

# Hard Rain

LIKE ANY GOOD STORM, THE HARD RAIN BEGAN WITH A SUDDEN thunderclap: a kilometer-wide rock that lit up eastern Europe with eerie, silent flashes as it skidded in across the upper atmosphere before digging into thick air somewhere around Odessa. Its trail set fire to dry leaves and combustible litter in the Crimea, then painted a long brushstroke of burning buildings and forests across the northeast rim of the Black Sea, ending with a long elliptical crater in the steppe between Krasnodar and Stavropol. The former city was first set on fire by radiant heat from the sky and then flattened by a blast wave. The latter got only the blast, followed by a rain of ejecta. Both disappeared from human ken.

After a few hours' respite, smaller bolides began to come down. They landed all over the world, but most often in the lower latitudes, close to the equator. Having been told, long in advance, that this would be the case, many people had moved toward the poles in recent months, prompting Rufus MacQuarie and his friends, family, and associates to establish a defensive perimeter around their works in the Brooks Range. That was a terrible place in November. The only refugees likely to make it up that far would be well equipped and well prepared, but those were exactly the kinds of uninvited visitors that Rufus didn't want creeping around. Unencumbered by the limits on bandwidth that applied to all the other radios in the Cloud Ark, Rufus and Dinah had kept up their Morse code correspondence during the three-day "grace period" between the White Sky and the Hard Rain. Rufus was still transmitting from his truck, which he had parked before the entrance to the mine. He had considered erecting a larger antenna on the top of the mountain and hooking it up to an underground transmitter via armored cables, but Dinah, after surveying the predicted effects of the Hard Rain, had told him not to waste his time.

Ivy had said goodbye to the Maternal Organism several days earlier, immediately before the Morg had swallowed her government-issue euthanasia pill. The one person on Earth she was still in touch with was Cal, aboard his submarine, keeping station on the surface offshore of the Norfolk Naval Base, out where the water got blue enough to facilitate a deep dive when the time came. In those days Ivy's main link to her family came through music. For the Morg had given five-year-old Ivy a choice between becoming the best pianist in Southern California or the best violinist in Southern California, and Ivy had opted for the violin. She had never become the best in Southern California, or even close to it, but she had played in various youth orchestras and developed some familiarity with the classical orchestral repertoire. She had a violin aboard Izzy, which she would tune up and play from time to time.

When the Bolide Fragmentation Rate shot up through a certain level on Day 701, marking the formal beginning of the White Sky, a number of cultural organizations launched programs that they had been planning since around the time of the Crater Lake announcement. Many of these were broadcast on shortwave radio, and so Ivy had her pick of programs from Notre Dame, Westminster

Abbey, St. Patrick's Cathedral, the Imperial Palace in Tokyo, Tiananmen Square, the Potala Palace, the Great Pyramids, the Wailing Wall. After sampling all of them she locked her radio dial on Notre Dame, where they were holding the Vigil for the End of the World and would continue doing so until the cathedral fell down in ruins upon the performers' heads and extinguished all life in the remains of the building. She couldn't watch it, since video bandwidth was scarce, but she could imagine it well: the Orchestre Philharmonique de Radio France, its ranks swollen by the most prestigious musicians of the Francophone world, all dressed in white tie and tails, ball gowns and tiaras, performing in shifts around the clock, playing a few secular classics but emphasizing the sacred repertoire: masses and requiems. The music was marred by the occasional thud, which she took to be the sonic booms of incoming bolides. In most cases the musicians played right through. Sometimes a singer would skip a beat. An especially big boom produced screams and howls of dismay from the audience, blended with the clank and clatter of shattered stained glass raining to the cathedral's stone floor. But for the most part the music played sweetly, until it didn't. Then there was nothing.

*Paris is gone*, she texted. Through the military systems, which were patched in with NASA's, she could still communicate with Cal.

*Dive bbs*, he answered. Which by itself was pretty enigmatic, but she knew its meaning: the submarine had to dive below the surface for a little while, to avoid some danger, but he expected he'd be back soon.

But he might be wrong about that. She might never hear from him again. She decided it was long past time. She texted him a message that he would find waiting when and if his boat returned to the surface: *I release you from your vow*.

Then she felt a strange wave pass through her body, almost as if she were in a submarine in the Atlantic when a pressure wave rolled through from some distant meteor strike. She assumed it was an emotional reaction to what she had just done. But then she noticed that every loose floating object in her workspace was drifting in the same direction, toward the wall against which she had braced her back. Pops and creaks and groans propagated through Izzy. The space station was accelerating gently, at just a fraction of a gee. The thrusters must be firing.

The lights had turned red. The PA speaker in her module emitted a slight pop as it came on. "Alert," said a synthesized voice. "All personnel should now be awake and at stations for urgent swarm maneuver. This is not a drill."

So it had happened. They had been practicing this for months. But this was the first real Streaker Alert. It meant that a bolide had been detected by SI—the Sensor Integration team—on an unusual trajectory that might pose a danger to Izzy unless the course was corrected slightly.

Her first, nervous impulse was to look out the window toward Amalthea. The big rock was still there. The maneuver hadn't caused it to snap off.

But this was Ship thinking: placing top priority on Izzy. She, and everyone else, needed to get in the mental groove of Cloud thinking. The majority of the population lived on arklets. Izzy's purpose was to help the arklets survive.

So she wrenched her gaze away from the window—an antiquated thing, that—and brought up a display on her tablet showing the disposition of every vessel in the Cloud Ark. It was an app called Parambulator. It was not a literal rendering of what the cloud looked like, though you could make it show you that if you clicked the right menus. Parambulator was a tour de force of data visualization that would only make sense to people like Ivy, Doob, and most of the Arkies, who had spent a lot of time learning about orbital mechanics. Starting with empirical observations from Lina Ferreira and other mathematically sophisticated biologists, mathematicians like Zhong Hu had extrapolated swarm

algorithms from three to six dimensions and physicists like Ivy had figured out how to make these algorithms work under the special constraints of orbital mechanics. In general, every vessel in the cloud was shown as a dot on a three-dimensional scatter plot showing information about its orbit. Six numbers—the orbital parameters, or, as everyone up here had begun to call them, the params—were required to convey everything about an orbit. Only three could be visualized in any given plot. So that was where the user-interface legerdemain came into play, and where someone like Ivy had to pay attention and engage all available brain cells. But the gist of it was that each arklet was a projectile that could strike Izzy, or another arklet, if its params were wrong. In a hypothetical, extremely simple Cloud Ark consisting of only two arklets, only one calculation needed to be performed: namely, the calculation that answered the question “Will Arklet 1 bang into Arklet 2 if both stay on their current courses?” In a three-arklet cloud, it was also necessary to figure out whether Arklet 1 would collide with Arklet 3, and whether 2 and 3 were going to collide. So, that was a total of three calculations. If the cloud expanded to four arklets, six calculations were needed, and so on. In mathematical terms these were known as triangular numbers, a kind of binomial coefficient, but the bottom line was that the number of calculations went up rapidly with the number of arklets in the cloud. For a hundred-arklet cloud it was 4,950 calculations, for a thousand-arklet cloud, about half a million. It would have flummoxed the simple computers of Apollo days but was nothing by modern standards—provided that accurate information could be had about each arklet’s orbit. An old-school, centralized approach would have been for all the arklets to report their params to a computer on Izzy, which would then do all the calculations and report the results. The reliability of that process could be improved if Izzy’s radars, observing the arklets and plotting their movements, filled in gaps in the data. And indeed something like that was happening all the time, not just on one computer on Izzy but on several. But this, again, was Ship thinking. Cloud thinking dictated that each arklet make those observations and do those calculations separately. The computer on a single arklet—call it Arklet X— might not have all the information needed to track every single one of the other arklets in the cloud, but it could identify the ones most likely to be a danger and focus on those. Others, as well as the central processors on Izzy, could assist it by sending messages to the effect of “You might not be aware of it, but you are possibly in danger from Arklet Y and might want to move it to the top of your list of things to keep an eye on.” To which it might reply “Thank you, but I’m not getting good params for Arklet Y because Izzy is blocking my view on the radar.” The cloud would then respond by in some sense becoming aware that Arklets X and Y needed to know more about each other’s params and giving a higher priority to making that happen.

The cloud, in other words, became not just a physical cloud of flying objects in space but a computational cloud as well, a free-floating, self-regulating Internet. The function of Parambulator was to give its users an Olympian perspective on all that was happening in that network, and at some level all you really needed to know about it was that scary things were shown in red. Ivy looked at it now, more in curiosity than in alarm, since they had been practicing maneuvers for weeks and she thought she knew what to expect. Whenever Izzy fired her thrusters and changed her params, red propagated through the scatter plots like a drop of blood in a glass of water. All the free arklets, and all the ones connected to bolos or to heptads or triads, now needed to evaluate their params and see whether they were in danger of colliding with Izzy. Or—almost as bad—of drifting away so far that they could never get back to the swarm, a condition shown by a yellow dot in the display. It was a simple matter for any given arklet to plot a new course that would avoid both of those fates. Much more complicated was for three hundred arklets to do it at the same time without banging into each other. So a kind of negotiation had to take place, based not on awaiting commands from Izzy but on

observing what “nearby” arklets were doing and coordinating the firing of thrusters with them to minimize the amount of red showing up on the plot.

It was necessary to place the word “nearby” in scare quotes because it had a different meaning in this swarm than it did to a bird in a flock. To a bird, nearby meant just that. To things maneuvering in the six-dimensional parameter space of orbital mechanics, “nearby” meant “any set of params that is potentially interesting to me in the next few minutes,” and it could apply to objects that were currently too far away to be noticed. Once that was accounted for, however, the arklets could do as birds did when flying in flocks. In the simulations that they had seen shortly after the concept had been proposed, it had looked astonishingly like the behavior of schooling fish. And the reality of it, which had only been implemented in the last few months of round-the-clock launches from Kourou, Baikonur, Canaveral, et al., answered well to those simulations. It just happened more slowly in real time.

It was happening now, in response to Izzy’s course change. The red only spread so far, then began to recede, first fraying around the edges, then dying off in patches. A few dots went yellow, then corrected themselves as they caught up. Ivy’s expectation, based on the last few months’ tests and exercises, was that the last few red dots would turn white very soon and cease to be a concern. But this didn’t happen. Some remained stubbornly red. Spinning the plot around, looking at it in various modes, she zeroed in on those dots and queried them. Almost all of them were cargo modules or passenger capsules that had been launched during the Splurge: the last-minute effort made by all the spacefaring nations of the world to launch every last rocket they had capable of reaching orbit.

Her phone buzzed. A message had come back from Cal; his boat must have resurfaced.

*What’s that supposed to mean?*

He had only just now seen her last text.

*It means we are no longer engaged.*

That seemed a little blunt, so she added, *You need to find some nice mermaid.*

After a minute he answered *{crying} I was going to do the same. Your odds considerably better.*

She answered *Bullcrap*, which was an old joke between them. When she had first met him at Annapolis, he had been such a straight arrow that he was unable to speak the word “bullshit.”

*SAB = Straight Arrow Babe* came back.

*SAB is sad :( Why did you dive?*

*Big surface wave came through. Bad news for East Coast.*

*Who tells you? Do you have a chain?* Meaning chain of command.

*One rung left above me.* Then, after a pause, *POTUS has gone dark.*

She typed in *Thank God for that* and hesitated before sending it. But the world was coming to an end; she didn’t have to worry about repercussions. She hit Send.

She’d never talked to Cal about what had happened on Day 700: the fuel-air devices, the nuclear warhead. But she was certain it had been his finger on the button.

*May God have mercy on her soul*, Cal answered, and she knew the subtext: *and may He have mercy on mine.*

This exchange of messages was interrupted by one from Markus: *need u.*

She pocketed the phone to free her hands for movement through Izzy, maneuvered through the maze of habitation modules to the Stack, and headed aft, bound for the Tank. The trip down the Stack took no time at all. A week ago she would have had to maneuver around people clumped in twos and threes for conversation. Since Markus had declared PSAPS, this had changed; one of his edicts had been that the Stack must be kept clear for rapid movement of essential personnel. Right now it was as

empty as she'd ever seen it. Down in the Zvezdamodule she saw some comings and goings, and recognized, for a moment, the spiky profile of Moira's hair. She would be busy making preparations to disperse the Human Genetic Archive to the cloud, a project that in and of itself was at least as complicated as anything happening with swarms and params. Essential personnel indeed.

Luisa popped into view down in H1 and propelled herself up the Stack like she meant business. After nearly colliding with one of Moira's helpers, she let her momentum carry her up into Zarya, then stopped hard at the entrance to the tube that led to the Woo-Woo Pod. She looked into it for a few moments, evaluating, then made a decision and pulled herself into it.

Ivy passed by the same location a few moments later, slowed for a moment, and glanced down the length of the tube. It was possible to see straight down its length, across the spherical Pod, and through its windows to the Earth. Normally this meant the blue light of the oceans and the white light of clouds and ice caps. Sometimes, a lot of green when they were passing over well-watered parts of the world, or some yellow when over the Sahara.

Right now the light was orange because the Earth was on fire.

People were screaming down there in the Pod. Luisa must have been sent there to calm people down. Ivy was almost drawn in by a sort of magnetic power of fascination. Earth looked as if some god had attacked it with a welder's torch, slashing away at it and leaving thin trails of incandescence. Some of these were red and steady: things burning on the ground. Others were blinding bluish-white and evanescent: trails drawn through the atmosphere by meteorites.

She fancied she could almost feel the warmth radiating from the planet.

Markus needed her. She couldn't help the screaming people down in the Pod. She turned her head aft and pushed on.

Hovering in the entrance to the genetic storage modules, Moira was ticking off items on her tablet, listening, dead faced, to something on a large pair of headphones. She noticed Ivy. She peeled a headphone away from one ear and aimed it at her. Ivy recognized a cappella music, medieval polyphony. "King's College is holding up rather well," she said. "Do you know the piece?"

"I'm certain I've heard it before, but I can't place it," Ivy said.

"Allegri's 'Miserere mei, Deus,'" Moira said. Thanks to the Morg's insistence that she take Latin, Ivy knew what it meant: Have mercy on me, O God.

"It's beautiful."

"They would sing it at Tenebrae, in the wee hours, as they extinguished the candles one by one."

"Thank you, Moira."

"Thank you, Ivy."

A minute later she was in T3. As always, she stood flat-footed for a moment to get the feel of simulated gravity, then headed toward the Farm and the Tank. Passing through the utility section she considered getting herself a cup of coffee. Then she felt shock and shame over the fact that she was thinking about coffee while her planet was being set on fire.

Then she poured herself a cup of coffee anyway and stepped into the Farm. This was crowded. Most of the Situational Awareness Monitors were showing status displays relating to the functions of the Cloud Ark. The big one at the head of the room was just showing a view of Earth through a camera aimed in that direction. But the video image had nothing like the impact of seeing it directly through the windows of the Woo-Woo Pod. The arc-light intensity of the streaking bolides was reduced to a blurry flare of maxed-out pixels. Out of habit she wondered why they didn't change the channel to CNN, or Al Jazeera, or one of the other full-time news networks. Then she remembered what was happening.

She proceeded to the door that led into the Tank.

Flanking it was a pair of people who were doing nothing—just standing there. Odd.

She noticed that both of them had unfamiliar devices slung from their belts.

She realized that they were Tasers.

Before she could fully adjust to that, one of them—she recognized him now as Tom Van Meter, an engineer and sort of a jock—nodded politely and opened the door for her.

The Tank was a quarter the size of the Farm, just a medium-sized conference room with, at the moment, six people seated around the table working on tablets or laptops. At its far end was the door leading to Markus's office. This was ajar. Ivy went through it, and for the first time since coming to Izzy three years earlier, she felt ill at ease doing so, as if someone might jump out and Tase her. But Markus was sitting there talking to Doob.

“Have you been watching Parambulator?” Markus asked her.

“Yes. After we made that course change, a few minutes ago.”

“The performance of the cloud was not everything we could have hoped for.”

“There were some stragglers.”

“Still are,” Doob said, and drew her attention to a projection screen on the wall.

“It looked like they were all new arrivals,” Ivy said. “Cargo modules, passenger carriers from the Splurge. I'm assuming they haven't logged on to the cloud yet, are not with the program.”

“That is all true but it is dangerous nonetheless,” Markus said.

“Of course it is.”

“It is distracting me.”

“I'll take care of it.”

“As far as bolides are concerned, the systems are working okay and Doob is keeping an eye out for anomalies. But I need to delegate to you, Ivy, this problem of the stragglers.”

“Consider it done.”

“We will destroy them if we have to.”

“How would you even do that, Markus? We don't have photon torpedoes.”

“We have a module full of freeze-dried dead people,” Markus reminded her, “that we need to jettison anyway. And I would be happy to jettison it in the direction of any straggler that is threatening the Cloud Ark.”

“I will keep that in mind,” Ivy said, “as a bargaining chip.”

Luisa entered, looking a little wild, her face wet with tears.

“Luisa?” Markus said politely. “Did you find out what was going on in the Vu-Vu Pod?”

“A few people getting very emotional,” Luisa said, “as you would expect. Nothing dangerous. Whoever called that in as a disturbance was being a little paranoid.”

“Thank you for investigating it.”

“Speaking of which—you have armed guards posted outside the door to the Tank!”

“I will speak briefly to that, because I am busy,” Markus said. “My feelings about it are basically the same as yours. But I am not here to express my personal feelings but to carry out certain operations to the best of my ability. I didn't want to be the king of the universe. Nevertheless, now I am. Everything I have ever seen in the history of human civilization, disagreeable as it might seem, says that someone in my position needs to have security.”

Luisa's face suggested that she could make all kinds of objections to that. But she got the better of it, and just let out a sigh. “We will talk about it later,” she said.

“Good.”

“Do you know what is happening down there?”

“I can guess what is happening. It is none of my concern.”

“Understood. But I think that the king of the universe needs to make an announcement pretty soon.”

“I have one prepared,” Markus said.

“Oh, yes, of course you would have one prepared. When were you thinking of delivering it? Because there are a lot of people who need to be calmed down.”

“Is one of those people you, Luisa?” Markus asked the question clinically, but not unkindly.

Luisa drew herself up. Ivy braced herself for a sharp reaction, but then a change came over Luisa’s face as she saw that Markus was merely asking for information. Not being snide.

“Yes,” she answered. “A few minutes ago, Manhattan was struck by a hundred-foot wall of water. I presume that the same is true of most of the East Coast. I was listening to the service from St. Patrick’s Cathedral when it went off the air.”

Markus nodded and changed the display on the projection screen to a live view of Earth.

Ivy was shocked by how far the fire had spread during the few minutes she’d been in here.

She pulled her phone out of her pocket and discovered a series of messages from Cal, sent during the last several minutes.

*Hey*

*You busy?*

*OK I guess you got pulled away*

*In case we get cut off I love you*

*Will look for a mermaid like you said but no substitute 4 u*

*Lost contact with Norfolk. No chain above me*

*Holy crap it is getting hot*

*Diving*

*Bye*

And the last message in the series was a photograph snapped on his cell phone’s camera. It took Ivy a minute of panning and zooming to figure out what she was seeing. Cal had taken the photo while standing in the conning tower of his boat, looking straight up the ladder at the open hatch above him. This provided a tunnel-vision view of a disk of sky.

The sky was on fire.

In his other hand he was holding up his engagement ring—a simple band of polished titanium. He was holding it between his thumb and index finger, shooting the picture through the ring, making it concentric with the disk of the burning sky.

She looked up. Someone had spoken her name.

“Mine just faded away,” Doob told her.

“I beg your pardon, Dr. Harris?” Ivy said, the Morg’s manners triumphing over all circumstances.

“I had been gearing up for these final goodbyes with Amelia, with my kids,” Doob said. He spoke quietly, without marked emotion, as if relating a mildly surprising anecdote. “But, you know, the communications just broke down slowly over a couple of days, and there was never really a goodbye.”

“Very well,” Markus said, “I will make the announcement.”

HOT ENOUGH TO BAKE TATERS ON HOOD OF THIS TRUCK

GO INSIDE DAD

NOT KIDDING ABOUT THERMAL EFFECTS. PAINT BUBBLING

I AM NOT KIDDING EITHER YOU HAVE TO GET INSIDE

GOT A SPACE BLANKET TO PROTECT ME WHEN I MAKE A RUN FOR IT

THEN FOR GODS SAKE USE IT DAD

AH BUT THEN I CAN'T CHEW THE RAG WITH YOU ANY LONGER DINAH

WHAT IF YOUR GAS TANK EXPLODES

HA HA WE DRAINED IT FOR GENERATOR FUEL. WAY AHEAD OF YOU KID

GOD U R A SMARTASS

Dinah was keying this in, thankful that Morse code still worked when your vision was blurred by tears and your voice choked by sobs, when a voice came out of a speaker. It was Markus's voice: "This is Markus Leuker."

"I know who you are," she answered. But then she understood that Markus was speaking on the all-Ark PA system, which supposedly reached into every corner of Izzy as well as to all of the arklets. They had tested it a few times with prerecorded messages, but never actually used it. Markus considered the thing a relic of the twentieth century, and detested it; communications ought to be targeted, busy people ought not to be interrupted by disembodied voices barking from speakers.

"The Cloud Ark Constitution is now in effect."

Dinah drew breath, knowing what this meant. Markus spelled it out anyway. "This means that all nation-states of Earth, and their governments and constitutions, no longer exist. Their military and civilian chains of command are no more. Oaths you may have taken to them, allegiances you may have held, loyalties you may have felt, citizenships you may have had are now and forever dissolved. The rights granted you by the Cloud Ark Constitution, no more and no less, are your rights. The laws and responsibilities of the Cloud Ark Constitution now bind you. You are citizens of a new nation now, the only nation. Long may it endure."

She keyed:

MARKUS IS CALLING IT

WHO SAID HE WAS BOSS?

Rufus's transmission was getting scratchy. Dinah wiped her eyes and looked out her window to see Earth encircled by a belt of fire. The trails of the incoming meteorites, once a pattern of bright scratches in the air, had merged into a blinding continuum of superheated air that had set fire to anything on the surface capable of burning. Since more of the rocks were coming in around the equator, the belt of radiance and fire was brightest there; but north and south of it, long swaths of the surface were aflame, and the belt was widening to envelop the high latitudes of Canada and South America.



She transmitted:

ABOUT TO LOSE YOU, TELL BOB AND ED AND GT AND REX I LOVE THEM. AND  
BEV.

ALREADY DID BUT WILL AGAIN. CHRIST IT IS HOT

GET INSIDE DAD

DONT WORRY I AM RIGHT BY THE DOOR. CAN HEAR THEM ALL SINGING  
BREAD OF HEAVEN.

THEN GO JOIN THE CHORUS DAD

OKAY BOB AND ED ARE COMING OUT TO GRAB ME. BYE HONEY DO US PROUD  
QRT

QRT QRT QRT QRT

She wasn't sure how many times she keyed that in.

She pulled herself out of her sobs, later, by imagining what had happened: her brothers, Bob and Ed, dressed in silver fireman suits, rushing out of the mine's entrance to haul Dad out of the old pickup truck, wrapping him in the space blanket to keep him from being broiled by the sky, and dragging him inside. An inch-thick steel plate being slammed across the doorway, the welders going to work laying down fat fillets made to last five thousand years. Once that was done, the heavy machinery fired up, shoving tons of rock and gravel up against the steel plate to bolster it against any shock waves powerful enough to punch it out of its frame.

Then silence, save maybe for the distant thuds of meteorite strikes, and sitting around the table to say grace and tuck into the first of fifteen thousand or so meals that the MacQuaries and their descendants would have to prepare and eat if they were ever to escape from that tomb. They had five hundred people down there, and, at least on paper, enough food-growing capacity to keep that many alive. Exactly how you made that a sustainable proposition wasn't clear to Dinah; she hadn't bothered Rufus for every last little detail of his plan.

Markus's announcement was continuing. He was telling everyone what they already knew, which was that Earth was over, and that the great dying that they had been expecting for the last two years was now in the past. Everyone knew it, but someone had to say it.

He asked for 704 seconds of silence: one second for each of the days that had passed since Zero. About twelve minutes. All nonessential duties would be suspended during that time, and it would be the sole responsibility of the survivors to think, and remember, and mourn. After that, they must put Earth in the past, as a thing that had once been, and apply their minds to what was now.

Drawn up into a fetal position, Dinah hovered alone in the middle of her shop, listening to weird squeals and hisses coming out of her radio's speaker. Alone of all the people in the Cloud Ark, she knew that her family was still alive, and might go on being alive for a long time. It was not clear to her whether this was better or worse than simply knowing that they were dead. All she had to go on was DO US PROUD, her father's final transmission. Morse code didn't leave a paper trail, or an email thread on the screen of your tablet. She would never be able to scroll back and reread the

exchange she'd just had with Rufus. She hoped she'd said the right things and that he'd remember it well, and that he would tell the others about it at dinner this evening.

She tried then to mourn for all the others who had died, but it was too big. Emotionally, it was little different from reading about a great war that had happened a hundred years ago. Which maybe was Markus's whole point. Even though the dying was still going on, they had to force themselves to think about it like the Irish potato famine, or like what had happened to the peoples of the New World when Columbus had arrived and infected them with a slew of deadly diseases. Regret, even horror were appropriate. But detachment was necessary. They all had 704 seconds in which to effect that detachment.

So Dinah thought about what exactly would be entailed in doing Rufus MacQuarie proud. There was a simple answer, which had to do with doing the right thing, being honorable, upholding a few rough-and-ready ethical standards. A sort of frontier code of conduct. All of which was easy to understand if not always quite so easy to live up to. But Rufus was not a cowboy, and he certainly wasn't a preacher. He was a miner: a delver, a demolisher, a builder, a businessman. If he lived by a simple code of ethics, it was not an end in itself, but a way to get something done without selling his soul or destroying his reputation. It was a tool to be wielded like a shovel or a stick of dynamite. Tools were for building things; and pride was something you could feel after the fact, when you stood back, looked at what you had built, and passed it on to your children. Dinah could spend the rest of her life living by her word, giving everyone a fair shake, and all of that. Rufus would no doubt approve of all those things. But it was not the charge he had given her. He had told her, though not in so many words, to get busy building a future.

"Are you about finished?"

She turned her head to see Ivy hanging in the SCRUM, looking at Dinah through the hatch.

"We're only, like, two hundred seconds into the—"

"Markus said I could skip it. He sent me on a mission. I need your help," Ivy said.

"Bitch."

"Slut."

"Shall we?"

"REMEMBER WHEN THE INTERNET WAS NEW, AND SOME PEOPLE IN your life just didn't get it?" Ivy asked. She was preceding Dinah through the seemingly endless maze of docked modules and hamster tubes, headed toward the periphery of Izzy.

"People in my world got it pretty fast. You don't know many miners, do you?"

"Not in my world. We had these throwbacks who would do stuff like printing their emails out on paper to read them, or asking you for your goddamn fax number two decades after you had thrown away your fax machine."

They were hurtling through an otherwise perfectly silent space station, still only about five minutes into the twelve minutes of silence. Faces in open hatches would turn to look at them in shock, then recognize them and go back to mourning, praying, meditating, or whatever it was that they were doing.

Dinah understood that this was terribly important but was secretly pleased that Ivy had given her dispensation to get to work.

"How does that apply to—"

"The system works—Parambulator and all of that—as long as every ship in the Cloud Ark is

playing by those rules. Logged on to the system, communicating with the agreed-on protocols, obeying the dictates of the swarm. If even one is just hanging out and doing its own thing, well, it might as well be a meteoroid, in terms of its destructive potential.”

“We’ve got one of those?”

“A few of them. But one in particular that is causing havoc.”

“Any collisions yet, or—”

“No, but every time it draws near it triggers an explosion of red in Parambulator and a hundred arklets have to burn fuel to alter their courses. It’s like the whole Cloud Ark is turning somersaults around the movements of this one ship.”

“What is it?”

“Optically it’s an X-37.”

“Fits,” Dinah said.

“Yeah,” Ivy said.

Translation: someone had looked at the craft through a telescope and thought it looked like a Boeing X-37 Orbital Test Vehicle, which resembled a miniature Space Shuttle. It was so miniature, in fact, that it couldn’t carry any crew; it had a cargo bay that accounted for most of its fuselage. It had been developed by DARPA in the late 1990s and early 2000s when it had become obvious that the Space Shuttle was going to be phased out and they needed a small, easily launched vehicle that could go up and, by remote control, perform maintenance tasks on the United States’ fleet of military satellites. Since then it had come in for very little actual use, but when it was used, it was for black-budget spook stuff that Dinah and Ivy wouldn’t know about. It was a footnote in history, obsolescent, not designed for the requirements of the Cloud Ark. It had probably been launched into orbit by some trigger-happy launch crew that just wanted to send up everything they could. With a sufficient amount of sifting through old emails they might be able to find some record of who had launched it, and what, if any, cargo was aboard; but for now it was easier to just go and look at the damned thing. Nearly all the engineering that had gone into it had been devoted to the problem of reentry. Most of its proudest features were therefore useless to them.

Approaching the end of a side-stack, they were able to see through the round orifice of a port into the vehicle docked to its far side: a Flivver, or Flexible Light Intracloud Vehicle. These had begun showing up a few months ago; they were the jeeps of the Cloud Ark, the small utility vehicles used to move people and valuable stuff from one arklet to another, or between an arklet and Izzy. Because they didn’t have to operate in the atmosphere, they had the same general utilitarian look as the arklets. But the pressure hull was smaller in diameter, and instead of an inflatable outer hull the Flivver had more practical stuff: two different styles of docking ports, an airlock big enough to accommodate a human in an Orlan, a robot arm, lights, thrusters. At Dinah’s suggestion they had studded the pressure hull with attachment points that a Grabb could latch on to; this made it possible for each Flivver to carry its own complement of Grabbs, Siwis, Buckies, and Nats, which swarmed all over it like crabs, remoras, and sea lice. Instead of being limited by the hard-engineered capabilities of the robot arm, the Flivver was constrained only by the imagination and ingenuity of the programmer inside, telling the robots what to do.

The silvery burr of Tekla’s head poked out in front of them; apparently she’d been dispatched to assist with closing the hatch and undocking the Flivver. She’d been waiting in the adjacent DC, or docking compartment, which was just a small side module tacked on to serve as an airlock and provide a little extra space for personnel in cases like this. She drew her head back in to make space as Ivy and then Dinah cruised by her. As soon as those two were inside the Flivver, Tekla emerged and

exchanged a nod with Ivy.

“Lamprey is in airlock and is functioning,” Tekla said, and closed the hatch. Dinah had some ambivalent feelings about Tekla, but there was no one she’d rather work with in a case like this. She was all business; she got the job done without useless conversation or touch-feely stuff. Dinah closed the Flivver’s hatch and began going through the undocking sequence while Ivy, strapped into the vehicle’s pilot seat, ran down the preexcursion checklist. Befitting a craft that had been designed in a hurry to be Flexible and Light, this wasn’t that lengthy, and so Flivver 3—one of a fleet of eight—was under way before Markus’s 704 seconds of silence had quite expired. Dinah strapped into a jump seat beside Ivy’s. The Flivver’s front end dome consisted largely of windows, bolstered by a sturdy web of curved aluminum struts, so from behind Ivy looked like a bombardier seated in the glass nose of a World War II bomber. She touched the controls and made the craft rotate in a way that caused Earth to pass beneath them, and then the resemblance became stronger. Dinah was reminded of a painting Rufus had shown her, depicting a bomber flying over a burning city, red light flooding into the plane from below. The same effect held now, save that the firestorm covered most of the surface of the Earth.

“I can feel the warmth on my face,” Ivy said.

Dinah couldn’t think of anything useful to say to that. During their passage from her shop to the Flivver she had forgotten about the fact that the Earth was burning, and she didn’t enjoy being reminded of it. Instead she tried to focus on the red light emanating coolly from the screen of her tablet, which was running Parambulator. Flivver 3 had been picked up on the swarm’s collective sensorium and identified as a bogey that might potentially collide with as many as a hundred different arklets if it stayed on its current course. Rather than controlling its thrusters directly, which would lead at best to confusion and at worse to a chain-reaction disaster, Ivy was negotiating a solution with the rest of the Cloud Ark, telling it where she wanted to go and finding a way of getting there that would minimize the amount of maneuvering demanded of all the others.

It was not a speedy way of getting around, and indeed ran at right angles to the fighter-jockey ethos of many of the ex-military types who had come up here in the astronaut and cosmonaut corps. But as they got farther away from Izzy they were able to move into orbits that caused minimal consternation to the rest of the cloud, and move in a more direct way to rendezvous with the wayward X-37.

This had been placed, by whoever the hell had launched it, in an orbit with the same period and plane as the Cloud Ark, but with somewhat greater eccentricity. The orbit of Izzy, and hence of the Cloud Ark, was almost perfectly circular. The X-37’s was more oval, meaning that about half of the time it was “beneath” the Cloud Ark and the rest of the time it was “above,” but twice during each ninety-three-minute orbit it crossed through, each time touching off the havoc that was wasting so much propellant and causing so much annoyance to Markus. Right now it was “above” and due to cross over in another twenty minutes.

“Any bolides we need to worry about before I focus on this?” Ivy asked her.

“Nothing in particular,” Dinah said, meaning that there was nothing so big as to force the entire Cloud Ark to make a course change.

“Let’s make this fast then,” Ivy said, and went over to manual control. For they were now far enough away from the Cloud Ark that she could execute solo maneuvers without making Parambulator screens turn solid red. “Can you scope it?”

Dinah spent a minute refamiliarizing herself with the user interface for the optical telescope mounted to the Flivver’s nose; this was an electronic eyeball about the size of an orange. The controls

were intuitive, but getting it to aim at a particular bogey took a bit of doing. Soon enough, though, she was able to see something white and bright. She locked on to it and zoomed in.

From longer zoom it was clearly a winged craft with a black nose, like the Shuttle of old, but it seemed to have taken on added parts. Zooming in further she was able to see that the cargo bay doors that constituted most of the X-37's "back" had been opened at some point after it had reached orbit. Its payload had then been lifted out of the bay using the built-in robotic arm, which was still holding it, frozen in position. The payload was almost as big as the X-37 itself; it was yet another dome-ended cylinder. But unlike a Flivver or an arklet, it lacked thrusters or any sort of visible power source. It was just a burnished aluminum capsule, gleaming white on one side from sunshine, red below where it reflected the planetary firestorm.

Ivy was looking at it too, dividing her attention between the Flivver's status displays and the window running this optical feed. "Can you get more detail on the forward end? There's a fitting there that might be a—"

"Yeah," Dinah said, zooming in and panning to center it. "That's a docking port all right."

"Well, I guess we're being invited to dock with it," Ivy said.

"It's weird. I don't like it."

"I agree," Ivy said, "but we can't come back later. That thing is tiny. Less than four feet in diameter. If there's humans in there, they are running out of stuff to breathe."

"Why would they send a human up in something like that?"

"It's some plan that went awry. An email didn't get answered, a transmission got garbled, now these people are marooned and probably waiting to die." Ivy spoke brusquely, a little irked by Dinah's questions.

Dinah heard thrusters pop and felt them nudging her around as Ivy maneuvered. She knew better than to distract her friend when her brain had gone into orbital mechanics mode. She unbuckled herself from the jump seat and moved to the docking port on the Flivver's "top" surface, steadying herself by reaching out to grab the adjacent handles whenever Ivy effected a little course adjustment.

Within a few minutes Ivy had matched orbits, maneuvered the Flivver into the right attitude, and driven it straight onto the capsule's docking port.

"Got a positive mate," Dinah remarked. She activated a valve that flooded the little space between the Flivver's hatch and the capsule's with air. "Here goes nothing."

She opened the Flivver's hatch. She was now looking at the outside of the capsule's hatch, which, until a few seconds earlier, had been exposed to space.

A strange detail: taped to the aluminum hatch was an ordinary sheet of 8½ x 11 inch North American printer paper. On this had been printed a color image: a yellow ring encircling a blue disk lined with stars. Spread-eagled on its center, an eagle with a red-and-white-striped shield. The printer that had spat this thing out had been low on cyan ink and so the image was strangely banded and discolored. Exposure to space hadn't done it any favors either.

Even though the United States had only ceased to exist a few minutes earlier—declared extinct by Markus under the authority granted him by the Cloud Ark Constitution—this image already seemed as old and quaint to Dinah as a pilgrim or a musketeer.

She heard a mechanism activating on the other side of it.

"It's aliiiiive!" she called. Then, in spite of this effort at jocularity, she held her breath.

The hatch swung open to reveal a haggard, space-bloated, sickly green face, hair floating around it in disarray. But the eyes in that face were as cold and hard as ever, and they were fixed on Dinah.

"Dinah," the woman said. It was her voice, more than her face, that Dinah recognized. "Even in

these tragic circumstances, what a relief to see a familiar face.”

“Madam Pres—” Dinah began. Then she caught herself. “Julia.”

Julia Bliss Flaherty looked as if she didn’t appreciate one bit being addressed that way.

Ivy was using the thrusters quite a bit. Now that the Flivver, the capsule, and the X-37 were all joined together mechanically into a single object, it was possible—though awkward—to maneuver them into sync with the Cloud Ark and clean up all of that Parambulator red. There was some lurching. Julia was getting knocked around a little, learning she had to keep a grip on those handles. Random stuff, including some filled barf bags and a large number of what looked like red marbles, were careering around inside her tiny capsule. Looking through it during a moment when Julia had been flung to one side, Dinah saw a man floating in the far end of the capsule. He was bloody, and he was kind of floppy too. He was dressed in the remains of a navy-blue suit. He was not the ex-First Gentleman.

“I’m sorry for your loss,” Dinah said.

“Who the hell is that?” Ivy was shouting. “Markus wants to know if we have survivors.”

“My loss?” Julia asked.

“Your husband,” Dinah said.

“He took the pill,” Julia announced, “in the limo.”

“Oh my god.”

“I’ll need your help getting Mr. Starling squared away. He’s too big for me to move.”

“No, he isn’t,” Dinah said.

“I beg your pardon?” Julia said sharply.

“You’re in zero gee,” Dinah pointed out. “So he’s not too big for you to move. But I can still help you if you want.”

“If you would be so kind,” Julia said. She got a hand over the rim of the hatch while reaching out with the other for a shoulder bag, and looked expectantly at Dinah, who was still blocking her path.

Dinah looked at the back of Ivy’s head. “Julia Bliss Flaherty requests permission to come aboard.”

Julia let out a hiss of exasperation.

“Granted,” Ivy said.

“One casualty on the way too,” Dinah said, and cleared out of Julia’s way.

Julia launched herself through the hatch too hard, flew across the Flivver, and slammed into the far side of it elbow and shoulder first. “Augh!” she cried. But Dinah didn’t think she was hurt, and so she pushed through into the capsule. One of those red marbles was drifting toward her face and she reached out with a hand to brush it away before realizing that it was blood.

Pete Starling was suffering from a number of lacerations, as if he’d been in a stick fight or a car crash. He was groggy, and gagging on blood—probably from a broken nose—which he would cough out explosively when it got in the way of his breathing. Dinah grasped the lapel of his jacket, trying to find a usable handhold. When she pulled on it, the front of the coat came away from Starling’s chest for a moment, revealing an empty shoulder holster.

No matter now. She planted her feet, put her back into it, and got him stretched out in the middle of the capsule, head aimed toward the docking port, drifting slowly in that direction. She was looking to Julia to reach through and pull her companion through the hole. But Julia, banged up from her first attempt to move, was still flailing around, learning the basics of zero gee locomotion the hard way.

Dinah was at the back of the capsule, staring at Pete’s feet, which were kicking weakly. One of his feet was stocking clad; the other still wore an expensive-looking leather shoe. She grabbed a foot with each hand and tried to push him toward the docking port, but he reacted against it. He had no idea

what was going on, didn't understand that he was in space, didn't like having his feet grabbed. She moved forward, got her waist between his knees, hugged him around the thighs, squeezing his legs together to either side of her body, and tried to get him re-aimed toward the port.

She heard a sharp pop and felt warm wet stuff all over her arms. More of it had splashed up her throat, all the way to the point of her chin. She smelled shit and heard a loud hissing noise. Pete Starling jerked once and then went limp.

She looked up toward the source of the hiss and saw starlight through a jagged hole in the skin of the capsule. The hole was about the size of a man's thumb. Triangles of metal were bent back away from it.

On second thought, the hissing was coming from two places at once. Another hole had been punched in the other side of the capsule. Pete Starling's body was between the two holes. The middle of his torso was just a rib-lined crater. Blood was hurtling out of it and accelerating through both holes.

Her ears had popped several times already.

She looked down the length of the capsule at Julia, who had finally gotten herself properly oriented and was looking into the hatch, wild eyed, utterly confused.

"Julia," Dinah said, "we've been struck by a small bolide. We're losing air, but not that fast. Pete's dead. He's in my way. If you could reach through and grab him by the collar and pull him toward you —"

The conversation, and her view of Julia's face, was cut off by the Flivver's hatch swinging shut.

ANY CURVE YOU COULD MAKE BY SLICING A CONE WITH A PLANE—A circle, an ellipse, a parabola, or a hyperbola—could be the shape of an orbit. For practical purposes, though, all orbits were ellipses. And most of the naturally occurring orbits in the solar system—those of the planets around the sun, or of moons around planets—were ellipses so round as to be indistinguishable, by the naked eye, from circles. This was not because nature especially favored circles. It was because highly elongated elliptical orbits tended not to last for very long. As a body in a highly eccentric orbit went rocketing in toward the central body and executed a hairpin turn at the periapsis—the point of closest approach—it was subject to tidal forces that could break it up. It might strike the central body's atmosphere or, in the case of heliocentric orbits, come too close to the sun's heat and suffer thermal damage. If it survived the plunge through periapsis, it would fly out on a long trajectory that would take it across the orbits of other bodies. After rounding the turn at apoapsis—the point of maximum distance—it would cycle back across the same set of orbits on its way back in toward the center. The solar system was sparse, and so the odds that it would strike, or come close to, any given planet or asteroid on any given circuit were small. But over astronomical spans of time, the likelihood of a close encounter or a collision was high. Collision would, of course, result in a meteorite strike on the planet and the destruction of the formerly orbiting body. A mere close encounter would perturb the body's orbit into a new and different ellipse, or possibly into a hyperbola, which would eject it from the solar system altogether. The sun still maintained a stable of comets and asteroids in highly eccentric orbits, but their number dwindled over time, and they were rare events to astronomers. In its early aeons the solar system had been a much more chaotic place, with a wider range of orbits, but the processes mentioned had gradually swept it clean and, by a kind of natural selection, produced a system in which nearly everything was moving in an almost circular orbit.

What was true of the solar system as a whole had also been true of the Earth-moon system. The

moon had circled the Earth in a nearly circular orbit. From time to time, a wandering stone from deep space would blunder in through a libration point and get captured into a geocentric orbit, but sooner or later it would hit the moon, hit the Earth, or be ejected by a close encounter with one of those bodies. Thus had the moon swept Earth's skies for billions of years and protected it from most big meteor strikes, making it a suitable place for the development of complex ecosystems and civilizations.

All the rocks that made up the White Sky had once shared the moon's orbit, and most of them, for the time being, remained at a safe distance of about four hundred thousand kilometers. Their orbits, for now, were of low eccentricity, meaning that they were nearly circular. However, the vast number of chaotic interactions within the White Sky had spawned a diversity of orbits. Some of those orbits were highly eccentric, meaning that their apogees might be far away, but their perigees were close to the Earth: close enough to get caught up in its atmosphere or to strike it directly. Any rock whose orbit was eccentric enough to come near the Earth could also come near Izzy. In general, rocks in such orbits were moving at about eleven thousand meters per second when they were that close to Earth. A bolide the size of a peppercorn, moving at that velocity, would have the same kinetic energy as a high-powered rifle bullet.

Of course, high-powered bullets were designed to strike things with great force and do damage in a predictable way, while moon rocks weren't designed at all. So the results of collisions could be unpredictable.

What had probably happened in this case was that a rock closer in size to a chickpea, and packing the energy of several rifle bullets, had punched through the wall of the capsule but, in so doing, fractured into several pieces that had sprayed outward across the capsule's volume in a narrow cone, striking Pete Starling's body something like a shotgun blast but with much more total kinetic energy. Most of that energy had gone into his flesh and caused him to basically explode. The largest single piece of the original rock had kept going through his body, or perhaps missed him entirely, and punched its way out through the opposite side of the capsule.

If the rock had passed a couple of meters to either side, it would have missed them entirely and they wouldn't even have known it was there. In the Earth's atmosphere, of course, it would have been a different story. The rock would have dissolved in a bright streak, turning most of its kinetic energy into heat. The air in its immediate vicinity would have gotten warmer for a bit. Had it happened at night, keen observers might have seen a streak of light. When the same thing happened on a large scale, all over the Earth, the air became so hot that it glowed, as it was doing now.

In any case Dinah now found herself locked into a capsule, lit only by a few strips of white LEDs that were darkened by blood spatter, as the air leaked out of it. She had, of course, been drilling for events such as this one for a significant part of her life. One of the first things they taught you was that the air wasn't really leaking out as quickly as you thought. Only so much air could get through a small hole. Nevertheless, plugging those holes was life-or-death. So Dinah's first move, once she had recovered from surprise, was to shove Pete Starling's remains up toward the larger of the two holes: the one through which the bolide had entered. With a wet sucking sound his bloody flesh sealed that hole. Her ears now enabled her to find the smaller exit hole, which was about the size of her pinkie. She slapped her bloody hand over it. The hiss stopped and she immediately felt a space hickey beginning to form where the Big Hoover was trying to pull her flesh out into the void. It hurt, but not that badly. She listened for a few moments until she was satisfied that there were no other hissing noises—no other leaks.

A bloody bandage floated past. She snatched it out of the air, peeled her hand away from the hole,



and stuffed it in there. Some of it got sucked out into space, but then it formed into a wad that moved no further. The hole was still hissing, though, so she grabbed an empty plastic bag and shaped that over the irregular mound of wet gauze. The vacuum sucked it inward and created a nearly airtight seal.

A softer hiss, more of a whooshing noise, emanated from the “back” of the capsule. Dinah’s ears felt a change in pressure, but they didn’t pop—suggesting that the pressure had just *increased*. She knew nothing about this capsule, but she did know how simple life support systems worked, and she knew that they would likely contain a store of compressed oxygen that would be bled in to compensate for what was being turned into CO<sub>2</sub> in the occupants’ bodies and absorbed by the scrubbers. The mechanism was probably trying to compensate for the air that had just been voided into space, bringing the pressure back up to normal.

If that were the case, then it should now be possible to open the hatch on the Flivver. Dinah floated toward it, reached through the capsule’s open hatch, and rapped on the metal, leaving bloody knuckle prints.

Nothing happened for a moment, and so she rapped out SOS: three dots, three dashes, three dots.

The hatch opened to reveal Ivy’s face. “My. Goodness. Gracious,” she said.

“Thanks, sister,” Dinah said, and vaulted through as Ivy got out of the way—partly just to be accommodating but largely, Dinah assumed, to avoid getting smeared with the bodily fluids of Julia’s late science advisor. Julia herself was strapped into one of the jump seats, buckled over into a fetal position suffering from the dry heaves, and keeping an eye on Dinah out of the corner of her eye.

*Welcome to space!* was on the tip of Dinah’s tongue, but she managed to stifle it.

“While you were, uh, busy, we flew through the Cloud Ark again. We have about forty-five minutes now on its nadir side,” Ivy said.

“Should be enough,” Dinah said. She strapped herself into the other jump seat, wiped her hands on her thighs, and pulled her laptop close. Holding it down with the heels of her hands so it wouldn’t float away, she brought up the set of interface windows that she used to communicate with robots. Over the course of a few seconds, the laptop established communication with all the robots that were within range—which is to say, that were riding along on the outside of this Flivver.

Meanwhile she pulled down a folding arm with a mitten-like contraption on its end. This was the interface for the Flivver’s external robot arm.

“Pop the airlock for me, sweetie?” she said.

“Already done, hon,” Ivy returned.

In her peripheral vision she could see Julia’s eyes swiveling back and forth, reacting to this exchange. She tried to ignore Julia in spite of—perhaps because of—her weird talent for demanding attention, and focused on the video feed from the camera on the end of the robot arm.

The airlock’s round orifice grew larger as she reached toward it, revealing the device Tekla had stashed inside.

The Lamprey was a box with a blinking light on it. On the side facing the airlock door it sported a lug, or handle. With the hand on the robot arm, Dinah was able to grapple this easily and pull the device out into the light.

“Any reason not to just ’biner it onto the X-37’s arm?” she asked.

“Can’t think of any.”

“What is it you’re doing?” Julia asked.

“Deorbiting that piece of space junk before it kills someone.”

“That piece of space junk happens to be carrying the earthly remains of a brave man who gave his

life in the name of—”

Dinah said, “Ivy, you want to take this or should I?”

“I’ll do it. You’re busy,” Ivy said. Dinah could hear her twisting around in the pilot’s seat to look at Julia. She spoke as follows: “Julia. Shut up. If you say another fucking word I’ll stave your fucking head in and put your corpse out the airlock. Nothing about this is acceptable. Starting with the fact that you are flapping your gums, posing a distraction to Dinah while she is carrying out a difficult mission-critical operation to protect the Cloud Ark. You just attempted to countermand a direct order from Markus, who is in charge of everything here under the PSAPS clause of the Cloud Ark Constitution. You are up here illegally. The Crater Lake Accord specifically barred the sending of national leaders to the Cloud Ark. You have violated that commitment and found a way to be launched up here anyhow, and judging from the looks of it there was no end of dirty dealing along the way. Your vehicle approached the Cloud Ark in a manner incompatible with our safety and security procedures, endangering the lives of everyone up here, and forcing arklets and Izzy itself to expend priceless and irreplaceable fuel to perform evasive maneuvers. We were sent here on an emergency basis, placing ourselves in harm’s way and expending more scarce resources to clean up the mess that you created by your cowardly and dishonorable act. For all of these reasons I am commanding you, by my authority as the commander of this vessel, to remain silent until we have docked safely at Izzy.”

“Very well,” Julia said.

Dinah looked up from her work to see Ivy and Julia glaring at each other.

“I’m sorry,” Julia said.

“You really are asking for it,” Dinah told her. And then she went back to work.

She had already accomplished much during Ivy’s soliloquy. The task at hand was to somehow attach the Lamprey to the X-37. The connection didn’t have to look good but it did have to be solid. Back in the days when every maneuver had been planned years in advance by NASA, this would have been a several-hours-long operation making use of custom-designed hardware. But lately the people of the Cloud Ark had been obliged to get good at lassoing random pieces of floating space junk, and so she ended up using a more highly evolved version of the trick that Rhys had come up with for reining in Tekla’s Luk. On that occasion, Dinah had fashioned a whip by chaining Siwis together. It had worked, but it was much heavier and more complicated than it needed to be. After the completion of T3 had left Rhys with some free time on his hands, he had begun tinkering with surplus Nats. Being old and obsolete, these were big, clunky, slow, and stupid compared to the new models—which was fine for Rhys’s purposes. He had turned them into a new kind of robot that he dubbed the Flynk, for flying link, and taught them to be really good at forming themselves up into chains and then doing the sorts of maneuvers in space that his great-great-great-great-uncle John, and Herr Professor Kucharski of Berlin, could only have dreamed about. There was much room for creativity here, but he had focused most of his efforts on problems that needed to be solved all the time.

Such as precisely the one Dinah needed to solve right now. The robot arm of the X-37 was sticking awkwardly out into space, an obvious target for grappling. A chain with a free end would whip around it easily, just as Rhys had once ensnared Dinah’s index finger with his necklace. All Dinah needed was a suitable chain. She happened to have one: a necklace of third-generation Flynks spiraled around the Flivver’s hull, ready for use. One end of it was already connected to the Lamprey. By invoking some computer code she was able to set the rest of it into motion, unwinding itself from around the Flivver and snaking out into free space, forming a U-shaped bend, or *Knickstelle*, that was aimed at the X-37’s robot arm.

“Ready to undock now,” she said.

Ivy had moved back to the port through which their guest had entered. “Undocking,” she said, and began running through the checklist that undocked the Flivver from the X-37.

Dinah meanwhile moved up to the pilot’s console and punched in a programmed series of thruster burns. As soon as Ivy confirmed separation, Dinah executed the program, effecting a small delta vee that made them back away from the X-37. The *Knickstelle* went into motion, as if the chain were passing around an invisible pulley, and began to propagate away from the Flivver and toward the X-37. Presently the chain’s end whipped around the robot arm and spiraled about it several times before grapplers on the Flynks found each other and engaged, lashing the chain into place for good.

Dinah released the Lamprey from the grip of the Flivver’s robot arm. The Flynk chain, still following a canned program, pulled the Lamprey in and made it fast to the X-37. The Flynk chain, the X-37, and the Lamprey were now a single object, and would remain thus until they were destroyed.

Dinah brought up the interface that controlled the Lamprey. This was a fire-and-forget device, but someone did have to fire it. She spun a control wheel that adjusted the box’s attitude, aiming its business end in a safe direction.

Getting things out of orbit was almost as complicated as launching them. Once a thing was in a legitimate, stable orbit, you couldn’t just drop it toward the Earth. It would stay in orbit indefinitely unless you slowed it down. Slowing it down generally meant using thrusters, which meant spending fuel. The Lamprey was a simple alternative.

“We’re undocked,” Ivy announced, moving back forward to the pilot’s chair. “Gonna nudge us free.”

A couple of pops from the thrusters signaled that they were gaining some distance from the X-37. Ivy spun the Flivver around so that they could see the X-37 perhaps a hundred meters away, floating upside down above the burning Earth, the elbow of its arm projecting toward the nadir, the Lamprey strapped to it and blinking.

“Okay, the Lamprey is giving me all green thingies. I see no red thingies. So I am activating it in three . . . two . . . one . . . now.” Dinah tapped the Deorbit button.

Most of the Lamprey—the entire box—jumped away, headed toward Earth, propelled by white plumes of solid rocket exhaust. After a couple of seconds the motors burned themselves out and the box continued to coast away, unreeling a wire behind it. This came to a stop a minute later, dangling half a kilometer below the X-37, and pulled taut by tidal force.

“We have positive current flow in the tether,” Dinah reported. “So it’s working.” The wire, sweeping through Earth’s magnetic field on its orbit, was picking up a weak electrical current, creating a force that would slow the X-37 down. The effect was slight, but within a few hours the X-37’s orbit would decay to the point where it no longer posed a danger to the Cloud Ark, and in days or weeks it would descend into the atmosphere and be annihilated.

Twenty minutes remained before the Flivver’s orbit would next cross Izzy’s. But the physical separation was only a few tens of kilometers and they were still “on swarm,” meaning that the Flivver’s computer was talking to the Cloud Ark network and searching parameter space for the safest and most efficient way to reintegrate with it and to dock. That, plus the Lamprey’s success in moving the X-37 out of the way, ought to have cleared up most of the red that had been maculating Paramulator displays at the time of their departure. But when Dinah and Ivy turned their attention back to those screens, they looked worse than before. It was not immediately clear why. Paramulator was a beautiful thing from the standpoint of mathematics and data visualization, but there were times when you just wanted to know what the hell was happening. You wanted a narrative.

A text came through on Ivy’s phone. It was from Markus. She read it out loud. “Approach using

visual observation and manual control,” it said. “Warning: collision debris.”

“Already?!” Dinah exclaimed. It wasn’t a good start if they’d already suffered a bolide strike a couple of hours into the Hard Rain.

“It was fratricide,” Ivy said, still reading. “Looks like an arklet got cornered.”

Getting cornered was a problem that had arisen in simulations. The swarm as a whole would look for solutions that would prevent arklets from banging into each other with minimum expenditure of propellant. In a pinch, of course, it was okay to burn a lot of propellant to avoid a collision. But there were situations where a collision was going to happen no matter what, and there was nothing to do for it but choose the least damaging outcome. Getting cornered wasn’t supposed to happen; everything about Parambulator was supposed to prevent it. But the number of possible scenarios was infinite and nothing was ever certain.

“A controlled collision,” Ivy said, “no fatalities. But then some follow-on. Still being evaluated. There might be loose debris drifting around. That’s why he wants me to fly it in manually.”

“What kind of debris?” Dinah asked. “Hard stuff or—”

“Thermal protection, looks like,” Ivy said. “So that’s good.”

Apparently one of the modules, or an arklet, had lost some of the layers of reflective foil and insulation that were used to shield it from the heat of the sun. The stuff was feather light and so probably didn’t pose much of a threat to the Flivver. But it would look huge on radar and make Parambulator go crazy.

Ivy, in the pilot’s chair, was monopolizing the only window. Dinah didn’t like flying blind, so she pulled up the interface for the Flivver’s eyeball camera.

Julia began to make a weird repetitive noise, a sort of wet, gurgling drone.

She was snoring.

“Long day for her, I guess,” Ivy remarked.

“Yeah.” Dinah had no precedents to tell her how she should feel toward the ex-president at a time like this. On the one hand, her behavior had been reprehensible. On the other, she had, within the last few hours, lost her husband, her daughter, her country, and her job.

With a few moments’ panning around, Dinah was able to center Izzy in the camera’s frame, then zoom in. Izzy was on the night side of the Earth just now. In normal times—or what used to be normal—it would have been dark, but now she was lit up from below by the red glow of the atmosphere, punctuated from time to time by bluish flashes, like lightning strikes, as large bolides plowed into the air three hundred kilometers below. Of course, Dinah had never seen Izzy so illuminated, and it took a bit of getting used to.

From a distance Izzy looked fine, but at higher magnification Dinah began to see visual noise that gradually resolved into drifting bits of debris—the shredded thermal protection that Ivy had mentioned.

Izzy had become unfathomably complicated in the last two years. Dinah rarely saw it from a distance, so she didn’t have a strong sense of what was normal. But the more she zoomed in, the more certain she became that something weird had happened on the nadir side, near the junction of Zvezda and Zarya.

Complicated though she might be, Izzy was complicated in a way that was orderly, stiff, and stable. The one exception to that rule was Amalthea, but even that had become more regular as the Mining Colony’s robots had reshaped it. What Dinah was zooming in on now was messy, and it was unstable: big expanses of thermal shielding material that had been torn loose and were now stirring randomly in the nearly imperceptible wind. At a glance, it did not look like a serious matter.

“Serious” would have meant a hull breach, air erupting from a hole, perhaps dragging debris, or even human bodies, along with it.

“I’m thinking maybe a grazing impact at most,” Dinah reported. “A near miss between an arklet, or something, and the nadir side of Zvezda. Destroyed some thermal shielding but caused little if any structural damage.”

“They are reporting zero serious casualties,” Ivy said. “Some bumps and sprains aboard an arklet. So maybe you’re right.”

“Maybe,” Dinah said. For they had now drawn close enough that the camera could provide more detail. What had been exposed by the damage to the thermal shielding looked unfamiliar to her at first glance: a big T-shaped construct that jutted out to the nadir side of the Stack like a pair of handlebars. It was studded with many long neat rows of small, identical objects, gleaming in the occasional flashes from below.

Finally it all snapped into place in her head: she was looking at Moira’s thing. The HGA, the Human Genetic Archive. Moira had given her a tour once, but that had been from the inside, or enclosed and pressurized part of it. Now Dinah was seeing the same thing from the outside. Until now, this had always been concealed from view by the thermal shielding. Once that was torn away, its internal structure could be seen: the rows and rows of hexagonal sample racks, each carrying its load of deep-frozen sperm, ova, or embryos, waiting in the near-absolute-zero cold and dark of space.

“How has Moira been doing with the dispersal project?” Dinah asked, forcing her voice to sound relaxed.

“Well . . . obviously, the schedule got compressed when we learned about the Eight Ball. Just like all of our other preparations did. But I guess my real answer is that I don’t know,” Ivy said.