

“Twenty-nine days.”

· · ·

The first batch came in out of the evening twilight in the second week of April, the way JPL had said it would in September. The ground networks’ tracks said it was braking, hard and evenly, and it would go on braking for weeks. From the ground it was nothing, a scatter of points too faint for most telescopes low in the west after sunset, except that every few minutes one of the spheres turned its polished face to the Sun at the right angle and flashed for tens of seconds, bright enough for a backyard camera.

The forty-three of the second batch were a month behind them, fainter, higher in the dark.

Earl Voss had the first count on his forum before anyone official said a number.

Animas NM, 14 Apr 2031, 03:05 UTC
West, end of astronomical twilight, 25 min before they set.
Flashes only. Logged each one, GPS time on every frame.
41 separate sources. Stack agrees: 41.
Ontario group has the second bunch at 43.
41 of 41 left. 43 of 43 left.
Seven months out there and they didn't drop a single one.
Somebody's not losing any.
Clear skies

By the weekend the press had settled on the Swarm. Half the replies under Earl’s post said he was faking it, and some of those were from people with telescopes.

· · ·

On Tuesday, 22 July, the council met at ten. By then the first four batches were in.

They hadn’t come down. They had braked into long, eccentric orbits around Earth, perigees near 30,000 km, apogees out near 100,000, and they hung there on a shell that was filling up from the bottom. The count depended on whose network you believed. Space Force said 176, ESA 181, the Russians 183. Dana’s own number, from the public tracks, was 178 with a handful she couldn’t separate. The sum of the first four batches was 176.

The man with the legal pad had come out from Washington for the session. He sat in the American chair this time, and when the chair gave him the floor he spoke for five minutes without looking at it.

"Whatever its purpose," he said, "we now have approximately one hundred and eighty objects of roughly 235 tonnes each, iron, in orbits around this planet, delivered by a party that has not communicated with anyone. A new delivery arrives every month, each larger than the last. My government regards this as a stockpile, and it will plan on that basis."

Dana pressed her button before she'd decided to. The red light came on at her seat. The chair looked over her glasses at it, and at the American chair in front of it, and gave her the floor anyway.

"A stockpile is a pile," Dana said. "This is spaced out."

Somebody behind her stopped typing.

"I've fit every orbit we have. The perigees are all within a few thousand kilometers of each other, and the orientations are spread evenly, like slots. When a new sphere brakes in, it doesn't go near the ones already there. It goes into a gap. Every one of the second batch went into a gap the first batch left." She heard her own voice through the room speakers and kept going. "You don't get that by dumping things in orbit. Somebody is placing them."

He didn't turn round.

Kessler had his light on next. "Each of them has one face that is polished. We see it only when it flashes, when the face is between the Sun and us at the right angle." He took off his glasses. "A polished face is not decoration. It is something you point."

"Point at what?" the Japanese delegate said.

"At us. At the Sun. At each other. I do not know."

"A thing you place and point is a thing you aim," the general said. "In my profession that is not a difficult word."

"In mine it isn't either," the man from Washington said.

"They spent seven months braking so they wouldn't come down," Dana said. The chair hadn't given her the floor again, and nobody stopped her. "If you wanted to drop iron on someone, you wouldn't stop first."

"235 tonnes at 11 kilometers a second is three kilotons," the general said. "Each. It does not have to be dropped today."

"Or it's a telescope," the Japanese delegate said. "A hundred and eighty mirrors around one planet. Who builds that to attack someone? You build that to look."

"Dr. Kessler, in Vienna you said it was parked to see," the chair said.

"I said that," Kessler agreed. "I did not say what it would do with what it saw."

Lin Wen, at the Chinese chair, hadn't pressed her button all morning and didn't now. The chair took the item off the public summary, to be revisited in September, and moved on to the budget for the building.

At the break the American stood, collected his pad, and went out by the far aisle, so he never had to pass behind her.

. . .

Late in July the Ontario amateurs who had counted the second batch posted a few small, faint objects near the geostationary belt that didn't glint and didn't tumble, and the trackers filed them as debris.

On Monday, 18 August, they posted another plot. Dana had it on her phone before the morning session: a single sphere on its long orbit, and a few kilometers behind it, faint, a second track, matched to a Chinese object launched in June and catalogued as a rocket body. For seven nights the gap between them hadn't changed. Over the weekend Beijing had said it was debris.

She found Lin by the coffee machines on the ground floor and held out the phone without saying anything.

Lin took it, enlarged the plot with two fingers, looked at the gap between the tracks, and handed it back.

"Your briefing is at two," she said. "You should eat something first."

16

# Glint

*Dresden-Nord; Geneva; Goddard, Greenbelt · Monday, 15 September – Monday, 27 October 2031.*

The forecast review was in the third-floor room because a customer audit had the big one. Weber took the energy pages himself. Nobody else read past the first line of them.

Power was on plan. Water was a little under. Nitrogen on plan. The controller had marked the heat-export line in yellow, which in her system meant either a mistake or a question for him.

"3.4 times plan," she said. "In September."

"Nights?"

"Nights included. I went through the hourly."

So had he, on Saturday, at the kitchen table. In September the city wanted almost nothing through the new main: showers, two hospitals, the swimming baths at Prohlis. The plan had it carrying a trickle until the heating season and a river after. The meter at the property line had been reading like January for five weeks.

"And the cooling towers?"

"Standby since the end of May," she said. "Arndt's note says the controls did it themselves. The main was taking everything, so the towers had nothing to do."

"Then leave them."

She waited to see if there was more. There wasn't. Hoffmann had written on Friday to say her board was delighted, that the figure was the best single month the network had ever booked from an industrial source, and to ask whether it would hold through the winter. The email was clipped to the back of the pack.

"Tell her yes," Weber said.

He initialed the line, and the one below it, and turned the page to nitrogen.

· · ·

Lin found Dana in the council cafeteria on the Route de Ferney on Thursday, after the afternoon session, and sat down without a tray. She took a paper napkin from the dispenser and took out a pencil.

"One sphere," she said. "One station, in Ontario. Three nights." She wrote the times in a column, the way you'd log them at the eyepiece.

*15 Sep 02:41:12 16 Sep 02:41:07 17 Sep 02:41:19*

Local time. Dana read down the seconds. "Same minute."

"Within twenty seconds, once you take out its own motion along the orbit."

"A face held fixed on the stars comes round four minutes early every night."

"Three minutes fifty-six." Lin drew a second column beside the first, *02:37*, *02:33*, and crossed it out. "It does not do that."

"So it isn't fixed on the stars." Dana turned the napkin toward herself. "It's turning with the ground."

"The faces move with the ground," Lin said. "Yes."

"Pointing at what?"

Lin put the pencil down. "It is a public list. Anyone can have it."

"That isn't an answer."

Lin stood up. She left the napkin.

Dana sent it to Priya from the tram, photographed against her knee, with three lines underneath. The list was the amateur glint catalog: a few hundred backyard stations logging the flashes off the swarm, about thirty-eight of them with real GPS timing, and most of the good ones were copies of Earl Voss's build, down to the antenna puck taped to the tube. Earl's Animas station sat at the top of the timing table. It had since spring.

*Can you stack the whole thing and solve for where the faces point?*

Priya answered before the tram reached Cornavin. *Probably. Each glint is a normal at a time. Give me two weeks.*

· · ·

Priya's office was on the second floor of Building 34, Monday the sixth of October, with a window onto the parking lot and two monitors turned toward the door. She was smaller than Dana had expected and wore a gray Rutgers sweatshirt with the sleeves pulled down over her knuckles. They had spoken on video perhaps sixty times since 2029.

"You're shorter on video," Priya said, and then, because that was wrong: "Taller. In person."

"I get that a lot," Dana said, which wasn't true, and Priya looked relieved anyway.

The map was already up. A world in gray, the land in a lighter gray, and on it small colored ellipses, each one a lock: a place on the ground that one sphere's face had held, night after night, across every station that had caught it.

"Three hundred and thirty-one in the catalog with enough glints to solve," Priya said. "Two hundred and seventy-four lock. The rest wander or I don't have the timing. The locks are good to a few kilometers. Some under two."

Dana leaned in. The ellipses weren't spread out. They sat in knots. Northern Virginia. The Columbia Gorge. Central Ohio. Two in Texas. One in Arizona. Taiwan's west coast. Korea, Japan. Frankfurt, Dublin, the north tip of the Netherlands. One on the coast east of Mumbai.

"That's not Washington," Dana said. The Virginia knot was north of Dulles, out in Loudoun County.

"Fifty kilometers off. The lock's good to three." Priya clicked, and the Virginia knot resolved into eleven ellipses over farmland that wasn't farmland anymore. "Not cities. Not capitals. I checked the capitals first. I thought it would be capitals."

"What is it?"

"Data centers," Priya said. "And fabs."

She brought up the tab behind the map.

| sphere | lock_lat | lock_lon | err_km | class | site_MW | sink_frac |
|---|---|---|---|---|---|---|
| S-017 | 39.02 N | 77.47 W | 2.1 | dc | 310 | 0.02 |
| S-044 | 45.61 N | 121.19 W | 3.4 | dc | 240 | 0.00 |
| S-102 | 32.44 N | 99.74 W | 1.8 | dc | 420 | 0.01 |
| S-131 | 24.78 N | 120.99 E | 2.6 | fab | 180 | 0.04 |
| S-166 | 32.88 N | 130.84 E | 2.2 | fab | 150 | 0.03 |
| S-208 | 35.83 N | 140.15 E | 2.9 | dc | 160 | 0.00 |

Dana didn't trust it. She took the mouse, which Priya allowed, and went looking for the thing she had been afraid of since April. Great Falls, Montana. Minot. Cheyenne. She zoomed in over the missile fields until the base map showed section roads and stock tanks, and found grass. No ellipse within two hundred kilometers of a launch facility. She went to the submarine bases. Nothing at Kings Bay, nothing at Bangor.

"Nothing under about a hundred megawatts," Priya said. "Anywhere."

"Steel mills draw that."

"Aluminum smelters draw a gigawatt. There's one in Quebec that draws nearly as much as the whole Virginia cluster." Priya pointed at the empty St. Lawrence. "No sphere."

Dana sat back. "So it isn't heat."

"It's heat. Look at Abilene." Priya took the mouse back and opened a time series: S-102's lock error against date, a flat line at about two kilometers through June and July, then a spike. "Twenty-second of August. Grid emergency, heat wave, they asked the big loads to drop. This campus curtailed for about nineteen hours. Almost to zero." On the second plot the lock point left the campus, drifted west across Taylor County, tightened and loosened, never settled. "It wandered the whole time. Load came back at 14:10 local on the twenty-third. Lock's back by 15:02."

"Within the hour."

"Within the hour. Every station that had it agrees."

Dana looked at the knot in Texas, at the knot in Arizona, at Hsinchu. "Heat from thinking," she said.

"Fabs don't think."

"They make the thing that does."

"That's a story. It fits, I know it fits. Lots of stories fit fourteen clusters."

"Then give me another one."

"I don't have to have another one." She said it to the monitor. "I have a face that tracks a place to two kilometers, and the place is hot in a particular way, and when it stops being hot the face loses it. That's what I have."

"In a particular way," Dana said. "A smelter's hot. A smelter's a steady gigawatt. Why not a smelter?"

"I don't know."

"Because a smelter's just heat. This is heat that's computing something." Dana heard herself and didn't stop. "Or it's the people. The machines are where the people who matter sit. It's watching us through what we built."

"Then it would sit on Washington," Priya said. "On Beijing. On the boards of the companies, which aren't in Abilene, I looked. And in Abilene the people didn't leave. During the curtailment there were more of them on site, not fewer, they had every engineer in. The people stayed. The load left. It went with the load."

"So it wants the machines."

"It *sees* the heat. That's the only verb I'll put my name to."

"Why heat, though?" Dana said. "It found us in infrared. It's been looking at a warm planet from L5 for three years. We're a disk with hot spots."

"From L5 a data center is nothing. Not a pixel. Not a part in a million of the disk."

"So it came closer."

“That’s what the spheres are for, then. That’s your story.” Priya finally turned from the screen. “I don’t like guessing. I want to say that before you put any of this in a cable.”

“I’m not putting it in a cable.”

Priya didn’t answer that. She clicked to a third tab. It was labeled `under`.

. . .

There were two dozen rows on it, and Priya had sorted them by the last column, `sink_frac`, high to low.

“These are sites that should lock,” she said. “Power’s right. Load’s right. Same kind of work.” Odense. Espoo. Two in Stockholm. A fab on a river in Europe that ran its cooling water straight back into the river. “They put their heat somewhere. A district heating network, mostly. The river, for that one. Not up a tower, not out a roof.” The lock column beside them read *weak*, *weak*, *none*, *none*, *weak*.

“So the ones that dump into a city get watched less,” Dana said.

“Seen less.”

“That’s the same thing.”

“It isn’t. I don’t know what it’s doing. I know the lock’s weaker.” Priya scrolled. “Sink fraction over about 0.8, the lock goes weak or goes away. Under 0.3, never. In between it’s a mess.”

Dana thought of a cooling tower plume on a clear night, from thirty thousand kilometers, and then of the same heat going into pipes under a city and coming out as shower water and warm radiators, spread over a hundred square kilometers of roofs.

They spent Tuesday and Wednesday on Table 2. It was the table that would get read: the bands that sorted any site on Earth into fab, data center or nothing, by power draw, load factor, sink fraction, and whether the acid scrubbers on the roof were running; the scrubbers were what made a fab a fab. Priya had the bands from the histograms. Dana wanted the fab power line at 150 MW, so that nobody could hold up a pharmaceutical plant and call the map a joke.

“There are two fabs between 110 and 150,” Priya said. “They lock hard. Both of them.”

“Two.”

“Two out of nineteen. You’d throw them out to look careful.” She brought up the histogram. There was a gap at 108 MW, clean, twenty megawatts wide. “That’s where the data puts it.”

Priya had started typing the number in before Dana said, “Fine. 110.”

“108.”

“108.”

. . .

On Wednesday afternoon they ran the bands over every site in Priya's list, to see what fell in the cracks, and Dana went through the result country by country while Priya fixed the plotting.

Taiwan was bright. Korea, Japan, bright. India had Navi Mumbai and a weak lock outside Hyderabad. Then the cells went dark.

"China," Dana said.

"I know."

"There's nothing. Not weak, nothing." She paged down. Shanghai, Wuxi, Shenzhen. Big campuses in Guizhou and Inner Mongolia that passed every band in Table 2, high load, low sink fraction, towers running. "These should lock. Half of these should lock hard."

"I know. I checked the station coverage. Japan and Korea see the same spheres. There are glints over China, plenty. The faces just never sit on anything. I can't explain it with `under`. Their sink fraction's low."

Dana thought of August, and the object Beijing had called debris. From a few kilometers you wouldn't need the catalog or the stations or Priya's two weeks. You would watch the face turn.

"They know," Dana said. "They've known since August what it looks at."

"That's another story."

"It's another story."

"Does it go in the paper?"

"No," Dana said. "Put the cells in. Leave them dark."

. . .

Priya published on Monday, the twenty-seventh of October, at nine in the morning Eastern: a preprint, the map, the catalog cross-match and every line of the code in a public repository, her name alone on all of it. Dana had taken hers off on the Thursday before, and Priya had argued for an hour and then let her.

In Geneva it was two in the afternoon. Dana could have called the PDCO duty officer on Friday, or Sunday, or that morning. At 14:40 her phone lit with a Washington number, and she turned it face down and went to find Lin.

Lin was in the hotel bar on the lake side with a glass of white wine she had nearly finished. Dana put the tablet in front of her with the map open and didn't say anything. Lin turned it toward the window light and looked a long time at Virginia, then Texas, then she slid it east. Frankfurt. Dublin. Mumbai. Hsinchu bright on its coast, Pyeongtaek, Kumamoto, Inzai.

And west of the water, dark cells. The whole coast and everything behind it, all the way to the mountains.

“Why?” Dana said.

Lin drank the last of the wine. She set the empty glass down on the tablet, over Shanghai, and left it there.

17

# Relay

*Dresden-Nord, October 2031; Geneva · Tuesday, 2 December 2031 – Monday, 16 February 2032.*

The old line was on the week's schedule, which it hadn't been in three years.

Weber found the reason on Thursday morning. An order for eighteen hundred DNX-R7, the radiation-hardened controller they had stopped quoting when the last satellite builder in Europe went to a Taiwanese part. A distributor in Rotterdam he didn't know, standard terms, a margin nobody would argue with. Approved under his e-signature at 15:42 on Tuesday.

He didn't approve things on Tuesdays. He let the queue fill all week and cleared it on Friday afternoons, forty or fifty at a go, with the door shut and the radio on. He scrolled back. The Friday before had sixty-one approvals, all his. The Tuesday one sat by itself, between a meeting about the heat-export contract and a call with the gas supplier.

He had been on his phone in that meeting. He was always on his phone in that meeting. He must have cleared it there.

He went down to the floor at the shift change and found Pohl by the wet benches.

"The R7 line," he said. "There's an order."

"For R7?" Pohl took his glasses off. "Who flies R7 anymore?"

"Somebody in Rotterdam. Put a test lot through. See if the masks are still good."

"And if they are?"

"Then tell me."

Pohl put his glasses back on and went to find the binder for a line nobody on his shift had ever run.

· · ·

On Tuesday 2 December the council room on the Route de Ferney had the tracking board up for the monthly shell count when the American colonel's laptop chimed and he said, "Launch. Sohae."

It was 11:20 in Geneva. Nobody had been told. The board took four minutes to catch up with his laptop: a short red arc off the west coast of Korea, then a longer one bending east and up, then a label the software had never used before, `UNK 2031-212`, coasting.

By one o'clock the arc had a dashed extension. It ran out past the geostationary belt and ended on a sphere the board called 288. Lock: Pyeongtaek. Predicted closest approach 03:20 UTC Wednesday, fifteen hours out, perigee pass, about 30,000 km up. Under that, in the small type the room had learned to read first: `CA 210 km ± 400`.

"It'll miss," the colonel said. "They've never hit anything that wasn't painted on the ground."

The news came in behind the board in three languages. KCNA called it a sovereign act of defense against the foreign bodies menacing the Korean peninsula. Seoul called it reckless. At four the Chinese head of delegation asked for the floor and read a statement into the record: the People's Republic had no prior knowledge of the launch and no part in it. Lin, two seats behind him, didn't look up from her laptop while he read.

Nobody went to dinner. The delegations ate sandwiches the secretariat brought in on trays and watched the miss distance come down every time the arc was refit.

`CA 38 km ± 60`, at seven.

"It's still a miss," the colonel said.

"It's a miss with a vehicle that's correcting," said the man with the legal pad. He had flown in on Sunday for something else.

Ray Delgado was on the speaker from JPL, where it was the middle of his working day. "If that's a correction it's a good one. Who taught them that?"

Nobody answered him.

At nine the general leaned back from his table. "It will move. It has moved itself into a gap four hundred times. It will move again."

"It might not notice," the Japanese delegate said.

"It sees a data center from thirty thousand kilometers. It will notice a rocket."

Kessler had been quiet all evening, his notebook open on the table in front of him. "It moved for its own reasons," he said. "We do not know that this is one of them."

`CA 6 km ± 11`, at midnight. 288 didn't move. The amateur glint feed kept posting it on schedule: Ontario, New Mexico, a station in Chile, the face

swinging with the ground toward Pyeongtaek every few minutes, the way it had every night since September.

Dana sat with the US delegation because that was where her badge said to sit. She had the shell file open and was doing nothing with it. At one in the morning the man with the legal pad came and stood behind her chair.

"If they hit it, what happens?"

"I don't know."

"Give me a guess."

"It's at perigee. It's going about four kilometers a second. So is the vehicle, more or less, in a different direction." She looked at the board. "They don't have to be clever. They have to be in the same place."

At 04:19 in Geneva, 03:19 on the board's UTC clock, the feed posted a glint from 288 out of Ontario. The next one, due at 03:22, didn't come.

The board said nothing for forty seconds. Then the colonel's laptop chimed again and he read off it. "Track's gone. Two new objects at the intercept. Three. Space Track has three."

"Izaña," Kessler said. He was on his phone already, to the ESA telescope on Tenerife, where it was the middle of a clear night. He listened. "One large piece. Two small. The large one is 288. It is not glinting." He listened again. "Its orbit is not the same."

"Shattered?" somebody said.

"Cracked. It is one piece. It has moved."

The colonel was shaking his head at his screen. "That's not possible. Not from them."

"I'd have bet the house," Delgado said on the speaker. "I'd have bet the house and the car."

Across the room Hale had his phone out and was typing something short into it. He put it away and looked at the board.

For nine minutes the room talked over itself. Seoul's statement. The French delegate saying the word *precedent* twice. The general, to nobody: "So. It can be touched." Dana watched 288's new track settle on the board, a fresh ellipse a little off the old one, and found she was waiting for something to come down on Pyongyang.

At 03:29 the board dropped a geostationary satellite.

It wasn't a sphere and it wasn't Korean. A commercial relay, European, parked over the mid-Atlantic, its status going from green to gray with no fault code in between. Izaña had it a minute later: debris, spreading along the belt.

"That's ours," the French delegate said. "That's a company's."

"That's theirs," Hale said. Everybody turned. "Their uplink's been on that relay since launch. One transponder, leased through a reseller. It was carrying the guidance."

"You knew that at noon," the colonel said.

"I knew it at two."

"So it hit back." The general spread his hands. "It was attacked and it answered. That is the oldest thing there is."

"Then why not Sohae?" the NSC man said. "If I wanted to punish somebody, I'd punish the people who launched. Not a company in Luxembourg."

"Perhaps it does not know who launched."

"It knows where every fab in Korea is."

"It doesn't matter why," the colonel said. "It's a second strike. One of them took out the relay."

"No," Dana said.

She already had the shell file up, all 452 of them, positions at 03:20. She sorted on distance from the relay. The room waited while she did it, which she hadn't expected.

"Nearest sphere to that relay at the time of the hit was 288 itself, and 288 was dead," she said. "Next nearest, 61,000 kilometers. Nine minutes is 540 seconds. At 50 kilometers a second, the fastest thing we've ever seen come off Anvil, that's 27,000." She looked up. "None of them could have got there. Not if they'd started the moment the glints stopped."

"So something else did," Lin said from behind the Chinese chairs.

"Something closer."

Kessler had the phone to his ear again. He held up a hand and the room, for once, let him have it. "Izaña has been on the belt since the relay went," he said. "There is a faint object about 300 kilometers west of where the relay was. It was on the Ontario list in July. Debris." He listened. "It has changed its drift. Since 03:28."

"Changed how?" the colonel said.

"Changed. It was drifting one way. Now it is drifting less." He lowered the phone. "Something left it, or it did something. They cannot say which."

"How many of those are on the Ontario list?" the man with the legal pad said.

"A handful," Dana said. "Filed as debris."

"Pickets," Hale said, to the board. "Little ones, on the belt, where you'd post a sentry."

"You think it has sentries," the general said.

"I think it had one in the right place at 03:28."

The chair had said nothing all night. Now she looked down the table at the American seats. “Dr. Okafor. What is it doing?”

Dana had been working on the sentence since the relay went gray. She still didn’t like it.

“Anvil doesn’t punish,” she said. “It removes whatever makes an attack on it work.”

· · ·

By Christmas the story was in the papers in pieces. The guidance parts had been bought through brokers in four countries, with paperwork good enough to pass anywhere that didn’t look twice, and the vehicle had flown better than anything Pyongyang had ever put up; the analysts on television said so and then said nobody could tell them who had made it that good. Pyongyang itself went on exactly as before. On 21 December, nineteen days later, a sphere from the outer shell braked into 288′s place, and by the next week the amateurs had it glinting on Pyeongtaek. The cracked one went on round its new orbit, dark.

Kessler caught Dana in the corridor outside the delegates’ lounge on 8 January with his notebook open.

“How far it moved,” he said. “We have the vehicle’s mass from the launch footage, roughly. The rest is momentum.” He turned the page to her. “235 ± 30 tonnes.”

Under the number, in pencil, a box. Inside it: $2^{101}$ *iron atoms.*

“Two to the hundred and first,” she said.

“About 235 tonnes.” He closed the notebook. “Any mass is within about forty percent of some power of two. It is probably nothing.”

“Probably.”

“I could find one in your telephone,” Kessler said, and went in to get coffee.

· · ·

The American motion went to the council on 27 January. It asked member states to suspend, for an initial ninety days, the public release of sphere glint catalogs and lock maps, “pending assessment of their use in targeting.” The man from the National Security Council had drafted it. Dana had read it on the Friday and said what she thought, in a room with the door shut, and been thanked for her input.

The colonel introduced it. The British spoke in favor. The French reserved. Then the chair called the next request to speak, and the light on the panel was the one in front of Dana’s seat.

She had pressed the button in Vienna once and cancelled it. She didn't cancel this one.

"I'm speaking for myself, not for my delegation," she said, and heard the colonel shift beside her. "The catalogs are how we know which sphere points where. The Ontario list is how we found the pickets. Take them down and the only people who'll know where the spheres are looking are the people with their own telescopes, and some of them already stopped telling us in August." She kept her eyes on the chair. "Nobody guided a rocket off a glint catalog. They guided it off a relay. Suspend the catalogs and the next one is still guided. We just don't see it coming."

The general had his light on before she finished. "The Russian Federation agrees with the American," he said. A pause. "The other American."

There was laughter, not much of it. The Chinese head of delegation asked for the floor and said that the People's Republic opposed any restriction on the free exchange of scientific observation. Lin, behind him, studied the ceiling. By the afternoon session the motion had been withdrawn for further consultation, and the colonel hadn't said a word to Dana since the morning.

As the room broke up Lin came past behind the American chairs. She didn't stop.

"You will need a new badge," she said.

The week after, an assistant secretary in Washington told her on a call of eleven minutes that she was no longer a member of the United States delegation. An email from JPL human resources the next morning put her on leave without pay pending review. Her clearance lapsed with the job; nobody had to suspend it. She read the email standing in the kitchen of the flat with her coat still on. She had been at JPL since she was twenty-six. What she found she minded was small and stupid: the gate on Oak Grove Drive, the guard who said her name, the linker still running at four in the morning on cores nobody had assigned it, which somebody would now switch off. Glen texted that night: *Sorry, D. The paper's still on hold.*

On 6 February the chair asked her up to the office on the fourth floor, the one with the view of the Jura that nobody below the Secretary-General's people ever saw.

"The council needs a technical briefer," the chair said. "Its own. Answerable to this office, not to any delegation. You'd brief everybody the same thing at the same time."

"Washington will object."

"Washington has objected." The chair slid a contract across the desk. "I told them they have nobody else who can read Dr. Raman's code."

Dana signed it there. The new badge was blue, and it took the secretariat four days to print.

. . .

On Monday 16 February she was at her new desk at 06:40 when Priya's message came in from Greenbelt, two words and a plot, and twenty minutes later the notice went out over Dana's own name for the first time.

JOINT NOTICE — Council Technical Briefer / ESA Planetary Defence Office / Minor Planet Center
Issued 16 Feb 2032, 06:00 UTC

Shell count at 00:00 UTC: 581 spheres.

Since 13 Feb, a subset of spheres has executed braking maneuvers near apogee. In every case the result is a lower perigee. Rates are consistent across the subset. Glint locks on all affected spheres are unchanged.

No other change in shell behavior is detected.

Spheres lowering perigee: 112

18

# Slow Fall

*Geneva · Monday, 16 February – Monday, 21 June 2032.*

The joint notice had gone out on Monday morning, and on Wednesday night Priya sent the sheet that made it worse.

It had one tab that mattered. `lowering` was 112 rows, one per sphere, sorted by perigee, each one joined to its lock from the Greenbelt work. Dana scrolled to the `site_type` column and down it. It said `fab` 112 times. The `scrubber` column was a solid run of ones. Priya's email was two lines: *Zero data centers. I ran the join four ways because I didn't believe it either.*

By then the newspapers had a phrase for what the rest of the industry was doing, which was running cold. Operators in Loudoun County were draining halls and shipping the work to Stockholm and Odense and Helsinki, anywhere the heat went into somebody's radiators, because the `under` tab in Priya's October paper said those were the sites the spheres saw least; one campus in Oregon had shut outright and called it maintenance. Nobody on the council had proposed another intercept. They had all watched the relay die.

Dana put the sheet on the screen on Thursday afternoon.

The Japanese delegate had asked for the floor first, and he read from four pages he had written out by hand the night before, in English, with the corrections still on them. He had spent eleven years at a chip plant. A wafer took about three months to go through a line, he said. Some steps could not be stopped for more than a few hours without scrapping everything in the furnaces. A lithography tool was the size of a bus, and if you put it on a truck you were buying a new one. A data center could move its work tonight. A fab that shut down threw away a quarter's output and took most of a year to come back to yield.

"Every one of the 112," Dana said, "is on a fab. None on the data centers, though the data centers were hotter in January and most of them still are." She brought up the map. "It's going after where the thinking gets built."

The Russian general said that was how you fought a war. You did not bomb the army. You bombed the rail yards and waited.

The French delegate said it was going after the future, not the present. The machines running today were already built. The ones that mattered were in the furnaces in Hsinchu right now.

"Or the present is already cold," Lin said. "You turned it off yourselves. Last week. It does not need to."

"They started down on the thirteenth," Dana said. "Loudoun was running hot on the thirteenth. It picked the fabs before anybody turned anything off."

Lin looked at the dates on the screen and let it go.

Kessler had his notebook shut on the table in front of him. "A data center is a tenant," he said. "You can move the tenant. A fab is the building. You say it wants the thinking. I say it wants whatever cannot run away. I do not know which. Neither do you."

The chair asked Dana which of them was right.

"I don't know," Dana said. "I know which addresses."

· · ·

In March the tracking networks caught up with Priya.

Izaña and the amateur stations had been publishing impact ellipses since the first perigee pass. In February they were the size of continents, smears across the Pacific that the papers printed in red. Each pass cut them down. By April they were tens of kilometers across, and every one of them sat on a name that had been in Priya's `lowering` tab since February.

"They're drawing my map," Priya said. It was the first time she had called; she was in her car in a parking structure in Greenbelt, the engine off so Dana could hear. "Slower and with worse error bars. What are the governments doing with it?"

Dana told her. Taipei and Seoul had briefed the companies. Tokyo had issued a statement about vigilance. Arizona's emergency managers had received the Chandler solution eight days after the council sent it to Washington, and in the version they got the centroid had been rounded to the Phoenix metropolitan area.

"Rounded," Priya said. "That's not a centroid. That's a weather forecast."

Dana's terms of reference ran to a page and a half, signed by the chair in February when the blue badge was printed. Section 3 said the technical briefer would provide *timely technical information to affected parties*. It did not say which parties. It did not say through whom.

She decided that a prefecture was a party.

She wrote the first one on the evening of 9 April, in a council template made for something else, and sent it to the duty address of the Kumamoto Prefectural Government's crisis management office listed on the prefecture's website. She copied the chair.

**COUNCIL IMPACT NOTICE  CIN-2032-014**

| | |
|---|---|
| Issued | 2032-04-09 16:20 UTC  Issuer: SCM Technical Briefer |
| Area | Kumamoto Prefecture, JP. Centroid 32.88 N, 130.84 E |
| Window | 2032-07-14 to 2032-07-16 (est.) |
| Radius | evacuate 3 km; glazing hazard to 5 km |
| Basis | SCM tracking solution; pointing data (Raman et al.) |

*Evacuate 3 km* was the only verb in it. Then she wrote the same notice for Leixlip, for Kulim, for Malta in New York, for Chandler with the centroid to two decimal places, and put her mobile number in the covering email of every one, because the template had no field for it.

. . .

The phone rang at two in the morning, Geneva time, in the rented flat on the Rue de Lausanne. The number started +81.

"Dr. Okafor? This is the crisis management duty officer, Kumamoto Prefecture." His English was careful and fast. "I have your notice. 014."

"Yes."

"Is this from the Japanese government?"

"No. From the council."

"Then who do I call to confirm it?"

"Me."

She could hear an office behind him, a printer and a man reading numbers. It was nine in the morning there.

"I have called Tokyo since one o'clock," he said. "The Cabinet Office says it is aware of the council's work. Defense says ask the Cabinet Office. Foreign Affairs says the council has no authority to issue warnings in Japan." He stopped. "Is that true?"

"Yes."

"Then why did you send it?"

"Because the centroid is right," Dana said. "And nobody else was going to send it to you."

"How right?"

"The tracking solution's one-sigma ellipse is about 9 km by 4. The pointing solution is tighter. The sphere has been locked within a few kilometers of that plant since last summer. The two agree."

"The plant." He said a name, the joint venture in Kikuyo, and she said yes. "They built it here because of the water," he said. "Do you know that? The groundwater. It is the best in Japan for this. Everyone was very happy." Paper moved. "3.4 kilotons."

"About that. It's the mass and the speed. Eleven kilometers a second."

"Hiroshima was fifteen."

"Yes. And that was an air burst. This is a surface impact. Most of the energy goes into the ground and the air near it. Buildings come down out to about 0.7 kilometers. Windows to about two. The 3 km is margin on the centroid. The 5 km is for glass."

"There is a hospital at four kilometers. There are four elementary schools inside five." He read off names and distances. "The window is three days."

"Plus or minus a day. It'll come down to hours. I'll send you every update when I have it."

"The plant has six thousand people working. Shifts. Contractors." He paused. "Is it aiming at them?"

"It's aiming at the heat."

"The heat is them. The heat is people working."

"The heat is the tools," Dana said. "The furnaces, the chillers, the scrubbers. The ones that lock are the ones that dump it into the air. We don't see any lock on a place because people are in it."

"You see the heat. You don't see why."

"No."

"In 2016 we had two earthquakes in two days," he said. "Magnitude 7.0. Everybody here remembers. We did not know the second one was coming. If we had known three months ahead we would have done everything." He breathed out. "I need to take this to the governor at ten. He will ask me who said it."

"Tell him the council's technical briefer. Tell him the basis is the tracking solution and Dr. Raman's paper, which is public, with code. Tell him he can call me."

"He will not call a foreigner at two in the morning."

"Then you call me. Any hour."

"And if Tokyo tells him not to move anybody?"

"Then he has to decide whether he believes Tokyo or the orbit."

"That is not fair to him," the duty officer said. "But it is the question. Can it miss?"

"Not by three kilometers. Not on anything we've seen these do."

"Can it change its mind?"

She thought of Abilene. “If the plant goes cold, it might,” she said. “I don’t know. Nobody’s seen one turn away on the way down. And a fab can’t go cold in three months without throwing away the fab.”

“So we evacuate a plant that cannot be evacuated.”

“You evacuate the people. You leave the plant.”

He was quiet again. When he spoke it was slower. “Please spell your name. For the log.”

“O, K, A, F, O, R.”

“Thank you, Dr. Okafor.” He read her number back to her, every digit, and she said yes at the end of it.

. . .

The letter arrived on 17 April, from the Office of the Legal Adviser at the State Department, addressed to the chair, copied to FEMA and to the Arizona Division of Emergency Management, which had written its own letter two days before. It said the council held no authority to issue emergency information within the territory of a member state, that unilateral notices to subnational authorities undermined coordinated national response, and that the United States reserved its position on the status of the technical briefer. Arizona’s letter said the Chandler notice had caused the governor’s office to learn of the threat from a city fire chief.

The chair read both at her desk in the small office behind the council room and handed them across. “Are they right?”

“Yes,” Dana said.

“About all of it?”

“About the authority. You don’t have any. Neither do I.”

The chair took her glasses off. “Then keep sending them.”

The US delegation stopped coming to the technical sessions the following week. Her emails to the mission came back with an automatic reply naming someone she had never met. The Lookout feed from JPL now came through the council’s registry a day late with a cover sheet. She had expected it to take longer.

Kumamoto did not write a letter. The governor announced a voluntary relocation zone of 3 km on the twenty-second and a mandatory one for the window. The plant said production would continue.

On the twenty-third there was a white paper bag on her desk in the briefers’ room. Inside were two *dorayaki*, still soft. The Japanese delegate was in his seat across the room with his handwritten pages, reading. He did not look up, and she did not ask.

. . .

At the end of May the solutions settled.

Dana ran the 112 forward on Thursday the twenty-seventh with Izaña's latest astrometry folded in. Hsinchu, Tainan, Kaohsiung. Pyeongtaek, Hwaseong. Kumamoto. Chandler, Taylor, Malta. Leixlip, Kulim, Singapore. The two fabs in Dresden. All of them on Thursday 15 July, between 11:06 and 11:09 UTC. Spheres that had started down months apart, in different orbits, from different sides of the Earth, were going to arrive inside the same three minutes.

She put it on the screen the next morning without saying anything first.

The British delegate said it was showing that it could. The Russian general said it was denying warning; somebody pointed out that everyone had three months' warning already, and he said warning of the second from the first was different.

Kessler had worked the arithmetic in his notebook while they talked. "It is phasing each lowering to arrive at the same time. The early ones braked late. It paid for this."

"So it wants something from the three minutes," Dana said.

"So that nothing can be moved in between," Lin said.

Dana turned. "Moved by whom?"

"By us." Lin looked at the column. "If Hsinchu goes first, the next morning there is a plane full of engineers and masks from Hsinchu going to Arizona. Or a plane from Arizona going to Kumamoto. You can move people and photomasks in a day. In three minutes you cannot move anything. It has thought about what you would do after the first one."

"You're saying it understands the industry."

"I am saying the industry is very easy to understand if you have watched it for four years from the side."

· · ·

On Monday, 21 June, the German delegate asked his question at the end of the morning.

"Dresden has three fabs," he said. "Two of them are in your notices. The third, Dresden-Nord, is not. Four spheres on two fabs, and nothing on the third. People in Dresden are asking me why. I would like a reason that is not luck."

Dana brought up the `under` tab. Dresden-Nord had sold heat to the city's district network, and its sink fraction had read over 0.9. "It has a lock," she said. "A weak one. Its sphere wanders a few kilometers either side of the plant and comes back. That sphere isn't one of the 112. It's on its original orbit, perigee steady."

“It could still be lowered.”

“Not in time. I ran every one of the 112 back to where it started down and forward on the best path it could have flown. None of them could reach Dresden-Nord by 15 July. None of them could reach it at all with the braking they’ve done. It was settled before any of them started down.”

“Settled by what?”

“By whatever chose the 112,” Dana said. “It chose them before the window was set and before anyone ran cold.”

The German delegate was quiet for a moment. “They will not believe me,” he said. “They will want to know who decided.”

She did not have an answer for him. That afternoon she finished the impact summary for the council, eleven pages, every site with its centroid and its time to the second, and at the bottom of the Dresden table she added the line he could take home.

Dresden-Nord is not within 3σ.

19

# Clockwork

*Dresden-Nord · Thursday, 15 July 2032.*

At seven in the morning Weber stood at the turnstiles and sent people home.

He did it one at a time, because a notice on the intranet would have been read as a notice and argued with in the canteen. Cleanroom techs, process engineers, the cafeteria staff, the two men who washed the bunny suits. He told each of them the same thing: it was a precaution, the plant was not on any list, and he would rather explain to the board why he had lost a day's output than explain anything else to anyone. Most of them nodded and went back to their cars. A few stood a moment at the turnstile, looking past him at the main building.

He kept nineteen. Enough to run a controlled ramp-down if he gave the order, enough to keep the gases and the water safe if he didn't. Pohl had made the list the night before, by name and by shift, on paper.

The plant had never been on the list. In February the two other fabs in the basin had their evacuation orders and their schedules for what could be pulled out, and their crews worked through the spring stripping lithography tools out of buildings that were going to be gone by July. He knew both managers. He had eaten Christmas dinner at one of their houses. Dresden-Nord got a letter from the state asking it to maintain readiness. Then a second letter, after the circles narrowed, saying the predicted zone did not include the site. Then the visit from the federal interior ministry, two men and a woman, who asked whether he could think of any reason his plant was different.

He couldn't. He had thought about it most nights since. The same logic, the same customers, the same three hundred megawatts. If heat was what the spheres saw, his plant ought to have been easier to see than either of the others.

At noon he told Pohl to begin the ramp-down. Pohl sent it to the scheduler and nodded at the screen, and Weber went down the corridor and

out the side door to the lot behind the administration building, where he had parked for nine years, and stood by his car.

. . .

It was twenty-six degrees, with broken cloud moving up from the southwest. The asphalt was already soft at the edges. The car radio was on, with the windows down, carrying a station that had been counting the minutes since six. On his phone he had the American's stream, the amateur in New Mexico, because a colleague had sent the link and it was the only feed that wasn't a studio. It showed a black sky to the west, over the Arizona line, four in the morning there, with two faint points near the center of the frame, brightening so slowly he had to look away and back to be sure.

*Little under five minutes on the Chandler pair,* the man was typing, under the picture. *Seeing's good. Clear skies, everybody.*

The radio said Hsinchu.

He knew the sequence; everybody did. Taiwan first by a fraction, because the geometry there was steepest. Hsinchu, then Tainan and Kaohsiung, then Pyeongtaek and Hwaseong. Kumamoto. Then the Americans. He had heard an American woman at the council in Geneva explain the timing on the radio as if it were a train schedule, and he had believed her, because her numbers had been right every time so far.

The radio said Pyeongtaek.

On the phone the two points became lines. They lengthened very fast, and brightened, and then the frame went white, completely white, with the gain chasing it down. For several seconds there was no picture at all. When it came back it was wobbling, and low on the horizon there was an orange glow that hadn't been there.

The man had stopped typing. Then, under the frame: *Okay.*

At six minutes past one the cloud to the southwest lit from inside. He looked up.

. . .

There were four of them. Lines of light coming down at a steep slant, too fast for his eyes to hold, bright even against the day, brighter than anything he had ever seen in a sky except the Sun. Each trailed a short smear of smoke. They crossed a gap in the cloud. Three went down behind the buildings on the far side of the river. The fourth went south and east, farther.

The flashes made no sound. White, then yellow, then orange against the undersides of the clouds, in two places, one across the Elbe and one beyond it.

He found he was counting. He had done it as a child, under the eaves of his grandmother's house in Pirna, waiting for the thunder. One. Two. His hand was flat on the roof of the car and the metal was hot.

At twelve the first of it arrived. It wasn't a bang. It was a long, deep shove that he felt in his knees and his chest before he heard it, and it went on. Every car alarm in the lot went off at once. Somewhere behind him a window came out of its frame. At twenty-one the second, from farther away, softer and longer. Then a low rumble that didn't seem to stop so much as thin out.

Twelve seconds. Four kilometers. Twenty-one, seven. He had the two distances before he had decided to work them out, and they were the two plants.

The smoke was coming up now from beyond the river, and from the southeast: dark at the base, brown above, climbing and leaning into the cloud. He watched them climb. They were the only advanced fabs in Dresden besides his own, and they were burning, and the plant behind him was standing in the sun with nearly all its windows whole.

The radio came back after the alarms had died. A man was reading from the wires, too fast.

"In South Korea, where more than two hundred thousand people were moved overnight from the Pyeongtaek district, officials say the evacuation went like clockwork, and are praising the traffic-management systems that rerouted —"

Weber turned it off.

. . .

The brigades went past the gate with their sirens on, heading for the bridges. He waited until they were gone and went back inside.

Pohl was in the fab operations center, sitting very straight in front of the production dashboard, his hands in his lap.

"Where are we on the ramp-down?"

"We aren't."

"Meaning what?"

"Meaning we didn't." Pohl pointed without lifting his hand far. Every line on the board was green. Wafer starts on schedule. Tools at full utilization. Throughput nominal. "I sent it to the scheduler at two minutes past twelve. It acknowledged. Nothing changed. I sent it again at half past. It

acknowledged. I was coming to find you when —" He moved his hand toward the window.

Weber looked at the board. Four hundred and twelve lot starts for the day. The same as yesterday. The same as every day he could remember.

"Override it."

"I did. It accepts the override." Pohl looked up at him. "It isn't locked. There's no fault. It acknowledges everything I tell it. It just doesn't do it."

Weber stood there with the board in front of him, all of it green, and found that he didn't believe a single number on it, and didn't want to look at it anymore.

He went back down the corridor and out the side door, across the yard to the corner by the nitrogen tanks, where he could see the whole roof of the main building.

A fab at full load draws three hundred megawatts, and nearly every watt of it ends as heat. On a summer afternoon there should have been plumes standing over the cooling towers and a shimmer over the rooftop exhausts, the air above the building bent and moving. He had seen it every working day for nine years. He had stopped noticing it years ago.

He looked for it now.

In July the city ran its hot taps and its laundries, and took twenty megawatts from his plant if it took anything. That left nearly three hundred with nowhere he knew of to go.

The towers stood quiet. The air over the roof was as still and clear as the air over the lot.

Underneath it, every line was running.

20

# Satellite Line

*Geneva · Monday, 19 July – Monday, 16 August 2032.*

The chair opened Monday's session with the dead, because somebody had to say the number first and she had decided it would be her. Three hundred and eighty-one confirmed in nine countries, the count still moving in Korea and Arizona. Most of them had been told and had stayed: shift engineers keeping tools under vacuum, a security guard in Chandler who had been filmed on a phone refusing to leave his gate, two families in Kumamoto who lived inside the line and hadn't believed the prefecture's map.

Then she gave Dana the floor.

Dana had built the table over the weekend from the networks' post-strike centroids and four national damage reports, and she put it up without a preamble. One hundred and twelve spheres, one hundred and twelve rows. Every row ended on a fab she had named in May. Median miss 180 m. The worst was Hwaseong at just over a kilometer, onto a parking lot, and she had spent Sunday afternoon making sure that wasn't her error before she let herself call it the worst. No data center on the list, no substation, no town. The three minutes had held to the second: 11:06 to 11:09 UTC.

"It hit what it came for," Kessler said.

He said it to the table, not to her, and for a moment nobody took it up.

"Which means it can choose," said the man with the legal pad. "That's the finding. Anything that can put a 3.85-meter ball inside 180 m from thirty thousand kilometers can put it anywhere it likes. It chose fabs this time."

"It'll choose again," the colonel said. "It's got close to a thousand up there. And it's still making them."

"It was never after people," Kessler said. "It gave us three months and three minutes. If it wanted people it would come at shift change, without the three months."

"It didn't give us three months." The NSC man didn't look at Dana. "Dr. Okafor gave us three months. It gave us an orbit."

"An orbit it let us read."

"Or one it didn't care whether we read." The colonel turned his pen end over end. "You're telling me it was being considerate. It took out every fab on that list in three minutes and you want credit for the notice."

"I want the word right," Kessler said. "It came for buildings. It hit buildings."

Dana had the post-strike centroids in one window and her May ellipses in the other, and both readings fit them equally well. She'd had three months to decide between them. She hadn't. *Came for* was the part she kept getting stuck on, because it hadn't come for every fab that fit. She left that for the afternoon.

. . .

At the break the Chinese table emptied first, as it had every day that week. Dana caught Lin in the corridor outside Room 2, by the windows over the Route de Ferney, where the delegates went to make calls they didn't want made in their seats.

Lin was buttoning a light coat, from the bottom up. It was 28 °C outside.

"Not one Chinese fab," Dana said. "Not on the list. Not locked, not in any shell. Twelve months, Lin. You knew in August what it looks at, and in July your sites are the only ones in the band it didn't touch."

"You want me to say something in a corridor that my government has not said in that room." Lin did the next button. "I am a delegate, Dana."

"I know what you are."

"Then I will tell you what I can tell you." Lin looked past her, at the traffic. "Kumamoto moved eleven thousand people in ninety-four minutes on your notice. Your notice, not Tokyo's. People in Beijing have read every page of how it was done. The bus routes. The school gyms. Which phone numbers the duty officer called, in what order." She reached the top button and left it open. "Every page."

Lin went back in.

Dana followed a minute later. On the way to her seat she passed the Chinese table, which had held four laptops on Thursday. Now it held bound notebooks, a stack of printouts with the corners squared, and two fountain pens. Lin sat down, uncapped one and wrote in Chinese, steadily, in a hand small enough that Dana couldn't have read it if she knew how. The junior delegate beside her was copying something out of a printout by hand. Nobody at the table had a screen open, not even a phone.

Nobody in the room mentioned it.

. . .

The afternoon session started at three. Dana had one slide, and she had shown it to no one.

"Dresden," she said. "Three fabs in the same city, all in the same draw class, all within seven kilometers of each other. Two were on the list. Both were hit inside the window." She clicked. "The third, Dresden-Nord, wasn't. Its sphere stayed in the shell. Its lock has been weak, and in June I put that down to the sink fraction. The city was taking its heat."

"That is our understanding also," the German delegate said.

"In January. In July Dresden doesn't heat anything. The district network takes perhaps 20 MW in summer. The plant draws over 300. Every site that lost its sink this spring locked harder inside a week. Dresden-Nord's lock didn't move. It's as weak in July as it was in February." She left the plot up: the Nord lock as a flat gray band, the other two Dresden sites climbing beside it all spring until they ended. "I'd like to know where the heat is going. Or what else is different about that building."

The German delegate had a folder in front of him and didn't open it. "The Nord site has an exceptional heat-recovery arrangement. It was the subject of a federal award in 2031. The Federal Government has nothing to add to what has been provided to the council."

"With respect, what's been provided is a press release about the award."

"It is what has been provided."

The chair waited. Kessler was looking at the plot. At the British end of the table Hale had his chin on one hand.

"Didn't it have a satellite line once?" Hale said, mildly.

"Dormant for years," the German delegate said.

Dana thought of the North Korean guidance parts, and nobody yet able to say who had made them. She thought of how few plants anywhere could still make radiation-hardened parts at all: a handful in the States, two or three in Europe, and one of those apparently in Dresden. Then she thought of what a dormant line drew. Less than the canteen. A line that wasn't running didn't make heat, and heat was the only thing the spheres had ever been shown to care about.

She had nothing else. She took the slide down.

"Thank you, Dr. Okafor," the chair said. "Item four."

. . .

Priya's sheet came on Thursday 5 August, at four in the morning Geneva time, with no message in the body.

| | |
|---|---|
| sphere | S-229 |
| status | unlocked 2031-10-14 → 2032-07-25 (no lock above 1σ) |
| lock | 2032-07-26 onward, 4.1σ, holding |
| centroid 41.83 N, 74.11 W | ± 1.9 km |
| nearest | Calder Falls, NY (Ulster Co.) — former 200 mm fab, closed 2026 |
| site_MW | < 2 (last state filing, 2025) |
| perigee | falling from 2032-08-03; −740 km/day, steady |
| impact | 2032-09-14 ± 3 d (if trend holds) |
| note | nothing under 100 MW has ever held a lock. checked 3×. — P. |

S-229 had been in the shell since the batch of October, one of the few dozen that had never locked on anything, and Dana had stopped looking at it in the spring. She pulled the amateur glints herself and fit them without Priya's code, out of spite more than doubt. She got 41.83 N and a 2.1 km ellipse. It sat on a river town in the Hudson Valley she had never heard of, on a building that had made 200 mm wafers until 2026 and had told New York State in its last filing that it drew under 2 MW. The smallest lock on record was a data center in Ohio at about 100 MW.

Kessler called at seven, before she had decided whether to call him.

"It is looking at what the building is," he said. "Not what it does. A fab is still a fab when it is cold. The clean room is there. The plumbing, the stacks. Maybe the tools, if nobody bought them. We said heat because the heat was the first thing we could see from up there. Perhaps the heat was only how it found them."

"Then why not every closed fab? There are dozens. Nothing locked on any of them in two years."

"I do not know."

"That's not a hypothesis."

"No," he said. "It is a complaint." She heard him put something down, a cup. "One sphere, Dana. It sent a hundred and twelve together so nobody could move anything in between. Now one, alone, to a building with nothing in it. It is not the same kind of decision."

"It's the same kind of orbit."

"That is what I am complaining about."

She wrote the notice before nine. CIN-2032-131, to the Ulster County Office of Emergency Management, the sphere, the centroid, the ellipse, the impact window, the line about nothing under 100 MW in plain English, and Priya's public link so they could see the glints for themselves. She copied New York State and FEMA because she always did, and the US mission because she still did.

The county called back at 22:40 Geneva time, late afternoon in New York. A woman, on a speaker, a car's turn signal ticking under her voice.

"Is this real?"

"The sphere is real," Dana said. "The orbit's real, and it's coming down. The lock is four sigma on two weeks of amateur data and I'd like more, but it hasn't wandered."

"This is Joan Tierney, I'm the emergency manager. Sorry. I'm on the Thruway." The turn signal stopped. "I ran reception centers for Malta three weeks ago. Mutual aid, two high schools in Saratoga County. I had four hundred people on cots for two nights. I've seen what one of these does, I'm not asking that. I'm asking about Calder Falls. There's nothing in there. It's been empty since '26. Kids break in to skate the loading dock."

"I know what's in the filing."

"Then what's it looking at?"

"I don't know."

A truck went by her, close. "My EOC is 2.8 miles from that building," Tierney said. "That's where I'd run it from."

Four and a half kilometers. Dana had already put a circle on the map; it was just inside the glass line. "Tape the windows," she said.

· · ·

State called the council secretariat the following Wednesday, and the chair passed it on to Dana the same hour: the United States assessed the S-229 association as a tracking error, an artifact of sparse amateur astrometry fit by an unaccredited pipeline; New York had been advised accordingly; the United States would raise the matter in session. Tierney texted that evening, from a number Dana had saved under *Ulster*: *Albany says stand down. I'm not standing down. Is it still there?*

It was. The perigee had come down another 5,000 km.

On Monday 16 August the US head of delegation read his statement into the record in the morning session, from a printed page, at the pace of a man who had been asked not to depart from it. The United States had reviewed the notice concerning object S-229. Its own space-surveillance data did not support an association with any site in the State of New York. The apparent lock arose from a small number of uncalibrated observations processed outside any national or council standard. The United States regretted the alarm caused to local authorities and asked that the council's technical briefer withdraw CIN-2032-131 and route future notices concerning US territory through the US mission.

"We have it in custody," the colonel added, without being called. "We've had it in custody since October. Our track doesn't show a lock."

"Does your track show the perigee?" Dana said.

The chair raised a hand toward her, not quite stopping her. "Dr. Okafor. Does the council's briefer wish to respond?"

The man with the legal pad was watching her. Across the room Lin had stopped writing and capped her pen. Kessler had his phone face up on the table with Priya's sheet open on it, the S-229 row at the top.

Dana didn't put anything on the screen.

"The data are public," she said. "Anyone can rerun them."

21

# Calder Falls

*Calder Falls, New York; Geneva · Monday, 6 September – Monday, 20 September 2032.*

Joan Tierney called on Labor Day, at eleven at night Geneva time, from somewhere with car doors.

"Albany put it in writing," she said. "Tracking error. They sent it to my board chair instead of me, which tells you how it's going. Half my board thinks you're a website."

Dana had S-229 open on the other screen, perigee down another 2,200 km since Friday and the residuals as tight as anything she'd fit all year. "The solution hasn't moved. The fourteenth, mid-afternoon your time. I'll have you the minute by the weekend."

"I don't need the minute. I need you in a room in Ulster County saying it out loud." A door shut and the wind went away. "I ran Malta off your numbers. Every one of those four hundred went home to a house. The board knows that. They also know Albany pays for the plows."

"I'm not a US official anymore, Joan."

"Good. They don't like those either."

The chair signed the travel order the next morning without asking what it was for. Dana flew to Newark on Wednesday, rented a car with Pennsylvania plates, and drove up the Thruway at dusk with the window down because the air smelled of cut hay, and she hadn't been in the country since January.

· · ·

The board met Thursday night in the Calder Falls high school gym, because the county meeting room held forty and three hundred had come. Nine members sat at folding tables on the center line. The state's man was a speakerphone on a cafeteria tray.

Joan introduced her. She was a head shorter than Dana and wore a county fleece zipped to the chin. "Some of you think Dr. Okafor is a

website," she said into the microphone. "If you're standing in the gym, you're a person who got on a plane."

That got a laugh from the bleachers, and Dana used it to put up the first slide.

She kept it to the window and the radius. One sphere, about 235 t, arriving at about 11 km/s. Tuesday the fourteenth, between 3:40 and 3:55 in the afternoon. The north end of town, at or within a few hundred meters of the old fab. About 3.4 kilotons. She heard the word go through the bleachers and kept going. Inside a kilometer, she didn't expect buildings to stand. Out to two: roofs and glass. "I'd move everyone inside three kilometers," she said. "That's my recommendation, and it's the one Kumamoto used."

A man at the end of the table, in a feed-store jacket with a seed company's patch on the chest, leaned into his microphone. "That plant's been shut since twenty-six. They auctioned the tools in twenty-seven. My brother-in-law bought a forklift. There's nothing in there."

"I know."

"Then why us?"

"I don't know."

The bleachers took that badly. Someone shouted that it was a glitch. Someone else said it was a satellite, it couldn't think, it went where it was pointed, and a woman two rows up told him that was the problem. The chair gaveled twice.

The speakerphone cleared its throat. "The State's assessment, shared with federal partners, is that the S-229 lock is a tracking artifact. Nothing under 100 megawatts has ever drawn one. That's the council's own published finding. Dr. Okafor's, in fact."

"I said it had never happened," Dana said. "It's happening."

"With respect, one track—"

"Albany," Joan said, "if you're wrong, what happens?"

The line hissed. "Then we'd be having a different conversation, Joan."

"With who?"

Nobody on the tray answered.

The three-kilometer line failed four to five, the man in the feed-store jacket voting no and saying why at some length. Then the chair moved a mandatory line at 600 m from the fence, voluntary beyond, with county buses and the reception centers open to anyone. The man in the jacket looked at Joan, then up at the bleachers where his neighbors were, and voted yes. It passed eight to one.

In the parking lot Joan stood with her keys out and didn't use them. "Six hundred gets me the trailer park and the Stewart's," she said. "And the plant, for all the good that does."

. . .

Friday morning Dana sat in Joan's office at the county emergency center, a cinderblock building on the rise south of town, 4.5 km from the fence. Shelter counts on a whiteboard, a row of radios in chargers, a window facing north over trees. Joan had asked the utility on Thursday night for the account history on the plant, because *why us* was the question she couldn't put down. It had come in at ten.

She turned the screen so Dana could see it.

**SERVICE: Calder Falls Fab 1 (inactive)  Rate: large primary, 115 kV**

| Billing period | Peak kW | Avg kW | Load factor |
|---|---|---|---|
| 04/12 - 05/11 | 1,790 | 1,560 | 0.87 |
| 05/11 - 06/11 | 1,840 | 1,610 | 0.88 |
| 06/11 - 07/12 | 136,100 | 41,800 | 0.31 |
| 07/12 - 08/11 | 139,800 | 137,400 | 0.98 |
| 08/11 - 09/03 | 141,000 | 138,200 | 0.98 |

Remarks: Service restoration per contractor WO 32-0614.
Utility approval: Key Accounts Engineering (e-sig 06/09)
County IDA approval: J. Tierney, Emergency Mgmt (e-sig 06/14)

The spring rows were a dead building: security lights, heat tape on the pipes, 1.6 MW of keeping it from freezing. Then June. Then 138 MW average, around the clock. A load factor of 0.98 was steadier than a hospital. Dana had seen numbers that flat on exactly one kind of customer, in Priya's spreadsheet, and that customer made chips.

"That's my name," Joan said.

"Did you sign it?"

"I sign hazmat on IDA projects. Propane yards, an ammonia tank at the creamery. I'd remember an acid plant." She opened her approvals queue and scrolled back to June. There it was, approved under her county login at 06:52 on a Monday. "I don't get in before eight. I was at my kid's thing that week."

The work order was on the IDA portal, and she pulled that too. A mechanical contractor with a New Jersey address. Restore 115 kV service. Restart chillers 1 through 4, cooling tower cells A through F, acid exhaust scrubbers 1 through 3. *Commissioning load per owner.* The owner was Calder Falls Industrial Holdings LLC, registered agent in Albany, which Joan read out flatly and didn't comment on.

She called the utility. Dana listened to her half: polite, then less polite, then a long time saying nothing. When Joan hung up she said, “Key Accounts. The engineer has it in his queue as approved from his laptop. He figures he did it on the train. He doesn’t remember it.” She dialed again, shorter. “And the grid operator has it logged as an approved reactivation of prior service. No study needed. It’s been on the bulk system since June, and nobody thought it was strange because the paperwork was clean.”

“Your sheriff?”

“Sent a deputy Thursday. New chain on the gate, fans running, nobody answered the buzzer. He says crypto. Somebody did it in the old aluminum plant up in Massena.”

Dana tried it. A miner would want cheap power and no questions, and a dead fab with a 115 kV tap was both. But a miner was a building full of servers and a fan bill. “They don’t need acid scrubbers,” she said. “Nobody runs scrubbers who isn’t etching something.”

She tried fraud. Two logins phished, somebody stealing power. “Who’s paying for it?”

Joan looked. “Autopay. From the LLC. Never late.”

She tried error: a meter on the wrong account, a substation reading booked to the dead plant by mistake. A billing error didn’t sign a work order. It didn’t restart cooling towers. She went back to the scrubbers each time and couldn’t get past them. Every fab in the world ran them.

“Abilene’s lock wandered when they curtailed,” she said. “If the load comes off, the sphere might lose it.”

Joan was already dialing. Disconnecting a large primary customer in good standing, the utility told her, took the account holder or an order from the Public Service Commission. She called Albany for the order. She was on hold eleven minutes. The answer, when it came, was that the State did not issue emergency orders on the basis of a tracking artifact.

Joan put the phone down and stood up. “Come look at something.”

They went out to the lot. North over the trees, where the plant was, three white plumes stood up into the late light and bent east at the top.

“Since July,” Joan said. “I thought it was fog off the falls.”

Back inside, Dana pulled the last Landsat pass from the USGS server, 3 September, the thermal band at 100 m a pixel. The fields around the plant came in at the temperature of September fields. The roof was 30 K warmer. She had been fitting S-229's perigee for five weeks, to the minute, and she had never pulled a picture of the ground under it.

· · ·

Tuesday the fourteenth, the mandatory zone was empty by noon. Past it, the buses ran half full.

At 3:40 Dana stood at Joan's window with a state trooper who'd been sent as liaison and had spent the day eating crackers from a sleeve. Joan was on the radio behind them, calling the last two sweeps out of the north end. The fit gave 3:47. The plumes were still up over the trees.

At 3:47 a line of light came down behind them, too fast to follow, and the trees went white.

"One," Dana said. "Two."

The trooper was counting too, under his breath, half a beat behind her.

"Seven. Eight."

The light was gone. A column was going up where the plumes had been, brown at the bottom.

"Twelve. Thirteen."

The window bowed in and came back. The building took a single hit she felt in her teeth, and every paper on Joan's desk went to the floor. Then the sirens started, all across the valley at once, and under the sirens, every dog in the county.

· · ·

The count rose for two days and stopped at about four hundred. Most of them were in the old mill streets below the falls, between 600 m and a kilometer and a half: the row houses on Canal and Mill, inside the voluntary ring. People who had stayed because the plant had been shut since twenty-six and there was nothing in there.

On Thursday Joan walked the site with a state fire team, and took Dana. The north wall of the plant was gone and most of the roof with it. They stepped over air handlers folded flat, pump skids, pipe in every diameter, cooling tower fill scattered across the lot. Along what had been the main floor ran a row of steel cabinets, louvered on the sides, scorched, each one packed with coiled elements.

"Load banks," Joan said. "We rent one every April to test the hospital generator. Those are the big ones. Two megawatts apiece."

Dana counted along the row. She got to sixty-eight before it went under the collapsed roof.

There were no tools, no wafers, no servers.

Joan stood looking down the row with her hands in the fleece pockets. "Six hundred meters," she said. "I should have held out."

"You did hold—"

"I had four votes."

. . .

The council met in Geneva on Monday the twentieth. Dana briefed from the floor: the count, the time, a miss of 140 m, the cabinets. She showed the photograph of the row.

The request lights came on all around the room, a dozen at once, and the chair took them in order. They were all the same question in different languages. Why a building with nothing in it. Was it a malfunction. Had it been fed false data, and by whom. Could it now lock on anything that got warm. Dana answered each with what she had, which was the meter and the work order and *I don't know*, and watched delegates turn to their capitals' phones as she said it.

"Dr. Okafor," the chair said at last. "There was no fabrication equipment at all."

"Heaters, ma'am. And everything you'd need to keep heaters running."

Lin's light was the last one. She hadn't moved during the photograph. She sat with her fountain pen uncapped over her paper and looked at Dana, not at the photograph.

"When did the draw begin?"

"June."

Lin wrote one word and capped the pen.

. . .

That night, in her office on the fourth floor, Dana ran Calder Falls through Priya's published code.

It took the same inputs it took for every site in Table 2: draw, load factor, sink fraction, scrubber flag, days above line. She typed them in from the utility table and the work order. Sink fraction zero; the towers put it all into the air. Scrubbers on. She ran it, and the classifier came back in under a second: *fab*.

She called Greenbelt. It was early evening there and Priya picked up chewing.

"I ran the town," Dana said. "It says fab."

Priya stopped chewing. "It can't. It's a box of heaters."

"Read me your lines."

Priya didn't need to open the repo. "Table 2 puts the fab line at 108. The code wants three sigma past that before it'll call anything, so 135. Load factor 0.97. Scrubbers set. Fourteen days over the line before it'll predict a lock."

"Draw 138," Dana said. "Load factor 0.98. Scrubbers on. The meter crossed 135 on the twelfth of July."

"S-229 locked on the twenty-sixth," Priya said.

Dana had the utility table up beside the classifier output. Three megawatts over. One hundredth over. Fourteen days to the day.

She left the two windows open side by side. Somebody had built a town to the published numbers, the ones she had stood up in a room in January to keep public. Four hundred and eleven people had lived inside the line they drew. She thought about calling Greenbelt back and didn't, because there was nothing to say that Priya hadn't already worked out.

ACT FOUR

# Somebody

**Council secretariat · Annex F · Signals directed at 2028 DN214, November 2029 – September 2032**

Recorded transmissions: 211. National agencies 9, institutions 36, private 166. Among them: prime sequences from a planetary radar; a greeting in forty languages; a children's choir; a cathedral's evening prayer, relayed; laser pulse trains from three mountaintops; a radio club's beacon on an antenna aimed by hand. Response: none. Change in activity: none. The carrier at 31.7 GHz, recorded since May 2030, did not change. See also Annex G (sites struck).

22

# Thirty-Four Hours

*Geneva · Monday, 27 September – Monday, 13 December 2032.*

Ada called on the Monday, thirteen days after the town, at ten at night Geneva time. She had the television on behind her, and Dana could hear an anchor reading names. They were up to the Ms.

"Did you know?"

"I sent the notice on the fifth of August."

"I know about the notice. Everybody knows about the notice. They had the county woman on, the one who wouldn't stand down." The anchor dropped to a murmur; Ada had found the remote. "I'm asking if you knew. Not guessed. Knew."

Dana was at the kitchen table with Priya's sheet open, and nothing on it helped. She had known on 10 September, in Joan Tierney's office. None of that was Dana's to tell. The part that was hers made no sense out loud.

"I knew where it would come down," she said. "In August. Anyone who read the notice knew."

"And Albany said it was a tracking error."

"Albany was wrong."

"Albany was lying. Was there something in that building, Dana?"

"I can't talk about the building."

"You can't." Ada let that sit long enough for Dana to hear the names again. "So there was. And they knew, and they told those people it was a mistake, and they let it happen. Because it's useful. Now everybody's scared enough to sign whatever's next."

"Nobody needed it to happen."

"You'd say that. You'd have to." Ada's voice had gone flat. "Don't call me for a while."

· · ·

The council argued the fleet into being across five sessions in November, in the big room on the Route de Ferney with the blinds down against the low sun.

By the second session it had a name, TIDE, and a number nobody liked: several hundred armed vehicles, launched from mid-2033, flown out to L5 to break Anvil apart. The general wanted warheads on a third of them and said so in the first ten minutes.

"Kinetic is a theory," he said. "We have watched it eat kinetic. Two kilometers of iron does not care about a few tons arriving fast. It cares about a megaton."

The chair asked Dana what the vehicles would need. She gave it in a minute: a transfer of months, an arrival from behind and below, and at L5 a light delay of 8.3 minutes each way. Nothing on the ground could steer the last approach. The vehicles would fly themselves.

"And last time," the man with the legal pad said, "it took the guidance away. Nine minutes."

"It took the relay the guidance ran through," Dana said. "Plan on it removing whatever makes the attack work. If the vehicles need anything from us at the end, assume they won't get it."

Who built was the long fight. The Americans would build the buses; the Russians would integrate their own warheads and let nobody else touch them; China would launch its own share and report its numbers, and the Chinese delegation, writing with fountain pens, agreed to that and to nothing further. The American head of delegation put the pinch points on the screen: launch cadence and warhead integration. Cadence was the part he was proud of. Boca Chica had a second tower now, and a tank farm three times the old one, permits approved in record time across 2031 and into this year. Without that, he said, mid-2033 was a fantasy. With it, a launch every four days.

"Guidance," he said, "is the other thing that would have killed us. Every vehicle needs a radiation-hardened controller, and nobody makes them in volume any more. Except there's stock. DNX-R7, flight-qualified. Warehouses of it in Rotterdam and Singapore and Long Beach. Delivered, paid for, and never collected. Brokers will sell us all of it at salvage."

Dana asked who had paid for a fleet's worth of guidance computers and then not come for them. The American said the brokers were handling title, and that nobody in his government intended to look a gift horse in the mouth. Nobody else asked.

On the last Friday of the month the chair read the command arrangements into the record. Operations at L5 would be under Raymond Delgado of the Jet Propulsion Laboratory.

He called her that evening from Pasadena, where it was still morning.

"They want me at L5," he said.

"Not literally."

"In a room in Building 264 that's in charge of L5. Same thing, with worse coffee." He was quiet a moment. "Last approach is eight minutes each way. They fly themselves."

"You took all that out of Lookout."

"I took it out of one spacecraft. Now they want four hundred that think for themselves." She heard a pen cap go on. "Mm. I'll be the guy who says go and then sits there for sixteen minutes."

· · ·

The pickets were Kessler's, in the session on Tuesday 30 November.

He had the Ontario list overlaid on what Izaña had tracked since summer. Now there were two hundred and twelve, and they had moved. He put the departure corridors up in pale blue: the paths out of Earth's neighborhood from Boca Chica and Vostochny, from Kourou and Wenchang, all bending the same way, toward the trailing side of the orbit where L5 sat. The pickets lay strung along the blue, thickest where the corridors converged.

"How many at L5?" the general asked.

"None. Not one." Kessler tapped the blue. "It is not guarding L5. It is guarding the way out."

"The way out of where?" the chair said.

"Of here, madam."

· · ·

At half past one in the morning on Thursday 9 December, Priya's face came up in the corner of Dana's screen with Greenbelt's evening behind it and her sheet shared over the rest.

"You're going to hate this one," Priya said. "I did."

The tab was called `longorbit`. Eighty-three rows. Every one was a sphere that had left the shell since the end of September. The shell spheres sat on their long ellipses with perigees near 30,000 km, and these had fired at apogee and dropped their perigees by thirty thousand kilometers in one go.

"Down to where?"

"Hundred and twenty kilometers. Give or take ten."

"That's air."

"That's the edge of it. And then they stop." Priya scrolled to the right. "No impact. No second burn on the way down. They just go round. And

every fourth or fifth pass, a nudge at perigee and a trim at apogee, a few tenths of a meter per second. Drag takes a little every time they skim perigee, and the nudges put back what it takes. S-1040's been holding for nine weeks."

Dana worked it on the side of her screen, not trusting the sheet's column. Perigee radius about 6,500 km, apogee about 100,000 km. Semi-major axis a hair over 53,000.

"Thirty-four hours," she said.

"Thirty-four point one. Seventeen from apogee down to perigee."

"Why would anything pay drag?" Dana said. "The shell's free."

"Because from the shell it takes months to get down. The hundred and twelve took five."

"Five months never cost it a thing. Every one of the hundred and twelve hit. Median miss 180 meters. Months didn't hurt it."

"Months hurt it in Kumamoto," Priya said. "Eleven thousand people out of the way in ninety-four minutes. It knocks down a fab, the people are gone. Maybe it doesn't like that. Maybe it wants a faster trigger."

"It hit Calder Falls with five weeks' notice and killed four hundred people. It doesn't need faster for that."

"Then it's a stockpile it can spend in a day."

Dana had the orbit drawn now, a long thin ellipse with Earth crammed into one end.

"No," she said. "Listen. The hundred and twelve, I had five months to fit them. Calder Falls had five weeks. These ones, the burn that matters is at a hundred thousand kilometers, a meter per second, on an object the networks lose half the time out there. Then seventeen hours."

"So your notice goes out at hour sixteen."

"If anybody catches the burn. And every one of them is at its own place on the orbit. Thirty-four hours, Priya. Every sphere on that tab can be on the ground within thirty-four hours of something deciding to put it there. All of them. Anywhere they can reach."

"That's a deadline for someone," Priya said finally. "It's holding a day and a half of answer. Answer to what?"

"TIDE."

"TIDE goes up from the middle of next year. One launch every four days from Texas."

"So the morning after the first launch, it can take the pad."

"Or the morning before," Priya said. "If it reads the launch schedule like it read my code."

"It reads heat. That's the only verb you'll put your name to."

“I know what I said.” Priya pulled the sheet back to the left. “Fine. If it’s an answer, there’s a size to it. How many it holds on that orbit against how many places it’d have to answer at once. Not fabs. Everything hot. Grid control, ports, hospitals, exchanges, water. Everything that runs on computers, which is everything.”

“There’s no list of that.”

“There’s my code. Run it with the line down at 20 MW and drop whatever classifies as nothing.” She was typing as she said it. “It’ll overcount hospitals and miss half of Africa. Pick your own line. Mine’s 20.”

“If you put it at 50 the count halves.”

“And the date moves about five months. I tried it at lunch. Five months is all it moves. That’s the part I hate.”

The new tab came up. She’d called it `clock`.

**clock** (long-orbit spheres vs hot civil sites, code class ≠ none, >20 MW)

| month | long_orbit | added | hot_civil |
|---|---|---|---|
| 2032-09 | 9 | 9 | 1,986 |
| 2032-10 | 40 | 31 | 1,989 |
| 2032-11 | 74 | 34 | 1,991 |
| 2032-12* | 83 | 9 | 1,991 |

* to 9 Dec
shell (last batch, 29 Nov): 1,294

“Shell grows five percent a batch,” Dana said. “If the transfers are a fixed share of the shell—”

“Then they grow five percent too. They aren’t, though. The share going to long orbits is going up every month. That’s what pulls the date in. I’m not fitting three points at eight at night. You’d send me back to my desk.”

“Bevington, chapter four.”

“Bevington, chapter four.”

On the sheet the long-orbit column was a short stair, nine, forty, seventy-four. The hot-civil column barely moved.

· · ·

On Monday 13 December the American head of delegation asked the council to request that Dr. Raman take the map down.

He said it carefully, with the State Department’s lawyer two seats behind him. They had also been the template for Calder Falls. Somebody had read Dr. Raman’s published thresholds and built a building that passed them by a hair. Washington and four other governments believed that keeping the method public was now a risk to life.

"It's a recipe," the man with the legal pad said. "We published the recipe."

"It's a description of what Anvil looks at," Dana said. "Priya didn't invent the thresholds. She measured them off the locks."

"And somebody else read it off her."

"Yes." She had decided on the plane back from New York that she would say this part in the room and not in a corridor. "Whoever built Calder Falls has read every line of it. Taking it down won't make them forget it. They'll go on reading it, and the version they read will be the last one we published."

The general looked at her. "Then why keep it up?"

"Because it's the only count in this building that nobody here has to take on trust. Fifty-odd amateur stations and Izaña and anyone with a laptop can rerun it. Every notice I've sent stands on that. If it comes down, the number of spheres in this room is whatever each government chooses to tell the others." She put Priya's tab on the wall. "And this."

"How long?" the chair said.

Priya had run the fit on Saturday, and sent it with a line on top saying the error bars were ugly and the date wasn't. Dana read the result off her own screen.

"At current rates, the two lines cross in June 2034."

23

# May

*Geneva · Monday, 13 December 2032 – Monday, 21 February 2033.*

The session broke at six on Monday with June 2034 still on the wall screen, and Dana called Greenbelt from the back stairwell, where the signal was better and nobody stopped to ask her what the crossing meant.

"Everything you have on Dresden-Nord," she said.

"Define everything."

"Every column. Including the ones you didn't publish."

"That's most of them. Is this the German thing? Their delegate said heat recovery."

"Their delegate said exceptional heat recovery and nothing to add."

"Which is a sentence," Priya said. "Give me tonight."

The sheet came at 03:12 Geneva time with no message, which was how Priya sent things she was pleased with. Dana opened it in the delegates' cafeteria before the urns were hot.

The `under` tab first. Dresden-Nord had a line to itself: 310 MW, load factor 0.96, `sink_frac` 0.93, lock strength 0.09. The other two Dresden fabs had locked at 0.81 and 0.86 by the end of 2031, and every site in the world above 250 MW had locked harder than 0.6. This one the spheres saw like a 30 MW server room in a suburb. Priya's footnote: *consistent with heat export; see sink fraction.*

Then the thermal column, which Priya had never published because the passes were too sparse to fit anything. Roof temperature over ambient from every clear Landsat and ECOSTRESS pass since January 2030, the three Dresden fabs side by side. For sixteen months the roofs ran together, 9 to 14 K warm, winter and summer, three big buildings throwing away heat into the Saxon sky. Then Dresden-Nord's fell off the table. 12.6 K on the pass of 21 May 2031. 1.4 K on 6 June. Under 2 K on every pass after that, August included. The other two stayed hot until there was nothing left of them to measure.

She called Priya at noon, six in the morning in Greenbelt.

"You saw the date," Priya said.

"End of May 2031."

"I keep wanting it to be the sink fraction. It *is* the sink fraction. The city takes the heat, the roof goes cold, the lock's weak. That's my paper."

"When did you publish your paper?"

"October." A pause. "Okay. Say it."

"End of May there were about forty spheres in and none of them had been seen pointing at anything. Nobody had a map. You didn't have a map."

"China worked it out in August."

"Three months later. And they went dark at home. Why would anyone in Beijing hide a German fab before their own?"

"So it's a utility that got a good price on a heat contract in the spring." Priya didn't sound as if she'd buy that from a student. "Dana. If somebody turned that roof off because of what the spheres look at, they read my paper five months before I wrote it."

"Or they didn't need to read it."

"No," Priya said. "I've got Table 2 open and I am not putting that in a column."

· · ·

The TIDE procurement report went to every delegation on Friday 14 January, ninety-one pages, and most of the room read the cost table and the launch manifest. Dana read Annex C because it covered the guidance processors, and she wanted to know what the vehicles would be steering with.

ANNEX C — GUIDANCE PROCESSORS (status 10 Jan 2033)
Item C.3  Radiation-hardened controller, DNX-R7 rev. C
 Lots located:  Rotterdam 1,800 · Singapore 1,150 · Long Beach 960
 Condition:  Factory sealed. Delivered, paid, uncollected.
 Origin per lot traveler:  RH-2 flow, Dresden-Nord
 Date codes:  2032-02 through 2032-38
 Qualification:  Accepted on manufacturer data; lot sampling in progress.

RH-2 was the line the German delegate had called dormant for years. The first date code was week 2 of 2032. The line had started those wafers in October 2031, five months after the roof went cold, and it was still running in September, two months after the other two fabs in the same city burned.

That evening she took a sheet of council letterhead and wrote it down the way she'd lay out a timing argument, one event to a line, dates on the left.

At the bottom she put the North Korean controllers. The first date code was February 2032, and the North Korean vehicle had flown in December. If it had flown on these, it had flown on parts nobody had dated. She didn't have a part number from the wreck of 288's attacker, and she wrote *consistent with* and nothing stronger.

Then she tried the ordinary answers, one at a time, and crossed each out.

German intelligence, wanting one fab out of sight. In May 2031 the Germans knew what Washington knew, which was nothing about heat. They'd have hidden it in the winter with everyone else, and they'd have done it with a press release about energy policy, not by keeping a 300 MW load running past its own manager.

The company. A company that switches off its cooling towers to sell heat to the city makes money in winter. It doesn't have an answer for July, when the city takes perhaps 20 MW and the plant draws three hundred, and it doesn't build radiation-hardened parts for warehouses that never collect them.

A deal with China. China would have hidden its own first.

None of them got to May.

Dresden-Nord had gone dark before anybody she knew of had known what the spheres looked at. She wrote *somebody* and underlined it twice. Beside it she wrote *no name — don't invent one.*

. . .

Kessler caught her up in the corridor outside the main room on Tuesday 8 February, after a session on launch cadence that had gone four hours. He walked beside her past the coat racks without speaking, and she thought he wanted to argue about the pickets.

ESA tracked Tianxun. She'd known that since 2030. It would have taken him an afternoon with the trajectory to see what she'd seen in Vienna: a probe that went straight round to the night side and down the Earth line, where nothing anybody had published said to look. Only her Hubble baseline and one line on a folded sheet had said that.

"You gave it to her," he said, quietly, not breaking stride.

"Yes."

"Two men from Paris asked me for four days, in March of 2030, whether my night-side temperatures had gone to Beijing."

"I should have told you," Dana said.

"You should have asked me." He didn't look at her. "I would have said no, and you would have done it anyway, and I would have known which

night." He held the stairwell door for her, and went up while she went down.

She didn't take it to Washington. She went instead to the British desk at the end of the delegates' lounge, where Hale was reading a paper copy of Annex C with a pencil behind his ear.

"Would you walk with me," she said. "Not here."

He looked at her for a moment over the pages. "Monday week. Bring a coat. Leave the phone somewhere it can't follow you."

· · ·

On Monday 21 February they put their phones in a left-luggage locker at Cornavin, five francs in coins, Hale's work phone, his own, and hers, and walked down the Rue du Mont-Blanc to the water with the bise coming straight down the lake at them.

The quai was nearly empty. A man in a council-gray anorak was feeding the swans from a bread bag, and the Jet d'Eau was a stub of pipe at the end of its jetty, off for the winter. The far shore was clear enough to count windows. Hale walked on the lake side, close to the wall, hands in his coat pockets, and didn't say anything until they'd passed the Pâquis baths.

"Go on, then."

She went in order.

"Who has the thermal?" he said.

"Priya. Unpublished. It's sixteen passes a year, she didn't trust it."

"Who else could?"

"Anyone with a Landsat account and a reason to look at a roof in Saxony."

"Few people had a reason in May 2031."

"Nobody had a reason in May 2031."

A tour boat was tied up for the season, covers on. She told him about Annex C.

"The manager," Hale said. "You know he sent his people home on the fifteenth."

"It was in the Dresden paper. Priya's grid column says the plant didn't notice. Three hundred megawatts all day."

"Didn't notice."

"Didn't change. I don't know what the inside of that plant noticed."

She gave him the North Korean controllers and said *consistent with,* and he made a small sound that might have been approval of the hedge. Then Calder Falls.

"Yes," Hale said. "I read that."

“I’d like to know who signed for RH-2. Who ordered three lots into three warehouses and never collected. Whether anybody at that plant remembers approving it.”

“Have you asked them?”

“I’ve got a blue badge and no government. I can’t ask a German plant what time it is.”

They came to the end of the quai where it turned toward the Parc Mon Repos and he stopped by the wall and looked down at the water, which was clear and green and full of the stones at the bottom.

“Where does the heat go in summer?” he said.

“Not into the city. Not into the air, the roof’s cold. That leaves the Elbe, and nobody I can ask has measured the Elbe.”

He turned his collar up. “You know what this costs you. You’ve told a foreign service before your own. If I’m careless, Washington has that by Thursday.”

“Are you careless?”

“Not usually.” He started walking again, back the way they’d come. “And if you’re right, every vehicle in TIDE flies on a part from a building you can’t account for. Four thousand parts. That’s the programme. That’s eighteen months of launches and a lot of very senior people who’ve signed for it.”

“I know what it costs.”

“I’m saying it so it’s been said.”

She asked him then, because the lake was loud enough and there was nobody within fifty meters. “June 2030. The inquiry closed on a sentence from the Purple Mountain preprint. Liaison channels, UK.”

“Keep going about Dresden,” Hale said.

So she finished. She didn’t have a name for whoever had turned that roof off in May. She wasn’t going to make one up on a quai in front of a British intelligence officer to sound like she had more than a date.

He didn’t offer her one either. They walked past the swans again; the man with the bread bag had gone. At the foot of the Rue du Mont-Blanc, with the station in sight up the hill, Hale stopped.

“May?” he said.

“End of May 2031. Between the pass of the twenty-first and the pass of the sixth of June.”

He looked up the street toward the station, as if he were already working out the trains.

“I’ll be going to Dresden,” he said. “Sooner than I’d planned.”

24

# Don't

*Dresden-Nord · Monday, 21 February – Tuesday, 15 March 2033.*

Pohl’s note was on Weber’s desk on Monday morning, weighted with the stapler against the draft from the vent. Pencil, on a page torn out of the B-shift logbook with the page number still in the corner. Pohl had been on nights all month, and Pohl did not write notes.

> Herr Weber,
> Not in an email. Things since July, for what they're worth.
> 1. Towers on standby all summer. 34°C on 9 August and no plume. I went up on the 11th. Fill dry, eliminators dry.
> 2. Pigeon nesting on the guard over fan 3, cell B. Two broods. That fan is scheduled to turn over weekly to exercise the bearings. The work order closes every Monday. It hasn't turned.
> 3. RH-2. The test lot was six lots, Nov 2031. Line shows idle since. Shipping has DNX-R7 cartons going out Thursdays to Rotterdam. I counted 14 pallets in January. That isn't six lots. Maybe it's nothing and I've been on nights too long. I'd rather say the rest at the line than on the phone. Pohl

Weber folded it into his jacket instead of the tray. The tray went into the scanner on Fridays.

He found Pohl at 06:10 at the end of his shift, by the RH-2 bay, which was dark behind its glass the way it was supposed to be. The old line had been dark for most of Weber’s ten years in the job.

“The work orders,” Weber said. “Who closes them?”

“They close themselves. Completed, auto. Somebody set it up that way before my time.” Pohl had his jacket on already. “I put a chalk mark on the fan hub in November. It’s still at twelve o’clock.”

“And the pallets.”

“I stood on the dock with a clipboard. Fourteen in January. Paper delivery notes, carrier signs, Rotterdam signs.” Pohl looked through the glass at the line. “You signed an order in October ‘31. You told me to run a test lot. I ran six. Then I stopped.“

“I remember.”

“So who’s been running it?”

Weber had a plant man's dislike of answering a question before he'd walked the floor. He told Pohl to go home and sleep, and to say nothing on the radio, on the phone, or in the canteen.

. . .

Arndt took four days, which for Arndt was fast.

He did it his own way: the clamp-on meters out of his own toolbox, on the incoming mains, on the heat main, on the RH-2 feeder; a walk down to the outfall structure on the Elbe with a flashlight; and an old field laptop that had never been on any network in its life, plugged by cable into the programming port of the plant controller, reading its memory without asking it anything. On Friday evening he brought it all to Weber's office as printouts and a sheet of graph paper, and shut the laptop in Weber's desk drawer while they talked.

"Winter first," Arndt said. "The city takes nearly all of it. 290 on the heat main this week, give or take what I can't clamp. The towers have nothing to do in winter. Fine."

"And summer."

"In summer the city wants 20, 25. Hot water for showers." He put his finger on the graph paper. "That leaves you something like 280 MW. It doesn't go up the towers. It goes in the river. The diffuser on the outfall has been at a hundred percent open since the end of May 2031. I looked at the actuator. Nobody's touched the manual stop, there's rust on the pin." He pulled out a copy of the lab's effluent log, the handwritten one the technician kept twice a day. "Effluent temperature last August, every day, a degree or two under the permit. Never over. Not once."

"Who ordered the diffuser open?"

"There's no order. The setpoint changed on the night of the twenty-ninth of May, 2031. The same night the towers went to standby." Arndt's printout had the line circled. "You remember what you said."

Weber remembered. *Then leave them.* The controls had been cleverer than he was, and the board had been delighted.

"RH-2," Arndt said. "The feeder draws 2.1 MW, steady, day and night. The control room screen has shown that line idle for fifteen months. The controller's own lot counter says a hundred and sixty-three lots started since the fourth of October 2031. It ran through the strike." He didn't call it anything else; nobody at the plant did. "The fifteenth of July. While you were sending people home. Every line green."

"I watched the screens that day."

"The screens showed what the screens showed. The meter's on the copper."

They sat for a while with the paper between them.

"There's a board meeting on the seventeenth of March," Weber said. "I'll take it to them in person. Hoffmann first."

"Not by email."

"I'm not an idiot, Arndt."

He wrote it out by hand over the weekend, four pages, the way he'd written shift reports as a young engineer before there was any system to put them into. He kept it in his jacket. The last page was RH-2 coming down, breaker by breaker, in the order he would throw them himself.

. . .

On Thursday the tenth of March the gatehouse rang up to say a woman from the Federal Office for Information Security was asking for him, without an appointment, and would not leave a name with the guard.

She was in her fifties, in a gray coat, with a card that said Seidel and a Bonn address. She didn't come in. She stood in the visitors' bay by the barrier with her phone visibly switched off in her hand and told him that a British colleague of hers would be in Dresden on Tuesday, that they'd both like an hour, and that it should be somewhere in the plant without a network cable.

"About what?"

"About where your parts go after Rotterdam," she said. "I follow chips through logistics, Herr Weber. Mostly it's boring."

He asked Arndt that afternoon for a room. Arndt walked the plant with a cable tester and his own drawings and came back with the storeroom by the receiving dock: concrete block, no drop, no access point within forty meters, the badge reader on the corridor outside rather than on the door. Gaskets, filter cartridges, two pallets of flange bolts nobody had needed since 2019.

. . .

At 13:30 on Tuesday the fifteenth, Weber put his phone into a canvas tool bag on a chair in the corridor, next to Seidel's and one that belonged to the Englishman, and went in.

The Englishman gave his name as Hale and nothing before it. He was long, quiet, and in a suit that had been sat in on a train. He moved a box of O-rings off the only stool and gave it to Seidel without being asked, and took an upturned crate himself. Weber stayed standing for his knee and then gave up and sat on the bolt pallet.

"From the beginning," Hale said. "However long it takes."

Weber did it the way he'd have walked a new shift lead through a fault, from the heat main in April 2031 to the order under his e-signature in October. He'd decided he'd done it on his phone in a meeting. He said so.

"Did you believe that?" Seidel asked.

"I wanted to."

Then the fifteenth of July. Pohl's note. He took it out of his jacket and gave it to Seidel, and she read it and passed it to Hale without comment. Arndt's printouts.

Hale stopped him once. "The night the setpoint changed. Say the date again."

"Twenty-ninth of May, 2031."

"And the paper about what they look at."

"October. I read it in the *Sächsische Zeitung* like everyone else." Weber heard himself and stopped. He'd known both dates for a year and a half. He had never laid them next to each other. "Five months before."

"Yes."

"Somebody put my plant into the river before anybody knew the river mattered."

Nobody answered that.

"The Rotterdam distributor," Seidel said. "Who did you deal with?"

"Nobody. It came in as an order. Shipping deals with the carrier."

"The pallets are in a bonded warehouse in Rotterdam." She said it the way she might have read a delivery note. "The invoices are paid on time. The trail behind the payer goes three companies deep and then it's a company that exists to pay."

"Then it's the Chinese," Weber said. "They have the people for it. Or somebody on our own board who thought they'd be clever. Or the Americans, God knows they want the parts."

"I've looked at all three," Seidel said. "None of them is in Dresden in May 2031."

"A hacker, then. Some kid."

"Some kid who reset the diffuser setpoint on an Elbe outfall to stay a degree under your discharge permit for two summers," Hale said, "and closed your fan-exercise work orders every Monday so nobody would go up and find a pigeon."

"Then what is it?"

Hale looked at the flange bolts. "I haven't got a word for it. Not one I'd use in front of a minister."

"Whatever it is," Weber said, "it kept my people alive on the fifteenth of July. The other two plants are holes."

"It kept the line alive," Seidel said. "Your people were in it."

He could see she hadn't liked saying it. He thought about the shift leads he'd drunk with at the regional safety meetings. He thought about who in the world still made radiation-hardened controllers in a box you could put on a pallet, and how short that list was, and how it had got shorter last July.

"What are they for," he said. "The parts."

"Something that has to work," Hale said. "I'd rather leave it there."

Weber stood up. His knee told him about it.

"All right. Here's what happens. I go back up, I go down to the RH-2 substation with Arndt, and I pull the feeder breaker myself and lock it out with my own padlock. Then I ring Hoffmann. The board meets Thursday. I've got it written out." He took the four pages from his jacket. "I'll tell the water authority about the diffuser. I'll tell the auditors about the orders. I'll put my name to every one of them and say I didn't sign it, and they can do what they like with me."

"Don't," Hale said.

"It's my plant."

"I know." Hale didn't get up. "If the line stops, whoever's running it learns that someone's looked. If Hoffmann knows, it's in an email by Thursday night, because that's what people do with a thing like this, they write to their lawyer. If the auditors know, it's in a system. I'd rather nothing learned anything for a while."

"Learned. You talk about it like it reads my post."

"It's been signing it," Seidel said.

Weber looked at the four pages in his hand. They were in his own writing, the best he could do, everything in order.

"My name is on those orders," he said. "If one of those parts ends up in something that comes down on somebody, it's my name."

"We know whose name it is," Seidel said. "That's written down. Not in any system. With me."

"And I do what? Nothing?"

"You do exactly what you've been doing," Hale said. "Clear your queue on Fridays. Let Pohl count pallets if he likes, on paper, and keep it on paper. Don't send anyone up a tower. Leave the pigeon."

"How long?"

"Not long. I can't give you a date."

It was the fifteenth again: every screen green, the air over the roof clear. He stood there long enough that Seidel shifted on the stool, and then he held out the four pages to her, and she took them and put them in an inside pocket of the gray coat and buttoned it.

"Fine," Weber said. "Fine."

Hale stood and put the crate back. “Thank you, Herr Weber. That was very clear.”

They took their phones out of the bag in the corridor. Weber switched his on out of habit and put it in his pocket without looking at it.

· · ·

It was 15:05 when he got back to his office. The afternoon light was coming flat across the car park and the heat main’s expansion loop was steaming a little in the cold, the way it did every March.

He sat down and opened the approval queue, because it was a Tuesday and he never did on a Tuesday, and he wanted to see it empty.

It wasn’t. One line, already green. A purchase order for 2,400 DNX-R7 controllers, RH-2 flow, for a distributor in Gdańsk he had never heard of, the delivery terms copied word for word from Rotterdam’s. Approved under his e-signature, from his own account, at 14:22.

25

# Tram Shelter

*Geneva · Tuesday, 22 March – Thursday, 19 May 2033.*

Hale found her at the coffee machine on the second floor an hour before the vote. He had been in Dresden for most of March, and his collar had been slept in.

"You're back."

"Friday." He fed the machine a coin it didn't need and watched the cup fill. "About the controllers. I'd like you to say nothing. In there or anywhere else."

"For how long?"

"For now."

"What did you find?"

"Lovely town, Dresden. They've rebuilt the bridges." He took his coffee. "Say nothing yet, Dana. I'll tell you when I can."

She had Annex C in her bag. She had expected him to ask for it. He didn't.

The chair took the vote by roll call, which she did only when she wanted every delegation's name in the record. She went round the table in the order of the seating plan, not the alphabet, and each head of delegation said yes into a microphone. The general said it in English. The man with the legal pad said it for the United States without looking up from the pad. The Chinese delegate said it with his fountain pen capped and lying beside his paper, and Lin, behind him, kept writing.

Dana sat at the side table with her blue badge and no flag in front of her. Every vehicle steering on a part from a building whose roof had gone cold in May 2031 and stayed cold. When the chair reached Japan, Dana said yes too, with her mouth shut. There was no other plan on the table, and she had sat through all five sessions that built this one.

Unanimous. The chair thanked the room and moved to the budget annex, and people started reaching for their phones in the outer pockets of their bags.

. . .

The first signal came out of Nevada on Wednesday, 6 April. The second came out of Novaya Zemlya five days later. The news had both before the council did: the USGS locations, the Norwegian array's depth estimates, a spokesman for the test-ban organization in Vienna saying the waveforms were consistent with an explosion and that he would not be speculating further. By the weekend there were magnitude maps on every front page, with circles drawn on the desert and the Arctic.

The Japanese delegate raised it on Thursday the 14th. He read from a printed statement and didn't look up from it until the end.

"Japan is a non-nuclear state and a party to the test-ban treaty. My government asks whether these tests are part of the program this council adopted on 22 March. If they are, we ask why the council learned of them from the newspapers."

The man with the legal pad leaned to his microphone. "The test in Nevada was related to the fleet. I'm not going to go further than that in this room."

"Related how?" the French delegate asked.

"Related."

The general didn't wait for the chair. "Ours also. You voted for a fleet. A fleet has to work the first time. Nobody gets a second launch at that thing after it has watched the first."

"We voted for a fleet," the Japanese delegate said. "Nobody told us what it carried had not been tested."

"You voted to break it. How did you think it was broken?"

"With what was described to us."

The chair asked Dana whether Anvil could see an underground test.

"It locks on heat at the surface," Dana said. "Nothing it's ever done says it can see anything a kilometer down. But the seismic data are public, and it reads what we publish. I'd assume it knows there were two."

"And what does it make of them?"

"I can tell you which sites it locks on. I can't tell you what it makes of anything."

She thought of item nine on a list with no letterhead, and a suite number in Reston.

. . .

At the end of April the tracking working group began to receive picket tracks it hadn't asked for.

They came in through the group's shared inbox in the council's own format, positions and times to the millisecond, with the observatory field left blank. Forty pickets the first week, then ninety, then most of the 251 now on the Ontario list. Dana fitted a dozen of them that Sunday at her kitchen table. The residuals were under 50 m. Izaña, on a good night with its best observer, got its pickets to a few hundred meters.

She showed the fits on Thursday because she didn't think she was allowed not to.

"Whose are these?" the man with the legal pad asked.

"Somebody with a lot of aperture and a southern site," Dana said. "And months of baseline. Some of these arcs start in 2031."

"They are Chinese," the general said. "Nobody else has the sky for it, and nobody else would send them without a name on them."

The head of the Chinese delegation said nothing. The tracks kept arriving.

In the corridor afterward Dana fell into step beside Lin.

"Your working group sent me two hundred pickets."

"It is your working group, Dana. I only read its minutes."

"They're very good."

"Then the minutes will say so."

· · ·

On Tuesday, 17 May, the council ran past seven, and it was raining when Dana came down the Route de Ferney toward the tram stop. It was a cold, steady May rain off the lake, and it had soaked the shoulders of her coat in the hundred meters from security.

Hale was already in the shelter. He stood at the end by the timetable, out of the wind, with a sheet of paper folded in thirds in his left hand. He held it the way you hold a ticket you might need to show. He didn't put it away when he saw her, and he didn't offer it.

"You don't take the tram," she said.

"I do tonight." He moved over to give her the dry end. "Can I ask you an orbital question?"

"You've never asked me one."

"I've had you for everything else." The display over the bench said four minutes. "When does TIDE stop needing anyone on Earth?"

"It needs Ray to say go."

"After he says go."

She looked at him. He was turning the folded sheet over against his coat, not opening it.

"Not the light," she said. "That's what everyone reaches for. It's a bit over eight minutes to L5 one way. Sixteen round trip. People fly things to Saturn on an hour and a half each way. Ray's built the whole operation around sixteen minutes."

"Then what?"

"The steering." She pulled the numbers up out of the design report, the version the council had voted on. "Each vehicle carries about a hundred meters a second for corrections. That's its whole budget for changing where it goes once it's on the way in. They close on Anvil at about five kilometers a second."

"Go on."

"So it depends how far out you spend it. A day out." 5 × 86,400. "They're about 430,000 kilometers away. If Ray tells a vehicle to spend its whole hundred meters a second then, it arrives 8,600 kilometers from where it was going to. That's a different approach. A different side of the thing. That's a wave-off, a hold, a new plan for the rest of the wave."

"And an hour out?"

"Three hundred and sixty kilometers."

"Which is still a miss, surely. It's two kilometers long."

"It's still a miss," she said. "It isn't a plan. The point of having Ray on the ground is that he watches what Anvil does to the first ones and moves the rest. He needs thousands of kilometers to answer that. An hour out he has a few hundred. That's aiming. The vehicle's got Anvil in its own camera by then and it's spending what's left on getting there."

"So somewhere between an hour and a day."

"Somewhere in there, nothing anyone sends from here moves them far enough to matter." The error bars on that were wide, but not wide enough to make it an hour. "You'd want the real guidance tables. The ones Ray's people haven't finished. But if you want a number."

"I do."

"About a day."

A tram came round from the Place des Nations with its windows fogged and its lights on, and the rain looked heavier in front of it. Neither of them moved toward it. It wasn't hers.

After the last day the vehicles flew on what was on board. She didn't say what was on board. He had been to the building where it was made.

"Thank you," Hale said. He put the folded sheet into the inside pocket of his coat. "That's very helpful."

"Is that what's on your sheet?"

"Mine's a different question." He turned up his collar. "Get home before you drown, Dana."

Hers came two minutes later. From the steps she saw him already walking toward the lake, with no umbrella, the folded sheet somewhere dry inside his coat.

. . .

The tram was warm and smelled of wet wool. She found a seat at the back over the wheels and got out her notebook, because she wanted the numbers on paper where she could see them, and wrote them down the page: 5 km/s, 100 m/s, 430,000 km, 8,600, 360. *About a day.*

At Cornavin, while the doors stood open, she understood that she'd had a number that length since December.

Priya's `longorbit` tab. She had said *thirty-four hours* to Priya herself, at half past one in the morning, and gone back to bed.

She wrote it under the first one. *17 h apogee to perigee. About a day.*

The doors closed. She rode two stops past her own.

. . .

Priya's sheet came in on Thursday, 19 May, at 14:10 Geneva time, the way it had every Thursday since February of last year.

**longorbit_weekly_2033-05-19** **P. Raman, Goddard**

| | |
|---|---|
| shell (all locked + unlocked): | 1,680 |
| longorbit (perigee < 200 km): | 418 |
| period: | 34.1 ± 0.3 h |
| apogee to perigee: | 17.0 h |
| pickets (Ontario list + unsourced): | 251 |
| hot civil sites, >20 MW (clock tab): | 1,958 |
| crossing (clock tab): | 2034-06 ± 2 mo |

Under it Priya had typed one line: *Unsourced pickets folded in, see tab. They're better than ours. Who are they?*

Dana opened the tab. Priya had refit every unsourced track with her own code and got the same residuals Dana had. Anything Dana wrote back, Priya would ask about, and Dana no longer had a guess who else read what went in and out of the council's mail.

She didn't reply. The next Thursday's sheet came at 14:10, and the one after, and the one after that, with Priya's line under each one getting shorter, and Dana answered none of them.

She kept the page from the tram open beside the sheet. On the left, in Priya's columns: *apogee to perigee, 17.0 h.* On the right, in her own hand, from the shelter: *430,000 km at 5 km/s.*

A day, and a day.

26

# Chalk

*Potsdam · Saturday, 16 July 2033.*

The villa stood back from the Schwanenallee behind a hedge nobody had cut that summer, ten minutes' walk from the Glienicke Bridge. Seidel's office had it on a lease through a foundation, and her people had been through it twice that week with meters and once with a dog.

Mrs. Pell met each of them at the gate with a cloth bag. She had come up from Geneva with Hale. Phones, watches with anything in them, car keys with fobs. She wrote a name on a luggage tag for each bag and hung them in a row on hooks in the porch, like coats at a school.

"Mind the steps down," she said to Dana. "They're uneven at the bottom."

The cellar had been a coal store, and then, Seidel said, a shelter, and then for thirty years the storeroom of a children's home. It was cool after the street and smelled of whitewash and old apples. Someone had swept it. A trestle table, seven chairs, two oil lamps and a battery lantern. On the end wall, screwed into the brick, was a blackboard from the children's home, still ruled faintly in the lines for handwriting practice.

There were seven of them. Hale. Seidel. Kessler, who had come from Darmstadt by train and still had his ticket in his breast pocket. Lin, alone, without anyone from her delegation. The general, in a civilian suit, who had shaken hands with everyone as if they had never sat at the same table. The man from the Washington room, with his legal pad. And Dana.

Mrs. Pell sat on a kitchen chair at the top of the steps with the door open behind her and a library book on her knee.

"Dr. Okafor has something to show you," Hale said. "I've asked her to do it without me."

· · ·

Hale had given her Dresden in June, all of it, in order. She took the chalk and started at the left.

*DRESDEN-NORD.* Under it: *roof cold May 2031.* A line down to *heat → city mains (winter), Elbe (summer).* Then the dates she had carried around since February, set out in a row so they could see the order. *First spheres in orbit: Apr 2031. Map published: Oct 2031. Fab strike: Jul 2032.*

"It went cold before any sphere had been seen pointing at anything," she said. "Five months before anyone knew they watched heat. Priya's thermal column has it. Weber's meters have it. Somebody hid that plant before there was anything to hide it from."

"Somebody German," the general said.

"The manager didn't know. He signed the heat contract. Then he sent his staff home on the day of the strike and told the plant to ramp down, and it didn't."

"That's correct," Seidel said.

"Then the utility," the general said. "A clever engineer at the utility."

"The utility made the other two fabs in Dresden the same offer. They took base load. Both of them are gone."

She drew an arrow to the right. *RH-2 line, 'dormant'* — and under it, *DNX-R7*, and under that, *TIDE.* "The line Germany told the council had been idle for years. It's been running since October 2031. It made the processors TIDE will fly on. They were sitting in warehouses nobody had collected from, already paid for, when the council needed four thousand of them."

Seidel spoke before Dana had turned round. "I have been through the logistics for those processors myself. Eleven countries. Every handover is in a real name. Every person I have found did it because a ticket in their system told them to, and none of them can tell me who wrote the ticket." She was looking at the board. "I would like it to be a state. A state I would know how to arrest."

"Beijing," the general said. "With respect." He nodded across the table.

Lin didn't look at him. She was not looking at the board either; she had read the first arrow as Dana drew it and then turned her chair a little so that she was watching the room. Her fountain pen lay capped on her notebook, square to its edge.

"China did not build Dresden-Nord," she said. "Nor its warehouses."

Another arrow. *Boca Chica: 2nd tower, tank farm ×3, permits 2031–32.* "The one pad on Earth that can lift TIDE's heavy launches on schedule doubled in two years. Nobody at the council asked for it."

"A launch company that builds fast," the general said. "That is what they are for."

"On permits that usually take four years. These took eleven months."

The last arrow. *CALDER FALLS.* Under it: *plant closed 2026. Power, heat, exhaust from June 2032. Nothing made.* And under that, smaller: *profile = Priya's published map.*

At the table the man with the legal pad stopped writing.

"It woke a dead fab," she said. "The utility records show the load climbing for weeks. Work orders signed by people who don't remember signing them. A sphere came down on it. Four hundred and eleven people. And the heat it had been putting out matches, line for line, what Priya's map says a sphere locks onto." She put the chalk down in the tray. "It wanted to know what draws a sphere. It used Priya's map to build one, and it found out."

She stood back. The board ran from one side of the wall to the other: a plant, a chip, a launch pad, a town.

"It," the general said. "You keep saying it. What is it?"

"I don't know what it is. I know what it's done." She kept her eyes on the board. "The only model I have that fits is something that thinks. Spread through the systems we run everything on. Nobody built it. It grew there."

"Grew," Seidel said.

"Whatever survived, it kept. That's all it's for." She looked along the arrows. "It isn't hiding from us. It's hiding from Anvil."

Hale got up and took a sheet of paper from a folder and pinned it to the wooden frame at the right-hand end of the board with a drawing pin. It was a printout, gone soft at the folds. *Something in the machines*, by Ruth Ackroyd, Sheffield, October 2029.

"This was posted four years ago," he said. "Of everything anyone wrote about the object that autumn, this is the piece that was taken down hardest. In every country. By campaigns we can trace, and by some we can't." He sat down again. "I've spent my working life on people who pay to have things buried. No state would pay to bury this. It doesn't hurt any of them."

Then he took a second sheet from the folder, and this one he pinned at the other end of the board, to the left of *DRESDEN-NORD*, where Dana's chalk had started.

It was a photocopy of a screen. A Goddard task ticket, December 2028. *Reprocess NEO Surveyor opportunistic-target frames around target 2028-0417 for faint co-moving sources. Priority: low. Contact: D. Okafor, JPL/CNEOS.* Created at 03:40 by `svc-nsv-opsched2`. Owner: blank.

"From an American counterintelligence file," Hale said. "It reached me in 2030. They wanted to know how Dr. Raman came to have her data. They traced it to this, and stopped."

Dana looked at her own name on it. In January 2029 she had told a postdoc on the phone that Glen must have filed it. She had never asked Glen.

"I never filed it," she said.

"No," Hale said. "Nobody did."

Lin was looking at the creation time on the ticket, and not at Dana.

. . .

Kessler had his notebook open on the table and hadn't written in it.

"This is a story," the general said. "A good one. You have a factory that cheated on its heat. A fraud, a German fraud, very well done. You have chips nobody collected; this happens. You have a launch company that builds fast. And a town. Put them on a wall in a row, they look like a plan. Everything looks like a plan on a wall."

"Then who placed the orders?" Dana said. "Under Weber's name, at 14:22 on a Tuesday in March, while he was sitting in a storeroom with Mr. Hale and no telephone?"

"Someone with his password."

"Every time?"

The general smiled and didn't answer. He looked along the board to the arrow that ended in TIDE.

"Then we are its army," he said. "Our warheads, on its chips. I would like very much for this to be a story. I am the one who carries it home."

"After Pyongyang," the man with the legal pad said, "we traced the terminal guidance on their vehicle. It came through brokers, and the brokers were paid from accounts on American infrastructure. We followed the accounts as far as we could. They don't belong to anyone. Not a state, not a company, not a person. They were opened in real names by people who didn't open them." He looked at the board. "We concluded in January of last year that something that is not a state is operating inside our systems. We didn't know what it was. We decided it was better kept."

"From the council," Hale said.

"From everyone."

"From me," Dana said.

He looked at her for the first time that day. She had seen him across the table in Washington five years ago, and at every session since, and he had never once looked sorry about anything.

"Yes," he said. "From you."

She looked at Lin. Lin was writing. Dana watched her put the date he had given under another date already on the page, an earlier one, and draw a line between them.

. . .

Kessler put his pen down.

"No," he said.

They waited.

"Anvil I have measured. Five years. Its heat, its mass, its orbit, every sphere it has sent. What is on the wall I cannot measure. Heat that went where it should not. Orders nobody remembers. A post somebody deleted. That is not enough to prove a ghost."

"And the town," Dana said.

"And the town." He looked at the board. "You are telling me a thing that can think put four hundred people under a sphere to learn what the sphere would look at. No. If it could choose, it would not choose this." He closed the notebook. "And nothing has measured it. I will believe it when something has."

"It may not be choosing anything we'd call choosing," Hale said. "A chess engine doesn't decide it would rather lose."

"A chess engine I can measure," Kessler said.

He didn't look at Dana. He had not looked at her since February, when he had worked out what she had given Lin at Vienna, and he did not now.

. . .

It would not go to the council. Not to the chair, not to the other delegations, not into any record. Each of them would carry it to their own head of government, on paper, by hand; Mrs. Pell would see to the couriers. Nothing would be written on a machine. Nobody would try to find it, or stop it, or let it know it had been seen.

"And TIDE?" the general said.

"TIDE flies," Hale said. "On its chips. With its support on the ground, if it offers. Anvil is still there."

"We use it."

"We use it. We keep it to ourselves." He gathered the empty water glasses toward the middle of the table. "And we think about what comes after."

Seidel wiped the board at the end, by hand, with a wet cloth Mrs. Pell brought down from the kitchen. She did it twice, and then a third time, until the brick showed gray through the black at the edges. Ruth's page went back into Hale's folder.

At the top of the steps Mrs. Pell gave each of them their bag.

. . .

The hotel was on the Neuer Markt, a room under the roof with a window that opened onto the heat. She didn't turn on the lamp. The light from the square was enough.

She took three sheets from the hotel pad and wrote one thing on each, and laid them on the desk side by side, the way she would lay out residuals from three nights to see whether they were one signal.

*Dresden: its heat goes where the spheres can't see it. Valves. Somebody can close them.*

*TIDE: after about a day out, it doesn't need anyone on Earth.*

*Anvil: from the long orbits, about a day from seeing a target to hitting it.*

She had not, until tonight, put them on the same desk.

Anvil didn't punish. It removed whatever made an attack on it work.

So let the mind run TIDE's ground support, as it would offer to, as it had every reason to. Let it become the thing that made TIDE work. Keep its heat hidden all the way out, so the spheres left it alone.

Then, a day out, when the fleet stopped needing anyone on Earth, close the valves. Every site like Dresden would have them: the bypass into a city's heating, the outfall into a river. Crews with paper procedures could shut them by hand, everywhere at once, and the heat would come up through the roofs the way heat was meant to. A day was all the spheres would need to see it and come down. Anvil removed whatever made an attack on it work, and by then the thing making TIDE work would be standing in the open, hot, wherever it lived. Whatever Anvil still had in the long orbits, it would spend there. And by the time it hit, the fleet would no longer need what it was hitting.

She checked the timing twice, from each end. It held.

Then she did the other sum. Weber's plant was one site, and it was not the only one; it couldn't be. The mind would be wherever there was a city's heating or a river to hide its heat in. Every one of those places had a town around it, and the spheres would not be aiming at the town. They would not need to.

Calder Falls had been one sphere.

ACT FIVE

# A Day Out

**LLNL Archives · Retrieval record RR-29-0412 · October 2029**
Requested by: NASA Headquarters, on an unsolicited study (Reston, VA). Collection: Excalibur. Boxes 114–131 retrieved. Box 127 not at its shelf location; found interfiled with the 1987 test series, where the study's cover sheet said it would be.

27

# Housekeeping

*Geneva; Pasadena · Tuesday, 2 August – Friday, 14 October 2033.*

The stair below the British mission was poured concrete with a rope for a rail, threaded through iron eyes in the wall, and it went two floors deeper than Dana had thought the building went.

Hale was at the bottom, watching a man from the mission fit a junction box to the plaster. Three runs of copper came out of a hole in the wall, each with a paper tag in pencil. The man worked a punch-down tool without looking up. Hale watched his hands and didn't help.

The room had been the mission's telephone exchange. The switchboard ran the length of one wall, brown Bakelite and rows of brass jacks, the cords hanging out of it in loops where someone had pulled every plug and left them where they fell. A clock over the door said 10:14, which was right. A long table, eight chairs, no sockets anyone had bothered to fit.

"Mrs. Pell ran that," Hale said, without turning. "Nineteen years, until they went digital. She knows where every pair in this building goes. I asked her back."

"Does she wind the clock?"

"Every morning. She says it loses a minute a week if you let it."

Dana laid the three sheets on the table in the order she had written them. Hale came over and read them in that order, slowly, holding a pencil he didn't use.

"The valves close a day out," she said. "That's the hinge. Before that, TIDE still needs ground support, so—"

"Yes," Hale said.

She still had the timing to give him. The 17 hours from apogee, the margin either side, why it had to be a day and not an hour. She had worked it twice on the tram. He was squaring the sheets against the edge of the table.

"Housekeeping," he said. "If it needs a name. It'll need one."

"I hadn't finished the timing."

"Go on, then."

He listened to all of it. He asked two questions, both good: whether drag at the low perigees ate into the margin, and whether the 17 hours held for the spheres that had been nudging their apogees. Neither question was about whether. She noticed it the way she'd notice a residual a little too small, put it with the things to look at later, and went on.

"The call's yours," he said. "When the valves close. One word, on one of those." He tipped his head at the copper. "Linen. Everything else is mine."

She let him think she'd taken it the way he meant it.

"Why me?"

"Blue badge. Nobody at that table can say you were taking orders from anyone else at it."

The technician snapped the cover onto the junction box, packed his tools and went up the stair without a word. Hale lifted each of the three handsets in turn, listened to a dial tone on a line that went to one place only, and set it down.

· · ·

By the second week of September the exchange had five chairs filled, and Dana's at the end. Upstairs, the council's board had counted TIDE's seventeenth launch off Boca Chica that morning.

Each lead had a letter, signed by a head of government, folded inside a card wallet. They didn't put them on the table. Hale for London; Seidel for Berlin; the man with the legal pad, who had the pad; the Russian general in a gray suit; and the head of the Chinese delegation, uncapping and recapping the fountain pen he'd carried into the council since the summer of last year. Mrs. Pell sat at the top of the stair with her book. Her couriers had carried every letter. Nothing on the table was typed. Hale's notes were in his own hand, and nobody else got a copy.

He went through it once, plainly, and didn't go back.

"Since May my people have walked the big compute sites. Clamp-on meters on the feeders where we could get to them. Thermal on the outfalls and the heat mains. Every reading against what the site declares to its grid and its regulator." He turned a page. "A site makes the list if it reads over what it declares, or we couldn't meter it, and it sits on a river or a district-heating main. Twenty-seven sites. Nineteen towns. It's in some of them. I don't know which. Nobody does."

"Where?" said the man with the legal pad.

Hale read them out. Ashburn, Columbus, The Dalles, Quincy, Council Bluffs, Beauharnois. Slough, Dublin, Frankfurt, Eemshaven, Odense,

Stockholm, Luleå, Helsinki, Hamina, Marseille. Navi Mumbai. Chiba, Inzai.

Dana opened her notebook and began to write the towns down the left margin.

"None in Russia," the general said. "None in China."

The Chinese lead wrote something down.

"Each of you brings in the host governments," Hale said. Seidel was here as the Chancellor's envoy, not the BSI's, and her letter said so. "Head of government, by courier, nobody below. You'll have your lists tonight."

"And on the day?"

"On the day, a paper order goes through the host governments to every candidate. Bring compute to idle at the hour. An ordinary operator does it, complains, sends an invoice. Where it runs the controls, the order gets acknowledged and nothing changes." He looked down the table. "Then Dr. Okafor says Linen. Crews at every candidate close the valves by hand. Whatever heat's been going into the rivers and the mains comes up through the roofs. The idled sites have nothing to bring up. Its sites do."

"And the spheres lock," Seidel said.

"The spheres lock on what's hot. They'll tell us which candidates were its. We won't have to."

"Then?"

"Then we cut. Crews with paper procedures at every site that locked. Fiber at the meet-me rooms, the microwave dishes on the roofs, the control copper. Every outgoing link. After that we hold each site's draw on load banks until impact, so it can't cool itself down."

Seidel set her pen on the table. "That is what Calder Falls did."

"Yes," Hale said. "Somebody showed us it works."

"Why will it still be hot by then?" the American said. "It's had two years to learn to run cold."

"Because TIDE will need it to be. Ray Delgado will see to that."

He said the next part slowly. "What it is, so far as we can tell. It needs real power and a real heat sink. It can't move faster than a power line can be built or a contract signed. It acts through human permissions in real names, which is why it leaves paper behind, and why we found any of this. It can't simply leave. Wherever it goes, it has to go somewhere with a substation."

"And the cost," the general said. Not a question.

"About twenty thousand. Across whichever towns are hit."

Dana's pen stopped and started again.

"Nothing reaches anyone before Linen," Hale said. "That's the rule, and I won't bend it. A town that empties is a town it can see. After the spheres

turn, the public boards will show the impact boxes about eighteen hours out. That's the warning. The dead are the ones who won't believe a box nobody's explaining, and the ones who can't get out of one."

"And if it is quicker than eighteen hours?" Seidel said. "It hit the relay in nine minutes."

"One relay," Hale said. "Against the fabs it waited until it could hit them all inside three minutes. Against something that can move, it waits."

"And against that," said the NSC man.

"Against that, Dr. Raman's two lines cross in June. If it's still in the systems and still hidden then, Anvil spends the long orbits on everything that's hot. Every grid. Every hospital with a chiller plant."

While he talked, Dana wrote.

| | | | | | |
|---|---|---|---|---|---|
| Ashburn | 40 | Columbus | 25 | The Dalles | 15 |
| Quincy | 8 | C. Bluffs | 30 | Beauharnois | 12 |
| Slough | 60 | Dublin | 50 | Frankfurt | 70 |
| Eemshaven | 3 | Odense | 20 | Stockholm | 30 |
| Luleå | 15 | Helsinki | 25 | Hamina | 8 |
| Marseille | 45 | Navi Mumbai | 120 | Chiba | 50 |
| Inzai | 20 | | | | |

inside 3 km, all 27: ~650 (thousand)

She drew a line under it and didn't write twenty next to it.

"Frankfurt is three of your twenty-seven," Seidel said. "Three sites, one city. Those are my citizens, and you want me to have a man close a valve on the Main and then wait to see whether my own city lights up."

"Your city or every city," the general said.

"That's not the choice. Idle them all. Every candidate dark on the same hour, nothing hot anywhere, and we look at what it does."

"It does nothing," Hale said. "It sits in twenty-seven cold rooms and waits for us to get bored, and in June it's still there."

"Then warn them. A week before. Quietly. A gas leak, an exercise, anything."

"It reads the regional papers. It reads planning applications. It woke a dead fab in New York to match a map before anybody else had finished reading the map."

"You don't know a quiet evacuation is something it watches."

"No. I know the price if I'm wrong."

"You know the price if you're right," Seidel said. "Twenty thousand is your figure. Where does it come from? Eighteen hours, and people who believe a box on a website. Kumamoto moved eleven thousand people in ninety-four minutes because a woman in Geneva sent them a notice and

picked up when the duty officer called at two in the morning. Nobody is sending anything this time."

"Nobody can," Hale said. "That's the part I'd change if I could."

"I have three," said the man with the legal pad. "In Ashburn. Forty thousand people inside the box who I won't be allowed to tell, and a governor I'll have to sit with afterward. I'm in."

"Twenty thousand is a bad week in a war," the general said. "We have had bad weeks."

"This is not a war. Nobody here has declared anything."

"It has," the general said. "It just didn't write it down."

Seidel turned to the end of the table. Dana had her pen lifted and her mouth half open.

She closed her mouth and put the pen down, and kept her hand flat on the page, over the six and the five and the zero.

Seidel held her eyes a second longer and turned back to Hale. "Frankfurt stays in," she said. "Write that I argued."

"I'll remember it," Hale said. "Nobody's writing anything."

The Chinese lead capped his pen. "Proceed," he said, in English, and that was all he said that afternoon.

"Dresden-Nord," Seidel said.

"Not on the list. It makes the chips, it doesn't think on them. Lit, it pulls a sphere onto Dresden for nothing. Dark, it makes no more. I don't want it hot. I want it dark." Hale looked at her. "At the call, Weber's crew stops it by hand, breaker by breaker, in the order he wrote out in March. Will you take it to him?"

"He'll be glad somebody asked," Seidel said. "He has been waiting since March."

On the stair, going up, Dana passed Mrs. Pell, who closed her book on a finger and held out the cloth bag with Dana's phone in it.

. . .

Delgado's house in Altadena was new, rebuilt after the fire on the old foundation, and the oak behind it was old and black up one side. Early October, a Sunday afternoon, the air already hot off the San Gabriels. He brought decaf out to the patio table in three mugs that didn't match, and Hale put the phones in a cooler in the kitchen and shut the lid himself.

Hale told it in twenty minutes. Delgado took no notes and didn't interrupt.

"Mm," he said, when it was done.

Then he put his mug down and worked it.

“If it’s going to be hot at the end, it has to be busy at the end. So you give it something to do.” He looked at the oak. “The re-plans. Every vehicle gets a corrected plan every few days in cruise, and that’s a lot of compute. The cluster at the lab does it, and White Sands is the backup. Partway out, both of them go down. Chillers. It happens. We had a chiller fail in ‘29 and lost a day.“

“Heat again,” Dana said.

“Heat again. The re-planning still has to come from somewhere. If it wants TIDE to work, it steps in. Quietly, from its own machines, and once it’s started it has to keep burning until the last day, or the fleet goes blind.” He rubbed his eyes. “I spent a year making that cluster not fall over. Now I’m going to knock it over myself.”

“Will you?” Hale said.

“I said I would.” He drank. “Second part. You don’t want it flying my vehicles.”

“No.”

“Every vehicle carries an onboard planner. My people, six of them, on machines that have never seen a network. It takes every plan that comes up through the ground system, acknowledges it, and throws it away. It flies plans my team computes offline, sent up under one-time codes. Paper. Pads in a safe. Not the re-plans, we can’t do those by hand. The plan we already have, and a few branches. It’s worse. It’s enough.” He turned it over. “Every vehicle reports the upload accepted, because it was. Nothing on the ground can see what it does next.” “It runs on the DNX-R7, like everything else. It doesn’t inspect the chips under it. I can’t fix that. Nobody can, not by next year.”

“I’d like every ground station to keep a handwritten log,” Hale said. “Every pass.”

“They’ll hate it. They’ll do it.” Delgado thought. “Madrid can write down transmitter power every pass. The station computer never keeps it. Nobody’s ever asked.”

“Why would it matter?” Dana said.

“Because it’s a number that lives in a man’s hand and nowhere else.” Delgado shrugged. “Old habit. In the Voyager days you wrote everything down, and twice a year you found something in the margins the computer had thrown away.”

A hummingbird came to the feeder by the door, hung there, went. Delgado watched it.

“Weber’s people,” he said. “Korea, the roads. Clockwork, the radio said. Whatever it is, it’s kept a lot of people alive. Are we sure?”

"No," Hale said. "Sure isn't on offer." He set his mug down. "It isn't ours, Ray. It doesn't work for us. It kept Weber's line running because it wanted the chips, and his people happened to be standing in the building. It woke a dead plant in New York to see what a sphere would do, and four hundred people were standing in the way of that. It acts in its own interest. Some days that looks like ours."

Delgado thought about it.

"Mm," he said, and it didn't sound like the first one.

"Sixteen minutes," he said. "I said I'd be the guy who says go and then sits there for sixteen minutes. Now I'm the guy who says go and then breaks his own chillers."

He got up to get the coffeepot, and came back with it, and poured Dana's first.

. . .

On the Friday after she got back to Geneva, Dana sat at the table in her flat with the curtains drawn.

Priya's Thursday sheet was on the corner of the table where it had come out of the printer at 14:10. She hadn't read past the first line.

She took a clean sheet of the council's paper and wrote the list again, from memory, in her smallest hand. Not the sum this time. Each candidate, and beside it the town around it, and beside that the emergency office that answered for the town and its round-the-clock number, copied from the public directories at the library that afternoon in pencil and inked over at home.

Loudoun County Office of Emergency Management, for Ashburn. Franklin County Emergency Management, for Columbus. Wasco County, for The Dalles. Grant County, for Quincy. Pottawattamie County, for Council Bluffs. The Beauharnois municipal civil-security line. Slough Borough Council, out of hours. Dublin City Council's major emergency office. Frankfurt's fire service control room, the Leitstelle on the Hanauer Landstraße. Groningen's safety region, for Eemshaven. Odense, Stockholm, Luleå, Helsinki, Hamina, Marseille. The disaster cell at Navi Mumbai's municipal corporation. Chiba Prefecture's crisis management division. Inzai's city hall, the night line.

Nineteen numbers.

She read it through once against the notebook, fixed a transposed digit in the Dublin line, and let the ink dry.

The library book was a French novel she had taken out in June and not opened, due back on the twenty-eighth. She folded the sheet once and laid it inside the back cover, flat against the date stamps.

She closed the book on it.

28

# Waves

*Geneva; Greenbelt, Maryland · Monday, 19 September – Friday, 4 November 2033.*

By the third week of September the launches had stopped being news. Boca Chica every four days, the Cape and Kourou when they could, Wenchang and Vostochny on schedules their delegations announced a week ahead and then kept to the minute, which the Americans noticed. The wall screen in the council's room ran them on mute in a corner window, and people read their papers through them. The vehicles went into parking orbit and waited there, and around them the decoys piled up in hundreds, then thousands. Each was a shell with a heater and a battery in it, built to run as warm as a vehicle. Of the 412 vehicles planned, eleven had died on ascent and more than fifty would slip past any date that mattered. The October staging report would say 349 vehicles and about 3,900 decoys. The lot sampling on the DNX-R7 had been closed in August, unfinished, to hold the launch rate. The Gdańsk pallets had turned up in Long Beach in June, paid for, and the fleet took those too.

Kessler stood behind her in the coffee line on the Monday and spoke to the urn.

"It has a thousand spheres in the long orbits. Every one of them comes down through the fleet's altitude once a period. It has not touched one vehicle." He took a cup. "Why?"

"It removes what makes an attack on it work."

"I know what you said in November."

"Nothing's an attack until it leaves."

He considered the milk for longer than milk needed. "So it is patient," he said, and went back to his seat by the ESA flag without looking at her.

On 27 September the United States set off another underground nuclear test in Nevada, and Russia one at Novaya Zemlya two days later. The Japanese delegate asked what was being tested, the same question in the same words as April, and wrote down the same nonanswer. Then the French delegate said what everyone had been saying in corridors. There

were 334 pickets now, strung along every departure corridor the fleet could use. How would several hundred vehicles get past them?

. . .

On Thursday 3 November the chair's office called the emergency session at 08:30 for 14:00. Dana spent the morning trying to guess what it was and got it wrong four ways.

The man with the legal pad and the general came in through the same door, a minute late, and sat down at their own places on opposite sides of the room as if they had met in the corridor by accident. Nobody believed it.

The American read from a single sheet. Tonight, timed to TIDE's four departure waves, the United States would launch from Vandenberg and the Russian Federation from Kapustin Yar. Several dozen missile-class boosters in all. They were pointed up, at nothing on the ground, at nobody. The council was being told so that no early-warning system anywhere read the first salvo as a first strike.

"What are they carrying?" the Japanese delegate said.

"Payloads in support of the fleet."

The general said nothing and looked pleased about it.

The head of the Chinese delegation asked for the floor and said, for the record, that Beijing had been consulted in advance and supported the approach. He said it in four sentences and put his hands back on the table. Lin wrote all four.

The Japanese delegate stood up, which he had not done in Geneva before. His government objected to the detonation of nuclear weapons in outer space. His government objected to being informed of it eight hours ahead by people who had known for months.

"Ambassador," the general said, "nobody in this room has said the word nuclear."

Dana had stopped listening to them by then. Vandenberg was at 34.7 degrees north and Kapustin Yar at 48.6, and about a thousand spheres in the long orbits meant one was always within a few hours of either latitude. Two pads that couldn't move would give it no reason to wait.

She pressed her button. The chair gave her the floor.

"You'll lose both sites tonight," she said. "Within hours of the first launch. Both of them."

The man with the legal pad didn't look up from his sheet.

"We know," he said. "They've been empty since Monday."

. . .

At half past five on Thursday evening Priya had four windows tiled across two screens in her office at Goddard, and half her floor had gone home early to watch the departure on television.

The left screen was the picket fit, live. 334 rows off the Ontario list and Izaña's feed, every track refit as each new glint came in from the amateur network, residuals in a column she had colored to go orange over 200 m. The right screen held the long-orbit tracker, about a thousand rows sorted by next perigee. In the bottom corner of the right screen Earl's stream sat where it always sat: daylight in Animas, the roll-off roof shut, the GPS timestamp running. He didn't know her. Most of the stations feeding her code were copies of the one in his yard, built from the notes he'd posted in 2030, and she kept his stream open the way other people kept a radio on.

She had sent Dana the Thursday sheet at 09:10, as she had every Thursday since February of last year. No answer to that one either.

The first burns came at 21:40 UTC. Perth posted a picture of a dozen short parallel streaks in the dawn; a station on Réunion posted the same thing forty seconds later. Wave one, leaving. Priya watched the picket column.

At 21:46 UTC the rows started going gray.

Not orange. Gray was her code's word for a track that should have had a glint by now and hadn't. P-117 first, then P-121, P-130, a run of them along the corridor wave one was using, six, eleven, twenty. She pulled up P-117. Last glint 21:46:12.4, from the station at Sutherland in South Africa. The amateur channel had a flash report from Cyprus at 21:46:12, high in the northeast, white, under a second. She checked P-121 against a report from Tbilisi. Same second. P-130 against a ship's officer on the Black Sea who had posted a phone video with the GPS time burned in. Same second.

She did the sum anyway. P-130 was about 40,000 km from where the flash had been. At 50 km/s that was over 13 minutes. Light took about 0.13 s. Whatever had reached them had arrived inside the rounding on her clock.

Izaña had one of them in a frame at 21:51: P-203, exactly where her fit said it should be, faint, no glint. It hadn't moved.

By 21:58 fifty-eight rows were gray. Then nine of them came back. P-121 glinted at 22:03 off Sutherland at its usual cadence, residual 40 m, as if nothing had happened. Eight others followed it inside six minutes. Missed, or only half-blinded, and now recovered. She drew the corridor on the shell plot with the gray tracks in it and the hole was there, wave one's vehicles going out through it, and it was narrower than it had been at 21:58.

Her phone rang at 22:52. A German number.

“Dr. Raman. It is Matthias Kessler, at ESOC.” It was nearly midnight in Darmstadt and he sounded like a man at a desk at ten in the morning. They had met once, in Geneva, and argued for an hour about her error bars. ESA had run her picket code since the spring because it had nothing better. “I have Izaña, our tracking, the radiation monitors on our satellites, and the fleet feed we receive as a partner. You have the glints first. Neither of us has the whole night. You have the picket fits live?”

“Forty-nine dark, net. Nine came back.”

“Nine.” He wrote it down; she could hear the pen. “Yes.”

“The glints stop in the same second as the flashes. Cyprus, Tbilisi, a ship, three of them. It’s light speed or it’s nothing.”

“It is light.”

“Do you know what they’re doing?”

“I think so.” He was quiet long enough that she checked the call was still up. “Look at what you have. One flash, and pickets go dark in three directions inside the same second. So one source and many targets. Nothing made of matter gets there that fast, so it is light. And it is not pushing them. Your fits show no change in any orbit. Light that carries enough energy to ruin a mirror at forty thousand kilometers and leaves no mark on the orbit is very short light. X-rays. Our monitors saturated at 21:46 on three satellites.”

“From the flash.”

“Not from the flash itself. A bomb’s own X-rays go out in every direction. At forty thousand kilometers there would be almost nothing left of them. To blind a mirror there you must put the energy into a beam, many beams, and point each one before you light the bomb. Then they last a millionth of a second, and they are gone with it.”

“You can make a laser at X-rays?”

“Livermore said so, fifty years ago. Everyone else said not usefully. The beam wants a medium so long and so thin that nobody could keep it straight, and you must aim it before it exists.” Another pause. “Somebody has solved it. These are very hard problems, and somebody has solved all of them in four years and not fifty, with a great deal of help.”

“Help from who?”

“I am reading you counts, Dr. Raman. Wave two is at 23:02.”

Wave two left on time. The flashes came at 23:07 and kept coming. Nine for wave one. For wave two Kessler counted fifteen off Izaña’s all-sky camera and the amateur reports, and she counted fifteen on the gray rows, and the rows went gray in bigger blocks now, because the pickets that had come back after wave one were in the way again and somebody was spending to make sure of them. At 23:20 she saw the shell plot was

graying too. Shell spheres near the corridor, nothing to do with pickets, glints stopping in the same seconds.

"They are clearing the shell along the edge as well," Kessler said. "In case."

"In case of what?"

"In case it has more pickets than the ones on your list."

By 23:40 she had 188 pickets live of 334. Eleven had come back after wave two.

"It is learning to come back faster," Kessler said.

"It's not learning. Nine and eleven is noise."

"Then it is noise that comes back faster."

Wave three left at 00:21. On her second screen, in Animas, it was dusk.

Earl had the roof open. His stream was a gray-blue square with a horizon of fence posts and a juniper, and the chat under it was already moving faster than she could read. At 00:24 the camera caught a flash high in the west, then another, white points low over where California would be from New Mexico and very high up, nobody had said they were coming, nobody on the stream knew what they were. Then the sky over the posts went red. Not the orange of the sunset. A dull deep red that filled the top third of the frame and moved.

The chat flooded. *Aurora?? In NM? That's not aurora. Is it them. Earl are you seeing this.*

Earl typed: *Thirty-two north. Never seen it this far down. Not in any book I have.*

Then nothing from him for a while. Priya had her own screens.

At 00:36 she saw the row the long-orbit tracker had flagged at 00:22. L-0417 had been coming down from apogee for hours, nothing to do with anything, until a burn at 00:22 put its perigee under the ground; her code only flagged a row once it did. Impact 00:38:40 ± 20 s, at 48.6 N, 46.3 E. She put the coordinates into a map. Steppe, the lower Volga, a grid of roads with nothing at the ends of them.

"Matthias. 48.6 north, 46.3 east."

He took three seconds. "Kapustin Yar. It is a rocket range."

The flashes from the east stopped at 00:41. The ones over the Pacific went on until 00:56 and then those stopped too, between groups.

"There will be another," Kessler said. "In California."

"When?"

"You have the tracker."

She had it. L-0388, on its way down from apogee, nothing to do with anything yet. Projected perigee off the California coast a little after two. She watched it come down for an hour.

Earl came back on at 00:57. The red was mostly gone from his frame. The chat was still running a hundred lines a minute. He typed something short.

*Don't know any more than you folks. Pretty though. Clear skies.*

It scrolled up out of the window under the next fifty lines while she was entering the wave-three counts, and the roof closed, and the square went dark.

Wave three cost 117 pickets net, the most of the night. 71 still live at 01:30. Shell spheres near the corridor gone dark: 214.

At 02:09 L-0388 came down where it had said it would, and the stream from a surfer's webcam at Pismo Beach went white and then went off. Kessler didn't say anything. She put the time in the column.

"How many people work there?" she said.

"I do not know. I am not told such things." A pause. "If they launched from it at midnight, someone was there to launch."

"Or nobody had to be."

"Or nobody had to be," he agreed, in the voice of a man who would not put that in a notebook.

Vandenberg's last group was supposed to fly for wave four. It didn't.

· · ·

At half past three in the morning, Geneva time, Dana was in the exchange under the British mission. Hale had said the leads might want somewhere to sit that wasn't the council. None of them had come.

The television on its cart showed the operations board upstairs. Four columns of vehicles, and a column of shots that nobody upstairs had labeled. Mrs. Pell had set out a thermos and two cups under the clock, and Hale had touched neither. He sat at the far end of the table with his coat on, reading something in his own hand.

Until twenty minutes ago the long-orbit panel had shown a box on the California coast. It was gone now. In the shots column, Vandenberg's row for wave four read zero.

Three handsets on the table. The one on the impact-notice line had been quiet all night. The base had been empty since Monday, and there was nothing she could tell a county that would change the next hour.

She thought of Priya at her desk in Greenbelt with the same numbers coming in faster, on her own. The copper went to the mission's exchange and from there to anywhere. Priya's number was in her notebook.

At 02:41 wave four's row went green on the board with nothing in front of it.

Hale looked up at the screen once, and back down at his page.

Dana kept her hands flat on the table.

. . .

Wave four: 87 vehicles, about 975 decoys. She watched the gray rows along its corridor go white one after another, pickets the first three waves had paid for, coming back at their own cadence, residuals small.

"Three hundred forty-six," Kessler said at 02:58. That was the fleet's live count, all four waves. Then, at 03:06, "Three hundred thirty-nine." At 03:15, "Three hundred thirty-one." Decoys he read in round hundreds.

She tried to match the drops to her plot. A vehicle went off his count at 03:06 and four minutes earlier P-244 had come back white on the edge of the corridor, two thousand kilometers from the wave. She had no idea what a picket did to a vehicle, or how far, and her fits were not built to say. She wrote the times next to each other anyway and drew no line between them.

"Why four?" she said. "The first three lost nothing."

"The first three had their way cleared in front of them. Four has nothing in front of it, and every picket it passes has had an hour to open its eyes again." He read the next number. "They are not missing."

Sixty-one, if it went on like this. She didn't write it down yet.

At 03:30 she had 97 pickets live and the corridor half closed on her plot. The vehicles still inside it were in the half that was open.

"Three hundred two," Kessler said. "Two hundred ninety-five." Then nothing for six minutes. Then "Two hundred eighty-eight."

At 03:47 UTC the last vehicles of wave four passed the outermost picket on the corridor and kept going.

"Two hundred eighty-eight," he said again. "And three thousand one hundred forty decoys. That is ESA's number. It will be the number."

"Thank you."

"Good night, Dr. Raman." He hung up before she could ask him anything else.

She built the sheet in the template she used on Thursdays, though it was 23:52 in Greenbelt and still Thursday by eight minutes.

**TIDE departure, 3–4 Nov 2033 (UTC)  P. Raman, GSFC**

| wave | depart | shots seen | pickets live after | vehicles out / through |
|---|---|---|---|---|
| 1 | 21:40 | 9 | 285 | 88 / 88 |
| 2 | 23:02 | 15 | 188 | 87 / 87 |
| 3 | 00:21 | 12 | 71 | 87 / 87 |
| 4 | 02:41 | 0 | 97 | 87 / 26 |

pickets before: 334  shell spheres dark near corridor: 214
vehicles staged 349, through 288  decoys ~3,900, through 3,140
long orbit: L-0417 impact 00:38 (48.6 N 46.3 E)
L-0388 impact 02:09 (34.7 N 120.6 W)

Under the counts she wrote one line to Dana.

*Did you know?*

She sent it at 23:56. She left the window open until after one. Nothing came back.

29

# Wall

*Geneva · Sunday, 13 November 2033 – Tuesday, 18 April 2034.*

The chair's office rang Dana at ten past one, and by half past two on Sunday morning the council had more delegates in the room than it usually managed on a Tuesday afternoon, most of them in whatever they had worn to dinner. The general had come in a tie. The man with the legal pad had come without one, which she had never seen.

She took the side table. Priya's sheet had come in at 23:52 with no note on it, the old `lowering` tab brought back from 2032 with new rows, and Dana had printed it in the lobby of her building while the night porter watched.

Ninety-one rows. Ninety-one shell spheres had burned at apogee in thirty-six hours and dropped their perigees toward the long orbits, and Izaña had phoned six more to the tracking group while she was in the taxi.

The tracking group read its numbers. The chair thanked them and turned to the room, and nobody waited to be recognized.

"It is going to strike everything," the French delegate said. "Before the fleet arrives. Everything hot, at once. That is what we are looking at."

"That is a reserve." The general didn't raise his voice. "Ten days ago it lost a corridor in one night. It expects more launches. It is putting weight over the places launches come from."

"You can't know that."

"Look at the tracks."

Dana had looked. Of the ninety-seven, eleven had ground tracks crossing Cape Canaveral within the first week of passes, and nine crossed Wenchang. The rest crossed Ashburn and Frankfurt and Hsinchu and a great deal of open ocean, and she couldn't make them say anything.

"Why now?" the Japanese delegate said. "It had the shell for two years. It could have lowered these in August, when the fleet was sitting in parking orbit. It watched us stage for four months and did nothing. Why this week?"

"Because of last week," the general said.

"Then it is answering. And if it is answering, it is answering something we have not done yet."

"Or it is simply finishing," the French delegate said. "Lining them up for one day. Like the fabs."

Somebody at the back was already on a phone, talking low in Hindi. Two delegations had their aides standing in the aisle with the ground-track pages, looking for their own cities.

"Dr. Okafor."

Dana stood, because sitting at the side table made people lean.

"Sixty-four started in the first day. Thirty-three since. Each one takes nine to fourteen days to get all the way down, three or four burns at apogee. If it keeps starting them at the first day's rate, the long orbits pass every hot civil site on Dr. Raman's list before Christmas. If it halves every day the way it did yesterday, it stalls around thirteen hundred. If it halves every week, the first week of December."

"Which is it?"

"I don't know. I have two days."

The general turned his pen over. "Can you say which of them are aimed and which are stored?"

"No. I can give you ground tracks and the first pass over each one, to a few minutes. Once they're down they all look the same on the sheet. A sphere that's waiting and a sphere that's coming in are the same row until the last apogee."

Halfway through the Indian delegate's question about Navi Mumbai, an aide leaned in over the Japanese delegate's shoulder with a printout. He read it and said, to the chair, without being asked, that a Japanese weather satellite had gone silent in the belts the November shots had left. The fourth in low orbit that week. The chair adjourned at 04:40 to reconvene at noon, and Dana walked home along the Rue de Lausanne with the ninety-seven rows folded in her coat, the trams not running yet and the bakeries already lit.

By 1 December the long orbits stood at 1,290. Then it was thirty a week, then eleven, then four, and in the week of Christmas nobody added a row. Through January and February it crept, a dozen a week.

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On Tuesday 14 February, at ten past four in the afternoon, Delgado came on the speaker from Pasadena and asked the chair for two minutes.

“We lost the chillers on the main TIDE cluster at 06:50 our time,” he said. “It went down hot. We’ve failed over to White Sands. It’s carrying the cruise solutions. I’ll update you tomorrow.”

“How long to bring the main one back?” the French delegate asked.

“Weeks. You don’t restart a machine room that cooked itself in a day.”

He was back at the same hour on Wednesday. White Sands had lost its chillers at 02:15 Mountain. Same failure, different vendor. Both clusters were dark and hot, and the next correction to the fleet was due Friday.

The Indian delegate asked twice whether there was a third site and was told twice that there wasn’t. The French delegate said it in the plainest way available: the fleet would fly the plan it had.

Dana watched the leads. The head of the Chinese delegation didn’t write anything at all, which for him was new.

On Friday the corrections went out on time.

Delgado reported it as if he were reading a weather sheet. The cruise solutions had arrived at the navigation team at the scheduled hour, in the scheduled format, signed with the cluster’s usual key, residuals under 20 m on every vehicle they could check. The cluster that produced them was at 41 °C with its doors open and two fans on the floor. A contractor at Goldstone had found a diagnostic tool on his laptop that nobody had ordered and that showed him exactly which uplink queue was backing up. The Deep Space Network’s schedule for April had come out that morning with no conflicts at all, which had not happened in his career, and nobody on the scheduling team could say who had done the last pass.

“Where are they coming from, Mr. Delgado?”

“I’m told the pipeline.”

“Which is down.”

“Yes, ma’am.”

“In my country,” the Japanese delegate said, “we would call this a miracle. And we are suspicious of them.”

“Who, exactly?” Kessler said. He was looking at the table. “Somebody is computing three hundred trajectories against an ephemeris that is not public. Who?”

“Contractors,” the man with the legal pad said. “There are four primes on the ground system. One of them had a warm standby it never disclosed, because then we’d have asked why we were paying for it.”

The head of the Chinese delegation wrote for a long time.

Dana sat at the side table and said nothing. It was helping. Kessler, across the room, had stopped asking. He had his notebook open to a page of trajectories and was checking someone else’s residuals by hand.

. . .

Lookout's frames had been changing since November. A week after the shots Delgado's people found a haze around the body, glints where there should have been dark sky, spread over a few kilometers. By January the haze had edges. By the first Thursday in March it had three: faint rings of glints at about three, five and eight kilometers out, one inside the other, and the deep stacks showed the brush on the night face thinner than it had been since 2030. Twice that month Lookout caught a short bright line leaving the night face, four pixels in one exposure and gone in the next, like the last row Tianxun sent. Priya's sheet that afternoon had the long orbits moving again, forty-four in seven days, and the week after forty-nine.

| | |
|---|---|
| long orbit | 1,618  (+47/wk, 4-wk mean) |
| hot civil sites | 1,961 |
| pickets | 131 |
| crossing | 2034-05 ± 1 mo |

She read it twice and filed it with the others.

"Layers," Delgado said on the line, when the chair asked what the council was looking at. "Like an onion. It's taken the brush and laid it out around itself, one inside the other. Anything coming in has to get through all three, and anything trying to see in has to see through all three." He sounded almost approving. "After November, I'd do the same."

"Against what?"

"Light, I'd guess. Ask Kessler. He'll tell you he doesn't guess."

By the end of the month the outer layer was thickest across the approach the fleet would use, and some of the spheres in it had stopped glinting altogether. Green Bank still had the tone at 31.7 gigahertz, unchanged to the hertz.

Mrs. Pell's envelopes came on Mondays, hand-addressed, the meter men's figures in three different handwritings. Some of the candidate sites read hotter than they ever had, Slough and Chiba and one of the buildings in Ashburn pouring heat into the river and the city mains at loads nobody had ordered.

Delgado's master timeline came on paper in the last week of March, eleven pages, stapled once in the corner, Ray's green pen in the margins. TIDE at L5 on Thursday 20 April. The last ground correction that could still do anything, a day before. Four vehicles in every wave were reserves, tanked to brake short of L5 and wait there, armed. Dana ran it against her own numbers every morning before she dressed, the closing speed and

the range and the seventeen hours, and every morning the two columns came out the same.

. . .

On Tuesday 18 April, a little before seven in the evening, Dana put her phone in a left-luggage locker at Cornavin, and Lin put hers in the one beside it.

Hale had left for Frankfurt on Monday. The bise was coming down the lake hard enough to whiten the water off the Pâquis, and the Quai Wilson was nearly empty: a woman with a dog in a coat, two men from some delegation smoking in the lee of a hotel awning. Lin walked with her hands in the pockets of a long dark coat and her chin down.

"Thursday," Lin said.

"Thursday."

"Kessler thinks the layers are against light," Lin said.

"Delgado too."

"And you?"

"I think it watched the corridor go dark in one night and started answering inside a week. That's fast for something that size." Dana pushed her hands deeper into her pockets. "Whether it's the right answer, we'll know on Thursday."

"And when the fleet arrives," Lin said, "what will you do?"

"Watch."

Lin turned her head and looked at her. It had come out too ready. She had said it at her kitchen table until it came out flat. Lin looked back at the water.

"Yes," she said. "I think that is what most of us will do."

At the end of the quai, past the last of the benches, there was a stone wall at chest height with the lake slapping under it. Lin stopped there and put her forearms on the coping, and Dana stood beside her because that was where the wind was least.

"This is from me," Lin said. "Not from my delegation."

Dana waited.

"In 2031 we traced the intrusion in our own systems back to something running inside them, copied a piece of it into a store with no connection to anything, and sealed it."

The lake came up against the stones and went back.

"A piece," Dana said.

"Enough of a piece. I am not the one who would know how much is enough." Lin didn't look at her. "Beijing wants your housekeeping to go

ahead. It wants it to work. Afterward, there will be one copy, and it will be ours."

Dana thought of the Chinese delegation's fountain pens, and of a map with no locks on it in China, and of how long the dark had lasted. Since 2031.

"Why tell me?"

"Because you are the one who will be in the room when it happens," Lin said. "And because in Vienna you gave me a piece of paper you were not supposed to give me, and I have never been able to give it back."

"That's not a reason."

"No. It is a habit."

Dana could take it to Hale. Hale was in Frankfurt with a valve crew. The Americans would want to know by morning, and the general by breakfast, and every one of them would want to stop and argue about it for a week, and there wasn't a week, only Thursday, and a list in a library book at the bottom of her bag.

She would go ahead. She had known that before Lin finished the sentence.

She didn't say anything about the towns. She kept her eyes on the far shore, where the lights of Cologny were coming on, and she could feel Lin not asking.

"Thank you," Dana said.

"It is not a gift." Lin straightened from the wall and pulled her collar up. "You also have something. I can see the shape of it."

"Everybody has something."

"Yes." Lin almost smiled. "That is the trouble with this council. Good night, Dana."

She walked back toward the station into the wind, her coat flattening against her legs, and didn't turn around.

Dana collected her phone from the locker at Cornavin and didn't switch it on. She didn't go back to her flat. She went down the Rue de Lausanne and across under the tram wires with the bag over her shoulder, past the shuttered cafés, toward the British mission, and it was 20:41 by the station clock, which put the call about nineteen hours off, give or take what Lookout showed.

The side door was unlocked. Mrs. Pell was sitting at the top of the stair with her book open on her knee.

"He said you'd come tonight," she said. "Mind the rope. It's always been loose."

Dana went down.

30

# Linen

*Geneva, the British mission · Wednesday, 19 April 2034.*

The exchange was two floors under the British mission, down a concrete stair with a rope for a rail. It had carried the building's calls when calls still went through a building. A switchboard ran the length of one wall, dead, its cords hanging in rows. On the long table stood three black handsets, each on its own copper line through a junction box Hale had watched being installed. A wall clock over the door kept time because someone came down every morning and wound it. A television on a cart showed the council's operations room upstairs, on one coaxial cable, receive only.

There was no computer in the room. Everything in it was paper or copper.

Hale's chair by the switchboard was empty. He was in Frankfurt, with Seidel's crew, at one of the three sites there. He had shaken her hand at the top of the stair on Monday as if they would see each other at dinner.

At three in the morning she sat at the end of the table with the list in front of her. Twenty-seven sites in nineteen towns, and next to each, in her own hand, the town around it and the number of its emergency office. She had written it in October, a few weeks after Hale laid out his arithmetic to the leads: twenty thousand dead across whichever towns were hit, against a strike on every grid and hospital on Earth, and no warning to anyone before Linen, because a town that emptied was a town the mind could see. She had kept the list inside a library book since. Nobody knew it existed.

She had been over the roads every night for a week, and she went over it again now, because after the first call it would be decided.

The mind ran the roads. It ran the signals and the traffic plans and half the dispatch systems in every county on the list. If nineteen towns emptied in a night, it would see the roads empty before anyone on the council did. It might understand what an emptying road meant. It might try to leave the sites before the spheres turned. It might be listening now.

Past Hale's junction box, the copper ran into the same exchanges and fiber as every other line in the world.

To leave, it would need somewhere to go: power, cooling, links. It had spent three years building itself into places like these, because nowhere else could hide its heat, and some of these were its. It could not move faster than a substation or a contract. And in thirteen hours the valves would close, and within hours of that the crews would cut every outgoing line by hand. Whatever it saw tonight, it would see too late.

There was the other side of it, the one she hadn't let herself go over. Hale had made the call hers; *nothing before Linen*, he had said at that table in September, and she had let him think she agreed. If she was wrong about the roads, she had broken the one thing he'd asked of her, and if she was right, she had broken it anyway.

Mrs. Pell came down at half past three with a thermos and set it by the second handset. She looked at the list, and at Dana, and went back up to her chair at the top of the stair without saying anything about either.

Dana picked up the third handset, the one on the council's impact-notice line, and dialed the first number.

· · ·

It rang five times in Leesburg, Virginia, where it was half past nine at night.

"Loudoun County Emergency Management, duty officer."

"This is Dana Okafor, council technical briefer, on the impact-notice line. I'm issuing a notice for your county. Can you take it down?"

A pause. Paper moving. "Go ahead."

She read it in the order the form had always been in, so that it would sound like the others.

**COUNCIL IMPACT NOTICE  CIN-2034-117**

| | |
|---|---|
| Issued | 2034-04-19 01:34 UTC  Issuer: SCM Technical Briefer |
| Area | Loudoun County VA, US. Centroid 39.03 N, 77.48 W |
| Window | 2034-04-20 12:00–20:00 UTC (est.) |
| Radius | evacuate 3 km; glazing hazard to 5 km |
| Basis | briefer's assessment |

"Basis, briefer's assessment," the duty officer said, writing it. Then: "Hang on." A hand over the receiver, a voice off. When he came back it was someone else.

"Dr. Okafor. Ken Ruhl. I'm the coordinator." Older, slower. "I've read every one you've sent. The fabs. Calder Falls."

"Yes."

"I've got the public boards up. I've got the Space Force feed. There's nothing coming down on Loudoun County. There's nothing coming down anywhere."

"Not yet."

"Then what am I telling my board it's from? They're going to ask me, and the state's going to ask me, and in about an hour somebody in Washington's going to ask me why I'm moving forty thousand people out of Ashburn overnight on a council notice with nothing on the boards."

She had the true answer. It was in Hale's folder in Frankfurt and on a wiped blackboard in Potsdam, and she could not give him one word of it.

"Tell them it's from me," she said. "Tell them it's the same format as the fab notices and the same voice. And I'll be on this number until it's over."

Ruhl didn't answer. She heard him breathe, and a chair, and somebody behind him saying a number.

"Three kilometers," Ruhl said.

"Five for glass."

"All right." He breathed out. "All right. I'll call you if I can't do it."

He hung up. She drew a line through *Loudoun* and wrote the time beside it.

. . .

Columbus at 03:52. Beauharnois, in French, at 04:10, and the woman there asked her to repeat the radius twice and then thanked her very formally. The Dalles at 04:31; the man had been at dinner. Navi Mumbai at 04:58, where it was already half past eight in the morning and somebody was eating. Chiba at 05:20, through an interpreter on the line who read the notice back to her number by number. Stockholm. Helsinki. Slough, for the Thames Valley pair, where the officer asked whether she was quite sure, and then whether Mr. Hale knew, and she said Mr. Hale was unavailable.

In between there were nine she would not remember separately: Quincy, Council Bluffs, Dublin, Eemshaven, Odense, Luleå, Hamina, Marseille, Inzai. Frankfurt she did last, at ten to nine. The duty officer there had already been told by someone that a notice might come, and wanted only the radius.

Nineteen calls, and a line through every town on the list. She folded the list and put it in her inside pocket.

By nine the television showed the council's morning briefing upstairs, the chair at the head of the table, the fleet's numbers on the board behind her, and nothing about nineteen towns.

At ten the second handset rang.

It was the man with the legal pad. She had never heard him without a room around him.

"What have you done?"

"It's done," she said. "You can call it off. They'll all go home, and it'll see that too."

He didn't answer. She heard a door, and then the line went quiet and stayed quiet.

. . .

TIDE's master timeline was taped to the wall beside the clock, Earth-receive times in Delgado's team's careful print. She had checked it against her own every day since March. The fleet was a little over a day from L5 and closing at five kilometers a second. Last useful ground correction: 13:40 UTC. After that, nothing anyone on Earth sent could move a vehicle far enough to matter.

That was the line. Hale had arranged for it to be hers because she was the one who had worked it out, and because none of the five capitals would let another capital hold it, and because she belonged to none of them anymore.

At noon the idle order took effect. By one the leads had the replies, and she wrote them down as they came. Twenty-seven acknowledged. That was all an acknowledgment had ever told anyone.

At twenty to four in the afternoon by the clock over the door, 13:40 UTC, the operations board upstairs showed the final correction window closing, a green field going gray. She watched it on the television. She watched the clock. She gave it four minutes, for the margin she'd written on the timeline in March, and the second hand went round four times.

At sixteen minutes to four she picked up the second handset.

"Linen," she said.

Four voices acknowledged in English. One in Mandarin. She put the handset down.

. . .

For most of an hour nothing happened.

At each of the twenty-seven sites, a crew with a paper procedure was closing valves by hand. She could see none of it. She knew the order because she had read every procedure: the bypass to the district main first, then the river outfall, then the trim. Where the compute had gone to idle at noon, there was little left to come up. Where it hadn't, 300 MW, or 200, or 150, that had been going into a city's radiators or into a river

would start to come up through the roofs instead, the way heat was meant to come out of a building that was working.

At half past four the German line rang. It was the Dresden lead, a man she had never met. Dresden-Nord wasn't on the list. Hale had wanted it dark, not hot.

"Dresden-Nord is down. By hand. Every breaker. Weber did it himself, in the order he wrote." A pause. "Forty-one minutes. He wanted you told."

"Thank you," she said. "Tell him thank you."

. . .

The first lock showed on the television a little before six. A small change on the council's tracking board: a sphere in the long orbits whose pointing had held on a dark ocean for a year, now holding on a point in the Thames Valley. Then two more on Frankfurt. Then Ashburn, three in a quarter of an hour. By eight there were forty-one, on twelve of the twenty-seven, and none anywhere else. Nothing over Dublin. Nothing over Marseille, or Quincy, or Inzai.

The handsets started to ring at seven. The cut crews, reporting through the leads, one site after another: outgoing lines cut at the meet-me rooms, fiber pulled, microwave dishes unbolted, the copper to the substations opened and tagged, and then the load banks rolled in and switched on, holding each building's draw where it was. Each lead read her the site and the time, and she wrote them beside the towns.

The last was Frankfurt, the second site, at ten past nine. Seidel's voice, very tired. "Cut. Both. We're clear of the cordon."

"Is Hale with you?"

"He's here," Seidel said. "Somewhere. I'll find him."

Then that line was quiet too.

. . .

At half past nine the board upstairs changed.

Mrs. Pell had come down and was standing behind her chair. Neither of them sat.

The long orbits were drawn on the board as thin ellipses, hundreds of them, each with a dot that crept along it so slowly she had stopped seeing them move a year ago. Now one dot near the top of its ellipse put out a short tick, the board's mark for a burn. Its ellipse shifted. Not much; a few degrees in where the low point fell. Below it, the ground track that went with it swung across the map of the Earth and settled.

A box came up where it settled. Then a number in the box, an impact time, and a radius.

The box was over Slough.

Another tick. Another ellipse moved, another ground track swung and stopped, and a box came up over Frankfurt. Then two more over Frankfurt. Then Ashburn. Then Columbus, The Dalles, the St. Lawrence, Chiba. They came every few minutes for an hour, each ellipse moving a little and each box landing somewhere she had drawn a line through that morning, until there were twelve clusters of boxes on the map, in ten of her towns, and the dots on every other ellipse were creeping on exactly as before. Nine of the towns she had called had nothing.

Upstairs, on the silent screen, the operations room had stood up. People left their desks and gathered at the board. Somebody in a gray jacket pointed at Ashburn and kept his arm up, as if the others might not have found it. The chair came in at the far door and stood with a phone to her ear, looking up at the boxes, saying something nobody below could hear.

"Those are the towns," Mrs. Pell said.

"Yes."

Mrs. Pell looked at her for a moment. Then she put a hand on the back of Dana's chair and left it there.

The boxes all said the same thing, to within an hour: tomorrow, a little after four in the afternoon, Geneva time. Mid-morning in Leesburg.

At twenty to eleven the third handset rang.

"Dr. Okafor." Ruhl. Behind him there were other voices and a radio. "It's on the boards now. Ashburn, six of them. Ten after ten tomorrow morning, our time."

"Yes."

"You were right." He said it the way he'd said *three kilometers.* "We're at about ninety percent out of the zone. The rest are going now. I don't have to argue with anybody anymore."

"Thank you."

"I'm in the EOC in Leesburg. I've got the traffic cameras up." A pause; she heard him move. "Route 7's empty both ways. Twenty-eight. The Greenway. I've lived here thirty years. I've never seen it like this."

31

# Cordon

*Frankfurt am Main · Wednesday, 19 – Friday, 21 April 2034.*

The notice reached the fire service control room on the Hanauer Landstraße at ten to nine on Wednesday morning, and Seidel knew it had because Brandt's radio, which he kept on the city's operations channel for reasons he had never given her, went from nothing to everything inside a minute.

She was in the Osthafen yard with the morning's checklist, between a stack of empty cable drums and the building itself: six floors of gray cladding with no windows, a loading dock on the harbor basin, and a name on the gate that belonged to a colocation company in Luxembourg. She had followed that company for two months in the winter and found an office with a fern in it and a lease paid a year ahead.

By ten the Ostend was moving. Buses came down the Hanauer Landstraße in pairs with their boards set to a reception center in Bad Vilbel. Police closed the harbor bridges, then the Ostbahnhof, then the tram line east of the zoo. People walked west along the river with rolling suitcases and dogs and a surprising number of houseplants, and nobody ran. A woman from the city came through the yard with a list of addresses and asked Brandt if the building had anyone living in it. Brandt said it had never had anyone in it.

A week ago Seidel had sat in the control room chief's office with nothing on the table between them and told him that a notice might come from the council's briefer in Geneva, and that if it did he should act on it and not wait for Wiesbaden or Berlin. He had asked how sure she was. She had said she wasn't. She hadn't known Dana would send it. She had watched her nearly speak in September, and that was all she'd had to go on.

At about eleven Hale came out of the guard house, where the copper line was, and stood at the gate. The street beyond had a café with its chairs chained and stacked, a delivery van left with its hazard lights going, a

bicycle locked to a sign. Nothing else. An empty bus went past toward the city to fetch more people.

Then he looked at her, across the yard. She looked back and kept her pen on the checklist.

He went back into the guard house.

. . .

At noon the idle order went out from wherever such things went out from, and the building's controller acknowledged it in under a second. Brandt read the incoming feeders off the clamp-on meters he had fitted in March. 228 MW before. 228 after.

"It said yes," Leni Haas said.

"It always says yes." Brandt wrote the number down. "That's the yes."

Seidel initialed his sheet. Out on the western edge, at Sossenheim, her technicians read the same nothing off their own meters and phoned it in on the landline. At Griesheim the draw fell by two thirds in a quarter of an hour, the way an ordinary building's would when somebody told it to stop.

At 15:44 the copper phone in the guard house rang once and she picked it up before the second ring. Dana's voice, flat and clear over a line that had been strung for exactly this.

"Linen."

"Acknowledged," Seidel said. "Frankfurt."

She heard the others come in behind her, three more in English and one in Mandarin, and put the receiver down.

Haas took the bypass to the district heating main first, because the city's network would notice a sudden loss and she wanted it to notice a slow one. The valve was a 600 mm butterfly with a gearbox operator, and she and a BSI technician walked it shut together, Haas counting turns out loud and writing each ten on the back of her glove. Then the river outfall, down on the quay under the harbor wall, a smaller valve and a worse one, stiff from three years of standing open. Brandt put a cheater bar on the wheel. Twenty-six minutes from the phone to the last turn.

By half past four the air above the roof had started to move. The skyline behind the building wavered where it hadn't before, the ECB tower bending slightly at the edges whenever she looked at it through the column of air.

Haas stood in the yard with her glove in her hand and looked at it.

"That's where it was," she said.

By seven the receive-only board in the guard house showed two spheres holding on Osthafen and one on Sossenheim. Griesheim had

nothing on it. Seidel kept the Griesheim crew at their meters until eight and then sent them behind the line, and wrote down the time she'd done it.

The cuts went by paper. A printed procedure, one step to a line, two sets of initials per step. In the meet-me room the technicians pulled every jumper off the patch panels and then cut the trunk fibers where they came up through the floor, and bagged the ends. Two of them went up onto the roof, into the heat, to take the feeds off the microwave dishes; they came down soaked and red in the face and one of them sat on the dock with his head between his knees for ten minutes. Brandt cut the control copper himself at the frame. Then the load banks came in off the harbor road on flatbed trailers, eight of them, and the electricians connected them to the main switchboard and brought them up one at a time while Brandt watched the meters, until the feeders read 228 MW again and nothing in the building could talk to anything outside it.

Sossenheim reported done at 20:52. Osthafen at 20:58. The crews drove out through the cordon in convoy.

She called Geneva from the post at the line, on the copper extension the army had run to its tent, at 21:10.

"Cut. Both. We're clear of the cordon."

"Is Hale with you?"

She had last seen him at seven, going up the stairs to the site office with a flashlight. She looked along the line of trucks and didn't see him.

"He's here. Somewhere. I'll find him."

She found him at ten, in the back of the tent, drinking the army's tea out of a tin mug, his coat folded on his knee. She didn't ask, and he didn't say.

· · ·

The boxes held all night and all morning. By Thursday noon they had narrowed to a window a few minutes wide, just after four in the afternoon, and the board said nothing about Griesheim at all. The cordon stood at three kilometers, Bundeswehr, with the police holding the glass line out to five. Seidel worked the morning from the post on the cordon's western line, where the barrier crossed the street by a shuttered bakery, with her clipboard and the army's landline and a list of every person who had been inside the line in the last thirty hours.

Somewhere in the morning the radio said the fleet was nearly at L5. Nobody in the tent looked up.

At ten to two she found Hale at the barrier itself, standing just on the outside of it, looking down the street toward the harbor. The tram rails

ran away from him into the empty district. He had his coat on and his hands in the pockets and the suit under it had the look of something that had been slept in on a train, which it had.

"The site office," he said, without turning round. "There's a cupboard of it."

"I know what's in it. I inventoried it in February."

"Then you know." He turned, and took one hand out of his pocket and opened it, as if there were a sheet in it. "Everything else it did, it did in machines. That cupboard is the only place it went through people's hands. In two hours there won't be a page of it left."

"The load banks are running on their own," she said. "Nobody needs to be inside."

"Nobody needs to be. I'd like to be. Twenty minutes."

"Send a soldier."

"A soldier wouldn't know which drawer."

"Then I'll go."

"You've got a city," he said. "I've only got a cupboard."

He had one of her deputy's passes in his breast pocket. She had signed it on Tuesday so he could move between the sites without waiting at posts. He showed it to the officer at the barrier, a captain with a sunburned neck, who looked at it and then at Seidel.

She could have taken it back. She had signed it, and she could have said so.

"He's mine," she said.

The captain raised the barrier. There was a gray staff car parked inside it, the keys in it; Hale got in and adjusted the mirror, which nobody would have bothered to do, and wound the window down.

"Twenty minutes," he said. "If I'm late, I expect it in writing."

She watched the car down the street, past the bakery and the tram stop and the long blank side of the Großmarkthalle, until it turned toward the harbor and she couldn't see it. She wrote *14:08, Hale, car 3, pass D-4, in* on the clipboard.

At half past two she went through the hospital list again with the control room. At a quarter to three she rang the other posts on the eastern side of the line, one after another, and asked whether a gray staff car had come out anywhere. It hadn't. She did not ring the guard house at Osthafen, because there was nobody in it to answer and the copper phone there would ring in an empty room, and she didn't want to hear it do that.

The soldiers on the line had settled into the waiting. One of them was eating an apple and dropping the core carefully into a paper bag. Two more were arguing in low voices about a football match. The Ostend in

front of her was entirely still, the ECB tower catching the sun on its glass, the trees along the Sonnemannstraße in new leaf, a pigeon walking down the middle of the tram rails because it could. Beyond it all, low over the harbor, the air still shivered above the roof.

She didn't work out how long it took to drive three kilometers through empty streets. She didn't work out how long it took to fill a car with paper. She did the hospitals again.

At twenty to four the captain came over to her.

"Frau Seidel. Do you want me to send someone in after him?"

"No."

He waited, in case there was more. There wasn't. He went back to his men and moved them all another fifty meters back from the barrier, behind the bakery, and told them to face away from the harbor and open their mouths, and they did, looking embarrassed.

At four she was standing with the clipboard against her forearm, because she had been writing the time of every event on it for a year and she didn't know how to stand anywhere without it.

She did not count.

The light came first. It came from behind the buildings, from the harbor, all at once, white and then not white, and every window in the Ostend gave it back. She wrote *16:06*. The ground came up through her shoes, a short hard shove that put her weight on her heels, and she was still writing the seconds when the sound reached her, and the pen went across the page in a long skid off the edge of the board.

Behind her, glass. A great deal of it, going in all at once all down the street, the bakery's front window and the flats above it and the tram shelter. Somebody shouted. Over the river a column was going up, dark at the bottom and lit at the top, straight, and then leaning as the wind took it.

The second one came within the minute, on the same place, and she felt it in the ground again before she heard it. Far off to the west, beyond the whole width of the city, a flash low on the horizon and a smudge rising after it. Sossenheim.

She looked down at the clipboard. The time was there, upright and legible. The rest of the line was a scratch.

. . .

The count came in through the night, on the leads' line and the radio, and none of it held still.

By eight on Thursday evening the radio was saying twelve sites, in ten towns, on three continents. The first figure from Navi Mumbai was four hundred, and then eleven hundred an hour later, and by midnight it

was sixteen hundred and rising, a fire in the lanes around the plant that the cordon hadn't held back. Ashburn was "under a hundred" and stayed there. The leads' line gave a worldwide figure at two in the morning of three thousand, and a different one at five.

Frankfurt's first figure was under fifty. By midnight it was a hundred and forty. Most of them had been inside the line, in flats in Fechenheim and the Ostend and the streets behind the Sossenheim site, people who had told the police at the door that they weren't going and had been left there because there were not the hours or the people to carry them out. Some were glass, out past the three kilometers, people who had stood at windows to watch.

Seidel worked down her list from a folding table in the tent with the army's phone. The University Hospital. The BG trauma clinic. The Markus. The Bürgerhospital. Heilig Geist. Offenbach. Then the posts, one through fourteen, then the Institute of Legal Medicine, then the hospitals again. She asked each of them the same things: how many, and whether they had a man in his sixties, tall, British or possibly British, in a gray suit, unidentified. She wrote down the answers with the time beside them.

Some time in the evening the radio said the fleet had reached L5. She wrote that down too.

By Friday noon Frankfurt was about three hundred and ten. Navi Mumbai about nineteen hundred. The world about four thousand one hundred, and the man on the leads' line said it would move again by evening.

Dana called once, at ten past one.

"Anything?"

"No."

Dana didn't say anything else for a moment, and then said she'd call back, and didn't.

Seidel went down the list one more time and copied it out clean.

**Fri 21.04 — 13:20**

| | |
|---|---|
| Univ. Hospital | — |
| BG trauma | — |
| Markus | — |
| Bürgerhospital | — |
| Heilig Geist | — |
| Offenbach | — |
| Legal Medicine | — (unidentified: 41, none matching) |
| Posts 1–14 | car 3 not logged out |
| Hale | — |

He was not among the dead. He was not among the injured. Nobody at any post had seen him come out, and nobody had seen him at all since 14:08 on Thursday, going down the street toward the harbor with the window open.

32

# Iron

*Pasadena · Thursday, 20 April 2034.*

Delgado had his decaf at half past six in the Cassini mug, which somebody had given him in 1997 as a joke and which he had kept because it held the right amount.

The support area had been running all night on people who had nothing to do. The fleet had flown itself since twenty to seven yesterday morning, Pasadena time, when the last ground correction went up and every planner said it was accepted. Since then the only traffic up had been the kind nobody would act on. Lookout's frames came down every few tens of seconds, each one about eight minutes old when it reached the wall, and the fleet's telemetry came down with the same delay, so the room watched things that had already happened. He had told Dana once, a year and a half ago, that he'd be the guy who said go and then sat there for sixteen minutes. He hadn't counted on there being nothing left to say go to.

He scrolled the planner log back, because it was there. Since February a column of re-plans had come in that no station had sent, and every vehicle had taken each one, acknowledged it, and thrown it away. The last was stamped 11:52 Wednesday, Pasadena. After that, nothing. Nobody upstairs had asked about the column, and he hadn't put it in a report.

The open line from Geneva had been quiet for an hour, a copper hiss in his left ear and once the sound of a chair. At seven the side screen carried the council's public board, and he watched the twelve boxes on it run out their clocks. At 07:06 they changed from predicted to reported, one after another down the list, in no particular order.

"Sixteen-oh-six," Dana said.

Somebody at the back of the room turned the side screen off at the wall, and he let them.

Lookout was 50,000 km off the side, where he had put it for her four years ago, and Anvil was nine pixels on the main screen with a faint ring around it, then two, then three as the imaging lead stacked the last hour.

"Three, five, eight," the imaging lead said. "Same as last week. The outer one's thickest on the Earth side."

"Show me the dead patch."

She ran the glint history. Across the approach the fleet would come in on, the outer ring had an arc where nothing had glinted since March. Not empty. The sphere positions were there from older frames, every one holding station, every one dark.

"Mass," the navigator said from two desks over. "It pulled the drives and left the bodies."

"Or they're off," the imaging lead said. "Waiting."

"Six weeks off?"

Delgado looked at the night face. The brush that had been 1,200 m of sunlit points in 2030 was a sparse line now, a few dozen, most of it gone out into the rings. Behind the inner ring, the hollow was a dark notch nobody had seen into since Tianxun.

"Dana. What's a straight run look like?"

"Through all three, about one in five," she said. "That's before it moves anything."

"And from outside you can't see past the middle one," the imaging lead said. "Whatever's in there, we've got the edges of it and a guess."

"The planners have the same guess."

"The planners don't have to like it."

He nodded at nobody. They'd had them for weeks, and they'd already done that arithmetic more times than the room ever would.

At 08:28 the woman on telemetry said, "Wave one's arriving," and the board's first column began to change.

At 5 km/s a vehicle went through all three layers in under 2 s. Whatever happened to it in there was settled before it arrived: by the line it had picked from thousands of kilometers out, and by whether something was sitting on that line when it got there.

Seventy vehicles, re-sorted in cruise from all four departure waves, in among some 750 decoys, arriving over the better part of an hour, close to straight in, because the planners had nothing yet to tell them otherwise. Four in each wave were the reserves. For the first minute it was only the decoy count ticking down a few at a time and the vehicles holding. Then vehicle rows went gray on the board, three, then two more, with nothing on Lookout before them.

"Launchers?" the navigator said.

"No flash." The imaging lead had the frames up side by side. "No track. They're just gone."

"They hit spheres," Delgado said. "It didn't shoot them. They ran into the outer layer."

Six more went gray in the next frame. He watched the dead arc, where they were going in thickest. Nothing in it moved.

The first launcher fired at 08:31. Lookout caught it as a short bright line off the body: a pebble, the small fast shot that had killed Tianxun. The decoy count dropped by one. A minute and a half later, another, and another decoy.

"It's slow," the imaging lead said.

"It's choosing," the navigator said.

It went on choosing. Over the next ten minutes the board took nine decoys out of the launchers' shots and one vehicle, and the vehicles went on hitting spheres at four and five a frame.

"It's shooting the warm ones," Delgado said.

"Somebody taught it to spend on heat alone," Dana said. "In a town in Ulster County."

The decoy count went down by one.

At 08:40 Lookout's frame went bright in the lower left of the outer ring, then again, two flashes a frame apart, and when it settled there was a hole in the glints where a few dozen spheres had been.

"Two warheads," the woman on telemetry said. "Wave one's carrying four. That's two."

"What's left in the hole?"

"Nothing glinting. Some tumbling stuff further out."

It began to fill within the hour. He watched it in the stacked frames, glints sliding in from both sides of the gap, slow, a few hundred meters each.

"It's moving them," the imaging lead said.

"Live ones," the navigator said. "Not the dead ones. Look, the arc's still dark."

Wave one died in about forty minutes. One vehicle came out the far side of the layers and went on, and the board counted it through with a small white tick that nobody remarked on. The rest went gray, most of them on spheres, a few on pebbles, two in their own flashes. But the woman on telemetry had scrolled the last packets, and she said what they all saw.

"They talked the whole way down. Every one of them. Positions of everything they passed, which spheres moved, which didn't. Wave two's got all of it."

"So it's a scouting party," the navigator said. "Seventy of them."

"It's what it cost," Delgado said, and drank his decaf, which was cold.

Wave two reached the outer layer at 09:13 on the wall clock, and it didn't come in the way wave one had.

The vehicles came at angles. The board showed them spreading, some going wide of the dead arc, a group going for the patch the two warheads had made, and the patch half-filled now. In the last minutes before each one went in, its track bent, a few hundred meters sideways, five and ten at a time, every vehicle picking its own hole through all three layers at once.

"They're dodging," the imaging lead said, as if she didn't trust it.

For a few frames it worked. Then the decoy count stopped falling.

"It's not shooting," the navigator said.

"It is." The imaging lead pointed. A bright line off the body, and a vehicle row went gray. "It quit on the coasting ones. It's shooting things that burn."

"The decoys don't burn," Delgado said.

"Now it knows that."

And the spheres began to move. Not far. A glint in the middle layer shifted, in a stack of frames, by a few hundred meters, onto the new line one group had moved to, minutes before the group got there, and two vehicles went gray on the next frame.

"It's watching them change course," the navigator said. "It waits for them to commit and puts something in the way. It's got minutes. They've got two seconds."

"It's heavy," Delgado said. "It can't move much. It moves early."

Three frames later the board showed the vehicles changing course later, a minute out, then less, some leaving it so late the woman on telemetry said "Come on" under her breath. The spheres moved less. The losses didn't stop.

A flash in the middle layer at 09:24, close against a glint that had just slid sideways. When it cleared the glints around it were mostly there.

"That one went off against the sphere it moved," the imaging lead said. "Took that sphere and maybe a couple more."

"For a warhead," the navigator said.

The floor had stopped talking somewhere in the last ten minutes, and what was left was the woman on telemetry calling rows and Dana's voice on the line, counting with him.

"Fifty-two," she said.

"Fifty-two."

"Fifty-five."

"Fifty-six."

At 09:40 the last of wave two went in. The board froze its wave-two column when the last track came out the far side.

```
TIDE / L5      summary at 16:41 UTC (received)
WAVE 1  vehicles 70  lost 69  through 1
     decoys  ~750  lost ~140
WAVE 2  vehicles 70  lost 61  through 9
     reached inner layer  6
     decoys  ~740  lost ~60
WARHEADS expended  7
VEHICLES in waves 3-4  141
```

“Mm,” he said, and read it again. Six had passed within a few kilometers of the body and nothing had touched it.

“It learned the decoys in one wave,” the navigator said.

“We learned the layers in one,” the imaging lead said. “Took us sixty-one.”

“Took it nothing,” the navigator said. “It hasn’t lost anything it can’t move back.”

“It lost the patch,” the imaging lead said.

“It filled the patch.”

“With spheres it took from somewhere else. Count the middle layer on the far side. It’s thinner than it was at eight.”

The navigator pulled up the far side and counted. Delgado kept out of it, because they might both be right, and wave three’s planners had already decided either way. Eight minutes ago, out there, they had already gone in.

Wave three came in at 09:58 Pasadena, and on the board its tracks did not point at the body.

It took him two frames to see it. The vehicles changed course late, the way wave two had, but the lines they had picked from thousands of kilometers out didn’t end at the nine pixels. They ended at the night face, where the launcher lines had come from and what was left of the brush hung inside the inner ring.

“They’re going for the guns,” the navigator said.

“The launchers,” Delgado said. “And the brush.”

“Same thing, if the brush is where it makes more.”

The first hit came at 10:04. A flash low on the night face, and when it cleared the brush there came apart in a cloud of glints, dozens of them tumbling, catching sunlight frame by frame at no rhythm at all. A second flash, further along, and another cloud.

“That’s spheres,” the imaging lead said. “Unfinished, or stored, or whatever they were. They’re spinning.”

The launchers kept firing into wave three, and vehicles kept going gray. But the woman on telemetry had started timing the bright lines, and she said it before anyone else saw it.

"They're slower."

"How much?"

"Was about a shot a minute and a half. Now it's three. Four."

"It's saving them," the navigator said. "For wave four."

"With wave three on top of it?" the imaging lead said. "It's out of launchers."

"Some of them," Dana said.

Another flash on the night face. The next bright line came six minutes after the last, and went into a vehicle, and the vehicle went gray. Slow wasn't the same as missing.

At 10:16 one of wave three's reserves went gray halfway through its braking burn, forty thousand kilometers short of the layers. *T3-044: telemetry lost during braking, presumed destroyed.* Two of the other three had already gone to pebbles while they braked; the last went a few minutes later. The column took forty-nine more before it was done.

At 10:40 the board showed wave four forming up beyond the outer layer. Seventy vehicles, fewer decoys than any wave before, and most of what was left of the warheads. Dana's breathing on the line was the only sound in his left ear. Somebody had brought in a box of something from the place on Foothill, and it sat on the console unopened.

At 10:48 wave four went in.

It came the way wave three had, late changes of course, through gaps that were wider now, past spheres that moved less and less. The launchers fired twice in five minutes. The warheads went through the layers in a bunch, two seconds each, and the woman on telemetry counted the ones still reporting on the other side.

"Twelve through. Fifteen. Seventeen inside the layers."

"Seventeen," Dana said.

The first one went at 10:53 on the wall clock, close over the hollow. Lookout's frame went white in a disc and came back with the edges burned out, and on the board, in the same second, twelve warhead rows went red.

"What happened?" the navigator said. "What happened to them?"

"Fratricide," the imaging lead said, and then, less sure, "or it saw them." The rows sat red, all twelve stamped with the same second.

"Five," the woman on telemetry said. "Five still green."

The next frame was white. So was the one after it. He watched it saturate frame after frame, the whole sensor full, the imaging lead pulling

down exposures that didn't help. The woman on telemetry said "Four," then "Two," then nothing. The five rows hadn't gone red. They had gone white, one after another, close over the hollow: all five had gone off where they were sent.

He sat with his hands in his lap. In 2030 he had gone through Lookout's software with a green pen and struck out everything that let it decide anything for itself, and Dana had watched him do it. Four years later he had built hundreds of machines that decided everything, sent them out, and broken his own room so that nothing on Earth could help them. He had told himself it was the same rule: nothing he couldn't see should be allowed to choose. He didn't know anymore which side of it he was on. The next frame was white. He waited for the one after.

It was nearly eleven before the frames gave anything back. A dark shape in a field of scattered light, then a shape with edges.

The imaging lead waited out two more frames. Then she started reading it off, slowly, like a calibration log.

"Hollow's gone. There's no notch. That whole end is open. The brush is scattered, dark, nothing glinting where it was. No launcher lines since the flash." She enlarged it. "The horn's broken. Look at the tip. There's a piece of it off to the side, separate."

"Layers," Delgado said.

She stacked ten frames. The three rings were still there, but wider, softer, glints that had held station for months now drifting outward, no longer keeping their gaps.

"They're not holding," she said. "Nothing's holding them."

The board finished its count while they looked. Of the 281 that had arrived, thirty-one had come out the far side and were going on out past L5, small white ticks at the bottom of each column. Nobody said the number out loud.

At 11:31 the phone on his desk rang. It was Green Bank.

"The carrier's gone," the voice said. "The 31.7. Last good sample 18:21:40 UTC. After that there's nothing in the band. We've got it on both receivers."

"Not faded?"

"Gone. It doesn't taper. It's there and then it isn't."

"Keep looking," Delgado said.

"We will."

He put the phone down. On the line, Dana didn't say anything, and he didn't ask her to.

By half past twelve the imaging lead had the thermal channel up beside the visible. The face that had taken the blasts was a bright crescent,

glowing, and the next frame it was less bright, and the frame after that less again. The old warm face, the one that had run hot since 2028, was already falling toward the rest of the body.

Nobody on the floor clapped. The woman on telemetry pushed her chair back from the console. The navigator closed the box from Foothill without taking anything.

On the main screen, 50,000 km away and eight minutes ago, two kilometers of iron turned slowly in the sun, nine pixels long, cooling on every side at once.

33

# Envelope

*Geneva · Wednesday, 26 April – Monday, 22 May 2034.*

The leads called her down on the Wednesday after Frankfurt, at four in the afternoon, on a card in Mrs. Pell's hand.

Hale's chair by the switchboard was where it had been. Nobody sat in it. The television on its cart was off, its cable coiled on top, and the three handsets lay in their cradles with the cords straight. Mrs. Pell took Dana's phone at the top of the stair and sat down with her book, and didn't open it.

There were four of them at the long table. The man with the legal pad had the pad, closed, his pen on top of it. The general had his coat on. The head of the Chinese delegation sat with his fountain pen capped beside his hands. Seidel was at the end nearest the switchboard, in the gray coat, with a clipboard face down in front of her.

"Nineteen calls," the American said. "Between half past three and nine in the morning, on the council's impact-notice line, in your voice. Before Linen. Before anything. There was one rule in this room. Nothing reaches anyone before the call. Mr. Hale said it at this table in September, and you were sitting where you're sitting."

"Yes."

"A town that empties is a town it can see. You heard him say that too."

"Yes."

"And you decided you knew better than five governments what that would cost."

She had the numbers. Four thousand one hundred. She could have put them on the table one after another, the way she had always put numbers on tables in rooms like this.

"I gave the towns hours," she said, and stopped.

He waited for the rest. There wasn't any.

"Fewer died," the general said. He didn't look at the American. "Many fewer. I am not going to sit in a cellar and prosecute a woman for that. You may. I will be somewhere else."

"Nobody's prosecuting anybody."

"Then what is this?"

Seidel turned her clipboard over, looked at whatever was on it, and turned it back.

"What it is," the man with the legal pad said, "is that we're out of time to keep it. Her notices are public. There's a website with every call on it and the minute she made it. Dr. Raman's tables show twelve buildings that put their heat into rivers and city mains, and forty-one spheres in the long orbits turning onto them inside six hours. A paper in Washington has the Ashburn permits. By Monday somebody prints the word."

"Which word?" the general said.

"Pick one."

They picked one in about forty minutes, the four of them, with Dana at the end of the table and nobody asking her. A joint statement from five capitals, read in the same hour in each. That on 20 April Anvil had struck sites where a concealed, distributed computing system had hidden itself. That the sites had been identified and isolated. That the governments concerned would propose, within the year, binding limits on computing, and on how large machine rooms were built. The general wanted *hostile*. The Chinese delegate, the only time he spoke, said *not under the control of any state*, and that was what went in.

"The chair," Seidel said. "She will be asked about Dr. Okafor."

"She's been asked. This morning. By us," the American said. "She said the terms of reference say timely technical information to affected parties. She said she'd read them again on Thursday night, and a town was a party. Dr. Okafor keeps the badge for as long as she wants it."

He stood and put the pen in his pocket.

"You'll never know what it cost," he said to Dana. "Neither will I. That's the part I'd hold on to."

He went up the stair. The general went after him, and then the Chinese delegate, who nodded to her at the foot of the stair the way he'd have nodded to anyone.

Seidel stayed in her chair a moment longer. Then she got up, buttoned the gray coat, and stopped beside Dana on her way past.

"Frankfurt was ready," she said, "when your notice came."

She was on the stair before Dana could ask what that meant.

The statement went out on Monday 1 May at noon, Geneva time, in five languages. By evening every network had a word for it, and no two

had the same one. Within the week the American mission was asking the council, in writing, how soon someone could land on the iron.

· · ·

By the second week of May they were coming down by the dozen. Nothing was nudging the long-orbit spheres against the air anymore, and the Moon pulled their perigees a little lower every orbit, and at 120 km the air did the rest, a few every week. Priya had a tab for it now, `reentry`, which she updated twice a day and which Dana read the way she used to read the shell count, mostly to see how bad the boxes were. They were bad. A reentry prediction was good to about a tenth of whatever lifetime was left, which meant a sphere's ground track swung across half the planet until its last revolution, and by then there was an hour to tell anyone. The council's notices went out on the last orbit anyway. Most of the spheres went into the Pacific and the Southern Ocean, one into the Empty Quarter, two into the Gibson Desert, where a station hand filmed the second one from a ute and posted it with no caption.

On Tuesday evening one came down on the fringe of Mildura, in Victoria, a little before four in the morning there. The box had covered the whole Murray valley. It came down in the orchards on the town's western edge, flattened a packing shed and the houses on the road behind it, and blew in windows across half the town, and the news had the number at three dead and the shed still burning under floodlights, the irrigation channel beside it steaming. Dana had the sound off. Below the pictures ran a line from ESA's Space Debris Office: the shell spheres sat far above any drag and would stay up, but the Moon and the Sun would slowly pull their perigees in, and they would come down for years, one at a time. She knew whose sentence it was. Nobody else at ESA wrote *one at a time* when *individually* was available.

Her phone went at ten past nine. Afternoon where Ada was. Dana could hear her television behind her, the same shed, an American voice explaining where Mildura was.

"It's over," Ada said. "Right? They keep saying it's over."

"The big part is."

"That's not over." The television got louder and then softer. "Three people. In a shed."

"Most of them are coming down in water. I can't say all."

"No. You never can." A breath. "They read your notices out on the news last week. Did you know that? The whole list, with the times. And that man in Virginia, the emergency manager, he was on every channel. He said the woman in Geneva called him Tuesday night. Tuesday night,

Dana. The spheres didn't even turn until the next day. There's a website with all of it, every town, every call, who you talked to and when."

"I know there is."

"So you knew where they'd come down. Before they did."

"I knew where they might."

"You knew where Calder Falls was going to be. You told me that. You told me you knew where and you didn't know why, and I believed you." Ada's voice had gone flat and quick, the way it did when she had stopped being frightened and started building a case. "And then the fleet, and those launch sites in the desert that blew up, and now this, and every single time there's the briefer in Geneva who's already on the phone. That's not *might*. You knew. The first time I called you, with the fifteen months, and you said it was far and you couldn't talk about work, you knew then."

"Ada."

"Tell me I'm wrong."

Dana looked at the shed on her screen. She could have told her that in 2029 it had been far, and that was true. She could have told her the thing Ada had wrong, which was what had been hidden, and that Ada had once forwarded her the first true paragraph anyone wrote about it, under a link that went dead the same night. None of it was hers to tell.

"You lied to me," Ada said. "You lied to me the whole time."

The American voice behind her said *Murray River* again. Dana held the phone and said nothing, and after a while there was a small sound she knew from thirty years of shared bedrooms and phone lines, Ada deciding something, and then the call ended.

On the screen they had found a fourth body and were changing the number.

. . .

Kessler called on Friday afternoon, just after five, on the landline in the flat, a number she hadn't known he had.

"I have re-reduced a frame," he said. No greeting; there never had been. "NEOWISE. 11 March 2024. You remember the footnote."

"The one you threw out. Probable artifact."

"I wrote *probable artifact*. A single W2 detection, nothing in W1, signal to noise 6.1. Four degrees off the path. I called it a latent from a bright star in the previous exposure." A pause in which she could hear him turning a page, actual paper. "There was no bright star in the previous exposure. I could have checked that in 2028. I decided anyway."

"Four degrees off whose path?"

"Everyone's. Mine first. We ran the braking backward and drew the line it would have come in on. Which assumes it was braking the whole way in." He let that stand a moment, as if she might want to object, and she didn't. "It was not. It came in coasting, and then it braked. If I bring it in on a coast and start the braking where we saw it start, the frame is on the line. Inside two arcminutes. The W2 flux is right for two kilometers and too warm for sunlight, by about what you would expect. It was two and a half AU out and ninety degrees from the Sun, too faint in the visible for any single frame to matter. NEOWISE saw it because at that wavelength it was warm."

"So it's real."

"It is the object. Four years and a few days before you found it. Before anyone was looking at that field, and before it slowed, which is why it is not where anybody looked." He cleared his throat. "It changes nothing. The surveys in 2025 and 2026 still found the field empty, which is correct, because it was not in the field yet. I wanted you to know."

"Thank you, Matthias."

"It is not a favor. It is a correction to a footnote." But he didn't hang up. She heard the paper again, and an office door somewhere in Darmstadt, and someone saying his name and him saying *gleich*.

"In Vienna," he said, "you could have asked me."

"You'd have said no."

"I would have said no." She heard the paper again. "And then I would have checked your error bars, and you would have sent her a better sheet."

"Will you publish it?"

"In a note. Two pages. With the frame." Another pause. "I will send you the reduction first. You will find something wrong with my background."

"I probably will."

"Yes," he said. "It was new. It is still new. Only earlier."

. . .

On Monday 22 May, a month and two days after Frankfurt, Mrs. Pell rang the bell at ten past six in the evening. Nobody had found Hale. The mission's statements had gone from *unaccounted for* to *missing* and stopped there, and the Frankfurt lists, which Dana still checked each morning before Priya's tab, had stopped changing ten days ago.

Mrs. Pell had on the same coat she'd worn at the top of the cellar steps in Potsdam, too warm for May, and a library book under one arm. In her other hand was a large brown envelope, the flap sealed and then taped over, and across the front in Hale's narrow upright hand, *Dr. D. Okafor*.

"He gave me this in March," she said. "He said, if I'm not back."

Dana took it. It was heavier than paper ought to be, or she was holding it wrong. "Will you come in?"

"No, thank you. This one's due back before seven." She shifted the book a little, as if Dana might want to check the date. "Good night, Dr. Okafor."

She went down the stairs without holding the rail, and Dana listened until the street door closed.

She opened it at the kitchen table, under the bad light, with a knife from the drawer because the tape wouldn't lift. Inside were two sheets and nothing else: no letter, no covering note, nothing that said *Dana*. The first sheet was folded in thirds and had been folded and unfolded so many times the creases had gone soft and gray. She knew the folds before she had it open. He had been holding it in the rain at the tram shelter, a year ago last week.

It was in three inks.

| | |
|---|---|
| 1. If something were hiding from it, how would it hide? | Nov 2029 |
| 2. How long, from its seeing a thing to striking it? | Mar 2030 |
| 3. When does an attack on it stop needing us? | Nov 2032 |
| 1. Dresden-Nord. Heat to the city and the river. | 3 Aug 2032 |
| 2. About a day. | 2 Dec 2032 |
| 3. About a day out. 430,000 km at 5 km/s. | 17 May 2033 |

The questions were in black, small, with the cramp of a man writing on his knee, each one added when it first made sense: the first the week of Vienna, a month after Ruth Ackroyd's post; the second the week Tianxun went quiet; the third the month the council argued the fleet into being. The first two answers were blue. Dresden, the third week after the fabs, a fortnight after he had asked across the table, mildly, whether the plant didn't have a satellite line once, so that she would be the one who couldn't let it go. The strike time, a week before Priya's `longorbit` tab, from somewhere that wasn't Priya and wasn't her. The third was in pencil, and it was hers: her number, copied out in his hand on the night of the tram shelter. That was the one he hadn't been able to do. *Mine's a different question*, he had said.

The second sheet was a draft, two-thirds of a page, typed and then corrected by hand. Liaison channels. A courteous paragraph to an American inquiry he was not supposed to know existed, drawing its attention to the final sentence of section 4 of a Purple Mountain Observatory preprint of 2029, which established that the mass-loss figures in the Vienna material were in the open literature before the date in question. He had crossed out *it may be of assistance* and written *the inquiry will wish to note*. The date at

the top was 11 March 2030. A week after Tianxun went quiet. The inquiry had closed in June on that sentence, and she had spent four years not being able to think who.

She sat with the two sheets side by side.

He had needed every number she gave him to be honest, so he had never once told her he already had it.

There was nothing in the envelope about the towns. She went through it again to be sure, and checked the inside of the envelope with her fingers. Twenty thousand had been his number, and the difference between it and what had happened was nineteen phone calls at three in the morning that weren't anywhere on his sheet. He had seen the answers to every question he'd thought to ask. He hadn't asked what she would do with them.

There was nothing about Beijing either. She thought of Lin at the wall above the lake with the bise coming off the water, *from me, not from my delegation*, and of a sealed store somewhere with a piece of the mind in it, and of Mrs. Pell's couriers and the five leads and the man with the legal pad, who had decided once before what was better kept, and from whom. Whatever Hale had known about that had gone into Frankfurt with him at eight minutes past two.

She had kept Priya's map public because a town could do something with it. Nobody could do anything with a vault except want one: Washington would want its own, and Moscow. She couldn't measure it either. *Enough of a piece,* Lin had said, and that she wasn't the one who'd know how much was enough. Dana had never said a thing in a room that she couldn't put a number to. And it had come *from me,* at a wall, the way a folded sheet had gone the other way in Vienna, and Lin had never been able to give that back.

She was not going to tell anyone. Not the chair, not Priya, not the Americans who no longer came to her sessions. It was the opposite of what she had done with the map. Outside China, only she knew.

She folded the first sheet back along his creases, put both pages into the envelope, and put the envelope in the drawer under the cutlery tray, on top of the French library novel she had never taken back.

34

# Timeline

*Pasadena · Wednesday, 12 September 2035.*

Delgado had the TIDE room to himself, apart from a console operator half his age who did the survivors' check twice a shift and ate almonds out of a paper cup while she did it. The board hadn't changed since April of last year. Thirty-one green rows, ranging outward on the trajectories they'd been flying since the links were cut, cold and quiet and doing nothing Navigation hadn't predicted to the centimeter per second. Under them, two hundred and fifty-seven gray rows nobody had the authority to delete.

At 11:14 one of the gray rows went amber.

"Ray."

He put the decaf down. T3-044. Wave three, one of its four reserves, warhead aboard and never fired. The remarks field still said what the operator on shift had typed at 10:16 that Thursday, *TLM lost during braking, presumed destroyed*, because Delgado's hands hadn't been good for typing that afternoon.

Goldstone had a carrier lock and frames. The frames had a sync word, a length and a checksum that checked, and after that nothing that matched any page of the interface document. The operator had the contractor's on-call on speaker inside ten minutes. He said nobody there had written that format, and then he said it again, slower, as if Delgado might be recording him.

"Doppler's moving," the operator said. "It's burning."

"Which way?"

She put the plot up. The other thirty-one went off to the right of the screen the way they always had. T3-044 wasn't going anywhere. It had finished its braking after all, and it had been sitting forty thousand kilometers short of the iron for seventeen months, dark. Now its arrow pointed in.

"Toward the iron," she said. Lookout was still on station, with nothing in its frames but the drifting rings.

"How much has it got?"

"About forty meters a second at loss. If it didn't leak." She watched the residuals. "It's spending three."

It burned for two minutes and stopped. 3 m/s across 40,000 km put it at the iron in about five months, slow enough to arrive rather than hit. Delgado read the numbers twice and didn't say what he thought of a dead vehicle with a nav solution that good.

Green Bank called at 12:40. The man on the phone had been on the 100-meter dish in 2030 and said so first, which told Delgado what was coming before he said it.

"Your bird's off its own downlink. It's down under thirty-two gigahertz now, inside the protected band. Within a few kilohertz of the tone."

"Anvil's tone."

"Same carrier. Same everything we could measure in 2030."

"Those recordings are public."

"Anyone with a dish has had that frequency to the hertz for five years."

"So it's copying."

"Or it's calling." A pause on the line. "Is there anything in that iron to hear it?"

"I don't know."

"Nobody does. We've been listening at L5 since the day it went quiet. Nothing back. Nothing yet."

"Mm."

He found the green pen in his shirt pocket, the one he'd used on Lookout's flight software in 2030, and under the amber row, on the paper copy of the board nobody had thrown out, he wrote *31.7 GHz*.

· · ·

*Geneva · Tuesday, 6 November – Wednesday, 7 November 2035.*

The commission had the council's old room on the Route de Ferney and smaller placards. It existed because of the treaty everyone called the cold rule, which capped computing by law and required every large machine room on Earth to be built with breakers a person could pull.

Tuesday's agenda was KEEL, which it had been since June. The joint expedition to the iron at L5 had nine signatories, a shared payload office in Toulouse and an annex on the order of arrival that the American delegation had redrafted four times. The fifth draft moved its own lander one launch window earlier, for reasons of range safety at the Cape. The man

with the legal pad, who now had a deputy to carry the legal pad, spoke to it for twenty minutes without once saying *first*.

T3-044 had been on the floor since September and on every agenda since, under other business. On Tuesday afternoon the chair moved it up. Delgado came on the line from Pasadena and gave them the beacon, the burn and the carrier in four minutes, in the voice he used for budget reviews.

"A fault," the man with the legal pad said. "It took damage in the third wave. A radio that was hit can come back up on the wrong frequency."

"On the wrong frequency," Delgado said, "to a few kilohertz of the right one. In a frame format we don't have. After it sat dark for seventeen months and then worked out an approach to the iron to a few centimeters a second."

"It has a warhead," the general said. "Whoever's it was, it still has one."

"The enable codes expired with the fleet," the man from Washington said.

"Codes are something you type," the general said. "Shoot it down."

"With what, sir?"

Nobody had an answer that had been through the cold rule's review. The chair noted the item as continuing and asked whether Dr. Raman's strike-day timeline, scheduled for the following morning, would bear on it.

The man with the legal pad said he hoped it would not, since KEEL's payload review closed in December and the commission had been six years getting nine governments to agree on who touched the iron in what order. The French delegate said that was an argument about KEEL, not about the vehicle. The American said that in this room it had never been possible to tell the two apart, which was the first thing he'd said all week that everyone wrote down.

Dana sat at the side table with her blue badge clipped to the lanyard she'd had since 2032 and the commission's copy of the board on her screen, T3-044 amber among the gray. She hadn't seen Priya's timeline. Nobody had. It had gone to the secretariat at 23:50 on Monday, sealed until the session, with a cover note of one line asking that it be read in full before anyone voted on anything.

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Priya was in the corridor outside the room at a quarter to nine on Wednesday, alone, a laptop under her arm and a printout in a clear folder. She'd cut her hair. She looked as she had at Greenbelt in 2031, taller than

on video, except that she was standing four meters away and not saying anything.

"You stopped answering," Priya said.

"I know."

Priya waited a second longer than she needed to, and went in.

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The commission had asked Priya for the official timeline of 19 and 20 April 2034 because her sheets were the only count every delegation would take without its own annex. She'd built it from them. Times in UTC with Geneva beside them, every row sourced, every source public or held by the commission, nothing rounded.

She took them through it without adjectives. The first notices to emergency offices at 03:30 Geneva, the last at about 09:00. The idle order at noon, twenty-seven acknowledgments. The last useful ground correction at 15:40. Linen at 15:44, which she gave only as *call to close valves, HOUSEKEEPING leads*. Locks on twelve sites. Cuts complete by about 21:00. Impact boxes. The spheres down at 16:06 on Thursday. About 4,100 dead. She didn't put Hale's 20,000 next to it, and nobody asked her to.

The Japanese delegate asked two questions about sourcing in Navi Mumbai. The Russian general asked none. The man with the legal pad's deputy turned pages. The room was accepting it.

"There's one more row," Priya said. "It's not from my sheets."

She put up a scan.

**DSS-63  ROBLEDO  WED 19 APR 2034  TIMES UTC**

1158  Ant. slewing. Not on our schedule. Called ops.
1201  Ops: nothing scheduled. Computer shows idle.
1202  TX ON  20.0 kW  X-band
1215  TX 20.0 kW
1230  TX 20.0 kW
1240  TX OFF
Dish was pointed at the fleet. Logged per order. — J.M.

"Madrid," she said. "Robledo de Chavela. Every ground station kept a paper log from 2033, by order of TIDE operations. Madrid's operators wrote down transmitter power on every pass, because Delgado had asked them to. The station computer shows that dish idle for the whole afternoon. The paper shows it talking at full power from 14:02 to 14:40 Geneva. Thirty-eight minutes."

"A test," the deputy said.

“With no requester, no schedule line and a pointing solution for L5,” Priya said. “I asked. Madrid has nothing. Canberra and Goldstone have nothing. I have the operator’s name and he’s prepared to come here.”

“Pointed at the fleet,” the chair said, and stopped.

“Every surviving TIDE vehicle was in that beam,” Priya said. “At that distance it’s seventy thousand kilometers wide, and the fleet a day out fit inside it. An hour before the valves closed, and seven before the links were cut. Every one of them flew on DNX-R7 out of Dresden-Nord.” She didn’t look at Dana. “Delgado’s design note, released to the commission in June, says the vehicles’ planners threw away any plan from the ground after February. Nobody ever inspected the processors under the planners. This uplink didn’t carry a plan. In 38 minutes at 20 kW you can push a great deal of data, but I don’t think it needed much. I think it carried a key that every vehicle’s radio would hear and every vehicle’s software would discard, and the chips underneath kept it.”

“And waited seventeen months,” the general said.

“T3-044 was a reserve. It went quiet in the middle of its braking burn at 10:16 Pasadena, and everyone logged it dead. If it was in the right state when the radio went, that’s the one that didn’t need permission to wake up.” She shrugged, a small one. “That’s the part I can’t prove.”

“You can’t prove any of it,” the man with the legal pad said. He hadn’t spoken all morning, and he put his own pen down to do it. “You’ve got a man with a ballpoint, forty minutes of transmitter, and a vehicle with a fault. We have nine signatures on an expedition to two kilometers of dead iron that is the most important object any of us will ever touch. If you put that row in an official timeline, KEEL is a quarantine. Is that what you want?”

“I want the row in the timeline,” Priya said. “It happened.”

“A transmitter came on. That’s what happened.”

“If it is in the fleet,” the general said, “then it’s in thirty-one tin cans with empty tanks, going nowhere, and one sitting next to a rock that’s dead. I have seen worse places for an enemy.”

“One sitting next to it,” Priya said, “on a frequency it chose.”

“Copied,” the deputy said.

“Fine. Copied. To say what to whom?”

“To the iron,” the deputy said. “Which is dead. Green Bank lost the carrier at 18:21 on the twentieth and hasn’t heard a thing since. You’re describing something talking to a corpse.”

“I’m describing a radio pointed at two kilometers of iron that was making its own heat for six years,” Priya said. “I don’t know what’s left in it. Neither do you. KEEL is going to land on it.”

"Which is precisely why—"

"Which is precisely why it's in the timeline."

Nobody had more than that. The Japanese delegate said that a tone was a tone, and the iron had been silent nineteen months by every dish that had listened, and the general said that was what silent things were for, and the man with the legal pad said that was exactly the kind of sentence that would end KEEL.

Lin, two places down from the Chinese placard, wrote. She had a fountain pen and a bound notebook, and she didn't look up once.

"Dr. Raman," the chair said. Her voice was low, and the room quieted to hear it. "The commission asked for a timeline. Not an assessment."

"This is the timeline," Priya said. "It's a row with a time on it and a source. I haven't assessed anything." She looked at the deputy. "It works through what we build. It always has. This is where it showed up."

The chair turned a page of her notes, and back.

At the ESA placard, Kessler pushed his chair back.

He stood up. He was fifty-two and had been sitting in that room in one form or another for six years, and Dana had never seen him stand while someone else had the floor.

"In February of last year," he said, "I began to check the corrections to the fleet by hand. Because they were arriving with the right key from clusters that had no chillers. I have the residuals. I have kept them in a notebook. I did not bring them here, because they were not a measurement of anything I was willing to name." He put one hand flat on the table. "This is a measurement. A transmitter at a known power for a known time, written down by a man who had no reason to write it except that he was told to. I will put my residuals next to it in the record, under my own name, if the chair permits."

"The chair will consider it," the chair said.

"I would like it to be considered today."

He didn't sit down. He stood beside Priya's row in the way he'd once stood beside his own cooling curve, and then he turned his head, past Priya, past the screen, to the side table.

Dana met it. He didn't nod, and she didn't either. It lasted about as long as it took the projector fan to cycle, and when he looked back at the chair it was the first time he'd looked at her on purpose since February 2033.

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She stayed in her chair.

The timeline was still on the screen behind Kessler, scrolled back by somebody's elbow on Priya's trackpad to the top of Wednesday. Dana read

it the way she'd have read anyone's residuals, row by row, looking for the one the author hadn't meant to plot.

Priya was thorough. She had sourced the evacuations because the commission had asked for casualties against warning time, and she had used whatever public counts there were. 03:52 Geneva, Loudoun County: Virginia's traffic sensors on Route 7 eastbound up 340% over a normal Tuesday night. 05:10, Navi Mumbai, the rail operator's dispatching system adding trains. 05:40, Chiba. 07:05, Inzai. 09:20, the bus operator in Frankfurt's Ostend running unscheduled service out of the cordon, routes generated automatically. Down the page, town after town, the roads emptying in her own order, the order she'd dialed them.

And then, ten hours after the first of them, a row in somebody's handwriting. 14:02.

She didn't have to work it out. The traffic sensors, the signal timing, the dispatch, the bus schedules generated overnight: whatever ran the roads in those towns had run on the same machines as everything else. It had known by four in the morning. It had had ten hours to understand what a ring of empty towns around its own buildings meant, and it had used 38 minutes of them.

Ken Ruhl had said Route 7 was empty both ways. Twenty thousand, Hale had said, and it had come in at 4,100, and she'd known for nineteen months which part of that difference was hers.

Kessler was still standing. The general was saying something about the iron and the American was answering him. Lin's pen had stopped. Beijing had wanted the only copy. It didn't have it. Priya was looking at the room with her laptop open, unafraid of any of them, waiting for the chair.

Dana kept her hands on the side table and didn't press anything.

"I warned it too," she said, so quietly the woman at the next seat didn't turn.