

HOW TO BRING A MOONSHOT DOWN TO EARTH

Want to turn a big idea into a real business? Here's an inside look at how Google's attention-grabbing "moonshot factory" does it—by thinking big, killing ideas quickly, reimagining problems, and every so often, producing a company like **Dandelion** that just might change everything.

by **FRANCES DODDS**



Elaine Weir is retired, which means that—apart from the swimming lessons she teaches a few times a week—she has a lot of time on her hands. So in the summer of 2019, when she saw a Facebook ad for the geothermal energy company Dandelion, she called them up to investigate. “I had no intentions of buying this thing,” she says, with a conspiratorial cackle. “But my daughter suffers from asthma, so I wanted to do my small part to reduce our footprint. We were considering an electric car, but then I saw this...”

She agreed to let a salesman come to her home, a 100-year-old Tudor in the New York City suburb of Scarsdale. “He explained this and that,” she says. “But when he said I could get rid of the air conditioning, that’s when my ears perked up.” Like many homes, her HVAC system required a giant, noisy set of outdoor AC condenser units. “I said, ‘You mean these don’t have to be here?’ They’re right next to my screened-in porch, and I can hear them in the middle of the night, and they’re just plain annoying.”

This wasn’t the only information that impressed Weir that day. She learned that geothermal energy is the most sustainable way to heat *and* cool a home—emitting about one-fifth of the annual carbon dioxide that a gas- or oil-fueled system does. Once installed, it’s also the most cost-efficient method out there, chopping down the average energy bill by 65% or more. Considering that geothermal technology has been around since the 1940s, Weir wondered, how was this the first she was hearing of this?

That’s exactly the question that Kathy Hannun, who founded Dandelion, began asking seven years ago—in a place far, far away from the tidy lawns of Scarsdale. Back then, Hannun was working at X, Google’s “moonshot factory” in Mountain View, California.

“At the beginning I was just trying to figure out: Why have geothermal heat pumps not taken off?” Hannun says. “And are any of those reasons *good* reasons? Meaning, if they were good reasons, there was probably nothing I could do about it. But what if all the problems were just circumstantial?”

For anyone interested in untangling a knotty, big picture problem, Hannun’s line of inquiry is a great place to start. And in her case, those questions would propel a long, complex project that gathered momentum at X, then spun out into its own startup, flopped, was reenvisioned, wiggled out of numerous chokeholds, and is now finally doing what many founders dream of: giving people something that makes their lives better, for less money, while helping the planet.

In other words, the story of how Hannun’s company started on the whiteboards of Google’s “moonshot factory” and made its way to Elaine Weir’s backyard is also a case study on what it takes to bring a moonshot down to earth.

Rule #1/ Kill great ideas.

There are a lot of big, exciting ideas in the world. Most of them are unattainable—but some of them are *almost* attainable. Those are the most dangerous ones, because founders can lose years or even decades of their lives trying to make them work.

At X, they have a saying: In order to create world-changing busi-

nesses, you have to be “passionately dispassionate.”

“We are obsessed with getting to big, exciting opportunities as efficiently as possible,” says Astro Teller, the CEO of X. “But once you commit to that efficiency, you have to winnow really harshly on the basis of evidence. We are paying people to be passionately dispassionate. You can get a lot done by being so passionate that you’ll just blast through obstacles. But if your idea isn’t right, or the world changes in various ways, it could just be hot coals out to the horizon. And you being willing to walk over them won’t change that fact.”

Teller is sitting in a conference room. On the wall behind him, there’s a banner that reads “Keep Alphabet Weird,” and on the table in front of him, there’s a thing that looks like a crystal ball. (“It’s actually a moon. Someone got me this because, you know, moonshots. It’s fun; it rotates.”) He’s wearing a Tigger T-shirt under a zip-up hoodie, and his gray hair is pulled back in a low ponytail. It all checks out for a CEO known to rollerblade between meetings.

Google X (now just X) was founded in 2010 as a laboratory for world-changing ideas that would, ideally, become profitable businesses for Google’s parent company, Alphabet. Housed in a converted shopping mall—with stratospheric internet balloons hanging in the lobby and robot prototypes rolling around, sorting trash—the moonshot factory is emblematic of a somewhat more optimistic era in big tech. Its highest-profile success is Waymo, Google’s self-driving car project. It also hatched Wing, which makes delivery drones; the cloud-based cybersecurity suite Chronicle; industrial robots company Intrinsic; and life sciences company Verily. Other X projects have been integrated into existing Alphabet companies, including deep-learning technology Google Brain, which fuels Google Search and Google Translate, and GCam, a camera software that’s part of Google’s Pixel phones. Some others, like an internet balloon company called Loon, have recently shuttered.

Working at X sounds like it would be fun—the closest you could get to living like a mad scientist. But it’s not for everyone. “There are people who are very entrepreneurial,” Teller says, “but they’re



PHOTOGRAPHS BY CHRIS MICHEL(ASTRO TELLER); DANDELION (KATHY HANNUN)

unhappy here because they have an idea and they just want their idea to win. They’re like, ‘But it *could* still work.’ And I’ll say to them, ‘I agree with you. But I don’t care that it *could* work.’” Teller has found that the instinct to assess exciting ideas with passionate dispassion is actually pretty rare.

But Kathy Hannun, it turns out, was a natural.

When she graduated from college in 2009, Hannun knew she wanted to work in renewable energy, and figured that nonprofits were the quickest route to making a difference. But after working with a few underfunded organizations in Mexico and the Philippines, she decided to “figure out how to be effective in the world.” For better or worse, that meant going where the money was. She saw a customer support opening at Google, and—despite never having wanted to work at Google, and having no interest in the job itself—she took it. “I was like, Google’s a big company, they’re highly effective in the world, they have a ton of resources. We’ll see where it goes,” she says.

While working as a full-time Googler, she completed a master’s degree in computer science at Stanford. That got the attention of the fledgling team at X, which was hiring for an entry-level marketer. And before long, Hannun saw her opportunity.

X is a collaborative culture, and even though she was junior on



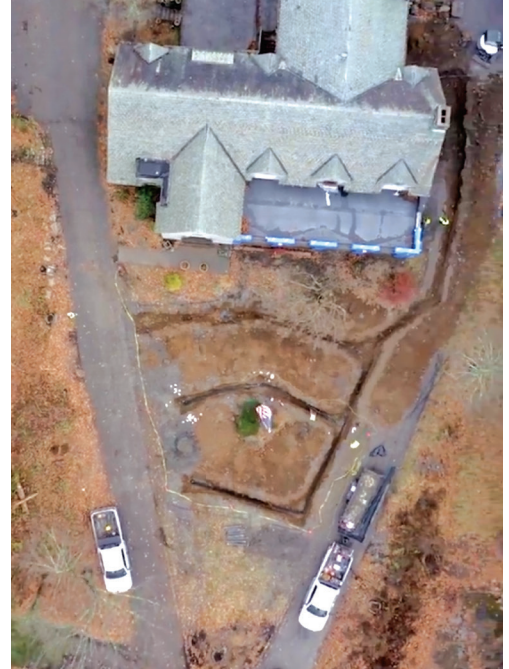
→ MAKING MOONSHOTS
Left: Astro Teller.
Right: Kathy Hannun,
presenting on
Dandelion.

the team, Hannun volunteered to lead a project that attempted to turn seawater into carbon-neutral fuel. She was in her mid-20s, and the only woman on a team of men at least a decade older, who all had Ph.D.s. But her readiness to jump in impressed leadership. “She had no background in any of this,” Teller recalls, “but she’s such a learning machine that she was like, ‘I’ll figure it out.’” And she did, Teller says. She brought the team together, made impressive progress, and oversaw the development of a machine that *did*, in fact, turn seawater into methanol. And then...she killed it. She published the results, and washed her hands of it.

“It’s one of the best kills we’ve ever had,” Teller says.

By that, Teller means that Hannun was able to assess the project with passionate dispassion, using a key tool in the idea-winning process: kill criteria. “Early on in a project,” he explains, “while things are still good and most people can be sort of reasonable, I’ll say, ‘What would be evidence that the reward-risk ratio just isn’t good? Tell me what you hope to learn over the next six months or year.’” That way, project leaders have a way to track their progress and an agreed-upon understanding of what success or failure would look like. “The ultimate purpose of the kill criteria,” Hannun says, “is a kind of forced clarity.”

In the case of the seawater fuel, the kill criteria was straightfor-



DIRTY WORK

From top left: Hannun working on seawater fuel, Hannun on site at a geothermal installation.

ward: They needed to be able to produce a \$5 gallon of gasoline equivalent, at scale. It was the only path to a viable business. And as Hannun developed the project, that looked increasingly unlikely. First, the membranes used to take carbon dioxide out of the seawater degraded too quickly, and were expensive. Then it was too difficult to pump seawater from a regulatory perspective, which meant they were reliant on desalination facilities that had no incentive to work with them—and anyway, those plants produce so much carbon dioxide that it made the carbon savings kind of moot. “She understood that her job wasn’t to make seawater fuel work at all costs,” Teller says. “Her job was to answer the question: Could this be a once-in-a-generation opportunity? And her conclusion was, ‘We think we could get to a \$15 gallon of gas equivalent. That’s just not gonna save the world.’”

For her part, Hannun says killing that project wasn’t as hard as it might have been, because she’d already started researching geothermal energy. “Ultimately it’s an opportunity cost thing,” she says. “In my ideal life, I would use my time to do something impactful. As soon as it became clear how many barriers there were to scaling seawater fuel, I was like, ‘Then why are we doing this?’ The heat pump thing could also be incredibly world-changing. And the problems just seemed so much more tractable.”

Rule #2/ Revisit ideas.

Where do breakthrough ideas come from? We like to think they appear out of thin air—a visionary’s stroke of genius. But the team at X knows better. Sure, some ideas *seem* to come from nowhere. But many are just in hibernation. They were tried and abandoned. They were ahead of their time. Or maybe they were only circulated in academic circles, and never given a real-world try.

“What we should be world-class at here is evaluating ideas,” Teller says, “whether they’re our ideas or somebody else’s. The ‘pride of ownership,’ and ‘not invented here’ attitude—those are sources of inefficiency.”

Geothermal systems, for example, had already been around for over half a century. That’s why Hannun’s first task was revisiting assumptions around them—without taking for granted that she could do better. “There are a lot of good reasons the world is the way it is,” Hannun says. “So it’s good to have humility, and not be too dismissive. But it’s also good to have curiosity—like, I’m sure there are reasons, but can I understand the reasons? Based on your research, sometimes you realize, ‘Yep, there *is* a good reason it’s always been done this way.’ But sometimes there isn’t.”

As she researched geothermal, she began to understand why it had never gone mainstream. ▶



Geothermal heat pumps work by transferring heat into and out of a home using a refrigerant, like an air conditioner does. But instead of moving heat into and out of the air outside the home, the heat pump is connected to ground loops, or plastic pipes, that extend vertically 250-500 feet into the earth, where the temperature is constant year-round (usually about 55 degrees). In the winter, the pumps extract heat from the ground loops to warm the house, and in the summer, the heat pumps remove heat from the house and dissipate it into the ground through the loops.

The mechanics are fairly simple, but the installation process is not. Traditionally, the rig needed to drill a hole that deep in the ground is the same kind you'd use to dig a well, which is about 21 feet tall, eight tons, and transported on a bed the size of a semitruck. Fitting that equipment in most suburban backyards is impossible. But could that be solved for? Yes, Hannun came to believe. No one had bothered to source smaller, more efficient geothermal drilling equipment—but only because there wasn't enough market demand. "So this is a chicken or egg situation where no one has the incentive to solve that problem," she says. "But I said, 'Okay, if a company existed specifically to solve this problem, that would be possible, right?'"

This was the idea she brought to the team at X, and they were into it: They could develop a robotic solution, with optimized drilling equipment. They called the project Dandelion, and got to work.

But that's when Hannun began exploring another problem: cost. While the lifetime price tag of a geothermal system is cheaper than a traditional gas or oil system (because it's so efficient to run), the upfront cost of installation was unaffordable for most homeowners: somewhere in the ballpark of \$60,000 to \$80,000. And there was no financing system available to help people pay over time. Hannun realized that to make geothermal accessible to the masses, she needed to develop an end-to-end marketplace that advertised geothermal, sold it, matched customers with HVAC companies to install the systems, liaised with banks to finance customers' purchases, helped customers understand ever-changing government rebates and incentives, and generally manage the whole experience.

This changed everything.

Teller says that, in the early stages of developing a business, it's often difficult to predict exactly what the nature of your problem will be, or who the best partner will be to help you get there. You must constantly revisit assumptions about where you're headed, and who to work with, and you can't force old ideas to work in new realities. That's what happened to Dandelion: It was conceived as a technology project, which was perfect for X, but it was morphing into a financial, marketing, and communications project, which was not.

Hannun believed in her concept. But it wasn't going to happen at Alphabet. "It was a startup," she says. So in April 2017, Dandelion spun out into the world.

Rule #3 / Focus on the hard problem(s) first.

When explaining the X approach to solving problems, Teller often uses a metaphor. Maybe you've heard it; the media has repeated it a lot. Say you were told to teach a monkey to recite Shakespeare while standing on a pedestal. What would you do first? Some might build the pedestal, to make quick progress. But Teller says that's foolish, because building the pedestal is the easy part. The hard part is teaching the monkey to recite Shakespeare. So until you've figured out if you can do that, you're wasting time with low-hanging fruit.

Hannun says this framework can be useful, but cautions that, in most cases, it isn't always clear which problems are big and which are small. "With Dandelion, there were many problems," she says. "So part of our journey was learning what problems matter *right now*."

The first was the outdated drilling process, which is most of what her team worked on at X. Once the company spun out on its own, she raised seed money, and began marketing and raising awareness. Then she needed to figure out who would actually *install* these geothermal systems, since she didn't have her own team of expert contractors. To solve this, she convinced a bunch of HVAC companies to offer geothermal installations on top of their existing businesses. Finally, they locked in a partnership to provide zero-down financing to customers. By its launch date, Dandelion had gotten a ton of interest from homeowners.

The hope was that all these solutions they'd worked out would hold together, but when Dandelion actually launched, Hannun says, their plan "pretty much immediately failed."

The big problem they hadn't foreseen was how hard it would be to maintain quality and customer experience. Because the geothermal industry was still so niche, almost no one at the HVAC companies they'd contracted with had experience actually installing these systems, which meant that many installations became a complicated, frustrating process for both the customer and the contractor. And because geothermal was only a small fraction of the HVAC companies' overall business, the geothermal jobs were lower priority, and the companies weren't willing to put resources toward training workers and streamlining their processes.

"We didn't recognize the workforce issue when we were at X because we hadn't gone to market," Hannun says. "But within a few months, it became clear that no one had done the fundamental groundwork of asking, 'How should these projects go?'"

Now Hannun had found the real problem: Before she could build anything else, she needed to learn how to actually install the thing she was selling. This meant vertical integration—hiring installers, dealing with warehouses and permits and licenses and all the dirty work. "All of it," she says. ►

Rule #4/ Think big, but be honest.

“All of it,” of course, was going to cost a lot more money. So Hannun started fundraising again. And in this endeavor, she confronted an unexpected problem: One of the most foundational lessons at X—to be “passionately dispassionate”—could actually be somewhat counterproductive in the real world.

Hannun had learned to be brutally honest and transparent about her project’s weak points. “But in fundraising, the norms are very different,” she says. “Investors are looking for the founder with the big vision who believes they’re gonna take over the world.” They wanted her to be more passionate, and less passionately *dispassionate*. Hannun has adapted, but never fully subscribed to this mindset. “I think it’s too bad,” she says. “I feel like that attitude among investors limits the type of personalities they fund in a way that might not always be useful to them.”

None of this is news to Teller. X was designed intentionally to shield the process of idea development from norms that govern the business world. When fundraising, Teller acknowledges, “being really honest is short-term stupid.” But he also started five companies before going to X, and remains convinced that founders should lean towards honesty, even if it’s not what investors expect.

“For my second company, I remember sitting down with the woman who gave us our first term sheet,” he says, “and I started trying to talk her down on the valuation. She was like, ‘Oh honey, I’m sure you’re a very good tech person, but you don’t understand how this works. You wanna talk me *up* on the valuation.’” But he insisted. And eventually, that investor would end up on the board of his company. “I really believe that, even from a brass tacks business perspective,” Teller says, “things like being honest and vulnerable and telling the truth—those behaviors are long-term smart.”

Rule #5/ Expertise is optional. Clarity is not.

When you set out to solve a giant problem, it’s understandable to wonder: *Can I really do this?* After all, most unsolved problems are complicated. Many require technical skills or intensive industry knowledge. What if you don’t have any of that?

Hannun was first seized with this sort of imposter syndrome when she was at X, leading the seawater fuel project. “Back then, I put a lot of value on domain knowledge,” she says, “which I did not have.” Her only real qualification was the fact that she’d asked to do it. “The opportunity felt very unlikely,” she says.

But as she muddled along and found her footing, she began to understand something about her role.

“Some people are domain experts, and some people are the connective tissue between domain experts,” she says. “My job was to see the perspectives of many stakeholders and bring them together. I didn’t need to know electrochemistry, because I had professors on the team who were experts in that. I just needed to be able to communicate with them about what was important, and why.”

As time went on, she began to trust the value of this skill set. The essence of her job, she now believes, is to give people *clarity*.

“I believe I can take on any problem as long as I have three things: an understanding of the nature of the problem, the experts needed to solve the problem, and the ability to motivate those experts,” she says.

With Dandelion, Hannun understood the nature of the problem for a long time. But she struggled with finding the experts to solve it. So for a few years, Dandelion busied itself with simplifying the drilling process and training workers on how to do it. “It was literally choking our growth,” Hannun says. But then, in 2021, they had a breakthrough. After going down a rabbit hole on YouTube, Hannun

“YOU CAN GET A LOT DONE BY BEING SO PASSIONATE THAT YOU’LL JUST BLAST THROUGH OBSTACLES. BUT IF YOUR IDEA ISN’T RIGHT, OR THE WORLD CHANGES IN VARIOUS WAYS, IT COULD JUST BE HOT GOALS OUT TO THE HORIZON.”

came across a video of geothermal drilling in Sweden, where 20% of homes run on geothermal energy. What she saw intrigued her, so the Dandelion team took a field trip across the pond. The “Swedish method,” as they call it, was a revelation. “It was literally five times better than anything we had seen,” Hannun says. “They had optimized for drilling equipment that was safe and small, inexpensive to transport, easy to train people how to use and service. They had 50 years on us to figure this out. And they were so eager to teach us.”

Since then, Hannun says, Dandelion’s growth has exploded. “It totally solved the bottleneck.” In 2022, their revenue more than doubled. They’ve cut the cost of installation for each home in half; it now averages \$25,000 to \$30,000, where it used to be \$40,000 to \$60,000, and Hannun says it will only go down from here. “I am so aware right now of all the things in our cost stack that are still under-optimized and more expensive than they need to be,” she says. “We’re still on the steep part of the cost curve, and I predict it will continue, like we saw with solar.”

As of last October, Dandelion announced that they’d installed 1,000 geothermal home systems—which, by 2050, will collectively reduce carbon emissions by 413,000 tons, the equivalent of removing 13,000 cars from the road.

OF COURSE, when Elaine Weir saw Dandelion’s ad on Facebook, she knew none of this. She just saw a company selling something that sounded better than what she had. Now she walks out of her house every day and delights in the change.

A few feet from her screened-in porch, where the noisy HVAC units used to be, there’s a towering sunflower that stands vigil over a “three sisters” garden, with corn, squash, and beans. “I got, like, 20 ears of corn!” she says. “They were disgusting, but I ate every one of them.”

That’s not the only thing growing. The real estate valuation of her house has gone up, thanks to the land she reclaimed and the value of the geothermal system itself. Plus, when everyone’s energy bills skyrocketed during the pandemic, hers stayed the same. And while the heat pumps aren’t advertised as basement dehumidifiers, Weir says they’ve made “the air very luxurious down there.”

So she’s become something of a geothermal evangelist. And not too long ago, her neighbor told her she’d decided to take the leap with Dandelion, too.

That’s how it goes at the beginning, with a world-changing idea. Problem by problem, person by person, leap by leap. And then, all of a sudden, all the reasons it once seemed impossible don’t seem like very good reasons after all. **E**

Frances Dodds is Entrepreneur’s deputy editor.