Chanoch Levin spearheaded the development of Israel’s famed defensive shield against short-range rockets. For the first time, he shares some of the previously undisclosed details of how a concept more likely to be found in a science fiction thriller became a reality.

by Dan Raviv

We have used only first names to maintain the anonymity of some Iron Dome team members.
Chanoch Levin, the project manager for Iron Dome, at the Israeli arms development company Rafael in 2009.

Chanoch Levin

had just returned to Israel when the rockets started falling.

It was 2006, and the weapons engineer and his wife, Ditza, had moved back to their small town in the northern part of the country after two years in Maryland, where Levin had been consulting with the United States Army on ways to neutralize the improvised explosive devices (IEDs) that were killing U.S. troops in Iraq. In mid-July, two months into his homecoming, Hezbollah fighters in Lebanon began shooting hundreds of rockets into the north of Israel each day. In five weeks, Hezbollah fired almost 4,000 rockets, about a quarter of which hit populated areas.

The storm of rockets was terrifying. Many residents ran to underground shelters when warning sirens blared, but still, more than 40 people were killed with many more seriously wounded. A quarter of a million citizens—almost three percent of the nation’s population—fled northern Israel, sleeping in hurriedly improvised hostels or moving in with friends and family elsewhere in the country. The economic cost to Israel was at least $1 billion.

The Levins and their adult children, Tamar and Yoav, stayed put, taking shelter in a lower-level computer room in their house night after night, listening to the rocket blasts and emerging hours later to discover the damage to their little town. So when Levin was approached by his employer—the government-owned weapons development company Rafael Advanced Defense Systems—to spearhead a project to combat these missiles, he immediately recognized its importance.

He recalls being told, “You might not be the brightest engineer we have at Rafael, but we noticed you always think outside the box, and with this project, that’s the only chance we have of making this work.” He was also told that he was not the first one to be offered the job. Others in the company had declined, fearing failure.

That he would be able to create a defensive shield system for Israel was anything but a sure bet, but Levin didn’t hesitate. He took the job.

The Project didn’t have a name, but as Levin would soon learn,
it had a powerful backer, Israel’s then-Defense Minister, Amir Peretz. Like Levin, Peretz knew what it was like to live under a barrage of rockets shot by hostile neighbors. He was from Sderot, the southern Israeli city at the wrong end of the first Qassam rocket fired from Gaza in April 2001. Rockets had been coming in sporadically since, making Sderot synonymous with danger. Almost half of the city’s children exhibited symptoms of post-traumatic stress disorder. So when Peretz, who had been Sderot’s mayor from 1983 to 1988, was appointed defense minister in May 2006, he was highly motivated to find a solution. Even more impetus came from a rocket strike in November 2006: In the attack, Peretz’s house was hit, and his bodyguard lost both his legs.

But Peretz had a hard time convincing his colleagues that a defensive shield could work. He recalls how one skeptic sarcastically asked: “What are we going to do? Put up huge volleyball nets so the Katyusha rockets bounce back to Lebanon and Gaza?” When he asked the General Staff commanders in the Israel Defense Forces (IDF) for their opinions, they told him the project was bound to fail and would be a waste of time and money. One general said: “The Qassam and Katyusha rockets are a problem we’ll have to live with. It’s a tactical issue, not strategic. It won’t destroy the State of Israel.”

Peretz, however, wouldn’t be dissuaded and ordered a Ministry of Defense division known as MAFAT (a Hebrew abbreviation for the Administration for the Development of Weapons and Technological Infrastructure) to initiate a study about what could be done. Danny Gold, a retired brigadier general who was at the time a senior research and development executive in MAFAT, began accepting proposals for technology that would deflect the rockets. Gold invited defense contractors to show what they had in the pipeline. One American firm, Northrop Grumman, offered a system that would fire laser beams at incoming rockets. Its product, Nautilus, rebranded as Skyguard, was marketed as a “laser cannon.” Another American company, Raytheon, pitched its Phalanx system, a rapid-fire gun that protects many U.S. Navy ships. Rafael and Levin put forth a totally different approach: They would build intercept tor missiles that would somehow track and destroy incoming rockets.

Largely because it would be an Israeli product, Peretz loved Rafael’s idea. He wanted to give the “made in Israel” invention a chance, although he stipulated that each interception would have to cost less than $100,000, and a system would have to be ready in 30 months. A project of this kind would typically take 15 years, and “smart” air-to-air missiles made by Israel’s factories cost $1 million each. Yet Rafael agreed to take on the challenge.

When Peretz briefed then-Prime Minister Ehud Olmert on the proposed project, his military advisers were not enthusiastic, and Olmert refused to divert government funds. But Peretz persisted, eventually bringing Olmert on board. In a vote in July 2007, Olmert’s
government approved the project and allocated a budget. Later that month, Rafael’s CEO, Yedidia Ya’ari, signed the contract that would give the company 811 million shekels (just over $200 million) to work on short-range missile defense. On December 23, 2007, the Security Cabinet gave its approval. The Defense Ministry then suggested a few names, the most popular one being Golden Dome—Kipat Zahav in Hebrew. The developers liked the name but worried that it sounded too extravagant. They suggested a different metal, and Iron Dome—Kipat Barzel—was born.

**THE PROJECT**

now had a name, but no team. To build an interceptor missile system, Levin needed 350 engineers, physicists, designers and technicians, all of whom would receive security clearances and specially coded passes that admitted them to facilities separate from other Rafael workspaces for extra protection. Levin was looking for more than raw skills and high IQs. He wanted a team that would think imaginatively, work unusually long hours and get along well.

Levin carefully assembled his team, including the core group of nine employees with whom he would work most closely. His first hire was David—the man who would become his deputy. A veteran of the Air Force who was in his 50s, David had spent more than half his life working on weapons and weapon-defense systems. Then there was Amnon, the chief systems engineer hired to develop the interceptor missile. In his mid-40s, Amnon was born on a kibbutz and had been deeply affected in early childhood by the death of his father, a Mossad agent, in the Yom Kippur War. Aharon, 57, was the expert on missile control who had a passion for designing features such as fins that helped missiles maneuver. Short and balding, the immigrant from the former Soviet Union had studied aeronautical engineering in Moscow. Aharon was a perfectionist who carefully examined every number and his calculations were trusted to be flawless. Then there was a renowned expert on navigation, Hector, who was tasked with making sure a missile’s electronic brain would know exactly where it was along the path to its target, even if that target was constantly and erratically changing direction. The Argentine native, who was in his late 50s, had a teenager’s giddy enthusiasm for soccer and was always delighted to discuss F.C. Barcelona’s latest match.

Initially, Levin didn’t see a role for...
Itai, a Rafael engineer in his mid-40s who, as a boy on a kibbutz in northern Israel, had sought underground shelter from Syrian rockets during the Yom Kippur War. But Itai kept coming back, until he won Levin over with his persistence. Itai felt strongly about everything, and his colleagues attributed his fiery temper to his red hair. He wasn’t the team’s superstar, but his obsessive work ethic proved useful to the joint effort.

A couple, Boris and Polina (not their real names), both 34, were at the center of Levin’s innermost team. Each had immigrated to Israel with their parents when they were teenagers—she from Soviet Moldova and he from St. Petersburg. In Israel, they grew up to become masters of algorithms. It was their role to come up with an entirely new way for the interceptor missile’s tiny computer to calculate when it was close enough to the attacking rocket to explode its warhead and destroy both projectiles. This had to occur in mere microseconds, since two fast-flying objects meeting nearly head-to-head would have only the briefest of encounters. Polina was a brilliant computer programmer, but testing her algorithms required trial-and-error repetitions on test platforms that had never been used before. Boris’s job was to combine his wife’s mathematical solutions with a unitary, working system that could communicate with software written by dozens of people. He referred to his challenge as a Tower of Babel.

There was one other woman in the inner circle. Tzipi, 25, an industrial and management engineer with a perpetual grin, was celebrated for her ability to crawl into Iron Dome’s launching tube. The upper two-thirds of her body would disappear into the chute from which future interceptor missiles would be fired. Checking all the connections, and then finding and correcting malfunctions, could take days using normal means, but with the slim and limber Tzipi, it took just hours. A sign at the exit door of the bunker where the launch assembly was built reminded teammates to “Check if you forgot Tzipi in the chute before leaving.”

The senior team also included a non-Jew. At 29, Mula was young for a major in the IDF. Always in uniform, he was assigned to Rafael while he studied for his doctorate in mechanical engineering. A member of the Druze community of northern Israel, Mula invited his teammates to all the big celebrations in his village, where they were warmly welcomed and treated to huge meals. Mula’s assignment was during the testing phase of the project and was to make sure that IDF soldiers would be in place and ready to fire the...
exact rockets that Hamas and Hezbollah would use. Levin says Rafael staffers never learned how those weapons were procured.

**LEVIN UNDERSTOOD**

that Iron Dome needed to be “quick and a bit dirty,” meaning cost and time had to be the primary factors in designing the launcher, the interceptor missile and the packaging for the entire system. “I don’t want a perfect solution to everything; just give me a mediocre system,” he told his team. Iron Dome might not win a beauty pageant or a Nobel Prize, but Levin was determined it was going to work.

First up was the interceptor itself, a missile the team nicknamed Tamir. Building an interceptor that could swivel, swoop, climb and dive, guided by its own electronic eye and computing chips, depended on little things that could make a huge difference. Levin needed durable and reliable switches, but he didn’t have the budget for the usual military suppliers’ high prices. One morning, he noticed a radio-controlled car his son used to play with and had an idea. Using a pocketknife and screwdriver, Levin took apart the vehicle and found that the switch would work just fine for Iron Dome. Rafael located the supplier of that component, a company in Asia that happily agreed to sell a large quantity of switches, unaware that the customer was an Israeli arms manufacturer.

A daunting challenge for the team was how to design a platform that would be able to hold 20 chutes for 20 Tamir interceptor missiles while still being highly mobile. Levin’s cheap solution was to borrow a concept from heavy dump trucks already designed for the load and terrain. Another major component was the radar system: It was crucial for the missile not to miss a single launch of an enemy rocket or shell, and radar was a key part of calculating the direction of the threat. Since there was no time to invent a new radar array, the team decided to use the one developed by the Israeli manufacturer ELTA Systems, which they determined had the best radar technology in the world.

Levin recalls that one of the great cost saving ideas came to him while in the bathroom. The IDF had observed that only about one-quarter of the rockets fired by Hamas and other radical groups in Gaza landed in places where Israelis could be hurt, and the team decided it didn’t make sense to launch missiles if incoming rockets were headed for unpopulated land. “We were so adamant about not wasting time that if I had to go to the men’s room, I told David or Amnon or both to come with me and we’d keep talking, and that’s where the big idea of not launching every time sprang to life.” The few female project members often listened in from the adjacent women’s bathroom.

To save time, humans were also written out of the equation. With the short-range Katyusha rockets and mortar attacks from Gaza, there would be less than 15 seconds to decide whether Iron Dome should fire an interceptor, a choice that would be made entirely by an automated system. Although five soldiers would sit in a battle management center, a portable
trailer near the launchers, monitoring what their Iron Dome was doing, there would be no time for humans to push a “Fire!” button.

**AFTER ALMOST** 18 months of preparations and computer simulations, the team was ready to test Iron Dome in June 2009. The odds were against success: To work, the ground-based radar would need to detect the rocket launch, and the computers and algorithms would need to decide when to ignite the Tamir interceptor’s engine. The Tamir itself would then need to precisely determine its own location, as well as the exact trajectory of the target, and where they would converge. It was a rapidly changing and moving physics problem, using the sky itself as the blackboard for millions of calculations per second.

All the team leaders, plus Ministry of Defense officials, gathered for the first time in the test facility in Makhtesh Ramon in Israel’s Negev desert. The test director, Dori, completed the countdown for the simulated enemy rocket. It took off and started heading toward the expected interception zone. But the countdown for Tamir’s launch led to nothing. The interceptor simply did not budge, as if its launch tube had not received the order to fire. The next day, the team tried again. Once more, the interceptor sat motionless in the tube and failed to fly. At this point, Levin morosely concluded: “We don’t have a project, after all that time and work.” Rafael’s Engineering Division led the post-mortem discussions and told Levin what he already knew: A formal investigation of the failure, likely to take a full year, would be required under the company’s standard procedures.

Levin retreated, numb, to his office in Haifa. Three days later, Israel Orbach, a senior electronics engineer at Rafael, called him at 10 p.m. with a theory: The problem was an incorrectly plugged-in cable. Levin investigated and saw Orbach was correct. The positive and negative connectors of the cable just needed to be reversed. But when Levin relayed this surprisingly simple explanation to the head of the Engineering Division, he was accused of wishful thinking. The chief engineer contended that the solution could not be that easy, and he refused to sign off on Levin’s request to reschedule a test. Each test was enormously expensive, even if only calculating the cost of transporting and housing 100 employees. Levin then appealed to the president of Rafael—his old combat colleague, Yedidia Ya’ari. “Are you sure you found the problem?” Ya’ari asked. “Yes,” said Levin, with all the confidence he could muster.

A month later, the team gathered in the Negev once again. Everyone was tense. Again the target rocket launched. Dori began the countdown for the interceptor missile. “Seven, six, five…” But the Tamir had a mind of its own, igniting its engine and flying away from the launcher when the count got to “three.” Levin did not like the early takeoff, but the radar and computers must have been telling the Tamir something that its human creators had missed.

Now that both missiles were in the air, the attention turned to a split-screen video. One side showed the target rocket cutting across the desert sky, wobbling as amateurishly manufactured rockets tend to do. On the other side was the nimble Tamir. Suddenly, on the screen, the interceptor took a sharp turn—and then it soared upward as though tugged by an invisible string. Then it deviated a little to one side, then the other, and then, boom! A precise collision, and a storm of fragments rained down.

The silence of the Ramon crater test site was shattered by applause and cries of joy. Broad smiles, warm hugs and mighty handshakes prevailed. Levin recalls that he found himself repeating to everyone on his left, on his right or in his arms: “We have a project!”

**MORE TESTS** had to be carried out, and among them were failures, successes and a lot of inbetween. They didn’t get much sleep out in the crater, but Levin and his team were learning from every single test. Their creation quickly advanced from the crawling stage through its first baby steps, eventually running more smoothly than the team had dared to hope.

On March 27, 2011, the first operational Iron Dome unit was rolled out on the northern edge of Beersheba, the biggest city in Israel’s Negev desert. The head of the Air Defense Corps, Brigadier General Doron Gavish, told reporters that deployment had been accelerated because of a spate of Katusha rocket launches from Gaza, about
30 miles west of Beersheba. Gavish revealed that two port cities just north of the Gaza Strip, Ashkelon and Ashdod, would each get an Iron Dome “battery”—consisting of the launcher for the Tamir interceptors, the radar system, power generators and a battle management center.

April 7, 2011 was a landmark day. At 6:16 p.m. Iron Dome achieved its first operational, real-world interception of a Grad rocket fired by Hamas from Gaza. It occurred while Levin and many of his engineers were Go-Karting, which Levin considered a great team-building exercise, in Haifa. Suddenly one of his engineers, Michal, who had just received a call on her cell phone, jumped onto the racetrack—waving her arms in the air, yelling something inaudible.

“What?” Levin shouted, as he brought his little Go-Kart to a stop. “What’s up?”

“Hay’yiroot!” She announced, with a huge smile: “There’s been an interception! There was an actual interception!”

Levin pulled out his own phone to find a string of missed calls. Colleagues from Rafael and the Ministry of Defense were calling him with congratulations. The Iron Dome was credited with preventing major damage to an important power plant in Ashkelon.

Two days later, Levin drove 100 miles south to the scene of the launch on Ashkelon’s outskirts. There he met then-commander of the Air Force Major General Ido Nechushtan, who had been a skeptic of the project. With a broad smile, Nechushtan slapped his own chest and announced: “You now have the biggest supporter you’ll ever have! I was wrong when I didn’t believe.”

It didn’t take long for Hamas to adapt. On August 20, 2011, it fired over 11 missiles simultaneously toward the city of Beersheba. While a few got through and caused damage, Iron Dome intercepted most of the incoming rockets. In March 2012, Iron Dome calculated that 71 rockets were heading toward populated areas and tried to intercept them, with a claimed success rate of 80 percent.

Levin and his team knew that the success rate would improve. As in testing, every successfully intercepted missile fed a large amount of valuable information into the constantly
recalibrating Iron Dome algorithms. By the time the 2014 Gaza war broke out, Iron Dome was more accurate than ever and proved indispensable.

But the more than 700 Tamir interceptors used by Israel during the grueling two-month war had a total price tag of around $50 million. Also, a need for additional Iron Dome units became obvious—and they cost millions of dollars apiece. Israel’s Defense Ministry asked the United States to help, and the American Israel Public Affairs Committee (AIPAC) lobbyists helped make the case to Congress and the Obama administration. The U.S. stepped up with hundreds of millions of dollars in extra aid—specifically to replenish Israel’s supply of interceptor missiles for Iron Dome.

There was, however, a price. The agreement required Rafael to hand over to the Americans details of various parts of Iron Dome technology, including the algorithms for the computer chips in the Tamir missile. Levin’s fervent hope had been that the project would be entirely “blue and white”—all Israeli—so he was disappointed to see that a major portion of Iron Dome production was being transferred to an American contractor, Raytheon.

In November 2017, at an arms show in Washington, DC, Raytheon exhibited an entire system, only slightly modified from Iron Dome, branded as SkyHunter. While South Korea and other nations have expressed interest in buying the system from its Israeli inventors, they also have the option of buying them from Raytheon in the United States. More significantly, the U.S. military can now order SkyHunter as a fully approved, domestically manufactured product to protect American bases and forward positions in South Korea, the Middle East and elsewhere. Nonetheless, as the original manufacturer and inventor, Rafael will earn commissions on every SkyHunter sale by Raytheon.

“I’m not saying that Raytheon is doing anything wrong,” Levin says. “Raytheon saw that President Barack Obama and Congress gave Israel a lot of money for the cost of more Iron Dome launchers and missiles,” and so it’s no surprise that Raytheon pushed to build a large proportion of the interceptors. “But I think my former colleagues are disappointed that the Americans picked up our ball—the ball we invented—and are running with it to all sorts of worldwide markets.”

When asked for comment, Raytheon’s public affairs department declined to react to Levin’s assessment. Officially, Rafael executives say that they are satisfied with the arrangement with the American company, which is partnering with Rafael to develop other projects.

AFTER IRON DOME

As Iron Dome was up and running in Israel, Levin moved back to Maryland to serve as Rafael’s chief representative in the United States. Others on his team, although their work on Iron Dome was secret, thrived in their professional paths.

Some took jobs in private industry, lured by the technical innovations—and potential of stock market riches—of the high-tech companies that give Israel the reputation of “the start-up nation.” Boris and Polina found work in the United States, where their talents for computer coding and algorithms have been recognized by Silicon Valley corporations. Most of the team stayed on in Israel at Rafael, working on defense systems unrelated to Iron Dome. Some moved to a project called David’s Sling, named for the simple weapon used by the future King David to launch the rock that felled the giant Goliath. While Iron Dome was designed to track and stop short-range, erratic rockets, David’s Sling is intended to destroy medium-range missiles before they reach Israeli airspace. Also with U.S. financial support, Israeli inventors have developed the Arrow, Arrow 2 and Arrow 3 systems for protection against long-range missiles. Most of the details of these projects are secret at this time.

There are critics who doubt that Iron Dome is as effective as Israel’s
military claims, and they question whether Hamas, Hezbollah or other enemies could overwhelm the system by firing hundreds or thousands of rockets all at once. “Iron Dome works really well as long as the threat is limited,” says Michael Armstrong, an associate professor of business at Brock University in Ontario, Canada, who recently published an article entitled “The Effectiveness of Rocket Attacks and Defenses in Israel” in the *Journal of Global Security Studies*.

“It is really good at dealing with small numbers of rockets, but if an attacker has enough rockets and fires them simultaneously, eventually the system just gets overloaded,” he says. “You could always double or triple the number of Iron Dome systems, but then they could double the number of rockets. It’s cheaper for them to double the number of rockets.” The result, he says, is a potential arms race in which the advantage would likely go to the attacker. Finally, as with all spending, there is the matter of opportunity cost. When “Israel is spending money on an Iron Dome system, what aren’t they spending that money on? Should they spend on better bomb shelters and warning systems, or something that would allow them to attack the rocket launchers or all the other things governments need to spend money on?”

There are also worries that as Israel’s fear of rockets raining down is reduced, the country has less incentive to pursue long-term peace. Although many of Israel’s top strategic analysts agree that Iron Dome is not perfect technologically, they view the defense system as something that opens, not closes, doors for avoiding bloodshed. “The system takes away from Hamas and other enemies in Gaza one of their key weapons, the rockets that fly over the security barrier,” says retired Israeli Air Force General Amos Yadlin. A former head of Israeli military intelligence, Yadlin adds: “The strategic effect is that Israel’s leaders and the army have more time to try various approaches, including diplomacy, when tensions and violence erupt on the Gaza border. Thanks to Iron Dome, the army doesn’t have to rush toward entering Gaza with ground forces, and there also isn’t so much need for our artillery and Air Force to attack rocket launchers, which Hamas places next to civilians. This change certainly reduces casualties on the Palestinian side, as well as saving Israelis.”

For Levin, now 67 and retired to his small northern Israeli town, Iron Dome remains his proudest professional accomplishment. He is fully aware that the breakthrough he helped invent hasn’t solved all of Israel’s defense problems, but he knows that, in recent months, Iron Dome has proven its worth again: The system shot down the first barrage of rockets from Syria fired by Iran’s Revolutionary Guards over Israel’s northern border. This time, he and his family didn’t need to spend nights huddled in their computer room.

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