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CRISIS MANAGEMENT

How the Other Fukushima Plant Survived

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When we hear the words "Fukushima disaster," most of us think of Fukushima Daiichi, the nuclear power plant wracked by three core meltdowns and three reactor building explosions following the March 2011 earthquake and tsunami in Japan. Without electricity to run the plant's cooling systems, managers and workers couldn't avert catastrophe: People around the world watched grainy footage of the explosions, gray plumes of smoke and steam blotting the skyline. Since the tsunami, Daiichi has been consumed by the challenge of containing and reducing the radioactive water and debris left behind.

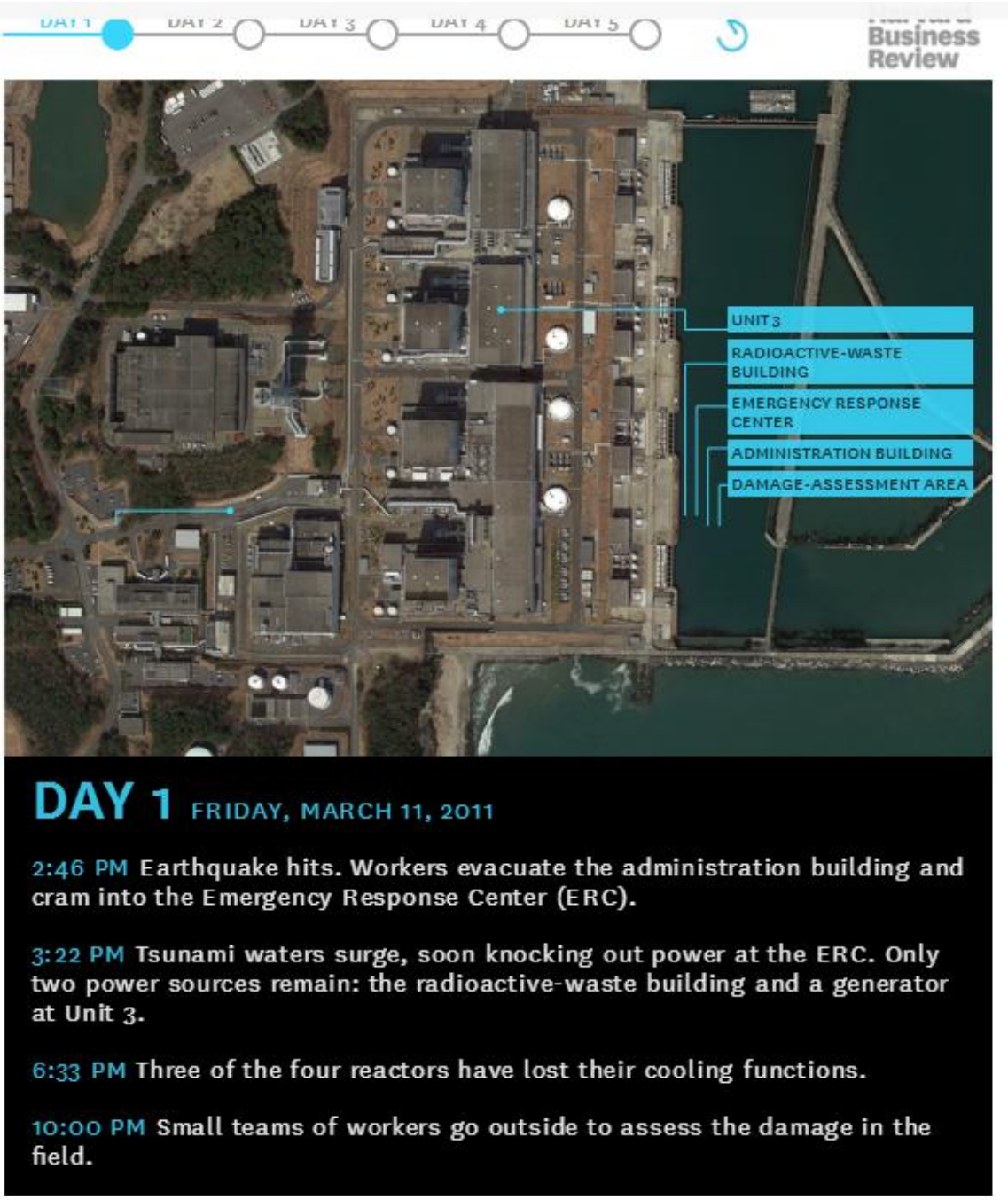
Less well known is the crisis at Fukushima Daini, a sister plant about 10 kilometers to the south, which also suffered severe damage but escaped Daiichi's fate. To shed light on how leadership shaped the outcome, we've reconstructed that story here—from several firsthand interviews; detailed reports by the Tokyo Electric Power Company (TEPCO), the utility that owns both plants; the Nuclear Energy Institute; and a number of public sources. In so volatile an environment, none of the usual rules for decision making and organizational behavior applied. But the site superintendent, Naohiro Masuda, and the rest of Daini's 400 employees charted their way through the chaos, and the plant survived without a meltdown or an explosion.

At a magnitude of 9.0, the earthquake was the largest in Japan's recorded history, and the waves it generated were three times as high as what Daini had been built to withstand. It was left with just one diesel generator and one power line intact. That single power line supplied electricity to the control rooms, where plant operators could monitor the water level, temperature, pressure, and other vital metrics for each reactor and containment vessel. But three of the four reactors lacked sufficient power to run a critical component of their cooling systems.

In two minutes, the tsunami overwhelms Daini.
Slide to see before and after.

To achieve cooldown and prevent the kind of devastation that was unfolding at Daiichi, Masuda and his team had to connect those reactors to Daini's surviving power sources. But the team was still reeling from a natural disaster of almost supernatural dimensions. What had *happened* here? How could the workers move forward and take action when all their expectations had been so violently shattered? Hanging over these questions was an even

scarier one: Was the worst really over? Natural disasters aren’t discrete events. The arthquake had been days in the making and would generate aftershocks for more than a ear. The tsunami wasn’t a single dreadful wave but a series of them.



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DAY 2 SATURDAY, MARCH 12, 2011

EARLY MORNING Unit 2 is at greatest risk. Naohiro Masuda, the site operator, maps a route for cables to draw power from the radioactive-waste building.

DURING THE DAY Awaiting additional supplies, teams begin laying the cables they have on hand.

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DAY 3 SUNDAY, MARCH 13, 2011

EARLY MORNING **Masuda realizes that his team can't connect all the cables to the radioactive-waste building in time. He adds the Unit 3 generator as a power source.**

MIDNIGHT **Having learned that a different reactor—Unit 1—is at greatest risk, workers finish rerouting the heavy cable.**

DAY 1 DAY 2 DAY 3 DAY 4 DAY 5

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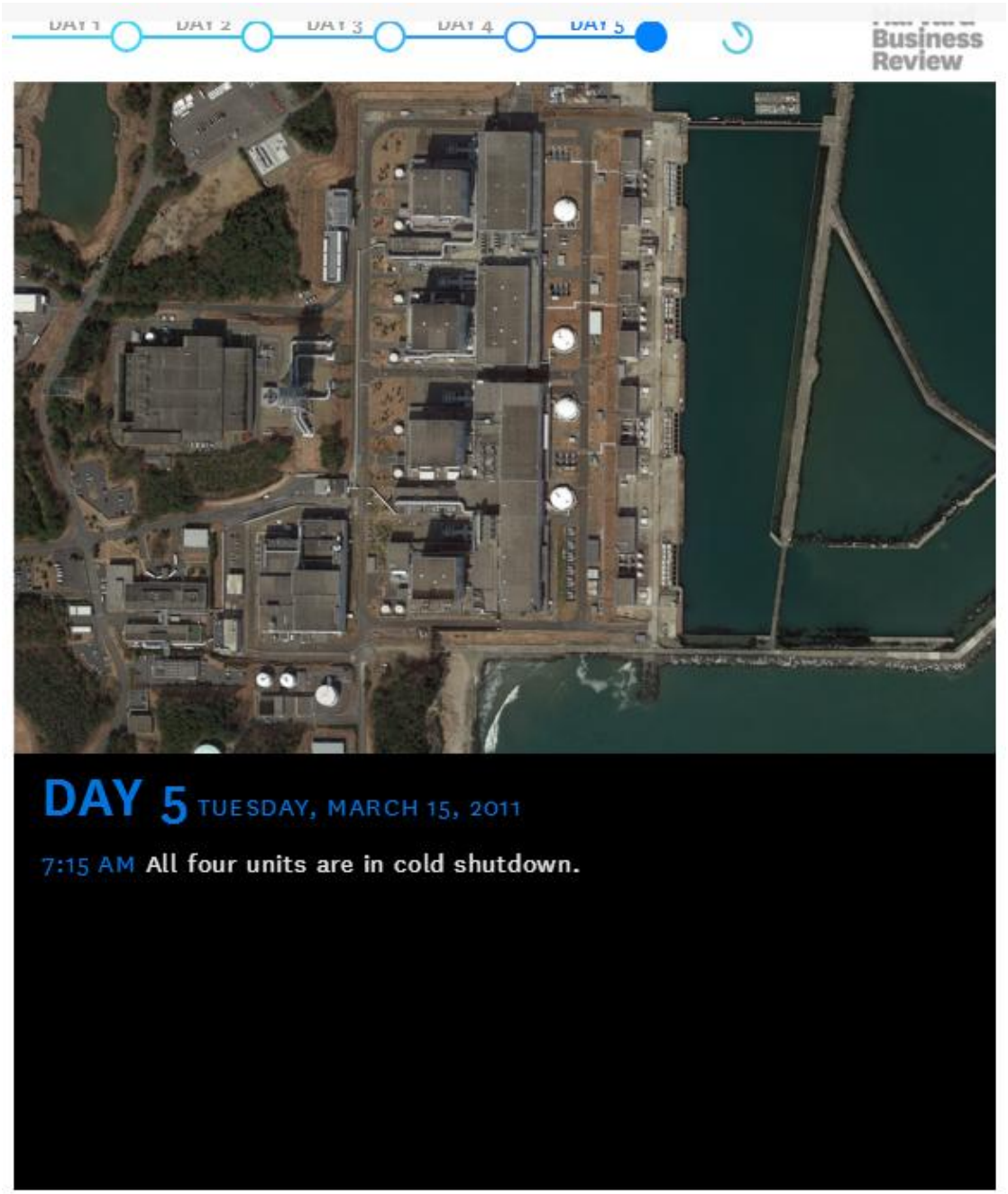
DAY 4 MONDAY, MARCH 14, 2011

1:24 AM Cooling function is restored to Unit 1.

7:13 AM Cooling function is restored to Unit 2.

3:42 PM Cooling function is restored to Unit 4.



To assess the damage and begin the dangerous work of restoring power to the reactors,Masuda didn’t simply make decisions and issue orders. He knew he had to persuade eople to act–against their survival instincts. His technical competence, knowledge of the

plant, and diligence helped him earn their trust. But more important, Masuda acknowledged the evolving reality in which they were operating. He shared the burden of uncertainty and doubt, engaging in what the organizational theorist Karl Weick and others have described as the "sensemaking" process: He arrived at a common understanding with his team members by revising and communicating what they "knew" so that they could together adapt to each twist and turn.

As a result, workers at Daini didn't lose focus or hope. While they acted, some things became more certain ("What's broken in the plant, and how can we fix it?"); some became less so ("Am I in danger from radiation?"); and some remained as unpredictable as ever ("Will these aftershocks lead to more flooding?"). Until the last reactor went into cold shutdown, Masuda and his team took nothing for granted. With each problem they encountered, they recalibrated, iteratively creating continuity and restoring order. As we describe below, they acted their way into a better understanding of the challenges they faced.

A Closer Look at Sensemaking

Sensemaking is adaptive behavior in which understanding and experience shape each other. We humans are attached to our expectations—we cling to the familiar. But a crisis disrupts the familiar. When past experience doesn't explain the current condition, we must revise our interpretation of events and our response to them. Bit by bit, we clarify an uncertain reality through action and subsequent reflection. Weick called this phenomenon "enactment."

Enactment isn't a linear process, however. In a crisis, people often need to venture down some wrong paths before finding their way. But the more publicly a leader commits to those paths, the more difficult it will be to seek out a new, better understanding. How to engage in sensemaking without becoming trapped by a flawed interpretation of events has been the subject of much research (such as Weick's analysis of the famous 1949 Mann Gulch wildfire in Montana). Masuda navigated that fine line as he pursued cold shutdown for the plant's four reactors.

Acting Decisively—Until Overtaken by Events

The earthquake hit on March 11 at 2:46 PM.It was the largest fault slip seismologists had ever seen: 50 meters of tectonic movement in two and a half terrifying minutes. Though Masuda had experienced countless earthquakes, this was the only one in his 29-year career that drove him under a table. When the violent rolling and shaking abated, he scrambled out from cover and grabbed a hard hat. He told all the workers to evacuate the administration building and gather in the plant's Emergency Response Center (ERC). On the upper story of that building, in a large room filled with evacuated workers, he located the manager of plant operations to request an update. The manager reported that all four of Daini's reactors had been shut down. With no evidence of damage to the plant as yet, Masuda and his team felt confident that they could carry out the next step—cooling down the reactors—without trouble.

But then, a little more than 20 minutes after the earthquake, Masuda saw the first tsunami alert. Initially the Japan Meteorological Agency (JMA) warned the Fukushima prefecture to prepare for a wave up to three meters high. Daini had been built to survive floodwaters up to 5.2 meters, so although Masuda didn't welcome this development, he didn't view it as disastrous. He dispatched a few members of his team to a bluff overlooking the ocean to watch for the tsunami.

At 3:14 PM, a new alert went out: The Fukushima prefecture should brace itself for a wave up to six meters high. Minutes later Masuda's lookouts sighted the tsunami. And at 3:22 PM, eight minutes before the JMA released its final tsunami estimate—more than 10 meters —the waters began to surge.

Crisis-management protocols had been serving Masuda and his workers well. But suddenly the second step on their checklist—cooldown—was in jeopardy. A tsunami higher than 5.2 meters ("beyond design-basis," in the parlance of the industry) would reach the pumps and perhaps even the reactor buildings.

Still, Masuda didn't expect the waters to hit the ERC, so he was shocked when its lights went out. He estimated that to knock out the lights, the waters must have been 17 meters high. He feared what might be happening to the plant's four reactor buildings, which lined

the shore. Part of the cooling system sat only four meters above sea level; the reactors themselves were only eight meters higher than that. If those systems were damaged or their power supply was compromised, cooldown would be next to impossible.

When the waters began to recede, a few hours later, Masuda learned that three of the four reactors had indeed lost their cooling functions. Despite the pre-tsunami shutdown, the fuel rods inside each core continued to generate heat that would normally have been removed by the cooling system and absorbed by the sea. Workers could still inject each reactor core with cold water, but Masuda worried that even if the cores retained their integrity, a buildup of steam pressure might compromise full function of their containment vessels. Then, if conditions worsened and a meltdown did occur, it would be difficult to prevent a radioactive breach. With so many aftershocks and an ongoing tsunami alert, this was a possibility he could not afford to ignore.

Because Masuda had no witnesses in the field, he didn't know what was broken or how badly. The control room operators had weathered the tsunami at their posts, but hundreds of other workers had evacuated to the ERC at Masuda's direction. Until he could persuade his team to venture out on the ground and examine the damage up close, he would not know exactly what had to be done to stabilize the plant.

Stepping Back to Make Sense

The workers Masuda needed to persuade were frantic for news of their families (most lived near the plant) and were operating beyond their training and experience. The tsunami waters had penetrated more deeply than anyone had expected, and frequent aftershocks, some greater than 7.0 in magnitude, continued to rock the plant.

"I was not sure if my team would go to the field if I asked, and if it was even safe to dispatch people there," Masuda says. But he didn't have time to be sure. If they couldn't rig up a cooling system in the next few days at the very most, they risked compromising containment. He had to move right away.

And yet he held back. Commandeering a whiteboard in a corner of the crowded ERC, Masuda began writing down numbers: the frequency and magnitude of the aftershocks. Marking a line for each new quake, he created a simple chart depicting—he hoped—the decreasing danger. "It was not convincing at all," he admits, "but I needed them to be convinced." As he added new lines to his chart, he refrained from making passionate speeches or issuing commands. He waited and he wrote.

Few would have been so patient in Masuda's position. Leaders often view themselves as intermediaries who digest the raw materials of the world—the unpredictable, the contingent—and transmute them into a more refined, reliable end product for their organizations. Even if Masuda had been so inclined, he could not have persuaded the Daini workers that way. They felt the instability of their position with the soles of their feet every time the earth trembled, and they saw it as they watched the sea heave sharks and cars across the plant's pavement. So he offered data, giving the workers an opportunity to confront and process the uncertainty for themselves. He prompted them to do their own sensemaking: to reflect on how their emerging reality fit their assessment of risk.

> The workers felt the earthquake through the soles of their feet as they watched the sea heave sharks and cars across the plant's pavement.

At 10 PM,standing face-to-face with his team leaders, Masuda finally asked them to pick four groups of 10 workers, one for each reactor unit, to go out and survey the damage. To his deep relief, no one refused.

Responding to a Shifting Reality

Masuda gave each group detailed instructions about where to go and what to do. (Having worked at the plant on and off for decades, he knew every nook.) Concerned about the effect that anxiety and fear might have on the workers' powers of recall, he made people repeat the instructions back to him before they went.

By 2 AM all four teams had returned to the ERC with an account of what still worked on the site and what didn't—and by dawn Masuda had made a list of operational priorities and the supplies needed to carry them out. What he had on hand was insufficient. With assistance from TEPCO headquarters and the Japan Self-Defense Forces, more supplies and cables would be brought in from off-site so that spoiled pump motors could be replaced and damaged parts of the cooling system could be connected to a building that was still drawing power. The cables came in 200-meter sections that weighed a ton each. Daini workers would have to lay more than nine kilometers' worth to hook up the three disabled units. Once the additional materials arrived, on the morning of March 13, they would have about 24 hours to complete the task. Under normal circumstances, a job like that would take 20 people using heavy machinery more than a month to finish.

Masuda returned to his whiteboard. He ordered a subordinate to write up the overall picture of the plant and an outline of the recovery strategy. He was determined to share information with his workers as it became available, slowly replacing uncertainty with meaning. But displaying those plans so openly had an unintended consequence: Workers interpreted that as a public commitment to seeing the plans through, which would (temporarily, anyway) reduce their ability to adapt to further surprises.

Masuda had initially chosen to use the radioactive-waste building as his power source, because its interior provided the least complicated pathway for the cables and he was loath to risk disabling his only operative generator. But he quickly saw that the building's remoteness made his plan unworkable. Each segment of cable would require 100 people to move it, so hooking everything up to the radioactive-waste building would take too long; they would need a supplementary, more convenient power source to hasten the process. Reluctantly he decided to use the generator.

This was not the last time Masuda had to revise something on his whiteboard. As unforeseen challenges emerged, the team members repeatedly had to act their way through them, making adjustments as they went. Masuda recalls several such obstacles: "First of all, a motor was delivered, but we could not get closer to the site because there was so much debris from the tsunami here. We needed to remove the debris with a bulldozer, but we did not have one, and no one knew how to use it even if we had. Once

we managed to bring the motor to the site, then we could not take it down from the truck. Now it was down on the ground, but we could not bring it inside the building, or could not install it, and so on." With each complication the team had to adjust and readjust its joint understanding of what could—and must—be done.

Meanwhile, Daini faced a new danger: Owing in part to an explosion at Daiichi, radiation levels at the neighboring plant were spiking. If the radioactive front drifted farther south, it could endanger Daini's workers and stop their progress. By the evening of March 13 it had begun to look as if another core meltdown might occur at Daiichi, producing even higher levels of radiation.

In this tense atmosphere Masuda made the last and most difficult course change. The night after the earthquake, engineers had carefully calculated the sequence in which the reactors should be supplied with power. Unit 2, the first to show signs of rising pressure, had been given top priority. But as the hours passed, the engineers noticed that the pressure was rising faster in Unit 1. They brought their observation to Masuda and suggested that Unit 1's containment was now the most vulnerable.

At this point Daini workers had been carting cable around a wet and debris-strewn plant for many hours. Most of them, including Masuda, had not slept at all. Although a few had been able to speak to their families, the news they'd received was not necessarily good. (Eight of them would lose family members, and 23 would lose their homes.) Radiation threatened from the north, where Daiichi presented the specter of what could yet go wrong. And now Masuda told the crews, Do it over. Shift from Unit 2 to Unit 1.

The site layout made it impossible to reroute the cable immediately, and Masuda later learned that his directive had caused a good deal of confusion among the workers in the field. Even so, they executed the pivot with amazing efficiency. Barely two days earlier Masuda had been recording aftershock frequencies for a room full of overwhelmed men and women, trying to coax them into action. Now they required no grand appeal. In part this was a triumph of team discipline—but it was also a feat of sensemaking. Because

Masuda had so calmly presented his people with the uncertainty of their situation, and because they themselves had confronted and conquered it time and again, they could embrace the unpredictable nature of their work.

Shortly before midnight on March 13, the workers finished laying the more than nine kilometers of cable that snaked through the site. Masuda led the entire workforce in a round of applause. And at 1:24 AM on March 14, two hours before Unit 1 would have exceeded its maximum pressure threshold, its cooling system came back online. At 7:13 AM the cooling system for Unit 2 went up, and at 3:42 PM Unit 4's was operating. By the morning of March 15—as Fukushima Daiichi was scrambling to deal with its third explosion—all four Daini reactors had achieved cold shutdown. The Daini plant experienced one disruption after another: the earthquake, the tsunami, the flooding, the power loss, threats to the containment vessels' integrity, changes in priorities for restoring power. Masuda and his crew assembled fresh explanations and plans each time, projecting their revised understanding of the crisis back onto the past and forward onto the future, making what had already happened knowable and what hadn't yet happened a little more predictable.

Masuda was not thinking about sensemaking in those sleepless March days. But in his handling of confusion and fear at Daini, he set a valuable standard. Though he felt tremendous pressure to manufacture a sense of physical and psychological security for his team, he did not make sweeping pronouncements and commitments in the critical early hours. He presented data and made and revised plans openly, investing in a shared understanding of the risks the workers faced and the actions they needed to take.

Without question, Masuda and his team were in a much better position than the workers at Daiichi, where greater physical damage had terrible consequences. Whereas Daini had at least a little electricity on its side, Daiichi lost all its off-site power sources and effectively all its emergency diesel generators. When the control rooms went dark, workers couldn't even monitor their deteriorating circumstances. The damage and the loss of power were the main contributors to the explosions. With containment breached, workers were potentially exposed to high levels of radiation. The Daiichi workforce at one point shrank to 69 people when employees sought safety, as recently released interviews with the site superintendent, Masao Yoshida, reportedly confirm. At Daini, Masuda had 400.

Still, unexpected challenges came at Masuda and his team thick and fast. In the heat of the crisis, problem by problem, they acted their way toward sense, purpose, and resolution. And three years later, Masuda continues to seek that resolution, now at Daini's sister plant: In April 2014 he was appointed Daiichi's chief decommissioning officer.

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