

A Comprehensive Introduction to Militarisation of Space

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First Edition, 2012

ISBN 978-81-323-4583-1

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Published by:

The English Press

4735/22 Prakashdeep Bldg,

Ansari Road, Darya Ganj,

Delhi - 110002

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Chapter- 1

Introduction to Militarisation of Space



A ground-based interceptor, designed to destroy incoming ICBMs, is lowered into its silo at the missile defence complex at Fort Greely, Alaska, July 22, 2004.

The **militarisation of space** is the placement and development of weaponry and military technology in outer space.

History

Acquisition of high grounds for military advantage has been a perennial feature of military campaigns. For thousands of years, military tacticians have exploited the concept of "capturing" or "keeping" the high ground in military campaigns. Fortifications were built on high points, with walls that enabled archers to rain down deadly volleys. Mobile towers served as siege weapons. Ships were equipped with crow's nests that facilitated long-range reconnaissance. Hot air balloons were lofted by Napoleon, during the American Civil War, and the first World War to observe troop movements. Aircraft were initially seen as useful for high level reconnaissance, which was quickly followed by aerial battles.

Aircraft revolutionized warfare during the twentieth century, leading to "command of the air" as a key strategic concept. The U.S. had already begun its Discoverer space program, now known as Corona, when Francis Gary Powers' U-2 aircraft was shot down in 1960 U-2. The quest for safer observation from space gained momentum. Initial attempts for control of the environment of space were led by both the US and the Soviet Union. They planned for controlling the realm of space with nuclear and conventional devices such as anti-satellite weapons (ASATs). The militarization of space began in the 1960s, and has now evolved into a key military capability for space-faring nations, potentially giving decisive military advantage. Militarization of space is the next step in this quest to gain higher ground. The idea of placing weapons in space can be found first in 20th century science fiction stories.

One needs to define "militarization" of space. Does militarization mean placing weapons in space, or does it include orbiting capabilities that are used by the military such as GPS navigation, communications, and reconnaissance? If the latter definition applies, then space has been militarized for over 50 years already since the first Discoverer/Corona satellite launched in 1959.

While military activities have certainly taken place in space (since the launch of Sputnik by the Russian military), and space is an operating location for many military spacecraft (such as imaging & communications satellites) or a temporary transit medium for weapons (such as ballistic missiles), it must be pointed out that permanent stationing of operational weapons in space has never been conducted.

World War II and the V-2 rocket

As early as 1927 members of the *Verein für Raumschiffahrt (VfR)* ("Spaceflight Society") had started experimenting with liquid-fuelled rockets. Rockets using a solid propellant had been used as weapons by all sides in WWI, and as a result, the Treaty of Versailles forbade solid fuel rocket research in Germany. By 1932 the Reichswehr started taking notice of their developments for potential long-range artillery use, and a team led by

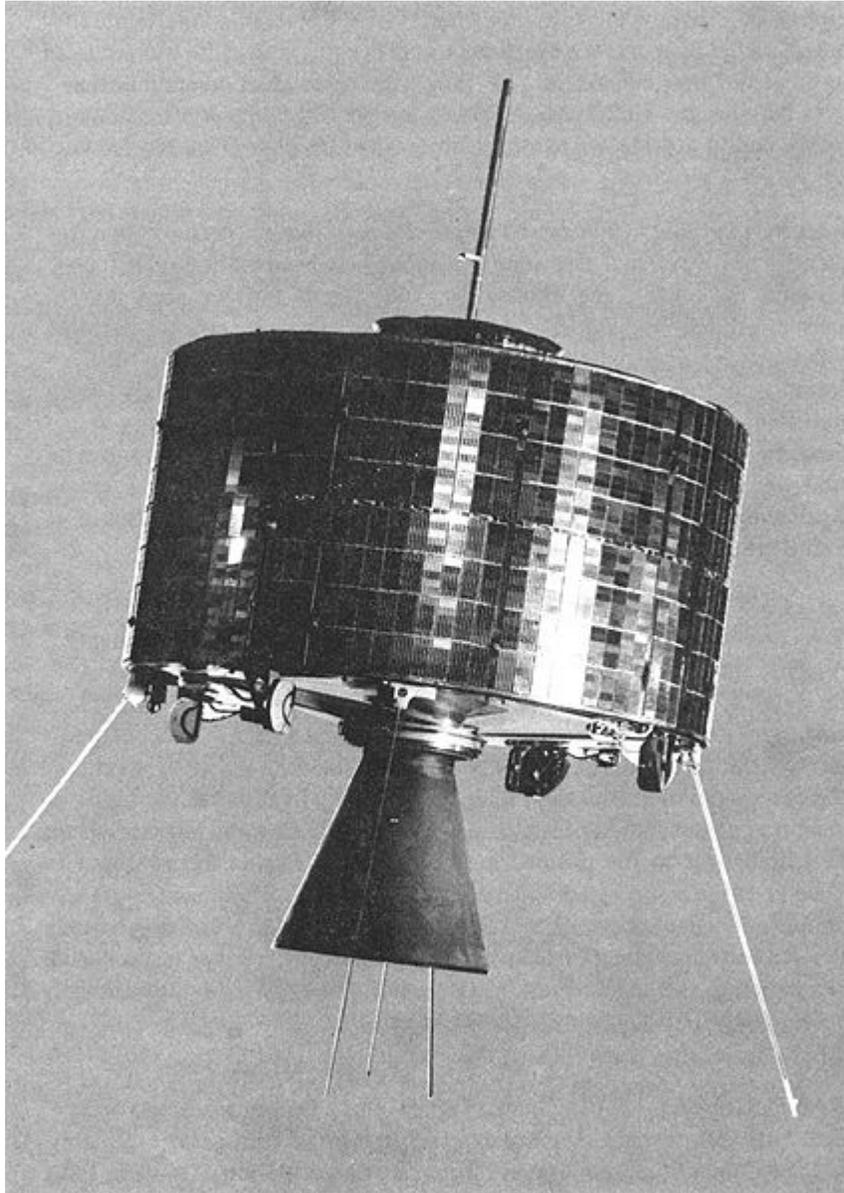
General Walter Dornberger was shown a test vehicle designed and flown by Wernher von Braun. Although the rocket was of limited ability, Dornberger saw von Braun's genius and pushed for him to join the military.

Von Braun did so, as eventually did most of the other members of the society. In December 1934 von Braun scored another success with the flight of the A2 (*A* for *Aggregat*) rocket, a small model powered by ethanol and liquid oxygen, with work on the design continuing in an attempt to improve reliability. Many different liquid fuels had been developed, but the German military specifically encouraged the use of ethanol as a rocket fuel because Germany had always been hampered by a shortage of crude-oil-based fuels. Throughout WWII a wide variety of military rockets were fuelled by ethanol that was primarily derived from potatoes.

By 1936 the team had moved on from the A2 and started work on both the A3 and A4. The latter was a full-sized design with a range of about 175 km (110 miles), a top altitude of 80 km and a payload of about a tonne. This increase in capability had come through a complete redesign of the engine by Walter Thiel. It was clear that von Braun's designs were turning into real weapons.

The A3 proved to be problematic, and a redesign was started as the A5. This version was completely reliable, and by 1941 the team had fired about 70 A5 rockets. The first A4 flew in March 1942, flying about 1.6 km and crashing into the water. The second launch reached an altitude of 11 km before exploding. The third rocket, launched on October 3, 1942, changed things by following its trajectory perfectly. It landed 193 km away, and became the first man-made object to enter space. Production started in 1943 on the wonder weapon *Vergeltungswaffe 2* (reprisal weapon 2), or the V-2 as it became better known, at the insistence of Goebbels' propaganda ministry.

The Cold War



The Syncom satellites set major milestones in space communications, Syncom 2 was the first geosynchronous satellite, Syncom 3 was placed in the first geostationary orbit.

During the Cold War, the world's two great superpowers — the Soviet Union and the United States of America — spent large proportions of their GDP on developing military technologies. The drive to place objects in orbit stimulated space research and started the Space Race. In 1957, the USSR launched the first artificial satellite, *Sputnik 1*.

By the end of the 1960s, both countries regularly deployed satellites. Spy satellites were used by militaries to take accurate pictures of their rivals' military installations. As time passed the resolution and accuracy of orbital reconnaissance alarmed both sides of the iron curtain. Both the United States and the Soviet Union began to develop anti-satellite

weapons to blind or destroy each other's satellites. Laser weapons, kamikaze style satellites, as well as orbital nuclear explosion were researched with varying levels of success. Spy satellites were, and continue to be, used to monitor the dismantling of military assets in accordance with arms control treaties signed between the two superpowers. To use spy satellites in such a manner is often referred to in treaties as "national technical means of verification".

The superpowers developed ballistic missiles to enable them to use nuclear weaponry across great distances. As rocket science developed, the range of missiles increased and intercontinental ballistic missiles (ICBM) were created, which could strike virtually any target on Earth in a timeframe measured in minutes rather than hours or days. In order to cover large distances ballistic missiles are usually launched into sub-orbital spaceflight. An intercontinental missile's altitude halfway through delivery is ca. 1200 km.



Test of the LG-118A Peacekeeper missile, each one of which can carry 10 independently targeted nuclear warheads along trajectories outside of the Earth's atmosphere.

As soon as intercontinental missiles were developed, military planners began programs and strategies to counter their effectiveness.

USA

Early American efforts included the Nike-Zeus Program, Project Defender, the Sentinel Program and the Safeguard Program. The late 1950s Nike-Zeus Program involved firing Nike nuclear missiles against oncoming ICBMs thus exploding nuclear warheads over the North Pole. This idea was soon scrapped and work began on Project Defender in the 1960s. Project Defender attempted to destroy Soviet ICBMs at launch with satellite weapon systems, which orbited over Russia. This program proved unfeasible with the technology from that era. Work then began on the Sentinel Program which used anti-ballistic missiles (ABM) to shoot down incoming ICBMs. The Safeguard Program was deployed in the mid 1970's and was based on the Sentinel Program. Since the ABM treaty only allowed for construction of a single ABM facility to protect either the nation's capital city or an ICBM field, the Stanley R. Mickelsen Safeguard Complex was constructed near Nekoma, North Dakota to protect the Grand Forks ICBM facility. Though it was only operational as an ABM facility for less than a year, the Perimeter Acquisition Radar (PAR), one of Safeguard's components, was still operational as of 2005. One major problem with the Safeguard Program, and past ABM systems, was that the interceptor missiles, though state of the art, required nuclear warheads to destroy incoming ICBMs. Future ABMs will likely be more accurate and utilize hit-to-kill or conventional warheads to knock down incoming warheads. The technology involved in such systems was shaky at best, and deployment was limited by the ABM treaty of 1972.

In 1983 American president Ronald Reagan proposed the "Strategic Defense Initiative" — a space-based system to protect the United States from attack by strategic nuclear missiles. The plan was ridiculed by some as unrealistic and expensive, and Dr. Carol Rosin nicknamed the policy "Star Wars", after the popular science-fiction movie franchise. The late astronomer Carl Sagan, amongst others, pointed out that in order to defeat "Star Wars" the Soviet Union had only to build more missiles, allowing them to overcome the defense by sheer force of numbers. Proponents of the "Star Wars" policy champion the strategy of technology for hastening the Soviet Union's downfall. According to this viewpoint, Communist leaders were forced to either shift large portions of their GDP to counter perceived "Star Wars" weapon systems or watch as their expensive nuclear stockpiles were rendered obsolete.

United States Space Command (USSPACECOM), a unified command of the United States military was created in 1985 to help institutionalize the use of outer space by the United States Armed Forces. The Commander in Chief of U.S. Space Command (CINCUSPACECOM), with headquarters at Peterson Air Force Base, Colorado was also the Commander in Chief of the binational U.S.-Canadian *North American Aerospace Defense Command* (CINCNORAD) and for the majority of time during USSPACECOM's existence also the Commander of the U.S. Air Force major command Air Force Space Command. Military space operations coordinated by USSPACECOM proved to be very valuable for the U.S.-led coalition in the 1991 Persian Gulf War.

The U.S. military has relied on communications, intelligence, navigation, missile warning and weather satellite systems in areas of conflict since the early 1990s, including the

Balkans, Southwest Asia and Afghanistan. Space systems are considered indispensable providers of tactical information to U.S. warfighters.

As part of the ongoing initiative to transform the U.S. military, on June 26, 2002, Secretary of Defense Donald Rumsfeld announced that U.S. Space Command would merge with USSTRATCOM. The UCP directed that Unified Combatant Commands be capped at ten, and with the formation of the new United States Northern Command, one would have to be deactivated in order to maintain that level. Thus the USSPACECOM merger into USSTRATCOM.

USSR

The Soviet Union was also researching innovative ways of gaining space supremacy. Two of their most notable efforts were the Fractional Orbital Bombardment System (FOBS) and Polyus orbital weapons system.

FOBS was a Soviet ICBM in the 1960s that once launched would go into a low Earth orbit whereupon it would de-orbit for an attack. This system would create a path to North America over the South Pole, striking targets from the opposite direction from which NORAD early warning systems are oriented. The missile was phased out in January 1983 in compliance with the SALT II treaty.

The SALT II treaty (1979) prohibited the deployment of FOBS systems:

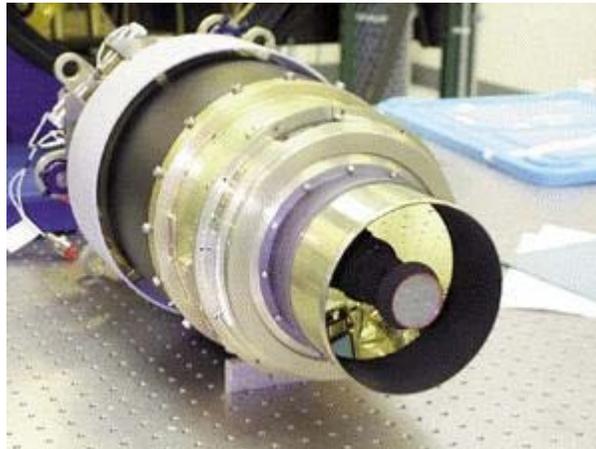
Each Party undertakes not to develop, test, or deploy:

(...)

(c) systems for placing into Earth orbit nuclear weapons or any other kind of weapons of mass destruction, including fractional orbital missiles;

On May 15, 1987, an Energia rocket flew for the first time. The payload was a prototype orbital weapons platform Polyus (also known as Polus, Skif-DM or 17F19DM), the final version of which according to some reports could be armed with nuclear space mines and defensive cannon. The Polyus weapons platform was designed to defend itself against anti-satellite weapons with recoilless cannon. It was also equipped with a sensor blinding laser to confuse approaching weapons and could launch test targets to validate the fire control system. The attempt to place the satellite into orbit failed.

Post-Cold War



A Lightweight Exo-Atmospheric Projectile (LEAP), which attaches to a modified SM-2 Block IV missile used by the U.S. Navy

As the Cold War ended with the implosion of the Soviet Union the space race between the two superpowers ended. The United States of America was left as the only superpower on Earth with a large concentration of the world's wealth and technological advancement. Despite the United States' new status in the world, the monopoly of space militarisation is in no way certain. Countries such as China, Japan, and India have begun their own space programmes, while the European Union collectively works to create satellite systems to rival those of the United States.

The USSR Space Forces were established as the Ministry of Defense Space Units in 1982. In 1991 the Soviet Union was broken up. The Russian Armed Forces were established on 7 May 1992, enabling the creation of Russian Space Forces later that year on 10 August. In July 1997 the Space Force was dissolved as a separate service arm and incorporated to the Strategic Rocket Forces along with the Space Missile Defense Forces, which previously were part of the Troops of Air Defense. The Russian Space Forces were officially reborn on June 1, 2001 as an independent section of the Russian military.

Post Cold War space militarisation seems to revolve around three types of applications. (The word "seems" is used because much of this subject matter is inconclusively verifiable, due to the high level of secrecy that exists among the great powers with regard to the details of space sensing systems.) The first application is the continuing development of "spy" or reconnaissance satellites which began in the Cold War era, but has progressed significantly since that time. Spy satellites perform a variety of missions such as high resolution photography (IMINT), communications eavesdropping (SIGINT), and covert communications (HUMINT). These tasks are performed on a regular basis both during peacetime and war operations. Satellites are also used by the nuclear states to provide early warning of missile launches, locate nuclear detonations, and detect preparations for otherwise clandestine or surprise nuclear tests (at least those tests or preparations carried out above-ground); this was the case when, in 1998, India and Pakistan both conducted a series of nuclear tests; in addition, a nuclear-detection satellite

of the Vela type was also reported to have detected a nuclear detonation in the Indian Ocean in 1978 that was believed to be a South African nuclear test in what was famously called the Vela Incident. Early-warning satellites can also be used to detect tactical missile launches; this capability was used during Desert Storm when America was able to provide advanced warning to Israel of Iraqi SS-1 SCUD missile launches.

Global Positioning Systems

The second application of space militarisation currently in use is GPS or Global Positioning System. This satellite navigation system is used for determining one's precise location and providing a highly accurate time reference almost anywhere on Earth or in Earth orbit. It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites. The GPS system was designed by and is controlled by the United States Department of Defense and can be used by anyone, free of charge. The cost of maintaining the system is approximately US\$400 million per year, including the replacement of aging satellites. The first of 24 satellites that form the current GPS constellation (Block II) was placed into orbit on February 14, 1989. The 52nd GPS satellite since the beginning in 1978 was launched November 6, 2004 aboard a Delta II rocket. The primary military purposes are to allow improved command and control of forces through improved location awareness, and to facilitate accurate targeting of smart bombs, cruise missiles, or other munitions. The satellites also carry nuclear detonation detectors, which form a major portion of the United States Nuclear Detonation Detection System. European concern about the level of control over the GPS network and commercial issues has resulted in the planned Galileo positioning system. Russia already operates an independent system called GLONASS (global navigation system), the system operates with 24 satellites that are deployed in 3 orbital planes as opposed to the 4 GPS is deployed in. The Chinese "Beidou" system provides China a similar regional (not global) navigation capability.

Military communication systems

The third current application of militarisation of space can be demonstrated by the emerging military doctrine of network-centric warfare. Network-centric warfare relies heavily on the use of high speed communications which allows all soldiers and branches of the military to view the battlefield in real-time. Real-time technology improves the situational awareness of all of the military's assets and commanders in a given theatre. For example, a soldier in the battle zone can access satellite imagery of enemy positions two blocks away, and if necessary e-mail the coordinates to a bomber or weapon platform hovering overhead while the commander, hundreds of miles away, watches as the events unfold on a monitor. This high-speed communication is facilitated by a separate internet created by the military for the military. Communication satellites hold this system together by creating an informational grid over the given theatre of operations. The Department of Defense is currently working to establish a Global Information Grid to connect all military units and branches into a computerised network in order to share information and create a more efficient military.

Military spaceplanes

It was revealed that Soviet officials were concerned that the US Space Shuttle program had such military objectives such as to make a sudden dive into the atmosphere to drop bombs on Moscow and these concerns were part of the motivation behind pursuing their own Buran program.

The NASA uncrewed spaceplane project X-37 was transferred to the US Department of Defense in 2004. It is unclear what its military mission would be. The X-37 is akin to a space version of Unmanned aerial vehicle.

Terrestrial-type weapons in space

Soviet Union, and later Russian cosmonauts have regularly carried small arms (handguns) on spacecraft, as part of the special emergency kit included in landing capsules. The weapon was included to protect the cosmonauts from wild animals after re-entry if the capsule landed in a wilderness area and could not be quickly retrieved. United States Astronauts are also provided a firearm for similar use

The Russian space station Salyut 3 was fitted with a 23mm cannon, which was successfully test fired at target satellites, at ranges from 500 m to 3000 m.

Space treaties

Treaties are agreed to when all parties perceive a benefit from becoming a signatory participant in the treaty. As mutually assured destruction (MAD) became the deterrent strategy between the two superpowers in the Cold War, many countries worked together to avoid extending the threat of nuclear weapons to space based launchers.

Outer Space Treaty

The Outer Space Treaty, considered by the Legal Subcommittee in 1966. Later that year, agreement was reached in the General Assembly. The treaty included the following principles:

- the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
- outer space shall be free for exploration and use by all States;
- outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- the Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- Astronauts shall be regarded as the envoys of mankind;

- States shall be responsible for national space activities whether carried out by governmental or non-governmental activities;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.

In summary, the treaty initiated the banning of signatories' placing of nuclear weapons or any other weapons of mass destruction in orbit of Earth, installing them on the moon or any other celestial body, or to otherwise station them in outer space. The United States, the United Kingdom, and the Soviet Union signed the treaty and it entered into effect on October 10, 1967. As of January 1, 2005, 98 States have ratified, and an additional 27 have signed the Outer Space Treaty.

Note that this treaty does not ban the placement of weapons in space in general, only nuclear weapons and WMD.

Space Preservation Treaty

The Space Preservation Treaty was a proposed 2006 UN General Assembly resolution against all space weapons. Three countries, most notably the United States of America, abstained from voting on most provisions of this treaty because the proposed treaty did not do enough to clearly define what is meant by a "space weapon", and therefore was open to wide interpretation and impossible to verify whether it was being violated.

Quotations

- "Control of space means control of the world." — Vice President Lyndon Johnson, 1961
- "It's politically sensitive, but it's going to happen. Some people don't want to hear this, and it sure isn't in vogue, but — absolutely — we're going to fight in space. We're going to fight from space and we're going to fight into space. That's why the US has development programs in directed energy and hit-to-kill mechanisms. We will engage terrestrial targets someday — ships, airplanes, land targets — from space." — Commander-in-Chief of US Strategic Command (1994–1996), Joseph W. Ashy
- "The competition between military forces is moving towards outer space ... this is a historical inevitability and a development that cannot be turned back"; "The air force will extend its reach from the sky to space, from defence of Chinese territory to attack [of threats] as well. We will improve the overall capability to strike a long-distance target with high precision, fight electronic or internet warfare with back-up from space ... and deliver our military strategic assets." — General Xu Qiliang, head of China's air force, 2009

Chapter- 2

United States Spy Satellites

Lacrosse



Lacrosse 4, under construction

Lacrosse and **Onyx** are the code names for the United States' National Reconnaissance Office terrestrial radar imaging reconnaissance satellite. While not officially confirmed by the NRO or anybody in the U.S. government, for a long time, there was and is widespread evidence to confirm its existence, including one NASA website. In July 2008, the NRO itself declassified the existence of their SAR satellite constellation.

According to former Director of Central Intelligence Admiral Stansfield Turner, Lacrosse had its origins in 1978 when a dispute between the Central Intelligence Agency and the U.S. Air Force as to whether a combined optical/radar reconnaissance satellite (the CIA proposal) or a radar-only one (the USAF proposal) should be developed was resolved in favor of the USAF.

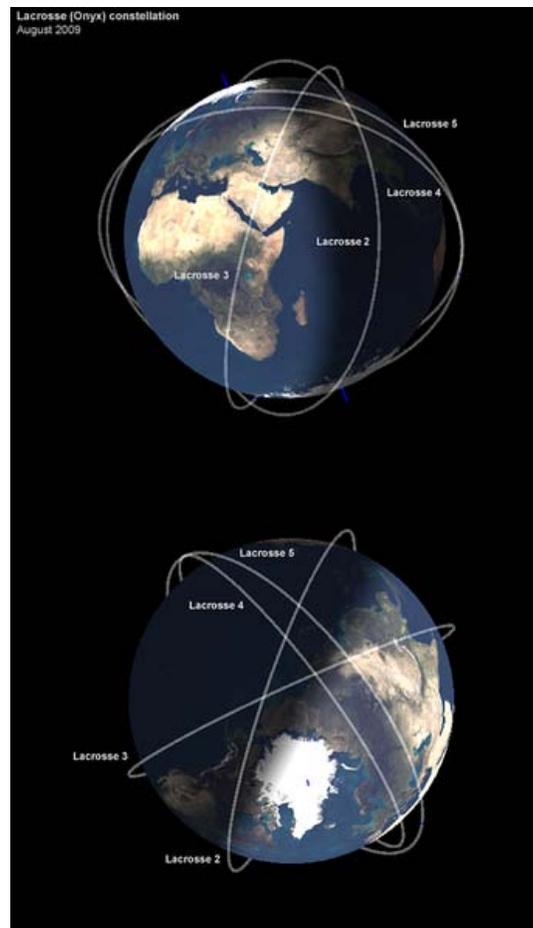
Lacrosse uses Synthetic Aperture Radar as its prime imaging instrument. It is able to see through cloud cover and also has some ability to penetrate soil, though there have been more powerful instruments deployed in space for this specific purpose. Early versions are believed to have used the Tracking and Data Relay Satellite System (TDRSS) to relay imagery to a ground station at White Sands, New Mexico. There are some indications that other relay satellites may now be available for use with Lacrosse. The name "Lacrosse" is used to refer to all variants, while "Onyx" is sometimes used to refer to the three newer units.

Unit costs (including launch) in 1990 dollars are estimated to be in the range of US \$ 0.5 to 1.0 billion (inflation adjusted US\$ 0.84 to 1.68 billion in 2011).

Future

It has been said that the B-2 bomber was originally intended to use directly down-linked targeting data from Lacrosse satellites in order to aid it in its role of hunting down and destroying Soviet mobile ICBM launchers. It had been anticipated that the Lacrosse satellites would be replaced by the radar component of the Future Imagery Architecture (FIA). The severe program problems encountered by FIA in the early 2000s appear to have led to off-loading of radar reconnaissance to the Space Based Radar, later simplified to Space Radar, with initial launch anticipated around 2015. This program itself was axed by Congress late 2008. The launch of NROL-41 (USA 215) in September 2010 has all orbital characteristics of a radar remote sensing platform and could be the first of a Lacrosse follow-up program. It's orbit is a retrograde version of the "frozen" Lacrosse orbit, the choice for a retrograde orbit itself indicating a SAR role.

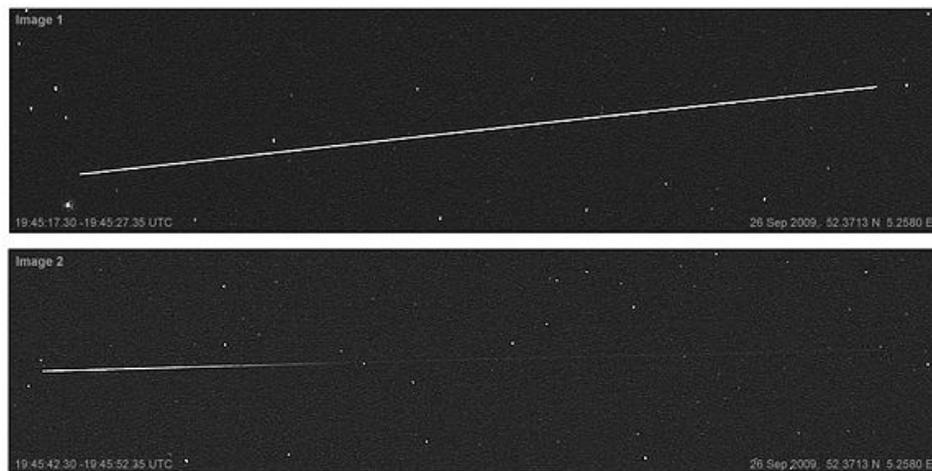
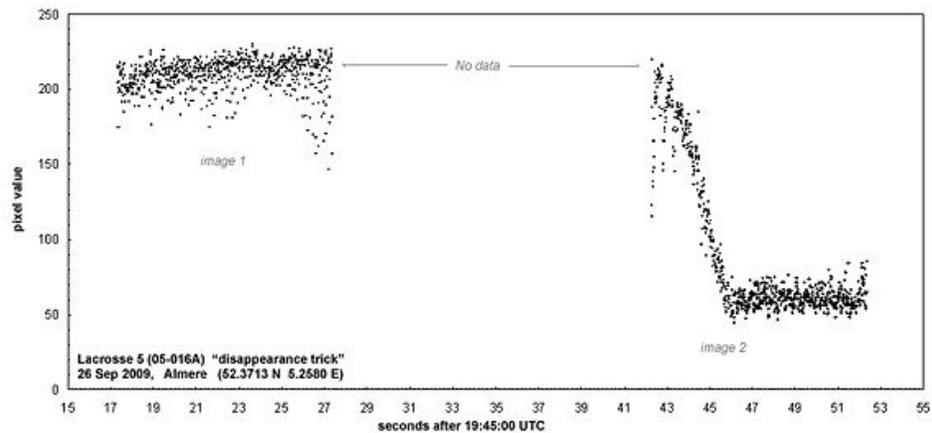
Launches



Constellation of the Lacrosse (Onyx) SAR satellites currently in orbit (August 2009)

Five Lacrosse spacecraft have been launched, with four currently in orbit.

- **Lacrosse 1: "Lacrosse 3000"**
 - Launch: December 2, 1988
 - Platform: Space Shuttle *Atlantis*, mission STS-27
 - Pad: Kennedy Space Center, Launch Complex 39B
 - Orbital apogee/perigee/inclination: 447 × 437 km @ 57.0°
 - Orbital period: 93.4 minutes
 - Decay: 1997
 - Status: Fulfilled mission, deorbited.
 - NORAD Number: 19671(USA 34) COSPAR ID: 1988-106B
- **Lacrosse 2:**
 - Launch: March 8, 1991
 - Platform: Titan IV-A
 - Pad: Vandenberg AFB, Space Launch Complex 4
 - Orbital apogee/perigee/inclination: 662 × 420 km @ 68.0°
 - Status: In active service, mission extended
 - NORAD Number: 21147 (USA 69) 1991-017A
 - Notes: The first West Coast launch of a Titan IV.
- **Lacrosse 3:**
 - Launch: October 24, 1997
 - Platform: Titan IV-A
 - Pad: Vandenberg AFB, Space Launch Complex 4
 - Orbital apogee/perigee/inclination: 679 × 666 km @ 57.0°
 - Status: In active service
 - NORAD Number: 25017 (USA 133) 1997-064A
 - Notes: Replacement for Lacrosse 1.
- **Lacrosse 4:**
 - Launch: August 17, 2000
 - Platform: Titan IV-B
 - Pad: Vandenberg AFB, Space Launch Complex 4
 - Orbital apogee/perigee/inclination: 695 × 689 km @ 68.0°
 - Mass: 14,500 kg



Lacrosse 5 (05-016A) brightness profile showing the sudden "dip" in brightness known as the "disappearance trick". These images and the derived graph were made by Dutch amateur observer Marco Langbroek, 26 September 2009.

- Status: In active service
- NORAD Number: 26473 (USA 152) 2000-047A
- Notes: After initial orbit, minor adjustments were made, sending it to $675 \times 572 @ 68.1^\circ$. An *Onyx* variant.
- **Lacrosse 5:**
 - Launch: April 30, 2005
 - Platform: Titan IV-B
 - Pad: Cape Canaveral
 - Orbital apogee/perigee/inclination: $718 \times 712 \text{ km} @ 57.0^\circ$
 - Mass: 16,000 kg
 - Status: In active service
 - NORAD Number: 28646 (USA 182) 2005-016A
 - Notes: Lacrosse 5 appears to differ somewhat from the previous four satellites. As determined by amateur observers, there are subtle differences

in its orbit and its color is somewhat whiter than the distinct red-orange tint of the earlier ones. Most strikingly, it sometimes fades from brightness to invisibility within the space of a few seconds while still in full sunlight. (The amateurs call this rapid fade its "disappearing trick".)

The orbital inclination of 68°, combined with their altitude gives the satellites a complete view of the earth's surface, including the poles.

Samos

The **Samos E** or **SAMOS** (Satellite and Missile Observation System) program was a relatively short-lived series of reconnaissance satellites for the United States in the early 1960s. Reconnaissance was performed with film cameras and television surveillance from polar low Earth orbits with film canister returns and transmittals over the U.S. Samos was first launched in 1960, but not operational until 1963 and all were launched from Vandenberg Air Force Base.

SAMOS was also known by the unclassified terms **Program 101** and **Program 201**.

Specifications

- Launch vehicles: Atlas Agena A, Agena B (early), Titan3B (later)
- Vehicle weights: 4,100 pounds (early), 6,600 pounds (later)
- Diameter: 58.5 inches
- Classification: Dept. of Defense classified, IMINT
- Launch site: Vandenberg AFB

Vehicle missions

Name	Launch date	Mass (kg)	Apogee (km)	Perigee (km)	Inclination (deg)	NSSDC ID	Comments
<i>Samos</i> 1	Oct. 11, 1960	1,845	-----	-----	-----	1960-F13, SAMOS-1	Launch Failure; satellite destroyed
<i>Samos</i> 2	Jan. 31, 1961	1,900	557	474	97.4	1961-ALPHA-1, 1961-001A	First generation photo surveillance; radio relay of images; micrometeoroid impact data.

							Decayed 10/21/71
<i>Samos</i> 3	Sept. 9, 1961	1,150	-----	-----	-----	1961-F09, SAMOS-3	Exploded on launch pad
<i>Samos</i> 4	Nov. 22, 1961	1,860	-----	-----	-----	1961-F13, NNN6101	Failed to orbit
<i>Samos</i> 5	Dec. 22, 1961	1,860	244	702	89.6	1961- ALPHA- LAMBDA- 2, 1961- 035A	Decayed 8/14/62
<i>Samos</i> 6	March 7, 1962	1,860	251	676	90.9	1962-ETA- 3, 1962- 007A	Decayed 6/7/63
<i>Samos</i> 7	April 26, 1962	1,588	203	204	92.0	1962-PI, 1962-016A	Decayed 4/28/62
<i>Samos</i> 8	June 17, 1962	1,860	-----	-----	-----	1962-PSI, 1962-023A	Decayed 6/18/62
<i>Samos</i> 9	July 18, 1962	1,860	184	236	96.1	1962-ZETA, 1962-030A	Decayed 7/25/62
<i>Samos</i> 10	August 5, 1962	1,860	205	205	96.3	1962- ALPHA- LAMBDA, 1962-035A	Decayed 8/6/62
<i>Samos</i> 11	November 11, 1962	1,860	206	206	96	1962- BETA-PI, 1962-064A	Decayed 11/12/1962
<i>Samos</i> 87	March 1, 1972	unk	unk	unk	unk	unk	DOD launch classified.

From October 1960 to November 1962, at least 11 launch attempts were made. Portions of the program are still considered classified information. It is believed that the program was cancelled because the imagery produced was poor. The program was operated by the United States Air Force, but was overshadowed by the Central Intelligence Agency's Corona program.

At least two different generations of the satellite were made, and at least four different types of cameras were used. Early on, the idea was to use frame readout cameras that would take a picture and send the scanned image via radio to ground stations on Earth. This system was apparently troublesome, so the program also developed a photographic film return system where the camera and used film would be ejected and be retrieved as it floated down through the atmosphere by parachute. Film-return satellites would remain

the standard until the KH-11 satellite with digital imaging capability emerged in the 1970s.

Equipment

Name	Type	Focal Length	Resolution	Swath
E-1	readout	1.83 m (72 in)	30 m (100 ft)	161 × 161 km
E-2	readout	0.91 m (36 in)	6 m (20 ft)	27 × 27 km
E-5	film	1.67 m (66 in)	1.5 m (5 ft)	98 km length
E-6	film	0.7 m (28 in)	2.4 m (8 ft)	280 km width

The **E-1** and **E-2** cameras used the readout method. Little is known about the **E-3** type of camera, which was eventually cancelled. It likely had higher resolution, and may have been superseded by the later **E-6**. An **E-4** camera was initially planned for relatively low-resolution mapmaking purposes, but it was cancelled with the functionality being taken up by the KH-5 (Argon) satellite. The **E-5** and **E-6** were panoramic format film cameras that appeared in later launches, but only a few were used. The E-5 would later be called upon in the short-lived KH-6 (Lanyard) program.

Some satellites were equipped with so-called Ferret devices, for "ferreting" information by spying on electronic communication. A more modern term for that activity would be Signals Intelligence. Toward the end of the program, satellites were only being launched with Ferrets, without any cameras. Two Ferret systems were created, designated **F-1** and **F-2**.

Some additional payloads were sometimes onboard, mostly scientific devices for learning more about the space environment so that future satellites could be better-designed for spaceflight. The satellites as launched varied in mass from 1845 to 1900 kilograms.

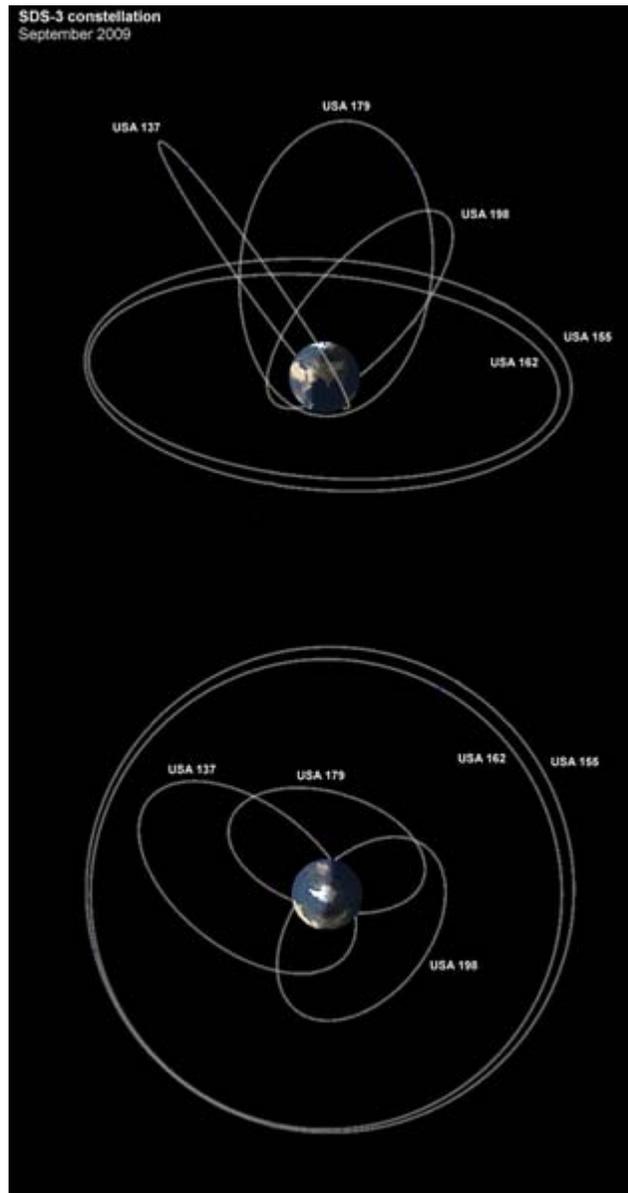
Orbit

Samos-2 was the first satellite to enter a sun-synchronous orbit.

Factoids

Sergei Khrushchev wrote in his memoirs about the partial recovery of what he believed was a Samos satellite, except the date was the winter before the program started. A second capsule was apparently recovered in early 1961, although the device had been disassembled by local farmers, exposing film and preventing the Soviets from determining the satellite's capabilities. It may or may not have been a Samos.

Satellite Data System

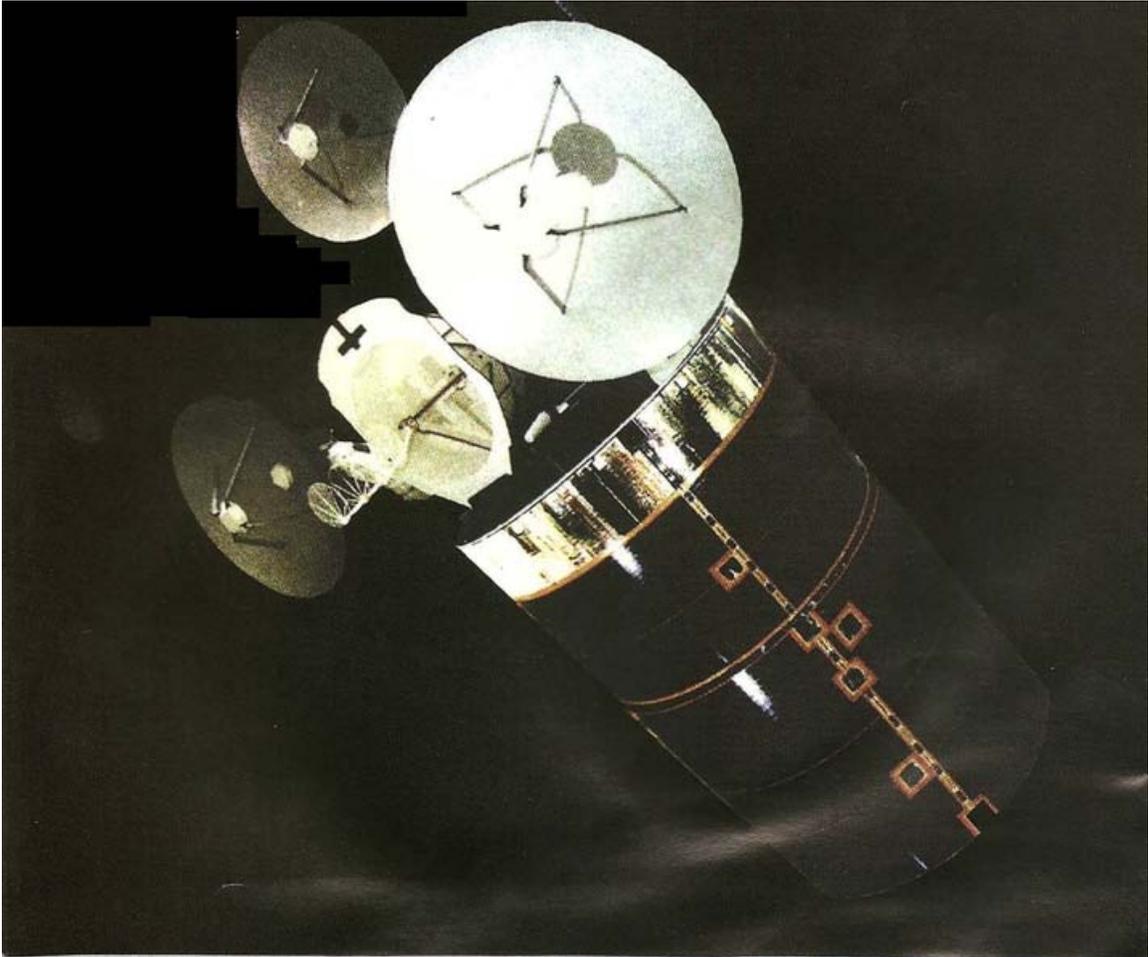


The current SDS-3 constellation, consisting of three Molniya orbit type and two geostationary satellites

The Satellite Data System (**SDS**) is a system of United States military communications satellites. At least three generations have been used: **SDS-1** from 1976 to 1987; **SDS-2** from 1989 to 1996; **SDS-3** from 1998 to the present. SDS satellites have a highly elliptical orbit, going from about 300 kilometers at perigee to roughly 39,000 km at apogee in order to allow communications with polar stations that cannot contact geosynchronous satellites. The high apogee meant that the polar regions were visible for long amounts of time, and only two satellites were required in order to achieve constant

communications ability. In addition, two geostationary satellites appear to be part of the system. The SDS satellites were constructed by Hughes Aircraft.

The primary purpose of the SDS satellites is to relay imagery from low-flying reconnaissance satellites, notably the Keyhole optic reconnaissance and Lacrosse/Onyx radar reconnaissance satellites to ground stations in the United States.



Releasable Picture of NRO satellite, possible SDS-1



The SDS 3-4 satellite (USA 179, 2004-034A) created a tiny trail perpendicular to the star trails in this 10 second exposure with a Zeiss Sonnar MC 2.8/180mm lens made by amateur satellite observer Marco Langbroek

Each SDS-1 satellite had 12 channels available for ultra-high frequency communication. They were cylindrical in shape, roughly 25 feet (7.6 m) long. 980 watts of electrical power were available from solar panels and batteries. The SDS-1 had a mass of 1385 pounds (630 kilograms) and was launched on Titan-3B rockets. The SDS-1 satellites had similar orbits to the Air Force's Jumpseat ELINT satellites.

The SDS-2 is significantly more massive at 5150 pounds (2335 kg), with three separate communication dishes, including one for a K band downlink. Two dishes are 15 feet (4.5 meters) in diameter, while the third is 6.6 feet (2 m) in diameter. The solar arrays generate 1238 watts of power. It is believed that the Space Shuttle has been used to launch several satellites, possibly on missions STS-28, STS-38, and STS-53. Other launches have used the Titan-4 rocket.

Quasar is the rumored code name for the communications satellite.

A recent Quasar may have been launched into a high-apogee orbit from Cape Canaveral on August 31, 2004 by an Atlas 2AS rocket.

Launches

SDS-1

- **SDS F-1** launched 1976-06-02 1976-050A (OPS-7837)
- **SDS F-2** launched 1976-08-06 1976-080A (OPS-7940)
- **SDS F-3** launched 1978-08-05 1978-075A (OPS-7310)
- **SDS F-4** launched 1981-04-24 1981-038A (OPS-7225)
- **SDS F-5A** launched 1984-08-28 1984-091A (USA-4)
- **USA-9** launched 1985-02-08 1985-014A (USA-9)
- **SDS F-6** launched 1987-02-12 1987-015A (USA-21)

SDS-2

- **USA-40** launched 1989-08-08 on STS-28 1989-061B (USA-40)
- **USA-67** launched 1990-11-15 on STS-38 1990-097B)(USA-67)(Some sources identify USA-67 as a Magnum SIGINT satellite)
- **USA-89** launched 1992-12-02 on STS-53 1992-086B (USA-89)
- **USA-125** launched by Titan IV 1996-07-03 1996-038A (USA-125)

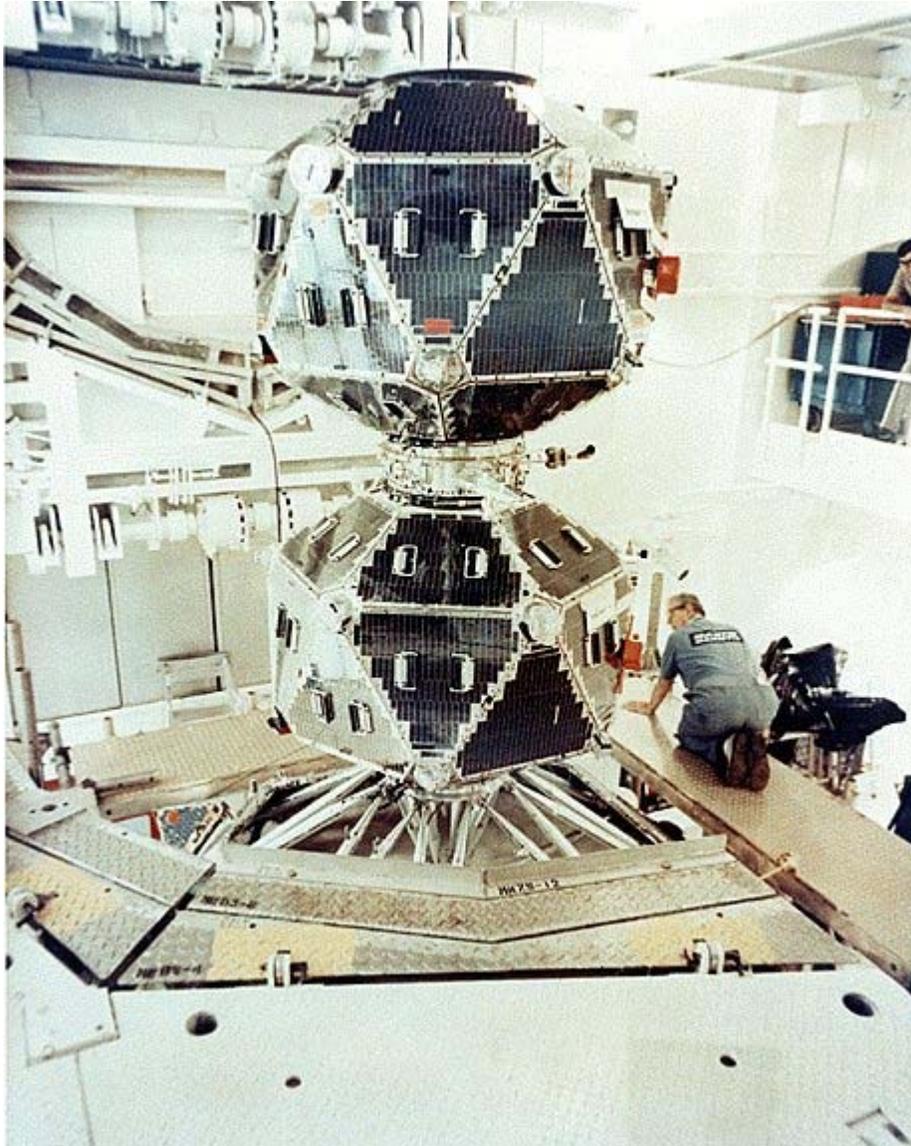
SDS-3

- **USA-137** *Capricorn* launched by Atlas IIA 1998-01-29 1998-005A
- **USA-155** *Great Bear* launched by Atlas IIAS 2000-12-06 2000-080A
- **USA-162** *Aquila* launched by Atlas IIAS 2001-10-11 2001-046A
- **USA-179** *Nemesis* launched by Atlas IIAS 2004-08-31 2004-034A
- **USA-198** *Scorpius* launched by Atlas V 401 2007-12-10 2007-060A

USA 155 and USA 162 are geostationary satellites.

Vela

Vela was the name of a group of satellites developed as the **Vela Hotel** element of Project Vela by the United States to monitor compliance with the 1963 Partial Test Ban Treaty by the Soviet Union, and other nuclear-capable states. It means *vigil* or "watch" in Spanish.



Vela-5A/B Satellite in Clean Room. (the two satellites, A and B, are separated after launch)

Vela started out as a small budget research program in 1959. It ended 26 years later as a successful, cost-effective space system. In the 1970s, the nuclear detection mission was taken over by the Defense Support Program (DSP) system, and in the late 1980s, augmented by the Navstar Global Positioning System (GPS) satellites. The program is now called the **Integrated Operational Nuclear Detection System (IONDS)**.

The total number of satellites built was 12 — six of the Vela Hotel design, and six of the Advanced Vela design. The Vela Hotel series was to detect nuclear initiations in space, while the Advanced Vela series was to detect not only nuclear explosions in space but also in the atmosphere.

All spacecraft were manufactured by TRW and launched in pairs, either on a Atlas-Agena or Titan III-C boosters, and placed in 63,000 to 70,000 mile orbits, well above the Van Allen radiation belts. The first Vela Hotel pair was launched in 1963, three days after the Test Ban Treaty was signed, and the last in 1965. They had a design life of six months, but were actually shut down after five years. Advanced Vela pairs were launched in 1967, 1969 and 1970. They had a nominal design life of 18 months, later changed to 7 years. However, the last satellite to be shut down was Vehicle 9 in 1984, which had been launched in 1969 and had lasted nearly 15 years.

The original Vela satellites were equipped with 12 external X-ray detectors and 18 internal neutron and gamma-ray detectors. They were equipped with solar panels generating 90 watts.

The Advanced Vela satellites were additionally equipped with two non-imaging silicon photodiode sensors called *bhangmeters* which monitored light levels over sub-millisecond intervals. They could determine the location of a nuclear explosion to within about 3,000 miles. Atmospheric nuclear explosions produce a unique signature, often called a "double-humped curve": a short and intense flash lasting around 1 millisecond, followed by a second much more prolonged and less intense emission of light taking a fraction of a second to several seconds to build up. The effect occurs because the surface of the early fireball is quickly overtaken by the expanding atmospheric shock wave composed of ionised gas. Although it emits a considerable amount of light itself it is opaque and prevents the far brighter fireball from shining through. As the shock wave expands, it cools down becoming more transparent allowing the much hotter and brighter fireball to become visible again.

No *single* natural phenomenon is known to produce this signature, although there was speculation that the Velas could record exceptionally rare natural double events, such as a meteoroid strike triggering a lightning superbolt in the earth's atmosphere, as may have occurred in the Vela Incident.

They were also equipped with sensors which could detect the electromagnetic pulse from an atmospheric explosion.

Additional power was required for these instruments, and these larger satellites consumed 120 watts generated from solar panels. Serendipitously, the Vela satellites were the first devices ever to detect cosmic gamma ray bursts.

Some controversy still surrounds the Vela program since on 22 September 1979 the Vela 6911 satellite detected the characteristic double flash of an atmospheric nuclear explosion. Still unsatisfactorily explained, this event has become known as the Vela Incident. The now-declassified report of the scientific panel appointed to evaluate the event concluded that it was "probably not from a nuclear explosion."

Vela 5A and 5B

The scintillation X-ray detector (XC) aboard Vela 5A and its twin Vela 5B consisted of two 1 mm thick NaI(Tl) crystals mounted on photomultiplier tubes and covered by a 0.13 mm thick beryllium window. Electronic thresholds provided two energy channels, 3-12 keV and 6-12 keV. In front of each crystal was a slat collimator providing a full width at half maximum (FWHM) aperture of $\sim 6.1 \times 6.1$ degrees. The effective detector area was $\sim 26 \text{ cm}^2$. The detectors scanned a great circle every 60 s, and covered the whole sky every 56 hr. Sensitivity to celestial sources was severely limited by the high intrinsic detector background, equivalent to about 80% of the signal from the Crab Nebula, one of the brightest sources in the sky at these wavelengths.

The Vela 5B satellite X-ray detector remained functional for over ten years.

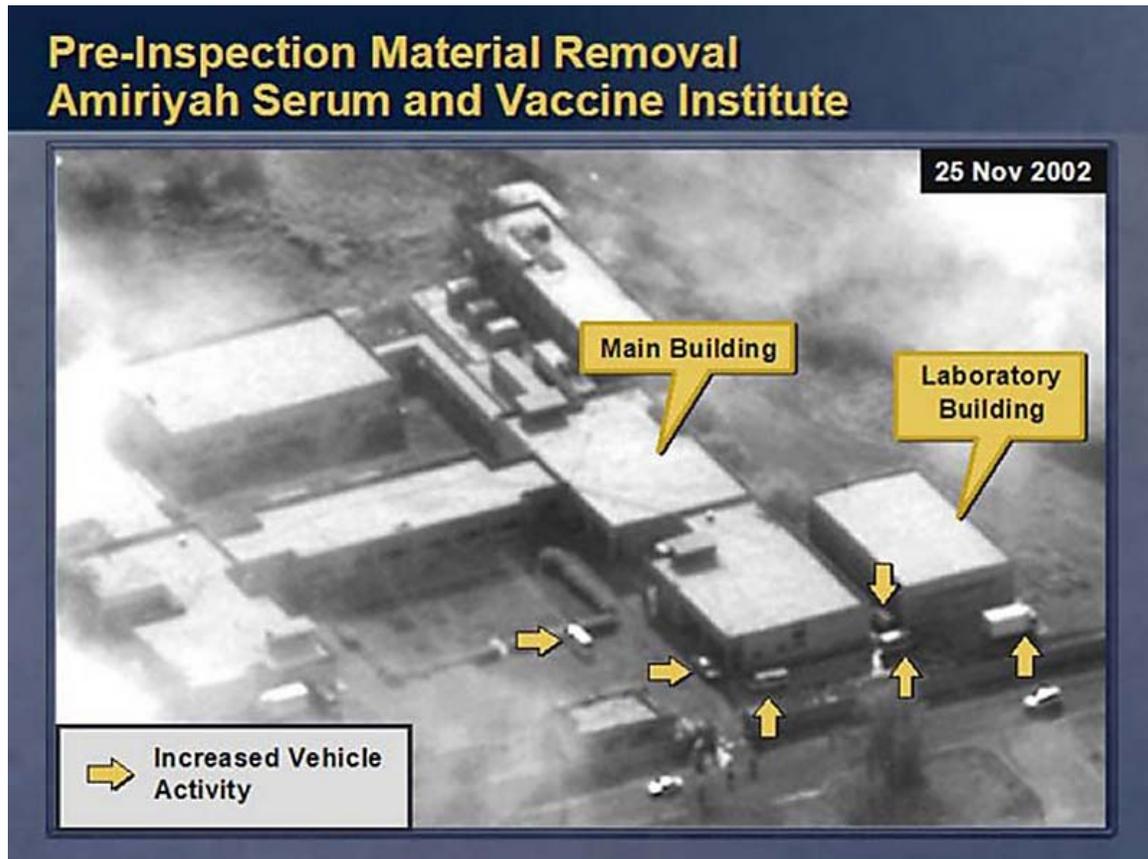
Vela 6A and 6B

Like the previous Vela 5 satellites, the Vela 6 nuclear test detection satellites were part of a program run jointly by the Advanced Research Projects of the U. S. Department of Defense and the U. S. Atomic Energy Commission, managed by the U. S. Air Force. The twin spacecraft, Vela 6A and 6B, were launched on 8 April 1970. Data from the Vela 6 satellites were used to look for correlations between gamma-ray bursts and X-ray events. At least 2 good candidates were found, GB720514 and GB740723. The X-ray detectors failed on Vela 6A on 12 March 1972 and on Vela 6B on 27 January 1972.

Role of Vela in discovering Gamma Ray Bursts (GRBs)

On July 2, 1967, at 14:19 UTC, the Vela 4 and Vela 3 satellites detected a flash of gamma radiation unlike any known nuclear weapons signature. Uncertain what had happened but not considering the matter particularly urgent, the team at the Los Alamos Scientific Laboratory, led by Ray Klebesadel, filed the data away for investigation. As additional Vela satellites were launched with better instruments, the Los Alamos team continued to find inexplicable gamma-ray bursts in their data. By analyzing the different arrival times of the bursts as detected by different satellites, the team was able to determine rough estimates for the sky positions of sixteen bursts and definitively rule out a terrestrial or solar origin. The discovery was declassified and published in 1973 as an *Astrophysical Journal* article entitled "Observations of Gamma-Ray Bursts of Cosmic Origin". This alerted the astronomical community to the existence of gamma-ray bursts (GRBs), now recognised as the most violent events in the universe.

Misty (classified project)



Serum and Vaccine Institute in Al-A'miriya, Iraq, as imaged by a US reconnaissance satellite in November 2002.

Misty is reportedly the name of a classified project by the United States National Reconnaissance Office to operate stealthy reconnaissance satellites. The satellites are conjectured to be photo reconnaissance satellites and the program has been the subject of atypically public debates about its worthiness in the defense budget since December 2004. The estimated project costs in 2004 dollars are US \$ 9.5 billion (inflation adjusted US\$ 11 billion in 2011).

Launches

The first satellite (USA-53 or 1990-019B, 19600 kg) launched for the program was deployed on March 1, 1990 by the Space Shuttle *Atlantis* as part of Mission STS-36. Objects associated with the satellite decayed on March 31, 1990, but the satellite itself was seen and tracked later that year and in the mid-1990s by amateur observers. The second satellite (USA-144 or 1999-028A) was launched on May 22, 1999, and by 2004 the launch of a third satellite was planned for 2009.

Design

Misty is reported to have optical and radar stealth characteristics, making it difficult for adversaries to detect (and thus predict the times it would fly overhead).

Almost everything about the program is classified information--but one clue about satellite camouflage has been found in the patent literature. Patent #US 5345238 describes an inflatable balloon that can be made rigid on exposure to ultraviolet radiation that can serve to lower the radar and optical signature of the satellite. Once deployed, the cone-shaped balloon could be steered to deflect incoming laser and microwave radar energy by sending it off into outer space. Whether or not these stealthy ideas are actually used in the MISTY satellite series is not publicly known.

Criticism

Porter Goss, a former Congressman and former CIA director, and George Tenet, former CIA director, have both vigorously supported successors to Misty, despite several attempts by Senators Dianne Feinstein and John D. Rockefeller IV to terminate the program. The primary contractor is Lockheed Martin Space Systems.

On June 21, 2007, the Associated Press reported that Director of National Intelligence John Michael McConnell has canceled the Misty program. While a spokesman of McConnell declined to comment on the report, he confirmed that McConnell has the authority to cancel projects.

Chapter- 3

Soviet Union Spy Satellites

Kosmos

Kosmos is a designation given to a large number of satellites operated by the Soviet Union and subsequently Russia. Kosmos 1, the first spacecraft to be given a Kosmos designation, was launched on March 16, 1962.

As of September 2010, 2,468 Kosmos satellites had been launched. The spacecraft do not form a single programme, but instead consist of almost all Soviet and Russian military satellites, as well as a number of scientific satellites, and spacecraft which failed during or immediately after launch, but still reached orbit. Control systems for 152 spacecraft which were later assigned Kosmos designations were developed and manufactured by NPO Electropribor (Kharkiv).

The designation is given only to satellites which are in Earth orbit. Typically, Soviet Lunar and planetary missions were initially put into an low Earth parking orbit along with an upper stage, which would later burn for around four minutes to place the spacecraft into a cislunar or a heliocentric orbit. If the engine misfired or the burn was not completed, the probes which would be left in Earth orbit would be given a Kosmos designation.

Most Soviet and subsequently Russian military satellites were given Kosmos designations. Spacecraft include optical reconnaissance satellites, communications satellites, early warning missile defence spacecraft, nuclear-powered radar reconnaissance satellites, anti-satellite weapons and their targets, navigation satellites and technology demonstrators. Some scientific spacecraft such as Dnepropetrovsk Sputnik, Bion and Meteor satellites were also given Kosmos designations.

Early Kosmos satellites

Kosmos 1

Kosmos 1, also known as Sputnik 11, was launched on March 16, 1962 at 12:00:00 UTC. Orbital mass 285 kg. It was the first satellite of the Soviet Earth Satellite series. Employed radio instruments in order to study the structure of the ionosphere.

Kosmos 2

Kosmos 2, also known as Sputnik 12, was launched on April 6, 1962 at 17:16:00 UTC. Orbital mass 285 kg. It was the second satellite of the Soviet Earth Satellite series. Employed radio instruments in order to study the structure of the ionosphere.

Kosmos 3

Kosmos 3, also known as Sputnik 13, was launched on April 24, 1962 at 04:04:00 UTC. Orbital mass 330 kg. It belongs to the Soviet Earth Satellite series. It was used to study the upper layers of the atmosphere, Earth and the outer space. Data was relayed to Earth by a multichannel telemetry systems equipped with space-borne memory units.

Kosmos 4

Kosmos 4, also known as Sputnik 14, was launched on April 26, 1962 at 10:04:00 UTC. Orbital mass 4600 kg. It was used to study the upper layers of the atmosphere, Earth and the outer space. It was developed to measure radiation before and after nuclear tests conducted during the US project Starfish. Data was relayed to Earth by a multichannel telemetry systems equipped with space-borne memory units.

Kosmos 5

Kosmos 5, also known as Sputnik 15, was launched on May 28, 1962 at 03:07:00 UTC. Orbital mass 280 kg. It was used to study the upper layers of the atmosphere, Earth and the outer space. Data was relayed to Earth by a multichannel telemetry systems equipped with space-borne memory units.

Kosmos 6

Kosmos 6, also known as Sputnik 16, was launched on June 30, 1962 at 16:04:00 UTC from Kapustin Yar. Orbital mass 355 kg. It was a Soviet DS (Dnepropetrovsk Sputnik) type military satellite built in Ukraine for launch by Kosmos launch vehicles. It was used for military and scientific research and component proving tests.

Kosmos 7

Kosmos 7, also known as Sputnik 17, was launched on July 28, 1962 at 09:21:00 UTC. Orbital mass 4600 kg. It was used to study the upper layers of the atmosphere, Earth and the outer space. Data was relayed to Earth by a multichannel telemetry systems equipped with space-borne memory units. It was used to measure radiation in the space environment in order to guarantee safety during the flight of the Vostok 3 and Vostok 4 spacecrafts.

Kosmos 8

Kosmos 8, also known as Sputnik 18, was launched on August 18, 1962 at 05:02:00 UTC from Kapustin Yar. Orbital mass 337 kg. It was a Soviet DS (Dnepropetrovsk Sputnik) type military satellite built in Ukraine for launch by Kosmos launch vehicles. It was used for military and scientific research and component proving tests.

Other Kosmos satellites

- Kosmos 110 - first Soviet biosatellite (contained biological experiments)
- Kosmos 133 - Soviet Soyuz programme test spacecraft
- Kosmos 186 and 188 - Soyuz predecessor, the first ever automatic docking of satellites
- Kosmos 212 and Kosmos 213 - Soyuz programme test spacecraft
- Kosmos 238 - final test series of Soyuz programme spacecraft
- Kosmos 419 - failed Mars mission
- Kosmos 482 - failed Venus mission, crashed in south New Zealand.
- Kosmos 605 - first of the Bion series, containing biological organisms
- Kosmos 782 - first mission in which the US participated in the Soviet Kosmos program
- Kosmos 954 - launched with an onboard nuclear reactor; failed (reasons uncertain) and re-entered atmosphere on January 24, 1978, strewing radioactive debris across northern Canada
- Kosmos 1001
- Kosmos 1074
- Kosmos 1129
- Kosmos 1267
- Kosmos 1402 - failed
- Kosmos 1514
- Kosmos 1667
- Kosmos 1686
- Kosmos 1818 - RORSAT with nuclear reactor
- Kosmos 1867 - RORSAT with nuclear reactor
- Kosmos 2251 - collided with an Iridium satellite in February 2009
- Kosmos 2441 - first in the a new series of spy satellites (Persona), features updated imaging technology and an extended lifetime of up to seven years, failed

Yantar

Yantar is a series of Russian (previously Soviet) reconnaissance satellites, which supplemented and eventually replaced the Zenit spacecraft. Kosmos 2175, a Yantar-4K2 or *Kobal't* spacecraft, was the first satellite to be launched by the Russian Federation following the dissolution of the Soviet Union. Yantar-Terilen was the first real-time digital system. Yantar satellites also formed the basis for the later Orlets, Resurs and Persona satellites. 173 have been launched, nine of which were lost in launch failures. The most recent launch was of Kosmos 2462 a Yantar-4K2M or *Kobal't-M*, on 16 April 2010. All Yantar satellites have been launched using the Soyuz-U carrier rocket.

Variants

Series	Other designations	GRAU index	First launch	Last launch	Number launched	Remarks
Yantar-1KFT	Kometa, Siluet	11F660	18 February 1981	2 September 2005	21	
Yantar-2K	Feniks	11F624	23 May 1974	28 June 1983	30	
Yantar-4K1	Oktan	11F693	27 April 1979	30 November 1983	12	
Yantar-4K2	Kobal't	11F695	21 August 1981	25 February 2002	82	
Yantar-4K2M	Kobal't-M	11F695M	24 September 2004	16 April 2010	6	Active
Yantar-4KS1	Terilen	11F694	28 December 1982	21 December 1990	15	
Yantar-4KS1M	Neman	17F117	10 July 1991	3 May 2000	9	

Zenit



Zenit re-entry capsule, showing camera ports

Zenit is the name of a series of military spy satellites launched by the Soviet Union between 1961 and 1994. To conceal their nature, all flights were given the public Kosmos designation. Over a 33 year period, over five hundred Zenits were flown making it the most numerous type of satellite in the history of spaceflight.

Description

The basic design of the Zenit satellites was similar to the Vostok manned spacecraft. It consisted of a spherical re-entry capsule 2.3 m in diameter with a mass of around 2400 kg. This capsule contained the camera system, its film, recovery beacons, parachutes and a destruct charge. In orbit, this was attached to a service module that contained batteries, electronic equipment, an orientation system and a liquid fuelled rocket engine that would slow the Zenit for re-entry, before the service module detached. The total length in orbit was around 5 m and the total mass was between 4600 kg and 6300 kg.

Unlike the American Corona spacecraft, the return capsule carried both the film and the cameras and kept them in a temperature controlled pressurised environment. This simplified the design and engineering of the camera system but added considerably to the weight of the satellite. An advantage was that cameras could be reused.

Early Zenits were launched using the Vostok rocket; later versions used the Voskhod and the Soyuz rockets. The first flights were launched from the Baikonur Cosmodrome but subsequent launches also took place at the Plesetsk Cosmodrome.

Most Zenits flew in a slightly elliptical orbit with a perigee of around 200 km and an apogee between 250 km and 350 km; the missions usually lasted between 8 and 15 days.

History

In 1956, the Soviet government issued a secret decree that authorised the development of 'Object D' which led to the program to launch Sputnik 3 (Sputnik 1 was a simplified spin-off of the Object D program.) The text of the decree remains secret, but it apparently authorised another satellite program – 'Object OD-1' - which was to be used for photo-reconnaissance from space.

By 1958, the OKB-1 design bureau was simultaneously working on Object OD-1 and Object OD-2—an early design for the Vostok manned spacecraft. The development of Object OD-1 was experiencing serious difficulties so the head of OKB-1, Sergei Korolev, initiated work to see if a design based on Object OD-2 could be used for an unmanned photo-reconnaissance satellite. This may have been a political manoeuvre that would enable him to continue the manned space program and avoid diverting more of OKB-1's resources into Object OD-1.

Despite bitter opposition from the military, the Soviet government endorsed Korolev's approach and issued decrees on 22 May and May 25, 1959 that ordered the development of three different spacecraft, all based on the same basic, Object OD-2, design. Spacecraft 1K would be a simplified prototype, 2K was to be a reconnaissance satellite and 3K was to be for manned flights. The name *Vostok* was also initially used for all three of these craft. But in 1961 the name became publicly known as the name of Yuri Gagarin's spacecraft so the 'Vostok 2' reconnaissance satellite was renamed 'Zenit 2'.

The first Zenit launch attempt took place on 11 November 1961, but there was a fault in the rocket's third stage and the spacecraft was destroyed using its destruct charge. The second attempt—publicly referred to as Cosmos 4—was successfully launched on the 26 April 1962 and re-entered three days later. However a failure in the orientation system meant no useful pictures were obtained. The third Zenit (Kosmos 7) was launched on the 28 July 1962 and successfully returned with pictures eleven days later. A further ten flights (including two more launch failures) took place before the system was considered operational.

Many versions of the satellite were developed for different reconnaissance missions and flights continued until 1994.

Zenit variants

Zenit 2

Zenit 2 was the first version to be launched in 1961 (there was no Zenit 1.)

The arrangement of cameras varied, but most flights carried four cameras of 1000 mm focal length, and one of 200 mm focal length. The single lower resolution camera was intended to provide low-resolution pictures that would help give a context to the high-resolution pictures.

Each camera had 1500 frames of film and from 200 km, each frame held an image of a 60 km by 60 km square. The ground resolution was stated to be 10–15 m although some unofficial sources claim it was much better—one source claims the number of cars in a car park could be counted. The cameras were developed at the Krasnogorsk Optical-Mechanical factory near Moscow. Curiously, this was also where the popular Zenit SLR cameras were made.

Zenit 2s also carried ELINT equipment to receive NATO radar signals. The satellites carried a parabolic antenna, around 1 meter in diameter, that is associated with this equipment. However, it is unclear if the antenna transmitted recorded signals to the ground or was for intercepting radar signals. In the latter case they would have been recorded on magnetic tape, to be retrieved after the return capsule landed.

There were 81 Zenit 2 launches, 58 were successful and 11 were partially successful. There were 12 failed missions, 5 because of a satellite malfunction and 7 because of a failure in the launch vehicle.

First flight - Kosmos 4, 1962. Last flight - Kosmos 344, 1970.

Zenit 2M

Improvements included a new camera system and the addition of solar panels. As the spacecraft mass was increased to 6300 kg, the Vostok rocket was replaced by the Voskhod and Soyuz rockets.

First flight - Kosmos 208, 1968. Last flight - Kosmos 1044, 1978.

Zenit 4

Unlike Zenit 2, little information on Zenit 4 has been released. The Zenit 4 was intended for high resolution photography and carried one camera of 3000 mm focal length as well as a 200 mm camera. The focal length of the main camera was greater than the diameter of the capsule so the camera made use of a mirror to fold the light path. The ground resolution is not publicly known but it is believed to have been 1–2 m.

The Zenit 4 weighted 6300 kg—around 1500 kg more than the Zenit 2. So, instead of the Vostok rocket, it was launched by the heavier Voskhod rocket. A probable total of 76 Zenit 4's were flown.

First flight - Kosmos 22, 1963. Last flight - Kosmos 355, 1970.

Zenit 4 M

An improved version of the Zenit 4, the Zenit 4M carried a new camera, solar panels, and a restartable engine so the satellite's orbit could be altered during the course of its mission. Mission duration was 13 days.

First flight - Kosmos 251, 1968. Last flight - Kosmos 667, 1974.

Zenit 4 MK / Zenit 4 MKM

These may have been versions of the Zenit 4 designed specifically to fly in lower orbits to improve image resolution. Some sources claim they were fitted with devices to compensate for aerodynamic drag and to withstand the effects of aerodynamic heating.

First flight - Kosmos 371, 1970. Last flight - Kosmos 1214, 1980.

Zenit 4 MT

A special version of the Zenit 4M intended for topographical photography. It carried a SA-106 topographic camera, a laser altimeter and Doppler apparatus.

First flight - Kosmos 470, 1971. Last flight - Kosmos 1398, 1982.

Zenit 6U

A 'universal' version of the Zenit, intended for both low-altitude, high-resolution missions and higher-altitude, general observation missions. All flights used the Soyuz launch vehicle. There were 96 launches.

First flight - Kosmos 867, 1976. Last flight - Kosmos 1685, 1985.

Zenit 8

This was intended for military cartographic photography. It used a Soyuz launch vehicle and launches took place from both Baikonur and Plesetsk. It had a 15 day orbital life. Similar satellites were referred to using the 'Resurs' designation.

Kosmos 2281, was the last Zenit flight.

First flight - Kosmos 1571, 1984. Last flight - Kosmos 2281, 1994.

Following the end of the programme, one Zenit-8 satellite was launched on the maiden flight of the Soyuz-2 rocket, as a DemoSat. The satellite was placed on a sub-orbital trajectory, and intentionally impacted the Pacific Ocean shortly after launch.

Almaz

The **Almaz** (Russian: Алмаз - "Diamond") program was a series of military space stations (or "Orbital Piloted Station" - OPS) launched by the Soviet Union under cover of the civilian Salyut DOS-17K (Durable Orbital Station) program after 1971.

Three Almaz stations were launched: Salyut 2, Salyut 3 and Salyut 5.

Salyut 2 failed shortly after achieving orbit, but Salyut 3 and Salyut 5 both conducted successful manned testing. Following Salyut 5, the Soviet Ministry of Defence judged in 1978 that the time consumed by station maintenance outweighed the benefits relative to automatic reconnaissance satellites.

Development

Almaz was promoted by Vladimir Chelomei as a response to the USAF's MOL project. Like its counterpart, the Almaz OPS would be launched with its initial crew atop Chelomei's UR-500 Proton rocket. After an extended stay of 30 to 60 days of military observation and photography the crew would return to Earth by way of a reusable Return Vehicle (VA).

Unlike the American MOL design the Almaz was equipped with a docking port for subsequent crews. These crews would arrive in manned TKS, also launched by the UR-500. And just like Almaz OPS, the TKS was equipped with its own return vehicle.

Also unique to the Almaz complex were small capsules which could be loaded with developed film for immediate return to Earth.

Orbital Piloted Stations (OPS)

The OPS basic design features are 4.15 meters in diameter and a weight of 20 tonnes. From 1965 to 1970, eight test models and two flight ready spaceframes were built. Five missions were executed with two considered a success. Total time spent in space in the program was 81 days.

OPS-1 (Salyut 2)

The first Almaz station (OPS-1 or Almaz 101.1), announced as Salyut 2, it was launched on April 3, 1973. For purposes of military secrecy, it was publicly designated Salyut 2 upon reaching orbit. A crew was prepared to fly to the station but an accident days after the launch left OPS-1 disabled and depressurized.

OPS-2 (Salyut 3)

OPS-2 (or Almaz 101.2), announced as Salyut 3, was launched on June 25, 1974. The crew of the Soyuz 14 spacecraft spent 15 days aboard the station in July 1974. A second expedition was launched toward OPS-2 in August 1974, but failed to reach the station. The station successfully remotely test-fired an onboard aircraft cannon at a target satellite while the station was unmanned. Salyut-3 was deorbited in January 1975.

OPS-3 (Salyut 5)

OPS-3 (or Almaz 103), announced after launch as Salyut 5, entered orbit on June 22, 1976. It was visited by two crews in the summer of 1976 and winter of 1977.

OPS-4

The next Almaz station, OPS-4, was to be the first station launched with a three panel Mech-A Synthetic Aperture Radar and a manned reusable Return Vehicle VA, however the VA was replaced by a second TKS docking port. This station's Shchit-1 23 mm defense cannon was also to be replaced with an advanced Shchit-2 space-to-space cannon. The Shchit-2 was reported to be a two projectile system, although no photographs of it have ever been published and it does not appear that this system was ever installed on the station. OPS-4 was grounded when the Almaz manned program was cancelled.

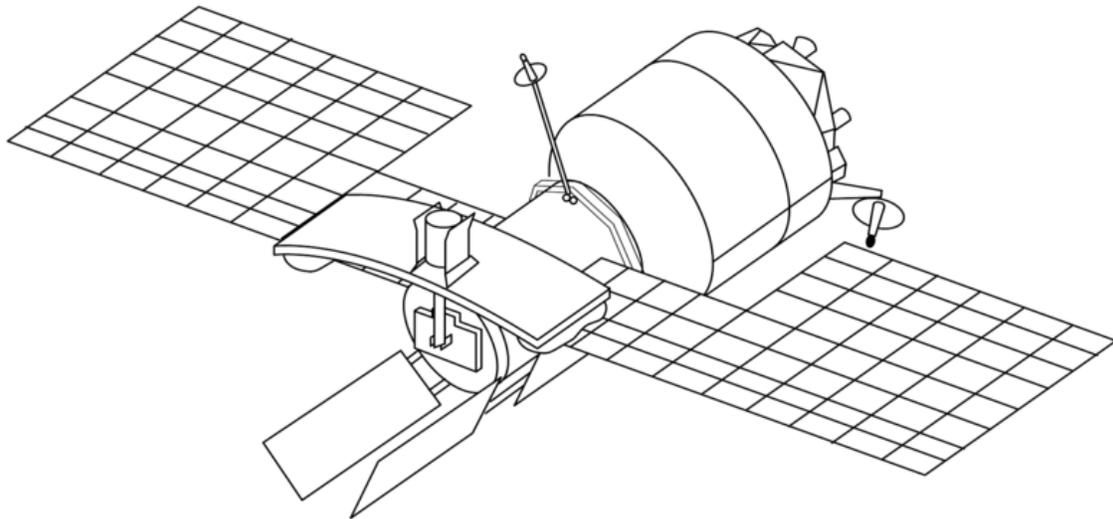
Defense measures

In addition to reconnaissance equipment, Almaz was equipped with a 23mm Nudelman rapid-fire cannon mounted in a stationary position to the forward belly of the station. This self-lubricating cannon was modified from the tail-gun of Tu-22 jet bomber and was capable of firing 950 rounds per minute. Each 200 gram projectile flew at a speed of 690 m/s relative to the station. To aim the cannon the entire station would be quickly reoriented facing the threat.

Salyut 3/OPS-2 conducted a successful test firing on a target satellite remotely with the station unmanned due to concerns over excessive vibration and noise.

OPS-4 was to have featured two unguided missiles instead of the aircraft cannon, but this system has not been shown publicly and may have never been fully manufactured.

Almaz-T (unmanned)



Almaz radar satellite (based on Almaz space station)

Following cancellation of the program, the Almaz station was reconfigured as an unmanned heavy radar-carrying reconnaissance satellite. Three such satellites were launched, two of which functioned successfully in orbit.

Almaz-T

- **Almaz-T** - The first Almaz-T blasted off from Baikonur on October 29, 1986. It did not reach orbit due to the failure of the first and second stages of the Proton launcher to separate. The safety system then destroyed the vehicle.

Kosmos 1870

- **Kosmos 1870** - On July 25, 1987, the second Almaz-T spacecraft successfully reached orbit with an inclination 71.92 degrees toward the Equator and it was officially identified as Cosmos-1870. The spacecraft functioned for two years, providing radar imagery with a resolution down to 25 meters, until it was deorbited on July 30, 1989.

Almaz-1

- **Almaz-1** - The third Almaz-T spacecraft was launched on March 31, 1991 under the name Almaz-1. After the launch a failure of the communications antenna designed to downlink the imagery via the Luch relay satellite was noted. Also one of the solar panels failed to deploy completely, leaving the main radar panel of the spacecraft partially blocked. After 18 months of successful work the Almaz-1 was deorbited on October 17, 1992 over the Pacific Ocean.

Almaz-2

- **Almaz-2 (Almaz-1V)** - Not flown. It had a new radar which would have provided a resolution of 5 to 7 meters. In addition, an optical-electronic payload on the station would have been capable of producing imagery with a resolution of 2.5 – 4 meters.

Other usage

The OPS spaceframes formed the basis of the Salyut, Mir and ISS space station base modules.

Currently, the private spaceflight company Excalibur Almaz has four space capsules derived from the TKS Return capsule, one will be used in support of space tourism while the other three capsules will be reserved for scientific and commercial payloads.

Chapter- 4

United Kingdom Spy Satellites

Zircon

Zircon was the codename for a British signals intelligence satellite, intended to be launched in 1988, before being cancelled.

During the Cold War, Britain's GCHQ was heavily reliant on America's National Security Agency (NSA) for communications interception from space. Concern heightened at the time of the Falklands War. GCHQ requested access to American Signals Intelligence satellites to assist in monitoring Argentine Communications, but reportedly struggled with the National Security Agency to gain appropriate tasking time, despite the special relationship between the two countries. The United States satellites were engaged in monitoring SIGINT traffic elsewhere in South America related to El Salvador. GCHQ therefore decided to produce a UK-designed-and-built signals intelligence satellite, to be called Zircon, a code-name derived from zirconium silicate, a diamond substitute. Its function was to intercept radio and other signals from the USSR, Europe and other areas. The Satellite was to be built at Marconi Space and Defence the Airport Portsmouth uk, at which a new high security building had been built and would have secured Jobs in the area. It was to be launched on a NASA Space Shuttle under the guise of Skynet IV. Launch on the Shuttle would have entitled a British National to fly as a Mission Specialist and a group of military pilots were presented to the press as candidates for 'Britain's first man in space'.

Zircon was cancelled by Chancellor Nigel Lawson on grounds of its cost in 1987. However, Duncan Campbell, an investigative journalist working for *New Statesman* magazine, planned to make a BBC television programme about the project, part of a six-part series called *Secret Society*. Campbell's thesis was that the cost of the satellite had been hidden from the British parliament, in particular the Public Accounts Committee.

As a result of TV interviews filmed with officials, particularly Sir Ronald Mason, the government's chief scientist, the government became aware that Campbell knew about the project. Shortly before the programme was due to be transmitted, in January 1987 the *New Statesman* published an account of Zircon. This triggered Special Branch police raids on the BBC offices in Glasgow, the offices of the *New Statesman*, and the homes of Campbell and his researchers, Jolyon Jenkins and Patrick Forbes. Master tapes were

removed from the BBC, the government obtained an injunction preventing transmission of the programme, and the BBC postponed the transmission of the entire series. Four episodes were transmitted in April and May 1987, and the Zircon programme was transmitted separately in September 1988. The sixth episode, titled "Cabinet," was held back indefinitely, and eventually remade and broadcast by Channel 4 in April 1991.

Skynet



Launch of the first Skynet satellite, Skynet 1A, by Delta rocket in 1969 from Cape Canaveral

Skynet is a family of military satellites, now operated by Paradigm Secure Communications on behalf of the UK Ministry of Defence, which provide strategic communication services to the three branches of the British Armed Forces and to NATO forces engaged on coalition tasks.

Models

Skynet 1

There were two Skynet 1 satellites; the first, launched in November 1969, failed after less than a year of operation. The apogee kick motor on the second failed, leaving it in geostationary transfer orbit.

Skynet 2

Following the failure of one of the Skynet 1 satellites, the timetable for the launch of the Skynet 2 system was delayed. When Skynet 2A was launched on 19 January 1974, the second stage of the Delta 2313 launch vehicle failed, placing the satellite in an unusable orbit. Despite not being in the right place, the ground stations successfully located and tracked the missing satellite, and were able to use telemetry readings from the solar panels to determine its alignment. Based on this analysis it was decided to use the alignment thrusters to deorbit the unit, and it was destroyed when it re-entered the Earth's atmosphere on 27 January.

Skynet 2B was successfully launched on 23 November 1974.

The Skynet 2 satellites were assembled and tested at the Marconi Space and Defence Systems establishment in Portsmouth, England, and were the first communication satellites built outside the US and USSR. The Skynet 2 system was very successful for its time, and remained in service for several years beyond the originally planned timeframe.

Skynet 3

Was cut due to budget restrictions, the capability being delivered using US assets. This dependence was identified as a weakness during the Falklands war and was one of the contributing factors for the emergence of the Skynet 4 tranche of space vehicles.

Skynet 4

Skynet 4 satellites have few similarities to the earlier generations. The cylindrical body of Skynet 1 and 2 was replaced by a large square body housing antennas with deployable solar-cell arrays. This marks the technological improvement from spin-stabilisation, used in earlier cylindrical satellites, to three-axis stabilisation using momentum wheels and reaction wheels controlling the satellite gyroscopically.

Skynet 4 were the first purely British built satellites, manufacture of 4A, 4B and 4C being carried out by British Aerospace Dynamics (BAe Dynamics). NATO adapted the design for the NATO IVA and IVB communication satellites, also manufactured by BAe Dynamics.

The improved Stage 2 satellites (4D, 4E and 4F) were built by Matra Marconi Space and Astrium to replace the earlier versions. Improvements included increased power and resistance to electronic jamming.

Skynet 4 provides SHF and UHF services using earth cover, wide area and spot beam coverage.

Skynet 5

Skynet 5 is the next generation of satellites, replacing the existing Skynet 4 Stage 2 system. It has been contracted via PFI to a partnership between Paradigm Secure Communications and EADS Astrium, a European spacecraft manufacturer. EADS Astrium were responsible for the build and delivery of Skynet 5 satellites in orbit, whilst Paradigm will be responsible for provision of service to the MoD. Paradigm have also been contracted to provide communications services to NATO using spare capacity on the satellites.

The Skynet 5 satellite is based on the Eurostar E3000 bus design, weighs about 4700 kilograms, has two solar panels each about fifteen metres long, and has a power budget of five kilowatts. It has four steerable transmission dishes, and a phased-array receiver designed to allow jamming signals to be cancelled out. They will also resist attempts to disrupt them with high-powered lasers.

The first of a constellation of three Skynet 5 vehicles was launched by a Ariane 5 rocket at 22:03 GMT on 11 March 2007, in a launch shared with the Indian INSAT 4B civil communications satellite, and entered full service on 10 May 2007. The launch was delayed from 10 March due to malfunction of a launch pad deluge system. Skynet 5A successfully separated from its launch vehicle and Telemetry was acquired by its dedicated Control Centre approximately 40 minutes after launch.

The second Skynet 5 UK military communications satellite was launched at 22:06 GMT on 14 November 2007, from Kourou in French Guiana, aboard an Ariane 5ECA rocket. This launch was delayed from 9 November due to problems with the electronics on one of the Solid Rocket Boosters, and 12 November due to a fueling problem with the launch pad. At time of launch the Ariane 5 ECA launcher set a new record on this mission, orbiting a total payload of more than 8,700 kg.

The third Skynet 5 UK military communications satellite was launched at 22:05 GMT on 12 June 2008, from Kourou in French Guiana, aboard an Ariane 5 ECA rocket. The launch had been delayed twice. Originally scheduled for 23 May, more checks were carried out on the launch vehicle and the launch was rescheduled for 30 May. A problem

with the launch software during pre-launch checks led Arianespace to reschedule the launch for a second time to 12 June.

The programme marks a change of approach in the UK from traditional defence procurement methods to a services-based contract which also includes provision of leased ground terminals, *Reacher* vehicles, the *Satellite Communications Onboard Terminal* (SCOT) for ships, and the associated baseband equipment.

Initially two Skynet 5 satellites were to be built, with insurance covering any launch loss; the MoD later decided to have a third satellite built in advance, and later still to have the third satellite launched to serve as an on-orbit spare. A fourth satellite, Skynet 5D, is planned for launch in 2013.

Information assurance

In early 1999, Reuters reported that the Skynet system was breached by a group of hackers who issued blackmail threats against the MoD. Duncan Campbell reported that the wire reports were wrong.

Satellite summary

Summary

Model	Manufacturer	Launch date	Launch vehicle	Comments
Skynet 1				
1A	Philco Ford	22 November 1969	Delta M	
1B	Philco Ford	19 August 1970	Delta M	Apogee motor failure
Skynet 2				
2A	Marconi Space Systems ¹	19 January 1974	Delta 2000	Rocket guidance failure

2B	Marconi Space Systems	23 November 1974	Delta 2000	
Skynet 4				
4A	British Aerospace	1 January 1990	Titan 34D	
4B	British Aerospace	11 December 1988	Ariane 44LP ²	
4C	British Aerospace	30 August 1990	Ariane 44LP	
Skynet 4 Stage 2				
4D	Matra Marconi Space ³	10 January 1998	Delta 7000	Replaced 4B
4E	Matra Marconi Space	26 February 1998	Ariane 44L	
4F	Astrium ⁴	7 February 2001	Ariane 44L	
Skynet 5				
5A	EADS Astrium ⁵	11 March 2007, 22:03 GMT	Ariane 5-ECA	Launched with Insat 4B
5B	EADS Astrium	14 November 2007, 22:06 GMT	Ariane 5-ECA	Launched with Star One C1

5C	EADS Astrium	12 June 2008, 22:05 GMT	Ariane 5- ECA	Launched with Turksat 3A
5D	EADS Astrium	Planned for 2013		

Chapter- 5

Other Space Spy Satellites

SAR-Lupe



A model of a SAR-Lupe satellite inside a Russian Cosmos-3M rocket

SAR-Lupe is Germany's first reconnaissance satellite system and is used for military purposes. SAR is an abbreviation for Synthetic Aperture Radar and "Lupe" is German for

magnifying glass. The SAR-Lupe program consists of five identical (770kg) satellites, developed by the German aeronautics company OHB-System which are controlled by a ground station which is responsible for controlling the system and analysing the retrieved data. A large data archive of images will be kept in a former Cold War bunker belonging to the *Kommando Strategische Aufklärung* (Strategic Reconnaissance Command) of the Bundeswehr.

SAR-Lupe's "high-resolution" images can be acquired day or night through all weather conditions. The first satellite was launched from Plesetsk in Russia on 19 December 2006, about a year after the intended launch date; four more satellites were launched at roughly six-month intervals, and the entire system achieved full operational readiness on 22 July 2008.

The five satellites operate in three 500-kilometre orbits in planes roughly sixty degrees apart. They use an X-band radar with a three-metre dish, providing a resolution of about 50 centimetres over a frame size of 5.5km on a side ('spotlight mode', in which the satellite rotates to keep the dish pointed at a single target) or about one metre over a frame size of 8km x 60km ('stripmap mode', in which the satellite maintains a fixed orientation over the earth and the radar image is formed simply by the satellite's motion along its orbit). Response time for imaging of a given area is ten hours or less. Thales Alenia Space provided the core of the Synthetic Aperture Radar sensors.

The testing of SAR-Lupe involved an inverse procedure, in which the satellite, mounted in a radome on Earth, was used to image the International Space Station, whose orbit is reasonably close to the one the satellite will eventually be in. One-metre resolution at the ISS was apparently achieved.

On 30 July 2002 a cooperation treaty between Germany and France was signed, under which the SAR-Lupe satellites and the French Helios optical reconnaissance satellite will operate jointly. Other EU countries have been invited to join as well and Italy has shown considerable interest.

Launches

Satellite	Date	Carrier rocket	Launch site	Launch status
SAR-Lupe-1	19 December 2006	Cosmos-3M	Plesetsk	Success
SAR-Lupe-2	2 July 2007	Cosmos-3M	Plesetsk	Success
SAR-Lupe-3	1 November 2007	Cosmos-3M	Plesetsk	Success
SAR-Lupe-4	27 March 2008	Cosmos-3M	Plesetsk	Success
SAR-Lupe-5	22 July 2008	Cosmos-3M	Plesetsk	Success

Contractors

- Prime Contractor: OHB-System AG (SAR-Lupe)
- LSE Space Engineering & Operations AG

COSMO-SkyMed

COSMO-SkyMed (COnstellation of small Satellites for the Mediterranean basin Observation) is an Earth observation satellite system funded by the Italian Ministry of Research and Ministry of Defence and conducted by the Italian Space Agency (ASI), intended for both military and civilian use.

The space segment of the system will include four medium-sized satellites equipped with synthetic aperture radar (SAR) sensors with global coverage of the planet. Observations of an area of interest will be repeated several times a day in all-weather conditions. The imagery will be applied to defense and security assurance in Italy and other countries, seismic hazard analysis, environmental disaster monitoring, and agricultural mapping.

Space segment

The four satellites are planned for sun-synchronous polar orbits, phased at 90° and at an altitude of 619 km with an orbit of 97 minutes. The expected operating life of each satellite is estimate in 5 years.

The satellites main components are:

- Two solar array for 3.8 kW at 42 V DC
- Stabilization, navigation and GPS systems
- Synthetic aperture radar working in X band
- 300 Gbit on-board memory and 310 Mbit/s data-link with ground segments

Launch

United Launch Alliance is providing launch services for the first three satellites. Satellite processing for the first two satellites was handled by the Astrotech Space Operations subsidiary of SPACEHAB. The first satellite was launched at 22:34 GMT, on 8 June 2007, aboard a Delta II 7420-10 rocket from Vandenberg AFB. An identical rocket launched COSMO-2 at 02:31:42 GMT on 9 December 2007, the launch having been delayed from 6 December due to bad weather, and problems with the rocket's cork insulation. COSMO-3 launched at 02:38 GMT on 25 October 2008, also aboard a Delta II 7420-10. A Delta II flying in the 7420-10 configuration will also be used to launch COSMO-4. Launched from Vandenberg Air Force Base on November 5, 2010 at 1920L.

Ground segment

The ground segment of the system is composed by:

- Command Center:
 -  Italian Centro Controllo e Pianificazione Missione del Fucino
- Tracking and data stations:

-  Argentinian Cordoba station
-  Sweden Kiruna station
- User Ground Segments:
 -   Italian Matera Civil User Ground Segment
 -   Italian Pratica di Mare Defence User Ground Segment
 -   France Defence User Ground Segment

The Argentinian and the France government are involved respectively in the civil and in the military segment of the system.

Fanhui Shi Weixing

Fanhui Shi Weixing (simplified Chinese: 返回式卫星; traditional Chinese:

返回式衛星; pinyin: *Fǎnhuí Shì Wèixīng*; literally "recoverable satellite") is a series of Chinese recoverable reconnaissance satellites. The satellites were used for both military and civilian observation needs, with a total of 26 flights. The first flight was FSW-0 on 1969-06-01 and the last SJ-8 on 2006-09-09.

Four models of the satellites were introduced: FSW-0, FSW-1, FSW-2, and the most modern being FSW-3. All satellites were put in orbit using the Long March rockets, most of them by the CZ-2C type.

Successful achievement of landing technology (third in the World after Soviet Union and United States) was the basis for the second Chinese manned space programme (period of 1978-1980), third manned programme Project 863 (late of 1980's), and current Shenzhou programme (since 1992).

History

China started developing this kind of satellite in the early 1970s. On 26 November 1975, China launched the first FSW satellite from Jiuquan in Inner-Mongolia. The satellite finished its mission successfully on 29 November 1975 and returned to earth safely, with the landing location in a special zone (Liuzhi Special District; 六枝特区) of Guizhou Province. It was the first Asian atmospheric reentry mission, and China became the third country to recover a satellite after its mission.

There are mainly three generations in history: **FSW-0**; **FSW-1**; **FSW-2** and the current **FSW-3**. Until the year 2003, China launched in total 22 of this kind of satellite, for climate, geographical and agricultural purposes.

Variants

- **FSW-0**

It was the first generation of China's returnable satellites. The main use was for the inspection of national land and natural resources. Satellites of this generation all carried prism-scan cameras. It did not have any complete orbit control system, so its decay or attenuation of orbit was fast; it thus had a relatively short orbit duration. Its accuracy for landing or return location was relatively low.

- **FSW-1**

This generation carried much more powerful cameras. The main use of this generation was for drawing geographical maps. Its resolution was as high as 10m.

- **FSW-2**
- **FSW-3**

	FSW-0	FSW-1	FSW-2	FSW-3
Satellite Mass (kg)	1800	2100	2800~3100	
Satellite Volume (m ³)	7.6	7.6	12.8	
Return Load (kg)	260	260	400	
Launch Load (kg)	340	450	500~600	
Mission Duration (day)	3~5	8	15~17	
Microgravity Gradient (g)	10 ⁻³ ~10 ⁻⁵	10 ⁻³ ~10 ⁻⁵	10 ⁻³ ~10 ⁻⁵	
Orbital Inclination (°)	57~68	57~70	57~70	
Periapsis (km)	172~180	200~210	175~200	
Apoapsis (km)	400~500	300~400	300~400	
Orbit Period (min)	~90	~90	~90	
Launch Rocket Type	Long March C	Long March C	Long March D	Long March C or D

Manned flights

Due to lack of information both about origins of FSW and about second manned space programme (that was announced few times in 1978 with the open publishing of some details including photos, but then was abruptly cancelled in 1980), first model FSW-0,

probably, was designed initially for manned use as spacecraft instead of first manned programme Shuguang aborted in early 70s.

More over, in the West were the rumours that after dozen of mostly successful launches of FB-1 and CZ-2 rockets and 4 successful annual launches of FSW (last one on 1978-01-26 claimed as dress rehearsal) China made in December, 1978 (or on January 7, 1979 according to another unconfirmed sources) the first attempt of launch of manned version of FSW spacecraft, but due to fail with loss of astronaut this programme was closed, and the FSW satellites (redesigned for unmanned goals as subsequent models) retrieved a flights in 1982 only.

Launches

Name	Launch Date (y/m/d)	Return Date (y/m/d)	Launch Load (kg)	Return Load (kg)	Apsis (km)	Apogee (km)	Period (min)	Angle(°)
FSW-0-1	1974/11/5	failed	1790	-	-	-	-	-
FSW-0-2	1975/11/26	1975/11/29	1790	600	181	495	91.2	63.0
FSW-0-3	1976/12/7	1976/12/10	1790	600	172	492	91.2	59.5
FSW-0-4	1978/1/26	1978/1/29	1810	650	169	488	91.2	57.0
FSW-0-5	1982/9/9	1982/9/14	1780	610	177	407	90.2	63.0
FSW-0-6	1983/8/19	1983/8/24	1840	630	175	404	90.2	63.3
FSW-0-7	1984/9/12	1984/9/17	1810	620	178	415	90.3	68.0
FSW-0-8	1985/10/21	1985/10/26	1810	620	175	409	90.2	63.0
FSW-0-9	1986/10/6	1986/10/11	1770	610	176	402	90.2	57.0
FSW-0-10	1987/8/5	1987/8/10	1810	650	172	410	90.2	63.0
FSW-1-1	1987/9/9	1987/9/17	2070	610	208	323	89.7	63.0

FSW-1-2	1988/8/5	1988/8/13	2130	640	208	326	89.7	62.8
FSW-1-3	1990/10/5	1990/10/13	2080	650	206	308	89.6	57.1
FSW-2-1	1992/8/9	1992/8/25	2590	640	175	353	89.1	63.1
FSW-1-4	1992/10/6	1992/10/13	2060	600	211	315	89.8	63.0
FSW-1-5	1993/10/8	return failed	2100	(650)	214	317	89.6	56.9
FSW-2-2	1994/7/3	1994/7/18	2760	770	178	333	89.5	62.9
FSW-2-3	1996/10/20	1996/11/4	2970	770	176	354	89.7	63.0
FSW-3-1	2003/11/3	2003/11/21						
FSW-3-2	2004/8/29	2004/9/25						
FSW-3-3	2004/9/27	2004/10/15						
FSW-3-4	2005/8/2	2005/8/29						
FSW-3-5	2005/8/29	2005/10/17						
SJ-8	2006/9/9	2006/9/24	3000		173	336	89.60	63.0

Chapter- 6

Space Weapon



LGM-118A Peacekeeper MIRVs re-entering Earth's atmosphere.

Space weapons are weapons used in space warfare. They include weapons that can attack space systems in orbit (i.e. anti-satellite weapons), attack targets on the earth from space or disable missiles travelling through space. In the course of the militarisation of space, such weapons were developed mainly by the contesting superpowers during the Cold War, and some remain under development today.

Space to Space weapons

The Soviet Almaz secret military space station program was equipped with a rapid-fire cannon to prevent hostile interception or boarding by American forces.

The Soviet unmanned Polyus weapons platform was designed to be equipped with a megawatt carbon-dioxide laser.

Earth to Space weapons



The Aegis Ballistic Missile Defense System. A RIM-161 Standard Missile 3 anti-ballistic missile is launched from USS *Shiloh*, a US Navy *Ticonderoga*-class cruiser.

Anti-satellite weapons, which are primarily surface-to-space and air-to-space missiles, have been developed by the United States, the USSR/Russia, and the People's Republic of China. Some test firings have been successful in destroying orbiting satellites.

In general use of explosive and kinetic kill systems is limited to relatively low altitude due to space debris issues and so as to avoid triggering the Kessler syndrome.

Strategic Defense Initiative

The **Strategic Defense Initiative (SDI)** was created by U.S. President Ronald Reagan on March 23, 1983 to use ground and space-based systems to protect the United States from

attack by strategic nuclear ballistic missiles. The initiative focused on strategic defense rather than the prior strategic offense doctrine of mutual assured destruction (MAD). The **Strategic Defense Initiative Organization** (SDIO) was set up in 1984 within the United States Department of Defense to oversee the Strategic Defense Initiative.

The ambitious initiative was "widely criticized as being unrealistic, even unscientific" as well as for threatening to destabilize MAD and re-ignite "an offensive arms race". It was soon derided as *Star Wars*, after the popular 1977 film by George Lucas. In 1987, the American Physical Society concluded that a global shield such as "Star Wars" was not only impossible with existing technology, but that ten more years of research was needed to learn whether it might *ever* be feasible.

Under the administration of President Bill Clinton in 1993, its name was changed to the Ballistic Missile Defense Organization (BMDO) and its emphasis was shifted from national missile defense to theater missile defense; and its scope from global to more regional coverage. It was never truly developed or deployed, though certain aspects of SDI research and technologies paved the way for some anti-ballistic missile systems of today. BMDO was renamed to the Missile Defense Agency in 2002.

Space-related defense research and testing remains heavily-budgeted to this day, irrespective of the program names, operative/reporting organizations, politics, or reports to the contrary in the press. Although it is difficult to compile actual spending totals across the complete spectrum of space-based defense programs (including classified "off-budget" "black projects"), the U.S. has certainly invested well over \$100 billion on "SDI" and follow-on programs, and holds a commanding lead over all current or potential future adversaries in the realm of space technology/warfare.

Under the SDIO's Innovative Sciences and Technology Office, headed by physicist and engineer James A. Ionson, Ph.D., the investment was predominantly made in basic research at national laboratories, universities, and in industry, and these programs have continued to be key sources of funding for top research scientists in the fields of high-energy physics, supercomputing/computation, advanced materials, and many other critical science and engineering disciplines: funding which indirectly supports other research work by top scientists, and which would be largely unavailable outside of the defense budget environment.

Strategic missile defense before SDI

SDI was not the first U.S. defensive system against nuclear ballistic missiles. In the 1960s, The Sentinel Program was designed and developed to provide a limited defensive capability, but was never deployed. Sentinel technology was later used in the Safeguard Program, briefly deployed to defend one U.S. location. In the 1970s the Soviet Union deployed A35/A135 missile defense system, still operational today, which defends Moscow and nearby missile sites.

SDI was distinctly different from earlier U.S. and Soviet missile defense efforts: It envisioned using space-based defensive systems as opposed to solely ground-launched interceptors. It also initially had the ambitious goal of providing a near total defense against a massive sophisticated ICBM attack, as opposed to previous systems which were limited in defensive capacity and geographic coverage.

Initial impetus

In the fall of 1979, at Reagan's request, Lieutenant General Daniel O. Graham conceived a concept he called the High Frontier, an idea of strategic defense using ground- and space-based weapons theoretically possible because of emerging technologies. It was designed to replace the doctrine of Mutual Assured Destruction, a doctrine that Reagan and his aides described as a suicide pact.

The initial focus of the strategic defense initiative was a nuclear explosion-powered X-ray laser designed at Lawrence Livermore National Laboratory by a scientist named Peter L. Hagelstein who worked with a team called 'O Group', doing much of the work in the late 1970s and early 1980s. O Group was headed by physicist Lowell Wood, a protégé and friend of Edward Teller, the "father of the hydrogen bomb".

Ronald Reagan was told of Hagelstein's breakthrough by Teller in 1983, which prompted Reagan's March 23, 1983, "Star Wars" speech. Reagan announced, "I call upon the scientific community who gave us nuclear weapons to turn their great talents to the cause of mankind and world peace: to give us the means of rendering these nuclear weapons impotent and obsolete." This speech, along with Reagan's Evil Empire speech on March 8, 1983, in Florida, ushered in the final major escalation in rhetoric of the Cold War prior to a thawing of relations in the mid- to late-1980s.

The concept for the space-based portion was to use lasers to shoot down incoming Soviet intercontinental ballistic missiles (ICBMs) armed with nuclear warheads. Nobel Prize-winning physicist Hans Bethe went to Livermore in February 1983 for a two-day briefing on the X-ray laser, and "Although impressed with its scientific novelty, Bethe went away highly skeptical it would contribute anything to the nation's defense."

Project and proposals

In 1984, the Strategic Defense Initiative Organization (SDIO) was established to oversee the program, which was headed by Lt. General James Alan Abrahamson, USAF, a past Director of the NASA Space Shuttle program. Research and development initiated by the SDIO created significant technological advances in computer systems, component miniaturization, sensors and missile systems that form the basis for current systems.

Initially, the program focused on large scale systems designed to defeat a Soviet offensive strike. However, as the threat diminished, the program shifted towards smaller systems designed to defeat limited or accidental launches.

By 1987, the SDIO had developed a national missile defense concept called the Strategic Defense System Phase I Architecture. This concept consisted of ground and space based sensors and weapons, as well as a central battle management system. The ground-based systems operational today trace their roots back to this concept.

In his 1991 State of the Union Address George H. W. Bush shifted the focus of SDI from defense of North America against large scale strikes to a system focusing on theater missile defense called Global Protection Against Limited Strikes (GPALS).

In 1993, the Clinton administration further shifted the focus to ground-based interceptor missiles and theater scale systems, forming the Ballistic Missile Defense Organization (BMDO) and closing the SDIO. Ballistic missile defense was revived by the George W. Bush administration as the National Missile Defense (since renamed "Ground-Based Midcourse Defense").

Ground-based programs



Extended Range Interceptor (ERINT) launch from White Sands Missile Range

Extended Range Interceptor (ERINT)

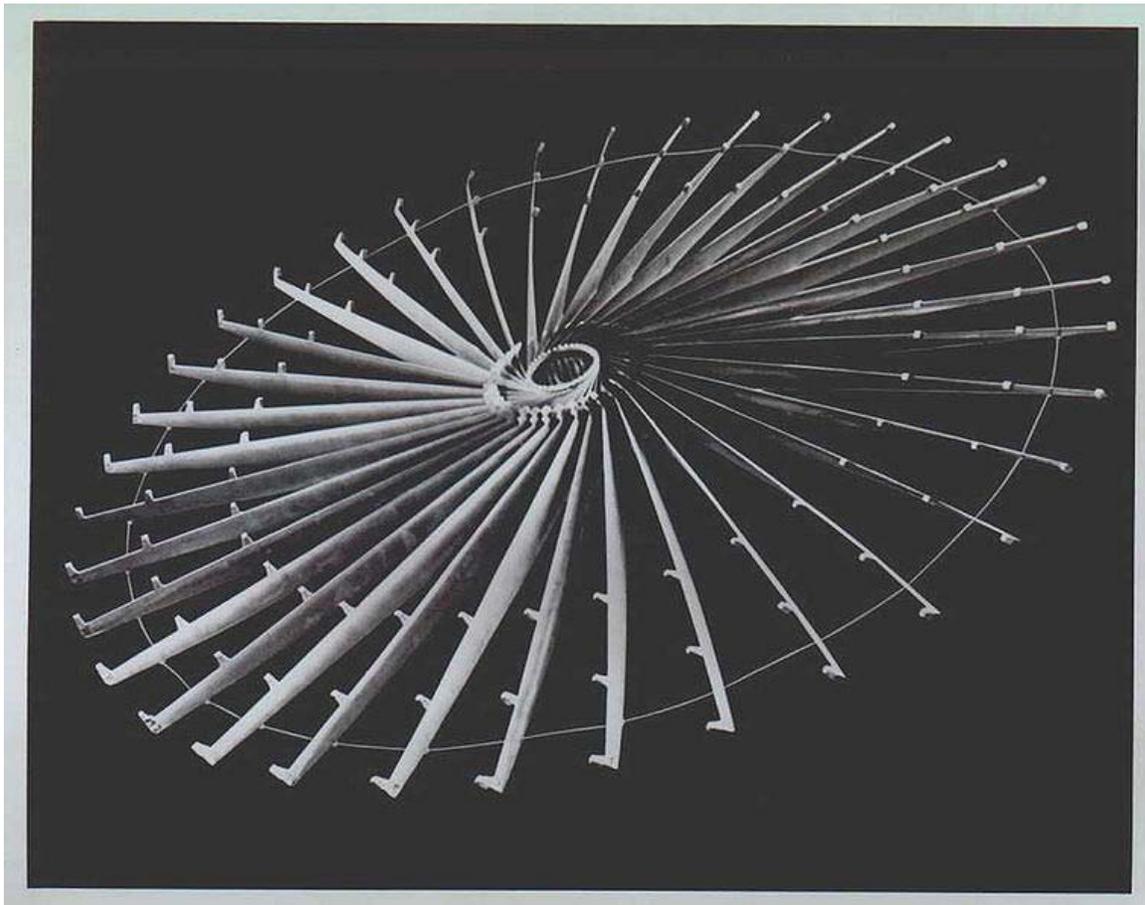
The Extended Range Interceptor (ERINT) program was part of SDI's Theater Missile Defense Program and was an extension of the Flexible Lightweight Agile Guided

Experiment (FLAGE), which included developing hit-to-kill technology and demonstrating the guidance accuracy of a small, agile, radar-homing vehicle.

FLAGE scored a direct hit against a MGM-52 Lance missile in flight, at White Sands Missile Range in 1987. ERINT was a prototype missile similar to the FLAGE, but it used a new solid-propellant rocket motor that allowed it to fly faster and higher than FLAGE.

Under BMDO, ERINT was later chosen as the Patriot Advanced Capability-3 (PAC-3) missile.

Homing Overlay Experiment (HOE)



4 m (13 ft) diameter web deployed by Homing Overlay Experiment

The Homing Overlay Experiment (HOE) was the first system tested by the Army that employed hit-to-kill. Given concerns about the previous programs using nuclear tipped interceptors, in the 1980s the U.S. Army began studies about the feasibility of hit-to-kill vehicles, where an interceptor missile would destroy an incoming ballistic missile just by colliding with it head-on.

The Homing Overlay Experiment (HOE) was the first successful hit-to-kill intercept of a mock ballistic missile warhead outside the Earth's atmosphere. The Army's HOE (Homing Overlay Experiment) used a Kinetic Kill Vehicle (KKV) to destroy a ballistic missile.

The KKV was equipped with an infrared seeker, guidance electronics and a propulsion system. Once in space, the KKV could extend a folded structure similar to an umbrella skeleton of 4 m (13 ft) diameter to enhance its effective cross section. This device would destroy the ICBM reentry vehicle on collision.

Four test launches were conducted in 1983 and 1984 at Kwajalein Missile Range in the Republic of the Marshall Islands. For each test a Minuteman missile was launched from Vandenberg Air Force Base in California carrying a single mock re-entry vehicle targeted for Kwajalein lagoon more than 4,000 miles (6,400 km) away.

After test failures with the first three flight tests because of guidance and sensor problems, the fourth and final test on June 10, 1984 was successful, intercepting the Minuteman RV with a closing speed of about 6.1 km/s at an altitude of more than 160 km.

Although the fourth test succeeded, the New York Times charged in August 1993 that the test had been rigged. Investigations into this charge by the Department of Defense, headed John Deutch for Secretary of Defense Les Aspin, and the General Accounting Office concluded that the test was a valid, successful test.

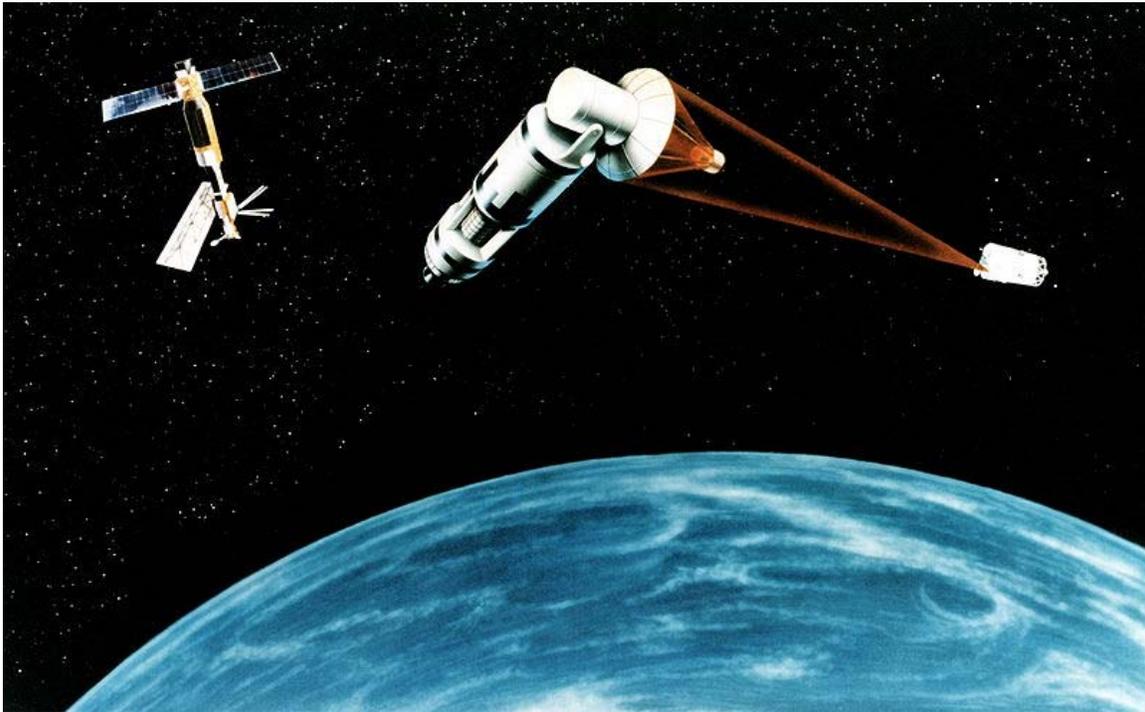
This technology was later used by the SDI and expanded into the Exoatmospheric Reentry-vehicle Interception System (ERIS) program.

Exoatmospheric Reentry-vehicle Interception System (ERIS)

Developed by Lockheed as part of the ground-based interceptor portion of SDI, the Exoatmospheric Reentry-vehicle Interception System (ERIS) began in 1985, with at least two tests occurring in the early 1990s. This system was never deployed, but the technology of the system was used in the Terminal High Altitude Area Defense (THAAD) system and the Ground Based Interceptor currently deployed as part of the Ground-Based Midcourse Defense (GMD) system.

Directed-energy weapon (DEW) programs

X-ray laser



An artist's concept of a Space Laser Satellite Defense System, 1984. (Not any one system specifically, just generalized concept artwork)

An early focus of the project was toward a curtain of X-ray lasers powered by nuclear explosions. The curtain was to be deployed using a series of missiles launched from submarines or, later on, satellites, during the critical seconds following a Soviet attack. The satellites would be powered by built-in nuclear warheads – in theory, the energy from the warhead detonation would be used to pump a series of laser emitters in the missiles or satellites, allowing each satellite to shoot down many incoming warheads simultaneously. The attraction of this approach was that it was thought to be faster than an optical laser, which could only shoot down warheads one at a time, limiting the number of warheads each laser could destroy in the short time 'window' of an attack.

However, on March 26, 1983, the first test, known as the Cabra event, was performed in an underground shaft and resulted in marginally positive readings that could be dismissed as being caused by a faulty detector. Since a nuclear explosion was used as the power source, the detector was destroyed during the experiment and the results therefore could not be confirmed. Technical criticism based upon unclassified calculations suggested that the X-ray laser would be of at best marginal use for missile defense. Such critics often cite the X-ray laser system as being the primary focus of SDI, with its apparent failure being a main reason to oppose the program. However, the laser was never more than one of the many systems being researched for ballistic missile defense.

Despite the apparent failure of the Cabra test, the long term legacy of the X-ray laser program is the knowledge gained while conducting the research. A parallel developmental program advanced laboratory X-ray lasers for biological imaging and the creation of 3D holograms of living organisms. Other spin-offs include research on advanced materials like SEAgel and Aerogel, the Electron-Beam Ion Trap facility for physics research, and enhanced techniques for early detection of breast cancer.

Chemical laser



SeaLite Beam Director, commonly used as the output for the MIRACL

Beginning in 1985, the Air Force tested an SDIO-funded deuterium fluoride laser known as Mid-Infrared Advanced Chemical Laser (MIRACL) at White Sands Missile Range. During a simulation, the laser successfully destroyed a Titan missile booster in 1985, however the test setup had the booster shell pressurized and under considerable compression loads. These test conditions were used to simulate the loads a booster would be under during launch. The system was later tested on target drones simulating cruise missiles for the US Navy, with some success. After the SDIO closed, the MIRACL was tested on an old Air Force satellite for potential use as an Anti-satellite weapon, with

mixed results. The technology was also used to develop the Tactical High Energy Laser, (THEL) which is being tested to shoot down artillery shells.

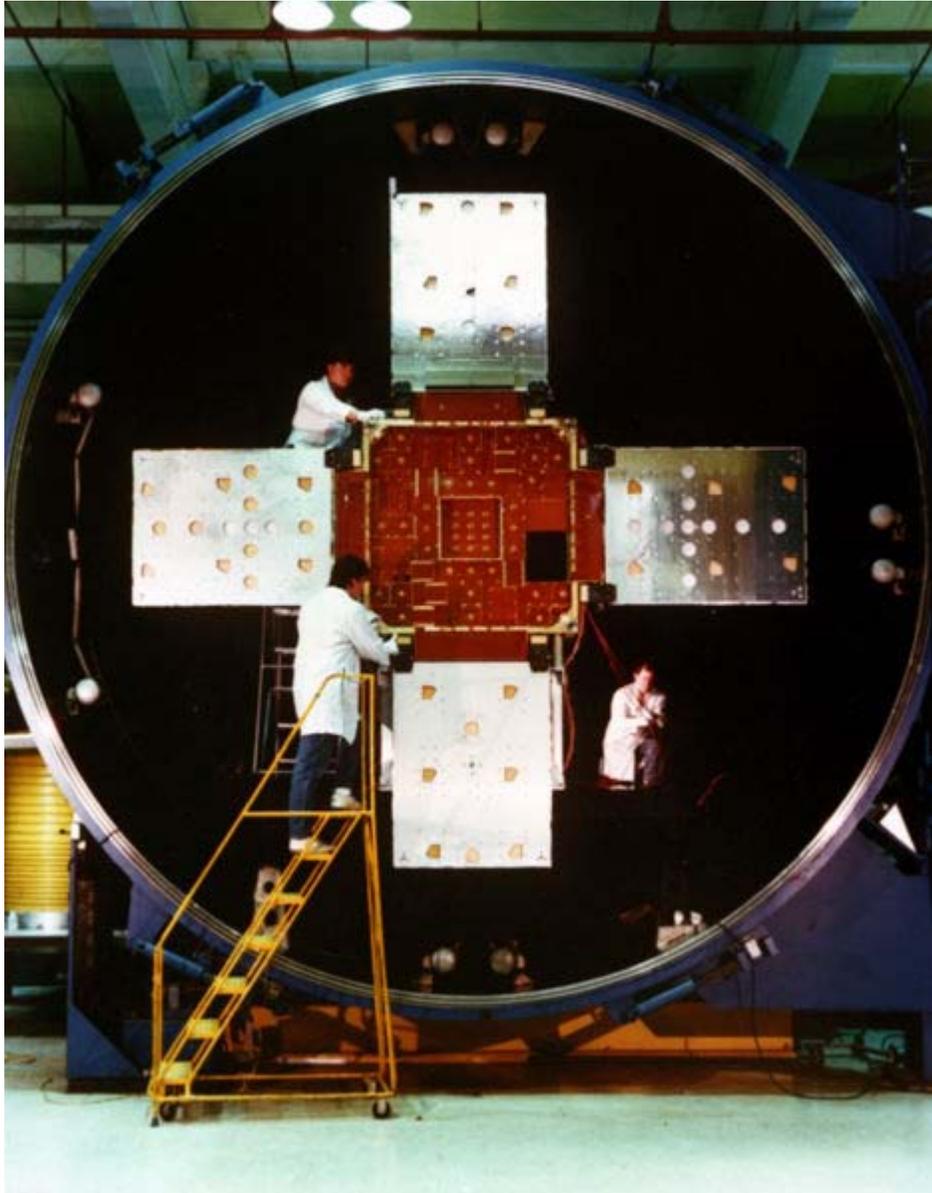
During the mid to late 1980s a number of panel discussions on lasers and SDI took place at various laser conferences. Proceedings of these conferences include papers on the status of chemical and other high power lasers at the time.

The Missile Defense Agency's Airborne Laser program uses a chemical laser which has successfully intercepted a missile taking off, so an offshoot of SDI could be said to have successfully implemented one of the key goals of the program.

Neutral Particle Beam

In July 1989, the Beam Experiments Aboard a Rocket (BEAR) program launched a sounding rocket containing a neutral particle beam (NPB) accelerator. The experiment successfully demonstrated that a particle beam would operate and propagate as predicted outside the atmosphere and that there are no unexpected side-effects when firing the beam in space. After the rocket was recovered, the particle beam was still operational. According to the BMDO, the research on neutral particle beam accelerators, which was originally funded by the SDIO, could eventually be used to reduce the half-life of nuclear waste products using accelerator-driven transmutation technology.

Laser and mirror experiments



Technicians at the Naval Research Laboratory (NRL), work on the Low-powered Atmosphere Compensation Experiment (LACE) satellite.

The High Precision Tracking Experiment (HPTE), launched with the Space Shuttle Discovery on STS-51-G, was tested June 21, 1985 when a Hawaii-based low-power laser successfully tracked the experiment and bounced the laser off of the HPTE mirror.

The Relay mirror experiment (RME), launched in February 1990, demonstrated critical technologies for space-based relay mirrors that would be used with an SDI directed-energy weapon system. The experiment validated stabilization, tracking, and pointing concepts and proved that a laser could be relayed from the ground to a 60 cm mirror on

an orbiting satellite and back to another ground station with a high degree of accuracy and for extended durations.

Launched on the same rocket as the RME, the Low-power Atmospheric Compensation Experiment (LACE) satellite was built by the United States Naval Research Laboratory (NRL) to explore atmospheric distortion of lasers and real-time adaptive compensation for that distortion. The LACE satellite also included several other experiments to help develop and improve SDI sensors, including target discrimination using background radiation and tracking ballistic missiles using Ultra-Violet Plume Imaging (UVPI). LACE was also used to evaluate ground-based adaptive optics, a technique now used in civilian telescopes to remove atmospheric distortions.

Hypervelocity Rail Gun (CHECMATE)

Research into hypervelocity rail gun technology was done to build an information base about rail guns so that SDI planners would know how to apply the technology to the proposed defense system. The SDI rail gun investigation, called the Compact High Energy Capacitor Module Advanced Technology Experiment (CHECMATE), had been able to fire two projectiles per day during the initiative. This represented a significant improvement over previous efforts, which were only able to achieve about one shot per month. Hypervelocity rail guns are, at least conceptually, an attractive alternative to a space-based defense system because of their envisioned ability to quickly shoot at many targets. Also, since only the projectile leaves the gun, a railgun system can potentially fire many times before needing to be resupplied.

A hypervelocity rail gun works very much like a particle accelerator insofar as it converts electrical potential energy into kinetic energy imparted to the projectile. A conductive pellet (the projectile) is attracted down the rails by electric current flowing through a rail. Through the magnetic forces that this system achieves, a force is exerted on the projectile moving it down the rail. Railguns can generate muzzle-velocities in excess of 24 miles per second. At this velocity, even a rifle-bullet sized projectile will penetrate the front armor of a main battle tank, let alone a thinly protected missile guidance system.

Rail guns face a host of technical challenges before they will be ready for battlefield deployment. First, the rails guiding the projectile must carry very high amperage and voltage. Each firing of the railgun produces tremendous current flow (almost half a million amperes) through the rails, causing rapid erosion of the rail's surfaces (through ohmic heating, and even vaporization of the rail-surface.) Early prototypes were essentially single-use weapons, requiring complete replacement of the rails after each firing. Another challenge with the rail gun system is projectile survivability. The projectiles experience acceleration force in excess of 100,000 g. In order to be effective, the fired projectile must first survive the mechanical stress of firing, the thermal effects of a trip through the atmosphere at many times the speed of sound, and then the subsequent impact with the target. In-flight guidance, if implemented, would require the onboard guidance system to be built to the same standard of sturdiness as the main mass of the projectile.

In addition to being considered for destroying ballistic missile threats, rail guns were also being planned for service in space platform (sensor and battle station) defense. This potential role reflected defense planner expectations that the rail guns of the future would be capable of not only rapid fire, but also of multiple firings (on the order of tens to hundreds of shots).

Space-based programs

Space-Based Interceptor (SBI)

Groups of interceptors were to be housed in orbital modules. Hover testing was completed in 1988 and demonstrated integration of the sensor and propulsion systems in the prototype SBI. It also demonstrated the ability of the seeker to shift its aiming point from a rocket's hot plume to its cool body, a first for infrared ABM seekers. Final hover testing occurred in 1992 using miniaturized components similar to what would have actually been used in an operational interceptor. These prototypes eventually evolved into the Brilliant Pebbles program.

Brilliant Pebbles



Brilliant Pebbles concept artwork

Brilliant Pebbles was a non-nuclear system of satellite-based, watermelon-sized mini-missiles designed to use a high-velocity kinetic warhead. It was designed to operate in conjunction with the Brilliant Eyes sensor system and would have detected and destroyed missiles without any external guidance. The project was conceived in November 1986.

John H. Nuckolls, director of Lawrence Livermore National Laboratory from 1988 to 1994, described the system as “The crowning achievement of the Strategic Defense Initiative”. Some of the technologies developed for SDI were used in numerous later projects. For example, the sensors and cameras that were developed for Brilliant Pebbles became components of the Clementine mission and SDI technologies may also have a role in future missile defense efforts.

Though regarded as one of the most capable SDI systems, the Brilliant Pebbles program was canceled in 1994 by the BMDO.

Sensor programs



Delta 183 launch vehicle lifts off, carrying the SDI sensor experiment "Delta Star", on March 24, 1989.

SDIO sensor research encompassed visible light, ultraviolet, infrared, and radar technologies, and eventually led to the Clementine mission though that mission occurred just after the program transitioned to the BMDO. Like other parts of SDI, the sensor system initially was very large-scale, but after the Soviet threat diminished it was cut back.

Boost Surveillance and Tracking System (BSTS)

BSTS was part of the SDIO in the late '80s, and was designed to assist detection of missile launches, especially during the boost phase. However, once the SDI program shifted toward theater missile defense in the early '90s, the system left SDIO control and was transferred to the Air Force.

Space Surveillance and Tracking System (SSTS)

SSTS was a system originally designed for tracking ballistic missiles during their mid-course phase. It was designed to work in conjunction with BSTS, but was later scaled down in favor of the Brilliant Eyes program.

Brilliant Eyes

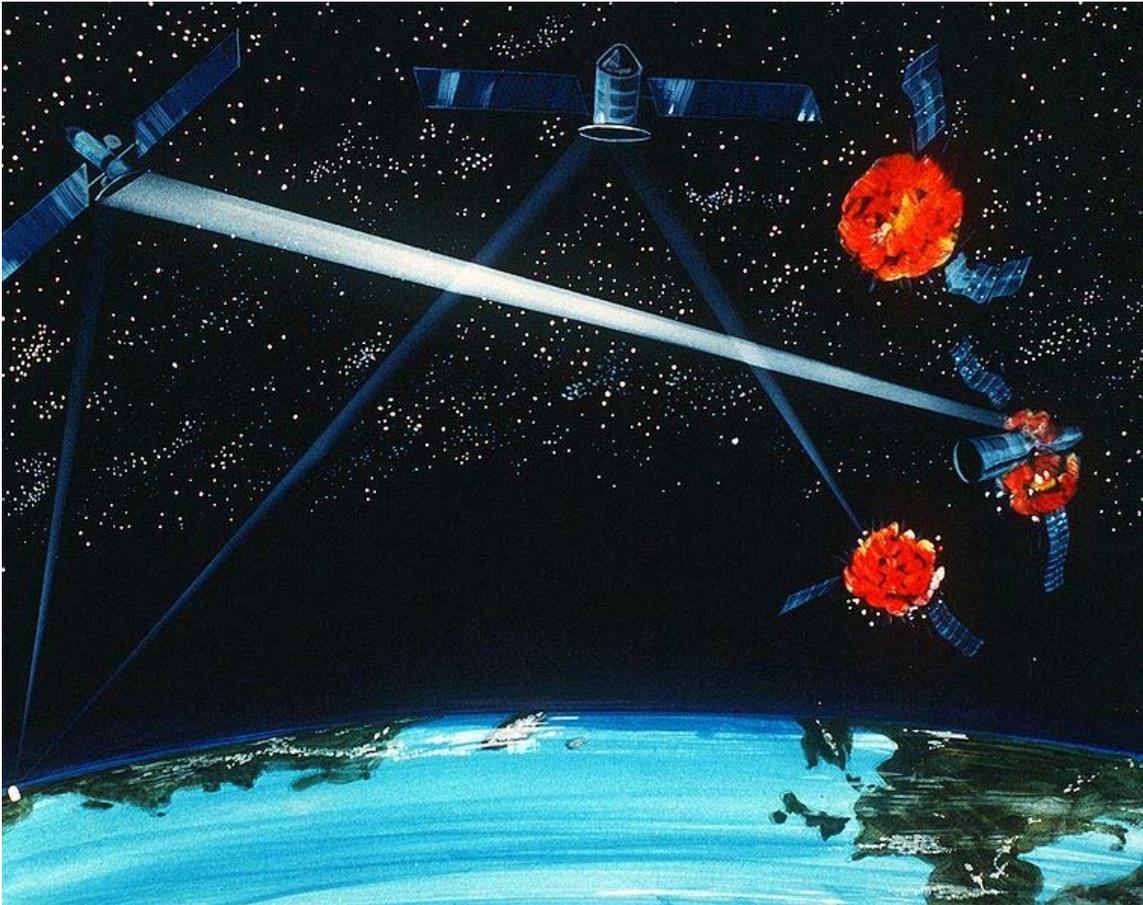
Brilliant Eyes was a simpler derivative of the SSTS that focused on theater ballistic missiles rather than ICBMs and was meant to operate in conjunction with the Brilliant Pebbles system.

Brilliant Eyes was renamed Space and Missile Tracking System (SMTS) and scaled back further under BMDO, and in the late 1990s it became the low earth orbit component of the Air Force's Space Based Infrared System (SBIRS).

Other sensor experiments

The Delta 183 program used a satellite known as *Delta Star* to test several sensor related technologies. Delta Star carried an infrared imager, a long-wave infrared imager, an ensemble of imagers and photometers covering several visible and ultraviolet bands as well as a laser detector and ranging device. The satellite observed several ballistic missile launches including some releasing liquid propellant as a countermeasure to detection. Data from the experiments led to advances in sensor technologies. Prior to the Reagan administration, software under the United States Military Advancement for Technological Progress grant began development of a piece of software code named Resolution Generator. Once Reagan was elected in 1981, the software and its code name were removed from the defense budget. Not much else is known, but historians believe that it was the government's first attempt at acquiring personal information from large corporate servers.

Countermeasures



An artist's concept of a ground / space-based hybrid laser weapon, 1984

In war-fighting, countermeasures can have a variety of meanings:

1. The immediate tactical action to reduce vulnerability, such as chaff, decoys, and maneuvering.
2. Counter strategies which exploit a weakness of an opposing system, such as adding more MIRV warheads which are less expensive than the interceptors fired against them.
3. Defense suppression. That is, attacking elements of the defensive system.

Countermeasures of various types have long been a key part of warfighting strategy. However, with SDI they attained a special prominence due to the system cost, scenario of a massive sophisticated attack, strategic consequences of a less-than-perfect defense, outer space basing of many proposed weapons systems, and political debate.

Whereas the current U.S. NMD system is designed around a relatively limited and unsophisticated attack, SDI planned for a massive attack by a sophisticated opponent. This raised significant issues about economic and technical costs associated with

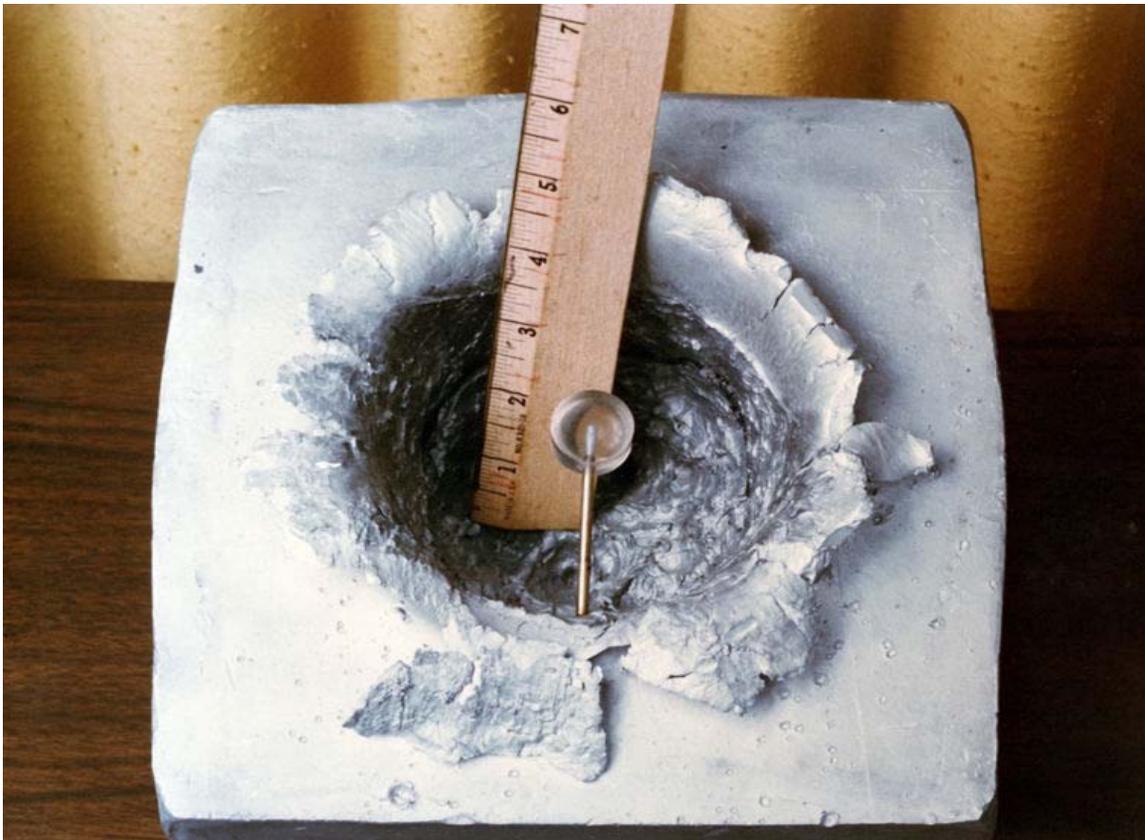
defending against anti-ballistic missile defense countermeasures used by the attacking side.

For example, if it had been much cheaper to add attacking warheads than to add defenses, an attacker of similar economic power could have simply outproduced the defender. This requirement of being "cost effective at the margin" was first formulated by Paul Nitze in November, 1985.

In addition, SDI envisioned many space-based systems in fixed orbits, ground-based sensors, command, control and communications facilities, etc. In theory, an advanced opponent could have targeted those, in turn requiring self-defense capability or increased numbers to compensate for attrition.

A sophisticated attacker having the technology to use decoys, shielding, maneuvering warheads, defense suppression, or other countermeasures would have multiplied the difficulty and cost of intercepting the real warheads. SDI design and operational planning had to factor in these countermeasures and the associated cost.

Controversy and criticism



SDI wasn't just lasers; in this Kinetic Energy Weapon test, a seven gram Lexan projectile was fired from a light gas gun at a velocity of 23,000 feet per second (7,000 meters per second or 15,682 miles per hour) at this cast aluminum block.

SDI may have been first dubbed "Star Wars" by opponent Dr. Carol Rosin, a consultant and former spokeswoman for Wernher von Braun. However, Missile Defense Agency historians attribute the term to a *Washington Post* article published March 24, 1983, the day after the Star Wars speech, which quoted Democratic Senator Ted Kennedy describing the proposal as "reckless Star Wars schemes." Some critics used that term derisively, implying it was an impractical science fiction fantasy, but supporters have adopted the usage as well on the grounds that yesterday's science fiction is often tomorrow's engineering. In comments to the media on March 7, 1986, Acting Deputy Director of SDIO, Dr. Gerold Yonas, described the name "Star Wars" as an important tool for Soviet disinformation and asserted that the nickname gave an entirely wrong impression of SDI.

Ashton Carter, a board member at MIT, assessed SDI for Congress in 1984, saying there were a number of difficulties in creating an adequate missile defense shield, with or without lasers. Carter said X-rays have a limited scope because they become diffused through the atmosphere, much like the beam of a flashlight spreading outward in all directions. This means the X-rays needed to be close to the Soviet Union, especially during the critical few minutes of the booster phase, in order for the Soviet missiles to be both detectable to radar and targeted by the lasers themselves. Opponents disagreed, saying advances in technology, such as using very strong laser beams, and by "bleaching" the column of air surrounding the laser beam, could increase the distance that the X-ray would reach to successfully hit its target.

Physicist Hans Bethe, who worked with Edward Teller on both the nuclear bomb and the hydrogen bomb at Los Alamos, claimed a laser defense shield was unfeasible. He said that a defensive system was costly and difficult to build yet simple to destroy, and claimed that the Soviets could easily use thousands of decoys to overwhelm it during a nuclear attack. He believed that the only way to stop the threat of nuclear war was through diplomacy and dismissed the idea of a *technical solution* to the Cold War, saying that a defense shield could be viewed as threatening because it would limit or destroy Soviet offensive capabilities while leaving the American offense intact. In March 1984, Bethe coauthored a 106-page report for the Union of Concerned Scientists that concluded "the X-ray laser offers no prospect of being a useful component in a system for ballistic missile defense."

In response to this when Teller testified before Congress he stated that "instead of [Bethe] objecting on scientific and technical grounds, which he thoroughly understands, he now objects on the grounds of politics, on grounds of military feasibility of military deployment, on other grounds of difficult issues which are quite outside the range of his professional cognizance or mine."

On June 28, 1985, David Lorge Parnas resigned from SDIO's Panel on Computing in Support of Battle Management, arguing in 8 short papers that the software required by the Strategic Defense Initiative could never be made to be trustworthy and that such a system would inevitably be unreliable and constitute a menace to humanity in its own right.

Space to Earth weapons

Orbital weaponry

Orbital weaponry is any weapon that is in orbit around a large body such as a planet or moon. As of 2010, there are no known operative orbital weapons systems, but several were designed by the United States and the Soviet Union during the Cold War. During World War II Nazi Germany also was developing plans for an orbital weapon called the Sun gun.

Development of orbital weaponry was largely halted after the entry into force of the Outer Space Treaty and the SALT II treaty. These agreements prohibit weapons of mass destruction from being placed in space. As other weapons exist, notably those using kinetic bombardment, that would not violate these treaties, some private groups and government officials have proposed a Space Preservation Treaty which would ban the placement of any weaponry in outer space.

Orbital bombardment

Orbital bombardment is the act of attacking targets on a planet, moon or other such object from *orbit* around the object, rather than from an aircraft, or a platform beyond orbit. It is most often encountered in fiction, but has been proposed as a means of attack for several real-world weapons systems concepts, including kinetic bombardment and as a nuclear delivery system.

During the Cold War, the Soviet Union deployed a Fractional Orbital Bombardment System from 1968 to 1983. Using this system, a nuclear warhead could be placed in low Earth orbit, and later de-orbited to hit any location on the Earth's surface. While the Soviet Union deployed a working version of the system, they were forbidden by the Outer Space Treaty to place live warheads in space. The fractional orbital bombardment system was phased out in January 1983 in compliance with the SALT II treaty of 1979, which, among other things, prohibited the deployment of systems capable of placing weapons of mass destruction in such a partial orbit.

Orbital bombardment systems with conventional warheads are permitted under the terms of SALT II. Some of the proposed systems rely on large tungsten carbide/uranium cermet rods dropped from orbit and depend on kinetic energy, rather than explosives, but their mass makes them prohibitively difficult to transport to orbit, and their effectiveness has not been proven.

Chapter- 7

Space Warfare

Space warfare is combat that takes place in outer space, i.e. outside the atmosphere. Space warfare therefore includes *ground-to-space warfare*, such as attacking satellites from the Earth, as well as *space-to-space warfare*, such as satellites attacking satellites.

It does not include the use of satellites for espionage, surveillance, or military communications, however useful those activities might be. It does not technically include *space-to-ground warfare*, where orbital objects attack ground, sea or air targets directly, but the public and media frequently use the term to include any conflict which includes space as a theater of operations, regardless of the intended target. For example, a rapid delivery system in which troops are deployed from orbit might be described as "space warfare," even though the military uses the term as described above.

A film was produced by the U.S. Military in the early 1960s called *Space and National Security* which depicted space warfare. From 1985 to 2002 there was a United States Space Command, which in 2002 merged with the United States Strategic Command. There is a Russian Space Force, which was established on August 10, 1992, and which became an independent section of the Russian military on June 1, 2001.

Only a few incidents of space warfare have occurred in world history, and all were training missions, as opposed to actions against real opposing forces. In the mid-1980s a USAF pilot in an F-15 successfully shot down the P78-1, a communications satellite in a 345 mile (555 km) orbit.

In 2007 the People's Republic of China used a missile system to destroy one of its obsolete satellites, and in 2008 the United States similarly destroyed its malfunctioning satellite USA 193. To date, there have been no human casualties resulting from conflict in space, nor has any ground target been successfully neutralized from orbit.

International treaties governing space limit or regulate conflicts in space and limit the installation of weapon systems, especially nuclear weapons.

History



A USAF F-15 Eagle launching a ASM-135 ASAT (anti-satellite) missile in 1985

Early efforts to conduct space warfare were directed at space-to-space warfare, as ground-to-space systems were considered to be too slow and too isolated by Earth's atmosphere and gravity to be effective. The history of active space warfare development goes back to the 1960s when the Soviet Union began the Almaz project, a project designed to give them the ability to do on-orbit inspections of satellites and destroy them if needed. Similar planning in the United States took the form of the Blue Gemini project, which consisted of modified Gemini capsules that would be able to deploy weapons and perform surveillance.

One early test of electronic space warfare took place in 1963 when the United States exploded a ground-launched nuclear weapon in space to test the effects of an electromagnetic pulse. The result was a deactivation of many then-orbiting satellites, both American and Soviet. The deleterious and unfocused effects of the EMP test led to the banning of nuclear weapons in space in the Outer Space Treaty of 1968.

1970s–1980s

Through the 1970s, the Soviet Union continued their project and test-fired a cannon to test space station defense. This was considered too dangerous to do with a crew on board, however, so the test was conducted after the crew had returned to Earth.

Space warfare strongly influenced the final design of the United States Space Shuttle. The distinctive delta wing shape was needed if the shuttle were to launch a military payload towards the Soviet Union and perform an immediate de-orbit after one rotation to avoid being shot down.

Both the Soviets and the United States developed anti-satellite weaponry designed to shoot down satellites. While early efforts paralleled other space-to-space warfare concepts, the United States was able in the 1980s to develop ground-to-space laser anti-satellite weapons. None of these systems are known to be active today; however, a less powerful civilian version of the ground-to-space laser system is commonly used in the astronomical technique of adaptive optics.

2000s

China successfully tested a ballistic missile-launched anti-satellite weapon on January 11, 2007. This resulted in harsh criticism from the United States of America, Britain, and Japan.

Space warfare system

A space system has three segments, each of which, in principle, offers opportunities for attack to an enemy. The system comprises: **(i)** the satellite, perhaps the constellation of satellites in orbit; **(ii)** the up and down links to and from the orbiting vehicle, commands from the ground stations and information flow from the satellite; **(iii)** and the ground station that controls the behaviour of the satellite and distributes its information to the users.”

Theoretical space weaponry

Ballistic warfare



A Trident missile launched from a Royal Navy *Vanguard* class ballistic missile submarine.

In the late 1970s and through the 1980s the Soviet Union and the United States theorized, designed and in some cases even tested an astonishing variety of bizarre and exotic weaponry designed for warfare in outer space. Space warfare was seen primarily as an extension of nuclear warfare, and so many theoretical systems were based around the destruction or defense of ground and sea-based missiles. Space-based missiles were not a target due to the Outer Space Treaty, which banned the use, testing or storage of nuclear weapons outside the Earth's atmosphere.

Systems proposed ranged from measures as simple as ground and space-based anti-missiles to railguns, space based lasers, orbital mines and other such futuristic weaponry. Deployment of these systems was seriously considered in the mid-1980s under the banner of the Strategic Defense Initiative (popularly known as Star Wars). If the Cold War had continued, then many of these systems could have seen deployment: the United States got as far as developing working railguns, and a laser that could destroy missiles at range, though the power requirements of both were phenomenal, and the ranges and firing cycles utterly impractical.

Electronic warfare



German Luftwaffe Tornado ECR

With the end of the Cold War and continued development of satellite and electronics technology, attention was focused on space as a supporting theatre for conventional warfare. Currently, military operations in space primarily concern either the vast tactical advantages of satellite-based surveillance, communications, and positioning systems or mechanisms used to deprive an opponent of said tactical advantages.

Accordingly, most space-borne proposals which would traditionally be considered "weapons" (a communications or reconnaissance satellite may be useful in warfare but

isn't generally classified as a weapon) are designed to jam, sabotage, and outright destroy enemy satellites, and conversely to protect friendly satellites against such attacks. To this end, the US (and presumably other countries) is researching groups of small, highly mobile satellites called "microsats" (about the size of a refrigerator) and "picosats" (approximately 1 cubic foot (≈ 27 litres) in volume) nimble enough to maneuver around and interact with other orbiting objects to repair, sabotage, hijack, or simply collide with them.

Kinetic bombardment



US Army THAAD launcher

Another theorized use involves the extension of conventional weaponry into orbit for deployment against ground targets. Though international treaties bar the deployment of nuclear missiles outside the atmosphere, other categories of weapons are largely unregulated. Traditional ground-based weapons are generally not useful in orbital environments, and few if any would survive re-entry even if they were, but as early as the 1950s, the United States has toyed with kinetic bombardment, i.e. orbiting magazines of non-explosive projectiles to be dropped onto hardened targets from low-earth orbit.

Kinetic weapons have always been widespread in conventional warfare—bullets, arrows, swords, clubs, etc.—but the energy a projectile would gain while falling from orbit would

make such a weapon rival all but the most powerful explosives. A direct hit would presumably destroy all but the most hardened targets without the need for nuclear weapons.

Such a system would involve a 'spotter' satellite, which would identify targets from orbit with high-power sensors, and a nearby 'magazine' satellite to de-orbit a long, needle-like tungsten dart onto it with a small rocket motor or just dropping a very big rock from orbit (such as an asteroid). This would be more useful against a larger but less hardened target (such as a city). Though a common device in science fiction, there is no publicly-available evidence that any such systems have actually been deployed by any nation.

Directed-Energy Weapons



A USAF Boeing YAL-1 airborne laser

Weapon systems that fall under this category include lasers, linear particle accelerators or particle-beam based weaponry, microwaves and plasma-based weaponry. Particle beams involve the acceleration of charged or neutral particles in a stream towards a target at extremely high velocities, the impact of which creates a reaction causing immense damage. Most of these weapons are theoretical or impractical to implement currently, aside from lasers which are starting to be used in terrestrial warfare. That said, directed-

energy weapons are more practical and more effective in a vacuum (i.e. space) than in the Earth's atmosphere, as in the atmosphere the particles of air interfere with and disperse the directed energy. Obviously, that problem would not occur in space.

Practical considerations

Space warfare is likely to be conducted at far greater distances and speeds than terrestrial combat. The vast distances involved pose difficult challenges for targeting and tracking, as even light requires a few seconds to traverse ranges measured in hundreds of thousands of kilometers. For example, if attempting to fire upon a target at the distance of the Moon from the Earth, the image one sees reflects the position of the target slightly more than a second earlier. A projectile from a railgun recently tested by the US Navy would take over eighteen hours to cross that distance (making the simplifying and optimistic assumption that it will travel in a straight line at a constant velocity of 5.8 km/s along its entire trajectory). Even a laser will need approximately 1.28 seconds, meaning a laser-based weapon system would need to lead a target's apparent position by $1.28 \times 2 = 2.56$ seconds.

Three factors conspire to make engaging targets in space very difficult. First, the vast distances involved mean that an error of even a fraction of a degree in the firing solution could result in a miss by thousands of kilometers. Second, space travel involves tremendous speeds by terrestrial standards—a geostationary satellite moves at a speed of 3.07 km/s whereas objects in low earth orbit can move at up to 8 km/s. Third, though distances are large, targets remain relatively small. The International Space Station, currently the largest artificial object in Earth orbit, measures slightly over 100m at its largest span. Other satellites can be orders of magnitude smaller, e.g. Quickbird measures a mere 3.04m. External ballistics for stationary terrestrial targets is enormously complicated—some of the earliest analog computers were used to calculate firing solutions for naval artillery, as the problems were already beyond manual solutions in any reasonable time—and the issues in targeting objects in space make a difficult problem even harder. Additionally, though not a problem for orbital kinetic weapons, any directed energy weapon would require large amounts of electricity. So far the most practical batteries are lithium batteries, and the most practical method of generating electricity in space is through photovoltaic modules, which are currently only 5-18% efficient, and fuel cells, which have limited fuel. Current technology might not be practical for powering effective lasers, particle beams, and railguns in space.

Regardless of one's reasons for going to war, at present those reasons are not likely to suggest major targets located in space. Most of the main theories which attempt to explain human proclivity for warfare—psychological, sociological, demographic, economic, political, or otherwise—would not indicate space as a likely location of conflict until a significant population is engaged in large-scale activity there. Until then, space warfare is likely to take a supporting role to conventional, terrestrial warfare.

Aside from applications such as communications, reconnaissance, GPS, and the like, which would be difficult or impossible without satellites, there do not appear to be any

major advantages to basing weapons systems in space. The main reason is simply cost. Space warfare that involves humans being deployed in space to fight each other is not currently practical because of the difficulty and cost of sustaining human life in space, especially over long periods of time.

Additionally, there are few things that could be accomplished by space warfare that any nation wealthy enough to finance them cannot accomplish far more cheaply through conventional means. Raising any significant mass beyond Earth's gravity will always require a large amount of energy, and the cost increases with mass. For example, though kinetic bombardment potentially offers the ability to strike any target anywhere in the world within minutes, both the United States and Russia, possibly the only nations with the resources and facilities necessary to implement such a system, have sufficiently long-range supersonic bombers that the same target could already be deployed in a matter of hours at a mere fraction of the cost.

Possible warfare over space

Most of the world's communications systems rely heavily on the presence of satellites in orbit around Earth. Protecting these assets might seriously motivate nations dependent upon them to consider deploying more space-based weaponry, especially in conflicts involving advanced countries with access to space. Even without the further militarization of space, a future conflict conducted largely on the ground through conventional means might well be sparked by actions conducted entirely in space. Alternatively, the very threat of space warfare may be enough to put considerable pressure on the political system of a nation, such as the pressure which caused the formation of the Outer Space Treaty.

Relatedly, though no infrastructure or economic interests exist at the moment to warrant the occupation of terrain on other terrestrial bodies within the Solar system, or to occupy orbital trajectories in outer space, some futurists have predicted that should such infrastructure be deployed, space-faring nations may go to war for control of extra-planetary resources. Such a conflict could easily involve warfare both within and outside the Earth's atmosphere. One suggested point of conflict is the helium-3 resources in the south polar region of the Moon. Russia has already stated its intention of developing this resource, and the Chinese lunar mission is scheduled to land in that area in 2024. However, the high abundance of this isotope would make war quite unlikely.

Chapter- 8

Anti-satellite Weapon



RIM-161 Standard Missile 3 launched from the US Navy USS *Lake Erie Ticonderoga* class cruiser, 2005.

Anti-satellite weapons (ASAT) are designed to incapacitate or destroy satellites for strategic military purposes. Currently, only the United States, the former USSR (now Russia) and the People's Republic of China are known to have developed these weapons. On September 13, 1985, the United States destroyed US satellite P78-1 using an ASM-135 ASAT anti-satellite missile. On January 11, 2007, China destroyed an old Chinese orbiting weather satellite. A year and a month later, USA destroyed a malfunctioning US spy satellite USA-193 using a RIM-161 Standard Missile 3 on February 21, 2008.

History

The development and design of anti-satellite weapons has followed a number of paths. The initial efforts by the USA and the USSR were using ground-launched missiles from the 1950s; many more exotic proposals came afterwards.

US programs



U.S. ASM-135 ASAT missile



U.S. Vought ASM-135 ASAT missile launch on Sep. 13, 1985

In the late 1950s the US Air Force started a series of advanced strategic missile projects under the designation **Weapon System WS-199A**. One of the projects studied under the 199A umbrella was Martin's *Bold Orion* air-launched ballistic missile (ALBM) for the B-47 Stratojet, based on the rocket motor from the Sergeant missile. Twelve test launches were carried out between 26 May 1958 and 13 October 1959, but these were generally unsuccessful and further work as an ALBM ended. The system was then modified with the addition of an Altair upper stage to create an anti-satellite weapon with a 1100-mile (1700-km) range. Only one test flight of the anti-satellite mission was carried out, making a mock attack on the Explorer 6 at an altitude of 156 miles (251 km). To record its flight path, the *Bold Orion* transmitted telemetry to the ground, ejected flares to aid visual tracking, and was continuously tracked by radar. The missile successfully passed within

4 miles (6.4 km) of the satellite, which would be suitable for use with a nuclear weapon, but useless for conventional warheads.

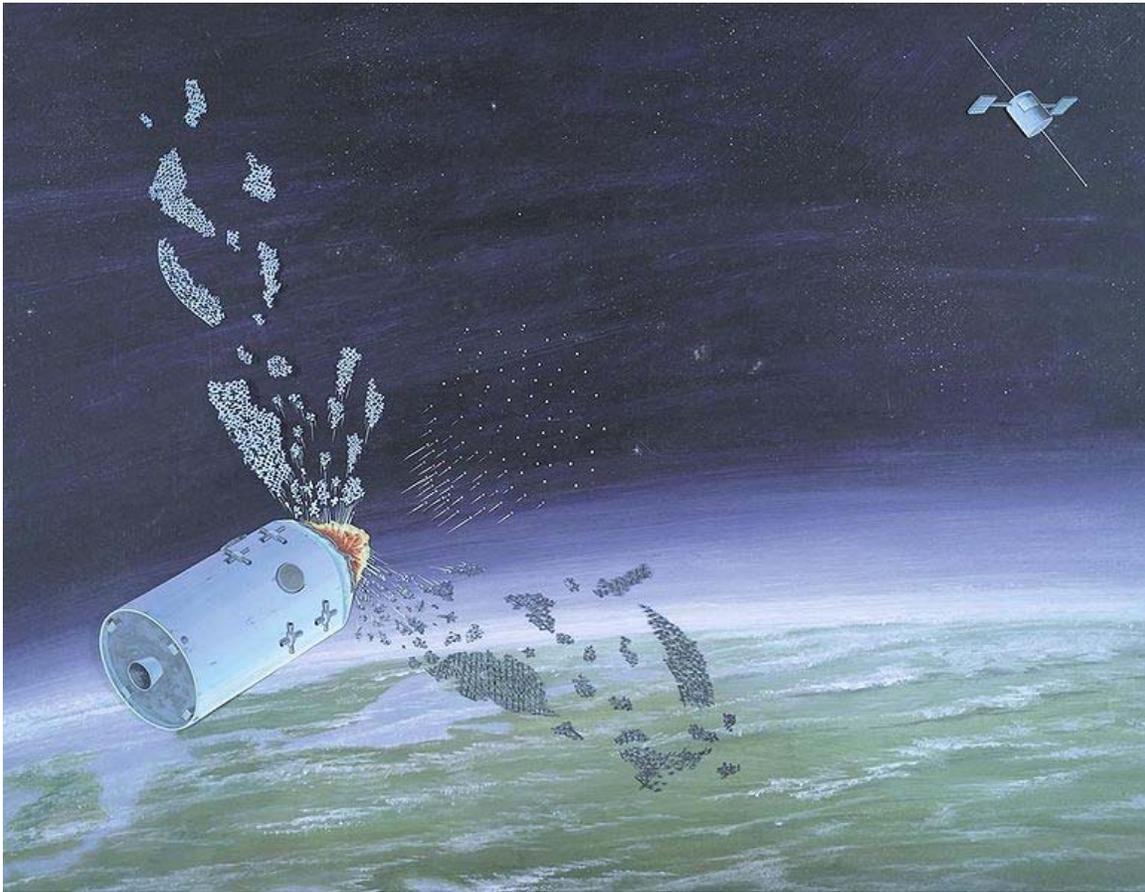
A similar project carried out under 199A, Lockheed's *High Virgo*, was initially another ALBM for the B-58 Hustler, likewise based on the Sergeant. It too was adapted for the anti-satellite role, and made an attempted intercept on Explorer 5 on 22 September 1959. However, shortly after launch communications with the missile were lost and the camera packs could not be recovered to see if the test was successful. In any event, work on the WS-199 projects ended with the start of the AGM-48 Skybolt project. Simultaneous U.S. Navy projects were also abandoned although smaller projects did drag on until the early 1970s.

The use of high altitude nuclear explosions to destroy satellites was considered after the tests of the first conventional missile systems in the 1960s. During the Hardtack Teak test in 1958 observers noted the damaging effects of the electromagnetic pulse (EMP) caused by the explosions on electronic equipment, and during the Starfish Prime test in 1962 the EMP from a 1.4 Mt warhead detonated over the Pacific damaged three satellites and also disrupted power transmission and communications across the Pacific. Further testing of weapons effects was carried out under the DOMINIC I series. An adapted version of the nuclear armed Nike Zeus was used for an ASAT from 1962. Codenamed *Mudflap*, the missile was designated DM-15S and a single missile was deployed at the Kwajalein atoll until 1966 when the project was ended in favour of the USAF Thor-based Program 437 ASAT which was operational until 6 March 1975.

Another area of research was into directed energy weapons, including a nuclear-explosion powered X-ray laser proposal developed at Lawrence Livermore National Laboratory (LLNL) in 1968. Other research was based on more conventional lasers or masers and developed to include the idea of a satellite with a fixed laser and a deployable mirror for targeting. LLNL continued to consider more edgy technology but their X-ray laser system development was cancelled in 1977 (although research into X-ray lasers was resurrected during the 1980s as part of the SDI).

ASATs were generally given low priority until 1982, when information about a successful USSR program became widely known in the west. A "crash program" followed, which developed into the Vought ASM-135 ASAT, based on the AGM-69 SRAM with an Altair upper stage. The system was carried on a modified F-15 that carried the missile directly under the central line of the plane. The F-15's guidance system was modified for the mission and provided new directional cueing through the pilot's heads up display, and allowed for mid-course updates via a data link. The first launch of the new anti-satellite missile took place in January 1984. The first, and only, successful interception was on September 13, 1985. The F-15 took off from Edwards Air Force Base, climbed to 80,000 feet (24,384 m) and vertically launched the missile at the Solwind P78-1, a US gamma ray spectroscopy satellite orbiting at 555 km (345 mi), which was launched in 1979. Although successful, the program was cancelled in 1988.

Soviet Union



1986 DIA illustration of the IS system attacking a target

The origins of the Soviet ASAT program are unclear. According to some accounts, Sergei Korolev started some work on the concept in 1956 at his OKB-1, while others attribute the work to Vladimir Chelomei's OKB-52 around 1959. What is certain is that at the beginning of April 1960, Nikita Khrushchev held a meeting at his summer residence in Crimea, discussing an array of defense industry issues. Here, Chelomei outlined his rocket and spacecraft program, and received a go-ahead to start development of the UR-200 rocket, one of its many roles being the launcher for his anti-satellite project. The decision to start work on the weapon was made in March 1961 as the **Istrebitel Sputnik (IS)** (Interceptor of satellites, or literally "Destroyer of satellites").

The IS system was "co-orbital", approaching its target over time and then exploding a shrapnel warhead close enough to kill it. The missile was launched when a target satellite's ground track rises above the launch site. Once the satellite is detected, the missile is launched into orbit close to the targeted satellite. It takes 90 to 200 minutes (or one to two orbits) for the missile interceptor to get close enough to its target. The missile is guided by an onboard radar. The interceptor, which weighs 1400 kg, may be effective up to one kilometer from a target.

Delays in the UR-200 missile program prompted Chelomei to request R-7 rockets for prototype testing of the IS. Two such tests were carried out on November 1, 1963 and April 12, 1964. Later in the year Khrushchev cancelled the UR-200 in favor of the R-36, forcing the IS to switch to this launcher, whose space launcher version was developed as the Tsyklon 2. Delays in that program led to the introduction of a simpler version, the 2A, which launched its first IS test on October 27, 1967, and a second on April 28, 1968. Further tests carried out against a special target spacecraft, the DS-P1-M, which recorded hits by the IS warhead's shrapnel. A total of 23 launches have been identified as being part of the IS test series. The system was declared operational in February 1973.

Testing resumed in 1976 as a result of the US work on the Space Shuttle. Elements within the Soviet space industry convinced Leonid Brezhnev that the Shuttle was a single-orbit weapon that would be launched from Vandenberg, maneuver to avoid existing anti-ballistic missile sites, bomb Moscow in a first strike, and then land. Although the Soviet military was aware these claims were false, Brezhnev believed them and ordered a resumption of IS testing along with a Shuttle of their own. As part of this work the IS system was expanded to allow attacks at higher altitudes and was declared operational in this new arrangement on July 1, 1979. However, in 1983, Yuri Andropov ended all IS testing and all attempts to resume it failed. Ironically, it was at about this point that the US started its own testing in response to the Soviet program.

The Soviet Union also experimented with large, ground-based ASAT lasers from the 1970s onwards, with a number of US spysats reportedly being 'blinded' (temporarily) during the 70s and 80s. The USSR had also researched directed energy weapons, under the *Fon* project from 1976, but the technical requirements needed of the high-powered gas dynamic lasers and neutral or charged particle beam systems seemed to be beyond reach. The USSR also experimented with military space stations with a capability for anti-satellite duty in its Almaz program.

In the early 80s, the Soviet Union also started developing a counterpart to the US air-launched ASAT system, using modified MiG-31 'Foxhounds' (at least six of which were completed) as the launch platform.

ASAT in the era of strategic defense

The era of the Strategic Defense Initiative (proposed in 1983) focused primarily on the development of systems to defend against nuclear warheads, however, some of the technologies developed may be useful also for anti-satellite use.

After the Soviet Union collapsed, there were proposals to use this aircraft as a launch platform for lofting commercial and science packages into orbit. Recent political developments (see below) may have seen the reactivation of the Russian Air-Launched ASAT program, although there is no confirmation of this as yet.

The Strategic Defense Initiative gave the US and Russian ASAT programs a major boost; ASAT projects were adapted for ABM use and the reverse was also true. The initial US

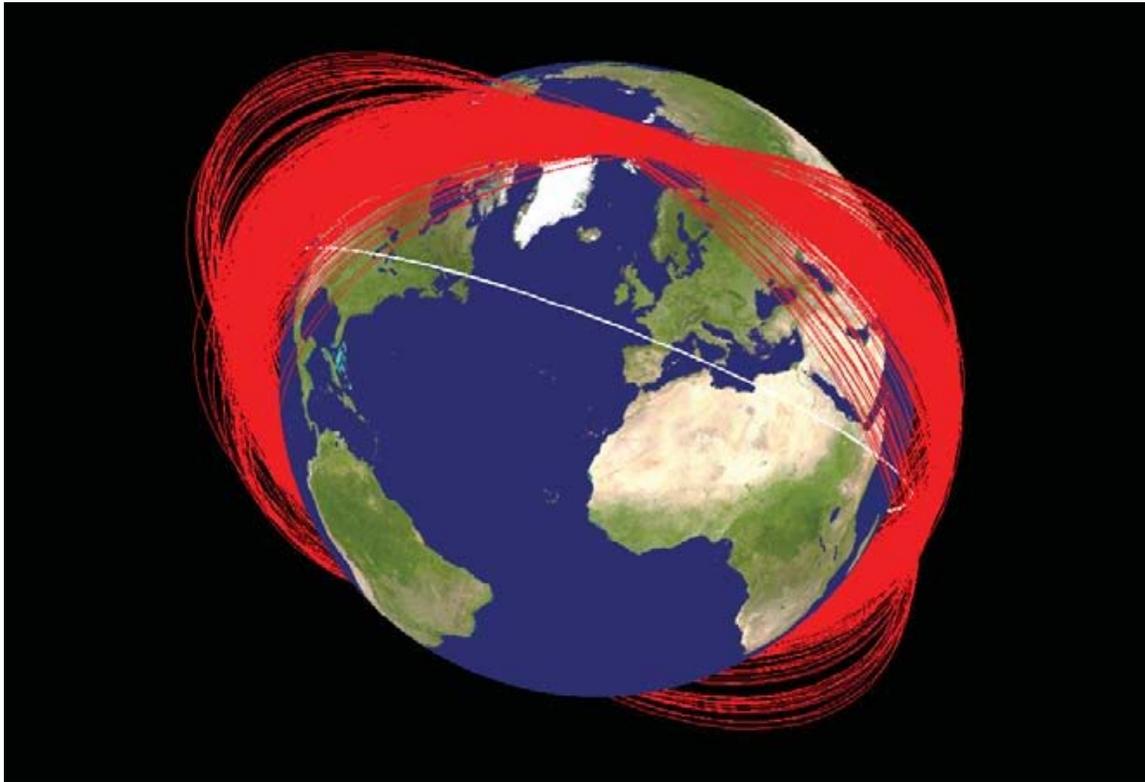
plan was to use the already-developed MHV as the basis for a space based constellation of about 40 platforms deploying up to 1,500 kinetic interceptors. By 1988 the US project had evolved into an extended four stage development. The initial stage would consist of the Brilliant Pebbles. defense system, a satellite constellation of 4,600 kinetic interceptors (KE ASAT), of 100 lb (45 kg) each, in Low Earth orbit, and their associated tracking systems. The next stage would deploy the larger platforms and the following phases would include the laser and charged particle beam weapons that would be developed by that time from existing projects such as MIRACL. The first stage was intended to be completed by 2000 at a cost of around \$125 billion.

Research in the US and Russia was proving that the requirements, at least for orbital based energy weapon systems, were, with available technology, close to impossible. Nonetheless, the strategic implications of a possible unforeseen breakthrough in technology forced the USSR to initiate massive spending on research in the 12th Five Year Plan, drawing all the various parts of the project together under the control of GUKOS and matching the US proposed deployment date of 2000.

Both countries began to reduce expenditure from 1989 and the Russian Federation unilaterally discontinued all SDI research in 1992. Research and Development (both of ASAT systems and other space based/deployed weapons) has, however, reported to have been resumed under the government of Vladimir Putin as a counter to renewed US Strategic Defense efforts post Anti-Ballistic Missile Treaty. However, the status of these efforts, or indeed how they are being funded through National Reconnaissance Office projects of record, remains unclear. The U.S. has begun working on a number of programs which could be foundational for a space-based ASAT. These programs include the Experimental Spacecraft System (XSS 11), the Near-Field Infrared Experiment (NFIRE), and the space-based interceptor (SBI).

Recent ASATs

China



Known orbit planes of Fengyun-1C debris one month after its disintegration by the Chinese ASAT

At 5:28 p.m. EST January 11, 2007, the People's Republic of China successfully destroyed a defunct Chinese weather satellite, FY-1C. The destruction was reportedly carried out by an SC-19 ASAT missile with a kinetic kill warhead similar in concept to the American Exoatmospheric Kill Vehicle. FY-1C was a weather satellite orbiting Earth in polar orbit at an altitude of about 537 miles (865 km), with a mass of about 750 kg (1,650 lb). Launched in 1999, it was the fourth satellite in the Feng Yun series. The missile was launched from a mobile Transporter-Erector-Launcher (TEL) vehicle at Xichang ([🌐28°14'49"N 102°01'30"E / 28.247°N 102.025°E](#)) and the warhead destroyed the satellite in a head-on collision at an extremely high relative velocity.

This test raised concerns in some other countries, partly because China did not publicly confirm whether or not the test had occurred until January 23, 2007 but mainly because of fears that it could prompt or accelerate an "arms race" in space. The EU stated that "...a test of an anti-satellite weapon is inconsistent with international efforts to avert an arms race in outer space and undermines security in outer space.". These concerns were also reflected in public statements from the governments of the United States, Canada, Australia and Japan. According to CNN, global security analysts stated at the time that the test was most likely aimed at the United States.

United States



Launch of the SM-3 missile used to destroy USA-193

USA-193 was an American spy satellite, which was launched on 14 December 2006 by a Delta II rocket, from Vandenberg Air Force Base. It was reported about a month after launch that the satellite had failed. In January 2008, it was noted that the satellite was decaying from orbit at a rate of 1,640 feet (500 m) per day. On 14 February 2008, it was reported that the US Navy had been instructed to fire an SM-3 ABM weapon at it, to act as an anti-satellite weapon.

According to the US Government, the primary reason for destroying the satellite was the approximately 1,000 lb (450 kg) of toxic hydrazine fuel contained on board, which could pose health risks to persons in the immediate vicinity of the crash site should any

significant amount survive the re-entry. On February 20, 2008, it was announced that the launch was carried out successfully and an explosion was observed consistent with the destruction of the hydrazine fuel tank.

Experts debated whether the hydrazine tank would have survived an uncontrolled reentry. However, if it had, any human fatality would still have been very unlikely. Although hydrazine is toxic, a small dose would not have been immediately lethal. The chance of the (assumed intact) hydrazine tank landing close enough to at least one person for that person to be killed if he or she lingered in the vicinity of the crash site was about one percent, while the cost of the intercept was about \$100 million. Since the satellite was completely uncontrollable, however, the United States chose to set an example of good stewardship of the space domain by taking action to bring the satellite down in a controlled fashion rather than take the risk, the liability for which could have easily exceeded \$100 million.

The intercept, however, was widely interpreted as a demonstration of US capabilities in response to the Chinese anti-satellite test a year earlier. The intercept was different from typical ASAT missions in that it took place at a much lower altitude (133 nautical miles or 247 kilometers) than would normally be the case, and the SM-3 missile as currently deployed would not have adequate range and altitude reach for typical ASAT missions in low-Earth orbit. However, the warhead was shown capable of hitting a satellite at orbital closing speeds, and the booster may be upgraded in the future.

ASAT development

India

In a televised press briefing during the 97th Indian Science Congress in Thiruvananthapuram, the DRDO Director General VK Saraswat announced that India was developing lasers and an exo-atmospheric kill vehicle that could be combined to produce a weapon to destroy enemy satellites in orbit. Saraswat also claimed that the "kill vehicle, which is needed for intercepting the satellite, needs to be developed, and that work is going on as part of the ballistic missile defense program". Furthermore, on February 10, 2010, DRDO Director-General and Scientific Advisor to the Defence Minister, Dr VK Saraswat stated that India had "all the building blocks necessary" to integrate an anti-satellite weapon to neutralize hostile satellites in low earth and polar orbits. He said that the propulsion module and kill vehicle already existed in principle on the Agni (missile) series of ballistic missiles, but that India did not have a formal anti-satellite weapon project as yet. He indicated, however, that the anti-satellite weapons could be developed as part of the Indian Ballistic Missile Defense Program, which will complete the development stage in totality by 2014. India had identified development of ASAT weapons "for electronic or physical destruction of satellites in both LEO (2,000-km altitude above earth's surface) and the higher GEO-synchronous orbits" as a thrust area in its long-term integrated perspective plan (2012–2027).

Russia

In the early 80s, the Soviet Union used modified MiG-31 'Foxhounds' as a launch platform for an Anti-Satellite weapon system. After the collapse of the Soviet Union, this project was put on hold due to reduced defense expenditures. However, in August 2009, the Russian Air Force had announced the resumption of this program. Further reports in May 2010 based on statements from Col. Eduard Sigalov in Russia's air and space defense forces, indicated that Russia was "developing a fundamentally new weapon that can destroy potential targets in space."