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ISRAELI WEAPONS OF MASS DESTRUCTION

An Overview

Anthony H. Cordesman
Arleigh A. Burke Chair in Strategy
acordesman@gmail.com

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Israel's nuclear capabilities and other efforts to develop weapons of mass destruction are some of its most secret and most controversial force developments. Although there have been many unclassified reports on such developments, only a few have been credible and these have consisted largely of reports on its missile forces or nuclear activities that took place several decades ago. Many estimates of Israel's nuclear weapons trace back to rough estimates made a decade ago. No official Israeli data or credible outside reports data have emerged on the details of Israel's strategic doctrine, targeting plans, or systems for planning and executing nuclear strikes, or how these have changed in recent years. However, a great deal of speculation has emerged over how Israel might act in a war or crisis.

Figure One summarizes current reporting on Israeli weapons of mass destruction, drawing on U.S. government and IAEA reporting, and additional sources sources like the Nuclear Threat Institute, Global Security, Jane's, the Federation of American Scientists, Institute for Science and International Security, and the Center for Nonproliferation Studies at the Monterey Institute of International Studies It should be stressed again that all of the estimates of this kind provided are highly uncertain and heavily dependent upon unclassified sources and the views of outside experts,

Probable Israeli Capabilities

Israel's biological weapons programs seem to be largely defensive, but advanced defensive programs provide the technology base for weapons production and Israel has advanced civil biotechnology and pharmaceutical programs with extensive dual capability to produce such weapons. There is no public evidence that the IDF has organized and trained for more than defensive chemical warfare. However, Israel has been detected importing significant amounts of precursors for chemical weapons.

It does seem highly likely that Israel can target virtually any Arab state and Iran with long-range missiles and deliver nuclear strikes using such missiles as well as by air using air-to-surface missiles. Israel almost certainly has "boosted" nuclear weapons with yields of 100 kilotons or more and may have thermonuclear weapons.

Israel probably has enough nuclear weapons, and a stock of weapons with low enough yields, so that it can use its nuclear strike capabilities against cities, populations, and military area targets and critical civilian facilities. There is no way to determine Israeli plans and targeting, but the fact that Israel's population is so small and concentrated may well mean that any Israeli retaliatory attack in response to the use of highly lethal weapons of mass destruction against Israel's population would take the form of massive retaliation against the enemy's continuity of government, economic recovery capability, and population.

It seems highly likely that Israel has long had tactical nuclear weapons. Israel is well aware of U.S., NATO, French, and former Soviet Union (FSU) doctrine and planning for the use and employment of such weapons, and probably has low yield weapons it can use in close proximity to its own territory and forces. In any case, airbursts of high-yield nuclear weapons largely eliminate fallout and allow the use of nuclear weapons under the same conditions.

Israel has acquired and developed intelligence satellites that could provide highly advanced targeting data for missile and air strikes, with some near-real time capability.

The current missile and air forces Israel would probably use to deliver nuclear strikes are somewhat vulnerable to air and missile attack. The survivability and effectiveness of such strikes is uncertain, and such threats would currently come from Iran or Arab states, which can use only chemical or conventional bombs and warheads. There are also indications that Israel relies on dispersal in a major crisis, and it certainly has capable enough sensors and battle management systems to maintain launch on warning and/or launch under attack capabilities. There are unconfirmed reports that Israel plans to sea base some of its nuclear weapons on ballistic or cruise missiles deployed on its *Dolphin*-class submarines as part of a possible second strike capability.

Shifts in Israeli Missile Defenses

Israel has acquired ballistic missile defense capabilities, although the real-world operational capability of such defenses is uncertain. Israel's testing programs have been minimal, and it has had to place an extraordinary reliance on engineering forecasts of effectiveness in moving to production and deployment.

Israel did declare that the improved Block 3 version of its Arrow ballistic missile defense system became active in April 2006, and further improvements in software are expected. It has improved its Green Pine and other radar warning and sensor systems and created a new battle management system, nicknamed the "Cube." It is working on Block 4 versions of both the Arrow and Green Pine to be deployed by 2009 capable of handling significantly greater numbers of missile tracks at the same time and intercepting incoming missiles with a higher closing velocity and at ranges of more than 700 kilometers. It is believed to be developing more advanced counter-countermeasures and the ability to detect decoy warheads.[i]

Figure One

Israel's Search for Weapons of Mass Destruction

Delivery Systems

- Israel has done technical work on a terrain contour matching-type smart warhead. It has examined cruise missile guidance developments using GPS navigation systems. This system may be linked to a submarine launch option.
- As part of its first long-range missile force, Israel deployed up to 50 "Jericho I" (YA-1) missiles in shelters on mobile launchers with up to a 400-mile range with a 2,200-pound payload and with possible nuclear warhead storage nearby. These missiles were near copies of the two-stage, solid-fueled, French MD-620 missile. Some reports claim the first 14 were built in France. (Some reports give the range as 500 kilometers.)
  - NTI reports that, "It appears that some time in the early 1970s, Israel took over production and testing of the missile and by 1978 had domestically constructed around 50 Jericho-I missiles. Previously France had delivered 14 complete missiles to Israel. There are conflicting reports as to when the Jericho-I entered service. Some sources indicated that the Jericho-I was deployed with nuclear warheads during the 1973 war with Egypt and Syria. Other sources, however, indicate that at the time, the Jericho-I still suffered from problems with guidance and control and was not yet operational. Those problems, however, may have had more to do with insufficient accuracy to deliver a nuclear warhead and the missile may have been deployed during the 1973 war even with the knowledge that its accuracy was unreliable...There seems to be no dispute though that the Jericho-I was designed to deliver nuclear warheads, despite Israel's policy of opacity with regards to its status as a nuclear weapon state." [ii]
  - Israel is thought to have conventional, chemical and nuclear warheads for the Jericho I.
  - The current deployment of the "Jericho I" force is unclear. Some sources say it has been phased out for the Jericho II missile.[iii]
- Israel has since gone far beyond the Jericho I in developing long-range missile systems. It has developed and deployed the "Jericho II" (YA-2).
  - The Jericho II began development in the mid-1970s and had its first tests in 1986.[iv] Israel carried out a launch in mid-1986 over the Mediterranean that reached a range of 288 miles (460 kilometers). It seems to have been tested in May 1987. A flight across the Mediterranean reached a range of some 510 miles (820 kilometers), landing south of Crete.[v] Another test occurred on September 14, 1989.
  - The Nuclear Threat Initiative reports that, "Some reports indicate that Israel began production of the two-stage Jericho-II ballistic missile as early as 1977. Other sources place the date several years later. In either case, Israel conducted several test-flights of the Jericho-II in the 1980s and 1990s. The Jericho-II was reported by a source to have entered service in 1989. However, during the first Persian Gulf War, Israel apparently balked at U.S. suggestions to limit any response to Iraqi Scud attacks to ballistic missile strikes in part because the Jericho was not yet fully operational. The Jericho-II is reported to have a range of between 1,500 and 3,500 km, depending on payload weight. It is said to be deployed in underground caves and silos primarily at the Zachariah facility….Much of the information about the Jericho-II has been gleaned from observation of launches of the Shavit space launch vehicle (SLV). The Shavit is a three-stage, solid-propellant launcher designed to carry payloads up to 250 kg into low earth orbit. It was speculated for some time that the first two stages of the Shavit were the Jericho-II. This was confirmed in 2001 when a spokesman for the Israeli Defense Forces admitted that the "Shavit is Jericho." Shavit launches are conducted from the Palmachim airbase near Tel Aviv. The first launch was in September 1988 and placed a satellite, the Ofeq-1, into orbit. The most recent launch was in June 2001 and placed the Ofeq-5 spy satellite in orbit." [vi]
  - Israel launched a missile across the Mediterranean that landed about 250 miles north of Benghazi, Libya. The missile flew over 800 miles, and U.S. experts felt it had a maximum range of up to 900-940 miles (1,450 kilometers) — which would allow the Jericho II to cover virtually all of the Arab world and even the southern former Soviet Union.[vii]
  - The most recent version of the missile seems to be a two-stage, solid-fueled missile with a range of up to 900 miles (1,500 kilometers) with a 2,200 pound payload.
  - Commercial satellite imaging indicates the Jericho II missile may be 14 meters long and 1.5 meters wide. Its deployment configuration hints that it may have radar area guidance similar to the terminal guidance in the Pershing II and probably has deployed these systems.

- Some Jericho IIs may have been brought to readiness for firing during the Gulf War.
- Israel began work on an updated version of the Jericho II no later than 1995 in an effort to stretch its range to 2,000 km. At least part of this work may have begun earlier in cooperation with South Africa. There have been unconfirmed reports of a Jericho III missile.

- Israel is also seeking technology to improve its accuracy, particularly with gyroscopes for the inertial guidance system and associated systems software.
- Israel is actively examining ways to lower the vulnerability of its ballistic missiles and nuclear weapons. These include improved hardening, dispersal, and the use of air-launched and sea-based delivery systems.
- There are reports that Israel is developing a Jericho III missile, based on a booster it developed with South Africa in the 1980s.
  - The tests of a longer-range missile seem to have begun in the mid-1980s.[viii] A major test of such a booster seems to have taken place on September 14, 1989, and resulted in extensive reporting on such cooperation in the press during October 25 and 26, 1989.
  - It is possible that that both the booster and any Israeli-South African cooperation may have focused on satellite launches.[ix] Since 1994, however, there have been numerous reports that Israel was seeking a missile with a range of at least 4,800 kilometers, and which could fully cover Iran and any other probable threat.
  - Jane's estimated that the missile has a range of up to 5,000 kilometers and a 1,000-kilogram warhead. This estimate is based largely on a declassified Defense Intelligence Agency estimate of the launch capability of the Shavit booster that Israel tested on September 19, 1988.[x]
- Reports of how Israel deploys its missiles differ. Initial reports indicated that 30-50 Jericho I missiles were deployed on mobile launchers in shelters in the caves southwest of Tel Aviv. A source claimed in 1985 that Israel had 50 missiles deployed on mobile erector launchers in the Golan, on launchers on flat cars that could be wheeled out of sheltered cases in the Negev. (This latter report may confuse mobile missile launchers with the rail transporter used to move missiles from a production facility near Be'er Yaakov to a base at Kefar Zeharya, about 15 kilometers south of Be'er Yaakov.
- More recent reports indicate that Jericho II missiles are located in 50 underground bunkers carved into the limestone hills near a base near Kefar Zeharya. The number that are on alert, command and control and targeting arrangements, and the method of giving them nuclear warheads has never been convincingly reported.[xi]
- *Jane's Intelligence Review* published satellite photos of what it said was a Jericho II missile base at Zachariah (God remembers with a vengeance) several miles southeast of Tel Aviv in September 1997.[xii] According to this report, the transport-erector-launcher (TEL) for the Jericho II measures about 16 meters long by 4 meters wide and 3 meters high. The actual missile is about 14 meter long and 1.5 meters wide. The TEL is supported by three support vehicles, including a guidance and power vehicle. The other two vehicles include a communications vehicle and a firing control vehicle. This configuration is somewhat similar to that used in the U.S. Pershing II IRBM system, although there are few physical similarities.
- The photos in the article show numerous bunkers near the TEL and launch pad, and the article estimates a force of 50 missiles on the site. It also concludes that the lightly armored TEL would be vulnerable to a first strike, but that the missiles are held in limestone caves behind heavy blast-resistant doors. It estimates that a nuclear-armed M-9 or Scud C could destroy the launch capability of the site. [xiii]
- The same article refers to nuclear weapons bunkers at the Tel Nof airbase, a few kilometers to the northwest. The author concludes that the large number of bunkers indicates that Israel may have substantially more nuclear bombers than is normally estimated – perhaps up to 400 weapons with a total yield of 50 megatons. [xiv]
  - 76 F-15s, 232 F-16s, 20 F-4Es, and 50 Phantom 2000 fighter-bombers capable of long-range refueling and of carrying nuclear and chemical bombs.
- Israel bought some Lance missile launchers and 160 Lance missiles from the United States in the 1970s. The United States removed them from active duty during 1991-1994. The status of the Israeli missiles is unknown.
  - IISS reports that Israel currently has some 20 Lance launchers in storage.
  - The Lance has a range of 130 km with a 450-kg payload.

- Reports indicate that Israel has developed conventional cluster munitions for use with the Lance rocket.

- Reports of a May 2000 test launch seem to indicate that Israel has a cruise missile with a range of 1,500 km capable of being launched from its new *Dolphin*-class, German-built submarines.[xv]
  - It is believed that such a cruise missile, an extended-range, turbofan powered variant of the Popeye cruise missile, called the Popeye Turbo, can carry a nuclear warhead.
- There are reports of the development of a long-range, nuclear-armed version of Popeye with GPS guidance and of studies of possible cruise missile designs that could be both surface ship and submarine based.
  - A variant of the Popeye air-to-surface missile is believed to be capable of delivering a nuclear weapon payload.
  - The MAR-290 rocket with 30 kilometers range is believed to be deployed.
  - MAR-350 surface-to-surface missiles with a range of 56 miles and a 735-pound payload capacity are believed to have completed development or to be in early deployment.
  - Israel was seeking supercomputers for Technion (Israel Institute of Technology) (designing ballistic missile RVs), Hebrew University (may be engaged in hydrogen bomb research), and Israeli Military Industries (maker of Jericho II and the Shavit booster).
  - Israel's current review of its military doctrine seems to include a review of its missile basing options and the study of possible hardening and dispersal systems. There are also reports that Israel will solve its survivability problems by deploying some form of nuclear-armed missile on its new submarines.

Chemical Weapons

- Israel is reported to have begun chemical weapons research in 1948. Some reports that its chemical and biological weapons efforts were merged in 1952 as part of the creation of the Israel Institute for Biological Research at Nes Tona.
- Some reports began a "crash" chemical weapons production effort in 1955.
- Reports of a mustard and nerve gas production facility established in 1982 in the restricted area in the Sinai near Dimona seem incorrect. May have additional facilities. May have capacity to produce other gases. Probable stocks of bombs, rockets, and artillery.
- Extensive laboratory research into gas warfare and defense.
- An El Al 747-200 cargo plane crashed in southern Amsterdam on October 4, 1992, killing 43 people in the apartment complex it hit. This led to extensive examination of the crash, and the plane was found to be carrying 50 gallons of dimethyl methylphosphonate, a chemical used to make sarin nerve gas. The chemical had been purchased from Solkatronic Chemicals in the United States and was being shipped to the Israel Institute for Biological Research. It was part of an order of 480 pounds worth of the chemical. Two of the three other chemicals used in making sarin were shipped on the same flight. Israel at first denied this and then claimed it was being imported only to test gas masks.[xvi]
- Israel did sign the Chemical Weapons Convention (CWC) on January 13, 1993, but has never ratified it.
- In 1998, Israel chose not to expand the facilities at the Israel Institute for Biological Research at Nes Tona because of concerns for the risk to the local population. It may later have constructed a new, remote site.
- Israel may have the contingency capability to produce at least two types of chemical weapons and has certainly studied biological weapons as well as chemical ones. According to one interview with an Israeli source of unknown reliability, Israel has mustard gas, persistent and nonpersistent nerve gas, and may have at least one additional agent.
- Development of defensive systems includes Shalon Chemical Industries protection gear, Elbit Computer gas detectors, and Bezal R&D aircrew protection system.
- Extensive field exercises conducted in chemical defense.
- Gas masks were stockpiled and then distributed to the population with other civil defense instructions during the first and second Gulf Wars.
- Warhead delivery capability for bombs, rockets, and missiles, but none now believed to be equipped with chemical agents.

- An unconfirmed October 4, 1998, report in the *Sunday Times of London* quotes military sources as stating that Israeli F-16s had been modified to carry out attacks using chemical and biological weapons produced at the Nes Ziona facility.[xvii]
- No firm evidence Israel has stockpiled chemical weapons, or has gone beyond improving its defense and decontamination capabilities.

Biological Weapons

- Extensive research into weapons and defense. Ben Gurion initiates a search for experts as early as April 1948. A center called HEMED BEIT is reported to be established, but any biological weapons activity is never confirmed.
- Ready to quickly produce biological weapons, but no reports of active production effort.
- According to some reports, Israel revitalized its chemical warfare facilities south of Dimona in the mid-1980s, after Syria deployed chemical weapons and Iraq began to use these weapons in the Iran-Iraq War.
- Israel has at least one major research facility with sufficient security and capacity to produce both chemical and biological weapons.[xviii] There are reports that HEMED BEIT was replaced in 1952 by a biological weapons research facility at the Israel Institute for Biological Research at Nes Tona, about 12 miles south of Tel Aviv, and that this same facility also has worked on the development and testing of nerve gas. This facility has created enough public concern in Israel so that the mayor of Nes Tona has asked that it be moved away from populated areas. The facility is reported to have stockpiled anthrax and to have provided toxins to Israeli intelligence for use in covert operations and assassinations such as the attempt on a Hamas leader in Jordan in 1997.[xix]
    - The Israel Institute for Biological Research is located in a 14-acre compound. It has high walls and exceptional security and is believed to have a staff of around 300, including 120 scientists. A former deputy head, Marcus Klingberg, served 16 years in prison for spying for the FSU.
- U.S. experts privately state that Israel is one of the nations included in U.S. lists of nations with biological and chemical weapons. They believe that Israel has at least some stocks of weaponized nerve gas, although they may be stored in forms that require binary agents to be loaded into binary weapons.
- They believe that Israel has fully developed bombs and warheads capable of effectively disseminating dry, storable biological agents in micropowder form and has agents considerably more advanced than anthrax. Opinion differs over whether such weapons are actively loaded and deployed. Unconfirmed reports by the British *Sunday Times* claimed that IAF F-16s are equipped for strikes using both these weapons and chemical weapons.[xx]
- No firm evidence Israel has stockpiled biological weapons, or has gone beyond improving its defense and decontamination capabilities.

Nuclear Weapons

- Uranium exploration began in Negev as early as 1949; Israeli Atomic Energy Commission began to discuss nuclear option in 1952. Cooperation with France in nuclear reactor design and technology began in 1950s. French-Israeli construction of a reactor in Dimona – whose actual capacity was much larger than its announced capacity, began in 1957. US detected the project in 1958, and visited the reactor during the 1960s, but Israel concealed its true output and performance characteristics.
- Britain sells 20-tons of heavy water to Israel in 1959-1960. It also sells beryllium and lithium-6. These sales are critical to bringing the kind of reactor Israel needs on line, and potentially useful in easing its problems in producing "boosted" fission and fusion weapons.
- Possible nuclear test (implosion proof of principle or "zero yield") in Negev on November 2, 1966.
- By 1968, the CIA publicly estimated that Israel had nuclear weapons. It estimated that Israel had 10-20 nuclear weapons.
- By 1986, leaks by Mordecai Vanunu, and from other sources, led to estimates that Israel had some 100-200 fission weapons. The possibility existed that it had "boosted" fission weapons with yields in the 60-100 kiloton (KT) range.
- October 1973: reports that Prime Minister Golda Meir orders IDF to assemble nuclear weapons for delivery in response to Egyptian and Syrian attacks, and that .Jericho missiles at Hirbat Zachariah and nuclear strike F-4s at Tel Nof are armed.

- Reports of joint nuclear test with South Africa in 1979, but never confirmed. Israel does seem to have cooperated with South Africa in missile design and booster testing.
- The director of the Central Intelligence Agency (CIA) indicated in May 1989 that Israel may be seeking to construct a thermonuclear weapon.
- June 2000: reports begin to surface that Israel will arm submarines with nuclear-armed cruise or ballistic missiles. Such reports have continued ever since. Reports that Israel had modified the Harpoon cruise missile to have nuclear warheads have been regularly repeated since 2003. Germany sells Israel advanced Dolphin-class submarines in 2005.
- Israel has two significant reactor projects: the 5 megawatt highly enriched uranium light-water IRR I reactor at Nahal Soreq; and the 75-200 megawatt heavy-water IRR-2 natural uranium reactor used for the production of fissile Plutonium material at Dimona. Only the IRR-1 is under International Atomic Energy Agency safeguards.
- Dimona has conducted experiments in pilot scale laser and centrifuge enrichment, purifies uranium dioxide ($UO_{2)}$, converts uranium hexafluoride ($UF_{6,}$), and fabricates fuel for weapons purpose.
- Uranium phosphate mining in the Negev, near Beersheba, and yellowcake is produced at two plants in the Haifa area and one in southern Israel.
- Pilot-scale heavy water plant operating at Rehovot.
- Estimates of numbers and types of weapons differ sharply.
    - No agreement exists over the plutonium output from the reactor at Dimona. Which is reported at power outputs from 75-200 megawatts. Satellite photos indicate that output is more likely to be below 140 megawatts.
    - Stockpile of at least 60-80 plutonium weapons.
    - May have well over 100 nuclear weapons assemblies, with some weapons with yields over 100 kilotons.
    - U.S. experts believe Israel has highly advanced implosion weapons. Known to have produced Lithium-6, allowing production of both tritium and lithium deuteride at Dimona. Facility no longer believed to be operating.
    - Some weapons may be ER variants or have variable yields.
    - Stockpile of up to 300-400 weapons is possible. Lower limit could be 70-100.
    - There exists a possibility that Israel may have developed thermonuclear warheads.
- Major weapons facilities include production of weapons-grade plutonium at Dimona, nuclear weapons design facility at Nahal Soreq (south of Tel Aviv), missile test facility at Palmachim, nuclear armed missile storage facility at Kefar Zekharya, nuclear weapons assembly facility at Yodefat, and tactical nuclear weapons storage facility at Eilabun in eastern Galilee.

Missile Defenses

- Patriot missiles with future PAC-3 upgrade to reflect lessons of the Gulf War.
- Arrow 2 two-stage **anti-ballistic missile system.** with slant intercept ranges at altitudes of 8-10 and 50 kilometers, speeds of up to Mach 9, plus possible development of the Rafal AB-10 close-in defense missile with ranges of 10-20 kilometers and speeds of up to Mach 4.5. Taas rocket motor, Rafael warhead, and Tadiran BM/C4I system and "Music" phased array radar.
- Israel plans to deploy three batteries of the Arrow to cover Israel, each with four launchers, to protect up to 85 percent of its population. The first battery was deployed in early 2000, with an official announcement declaring the system operational on March 12, 2000.
- The Arrow program has three phases:
    - Phase I: Validate Defense Concept and Demonstrate Pre-prototype Missile.
        - Fixed price contract: $158 million.
        - The United States pays 80 percent, Israel pays 20 percent.
        - Completed in December 1982.

- Phase II: Demonstrate lethality; develop and demonstrate tactical interceptor and launcher.
  - Fixed price contract: $330 million.
  - The United States pays 72 percent, Israel pays 28 percent.
  - Began in July 1991.
  - Successfully completed.
- Phase III: Develop and integrate tactical system, conduct weapon system tests, and develop and implement interoperability.
  - Program cost estimated at $616 million.
  - The United States pays 48 percent, Israel pays 52 percent.
  - Began in March 1996.
  - System integration in progress.
- The Arrow will be deployed in batteries as a wide area defense system with intercepts normally at reentry or exoatmospheric altitudes. Capable of multitarget tracking and multiple intercepts.

- Israel has designed the Nautilus laser system for rocket defense in a joint project with the United States. It has developed into the Theater High Energy Laser. The project has recently been expanded to include interception of not only short-range rockets and artillery, but also medium-range Scuds and longer-range missiles such as Iran's Shahab series.
- Israel is examining the possibility of boost-phase defenses. The Rafael Moab UAV forms part of the Israeli Boost-Phase Intercept System. This is intended to engage **ballistic missiles** soon after launch, using weapons fired from a UAV. Moab would launch an improved Rafael Python 4 air-to-air missile. Range is stated as 80-100 km depending on the altitude of release.

Advanced Intelligence Systems

- Israeli space program to date:

Satellite	Launch Date	Status	Function
Ofeq 1	9/19/1988	Decayed 1/14/1989	Experimental
Ofeq 2	4/3/1990	Decayed 7/9/1990	Communications experiments.
Ofeq 3	4/5/1995	Decayed 10/24/2000	Reconnaissance/experimental?
Ofeq 4 (Eros A)	1/22/1998	Launch failed during second-stage burn	Reconnaissance/commercial imaging?
Eros A1	12/5/2000	In orbit	Reconnaissance/commercial imaging?
Ofeq 5	5/28/2002	In orbit	Reconnaissance
Ofeq-7	6/11/2007	In orbit	Reconnaissance
TecSAR	01/21/2008	In orbit/Awaiting final certification	Reconnaissance/radar imaging

Note: This chart does not include Israel's commercial communications satellite ventures.

- The Shavit launched Israel's satellite payload on September 19, 1989. It used a three-stage booster system capable of launching a 4,000-pound payload over 1,200 miles or a 2,000-pound payload over 1,800 miles. It is doubtful that it had a payload capable of intelligence missions and seems to have been launched, in part, to offset the psychological impact of Iraq's missile launches.
  - It is believed that the vehicle was launched for experimentation in generation of solar power and transmission reception from space, for verification of the system's ability to withstand vacuum and weightless conditions, and for data collection on space environment conditions and Earth's magnetic field.
- Ofeq 2 launched on April 3, 1990 — one day after Saddam Hussein threatened to destroy Israel with chemical weapons if it should attack Baghdad.
  - This vehicle used the Ofeq 1 test-bed. Little open-source information exists on this vehicle although it is believed to be a test-bed for communications experiments.

- Israel launched its first intelligence satellite on April 5, 1995, covering Syria, Iran, and Iraq in orbit every 90 minutes. The Ofeq 3 satellite is a 495-pound system launched using the Shavit 1 launch rocket and is believed to carry an imagery system. Its orbit passes over or near Damascus, Tehran, and Baghdad.
    - The Shavit 1 differs from the Shavit only in the use of a somewhat different first stage. This change has not significantly affected vehicle performance. The Ofeq 3 and all subsequent launches have used the Shavit 1.
    - Reports conflict regarding whether this was an experimental platform or Israel's first surveillance satellite. Although it is thought to carry visible and ultraviolet wavelength imaging technology, the resolution is thought to be on the order of feet. The relatively low resolution, combined with its orbit, suggest to some observers that the satellite was capable of producing imagery of limited military usefulness.
- On January 22, 1998, the Ofeq 4/Eros A satellite was launched. Due to a failure in the second stage the satellite never made orbit. Reports conflict about whether this was a launch of a military reconnaissance satellite or was intended for producing commercial satellite imagery.
- The Eros A1 satellite was launched on December 5, 2000, on a Russian Start-1 rocket from the Svobodny launch site. This satellite produces commercially available satellite images. At a basic level, multispectral images with resolutions of 1.8 meters can be obtained. Currently, image processing techniques can yield resolutions of 1 meter. This is expected to improve to 0.6~0.7 meter resolutions in the next year or two. Some reports indicate that the Israeli government is a primary consumer of Eros imagery.
    - A successor craft, the Eros B, is reported to have a baseline ability to produce images with a panchromatic resolution of 0.87 meters and 3.5 meters for multispectral images. Launch on board a Russian vehicle was expected in early 2004, but this was not been confirmed.
- On May 28, 2002, the Ofeq 5 reconnaissance satellite was launched successfully.
- Agreement signed with the United States in April 1996 to provide Israel with missile early warning, launch point, vector, and point of impact data.
- Israeli Aircraft Industries, the manufacturer of the Shavit series SLV, is developing additional launchers to place satellites in polar orbits:
    - LK-A - For 350-kg-class satellites in 240x600-km elliptical polar orbits.
    - LK-1 - For 350-kg-class satellites in 700-km circular polar orbits.
    - LK-2 - For 800-kg-class satellites in 700-km circular polar orbits.
    - It is likely that these SLVs designed to place satellites in polar orbits could not be launched from Israel and would require an overseas launching site, such as the American site at Wallops Island.
    - On June 11, 2007, the Ofleq 7 reconnaissance satellite was launched successfully.[xxi]
    - Ofeq 7, which began transmitting on June 14, 2007, would complement the 2002-launched Ofleq 5, which had surpassed its four-year service lifespan.
    - The Ofeq 7's camera is believed to be superior to the older Eros-B1 system, which, it was declared, has a resolution of 0.7 m.
    - The upcoming Ofeq 8 should present a major leap in image resolution and capability.
- On January 21, 2008, the TecSAR reconnaissance satellite was launched successfully. TecSAR was Israel's first radar imaging satellite and was designed by Israel Aerospace Industries. At the time of writing, TecSAR was undergoing testing under various operational modes before being declared fully operational. While no immediate data was available on image resolution, and Israeli space official estimated TecSAR's footprint to cover more than 500 square kilometers in "mosaic mode." TecSAR is expected to play an integral role, along with Ofeq-5, Ofeq-7 and Eros A and B in countering potential strategic threats posed by Iran and Syria.[xxii]

[i] Barbara Opall-Rome, "Israel Explores Options in Face of Iran's Nuclear Work," Defense News, May 29, 2006, p. 6.

[ii] Nuclear Threat Initiative, country profile on Israel, "missile overview," http://www.nti.org/e_research/profiles/Israel/index.html

[iii] Some reports give the range as 500 kilometers; Jane's Defense Weekly, March 10, 1999, p. 50-64.

[iv] Baltimore Sun, November 23, 1988; Washington Post, September 16, 1989.

[v] Tass International, 1216 GMT, September 15, 1989; Washington Post, September 16, 1989; Jane's Defense Weekly, November 19, 1988, September 23, 1989, p. 549; Washington Times, July 22, 1987, p. D-4; International Defense Review, 7/1987, p. 857, and New York Times, July 22, 1987, p. A-6, July 29, 1987; Mideast Markets, November 23, 1987, p. 11; in Harold Hough, "Israel's Nuclear Infrastructure, Jane's Intelligence Weekly, November, 1994, pp. 505-511.

[vi] Nuclear Threat Initiative, country profile on Israel, "missile overview," http://www.nti.org/e_research/profiles/Israel/index.html

[vii] BBC and ITV reporting efforts seem to give more credibility to the idea that Israel has some form of relatively short-range nuclear-armed missile. Ranges of anywhere from 750-930 NM have been reported, with accuracy's of anywhere from 0.1 Km to radar correlator guidance packages capable of CEPs of 10 meters. Bulletin of Atomic Scientists, Vol. 46, Jan/Feb. 19980, p. 48; Washington Post, September 16, 1989, p. A-17, November 15, 1989, p. A-14; Economist, August 1, 1987, p. 41; Washington Times, July 22, 1987, p. D-4; July 24, 1987, p. A-9 and April 4, 1988, p. 17; International Defense Review, 7/1987, p. 857, and New York Times, July 29, 1987, p. A-10.

[viii] Tass International, 1216 GMT, September 15, 1989; Washington Post, September 16, 1989; Jane's Defense Weekly, November 19, 1988, September 23, 1989, p. 549; Washington Times, July 22, 1987, p. D-4; International Defense Review, 7/1987, p. 857, and New York Times, July 22, 1987, p. A-6, July 29, 1987; Mideast Markets, November 23, 1987, p. 11; in Harold Hough, "Israel's Nuclear Infrastructure, Jane's Intelligence Weekly, November, 1994, pp. 505-511.

[ix] Washington Post, October 26, 1989, p. A-36; Boston Globe, October 30, 1989, p. 2; Newsweek, November 6, 1989, p. 52.

[x] Jane's Intelligence Review, September, 1997, pp. 407-410; Jane's Defense Weekly, March 10, 1999, p. 50-64; International Defence Review, Extra, 2/1997, p. 2.

[xi] It is also possible that Israel may have deployed nuclear warheads for its MGM-55C Lance missiles. Israel has 12 Lance transporter-erector-launchers, and at least 36 missiles. The Lance is a stored liquid fueled missile with inertial guidance and a range of 5-125 kilometers. It has a warhead weight of 251 kilograms, and a CEP of 375 meters. It was deployed in US forces with the W-70 nuclear warhead. International Defense Review, 7/1987, pp. 857; Economist, May 4, 1968, pp. 67-68; New York Times, July 22, 1987, pp. A-6; Washington Times, July 22, 1987, pp. D-4; Defense and Foreign Affairs, June, 1985, pp. 1; Aerospace Daily, May 1, 1985, pp. 5 and May 17, 1985, pp. 100; Aerospace Daily, May 1, 1985, May 7, 1985; Shuey, et al, Missile Proliferation: Survey of Emerging Missile Forces, pp. 56; CIA, "Prospects for Further Proliferation of Nuclear Weapons, " DCI NIO 1945/74, September 4, 1974; NBC Nightly News, July 30, 1985; New York Times, April 1, 1986; US Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers, Washington, GPO, 1989, pp. 18; Michael A. Ottenberg, "Israel and the Atom," American Sentinel, August 16, 1992, pp. 1.

[xii] Harold Hough, "Could Israel's Nuclear Assets Survive a First Strike?," Jane's Intelligence Review, September, 1997, pp. 407-410.

[xiii] Harold Hough, "Could Israel's Nuclear Assets Survive a First Strike?," Jane's Intelligence Review, September, 1997, pp. 407-410.

[xiv] Harold Hough, "Could Israel's Nuclear Assets Survive a First Strike?," Jane's Intelligence Review, September, 1997, pp. 407-410.

[xv] Uzi Mahnaimi and Matthew Campbell, "Israel Makes Nuclear Waves With Submarine Missile Test," Sunday Times (London), June 18, 2000; Walter Pincus, "Israel Has Sub-Based Atomic Arms Capability," Washington Post, June 15, 2002, pp. A1.

[xvi] Associated Press, October 5, 1998, 0316, October 8, 1998, 1350; Philadelphia Inquirer, November 1, 1998, pp. A-7.

[xvii] Uzi Mahnaimi, "Israeli Jets Equipped for Chemical Warfare," *Sunday Times* (London), October 4, 1998.

[xviii] This information is unconfirmed, and based on only one source. Israel does, however, have excellent research facilities, laboratory production of poison gas is essential to test protection devices as is the production of biological weapons to test countermeasures and antidotes.

[xix] Philadelphia Inquirer, November 1, 1998, pp. A-7; Associated Press, October 8, 1998, 1350.

[xx] Washington Times, October 7, 1998, pp. A-14.

[xxi] Alon Ben-David, "Israel Bolsters Reconnaissance Capabilities with Ofeq-7 Launch," *Jane's Defense Weekly*, June 20, 2007.

[xxii] Barbara Opall-Rome, "Israel Tests 1st Radar-Imagery Satellite," Defense News, February 4, 2008, p. 8.