

COVER

Spies in space:

# The story of the Ofek satellite program

How the successes of those who dare to dream can stagnate under those who fail to follow through

**AN ENGINEER** works on a small chamber at a laboratory at Israel Aerospace Industries in Lod, in May 2014.





• BARBARA OPALL-ROME  
Photos by HEIDI LEVINE

If you're looking for a story that captures Israeli innovation, cunning and can-do chutzpa, think spy satellites. Look to Ofek, the Hebrew word for horizon. It's all there in Israel's military satellite program, the newest of which – Ofek 11 – is struggling to stabilize itself in space after its launch earlier last week.

Inserted successfully into orbit by the country's homemade Shavit launcher, the newest and most advanced satellite is likely to soldier on in space, but with limited lifespan and ability to perform its high-resolution spy duties. White-knuckled technicians and program managers toiling around the clock at Israel Aerospace Industries' (IAI) ground control station near Ben-Gurion Airport are still hoping for a favorable ending to the latest chapter still unfolding. But like the chapters that have gone before, Ofek 11 represents the highs and lows of a story driven by strategic need and enhanced by its share of diplomatic intrigue.

*'Although Israeli technology is high quality and generally cost-competitive, Israeli manufacturers have less global scale than their counterparts'*

Conceived in secret, it's a story of battling the laws of physics; and struggling on a shoestring budget to build rockets strong enough to loft satellites small enough into retrograde orbit against Earth's eastward spin.

It's also a story of fortitude. How the euphoria of reaching space in 1988 was followed by bitter back-to-back failures that saw two satellites swallowed by the sea. And how the heroes of our story finagled their way back from the brink with the 1995 launch of Ofek-3, Israel's first operational imaging satellite whose progeny continue to fuel the regional power status of the Jewish state.

"Small countries can be great only if they dream big," said former president Shimon Peres. "With Ofek, we penetrated space and skepticism."

Interviewed before the stroke that befell the pioneer of Israel's aerospace and defense industry, Peres said Israel's small size makes it uniquely positioned as a "center of excellence" for advanced research and development. "Our advantage is creative, out-of-the-box thinkers who push the boundaries of what was deemed impossible."

But with all due respect to Israel's senior statesman, this is where our tale



AN ENGINEER works inside the bus of a OPSAT 3000 satellite in a laboratory at Israel Aerospace Industries (IAI) in Lod, May, 2014.

takes a cautionary turn.

Because the flip side of this story is one of untapped potential and failure to leverage billions of dollars invested in military space to assure commercial competitiveness on the global market.

The US Futron Corp. consistently ranks Israel eighth in an annual competitiveness survey based on myriad criteria, including government investment, national space policy, the ability to attract financing and annual sales. In its latest Space Competitive Index (SCI), we have dropped to number nine.

"Israel continues to be a leader in space technology, but has limited commercial sales," Futron reported in its first SCI survey from 2008. The same holds true today.

"Although Israeli technology is high quality and generally cost-competitive, Israeli manufacturers have less global

scale than their counterparts," Futron senior analyst Jonathan Beland told the *Jerusalem Post Magazine*.

But let's go back.

**OUR STORY** begins in the late 1970s. US President Jimmy Carter was proving relentless in prodding Israel and Egypt toward peace. In the run-up to Camp David, the era of Israeli Air Force reconnaissance flights over Sinai was about to end.

Plan Treasure was a top-secret forum where US and Israeli officials hashed out compensation to come from the 1978 accord. Among Israel's requests: access to imagery from US spy satellites.

"The Americans didn't even answer us; they ignored the request," recalls David Ivry, a retired major general who commanded the Israel Air Force at the time.





*Every kilo counts, so much so that Israel had to develop new composite materials and super performing substructures. Even the screws holding it all together had to be hollow.*

That's when the indigenous Israeli satellite program started to gain traction. Ivry said. "We knew after the treaty was signed, we would be obliged not to violate Egyptian sovereignty by overflying their airspace as we used to do," he added.

Even prior to the US slow-roll, Israel had been dabbling in military satellite research. Rafael Ltd., then an R&D arm of the Defense Ministry had the lead, but all three Israeli government-owned firms were involved in aspects of rocketry.

In any case, Israel did not start from scratch with continuously upgraded versions of the three-stage Shavit rocket that launches Ofek into space.

From here our story turns to the courageous few who fought for funding as fiercely as the technological hurdles blocking their way.

Chaim Eshed is a key protagonist. He's now a retired brigadier general, teacher and chairman of the national committee for space R&D, but then a young Air Force lieutenant colonel working technical issues for military intelligence. Eshed ran the Ofek satellite part of the program, subsequently serving for decades as Israel's military space czar.

Another key character in our story is Uzi Rubin. An aeronautical engineer hailing from the IAI, Rubin headed the Shavit launch effort for the Defense Ministry and went on to establish Israel's missile defense organization.

Together they toiled in secret – without the benefit of external assistance or outside consultants – on tenuous funds, working with guys named Moshe Bar-Lev, Aby Har-Even, Ilan Porat and a few dozens of others involved in the effort.

Success was achieved in September 1988, when the Israeli-built Shavit launched a test satellite named Oz into space. With Oz – Hebrew for courage – Israel joined only seven other nations at the time to launch satellites in space.

Confidence grew with a second success. Just 18 months after the first Oz entered orbit, another Shavit launched Oz number 2, another test satellite capable of communicating with its ground-based operators, but not yet endowed with a payload to capture images from space.

As testament to their confidence of the horizon ahead, they changed the name of the satellite program from Oz to Ofek. But that horizon proved elusive with two failures that followed. Problems with the Shavit rocket sent two Ofeks fully equipped with imaging cameras plummeting into the sea.

TO THIS day, Israel only acknowledges one failure – of Ofek 2 in September 1994 – prior to the successful April 1995 launch of Ofek 3. The name change offered a convenient cover for public consumption, but those back-to-back failures put the program on borrowed time.

No courage and conviction would



ENGINEERS BY a Collimator at a laboratory at Elop in Rehovot, Israel, April, 2014.

save them from another failure.

"After the first failure, there was tremendous pressure to cancel the project. But we managed to continue," recalls Ivry, who by this time was chief executive of the Defense Ministry.

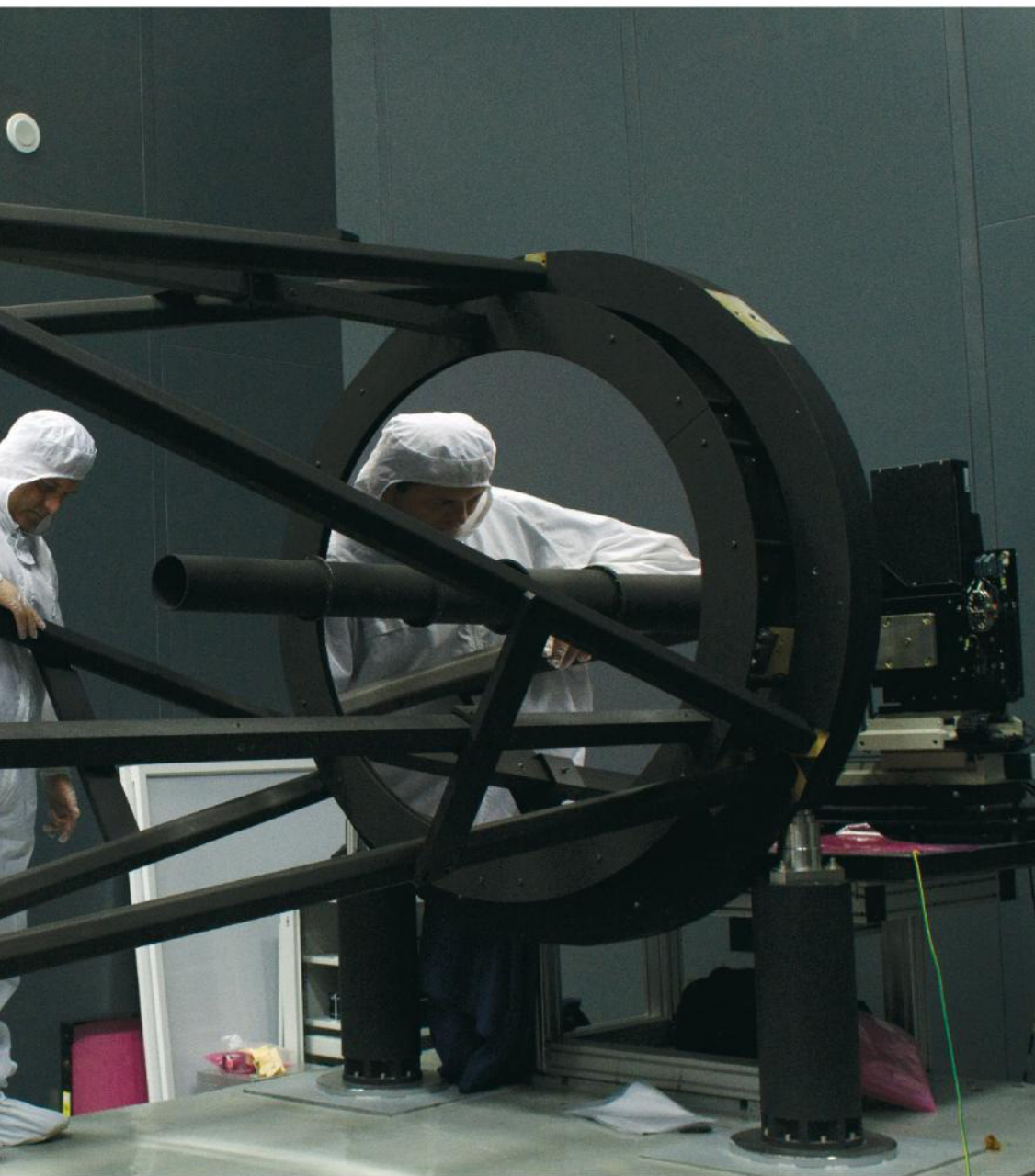
"After the second failure, it was really a crisis. I managed to find a small amount of money to keep the team and continue the program... But I must say, if it failed yet again, we wouldn't have been able to proceed," Ivry said.

Eshed estimates the penalty of

launching from Israel westward – over the Mediterranean rather than above its neighbors – at nearly 40 percent. To make up for it all, the launcher had to lift well above its weight class and Ofek satellites had to weigh a lot less and be more maneuverable than those that benefit from the initial velocity from Earth's rotation.

Every kilo counts, so much so that Israel had to develop new composite materials and super performing substructures. Even the screws holding





it all together had to be hollow.

From his high-rise Tel Aviv sea-view flat, Eshed credited "the shadow of the guillotine" for the engineering feats.

"We had no choice. To do otherwise could be construed by our neighbors as an act of belligerence that could trigger a war... We had to struggle both ways with miniaturization of the satellite and added thrust to our launchers. Under the shadow of the guillotine, we can do wonders."

In an interview at a popular Tel Aviv

café, Rubin remembered the intense pressure to perform.

"We were out of money. We were desperate. And then the chief of my financial department figured out an aggressive accounting formula that basically allowed us to build the next launcher on credit, something that was not and is still not permitted."

As they struggled to identify and fix failures with the launcher, a separate team was racing to ready a replacement satellite.

"We were caught in a vise; pressed by both ends to come up with the launcher and satellite that would finally succeed," said Moshe Keret, former president and chief executive officer of IAI, the state-owned firm that still builds the Shavit launcher and all Israeli-made satellites.

With no more satellites on the shelf and no funds for new builds, they scavenged for the components that would transform a test satellite into an operationally capable vehicle.

"It was a qualification model; not

flightworthy. But we had to make it work," recalls Uzi Eilam, a retired brigadier general who managed the entire effort as head of the Defense Ministry's research and development directorate.

After overcoming the breakdown of tracking radars, and other upsets too many to count, Israel managed to find a window between freak rainstorms and Russian satellites orbiting overhead for the ultimately successful April 1995 launch. Ofek 3, Israel's first orbital spy, finally made it to space.

Rubin said he would never forget the reaction of then-prime minister Yitzhak Rabin upon hearing the news.

"Uzi [Eilam] and I went to brief Rabin, and when we told him the satellite was going to take pictures, the first thing he blurted out was, 'What will Amr Moussa say?' ... Rabin hated his guts," Rubin said, referring to Egypt's foreign minister at the time.

Like earlier high points, success proved short-lived, when a January 1998 launch failure sent Ofek 4 plummeting into the Mediterranean. After that setback, the program was again in crisis; actually on the brink of bankruptcy.

**BUT A** big part of this story is refusing to go down for the count.

Here's where Ilan Biran enters in a big way. A retired major general who hailed from Israel's can-do Golani infantry brigade, Biran succeeded Ivry as Ministry of Defense managing director. When informed by his bosses that no more funds would be approved for the program, what did he do?

He sold some 1000 MoD-owned apartments, from Safed in the Galilee down to Eilat on the Red Sea, netting some 400 million shekels (\$115.69 million), enough, he maintained, to keep the program afloat for the coming years.

"It doesn't sound like a lot of money, but for us, it was plenty enough to stabilize the program," Biran recalled.

"Instead of carrying on month-by-month or - in best cases - year-by-year, we finally had the multi-year funding that brought us additional electro-optic satellites and especially the all-weather/day-night SAR [synthetic aperture radar] satellite, which at the time, was a kind of dream," he said.

Israel went on to deploy that first radar satellite, dubbed TecSAR, ahead of schedule in January 2008, thanks in large part to Biran's real estate sales and funding from India, according to publications. Now known as Ofek 8, TecSAR was the first MoD satellite to be launched abroad; part of a joint venture agreement whose details remain under wraps to this day. The satellite was launched in India from an Indian PSLV launcher.

At the same time, Biran threw Defense Ministry support into a new commercial venture that joined IAI, the nation's sole satellite producer; Elbit's Elop Electro-Optical Industries, >>>





FROM LEFT to right:  
Ilan Biran, Chaim Eshed, Uzi Rubin.



producer of the high-resolution payload; and a commercial US firm then called Core Software Technology.

The resulting company, ImageSat International (ISI), would own and operate Ofek spinoff satellites for the commercial market under a new line called Eros (Earth Remote Observation System). Their first Eros reached orbit in December 2000 aboard a Russian Start-1 rocket.

And it's a good thing that it did, because at the time, Israel's defense establishment was still struggling to upgrade its Shavit launcher from the Ofek 4 failure while its sole pair of eyes in the sky – Ofek 3 – was running out of fuel. For nearly two years – from the eventual hero's death of Ofek 3 until the successful May 2002 deployment of Ofek 5 – that Eros satellite was Israel's prime source of space-based intelligence.

In the years that followed, Israel continued to put increasingly higher performance satellites into space, while suffering just one additional failure, that of Ofek 6 in 2004.

But instead of reaping the commercial benefits of the ImageSat venture – which aspired to a constellation of eight Eros satellites – turf battles and competing agendas led to the largest and most potentially damaging lawsuit in Israeli aerospace history.

IAI finally resolved the issue in 2014 by acquiring full control of ISI and settling claims out of court. Today, it

has sole authority over the Eros satellite sector and is busy building a third Ofek-derived commercial satellite, dubbed Eros C.

Experts including Tal Inbar of the Fisher Institute for Strategic Air and Space Studies lament the lost time spent battling one another instead of growing Israel's observation satellite sector.

"This industry was built to support strategic needs, but we all knew it could never survive only on low volume orders from the MoD. In order to be truly self-sustaining, we needed to export," Inbar said.

But barring a few notable exceptions – which include an imaging payload to South Korea and joint scientific projects with the French, Italian and European Space Agencies – export and commercial orders failed to come. Industry titans at the time were in such distress they went public with heretofore closed-door appeals for state-level funding.

"We've had some successes, but on balance, it's been a failure," Haim Rouso, former president of Elbit Elop, a publicly traded firm that provides Israel's electro-optical imaging payloads, told an international conference here in early 2011.

"We Israelis, instead of relying on chutzpah and innovation to cover our share, must be able to tap into a significant, long-term, non-military budget, not crumbs," Rouso said.

For years, the Israel Space Agency had

been subsisting on a joke of a budget; a mere \$700,000 in 2000 that failed to breach the \$1 million level until recently. After years of complaints and threats to close down key parts of Israel's satellite sector, the Treasury, in 2012, authorized 200 million shekels (\$57.67 million) over two years.

Today, the Israel Space Agency's budget stands at 78 million shekels for 2017 and 86 million shekels for 2018.

Zvi Kaplan, a former Israel Space Agency director, welcomed the budget boosts, yet cautioned: "If you don't come out with a satellite every two or three years, the line goes cold. Your technology grows stale. And even if you manage to secure new collaborative projects every four or five years, if they

*Aside from Ofek 11, which was recently sent into space, two other IAI-built imaging satellites – one of the French Space Agency and another for the Italian Space Agency – are planned for launch in 2017.*

are persistently plagued by funding flow, the market catches up."

But ours is a tale with an ending unknown.

**IF YOU** ask Joseph Weiss, IAI president and chief executive, it's already a feel-good story, and much like good wine, Weiss says the story only gets better with time.

"Look what we've done since the Camp David days, when less than a handful of countries could utter the word 'space.' We dived into an empty pool and slowly and surely, without budget, here we are: one of only eight or nine in the world who can really deliver a turnkey project to design, develop, manufacture, launch, operate and of course maintain the satellite throughout its life."

Weiss acknowledged numerous disappointments and missed

**Oz 1.** (retroactively renamed Ofek 1) – Successful launch in September 1988

**Oz 2.** Successful launch in March 1990

**Ofek 1.** Failed launch in early 1990s (date unknown)

**Ofek 2.** Failed launch in September 1994

**Ofek 3.** Successful launch in April 1995

**Ofek 4.** Failed launch in January 1998

**Eros A.** Successful launch (from Siberia) in December 2000





# The loss of Amos-6

## A setback or an opportunity?

Israel's remote sensing industry will remain in business indefinitely, due to the strategic need for spies in space, but the communications satellite (ComSat) sector is a different story.

Absent a new government policy and sufficient multi-year funding, the Amos-6 satellite that exploded earlier this month in Cape Canaveral, Florida aboard a Space-X launcher could very well be the last of the ComSats produced by state-owned IAI.

Unlike the Ofek and its Eros offspring, which weigh no more than 400 kilograms, are launched primarily from Israel and orbit Earth every 90 minutes, latest Amos satellites weigh in at 5.3 tons, are always deployed by foreign launchers, and remain in geostationary orbit at the Israeli government-procured slot of 4-degrees West longitude.

While Israel's defense establishment and various sectors of the Israeli economy have come to rely on Amos-provided services, alternatives do exist. The government has never codified the need for a dedicated ComSat or declared the Amos-series of satellites as a national strategic asset.

Had that planned September 3 launch been successful, Tel Aviv-based Spacecom, owners and operators of the IAI-built series of Amos satellites, would most likely have consummated its planned sale to Xinwei Technology Group, a Chinese conglomerate, for \$285 million in cash. Once Spacecom was in Chinese hands, the Israeli government would have had significantly reduced influence, not only on the services it receives from the transmitting spacecraft, but on the companies it selects to build follow-up satellites in the Amos line.

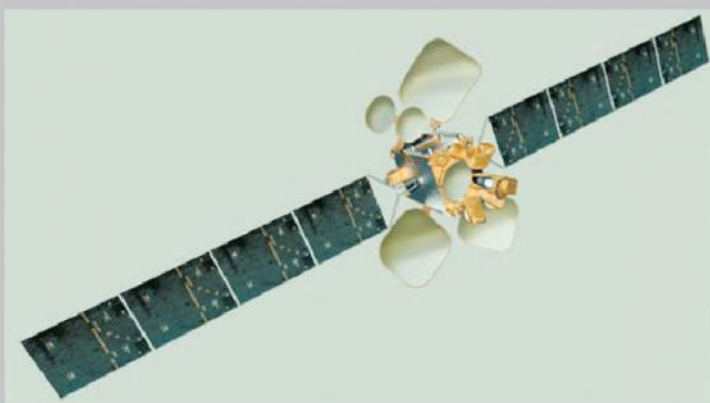
Like ImageSat International, the company created to vector additional demand for locally built imaging satellites, Spacecom is an IAI spinoff, an entity born from the desire to promote Israel's ComSat sector.

IAI sold off its shares of Spacecom in 2010 for reasons that

are still unclear to its CEO, Yossi Weiss. "I don't know why we sold our shares. It must have been for a good reason," he said.

Since then, the publicly traded Tel Aviv-based satellite operator has made clear that its first duty is to its shareholders. If IAI cannot prove competitive – as was the case with Amos-5, a satellite ultimately awarded to a Russian firm – Spacecom is not obliged to sustain this sector of Israel's satellite industry.

Weiss says IAI is developing a small, electrically powered ComSat projected to weigh less than half and cost "tens of percents" less than comparable spacecraft on today's market. But due to nonexistent quantities of scale, he says



(Israel Space Agency)

IAI will need \$40 million to \$50 million annually to remain globally competitive.

Science, Technology and Space Minister Ofer Akunis has pledged to pursue government action aimed at retaining Israel's indigenous ComSat capabilities. And experts at Israel's Fisher Institute for Strategic Air and Space Studies are urging the government to declare a national need for a dedicated ComSat.

Only time will tell if the launch pad loss of Amos-6 is an irreversible strategic setback or an opportunity to revive and secure Israel's ComSat sector.

—B.O.R

noted, the Eros C and at least two more successors to Ofek 11. As for new business, IAI is eyeing Brazil, Chile, Columbia and Mexico, among others.

Equally upbeat is Isaac Ben-Israel, a retired major general and former head of the Defense Ministry's Research and Development Directorate who now serves as chairman of the Israel Space Agency.

Ben-Israel led the effort to vector for commercial and civil space the approximately \$80 million that the government invests annually in its military space program. He maintains that every dollar the government invests in space can yield fruit 15 times more than initial investment.

"I'm telling you that with \$100 million investment, we can get to \$1.5 billion, which is about 1 percent of the global space market. This year, the global space sector is about \$200 billion all told – products and services – and all I want to get is one percent."

**MEANWHILE, ESHED**, our protagonist from the beginning of this tale, refuses to stop dreaming big. He's now pushing to develop a world-leading sector for nano-satellites, each comprising several units weighing one-to-10 kilograms programmed to operate in small clusters or even huge swarms.

He's gathering inter-ministerial government support for a national program called "Israel 70," which aims to launch 70 such satellites built by 70 different local schools to mark Israel's 70th birthday in 2018.

"Imagine a swarm of 2000 nano-satellites working coherently together; you can get a huge aperture telescope far larger than the sum of their individual parts."

Eshed acknowledges that this vision is yet not widely shared by Weiss and other big players in Israeli industry. But he insists Israeli industry salvation will not be achieved with more and better of the same, but by a whole new class of capabilities for government, commercial and scientific needs.

"Israel has all the means of becoming the world's fourth or fifth leading power in space... We have the manpower, we have the technology, we have 30 years of heritage, and that's the direction I'm trying to move us in," said Eshed.

"You can dream the dream as long as it does not contradict the laws of physics. You may need to be courageous; even a little crazy, but that's what happened with Oz and Ofek. It's the same story."

opportunities. Among them, failure to translate the performance of the indigenous Shavit launcher into a business success; a failed joint venture with state-owned Rafael to develop micro-satellites weighing less than 120 kilograms; and competitions lost in

Turkey.

The IAI chief insists the firm's earth imaging sector is not only surviving, but profitable, due to steady work from the Defense Ministry and occasional export orders. "Now I'm not saying its billions. That will take some time. Perhaps we'll

need some partners."

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