It's Come to This

David Battisti had arrived in Cambridge, Massachusetts, expecting a rout, a farce, a bloodbath. So had many of the other scientists who had joined him that frigid morning from around the country. It was an invitation-only workshop on climate science in November of 2007 for which they convened at the American Academy of Arts and Sciences, an airy temple to diligence and scholarship one block from Harvard University. Battisti shuffled out of the Massachusetts morning air and into the Academy's expansive premises.

The workshop's unholy topic was geoengineering: the concept of manually tinkering with Earth's thermostat to reverse global warming. Organizers had arranged the event to find out whether respected climate scientists such as Battisti might support research into the controversial idea. In a button-down shirt opened two buttons down, Battisti poured his coffee and watched the scientists fiddle with their muffins. One couldn't take planethacking seriously, he figured, because there's no way we'll ever know enough about the atmosphere to claim we can control it. Just because the radical notion had made it from the outer fringes of Earth science all the way to Cambridge didn't mean the group was going to legitimize it, he thought.

Since the 1960s, a handful of scientists had dreamed up various schemes to intentionally alter the atmosphere on a global scale: flying enormous sunshades above Earth, creating billions of thicker clouds at sea, or spewing light-blocking sulfate pollution at high altitude to mimic the cooling effects of volcanic eruptions. Ecologists imagined brightening the planet's dark surfaces to reflect more sunlight, by spreading white plastic across certain deserts. Marine biologists explored growing algae blooms to suck billions of tons of carbon dioxide from the sky.

Each concept took a smidgen or two of sense and added scientific optimism and a dollop of whimsy. Mostly back-of-the-envelope affairs, the papers that described them included just enough observations or calculations to suggest the ideas might work. The scientists who wrote them knew the concepts were raw and with few exceptions understood them to be options reserved for worst-case scenarios. To the broader community of climate scientists, proposing even to *study* deliberately altering the atmosphere was a heretical idea.

As Battisti poured himself coffee, he saw one of the heretics standing beside the buffet table. "That guy is scary," Battisti whispered to a colleague. It was Lowell Wood, a nuclear physicist with a broad, reddish beard and a dark jacket. His wide torso was bisected by a tie featuring the periodic table of elements. From his perch at a California nuclear weapons lab, Lawrence Livermore National Laboratory, Wood had won notoriety, if not ridicule, for proposing in 1997 to control the atmosphere's thermostat by scattering chemicals in the atmosphere. He had done so in collaboration with his aging mentor Edward Teller, the father of the hydrogen bomb. Teller, whose conservative views had often put him at odds with the left-leaning scientific establishment, had advocated in the same year that geoengineering was a better way to tackle the climate crisis than the Kyoto accords.

Wood was among a handful of geoengineering enthusiasts (for lack of a better term) who had organized previous gatherings in recent years on the topic. Organized in part by Harvard University, the

2007 meeting was to bring the geoengineering true believers together with top scientists who had long dismissed the idea as a dangerous—or, moreover, a ridiculous—fantasy. "I want to get the mainstream climate community together, the brightest stars," the meeting's co-organizer, Dan Schrag, had told me. Schrag was a geochemist at Harvard who managed to know everybody in the climate community despite a reputation as a bit of an agitator. It had taken someone like Schrag, naturally, to bring together scientists like Lowell Wood and David Battisti. "I wanted to broaden the discussion," he told the scientists as they sat down in a conference room with high ceilings.

From Harvard had come scientists in geochemistry and the atmosphere, as well as a distinguished physicist wearing a small cap. MIT contributed ocean and hurricane specialists. Battisti, from the University of Washington in Seattle, was an expert on atmospheric patterns and dynamics. He told me he felt skeptical of technological solutions to massive problems such as accumulating greenhouse gases. He'd grown up with a simpler understanding of the environment, he said, regularly visiting a family dairy farm. Battisti called himself a "progressive on most issues," and had joined seventeen colleagues in petitioning the U.S. Supreme Court in a case in which they argued that the Bush administration had "mischaracterized" scientific findings they had published. You don't have to convince *me* of the severity of the climate crisis, thought Battisti. He found a chair along a set of floor-to-ceiling windows looking out on an icy patio. But if the scientists in the room called for more studies of ideas such as Wood's, it would mean endorsing a research field that had always been considered closer to science fiction.

Or, suggested Dan Schrag in his introductory remarks at the meeting, if geoengineering was only to be explored in a worst-case scenario, the decision to conduct research on it would be tantamount to acknowledging that the worst-case scenario had come or was frighteningly close. Accordingly, the slides in Shrag's PowerPoint presentation were dread-inspiring. Fossil fuel emissions were growing by

3 percent a year, he said, and China and India were only getting started burning their share of the world's coal. The level of carbon dioxide in the atmosphere seemed headed for twice the pre-industrial level, he said, and it seemed plausible that it would reach that concentration by the end of the twenty-first century. "We're not only at the business-as-usual, but we are well above all of the business-as-usual scenarios." "Business as unusual," I thought. Earth's atmosphere had warmed 1.3°F since the 1950s and was certain to gain another degree this century as the oceans warmed. The world was rallying to set up rules to regulate carbon dioxide pollution, but few in the room were optimistic that regulations passed by the United States or the international community would be aggressive enough to stem the problem.

Schrag flipped to a slide showing Antarctica. "Are the polar ice sheets vulnerable?" the caption read. "If Greenland and/or West Antarctica started to slide into the ocean, could we engineer a way to stop it?" The seasonal ice that waxed and waned on the surface of the Arctic Ocean was disappearing at an alarming rate of 3 percent a decade. "The way the Arctic ice holds on is by the skin of its teeth," said a Harvard climate scientist. Everyone in the room had heard the body of evidence and knew how damning it was. But there was a unique intensity to hearing it all at once, in a small room, with a few dozen of the world's top scientists dispensing with the niceties. The sense of desperation hung in the air like smoke from a coal-burning power plant.

Then came the would-be saviors, played by scientists, blueprints in tow. A physicist described how to use navy guns to fire droplets of sulfate pollution into the upper atmosphere, where they would reflect a small percentage of the Sun's rays, providing a modest but dependable cooling effect. By launching billions of tiny disks into orbit around the Sun, said an expert on telescopes, engineers would be able to redirect a small amount of light from striking Earth, having a similar effect. ("I got a little money from the Discovery Channel to make some of this stuff," he explained.) Modeling research had suggested that the sulfate

aerosols method could be performed for a fraction of the cost of transforming the world's energy system. That technique mimicked the cooling role that volcanic eruptions played in Earth's climate. By studying previous volcanic eruptions, scientists estimated that geoengineering the upper atmosphere with this particular technique could cool Earth by as much as 4°F in a few years.

Local climates, one scientist suggested, could be "adjusted to taste." Might the aerosols method, with years of study and improvement, be a "technical pathway to Mediterranean climates" for most anyone who wanted them, as one scientist suggested? Chris Field, a prominent ecologist from the Carnegie Institution of Washington blanched slightly. (Among other problems with that particular suggestion, he said, is that wheat and other major crops require a rainy season not found in Mediterranean climates.)

Radical notions like those were why so many scientists in the mainstream have avoided geoengineering for so long. "Right now a very small number of people have worked on this for a small percentage of their time, as enthusiasts," said physicist David Keith, whose early papers on the radical concepts gave him particular authority among the armchair geoengineers. Keith was a wildly bright guy with antiestablishment leanings. He'd turned down an academic job at Princeton University to start a special energy group at the University of Calgary. There he'd made his name as an innovative energy and climate scientist, attacking more than his share of sacred cows while blessing heresies. Wind power could disrupt the weather; burning wood made climate sense—if you captured the gases you produced; and hacking the planet, though not a concept to be taken lightly, deserved attention beyond the pages of *Popular Mechanics*. Since graduate school, Keith had struggled over the question of whether studying and publicizing the idea of geoengineering would undercut efforts to reduce emissions of carbon dioxide. "A few of us are nervous to talk about this publicly," he admitted to the group.

"The engineering that dare not speak its name," mused a Harvard physicist named Bob Frosch. Sixteen years earlier, he had

battled with fellow members of a federally sponsored panel who opposed his effort to include a chapter analyzing geoengineering concepts in a major national report on climate. "It was the only time things got vituperative on one of these panels," said Frosch. (The little-noticed chapter was included.) By the same token, an atmospheric scientist had told the organizers before the Harvard meeting that it should not be sponsored by the school in case the setting could be construed "as an endorsement" of the wild idea.

"This is generation zero for climate modeling for geoengineering," Ken Caldeira of the Carnegie Institution of Washington told the group when it was his turn to talk. Since 2000, the geochemist had published studies in which relatively crude computer simulations suggested that cutting the amount of sunlight received by Earth by 2 percent might counteract the warming expected in the twenty-first century. In the intervening years, he had argued for others to pursue the research while leading a small band of true believers who for years had toiled on the edges of respected science conducting geoengineering research on paper, without federal sponsorship.

This was the Geoclique, as I called them, led informally by Caldeira and Keith. Some were topflight scientists, such as Caldeira; some were knowledgeable retirees or what seemed to be hobbyists. On an online discussion group they discussed the scientific merits of various techniques and vented about the political obstacles facing their controversial field. Caldeira's expertise was the ocean, though he had been a philosophy major in college, a programmer on Wall Street, and a researcher in the rainforest. While he had gained proficiency in atmospheric science, in part because of his interest in geoengineering, his value to the nascent geoengineering cause was as much a spokesman-organizer as it was a researcher. He and Keith managed a $1.5-million fund provided annually by Bill Gates to study geoengineering.

Keith likes to think of scientists studying geoengineering as members of either the Blue Team or the Red Team, depending on their temperament and role. Blue Team members, such as Lowell Wood,

have personalities that incline them to invent ways to alter the atmosphere. Keith leans blue. Russian climate scientist Yuri Izrael and his team also are solid Blue-Teamers. Red Team members, such as a plucky climate modeler named Ray Pierrehumbert, were generally skeptical of geoengineering and strove to find flaws in the blue team's work. Caldeira was bluish-purple. During his presentation he explained why he believed the sulfate technique might protect the world's coasts from the rising seas: "By dialing the radiation where you want it you can get more or less ice," he said. "If you're trying to get snow to fall on top of Greenland, this may be what you want." Having dismissed the concept of geoengineering out of hand before the meeting began, Battisti wasn't a member of either team, though his inclination seemed Blue.

At lunch, Battisti challenged Caldeira's contention that the sulfate technique would reverse the melting of the polar ice caps. "I don't know that," said Battisti, citing the model's simplistic depiction of the ocean. The best atmospheric scientists in the world, including himself, he said, simply didn't know enough about Earth's atmosphere to be making claims about how a renovation effort would turn out.

It's difficult to weigh the risks and possible benefits of planet-hacking concepts when both were uncertain. "I don't actually work on geoengineering, and I don't especially want to work on geoengineering," said Pierrehumbert. "But now that the genie is out of the bottle, I feel I have to." He shared with the group an unpublished experiment using a computer model of the atmosphere. In it, he quadrupled the amount of carbon dioxide in the sky, but kept the planet cool with a yearly dose of aerosol geoengineering. He warned that once the experiment began, a halt in the geoengineering effort—"by, say, a war or revolution"—would result in a hellish 14°F temperature jump in the tropics over three decades, bringing with it, presumably, unimaginable ecological impacts. (One climate scientist later compared the global climate addiction to alcoholism, and geoengineering to dialysis that allows the patient to continue drinking. Disrupting the geoengineering, he said, would be like

unplugging the dialysis machine. So blocking the Sun's rays might buy humanity a little time, but it made cutting carbon pollution even more important, not less.)

Could scientists hope to answer the question about whether geoengineering could help to reverse the catastrophic demise of Greenland's ice sheets, if scientists found that happening? "We don't know how to model the ice sheets," Pierrehumbert told the group. "We may not have time to understand the system well enough before we act," said a Canadian postdoc.

"In the next twenty years a president may decide that he or she wants to know whether geoengineering can help prevent Greenland from melting," Schrag told me. Facing dire straits in the future, policymakers would no doubt turn to climate scientists to ask whether radical means to take control of Earth's climate could work. "Will we have done research to have a good answer or not?" Some of the scientists in the room questioned whether their field would *ever* be able to provide a sufficiently certain answer to allow society to make a truly informed decision about planethacking. Which meant there was a decent chance it could be deployed without sufficient care. "I am really darn scared," Battisti told the group. "No one wants to see this happen. No one wants to deploy this stuff."

"If we communicate to the general public that geoengineering is a tool in our back pocket in case of an emergency, we're doing them a disservice," said a Canadian policy expert. "The public will then do less to lower their carbon emissions."

Keith seemed to resent the implication. "Being silent is unethical and arrogant," he said.

Pierrehumbert looked indignant and jumped in. "There's no denying that there's a risk that this will undercut burgeoning mitigation efforts." he said. "I would ask people not to accuse others of being unethical if they are acting so as not to let the cat out of the bag."

On the morning of the second day of the meeting Battisti began to feel his resistance to studying the idea of geoengineering dissolve. That, he told me, was an alarming consequence of what

things "had come to." Particularly devastating, he said, was a discussion about the low initial cost of the sulfates technique—might any one country for a few billion dollars deploy a global geoengineering program? And if that was the case, then scientists had no choice but to study it. Even if every nation signed a global ban, they felt impelled to understand the risk if rogue states took it up.

Things had come to Robert Socolow, a senior scientist from Princeton, saying that the climate problem "is a problem we are going to solve with a portfolio. If geoengineering can prove itself . . . it deserves to be in the big leagues." Things had come to former Harvard president Larry Summers, one of the most well-connected economists in the country, signaling his support for the research. Things had come to this very prominent group subconsciously moving beyond the question of *whether* scientists should start to look at the controversial idea and on to the question of *how* they would study it.

Underlying it all, said Battisti, was a sense of fear and the larger implications for the planet, for scientists, for his sense of moral responsibility. It all hit him that morning "like a horrible train wreck," he would say later. He felt himself propelled from the room out into the Academy's softly lit front vestibule, where he paced for a few minutes. On the walls hung letters written by some of the institution's most prominent members, including Martin Luther King Jr. and Albert Einstein, accepting their invitation to become members. Battisti used his cell phone to call Seattle, where it was early in the morning. His wife answered. "This meeting is scaring the daylights out of me," he told her. The choices were stark, and the scene, he said, one of eerie inevitability. "I remember having a feeling of surrealness—that the conversation didn't really happen," his wife, scientist Lynn McMurdie, says, recalling the "powerlessness" in her husband's voice. "I don't see any reason that this can be stopped," Battisti told her. Soon after he returned to the room, the scientists voted in a straw poll to support geoengineering research, with Battisti voting in favor.

And so some of mainstream climate science's leading lights had blessed geoengineering, their unholy child. Battisti felt a little numb, defeated. "It's wrong for us not to figure out a way to pursue research," he told me the next day. "But it would be incomprehensible that we deploy this." A year after the Harvard meeting, as its attendees have come to call it, he found himself in a conference room in Santa Barbara, California, with nine other scientists. He'd agreed to join a week-long exercise to map out a hypothetical ten-year research plan to understand how to hack the atmosphere with sulfate droplets. With equal parts seriousness and melodrama, the organizer of the group, a physicist named Steve Koonin, told him to imagine that "the president has just called you. There's a climate emergency." Battisti took out a pen and began to work. He'd joined the Geoclique, playing somewhere between the Red and Blue teams.

Since the Harvard meeting, almost every forum relevant to the climate crisis has reached out to embrace, if tentatively, the former pariah called geoengineering. In 2008 the British Royal Society devoted a full issue of its prestigious *Philosophical Transactions* to the topic; the following year an expert panel convened by the society called for "coordinated and collaborative" research into planethacking to augment efforts to cut carbon emissions. Its sister organization, the U.S. National Academies, sponsored a two-day workshop on the topic that same year. The Pentagon's secretive research agency, the Defense Advanced Research Projects Agency, has considered geoengineering studies. The American Meteorological Society has called for geoengineering research since, among other reasons, it could serve to "offer strategies of last resort if abrupt, catastrophic, or otherwise unacceptable climate-change impacts become unavoidable." President Obama's science adviser, John Holdren, has said that the topic is being discussed in the White House, and top officials at the Department of Energy are quiet advocates of federal spending on the concept. (President Obama's

energy secretary, physicist Steven Chu, said five months into his new job that painting roofs white could have a substantial impact on Earth's climate.) Two years ago, it was possible to read the relevant literature in the field on a train from Boston to Washington. Now, publications proposing or analyzing various means of large-scale intervention appear every few weeks.

The muted volume of dissent over geoengineering research so far has been as striking as the groundswell of interest in it. The most public opposition has come in response to a handful of medium-scale efforts by scientists aboard research vessels to grow algae on the high seas. ETC group, a Canadian environmental organization, has been among the harshest critics of geoengineering, calling it uncivil "geopiracy." (In 2009 it awarded first place in its April Fool's Day "invent-a-geoengineering-scheme" contest to a plan to pull Earth away from the Sun with space shuttles.) But even ETC thinks scientists should be allowed to study the concept.

With little public opposition, into this new arena have come a variety of Red and Blue teamers alike: confident would-be geoengineers, reluctant ones, wild inventors, and senior modelers warily turning the knobs on humming supercomputers that simulate Earth's endlessly complex biosphere. Longtime Geoclique members such as Caldeira, Keith, and Wood are in demand, and out of the woodwork have come new scientists interested in the idea. The Discovery Channel filmed a one-hour segment in a series called *Project Earth* in which a scientist tried to protect ice on Greenland by wrapping it with reflective plastic blankets. A Bay Area engineer wants to float white, breathable panels on the surface of the polar ocean to reflect solar energy, and a nuclear weapons expert in Boston told me he asked the journal *Science* whether it would be interested in publishing details on his scheme to lighten the ocean's surface with trillions of tiny bubbles.

Is geoengineering a bad idea whose time has come? Driving hybrid cars, using solar, wind, and nuclear power, or storing carbon dioxide

from coal plants in the ground are the conventional solutions that would reduce the amount of carbon we emit into the atmosphere. But they may or may not be enough to avert disaster. For one thing, living sustainably won't solve the problem of the carbon that has already accumulated above our heads. "Unless we can remove carbon dioxide from the atmosphere faster than nature does, we will consign Earth to a warmer future for millennia or commit ourselves to a sustained program of climate engineering," says Keith. If things get out of hand, there could be few alternatives. "The recognition that there is no other way to actually prevent further warming this century is a sobering thought and forces us to look at these options," Caldeira says.

There are two broad categories of schemes to engineer the climate. Techniques that deflect sunlight back into space before it can strike Earth's surface are the more radical and more potent variety. Mimicking the cooling effects of volcanoes and brightening clouds over the ocean are two examples that have gotten the most attention. Scientists have also envisioned launching enormous reflectors into orbit around the Sun or Earth, or genetically altering plants to make them shinier. Enhancing the planet's natural reflectivity is generally "fast, cheap, and uncertain, but it does very little to manage the carbon in the air," says Keith.

The other type of geoengineering strategies work by reducing the greenhouse effect by drawing down carbon dioxide from the atmosphere. These include growing algae in the ocean or altering the chemistry of the ocean to enhance the natural process in which it acts like a sponge to suck up carbon dioxide. "Slow and expensive, but it gets the carbon out," says Keith.

Geoengineering invites mishap by altering aspects of the climate system about which we know the least. Adding sulfates to the sky and brightening clouds rely on the role of tiny droplets known as aerosols, which have a huge but mysterious influence on climate. The carbon-sucking category of geoengineering generally depends on the global cycle that governs the planet's flows of carbon, another big unknown in various climate models. It's not even

clear right now that we understand our proximity to disaster. We're not sure how ice sheets melt, or how quickly. We can't quite track the world's carbon, whether it escapes into the atmosphere from a compact car or a rotting tree stump. Over the past century, scientists have steadily realized how subtle changes in the ocean, the sky, and the continents can have profound global effects. That raises the frightening possibility of catastrophes such as droughts and stronger snowstorms or hurricanes happening with little notice or after seemingly small pushes. But, conversely, a system that is responsive to subtle perturbations raises the hope that scientists might be able to use such levers in an effort to avert one disaster or another.

Holdren, Obama's science adviser, compares the climate crisis with sitting "in a car with bad brakes driving toward a cliff in the fog." The bad brakes are the natural buffers that usually maintain the planet's temperature, which are slow to react and may be overwhelmed by the warming our pollution is causing. If we stopped our carbon dioxide–pollution binge today, at least one degree of warming would still occur, due to the long life of CO_2 in the atmosphere and the relentless warming of the oceans. The cliff is the possibility that the greenhouse gases spewing into the atmosphere will cause a catastrophe. The fog is the uncertainty that pervades climate science—the precipice could sit a hundred feet or a mile away. It clouds decisions about how severe the problem is, how much cost we should be willing to bear to avoid it, and what the repercussions might be—how steep the ravine—if we fail. Geoengineering? That's downing half a pint of Jägermeister, yanking out the car's power steering cable, and possibly hitting a tree before the cliff ever arrives, hoping the damage isn't worse than the fall would have been. Famed environmental scientist and writer James Lovelock compares the concept of geoengineering to "19th-century medicine," with all its implied ignorance.

In 2008, Colby College weather and climate historian James Fleming told me he thought climate scientists had "lost their minds" in their enthusiasm to pursue geoengineering studies. Or, as he put it later, scientists were "sincere but perhaps deluded." Indeed, humanity

has never tried anything as audacious as geoengineering—unless you count our 160-year effort to take carbon from the ground and put it into our atmosphere. To cogently oppose geoengineering research, however, one has to accept one of two faulty propositions: either the problem is not that serious, or we're on our way to solving it. These days, one will be hard pressed to find many takers for either.

Which is why there's been next to no opposition as the meme has spread steadily since the Harvard meeting. Environmental groups in Washington, D.C., have kept mostly quiet on the idea, though representatives from both Greenpeace and the Natural Resources Defense Council have signaled support for regulated research. Left-wing climate blogger Joseph Romm argued in 2009 that it would be foolish to "choose an experimental combination of chemotherapy and radiation therapy that might make you sicker if your doctors told you diet and exercise—albeit serious diet and exercise—would definitely work." And yet, like ETC Group, Romm admits that "there is no reason not to do some research."

It's one thing to take climate scientists' word when they describe palpable impacts that climate change is having on the globe. It would be quite another to believe them in the future if they say they know the planet's moods well enough to reasonably predict what altering them might cause, regardless of how gently they push. Taking planethacking seriously means weighing its possible unknown risks versus the unknown risks of the planet's current, frightening trajectory. The Santa Barbara geoengineering study, which Battisti had joined after the Harvard meeting, grappled with the issue as it prepared to release its report in 2009. An early draft of the press release described reducing emissions as "the preferred Plan A" to solving the climate crisis. Geoengineering the stratosphere, it said, was "little more" than an idea that may or may not work, "a Plan B to buy time if mitigation is not succeeding." But several members of the study worried that the wording too explicitly connected the two options. The draft that was eventually published said that

geoengineering "might" possibly provide planetary insurance, since "even with aggressive global efforts to reduce greenhouse gas emissions, scientists cannot rule out the possibility of rapid changes in the climate system."

In 2000, Nobel Prize–winning chemist Paul Crutzen, writing with colleague Eugene Stoermer, suggested provocatively that Earth had entered a new geologic epoch that humans had instigated. Previous epochs, such as the Eocene and the Pleistocene, were marked by natural geologic and climatological shifts such as glacial retreats or the establishment of the savannas. In contrast, they wrote, humanity's greenhouse gas problem, deforestation, the destruction of the ozone layer, and the accumulation of a variety of pollutants in the atmosphere characterized the new era. Up to half of Earth's surface has been transformed by humans. We have supercharged the rate of species extinction up to ten thousand times in the tropical rainforests. "It seems to us more than appropriate to emphasize the central role of mankind in geology and ecology by proposing to use the term 'Anthropocene' for the current geological epoch," they wrote. Barring a global catastrophe such as an epidemic or an asteroid impact, they said, "mankind will remain a major geological force for many millennia."

The advent of geoengineering takes the concept of the Anthropocene one step beyond the inadvertent impacts that humanity has already had on the climate. It could be the deliberate control of the atmosphere that will redefine our species' dominant ecological role on Earth as the Anthropocene unfolds. Perhaps there's something about us that makes it natural to pursue that course. And yet it can be unsettling to detect the hardwired urge to solidify that dominance. Even when scientists feel a moral compunction to stop what they're doing, there's a natural drive, a curiosity, an inclination to tinker that tends to override even strong ideological misgivings.

Robert Wilson, a physicist who had led the cyclotron effort at the Manhattan Project, said decades later he "cannot understand" why his strong moral misgivings did not lead him to quit the project

after Germany was defeated in 1945. "Our life was directed to do one thing," he said. "We as automatons were doing it."

"When V-E Day came along, nobody slowed up one little bit," said physicist Frank Oppenheimer, brother of Robert, the head of the project. "It wasn't because we understood the significance against Japan. It was because the machinery had caught us in its trap and we were anxious to get this thing developed."

David Battisti told me he'd experienced a similar sensation of momentum upon arriving at Santa Barbara to design the world's first comprehensive geoengineering research effort. He was explicit about the comparison. "This feels like what I've read about [what] developing the bomb felt like," he told the others on the second day of the effort. "You have to do this because, God help you if you actually use it, you want to make sure it works. You hope to God this is never used but if you have to use it, you better know how it behaves."