HOMES DESTROYED. BODIES WRECKED. FAMILIES RIPPED APART. THE BASHAR AL-ASSAD REGIME'S INDISCRIMINATE AIR STRIKES HAVE TERRORIZED SYRIAN CIVILIANS FOR YEARS. NOW A SMALL BAND OF ACTIVIST-ENTREPRENEURS IS BUILDING A SENSOR NETWORK THAT LISTENS FOR WARPLANES AND WARNS PEOPLE WHEN AND WHERE THE BOMBS WILL FALL—GIVING THEM JUST ENOUGH TIME TO SURVIVE.

by

DANNY GOLD

EVERY SECOND COUNTS

ON THE MORNING OF APRIL 11,

Abu al-Nour was lounging at home in a small town in Syria's Idlib Province. It was a pleasant day, and his seven children—ages 2 to 23—were playing outside or studying inside. The house was small, but al-Nour was proud of it. He had built it himself and enjoyed having family and friends over to spend time in the big yard. His wife was cooking lunch in the kitchen.

Al-Nour is a farmer, as were many of the town's residents, but since the Syrian civil war started in 2011, fuel and fertilizer prices had shot up well beyond his means. Al-Nour had been getting by with the odd construction job or harvest work here and there. The area had fallen to rebel forces in 2012, and though his village was too tiny for the rebels to bother with much, he'd noticed fighters from the Free Idlib Army and Jaysh al-Izza groups passing through on occasion.

Being in rebel-held territory meant government air strikes. The bombings began in 2012 and got worse in 2014. Many villagers fled out of fear. Others fell deeper into poverty, their businesses ruined by the relentless conflict. When the first air strike hit al-Nour's neighborhood, he says, it killed eight people from one family. Al-Nour tried to help with rescue efforts, but instead was overcome with grief, unable to move. Afterward, he couldn't stop imagining what could happen to his family. Finally, five long years into this reality, he heard about a service called Sentry from a friend. If he signed up, it would send him a Facebook or Telegram message to let him know a government warplane was heading his way.

Around noon on that day in April, al-Nour's phone lit up with an urgent warning: A Syrian jet had just taken off from Hama air base 50 miles away. It was flying toward his village.

He panicked.

He shouted to his family and grabbed the younger children. The group dashed out to a makeshift bomb shelter that al-Nour called his "cave." Many residents of the heavily bombed areas in Idlib had dug similar shelters—really, just holes in the ground—and fitted them with something like storm-cellar doors.

Al-Nour managed to get all his children into the cave, but not his wife. He kept calling her name as he heard the awful sound of an approaching jet overhead. His wife reached the door to the shelter just as a bomb hit. Al-Nour remembers the door blowing off the cave, everything shaking, and an almost unbearable pressure in his ears. "It smelled of dust and fire," he says. "The dust was everywhere."

Shrapnel had pierced his wife's back. Some of his children were in shock; others were crying. Through the smoke, he could tell that his house was destroyed. Still, everyone was alive. For that he was grateful. "We saw the death with our own eyes," al-Nour says over the phone through an interpreter. "Without the Sentry warning, my family and I would probably be dead." (Al-Nour is a pseudonym; he fears using his real name.)

In the seven years since the start of Syria's civil war, it's estimated that at least 500,000 Syrians have been killed. That number includes tens of thousands of civilians killed in air strikes carried out by Syrian president Bashar al-Assad's regime and its allies. (Meanwhile, US and coalition forces are estimated to have killed as many as 6,200 Syrian civilians in their air campaign against ISIS.) Assad's forces have been accused by the international community of war crimes for indiscriminate bombings. Six million Syrians have fled the country, creating a refugee crisis in the region and the world. International efforts to find a peaceful resolution continue to fail. The Assad regime has slowly regained territory; about two-thirds of the people in Syria currently live in areas under government control. The rest are in places held by an array of rebel groups as well as Kurdish and Turkish forces. Millions of people still live in unending fear of the sound of fighter jets overhead.

The conflict has left many Syrians feeling defeated. Huge swaths of the country have been laid to waste, and the humanitarian crisis isn't expected to get better with coming government offenses. And yet even if these larger forces are implacable, a small effort can sometimes make a meaningful difference—like helping a family of nine escape with their lives.

The warning that came over al-Nour's phone was created by three men—two Americans, one a hacker turned government technologist, the other an entrepreneur, and a Syrian coder. The three knew they couldn't stop the bombings. But they felt sure they could use technology to give people like al-Nour a better chance of survival. They're now building what you might call a Shazam for air strikes, using sound to predict when and where the bombs will rain down next. And thus opening a crucial window of time between life and death.

As a kid in rural McHenry County, Illinois, John Jaeger didn't have much to do until his stepdad built him a homebrew 486 computer. It was the late '80s—still the early days of PCs—and he mostly played videogames. Eventually he found his way onto a BBS with connections to the demoscene, an early underground subculture obsessed with electronic music and computer graphics. By the time he was 15, Jaeger was in deep with hackers, software crackers, and phone phreakers.

"We would exploit weaknesses in computer networks in order to gain administrative privileges and learn how the networks worked," Jaeger says. He messed around but adds that he didn't do anything more "destructive" than hack into Harvard's system to give himself a Harvard.edu email address.

Jaeger took a job at modem manufacturer US Robotics right out of high school, followed by a gig at General Electric Medical Systems. The promise of "good drugs and startup parties" lured him to Silicon Valley in the late '90s. The adventure, he says, was "forgettable." He took computer security and network management jobs before working his way up to IT director. "I basically made all the wrong decisions," he says. "Instead of becoming a multibillionaire, I went and worked for three companies that don't exist anymore."

Jaeger moved to Chicago and got a job in the financial industry. He designed and developed a trading platform and did risk management analysis. He was enjoying the work, but then the financial crisis hit. "I saw 20- and 30-year veterans of Wall Street soiling their trousers, genuinely scared," he says. "It was really humbling." That experience, he says, turned him off finance. But it was another three years before he finally left the industry.

Through a friend who had worked on President Barack Obama's reelection campaign, he got an introduction to someone in the State Department. It was 2012, a year after the start of the Arab Spring, and the US government

was recruiting people who could bring corporate experience and technical expertise to Syria. Jaeger wasn't exactly familiar with the civil war that was building. "I had no idea what was going on," he says. But he wanted to go overseas, so he relocated to Istanbul and basically became a consultant for the people trying to achieve a semblance of normalcy in areas of Syria that weren't under Assad's control.

"You had a whole lot of chiropractors and dentists suddenly respond to the needs of their local communities in a way they had never anticipated," Jaeger says. "These guys need clean water. These guys need power. These folks need medicine." Jaeger's job was to help them figure out how to provide services and maintain some stable governance.

In October 2012, he started working with journalists and developing a program to support Syrian independent media. But two years in, the conflict started wearing on him. Jaeger had grown attached to many of his Syrian contacts and mourned when they were killed. Everyone he knew had lost family. It became clear that the biggest problem he could address was the bombing of civilians.

Options for mitigating the damage from air strikes, Jaeger knew, were few. And most were out of his reach. You could stop them. But even the international community had failed to do that. You could treat people after the air strikes hit. Various groups, like Syria Civil Defense, were doing that work. Or you could warn people ahead of time.

That last option seemed within his technical expertise. So he approached the State Department. But when he couldn't rally any interest in the idea of an early-warning alert system, he left the agency in May 2015. He was convinced he was onto something. But he needed help.

Dave Levin is a Wharton MBA who had worked for the UN Global Compact under Kofi Annan, had been an entrepreneur in the Philippines, and had consulted for McKinsey. In 2014, Levin founded Refugee Open Ware, an organization that helps people start projects using tech to do good in troubled regions. He was working in Jordan on an effort to develop 3-D-printed prosthetics for victims of war when a Syrian activist connected him to Jaeger. Levin flew to Turkey and the two met to talk about Jaeger's idea. Levin signed on right away. (Refugee Open Ware has since invested in the project, and Levin splits his time between the organizations.)

In November 2015, two months after he met Levin, Jaeger got another lead. An expat friend in Turkey told him there was someone he needed to meet, a Syrian coder who was looking for ways to warn civilians about air strikes. The man, who goes by the alias Murad for safety reasons, grew up in a prominent, largely apolitical family in Damascus.

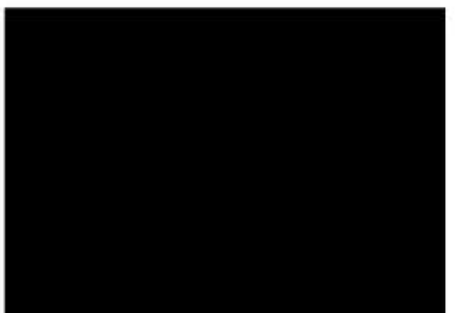
At university, Murad met people from other parts of Syria, young men and women who hadn't grown up as sheltered as he had. Their stories of poverty and repression, of relatives imprisoned or killed by the government, shook Murad. He started to understand the grim authoritarian reality of his country.

When the war started, Murad was in his mid-twenties and a recent graduate with a degree in management information systems. He started working with groups that were housing displaced people. Eventually

OBSERVERS WERE ALREADY WATCHING FOR PLANES. IF HALA COULD CAPTURE THAT DATA AND CONNECT IT TO WHERE THOSE PLANES DROPPED BOMBS, IT WOULD HAVE THE FOUNDATION OF A PREDICTION SYSTEM.

JOHN JAEGER

PHOTOGRAPHS BY RENA EFFENDI



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he realized that this activity had made him a target of the regime, and he fled to Jordan. There, he volunteered as a teacher in a refugee camp. But six months later, troubled by stories he heard from Syrians who were fleeing their homes, he felt he had to return.

Once he got back to Syria, Murad began teaching activists how to keep the government from intercepting digital communications. But regime thugs threatened his family, and he had to flee again. This time he went to Turkey. He started organizing schools for the growing community of Syrian refugees there and helping Syria Civil Defense with data management. As the air war ramped up, he saw more and more Syrians arriving mutilated—and traumatized. "This was horrible," he says. "People without arms or legs."

Murad had an idea: Start connecting civil defense organizations in different towns so they could better communicate about impending attacks. He mentioned the idea to Jaeger's friend. Jaeger and Murad soon met for coffee, and Jaeger offered him a job. It came with low pay, long hours, and no job security. Murad was all in.

With a team in place, the group was ready for the most arduous startup task: fundraising. Jaeger went to VCs, who told him the idea was great—but would never generate billions. They pointed him toward social-impact investors, who told him the idea was great—but they didn't invest in the "conflict space." They suggested foundations—which said they didn't invest in for-profit businesses and sent him to VCs.

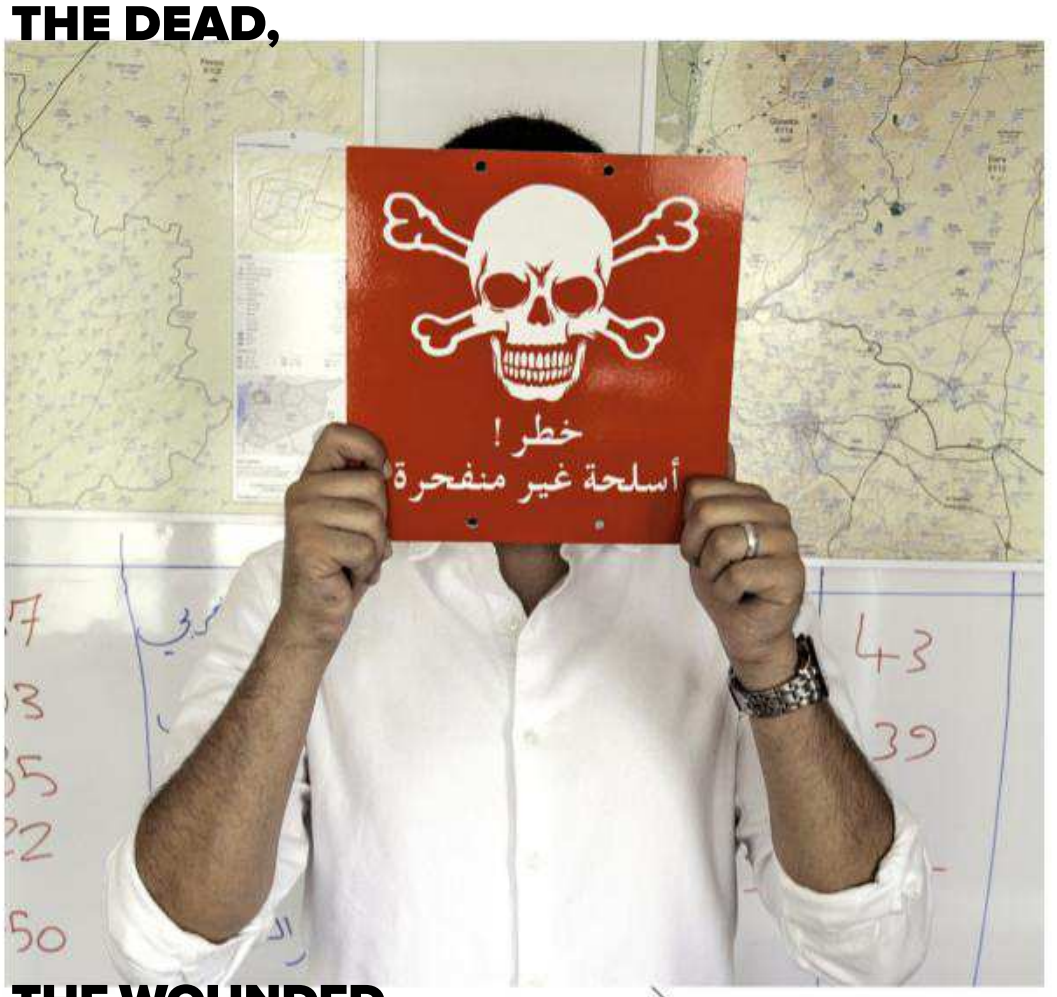
Screw it, thought Jaeger. In late 2015, the cofounders put together what they could from their personal bank accounts and managed to get some funding from an angel investor Levin knew. It was time for their startup, which Jaeger had named Hala Systems, to try to make a business out of saving lives.

During World War II, British farmers and pub owners in rural areas along the flight paths of German warplanes would phone ahead to big cities, warning them when the Luftwaffe was on the way. Seventy years later, Syrian civilians set up a similar ad hoc system. People who lived near military bases kept watch; when they saw a warplane take off, they used walkie-talkies to notify other people, who would contact others, spreading the word up the chain. Many of the participants were members of Syria Civil Defense, known as the White Helmets, who also served as rescue workers. But the process was spotty, unreliable. There was no systematic way for observations to come in and warnings to go out.

Jaeger thought that with the right technology it should be possible to design a better system. People were already watching for planes. If Hala could capture that information and connect it with reports of where those planes dropped their bombs, it would have the foundation of a prediction system. That data could be plugged into a formula that could calculate where the warplanes were most likely headed, taking into account the type of plane, trajectory, previous flight patterns, and other factors.

The Hala team started reaching out to the people who were monitoring the planes, including the White Helmets. At the same time, the team hacked together the first iteration of a system that would analyze data

DAY AFTER DAY, FROM HALA'S OFFICE, MURAD MONITORED THE AFTERMATH OF THE AIR STRIKES—THE DEAD, THE WOUNDED AND THE DYING, THE BODIES, THE BLOOD, AND THE MAIMED LIMBS. "YOU CANNOT STOP CRYING. AND YOU CAN'T GET USED TO IT."



MURAD

ABOVE, MURAD HOLDS A SYRIA CIVIL DEFENSE WARNING SIGN THAT READS "DANGER! UNEXPLODED ORDNANCE."

from the aircraft monitors, predict where the planes were headed, and broadcast alerts to people under threat of attack. Jaeger and Murad sketched it out, eventually filling up a notebook and using napkins to get the rest down. Jaeger says at first the system was just a bunch of if/then statements, a logic tree, and an Android app.

Basically, if someone saw, for example, a Russian-built MIG-23 Syrian warplane take off from Hama air base, then entered that information into the system—now called Sentry—it would issue a warning via social media with predictions about when an attack could be expected to hit a targeted area. It might estimate that the jet could be headed for the town of, say, Darkush with an ETA of 14 minutes, or Jisr al-Shughur in 13. When more people reported a specific plane as it flew over different locations, Sentry could then send more specific and accurate warnings directly to people in threatened areas.

As the team gathered data, they constantly tweaked the formula. Everything was trial and error. "One of the things we learned early on was that our model for predicting arrival times was super aggressive," Jaeger says of Sentry before it was released to the public. "It had planes arriving much faster than they actually did." They couldn't figure out what was wrong. Then they talked to a pilot who had defected from the Syrian air force. "Oh, that's not how we fly that plane," the pilot told Jaeger when the team showed him the system. The program assumed jets would always fly at maximum cruising speed, but the actual speeds were much lower, most likely to conserve fuel. "When we fly that plane, we fly it at exactly these altitudes and speeds at these intervals, using these waypoints," the pilot said. With that information, the Hala team was able to fine-tune Sentry's predictions to be accurate to within 30 seconds of the warplane's arrival.

DAVE LEVIN

HOW THE SENTRY SYSTEM WORKS

Hala's warning system relies on both human observers and remote sensors to collect data on potential air strikes. The startup is working toward making its network more autonomous, the better to save lives. —Andrea Powell

1__When observers near government air bases spot warplanes taking off, they enter the type of aircraft, heading, and coordinates into an Android app, which sends the info to Hala's servers.

2__Sensor modules placed in trees or atop buildings collect acoustic data, which helps Sentry confirm the type of plane, its location, and flight path.

3__Software crunches all the data and compares it to past attacks, predicting the likelihood of an air raid, as well as when and where it might occur.

4__If the potential for an air strike is high enough, the system generates an alert that's broadcast via social media. Hala has also set up air raid sirens that Sentry can activate remotely. The warning system now gives people an average of eight minutes to seek shelter.

5__Using a neural network, an automated system continuously scans Facebook, Twitter, and Telegram for posts that might indicate air strikes.

Precision was essential, Murad says. If Sentry went live too early and was inaccurate, civilians wouldn't trust it, and it would fail to catch on. But Murad was eager to get it out there. Every day it was in development was another day people could be dying. At this point, part of his job was to watch videos of air strikes and look for eyewitness accounts on social media and in news reports to verify the information they received from people on the ground. Day after day, from Hala's office, he monitored the aftermath of the strikes—the dead, the wounded and the dying, the bodies, the blood, and the maimed limbs. "You cannot stop crying, you can't stop yourself," he says, "and you can't get used to it."

Even though the Hala team was still getting by on scant funding, they managed to hire three more Syrians to help Murad look at the video and social media evidence and match it against Sentry's predictions. But it took hours to verify the trajectory of a specific plane from air base to bombing site. And some days there were dozens of strikes. The new staffers couldn't keep up. So the team figured they needed to automate the process. Jaeger hired engineers and researchers to develop software that, with the help of a neural network, could search Arabic language media for keywords that would help confirm the location and timing of an air strike. More data on more air strikes meant better information and better predictions.

As they were working to get accurate data, they also needed a way to get the warnings out to civilians. Murad wrote scripts for Telegram, Facebook, and Twitter, as well as the walkie-talkie app Zello.

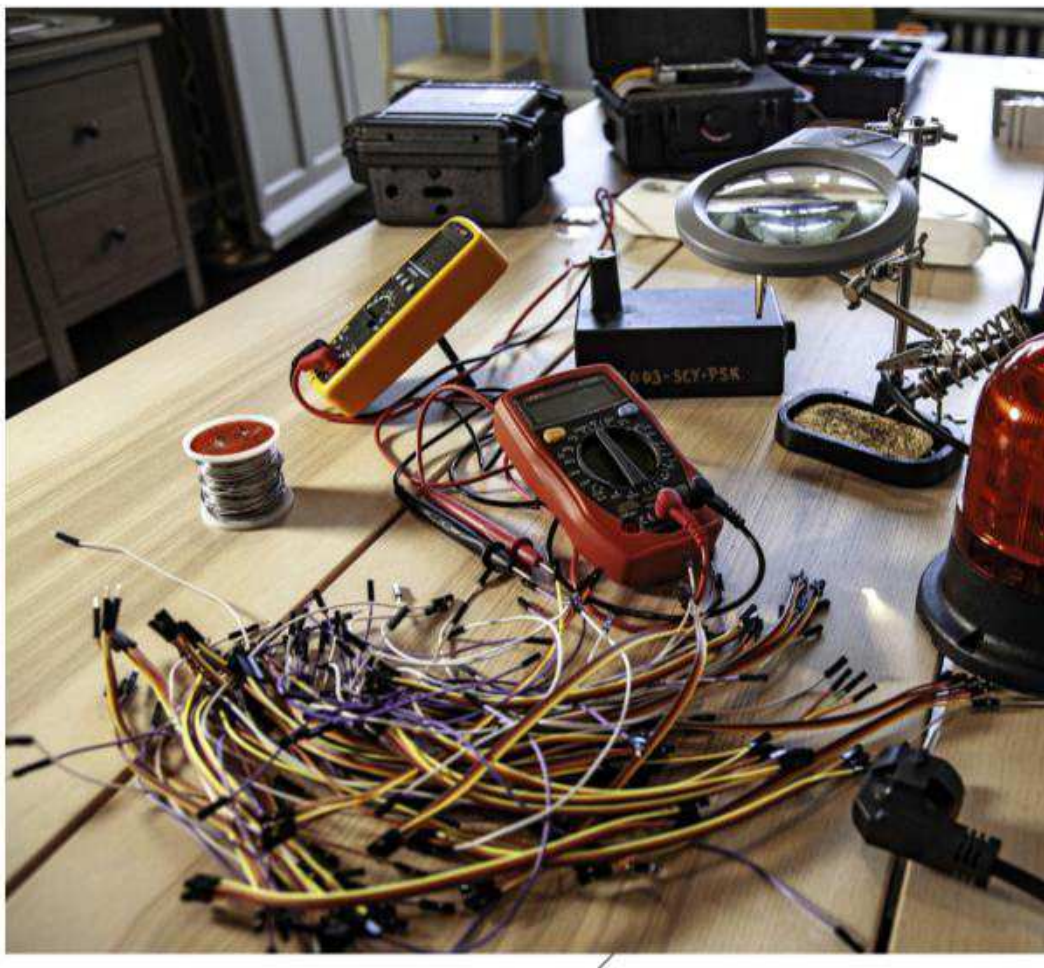
On August 1, 2016, Sentry was ready to go live. The team started small, launching it in part of Idlib Province, which was getting hit hard by air strikes. They reached out to Syrian contacts and shared the news on social media. Volunteers passed out flyers. "Within a day and a half," Jaeger says, "we got a testimonial video from someone who said, 'My family is alive because I logged in and I got this message and I moved from my house. The house got blown up, my neighbors got killed.'"

He showed me the video, sent to him by someone in Syria. In it, a young man, visibly shaken and standing near a pile of rubble, confirms what happened. When Jaeger first saw it, he cried. "It was the first time we actually realized what we had done," he says. "One family being saved. It was all worth it." After that, no one was going to take a break. Levin remembers putting in 90- and 100-hour workweeks. Murad once toiled for three days straight without sleep.

All those hours led to a number of important improvements. Take the warnings. They need to reach as many people as possible, even those without access to cell phones, computers, or radios. Some areas in Syria already had air raid sirens, but they had to be manually activated. That meant running across town. "You're bleeding off minutes at that point," Jaeger says. So Hala modified a siren by adding a component that would let Sentry activate it remotely. The team shipped prototypes, each about the size of a cigarette carton, to the White Helmets, who helped test the units by placing them in civil defense bases and hospitals. There are now as many as 150 of these sirens inside the country, and Hala is figuring out how to make them work even during power and internet outages.

The latest addition to Sentry is a sensor module that's designed to distinguish between airplanes, and gauge speed and direction. Every sound has a unique signature, whether it's a reggae song, a human voice, or the roar of a warplane. To capture the signatures they needed to train Sentry's sensors, Jaeger's team used open source data and field recordings of Syrian and Russian jets. According to Hala, at optimal range Sentry can now identify threatening aircraft about 95 percent of the time.

Jaeger is cagey about how many of Hala's sensor modules are deployed in Syria, but he says they've been operational since March. People have placed the briefcase-sized units on rooftops in opposition-held areas, giving clear access to the sound signatures of government warplanes overhead. The modules are still in development but have been made entirely from cheap, off-the-shelf technology. "Ten years ago this was impossible," Jaeger says, "especially at such a low cost." What Hala has done, essentially, is give Syrian civilians a radar system—and a better chance of surviving against overwhelming and indiscriminate force.



TESTING GEAR IN HALA'S OFFICE

“WE CAN NOW LINK BOMBINGS AND HUMAN CASUALTIES AND ALL THESE WAR CRIMES TO AN AIRPLANE, TO A PILOT, TO AN AIR BASE, TO AN AIR WING, TO A COMMANDER.”

In a five-story walk-up, Jaeger, Murad, and Levin work out of a three-bedroom apartment that has served as Hala’s headquarters since October 2017. Perched on couches, they could pass for cofounders of any startup. A very basic startup: There are a few laptops lying around and not much else. Most coordination with the company’s now 18 employees is done over Slack—many work in cities like London and Washington, DC. Jaeger is fond of mentioning the PhD engineers, researchers, and data scientists he has on his meager payroll.

The company is currently surviving off the initial investment, grants and contributions from the UK, Denmark, US, and Canadian governments, and a small round of funding from friends, family, and a couple of other investors.

As we talk, Murad pulls out his cell phone. A warning has come in: A Russian warplane is circling Jisr al-Shughur, an opposition-held city. Within a minute, Sentry reports it has activated a siren. Minutes later, Murad pulls up a tweet from a Syrian account confirming that an air strike has hit the city. Hala’s data shows that about 11 minutes elapsed between the siren and the bombing. Later analysis showed no deaths or injuries.

Everything about Sentry hinges on a simple fact: The more time someone has to prepare for an air strike, the greater their chance of survival. And now lots of people are relying on Sentry for that edge: 60,000 follow the Facebook page. Its Telegram channels have 16,400 subscribers. A local radio station broadcasts Sentry alerts. And there are all the people within range of the sirens. In surveys conducted in Syria, Hala found that people need a minimum of 1 minute to seek adequate shelter. Had Abu al-Nour not had time to gather his children, they certainly would have been injured or possibly killed. A few seconds more would have kept his wife from injury. Jaeger says Sentry now averages a warning time of eight minutes.

The team knows they have saved lives. But they also did something they hadn’t foreseen: gathered a critical set of data. “We believe we have the most complete picture of the air war in Syria outside of the classified environment,” Jaeger says. That data is invaluable for groups trying to address human rights issues and war crimes. Hala has already made data available to the UN. “From a prosecution perspective, it’s invaluable,” says Tobias Schneider, a research fellow at the Global Public Policy Institute who studies chemical weapons and war crimes in Syria. “We can now link bombardments and human casualties and all these war crimes; we can connect them to an airplane, which means we can connect them to a pilot, we can connect them to an air base, to an air wing, to a commander.”

An official involved in investigating war crimes at an international human rights organization says Hala has played a key role in identifying the perpetrators of attacks on targets like schools and hospitals: “They have laid the groundwork for the attribution of human rights violations to specific parties and, ultimately, for their accountability.”

Jaeger imagines other valuable applications for Hala’s technology, often to monitor hard-to-govern spaces. It could track poachers in Kenya or help poor countries with border security. Essentially, he says, the tech could be useful wherever sound signatures—gunfire, vehicles—can help monitor wrongdoing. It’s like a mash-up of ShotSpotter’s sensor capabilities and Palantir’s data analytics, but aimed at markets that neither of those companies would likely find lucrative enough.

Of course, it could also be used for other, less beneficent, purposes. One need not look far in the tech sector to find products intended to do good that instead cause a lot of harm. Sure, Sentry could be used to stop poaching or track Boko Haram, but could poachers use similar tech to locate elephants, or could a dictator use it to monitor activists? How do you stop it from getting into the hands of bad actors, from being repurposed to target the very people it was designed to protect? What if the Assad regime figures out how to hack Sentry?

Jaegar acknowledges the potential for misuse. Hala is a for-profit business that wants to offer its services to public and private entities and license its tech to other companies. There’s no telling who might be interested in it and how big an offer might be. Jaeger says that Hala will be picky about its clients. Every technology has many uses, he adds. The team’s only goal is to save lives, he says, and he’s confident they can uphold their mission: “We’re not making things that are inherently dangerous. We’re not making weapons.”

After al-Nour’s home was bombed, he and his family salvaged what they could and relocated to a not-too-distant town. Air strikes followed not long after. They fled to a camp for displaced people. When the conditions there became unbearable, they moved to a house near their home village. Al-Nour has tried to find work in factories but hasn’t had any luck. For a while he thought he’d never go back to his home. His children were terrified to return, and he feels a sort of hatred toward it. But he was spending so much of what little money his family had on rent that he decided to restore the ruined structure. He now spends his days trying to erase traces of the bombs that shattered their lives.