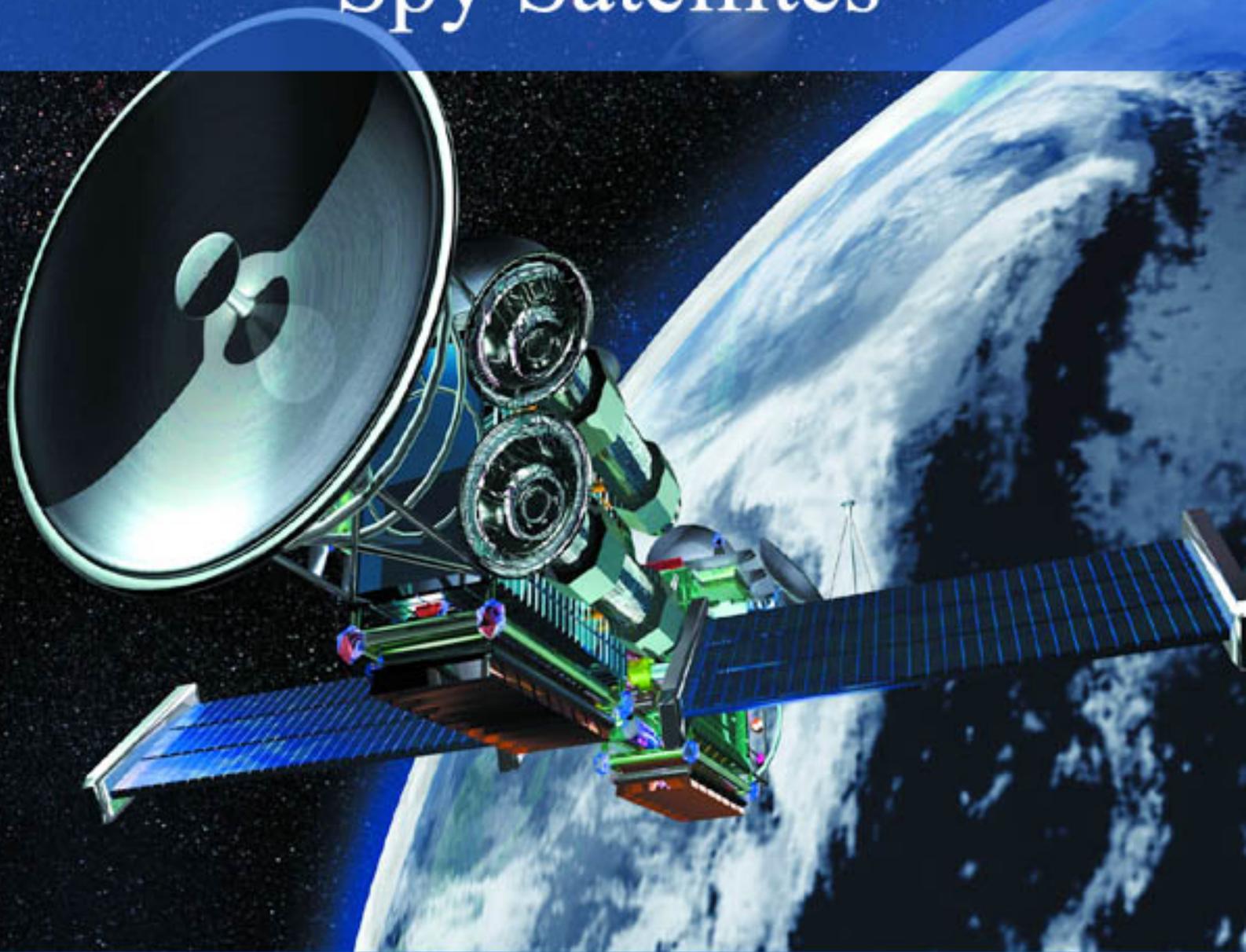


# Handbook of Spy Satellites



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# **Table of Contents**

Introduction

Chapter 1 - Spy Satellites of Israel

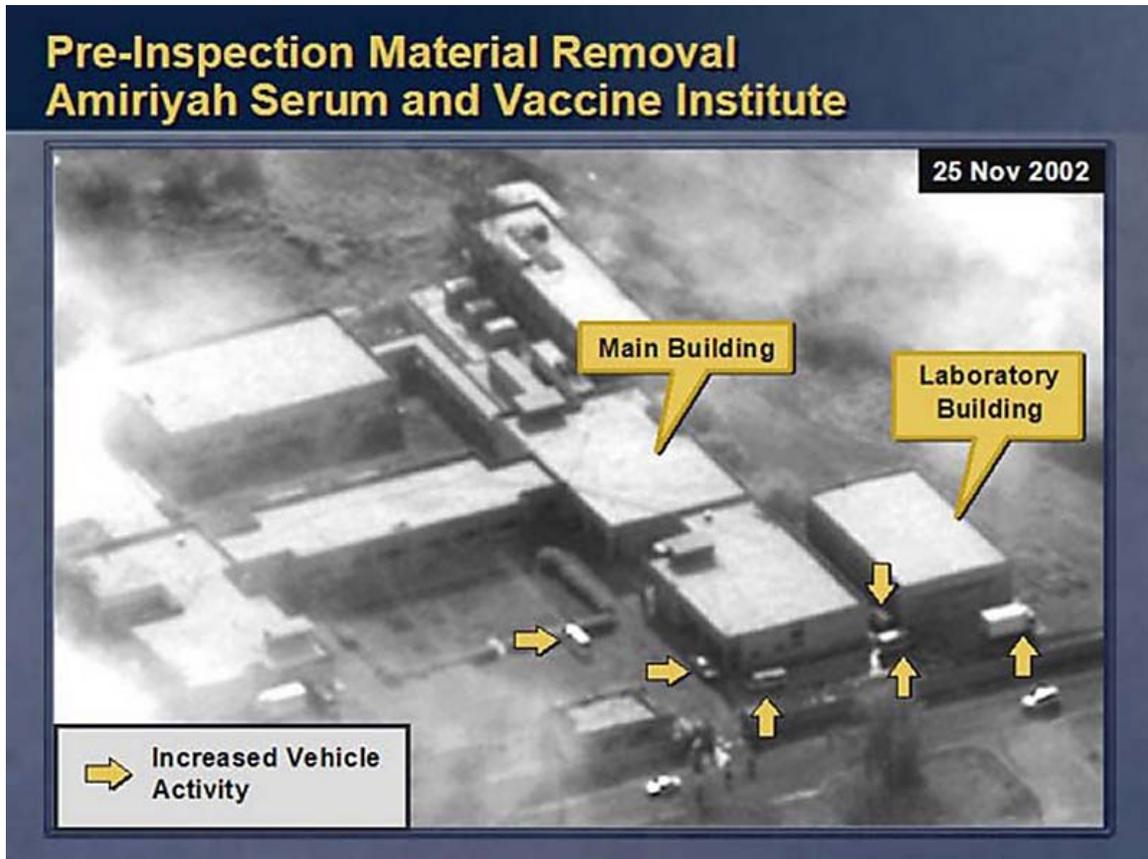
Chapter 2 - Spy Satellites of Russia

Chapter 3 - KH-11 Kennan- Spy Satellite of the United States

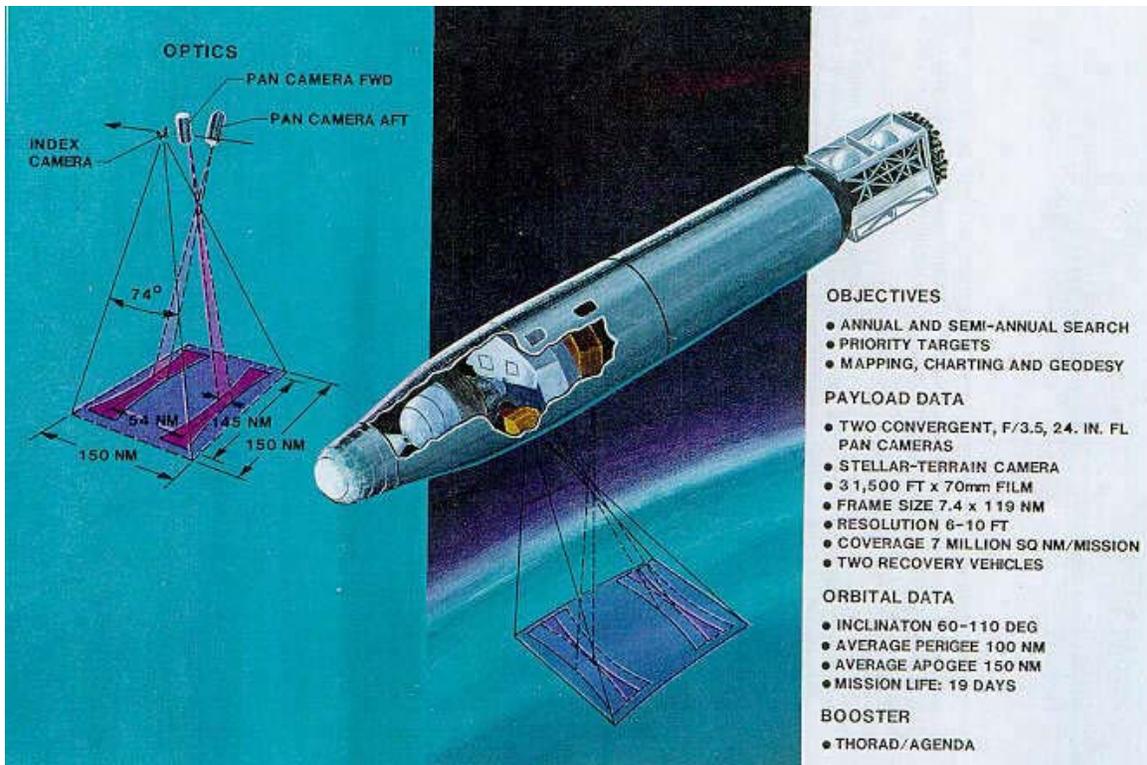
Chapter 4 - Manned Orbiting Laboratory

Chapter 5 - Spy Satellites of the United States

# Introduction



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



KH-4B Corona satellite



U.S. Lacrosse radar spy satellite under construction



A model of a German SAR-Lupe reconnaissance satellite inside a Cosmos-3M rocket.

A **spy satellite** (officially referred to as a **reconnaissance satellite**) is an Earth observation satellite or communications satellite deployed for military or intelligence applications.

These are essentially space telescopes that are pointed toward the Earth instead of toward the stars. The first generation type (i.e. Corona and Zenit) took photographs, then ejected canisters of photographic film, which would descend to earth.

Corona capsules were retrieved in mid-air as they floated down on parachutes. Later spacecraft had digital imaging systems and downloaded the images via encrypted radio links.

In the United States, most information available is on programs that existed up to 1972. Some information about programs prior to that time are still classified, and a small trickle of information is available on subsequent missions.

A few up-to-date reconnaissance satellite images have been declassified on occasion, or leaked, as in the case of KH-11 photographs which were sent to *Jane's Defence Weekly* in 1985.

## **Origins**

On March 16, 1955, the United States Air Force officially ordered the development of an advanced reconnaissance satellite to provide continuous surveillance of 'preselected areas of the earth' in order 'to determine the status of a potential enemy's war-making capability'. In October 1957, the Russians launched Sputnik. It was the first man made object to be put into Earth's orbit.

## **Missions**

Examples of reconnaissance satellite missions:

- High resolution photography (IMINT)
- Measurement and Signature Intelligence (MASINT)
- Communications eavesdropping (SIGINT)
- Covert communications
- Monitoring of nuclear test ban compliance
- Detection of missile launches

## Chapter- 1

# Spy Satellites of Israel

## Ofek-7



ofeq 7 launch through shavit space launch vehicle

**Ofek-7**, also known as **Ofeq 7**, is part of the Ofeq family of earth observation satellites designed and built by Israel Aerospace Industries (IAI) for the Israel Ministry of Defense.

The Ofek 7 was launched by a Shavit space launch vehicle on June 11, 2007. Equipped with advanced technology and a series of new enhancements to provide improved imagery, it is placed into an elliptical orbit of 300x600 kilometers. Three days after its

launch, IAI/MBT Space Division received the first images taken by the satellite. The Ofek 7 is a follow-on spacecraft to Ofek 5 that was placed into orbit in 2002.

## Ofek-9

### Ofek-9

<b>Operator</b>	Israeli Ministry of Defence
<b>Major contractors</b>	IAI
<b>Mission type</b>	Optical reconnaissance
<b>Launch date</b>	22 June 2010
<b>Carrier rocket</b>	Shavit
<b>Launch site</b>	Palmachim

### Orbital elements

<b>Regime</b>	Low Earth (Retrograde)
---------------	------------------------

**Ofek-9**, also known as **Ofeq 9**, is part of the Ofeq family of reconnaissance satellites designed and built by Israel Aerospace Industries (IAI) for the Israeli Ministry of Defense.

It was launched on June 22, 2010 from Palmachim Airbase in Israel. It was delivered using an improved version of the Shavit launcher. The payload is believed to be the multi-spectral 'Jupiter' space camera produced by El-Op. While precise imaging capabilities remain classified, sources say that like the still operating Ofeq 5 and Ofeq 7, Ofeq 9 offer resolution "much better than" a half-meter. The satellite was also said to be able to detect objects being carried by people.

## Ofeq

**Ofeq**, also spelled **Offek** or **Ofek** (Hebrew: אופק, *lit.* Horizon) is the designation of a series of Israeli reconnaissance satellites first launched in 1988. All Ofeq satellites have been carried on top of Shavit rockets from Palmachim Airbase in Israel, on the Mediterranean coast. The Low Earth Orbit satellites complete one earth orbit every 90 minutes. The satellite launches made Israel only the eighth nation to gain an indigenous launch capability. Both the satellites and the launchers were designed and manufactured by Israel Aerospace Industries (IAI) with Elbit Systems' El-Op division supplying the optical payload.

## Description

While exact technical details and capabilities are classified, it is assumed that the Ofeq satellites have ultraviolet and visible imaging sensors, and an effective operational lifespan of 1-3 years. Some early reports stated the reconnaissance capabilities as such that would allow "reading license plates in Baghdad", but that can be ruled out on grounds of physical optics. Other reports more plausibly place the imaging resolution at 0.8 meters for Ofeq 5.

Most non-Israeli satellites are launched eastward to gain a boost from the Earth's rotational speed. However, Ofeq satellites are launched westward (retrograde orbit) over the Mediterranean to avoid flying over, and dropping spent rocket stages over, populated areas in Israel and neighboring Arab countries. Other Israeli satellites (such as the Amos series) are launched from locations in other countries.

Ofeq's east-to-west orbit at 36 degrees inclination is phased to give optimal daylight coverage of the Middle East. Ofeq makes a half-dozen or so daylight passes per day over Israel and the surrounding countries, whereas U.S. and Russian spysats only get one or two passes per day from their higher inclination orbits. This optimal coverage degrades after several months, nevertheless keeping a very good coverage of the Middle East.

Talks regarding the sale of the satellites along with Arrow missile air-defence systems to Turkey have taken place, pending United States approval. The systems would be a generational leap for the Turkish military and intelligence capabilities.

## Launch history

- **Ofeq 1**, launched September 19, 1988, possessed a weight of 155 kg and circled the earth on an orbit with a perigee of 249 km and an apogee of 1149 km on a course bent around 142.9 degrees. It accomplished mainly solar cell and radio transmission tests.
- **Ofeq 2**, was launched April 23, 1990 on a course with a perigee of 149 km and an apogee of 251 km, bent around 143.2 degrees. It also accomplished communication tests.
- Another satellite of the Ofeq series, possibly attempted to be launched on September 15, 1994, was possibly aborted or had a failure during launch.
- **Ofeq 3**, launched April 5, 1995, was the first operational Israeli satellite with reconnaissance (photography) capabilities. It weighed 225 kg and had a perigee of 369 km and was launched on a new version of Shavit.
- **Ofeq 4**, launched January 22, 1998, did not achieve earth orbit due to a launcher failure and was lost.

- **Ofeq 5**, was launched 28 May 2002. The 300 kg Ofeq 5 orbited the earth on a course with a perigee of 262 km and an apogee of 774 km, bent around 143.5 degrees. During the course of its mission, its perigee was raised to 369 km and its apogee was lowered on 771 kilometers, in an attempt to prolong the satellite's lifespan. Some observers believe that the 300 kg weight of the satellite, combined with the additional propulsive requirements of the retrograde orbit, constitute a de facto demonstration of the Shavit's ICBM potential.
- **Ofeq 6**, launched September 6, 2004 encountered another launcher failure, failed to achieve low earth orbit and also crashed to the sea. The launcher failure was due to the third stage of the Shavit launcher.
- **Ofeq 7** was successfully launched on June 11, 2007.
- **Ofeq 8** designation is used for the TecSAR synthetic aperture radar satellite launched by an Indian rocket on 21 January 2008.
- **Ofeq 9** was successfully launched on June 22, 2010 from Palmachim Air Base.

## TecSAR

### TecSAR (TechSAR/Polaris)

<b>Operator</b>	IAI
<b>Mission type</b>	Reconnaissance
<b>Launch date</b>	21 January 2008, 03:45 GMT
<b>Carrier rocket</b>	PSLV-CA
<b>COSPAR ID</b>	2008-002A
<b>Homepage</b>	IAI
<b>Mass</b>	295 kg
<b>Power</b>	750 watts from solar panels
	<b>Orbital elements</b>
<b>Regime</b>	LEO
<b>Inclination</b>	41°
<b>Apoapsis</b>	580 kilometres (360 mi)

**Periapsis**                    450 kilometres (280 mi)

**Orbital period**            ~90 minutes

**TecSAR**, also known as **TechSAR**, **Polaris** and **Ofek-8**, is an Israeli reconnaissance satellite, equipped with synthetic aperture radar developed by Elta Systems. It was successfully launched at 03:45 GMT (09:15 local time) on 21 January 2008, by an Indian PSLV rocket, from the Satish Dhawan Space Centre in southern India.

The TecSAR satellite is fitted with a large dish-like antenna to transmit and receive radar signals that can penetrate darkness and thick clouds. Built by Israel Aerospace Industries, TecSAR ranks among the world's most advanced space systems.

Elta Systems Ltd cooperates with Azerbaijan to produce the country a TecSAR reconnaissance satellite system. According to Azerbaijani military experts, this is an indispensable system for military operations in the mountainous terrains of Azerbaijan.

## Launch

The satellite was successfully delivered into its target orbit about twenty minutes after launch. The four-stage PSLV rocket flew in the CA, or "Core Alone" configuration, with no strap-on solid rocket boosters. PSLV-C10, as the rocket used to launch TecSAR was designated, was the second flight of a PSLV-CA, and the twelfth overall for the PSLV series. Launch was contracted by the Antrix Corporation, the commercial department of the Indian Space Research Organisation, ISRO. The TecSAR represents the first Israeli use of the Indian PSLV launcher. This made possible an orbit that could not be reached from Israel, with an altitude of 450-580 kilometers and inclination of 41 degrees. As a result, TecSAR cruises from west to east, unlike all the other surveillance satellites launched from Israel itself.

The PSLV was selected as TecSAR's launch vehicle since the Shavit rocket that was used to launch the Ofeq series of satellites put constraints on possible satellite orbits. Any launch from Israeli territory must be directed westwards, towards the sea, in order to prevent the launcher's first stages (or the satellite itself, in case of a malfunction) from falling on populated areas or on foreign territory. A westward launch, that is, against the direction of the Earth's rotation, seriously restricts the weight of the satellite that the launch vehicle can carry. In the past, Israel also experienced several failures - the most recent example being the attempted Ofeq-6 launch in March 2004. In such cases, security links and the operational experience of another partner can allow alternative launches when needed.

The launch was delayed several times for unclear reasons. At one point, it was rumoured that the launch had been cancelled completely due to pressure from the US Government . Indian and Israeli authorities denied this, however, citing technical problems instead. In

Israel it was rumoured that the launch had been delayed due to Iranian pressure on the Indian government. However this was eventually proven to be baseless speculation.

## **Orbit**

TecSAR was placed into a Low Earth orbit with an apogee of 580 kilometres (360 miles), a perigee of 450 kilometres (280 miles), and an equatorial inclination of 41 degrees.

## **Mission**

It is capable of imaging with a resolution of up to 10 centimetres , through an X-band radar system . The satellite's maximum resolution is believed to be around 1 metre . TecSAR is the first Israeli satellite to feature Synthetic Aperture Radar, or SAR, which will provide images day or night and under all weather conditions . The satellite is being operated by Israel Aerospace Industries.

TecSAR started transmitting high quality images from 1 February 2008. The first image transmitted was that of the Latrun memorial monument.

## **Strategic Significance**

TecSAR considerably enhances Israel's intelligence-gathering capability. The satellite could potentially be the start of new strategic relations between Israel and India, and could affect the ongoing conflict in the Middle East.

Israeli media discussed the strategic significance of the satellite, particularly with regard to Iran. It was reported that TecSAR's ability to produce images in adverse weather and at night would allow Israel to obtain more information about the suspected Iranian nuclear weapons program. It was also reported that it would be capable of producing images of Iranian activities which previous satellites were unable to view.

Another report claimed that should Israel enter a conflict with Iran in the future, information provided by TecSAR could prove critical.

## **Iranian reaction**

A fortnight after the launch, Iranian Ambassador Seyed Mehdi Nabitzadeh announced in a press conference in New Delhi that he had conveyed Iran's point of view to the Indian government regarding the launch. He emphasized his hope that "wise and independent countries like India do not give their advanced space technologies to launch spying operations against Iran". The Indians however stress that the launch was purely a commercial one

## Chapter- 2

# Spy Satellites of Russia

## Kosmos (satellite)

**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 a 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

# Kosmos 1

## Kosmos 1

<b>Major contractors</b>	Yuzhnoye
<b>Bus</b>	DS-2
<b>Mission type</b>	Ionospheric Technology
<b>Launch date</b>	16 March 1962 11:59 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Mission duration</b>	2 months
<b>Orbital decay</b>	25 May 1962
<b>COSPAR ID</b>	1962 Theta 1
<b>Mass</b>	47 kilograms (100 lb)

## Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	49°
<b>Apoapsis</b>	649 kilometres (403 mi)
<b>Periapsis</b>	207 kilometres (129 mi)
<b>Orbital period</b>	93.1 minutes

**Kosmos 1** (Russian: Космос 1 meaning **Cosmos 1**), also known as **DS-2 #1** and occasionally in the West as **Sputnik 11** was a technology demonstration and ionospheric research satellite launched by the Soviet Union in 1962. It was the first satellite to be designated under the Kosmos system, and the first spacecraft launched as part of the Dnepropetrovsk Sputnik programme to successfully reach orbit. Its primary missions were to measure the performance of its carrier rocket, and to conduct research into the ionosphere.

It was launched on Kosmos-2I 63S1 s/n 6LK. It was the third flight of the Kosmos-2I, and the first to successfully reach orbit. It was also the first Kosmos rocket of any type to successfully place a satellite into orbit. The launch was conducted from pad 2 of the

Mayak Launch Complex at Kapustin Yar, and occurred at 11:59 GMT on 16 March 1962. Kosmos 1 was placed into a low Earth orbit with a perigee of 207 kilometres (129 mi), an apogee of 649 kilometres (403 mi), 49 degrees of inclination, and an orbital period of 93.1 minutes. It decayed on 25 May.

Kosmos 1 was a DS-2 satellite, the first of two to be launched. The second was launched on 1 December 1964, but did not reach orbit after the payload fairing of the rocket carrying it failed to separate. The DS-2 was a scaled down version of the earlier DS-1 satellite, lacking an avionics system, which was built after the first two DS-1 spacecraft failed to reach orbit.

## Kosmos 2

### Kosmos 2

<b>Major contractors</b>	OKB-1
<b>Bus</b>	1MS
<b>Mission type</b>	Research Technology
<b>Launch date</b>	6 April 1962 17:15 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Orbital decay</b>	20 August 1963
<b>COSPAR ID</b>	1962 Iota 1
<b>Mass</b>	285 kilograms (630 lb)

### Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	49°
<b>Apoapsis</b>	1,485 kilometres (923 mi)
<b>Periapsis</b>	207 kilometres (129 mi)
<b>Orbital period</b>	101.8 minutes

**Kosmos 2** (Russian: Космос 2 meaning **Cosmos 2**), also known as **1MS #1** and occasionally in the West as **Sputnik 12** was a scientific research and technology

demonstration satellite launched by the Soviet Union in 1962. It was the second satellite to be designated under the Kosmos system, and the first spacecraft to be launched as part of the MS programme. Its primary missions were to develop systems for future satellites, and to record data about cosmic rays and radiation.

It was launched aboard Kosmos-2I 63S1 s/n 5LK. It was the fourth flight of the Kosmos-2I, and the second to successfully reach orbit. The launch was conducted from pad 2 of the Mayak Launch Complex at Kapustin Yar, and occurred at 17:15 GMT on 6 April 1962.

Kosmos 2 was placed into a low Earth orbit with a perigee of 207 kilometres (129 mi), an apogee of 1,485 kilometres (923 mi), 49 degrees of inclination, and an orbital period of 101.8 minutes. It decayed on 20 August 1963.

Kosmos 2 was a 1MS satellite, the first of two to be launched. The second was launched on 25 October 1962, but failed to reach orbit. The 1MS was the first of two types of MS satellite to be launched, and was succeeded by the 2MS satellite.

## Kosmos 3

### Kosmos 3

<b>Major contractors</b>	OKB-1
<b>Bus</b>	2MS
<b>Mission type</b>	Research Technology
<b>Launch date</b>	24 April 1962 04:00 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Orbital decay</b>	17 October 1962
<b>COSPAR ID</b>	1962 Nu 1
<b>Mass</b>	305 kilograms (670 lb)

### Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	49°

<b>Apoapsis</b>	1,142 kilometres (710 mi)
<b>Periapsis</b>	204 kilometres (127 mi)
<b>Orbital period</b>	93.8 minutes

**Kosmos 3** (Russian: Космос 3 meaning **Cosmos 3**), also known as **2MS #1** and occasionally in the West as **Sputnik 13** was a scientific research and technology demonstration satellite launched by the Soviet Union in 1962. It was the third satellite to be designated under the Kosmos system, and the second spacecraft to be launched as part of the MS programme, after Kosmos 2 which was launched 18 days earlier. Its primary missions were to develop systems for future satellites, and to record data about cosmic rays and radiation.

It was launched aboard Kosmos-2I 63S1 s/n 4LK. It was the fifth flight of the Kosmos-2I, and the third to successfully reach orbit. The launch was conducted from pad 2 of the Mayak Launch Complex at Kapustin Yar, and occurred at 04:00 GMT on 24 April 1962.

Kosmos 3 was placed into a low Earth orbit with a perigee of 204 kilometres (127 mi), an apogee of 1,142 kilometres (710 mi), 49 degrees of inclination, and an orbital period of 93.8 minutes. It decayed on 17 October 1962.

Kosmos 3 was a 2MS satellite, the first of two to be launched. The second was launched as Kosmos 5 on 28 May 1962. The 2MS was the second of two types of MS satellite to be launched, following the first 1MS spacecraft which had been launched as Kosmos 2.

## Kosmos 4

<b>Kosmos 4</b>	
<b>Major contractors</b>	OKB-1
<b>Bus</b>	Zenit-2
<b>Mission type</b>	Reconnaissance
<b>Launch date</b>	26 April 1962 10:02 GMT
<b>Carrier rocket</b>	Vostok-K
<b>Launch site</b>	Baikonur Site 1/5
<b>Orbital decay</b>	29 April 1962
<b>COSPAR ID</b>	1962 Xi 1

**Mass** 4,610 kilograms (10,200 lb)

#### **Orbital elements**

**Regime** Low Earth  
**Inclination** 65°  
**Apoapsis** 317 kilometres (197 mi)  
**Periapsis** 285 kilometres (177 mi)  
**Orbital period** 90.5 minutes

**Kosmos 4** (Russian: Космос 4 meaning **Cosmos 4**), also known as **Zenit-2 #2** and occasionally in the West as **Sputnik 14** was the first Soviet reconnaissance satellite to successfully reach orbit. It was the fourth satellite to be designated under the Kosmos system, and the second Soviet attempt to launch a reconnaissance satellite, the previous attempt having failed after one of the carrier rockets engines shut down prematurely.

It was launched on a Vostok-K rocket, which was making its seventh flight. It was the last Zenit launch to use the Vostok-K, before launches switched to the Vostok-2 starting with the next launch attempt in June 1962. The launch was conducted from Site 1/5 at the Baikonur Cosmodrome, and occurred at 10:02 GMT on 26 April 1962.

Kosmos 4 was placed into a low Earth orbit with a perigee of 285 kilometres (177 mi), an apogee of 317 kilometres (197 mi), 65 degrees of inclination, and an orbital period of 90.5 minutes. It conducted a four day mission, before being deorbited and landing by parachute on 29 April. The spacecraft's orientation system failed, which resulted in only partial completion of the mission. It was to be followed by another satellite in May, however this was delayed to June, and then failed to reach orbit.

Kosmos 4 was a Zenit-2 satellite, a reconnaissance satellite derived from the Vostok spacecraft used for manned flights. The next Zenit launch attempt failed, and the next launch after that successfully reached orbit as Kosmos 7.

## **Kosmos 5**

### **Kosmos 5**

**Major contractors** OKB-1  
**Bus** 2MS  
**Mission type** Research  
Technology

<b>Launch date</b>	28 May 1962 03:00 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Orbital decay</b>	2 May 1963
<b>COSPAR ID</b>	1962 Upsilon 1
<b>Mass</b>	280 kilograms (620 lb)

#### Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	49.1°
<b>Apoapsis</b>	1,578 kilometres (981 mi)
<b>Periapsis</b>	192 kilometres (119 mi)
<b>Orbital period</b>	102.6 minutes

**Kosmos 5** (Russian: Космос 5 meaning **Cosmos 5**), also known as **2MS #2** and occasionally in the West as **Sputnik 15** was a scientific research and technology demonstration satellite launched by the Soviet Union in 1962. It was the fifth satellite to be designated under the Kosmos system, and the third spacecraft to be launched as part of the MS programme, after Kosmos 2 and Kosmos 3. Its primary missions were to develop systems for future satellites, and to record data about artificial radiation around the Earth.

It was launched aboard Kosmos-2I 63S1 s/n 3LK. It was the sixth flight of the Kosmos-2I, and the fourth to successfully reach orbit. The launch was conducted from pad 2 of the Mayak Launch Complex at Kapustin Yar, and occurred at 03:00 GMT on 28 May 1962.

Kosmos 5 was placed into a low Earth orbit with a perigee of 192 kilometres (119 mi), an apogee of 1,578 kilometres (981 mi), 49.1 degrees of inclination, and an orbital period of 102.6 minutes. It decayed on 2 May 1963, after nearly a year in orbit.

Kosmos 5 was a 2MS satellite, the second of two to be launched, following the first which was launched as Kosmos 3 on 24 April. The 2MS was the second of two types of MS satellite to be launched, following the first 1MS spacecraft which had been launched as Kosmos 2. Kosmos 5 was the penultimate MS satellite to be launched, and the last to successfully reach orbit. The last launch attempt, of a 1MS satellite, occurred in October, and failed to reach orbit.

# Kosmos 6

## Kosmos 6

<b>Major contractors</b>	Yuzhnoye
<b>Bus</b>	DS-P1
<b>Mission type</b>	Radar target Technology
<b>Launch date</b>	30 June 1962 16:00 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Orbital decay</b>	8 September 1962
<b>COSPAR ID</b>	1962 Alpha Delta 1
<b>Mass</b>	355 kilograms (780 lb)

## Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	48.90°
<b>Apoapsis</b>	348 kilometres (216 mi)
<b>Periapsis</b>	261 kilometres (162 mi)
<b>Orbital period</b>	90.6 minutes

**Kosmos 6** (Russian: Космос 6 meaning **Cosmos 6**), also known as **DS-P1 #1** and occasionally in the West as **Sputnik 16** was a prototype radar target satellite for anti-ballistic missile tests, which was launched by the Soviet Union in 1962. It was the sixth satellite to be designated under the Kosmos system, and the second spacecraft launched as part of the DS programme to successfully reach orbit, after Kosmos 1. Its primary mission was to demonstrate the necessary technologies for radar tracking of spacecraft, which would allow future satellites to function as targets. It was the first solar-powered satellite manufactured by Yuzhnoye.

It was launched aboard the seventh flight of the Kosmos-2I 63S1 rocket. The launch was conducted from pad 2 of the Mayak Launch Complex at Kapustin Yar, and occurred at 16:00 GMT on 30 June 1962.

Kosmos 6 was placed into a low Earth orbit with a perigee of 261 kilometres (162 mi), an apogee of 348 kilometres (216 mi), 48.90 degrees of inclination, and an orbital period of 90.6 minutes. It decayed on 8 September 1962.

Kosmos 6 was a prototype DS-P1 satellite, the first of four to be launched, . Of the other three satellites, one was lost in a launch failure, and the remaining two successfully reached orbit as Kosmos 19 and Kosmos 25.

## Kosmos 7

### Kosmos 7

<b>Major contractors</b>	OKB-1
<b>Bus</b>	Zenit-2
<b>Mission type</b>	Reconnaissance
<b>Launch date</b>	28 July 1962 09:18:31 GMT
<b>Carrier rocket</b>	Vostok-2
<b>Launch site</b>	Baikonur Site 1/5
<b>Orbital decay</b>	1 August 1962
<b>COSPAR ID</b>	1962 Alpha Iota 1
<b>Mass</b>	4,610 kilograms (10,200 lb)

### Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	64.9°
<b>Apoapsis</b>	356 kilometres (221 mi)
<b>Periapsis</b>	197 kilometres (122 mi)
<b>Orbital period</b>	90 minutes

**Kosmos 7** (Russian: Космос 7 meaning **Cosmos 7**), also known as **Zenit-2 #4** and occasionally in the West as **Sputnik 17** was a Soviet reconnaissance satellite launched in 1962. It was the seventh satellite to be designated under the Kosmos system, and the second successful launch of a Soviet reconnaissance satellite. It also marked the first

successful launch of a Vostok-2, on the second attempt. The first Vostok-2 launch, also carrying a Zenit-2 satellite, suffered an engine failure seconds after launch, fell back to earth and exploded within 300 metres of the launch pad.

Vostok-2 s/n T15000-07 was used to launch Kosmos 7. The launch was conducted from Site 1/5 at the Baikonur Cosmodrome, and occurred at 09:18:31 GMT on 28 July 1962.

Kosmos 7 was placed into a low Earth orbit with a perigee of 197 kilometres (122 mi), an apogee of 356 kilometres (221 mi), 64.9 degrees of inclination, and an orbital period of 90 minutes. It conducted a four day mission, before being deorbited and landing by parachute on 1 August.

Kosmos 7 was a Zenit-2 satellite, a reconnaissance satellite derived from the Vostok spacecraft used for manned flights. It was the second Zenit-2 to reach orbit, the first being Kosmos 4. The next Zenit-2 launch was Kosmos 9. Kosmos 7 carried an area survey reconnaissance payload. In addition to reconnaissance, it was also used for research into radiation.

## Kosmos 8

### Kosmos 8

<b>Major contractors</b>	Yuzhnoye
<b>Bus</b>	DS-K-8
<b>Mission type</b>	Technology
<b>Launch date</b>	18 August 1962 15:00 GMT
<b>Carrier rocket</b>	Kosmos-2I 63S1
<b>Launch site</b>	Kapustin Yar Mayak-2
<b>Orbital decay</b>	17 August 1963
<b>COSPAR ID</b>	1962 Alpha Xi 1
<b>Mass</b>	337 kilograms (740 lb)

### Orbital elements

<b>Regime</b>	Low Earth
<b>Inclination</b>	49°
<b>Apoapsis</b>	598 kilometres (372 mi)

<b>Periapsis</b>	244 kilometres (152 mi)
<b>Orbital period</b>	92.9 minutes

**Kosmos 8** (Russian: Космос 8 meaning **Cosmos 8**), also known as **DS-K-8 #1** and occasionally in the West as **Sputnik 18** was a technology demonstration satellite which was launched by the Soviet Union in 1962. It was the eighth satellite to be designated under the Kosmos system, and the third spacecraft launched as part of the DS programme to successfully reach orbit, after Kosmos 1 and Kosmos 6. Its primary mission was to demonstrate the technologies for future Soviet military satellites. It also carried a micrometeoroid research payload which discovered meteoroid flux.

It was launched aboard the eighth flight of the Kosmos-2I 63S1 rocket. The launch was conducted from pad 2 of the Mayak Launch Complex at Kapustin Yar, and occurred at 15:00 GMT on 18 August 1962.

Kosmos 8 was placed into a low Earth orbit with a perigee of 244 kilometres (152 mi), an apogee of 598 kilometres (372 mi), 49 degrees of inclination, and an orbital period of 92.9 minutes. It decayed on 17 August 1963, one day short of a year after its launch. Kosmos 8 was the only DS-K-8 satellite to be launched.

## Monitor-E

**Monitor-E** is the first Russian satellite of a fleet of newly designed, small Earth observing satellites. It was launched August 26, 2005 (local time) from Plesetsk Cosmodrome, and placed in a Sun synchronous orbit of 540 km.

### Design

*Monitor-E* has a set of remote sensing devices. They are intended to make maps of the Earth's surface to be used for ecological monitoring and chart geological features. It was built by the Khrunichev State Space Research Center.

### Specifications

#### Sensors

- 8 m panchromatic (0.51-0.85  $\mu\text{m}$ ), swath width of not less 90 km
- 20–40 m multispectral (0.54-0.59/0.63-0.68/0.79-0.90  $\mu\text{m}$ ), swath width of not less than 160 km

#### Onboard storage

- 2x200 gigabit capacity

## Data communications

- Transmission speeds of 15.36/61.44/122.88 Mbit/s

## Orbit

- Altitude: 550 km - 97.5 degree sun synchronous inclination

## Spacecraft

- Active life: 5 years
- Orientation precision: 0.1 degrees
- Stabilization precision: 0.001 degrees/s
- Average daily power consumption: 450 W
- Mass: 750 kg

## Communications problems

After launch communications with *Monitor-E* was difficult to establish, initially. But a few hours later it was successfully contacted. On October 19 new problems developed and no communication was possible since then. Later on communications were restored and photographs from both cameras have been published on November 30, 2005.

# Oko

## Oko

### General Information

<b>Manufacturer</b>	TsNII Kometa NPO Lavochkin
<b>Country of Origin</b>	 Soviet Union  Russia
<b>Applications</b>	Missile defence
<b>Orbit regimes</b>	Molniya

### Production

<b>Status</b>	Operational
<b>Built</b>	86+
<b>Launched</b>	85

<b>Lost</b>	3
<b>First launch</b>	Kosmos 775 8 October 1975

**Oko** (also called **US-KS**) (*Russian: Oko (УС-КС)*) is a Soviet and Russian satellite system, used to detect missile launches. It consists of a constellation of satellites, usually in molniya orbits, designated under the Kosmos (Cosmos) system. The satellites are built by the company NPO Lavochkin and are launched on Molniya-M rockets. Oko can be directly translated as the Russian word for eye.

## History

### Soviet era

The Oko (US-KS) early warning system was introduced in the Soviet Union in the 1970s, and declared operational in 1982. The satellites operated in molniya orbits with the parameters 600 x 39,700 km, 63 degrees and 718 minutes, passing over the Northern Hemisphere every 12 hours. They could spot the flame of a missile launch against the stellar background within 20 to 30 seconds, leaving enough time to launch a counterstrike. Propellant dumps from the Molniya-M a rocket's upper stage during Oko launches were connected to several UFO detections in Uruguay, Chile and Argentina after 1977. The system requires at least 4 functioning satellites in order for it to be effective. This was achieved in the 1980s, but the system often fell short of this goal.

Shortly after midnight Moscow time on 26 September 1983, one of the Oko satellites reported several US ICBMs being launched. This resulted in a major nuclear false alarm. The satellite reports were passed to the Oko control center, the Serpukhov-15 bunker outside in Kurilovo, outside Moscow, where Stanislav Petrov was in command at the time. Examining the reports, Petrov was convinced the reports were in error, and refused to report the "launches" to his superiors. As he later explained, "when people start a war, they don't start it with only five missiles." Later study suggests that the angle between the sun, the satellite and the missile fields resulted in reflections off high-altitude clouds that caused the reports. Geoffrey Forden published a report for the Cato Institute that identifies Kosmos-1382 as the most likely culprit for the false alarm.

Another early warning system, called the Prognoz, was launched in 1984. Its first satellite was Cosmos 2133. Prognoz was designed to use a 24-hour geosynchronous orbit to provide continuous coverage, in contrast to the 12-hour orbit used by Oko. It is unclear whether Prognoz was meant as a replacement for Oko or to supplement it. Some Oko-designated satellites were also adapted to use a 24-hour orbit.

## Russian Federation

After the dissolution of the Soviet Union, the rate of launches decreased, but Russia remained committed to the program. A fully functioning constellation with 5 satellites was restored in 2001, but a fire in May 2001 in the Oko control facility at Kurilovo (Kaluga Region) reduced the number of operational satellites to 2. A further satellite was launched in the same year. Between 2002 and 2006 there were no Oko launches, until another Oko satellite, designated Cosmos 2422, was launched in July 2006.

In 2006, Russia had one operational US-KMO Prognoz (Cosmos 2379) satellite and four US-KS Oko satellites (Cosmos 2422, Cosmos 2393, Cosmos 2351, Cosmos 2368).

## Satellites

The Oko satellites are drum-shaped, 2 meters long and with a diameter of 1.7 m. They weigh 1,250 kilograms without fuel and 2,400 kilograms when fully loaded. They have a 350-kg infrared telescope pointing toward Earth, with a 4-m conical sunshield and an instrument bus. The telescope, which is the satellites' main instrument, is able to detect radiation from ascending missiles. Two solar panels provide a total of 2.8 kW of power. There are also several smaller, wider-angle telescopes to supplement the main instrument. The satellites have 16 liquid fuel engines for altitude control and 4 for manouvering.

The system requires at least 4 satellites to be fully functional. The danger of false alarms increases when there are less than 4 satellites in orbit, due to the inability to double-check a detection.

The satellites are built by NPO Lavochkin and launched with Molniya-M rockets. The advantages of Oko include that the system is reliable and well-established, and that it uses the relatively inexpensive Molniya launcher.

## Orlets-1

**Orlets-1** or **Don** (GRAU index 17F12) is a Russian (previously Soviet) reconnaissance satellite.

Orlets-1 was made after it was concluded that the Yantar-2K satellite was not capable of providing strategic warning of attack, and drew on features of an existing draft project designated Yantar-6K. It has a wide-spectrum panoramic camera, carries 8 film return capsules and has a design life of 60 days, After its mission has ended, the satellite is detonated in its orbit.

Orlets-1 is being launched by the Soyuz-U or Soyuz-U2 launch vehicle.

An improved version of Orlets-1 exists, called Orlets-2.

# Persona (satellite)

## Kosmos-2441 (Persona-1)



Artist's impression of a Persona satellite

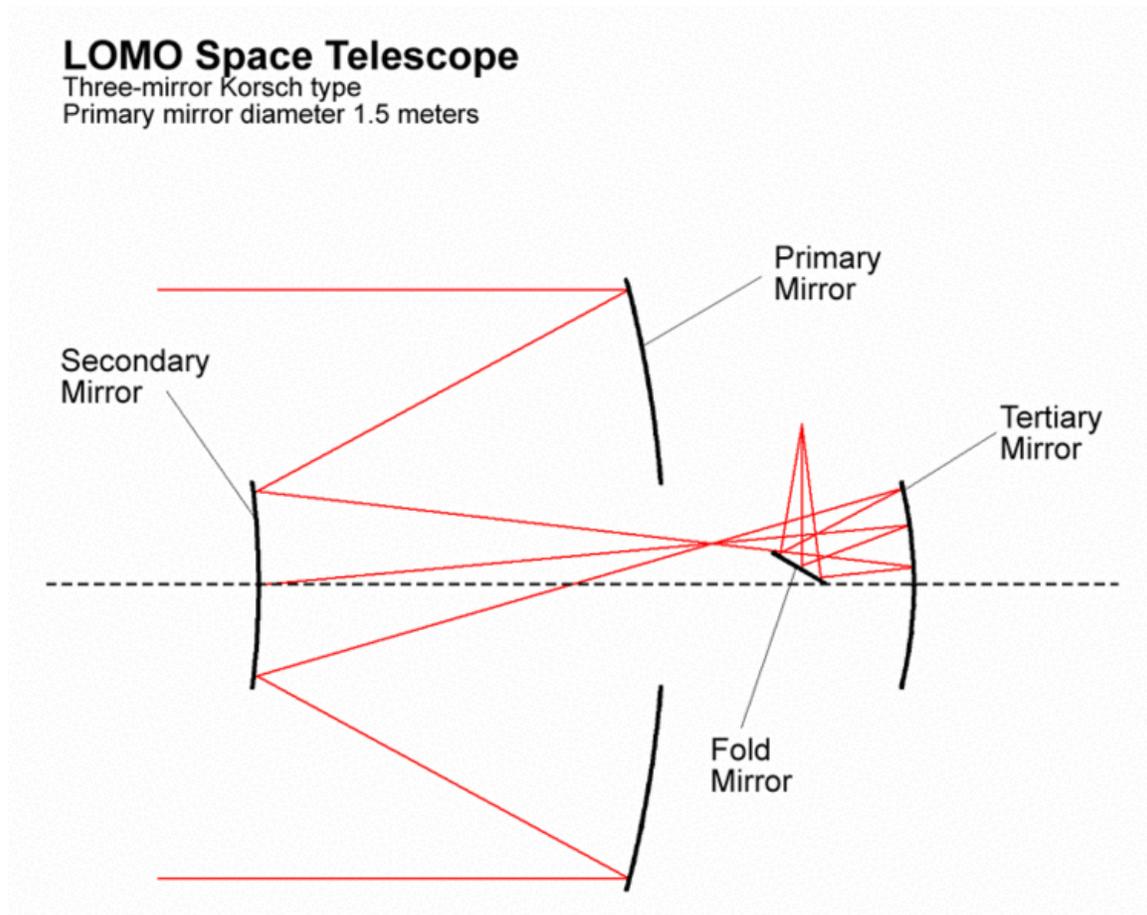
<b>Operator</b>	VKS TsSKB Progress
<b>Major contractors</b>	LOMO Vavilov State Optical Institute NPO Opteks
<b>Mission type</b>	Reconnaissance
<b>Launch date</b>	18:31 GMT, 26 July 2008
<b>Carrier rocket</b>	Soyuz-2.1b
<b>Launch site</b>	LC-43/4, Plesetsk
<b>Orbital elements</b>	
<b>Regime</b>	SSO
<b>Inclination</b>	98.3°
<b>Apoapsis</b>	732 kilometres (455 mi)
<b>Periapsis</b>	714 kilometres (444 mi)

**Persona** is a class of Russian reconnaissance satellites, derived from the Resurs DK class of remote sensing satellite, itself derived from the Soviet Yantar reconnaissance satellites. The satellites are built by TsSKB Progress, and the optics by LOMO and the Vavilov State Optical Institute.

The first satellite, identified as Kosmos 2441, was launched into a 750 km sun synchronous orbit on 26 July 2008, atop a Soyuz-2.1b carrier rocket from LC-43/4 at the

Plesetsk Cosmodrome It reportedly failed to return useful imagery due to an electrical malfunction.

The satellites have a mass of 6,500 kilograms (14,000 lb), are 7 metres (23 ft) long, and 2.7 metres (8.9 ft) in diameter.



Persona optics

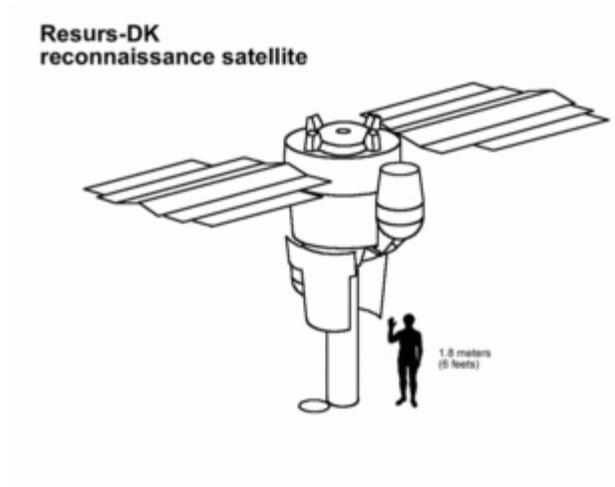
The satellites optical subsystems are believed to be based on a 3-mirror Korsch type telescope with a primary mirror diameter of 1.5 metres (4.9 ft) and focal length of 20 metres (66 ft).

The CCD sensor is probably ELCT1080v1U with a pixel size of 9  $\mu\text{m}$ . The CCD is produced by ELAR, previously known as ELECTRON-OPTRONIC. The focal plane unit is manufactured by NPO Opteks.

The satellites have a nadir image resolution of 33 centimetres (13 in), using panchromatic imagery. They are planned to operate for 7 years.

# Resurs DK

## Resurs-DK1



<b>Organization</b>	NTs OMZ
<b>Mission Type</b>	Earth observation
<b>COSPAR ID</b>	2006-021A
<b>Contractor</b>	TsSKB Progress
<b>Satellite of</b>	Earth
<b>Launch</b>	June 15, 2006
<b>Launch vehicle</b>	Soyuz-FG
<b>Launch site</b>	Baikonur Cosmodrome
<b>Mission duration</b>	5 years
<b>Mission elapsed time</b>	4 years, 7 months, and 27 days
<b>Mass</b>	6550 kg
<b>Payload mass</b>	1200 kg
<b>Max length</b>	7930 mm
<b>Max diameter</b>	2720 mm
<b>Solar panel</b>	36 m <sup>2</sup>
<b>Axis orientation accuracy</b>	0.2 arcmin
<b>Angular velocity stabilization accuracy</b>	0.005 degrees per second
<b>Webpage</b>	<a href="http://eng.ntsomz.ru/ks_dzz/satellites/resurs_dk1">http://eng.ntsomz.ru/ks_dzz/satellites/resurs_dk1</a>

### Orbital elements

<b>Inclination</b>	69.9 degrees
<b>Orbit</b>	circular
<b>Min altitude</b>	567 km
<b>Max altitude</b>	573 km
<b>Period</b>	94.02 min

#### Instruments

<b>Visible cameras</b>	0.9 m panchromatic 1.5 m multispectral at 360 km altitude
<b>Scientific</b>	PAMELA and Arina

**Resurs-DK1** is a commercial Earth observation satellite capable of transmitting high-resolution imagery (up to 0.9 m) to the ground stations as it passes overhead. The spacecraft is operated by NTs OMZ, Russian Research Center for Earth Operative Monitoring.

The satellite is designed for multi-spectral remote sensing of the Earth's surface aimed at acquiring high-quality visible images in near real-time as well as on-line data delivery via radio link and providing a wide range of consumers with value-added processed data.

## Spacecraft

The *Resurs-DK1* spacecraft was built by the Russian space company TsSKB Progress in Samara, Russia. It is modified version of military reconnaissance satellite Yantar-4KS1 (Terilen) . The spacecraft is three-axis stabilized. The design lifetime is no less than 3 years, 5 years is expected. Ground location accuracy is 100 m. Onboard storage is 768 G-bits. Data link speed to the ground station is 300 Mbit/s. Maximum daily productivity is 1 million square km.

*DK* in the name stands for *Dmitry Kozlov*, chief designer of the first satellite of this class *Yantar-2K*. *Resurs* is Russian for "Resource".

## Optical subsystem

- Type: apochromatic telephoto
- Focal length: 4000 mm
- Objective diameter: 500 mm
- Spectral range: 0.5-0.9  $\mu\text{m}$
- Mass: 310 kg

Made by Vavilov State Optical Institute, Russia.

## Spectral Resolution

- 0.58-0.8  $\mu\text{m}$  panchromatic
- 0.5-0.6  $\mu\text{m}$  green
- 0.6-0.7  $\mu\text{m}$  red
- 0.7-0.8  $\mu\text{m}$  visible near IR (near infrared)

It is not possible to represent an image in true color because there is no blue band (0.4 - 0.5  $\mu\text{m}$ ). However, it is possible to combine red, green and near IR in such way that the appearance of the displayed image resembles a visible colour photograph, i.e. vegetation in green, water in blue, soil in brown. This is not always possible because two similarly coloured objects can have completely different reactions to near IR light.

Green, red and near IR are typically combined to make a traditional false color composite where the near IR is displayed in red, the red is displayed in green, and the green is displayed in blue. This combination is favoured by scientists because near IR is useful for detection of numerous vegetation types. Vegetation appear as redtones, the brighter the red, the healthier the vegetation. Soils with no or sparse vegetation range from white (sand, salt) to greens or browns depending on moisture and organic matter content. Water appears blue, clear water is dark blue to black while shallow waters or waters with high sediment concentrations are lighter blue. Urban areas will appear blue towards gray. Clouds and snow are white.

## Focal Plane Unit

Unit features 4 TDI (Time Delay and Integration) sensor arrays, one panchromatic and three multispectral. Each sensor array is composed of 36 "Kruiz" CCD chips. Effective length of the single array is about 36000 pixels. Arrays are grouped in 3 separated lines:

- near IR
- panchromatic and red
- green

This separation is causing a time delay of the colour images combined from green, red and near IR, so fast moving objects are shown in triplets. Moving object speed and direction can be calculated. All 4 arrays can work simultaneously, so it is possible to combine panchromatic and 3 multispectral images in one pansharpned color composite.

System use 10-bit ADC

Focal Plane Unit is made by NPO Opteks, Russia

## **CCD**

The CCD "Kruiz" is a 1024 pixel x 128 line, high speed TDI sensor. The active imaging area is organized as 1024 vertical columns and 128 horizontal TDI rows.

- Pixel size: 9 x 9  $\mu\text{m}$
- Number of TDI stages electronically selectable: 128, 64, 32, 16, 8
- Two readout shift registers and two output amplifiers allowing twice faster readout
- Selftest without illumination
- Full well capacity: 120 000 electrons
- Dynamic range: 2500
- Charge transfer efficiency in any direction: more than 0.99998 per transfer
- Maximum quantum efficiency: 0.33 (at 0.72  $\mu\text{m}$ ).

Designed jointly by NPO Opteks and ELECTRON-OPTRONIC.

Produced by ELECTRON-OPTRONIC (now is ELAR )

## **Spatial resolution**

### **Panchromatic**

At the altitude of 360 km

- Nadir: 0.9 m
- 30 degrees tilt: 1.0 m

At the altitude of 604 km

- Nadir: 1.5 m
- 30 degrees tilt: 1.7 m

### **Multispectral**

1.5-2 m

## **Temporal resolution**

The revisit rate is 5 to 7 days off-nadir.

## **Swath**

Swath width at the altitude of 350 km:

- 4.7 - 28.3 km (at nadir)
- 40 km (at  $\pm 30^\circ$ )

## **Arina**

Russian research hardware for detection of high-energetic electrons and protons, their identification, detection of high-energetic particles bursts – earthquake signs.

- Mass: 9 kg

## **PAMELA**

**PAMELA** Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics is an attached module built by Italian researchers with international partners. Its purpose is basic physics research of primary cosmic rays.

- Mass: 470 kg

## **Major Current Tasks**

- Data supply for resource management and economical activity (inventory of natural resources, topographic and thematic mapping).
- Monitoring of pollution sources of the atmosphere, water and soil with the view of providing Federal and regional environmental authorities with the relevant information to make management decisions.
- On-line monitoring of man-caused and natural emergencies for the purpose of effective planning and timely performing of measures to eliminate damages.
- Supplying home and foreign consumers on a commercial basis.
- Research activities (PAMELA and Arina experiments).

## **Related development**

Kosmos-2441 (Persona-1) reconnaissance satellite

## **Major orbit change**

The satellite has been in a 355 x 573 km orbit since its launch in 2006, raised its orbit on Sep 10, 2010. to a circular 567 x 573 km x 69.9 deg.

## Zenit (satellite)



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.

## Chapter- 3

# KH-11 Kennan- Spy Satellite of the United States



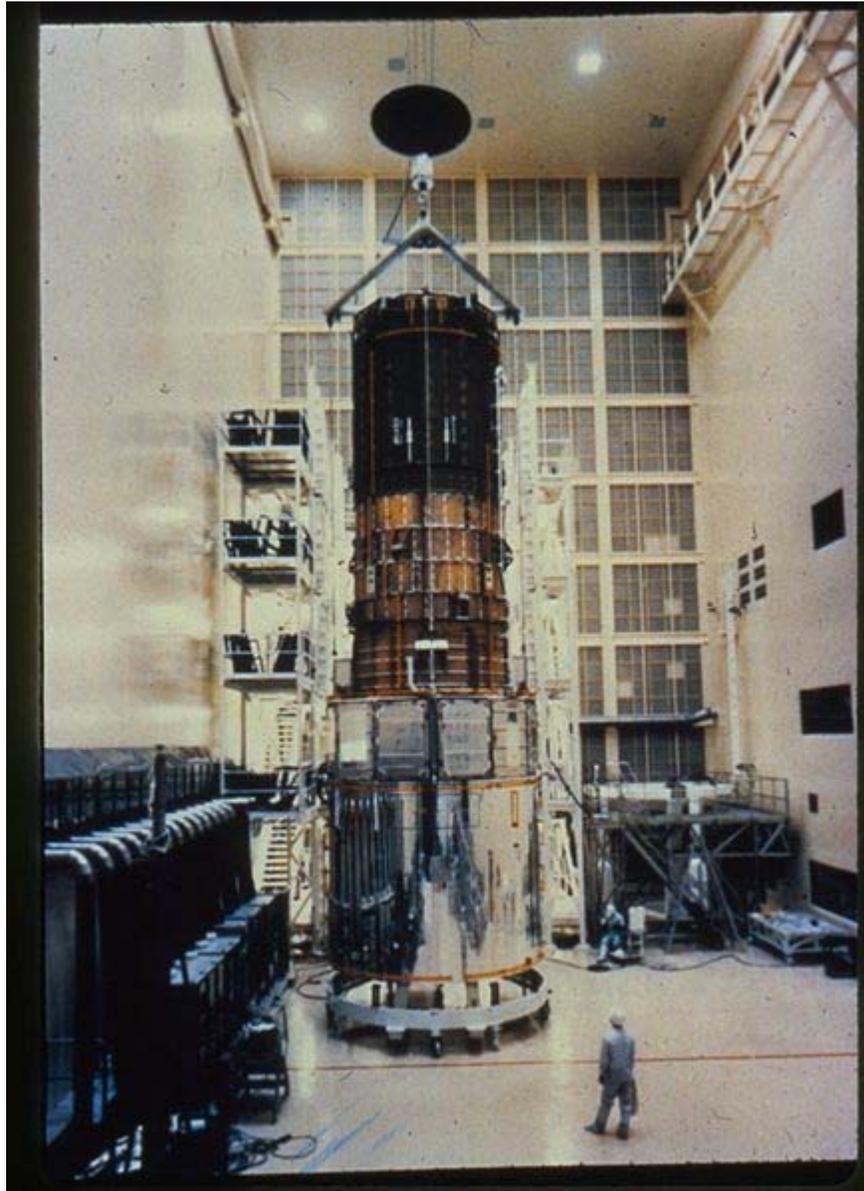
U.S. reconnaissance satellite image of the Al-Shifa pharmaceutical factory, attributed to KH-11

The **KH-11 KENNAN**, renamed **CRYSTAL** in 1982 and also referenced by the codenames **1010**, and "**Key Hole**", was a type of reconnaissance satellite launched by

the American National Reconnaissance Office between December 1976 and 1990. Manufactured by Lockheed in Sunnyvale, California, the KH-11 was the first American spy satellite to utilize electro-optical digital imaging, and create a real-time optical observation capability.

Later KH-11 satellites have been referred to by outside observers as KH-11B or KH-12, and by the names "Advanced KENNAN", "Improved Crystal" and "Ikon". The Key Hole series was officially discontinued in favour of a random numbering scheme after repeated public references to KH-8 Gambit, KH-9 Hexagon, and KH-11 satellites. KH-11 satellites are believed to have been the source of some imagery of the Soviet Union and China made public in 1997, as well as images of Sudan and Afghanistan made public in 1998 that were related to the response to the 1998 U.S. embassy bombings.

## Design



Hubble Space Telescope integration at Lockheed

It is believed to resemble the Hubble Space Telescope in size and shape, as the satellites were shipped in similar containers. Furthermore, a NASA history of the Hubble, in discussing the reasons for switching from a 3-meter main mirror to a 2.4-meter design, states: "In addition, changing to a 2.4-meter mirror would lessen fabrication costs by using manufacturing technologies developed for military spy satellites." A CIA history states that the primary mirror on the first KH-11's measured 2.34 meter, but sizes increased in later versions. NRO led the development of a computer controlled mirror polishing technique, which was subsequently also used for the polishing of primary mirror of the Hubble Space Telescope.

Assuming a 2.4-meter mirror, the theoretical ground resolution with no atmospheric degradation and 50% MTF would be roughly 15 cm (6 inches). Operational resolution would be worse due to effects of the atmosphere. Different versions of the KH-11 vary in mass, with earlier blocks ranging from 13,000 to 13,500 kilograms, whilst later blocks have a mass of around 19,600 kg. Its length is believed to be 19.5 meters, and diameter is 3 meters or less. Data was transmitted through the United States military's Satellite Data System relay network.

KH-11 was the first reconnaissance satellite equipped with Charge-coupled device (CCD) array technology for imaging. The ground station for the processing of the electro-optical imaging was a secret National Reconnaissance Office facility in Area 58, located in the continental United States. Data is transmitted through a network of communications satellites; the Satellite Data System.

Later block satellites may include signals intelligence capabilities and greater sensitivity in broader light spectrums (probably into infrared), as well as an in-flight refueling capability for extended life span and maneuverability.

### **Zhawar Kili Al-Badr Camp (West), Afghanistan**



KH-11 image of the Zhawar Kili camp in Afghanistan

Later satellites had larger mirrors, with a diameter of around 2.9–3.1 m. *Jane's Defence Weekly* indicates that the secondary mirror in the Cassegrain reflecting telescope system

could be moved, allowing images to be taken from angles unusual for a satellite. Also, there are indications that the satellite can take images every five seconds.

Unit costs, including launch, in 1990 dollars are estimated to be in the range of US \$ 1.25 to 1.75 billion (inflation adjusted US\$ 2.1 to 2.94 billion in 2011).

Four generations of U.S. electro-optical reconnaissance have been identified:

### **Block I**

Block I refers to the original KH-11 Kennan satellite, of which five were launched between 19 December 1976 and 17 November 1982.

### **Block II**

The three Block II satellites are in the open literature referred to as KH-11B, the alleged BYEMAN codename *DRAGON*, or *Crystal*, and are believed to be capable of taking infrared images in addition to optical observations. The first or second Block II satellite was lost in a launch failure.

### **Block III**

Four Block III satellites, commonly called KH-12 or *Improved Crystal* were launched between November 1992 and October 2001. The name "Improved Crystal" refers to the "Improved CRYSTAL Metric System" (ICMS), which adds reference markings for accurate mapping to images obtained by the satellite.

### **Block IV**

Two electro-optical satellites launched in October 2005 and January 2011 are attributed to Block IV.

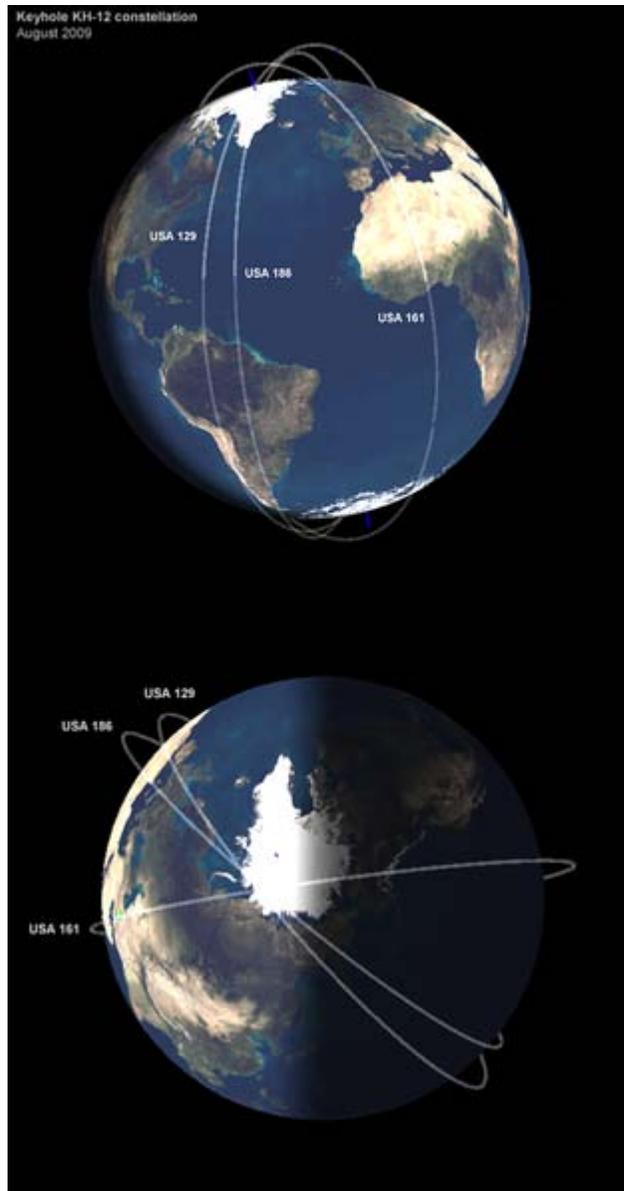
## **Derivatives**

The *Misty* satellite is believed to have been derived from the KH-11, but modified to make it invisible to radar, and hard to detect visually. The first Misty satellite, USA-53, was released by the Space Shuttle *Atlantis* on mission STS-36. The USA-144 satellite, launched on 22 May 1999 by a Titan IVB from Vandenberg Air Force Base may have been a second Misty satellite, or an Enhanced Imaging System spacecraft. The satellites are sometimes identified as KH-12s.

## Compromise

In 1978, a young CIA employee named William Kampiles sold the Soviets a technical manual describing the design and operation of KH-11s. Kampiles was convicted of espionage and sentenced to 40 years in prison.

## KH-11 missions



Orbital constellation of the KH-11 satellites currently in orbit (August 2009)

Nine KH-11 satellites were launched between 1976 and 1990 aboard Titan-3D and -34D rockets, with one launch failure. For the following five satellite launches between 1992 and 2005, a Titan IV launch vehicle was used. The most recent launch in 2011 was

carried out by a Delta IV Heavy rocket. The KH-11 replaced the KH-9 film return satellite, among others, the last of which was lost in a liftoff explosion in 1986.

KH-11 satellites are in either of two standard planes in Sun-synchronous orbits. As shadows help to discern ground features, satellites in a standard plane east of a noon/midnight orbit observe the ground at local afternoon hours, while satellites in a western plane observe the ground at local morning hours. Historically launches have therefore been timed to occur either about two hours before or one hour after local noon (or midnight), respectively.

Name	KH-11 Block	Launch date	ID	NROL number	Orbit	Plane	Orbital decay date
OPS 5705	1-1	19 December 1976	1976-125A		247 km x 533 km, i=96.9°	West	28 January 1979
OPS 4515	1-2	14 June 1978	1978-060A		276 km x 509 km, i=96.8°	West	23 August 1981
OPS 2581	1-3	7 February 1980	1980-010A		309 km x 501 km, i=97.1°	East	30 October 1982
OPS 3984	1-4	3 September 1981	1981-085A		244 km x 526 km, i=96.9°	West	23 November 1984
OPS 9627	1-5	17 November 1982	1982-111A		280 km x 522 km, i=96.9°	East	13 August 1985
USA-6	2-1	4 December 1984	1984-122A	N/A	335 km x 758 km, i=98°	West	10 November 1994
Unknown	2-2	28 August 1985	N/A		Failed to orbit	East	N/A
USA-27	2-3	26 October 1987	1987-090A		300 km x 1000 km, i=98°	East	11 June 1992
USA-33	2-4	6 November 1988	1988-099A		300 km x 1000 km, i=98°	West	12 May 1996
USA-86	3-1	28 November 1992	1992-083A		408 km x 931 km, i=97.7°	East	5 June 2000
USA-116	3-2	5 December 1995	1995-066A		405 km x 834 km, i=97.7°	East	19 November 2008
USA-129	3-3	20 December 1996	1996-072A	NROL-2	292 km x 894 km, i=97.7°	West	
USA-161	4-1	5 October 2001	2001-044A	NROL-14	309 km x 965 km, i=97.9°	East	
USA-186	3-4	19 October 2005	2005-042A	NROL-20	256 km x 1006 km, i=97.9°	West	
USA-224	4-2	20 January 2011	2011-002A	NROL-49	290 km x 985 km, i=97.9°	East	



A bright pass of USA-129, a Block III satellite

KH-11 satellites require periodic boosts to counter atmospheric drag, or to adjust their ground track to surveillance requirements. Based on data collected by amateur observers, the following orbital characteristics of OPS 5705 were calculated by amateur skywatcher Ted Molczan.

<b>OPS 5705 Time period</b>	<b>Periapsis (AMSL)</b>	<b>Apoapsis (AMSL)</b>	<b>Apogee at end of period (AMSL)</b>
1976 Dec 19 – Dec 23	253 km (157 mi)	541 km (336 mi)	541 km (336 mi)
1976 Dec 23 – 1977 Mar 27	348 km (216 mi)	541 km (336 mi)	537 km (334 mi)
1977 Mar 27 – Aug 19	270 km (170 mi)	537 km (334 mi)	476 km (296 mi)
1977 Aug 19 – 1978 Jan	270 km (170 mi)	528 km (328 mi)	454 km (282 mi)
1978 Jan – 1979 Jan 28	263 km (163 mi)	534 km (332 mi)	Deorbited

## Chapter- 4

# Manned Orbiting Laboratory

*Manned Orbiting Laboratory*



MOL test launch Nov. 3, 1966 from Cape Canaveral, FL. (USAF)

**Station statistics**

<b>Crew</b>	2
<b>Mission status</b>	Cancelled
<b>Mass</b>	14,476 kilograms (31,910 lb)
<b>Length</b>	21.92 metres (71.9 ft)
<b>Diameter</b>	3.05 metres (10.0 ft)
<b>Pressurised volume</b>	11.3 square metres (122 sq ft)
<b>Orbital inclination</b>	polar or sun synchronous orbit
<b>Days in orbit</b>	40 days

The **Manned Orbiting Laboratory (MOL)**, originally. the **Manned Orbital Laboratory** and **Key Hole 10 (KH-10)** was part of the United States Air Force's manned spaceflight program, a successor to the cancelled Boeing X-20 Dyna-Soar military reconnaissance space plane project. The project was developed as a manned space station to be used for reconnaissance purposes. MOL crews would use the **Gemini B** spacecraft that was derived from NASA's Gemini program to travel to and from the station.

The MOL program was announced to the public on December 10, 1963, as a manned platform to prove the utility of man in space for military missions. Astronauts selected for the program were later told of the reconnaissance mission for the program. The contractor for the MOL was the Douglas Aircraft Company. The Gemini B was externally similar to NASA's Gemini spacecraft although it underwent several modifications. The most obvious was the addition of a circular hatch through the heat shield to allow passage between the spacecraft and the laboratory. The MOL project was cancelled in 1969 during the height of the Apollo program, and U.S. space station development was put on hold until the NASA Skylab project in the mid-1970s.

Concurrently, the Soviet space program's Almaz project, very similar to the MOL in intent and even timing (if not more ambitious), was launched successfully, but cancelled in the mid-1970s.

## History

There was one test flight of an MOL mockup that was built from a Titan II propellant tank. The Gemini 2 spacecraft was re-flown on a 33-minute sub-orbital test flight. After the Gemini was separated for its sub-orbital reentry, the MOL mockup continued on into orbit and released three satellites. A hatch was installed in the Gemini 2 heat shield to provide access to the MOL and was tested in the sub-orbital reentry. The test flight was launched by the USAF on November 3, 1966 at 13:50:42 UTC on launch vehicle Titan IIC-9 from LC-40 at Cape Canaveral Air Force Station. The Gemini 2-MOL space capsule was recovered near Ascension Island in the South Atlantic by the USS *La Salle*.

The MOL was going to have a helium-oxygen atmosphere. It used a Gemini B spacecraft as a reentry vehicle. The crew were to be launched with the Gemini B and MOL and returned to earth in the Gemini B. They would conduct up to 30 days of military reconnaissance using large optics, cameras, and side-looking radar.

In response to the announcement of the MOL, the USSR commissioned the development of its own military space station, Almaz. Three Almaz space stations flew as Salyut space stations.

In 2005, two MH-7 training space suits from the MOL program were discovered in a locked room in the Launch Complex 5/6 museum on Cape Canaveral.

## **MOL astronauts**

- **MOL Group 1 - November 1965**
  - Michael J. Adams (Air Force) (killed on X-15 flight, November 15, 1967)
  - Albert H. Crews Jr. (Air Force)
  - John L. Finley (Navy)
  - Richard E. Lawyer (Air Force)
  - Lachlan Macleay (Air Force)
  - Francis G. Neubeck (Air Force)
  - James M. Taylor (Air Force)
  - Richard H. Truly (Navy) (pilot: Space Shuttle Enterprise ALT #2, STS-2; commander: STS-8) (Administrator: NASA)
  
- **MOL Group 2 - June 1966**
  - Karol J. Bobko (Air Force) (pilot: STS-6; commander: STS-51-D. STS-51-J)
  - Robert L. Crippen (Navy) (pilot: STS-1; commander: STS-7, STS-41C, STS-41G) (Director: Kennedy Space Center)
  - Charles G. Fullerton (Air Force) (pilot: Space Shuttle Enterprise ALT #1, STS-3; commander: STS-51-F)
  - Henry W. Hartsfield, Jr. (Air Force) (pilot: STS-4; commander: STS-41-D, STS-61-A) (Director: Human Exploration and Development of Space Independent Assurance)
  - Robert F. Overmyer (Marine Corps) (pilot: STS-5; commander: STS-51-B)
  
- **MOL Group 3 - June 1967**
  - James A. Abrahamson (Air Force) (Director: Strategic Defense Initiative)
  - Robert T. Herres (Air Force) (Vice Chairman: Joint Chiefs of Staff)
  - Robert H. Lawrence, Jr. (Air Force) (killed in training accident, December 1967)
  - Donald H. Peterson (Air Force) (mission specialist: STS-6)

## **MOL flight schedule**

### **Completed**

- 1966 November 3 - **MOL mockup** - refurbished Gemini 2 capsule launched unmanned

## Proposed

- 1970 December 1 - **MOL 1** - First unmanned Gemini-B/Titan 3M qualification flight (Gemini-B flown alone, without an active MOL).
- 1971 June 1 - **MOL 2** - Second unmanned Gemini-B/Titan 3M qualification flight (Gemini-B flown alone, without an active MOL).
- 1972 February 1 - **MOL 3** - A crew of two (James M. Taylor, Albert H. Crews) would have spent thirty days in orbit.
- 1972 November 1 - **MOL 4** - Second manned mission.
- 1973 August 1 - **MOL 5** - Third manned mission.
- 1974 May 1 - **MOL 6** - Fourth manned MOL mission. All Navy crew composed of Richard H. Truly and Robert Crippen.
- 1975 February 1 - **MOL 7** - Fifth manned MOL.

Operational MOLs were to be launched on Titan IIIM rockets from SLC-6 at Vandenberg AFB, California and LC-40 at Cape Canaveral, Florida.

## KH-10

Starting in 1965 a large optical system was added to the spacecraft for military reconnaissance. This camera system was codenamed "Dorian" and given the designation KH-10. The project was cancelled on June 10, 1969 before any operational flights occurred.

The KH-10 intended for the MOL program was succeeded by the unmanned KH-11 which launched in 1976 as the Soviet Union was winding down its manned space reconnaissance program. The KH-11 achieved the goal of 3 inches (76 mm) imaging resolution and introduced video transmission of images back to Earth.

## Cancellation

The first launch of the MOL was scheduled for December 15, 1969, but was pushed back to the fall of 1971. The program was canceled by Defense Secretary Melvin R. Laird in 1969 after the estimated cost of the program had risen in excess of 1 billion dollars, and had already spent \$300 million. It was determined the capabilities of unmanned spy satellites met or exceeded the capabilities of manned MOL missions. There were 14 MOL astronauts in the program when it was canceled, and NASA offered those under 35 years of age the opportunity to transfer to the NASA astronaut program. Seven of the 14 MOL astronauts were younger than 35 and took the offer: Richard H. Truly who later became the NASA Administrator, Karol J. Bobko, Robert Crippen, C. Gordon Fullerton, Henry W. Hartsfield, Robert F. Overmyer, and Donald Peterson. All eventually flew on the Space Shuttle.

The Gemini 2 capsule used in only flight of the MOL program is on display at the Air Force Space & Missile Museum on the Cape Canaveral Air Force Station. A test article

at the National Museum of the United States Air Force, at Wright-Patterson AFB, Ohio is the Gemini B spacecraft (sometimes confused with Blue Gemini). It is recognized by its distinctive "US Air Force" written on the side, and the circular hatch cut through the heat shield.

## Specifications

- Crew: 2
- Maximum duration: 40 days
- Orbit: Sun synchronous or polar
- Length: 21.92 m
- Diameter: 3.05 m
- Cabin Volume: 11.3 m<sup>3</sup>
- Mass: 14,476 kilograms (31,910 lb)
- Payload: 2,700 kilograms (6,000 lb)
- Power: fuel cells or solar cells
- RCS system: N<sub>2</sub>O<sub>4</sub>/MMH

## Chapter- 5

# Spy Satellites of the United States

## Canyon

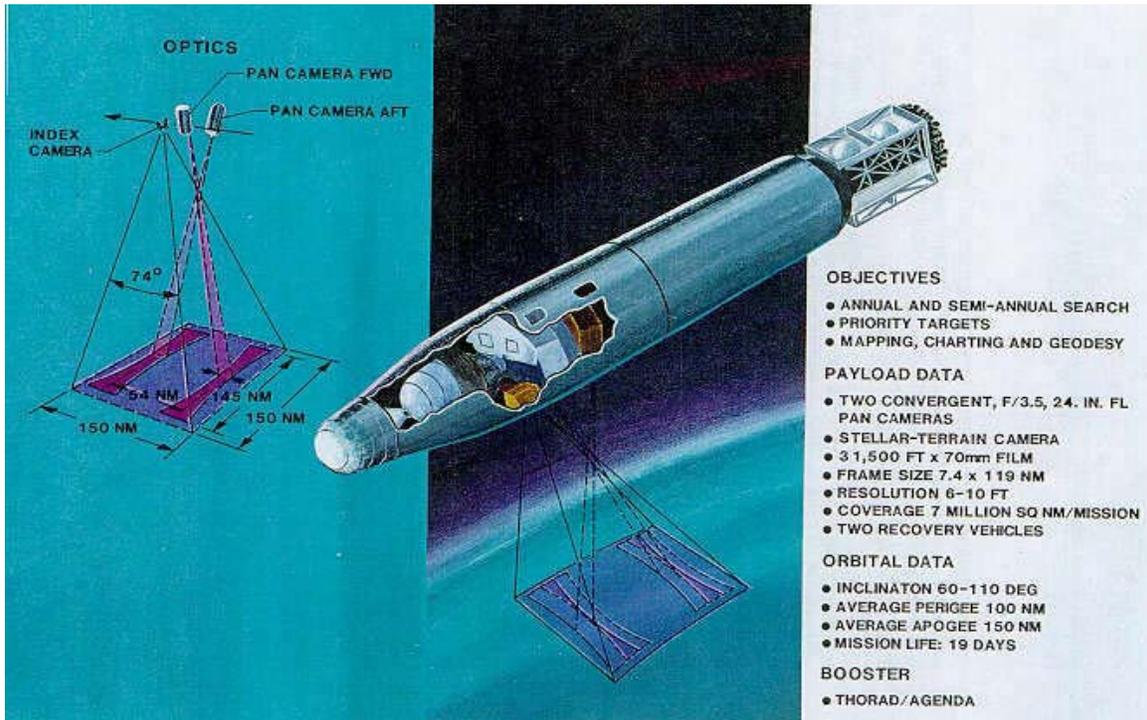
**CANYON** refers to a series of seven United States spy satellites launched between 1968 and 1977. Also known as AFP-827, the satellites were developed with the participation of the Air Force. The Canyon project is credited as being the first American satellite system tasked for COMINT.

The satellites weighed 700 kg and were launched from Atlas/Agena D rockets into near-geosynchronous orbits. They carried large parabolic reflecting dishes, estimated at 10m in diameter. The Canyon satellites were eventually replaced with the next generation of COMINT satellites, the Vortex/Chalet series. The program remains classified.

### List of Launches

<b>Name</b>	<b>Launch date</b>	<b>Alt. name</b>	<b>COSPAR ID</b>
<i>Canyon 1</i>	6 Aug 1968	OPS 2222	1968-063A
<i>Canyon 2</i>	13 April 1969	OPS 3148	1969-036A
<i>Canyon 3</i>	1 September 1970	OPS 7329	1970-069A
<i>Canyon 4</i>	4 December 1971	AFP-827, 1971-F13	failed to achieve orbit
<i>Canyon 5</i>	20 December 1972	OPS 9390	1972-101A
<i>Canyon 6</i>	18 June 1975	OPS 4966	1975-055A
<i>Canyon 7</i>	23 May 1977	OPS 9751	1977-038A

# Corona



KH-4B Corona satellite



Recovery of Discoverer 14 return capsule (typical for the Corona series)

The **Corona** program was a series of American strategic reconnaissance satellites produced and operated by the Central Intelligence Agency Directorate of Science & Technology with substantial assistance from the U.S. Air Force. The Corona satellites

were used for photographic surveillance of the Soviet Union (USSR), the People's Republic of China, and other areas beginning in June 1959 and ending in May 1972. The name of this program is sometimes seen as "CORONA", but its actual name "Corona" was a codeword, not an acronym for anything.

The Corona project was pushed forward especially following the shooting down of a U-2 spy plane over the Soviet Union in May 1960.

The Corona satellites were designated **KH-1**, **KH-2**, **KH-3**, **KH-4**, **KH-4A** and **KH-4B**. KH stood for "Key Hole" or "Keyhole" (Code number 1010) , and the incrementing number indicated changes in the surveillance instrumentation, such as the change from single-panoramic to double-panoramic cameras. The "KH" naming system was first used in 1962 with KH-4 and the earlier numbers were retroactively applied. There were 144 Corona satellites launched, of which 102 returned usable photographs.

## Technology

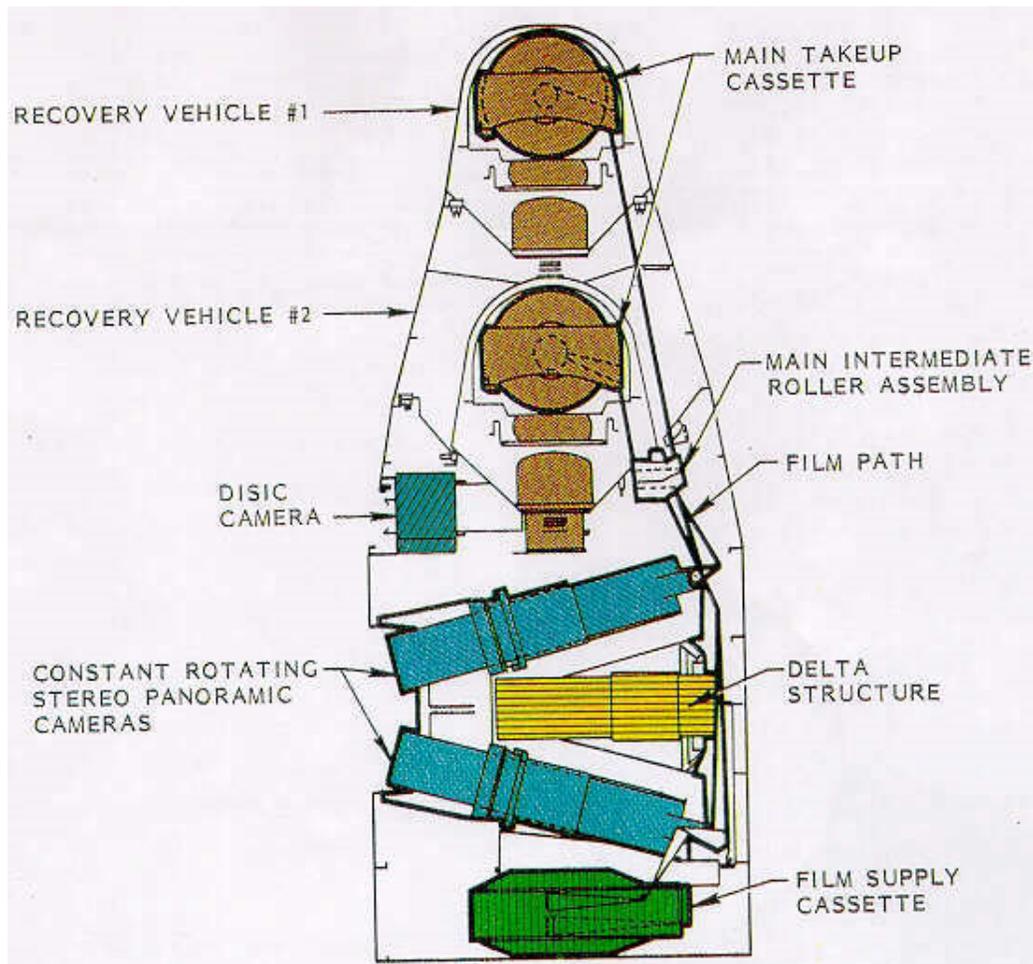


Diagram of "J-1" type stereo / panoramic constantly rotating Corona reconnaissance satellite camera system used on KH-4A missions from 1963 to 1969.

The Corona satellites used 31,500 feet (9,600 meters) of special 70 millimeter film with 24 inch (60 centimeter) focal length cameras. Initially orbiting at altitudes from 165 to 460 kilometers above the surface of the Earth, the cameras could resolve images on the ground down to 7.5 meters in diameter. The two KH-4 systems improved this resolution to 2.75 meters and 1.8 meters respectively, because they operated at lower orbital altitudes.

The code name "Corona" was more fitting than its originators had ever imagined. The initial missions of the program suffered from many technical problems, among them, mysterious fogging and bright streaks that were seen on the returned film of some missions - only to disappear on the next mission. Eventually, it was determined by a collaborative team of scientists and engineers from the project and from academia, (among them: Luis Alvarez, Sidney Beldner, Malvin Ruderman, and Sidney Drell) that electrostatic discharges (called corona discharges) caused by some of the rubber components of the cameras, were exposing the film. Recommended corrective measures for solving this problem included better grounding of the satellites' components and testing the outgassing of many parts before the cameras were assembled. These practices are still used on all reconnaissance satellites today, whether they are to orbit the Earth or to orbit another planet, such as Mars or Jupiter.

## **Manufacturing and ground support**



Lockheed's Covert "Advanced Projects" Facility at Hiller Aircraft (Menlo Park, CA)

The procurement and maintenance of the CORONA satellites was managed by the Central Intelligence Agency, which used cover arrangements lasting from 1 April 1958 to 1969 to get access to the Palo Alto plant of the Hiller Helicopter Corporation for the production. In this Advanced Project Integration Facility, the CORONA second rocket stage Agena, Itek cameras, Eastman Kodak Cooperation films, and General Electric

reentry capsule were assembled and tested before shipment to Vandenberg AFB. In 1969, the program was relocated to the Lockheed facilities in Sunnyvale, CA.

The Air Force credits the Onizuka Air Force Station as being the "birthplace of the Corona program."

## **Discoverer**



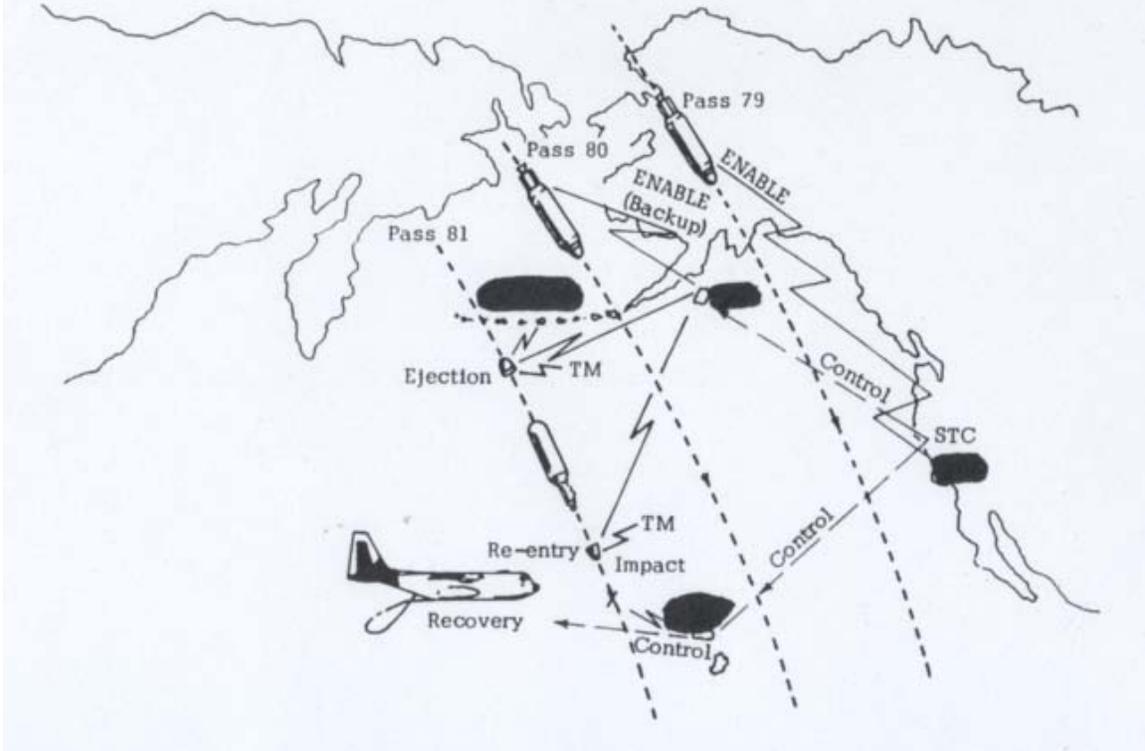
Corona image of the Pentagon, 25 Sep 1967



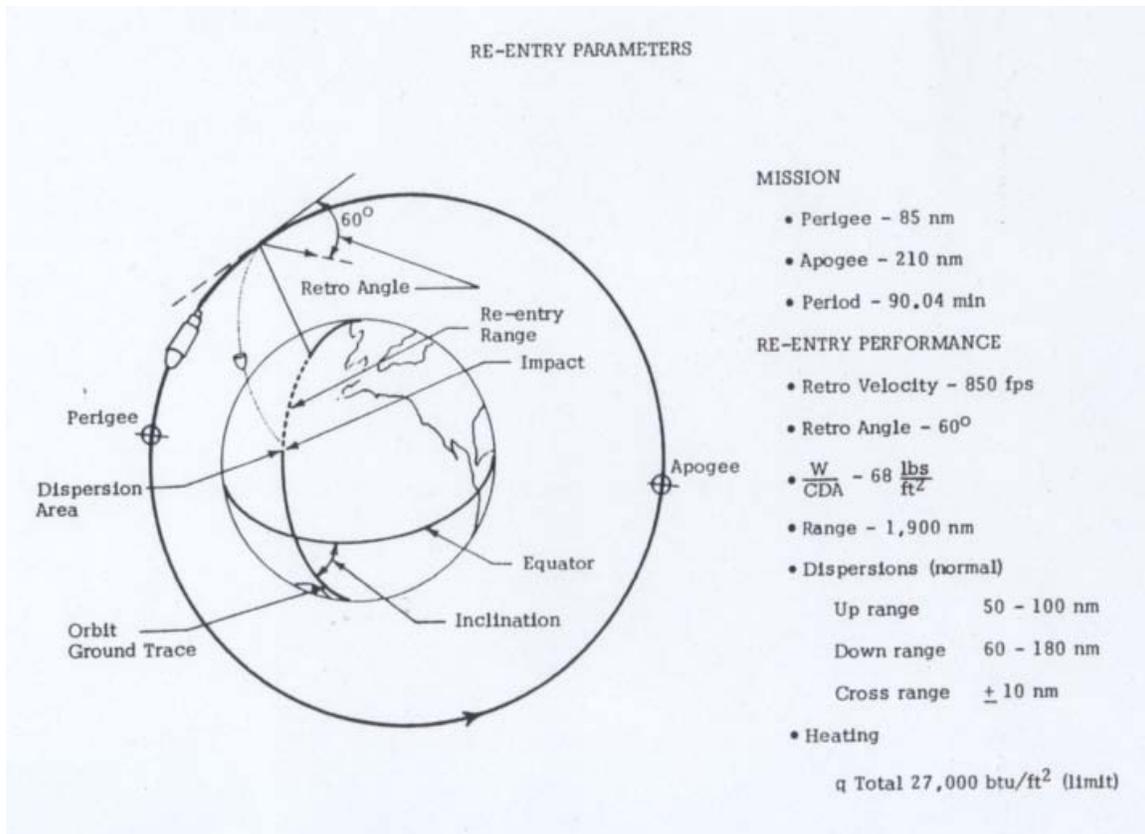
Corona film bucket payload

The first dozen or more Corona satellites and their launches were cloaked with disinformation as being part of a space technology development program called the *Discoverer* program. The first test launches for the *Corona/Discoverer* were carried out early in 1959. The capsule of *Discoverer 2* might have been recovered by the Soviets, after landing on Spitsbergen Island. The first Corona launch containing a camera was carried out in June 1959 with the cover name *Discoverer 4*. This was a 750 kilogram satellite launched by a Thor-Agena rocket.

SATELLITE CONTROL FACILITY OPERATION IN RECOVERY



AF Sat Ctrl Facility during recovery ops



### CORONA re-entry parameters

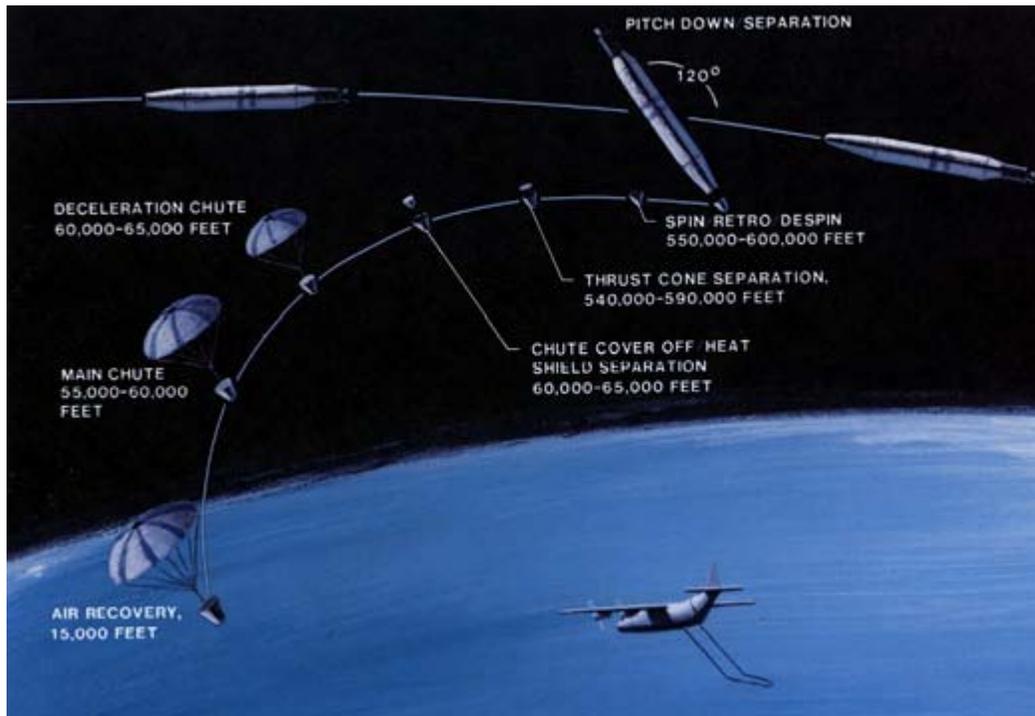
The plan for the Corona program was for its satellites to return canisters of exposed film to the Earth in re-entry capsules, called by the slang term "film buckets", which were to be recovered in mid-air by a specially-equipped U.S. Air Force planes during their parachute descent. (The buckets were designed to float on the water for a short period of time for possible recovery by U.S. Navy ships, and then to sink if the recovery failed, via a water-dissolvable plug made of salt at the base of the capsule. This was for secrecy purposes.)

The return capsule of the Discoverer 13 mission, which launched August 10, 1960, was successfully recovered the next day. This was the first time that any object had been recovered successfully from orbit. After the mission of Discoverer 14, launch on August 18, 1960, its film bucket was successfully retrieved two days later by a C-119 Flying Boxcar transport plane. This was the first successful return of photographic film from orbit. In comparison, Sputnik 5 was launched into orbit on August 19, 1960, one day after the launch of Discoverer 14. Sputnik 5 was a biosatellite that took into orbit the two Soviet space dogs, Belka and Strelka, and then safely returned them to the Earth .

At least two launches of *Discoverers* were used to test satellites for the Missile Defense Alarm System (MIDAS), an early missile-launch-detection program that used infrared cameras to detect the heat signature of rockets launching to orbit.

The *Corona* film bucket was later adapted for the KH-7 GAMBIT satellite, which took higher resolution photos.

The last launch under the *Discoverer* cover name was *Discoverer 38* on 26 February 1962. Its bucket was successfully recovered in midair during the 65th orbit (the 13th recovery of a bucket; the ninth one in midair). Following this last use of the *Discovery* name, the remaining launches of *Corona* satellites were entirely top secret. The last *Corona* launch was on 1972-05-25. The project was abandoned after a Soviet Navy submarine was detected waiting beneath a *Corona* mid-air retrieval zone in the Pacific Ocean. The best sequence of *Corona* missions was from 1966 to 1971, when there were 32 consecutive successful missions, including film recoveries.



Corona film recovery maneuver

An alternative program to the *Corona* program was named *SAMOS*. This program included several types of satellite which used a different photographic method. This involved capturing an image on photographic film, developing the film on board the satellite and then scanning the image electronically. The image was then transmitted via telemetry to ground stations. The Samos E-1 and E-2 satellite programs used this system, but they were not able to take very many pictures and then relay them to the ground stations each day. Two later versions of the Samos program, such as the E-5 and the E-6, used the bucket-return approach, but neither of these programs carried out any successful missions.

## ELINT subsatellites

Nine of the KH-4A and KH-4B missions included ELINT subsatellites, which were launched into a higher orbit.

## Corona launches

*Source:* USGS

Time period	No.	Nickname	Resolution	Notes	Number
Jun 1959– Sep 1960	KH-1	"Corona", C	7.5 m	First series of American imaging spy satellites. Each satellite carried a single panoramic camera and a single return vehicle.	10 systems; 1 recovery.
Oct 1960– Oct 1961	KH-2	Corona', C',(C-prime)*	7.5 m	Single panoramic camera and a single return vehicle.	7 systems; 4 recoveries.
Aug 1961– Jan 1962	KH-3	Corona''', C''',(C-triple-prime)*	7.5 m	Single panoramic camera and a single return vehicle.	9 systems; 5 recoveries.
Feb 1962– Dec 1963	KH-4	Corona-M, Mural	7.5 m	Film return. Two panoramic cameras.	26 systems; 20 recoveries.
Aug 1963– Oct 1969	KH-4A	Corona J-1	2.75 m	Film return with two reentry vehicles and two panoramic cameras. Large volume of imagery.	52 systems; 94 recoveries.
Sep 1967– May 1972	KH-4B	Corona J-3	1.8 m	Film return with two reentry vehicles and two panoramic cameras.	17 systems; 32 recoveries.
Feb 1961– Aug 1964	KH-5	Argon	140 m	Low-resolution mapping missions; single frame camera.	12 systems; 5 recoveries.
Mar 1963– July 1963	KH-6	Lanyard	1.8 m	Experimental camera in a short-lived program.	3 systems; 2 recoveries.

\* (The stray "quote marks" are the original designations of the first three generations of cameras, as described in Perry's history.)

# Defense Support Program



Painting of a DSP satellite on station. Primary sensor (lower left) is pointed at Earth. The star sensor is seen pointing off to the side, above and to the right.

The **Defense Support Program** (DSP) is a program of the U.S. Air Force that operates the reconnaissance satellites which form the principal component of the *Satellite Early Warning System* currently used by the United States.

DSP satellites, which are operated by the Air Force Space Command, detect missile or spacecraft launches and nuclear explosions using sensors that detect the infrared emissions from these intense sources of heat. During Desert Storm, for example, DSP

was able to detect the launches of Iraqi Scud missiles and provide timely warnings to civilians and military forces in Israel and Saudi Arabia.

The satellites are in geostationary orbits, and are equipped with infrared sensors operating through a wide-angle Schmidt camera. The entire satellite spins so that the linear sensor array in the focal plane scans over the earth six times every minute.

Typically, DSP satellites were launched on Titan IVB boosters with Inertial Upper Stages. However, one DSP satellite was launched using the Space Shuttle Atlantis on mission STS-44 (November 24, 1991).

The last one (flight 23) was launched in 2007 aboard the first operational flight of the Delta IV Heavy rocket, as the Titan IV had been retired in 2005. All 23 satellites were built by prime contractor Northrop Grumman Space Technology, formerly TRW, in Redondo Beach, CA.



2d Space Warning Squadron



8th Space Warning Squadron



11th Space Warning Squadron



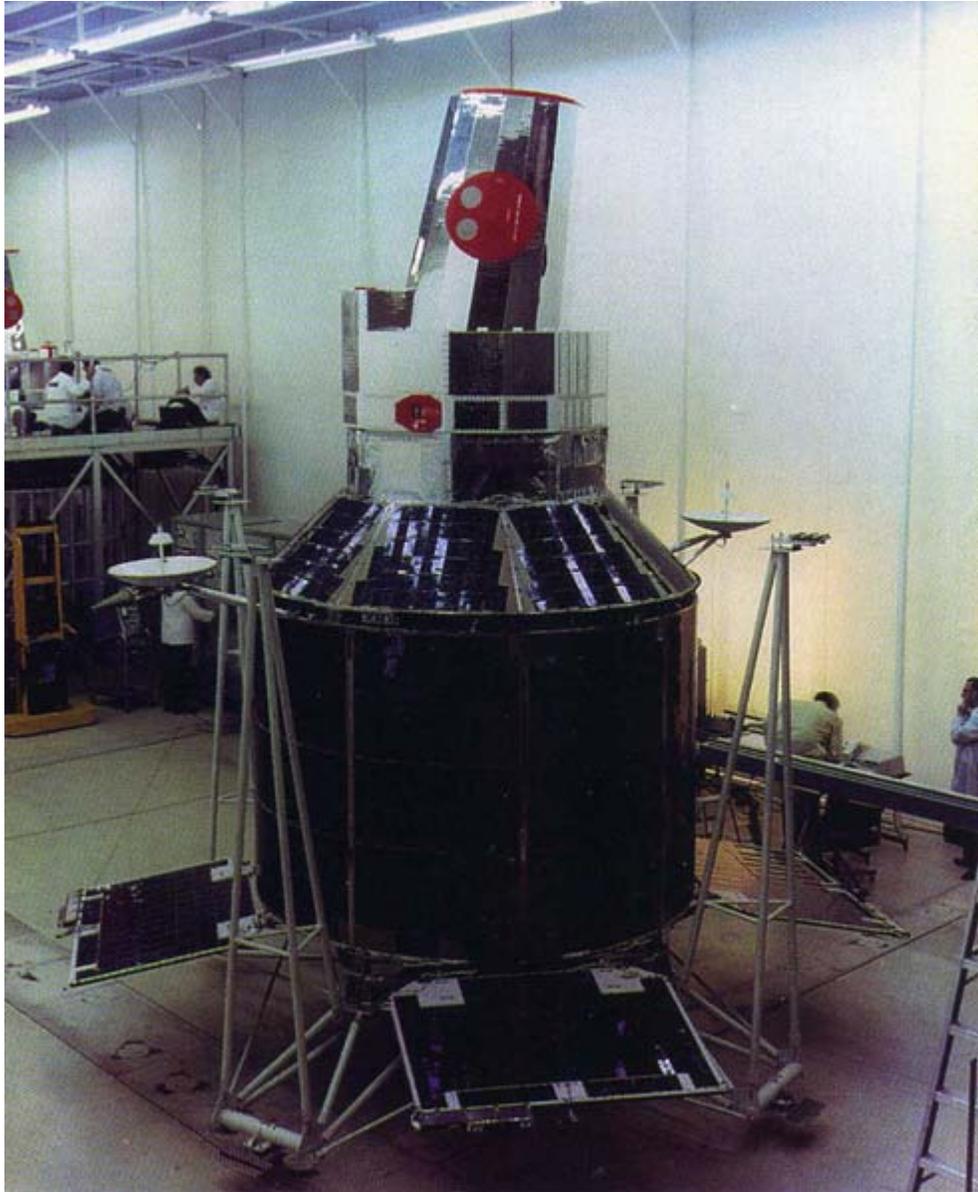
DSP Flight 1

The 460th Space Wing, with headquarters at Buckley Air Force Base, Colo., has units that operate DSP satellites and report warning information, via communications links, to the NORAD and USSTRATCOM early warning centers within Cheyenne Mountain, Colorado. These centers immediately forward data to various agencies and areas of operations around the world.

Air Force Space Command's SBIRS Wing at the Space and Missile Systems Center, Los Angeles AFB, California is responsible for development and acquisition of the satellites.



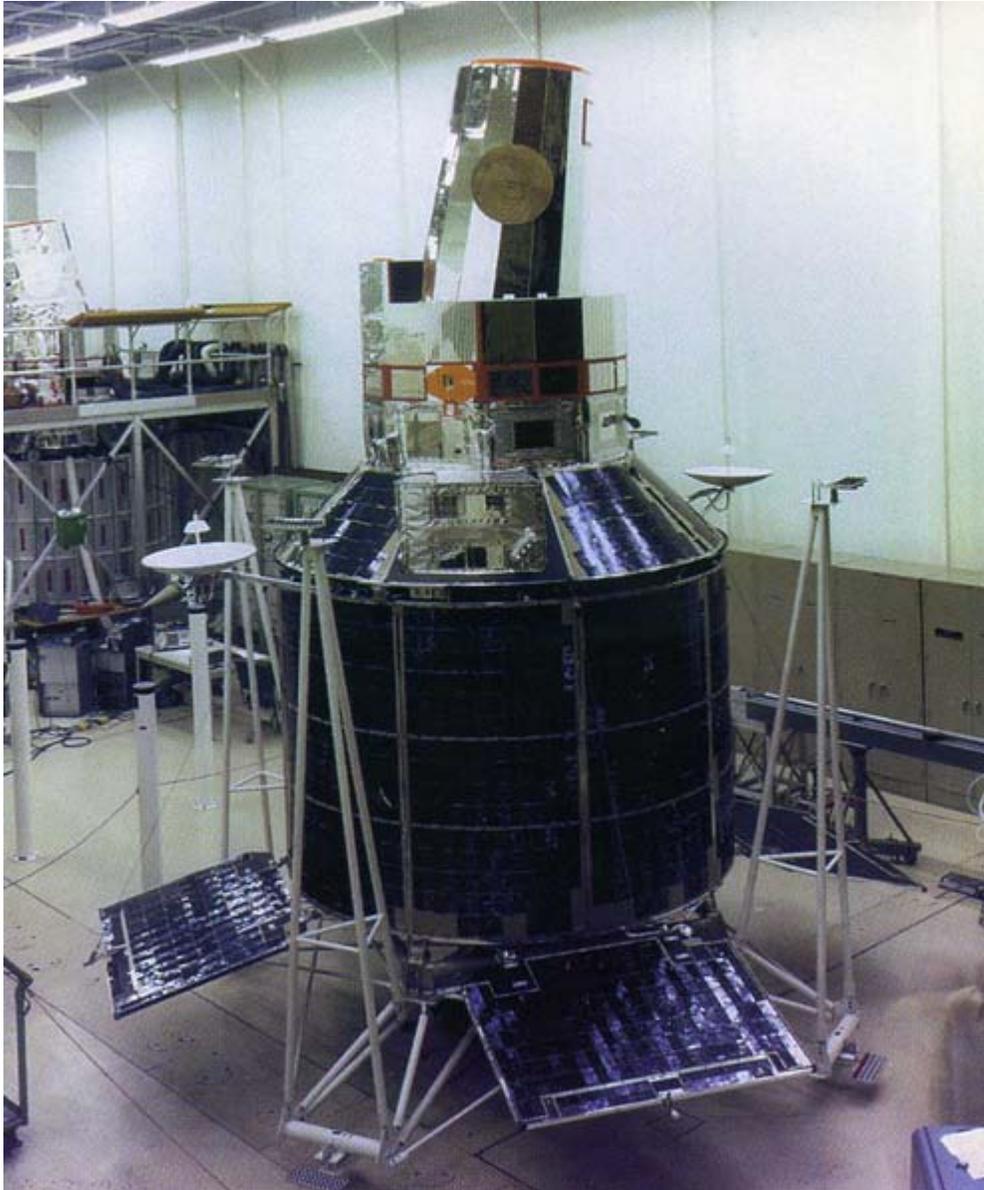
DSP Flight 2



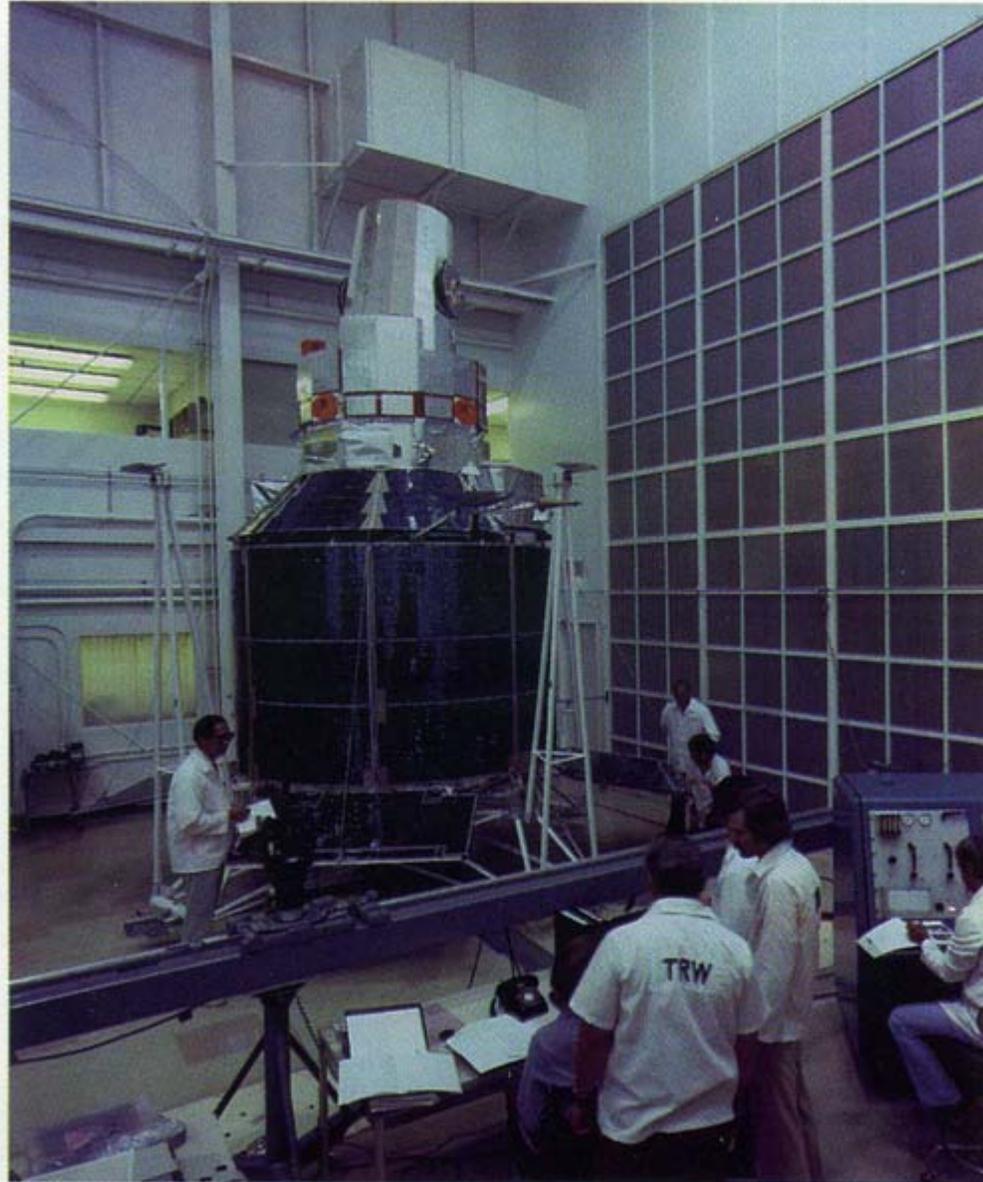
DSP Flight 3



DSP Flight 4



DSP Flight 5



DSP Flight 7

## History

The Defense Support Program replaced the 1960s space-based infrared Missile Defense Alarm System (MiDAS). The first successful launch of MiDAS was May 24, 1960 and there were twelve launches before the DSP program replaced it in 1966.

The first launch of a DSP satellite was on 6 November 1970 and since then it has become the mainstay of the United States ballistic missile early warning system. For the last 40 years they have provided an uninterrupted space-based early warning capability. The

original DSP satellite weighed 2,000 pounds (900 kg) and had 400 watts of power, 2,000 detectors and a design life of 1.25 years.



DSP Flight 13

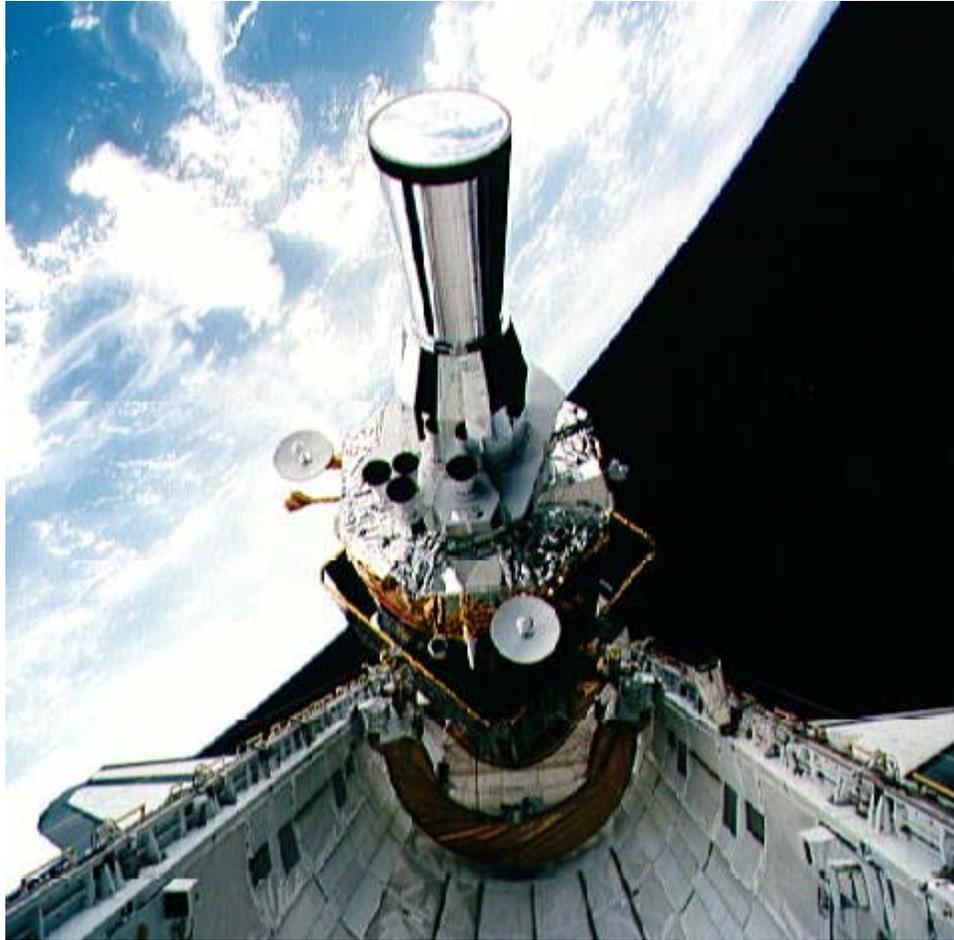


DSP Flight 14



DSP Flight 15

Throughout the life of the program, the satellite design has undergone numerous improvements to enhance reliability and capability. The weight grew to 5,250 pounds (2,380 kg), the power to 1,275 watts, the number of detectors increased threefold to 6,000 and the design life has been increased to a goal of five years.

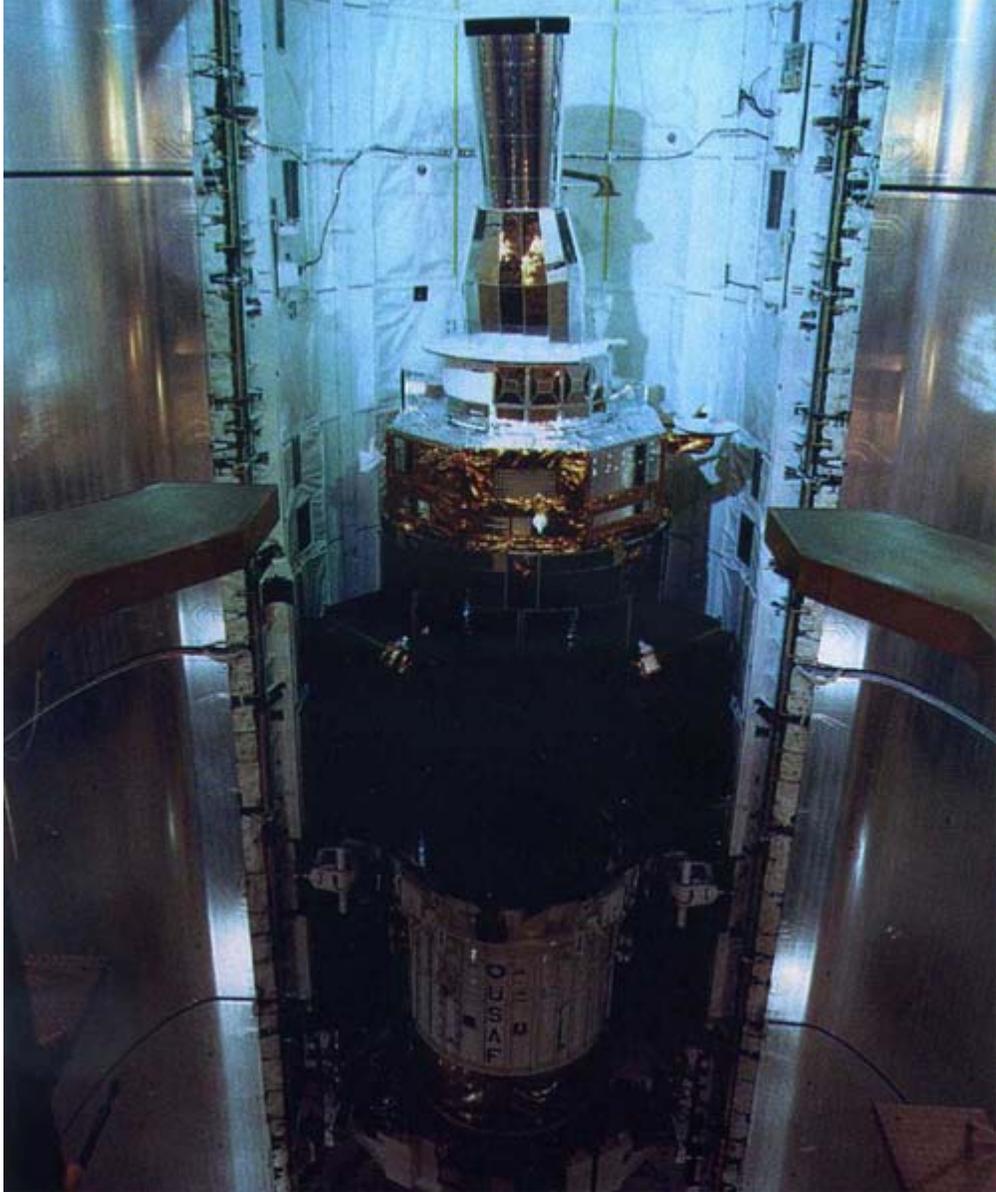


DSP satellite deployment during STS-44

The numerous improvement projects have enabled DSP to provide accurate, reliable data in the face of evolving missile threats. On-station sensor reliability has provided uninterrupted service well past their design lifetime. Recent technological improvements in sensor design include above-the-horizon capability and improved resolution. Increased on-board signal-processing capability improves clutter rejection. Enhanced reliability and survivability improvements were also incorporated.

The 23rd, and last DSP satellite was scheduled to be launched on April 1, 2007, aboard a Delta IV Heavy rocket, but the launch was postponed until mid-August 2007 after two structural cracks were found in the metal launch table at pad 37B, caused by a fuel leak during testing.

Further delays forced the launch back to November 11, 2007, when the satellite launched at 01:50:00 GMT (20:50 EST on 10 November). This satellite died in space sometime during 2008, for reasons unknown. It is now adrift in geosynchronous orbit and remains a potential hazard to other craft. The Department Of Defense sent a MiTEx spacecraft to inspect DSP 23 sometime in 2008.



DSP Flight 16



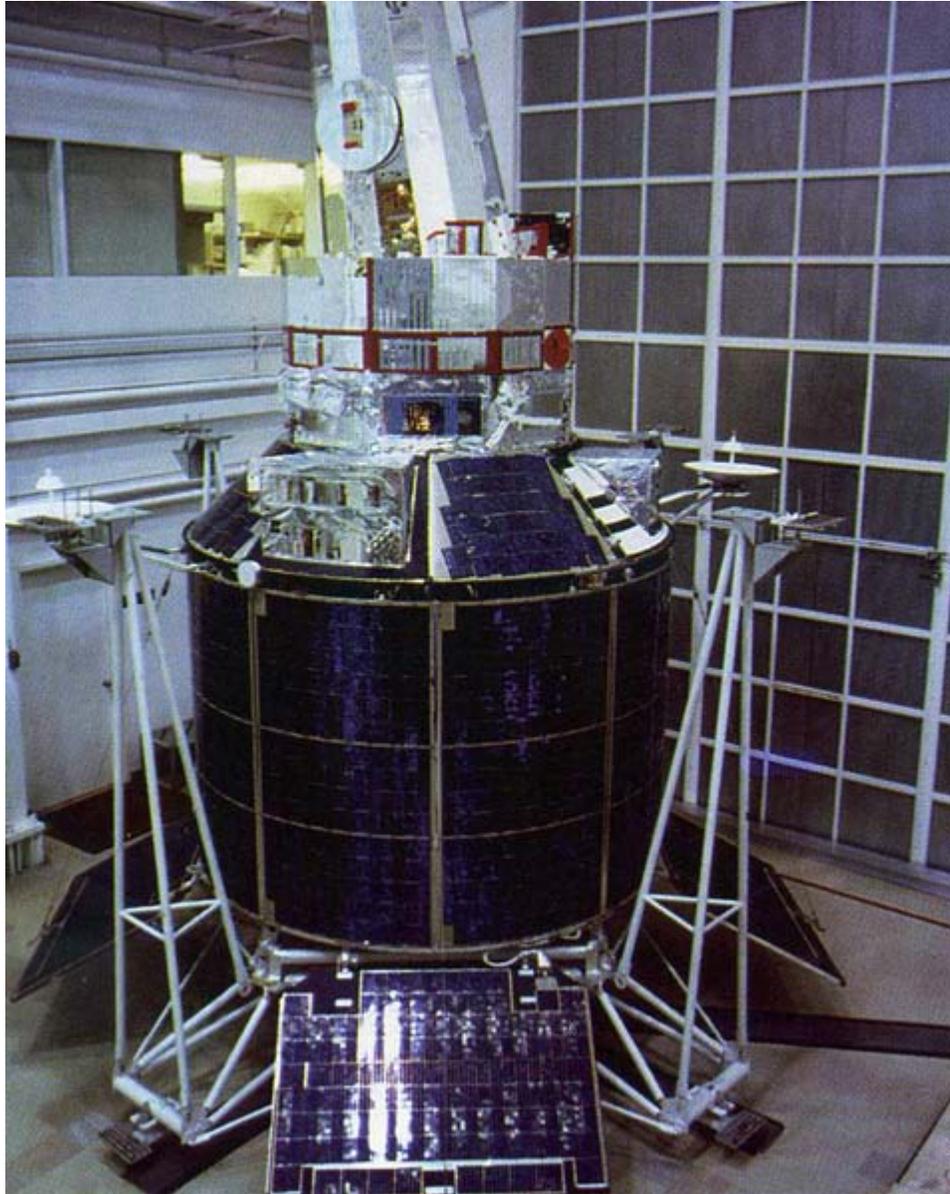
DSP Flight 17



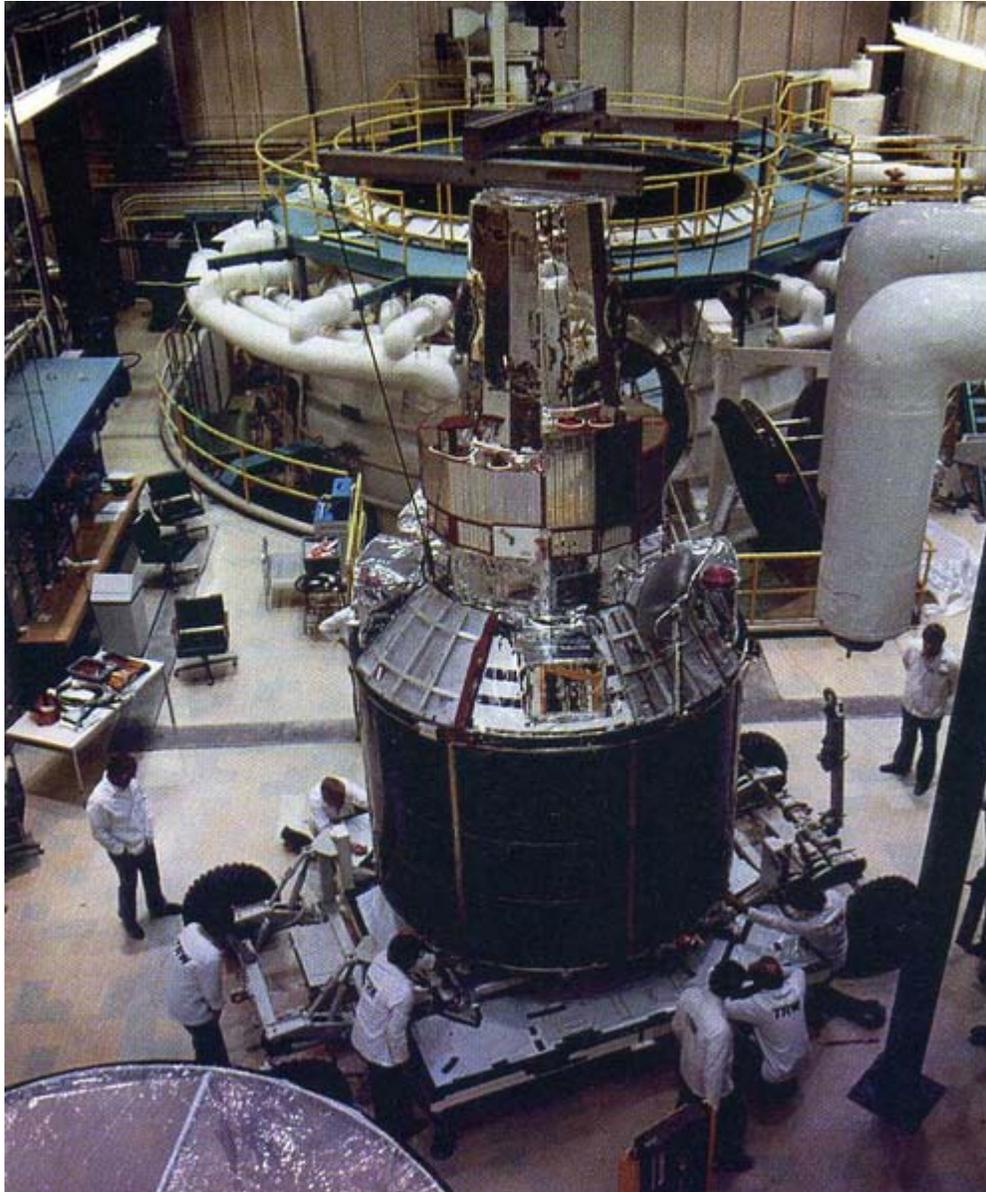
DSP Flight 18



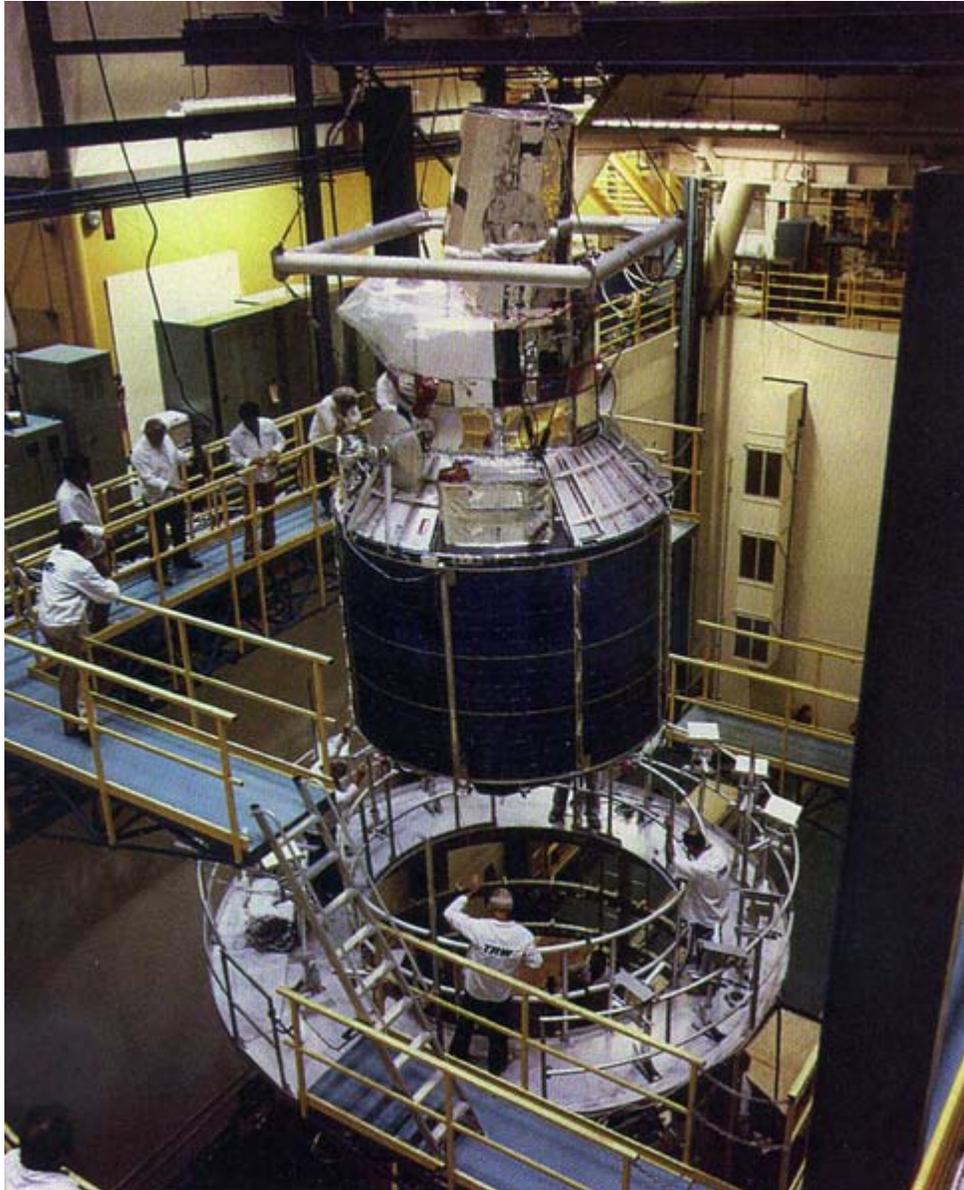
DSP F1 Launch 6 Nov 1970



DSP Flight 8



DSP Flight 9



DSP Flight 10

Another DSP satellite was lost in 1999, after its Inertial Upper Stage failed following launch from a Titan 4 booster.

DSP satellites will be replaced by the **Space-Based Infrared System (SBIRS)** satellites. The project was originally to have had a life of 25 satellites, but the last two have been canceled, mainly due to SBIRS.

There were five major improvement programs prior to the current block:

1. Block 1: Phase I, 1970–1973, 4 satellites
2. Block 2: Phase II, 1975–1977, 3 satellites

3. Block 3: Multi-Orbit Satellite Performance Improvement Modification (MOS/PIM), 1979–1984, 4 satellites
4. Block 4: Phase II Upgrade, 1984–1987, 2 satellites
5. Block 5: DSP-I (DSP-Improved), 1989

More recently, there has been some effort put into using DSPs' infrared sensors as part of an early warning system for natural disasters like volcanic eruptions and forest fires.

## Limitations

The DSP constellation may have offered an excellent vantage point for an early warning system against state-centric threats such as missiles, but military analysts warn its ability to collect intelligence on non-state actors is severely limited.

## General characteristics

- Primary mission: Strategic and tactical missile launch detection
- Contractor team: Northrop Grumman, formerly TRW (for satellite bus) and Northrop Grumman Electronic Systems, formerly Aerojet Electronics Systems (for IR sensor)
- Weight: 5,250 lb (2,380 kg)
- Orbit altitude: 22,000 miles (35,900 km)
- Power plant: Solar arrays generate 1,485 watts
- Height: 32.8 ft (10 m) on orbit; 28 ft (8.5 m) at launch
- Diameter: 22 ft (6.7 m) on orbit; 13.7 ft (4.2 m) at launch
- Date first deployed: 1970
- Latest Satellite Block: Sats 18-23
- Unit Cost: \$400 million

# Discoverer 1

<b>Discoverer 1</b>	
<b>Launch date</b>	1:49 PST 1959-02-28
<b>Launch vehicle</b>	Thor Agena
<b>Launch site</b>	Vandenberg Air Force Base
<b>Orbital decay</b>	Failed to reach orbit
<b>Orbital elements</b>	
<b>Regime</b>	LEO - Polar orbit

## Instruments

**Main instruments**      None (test flight)

**Discoverer 1** was the first of a series of satellites which were part of the Corona reconnaissance satellite program. It was launched on a Thor-Agena rocket on February 28, 1959 at 1:49 PST from Vandenberg Air Force Base in California. It was a prototype of the KH-1 satellite, but did not contain either a camera or a film capsule. . It was the first satellite launched toward the South Pole in an attempt to achieve polar orbit, but was unsuccessful. A CIA report, later declassified, concluded that "Today, most people believe the DISCOVERER I landed somewhere near the South Pole."

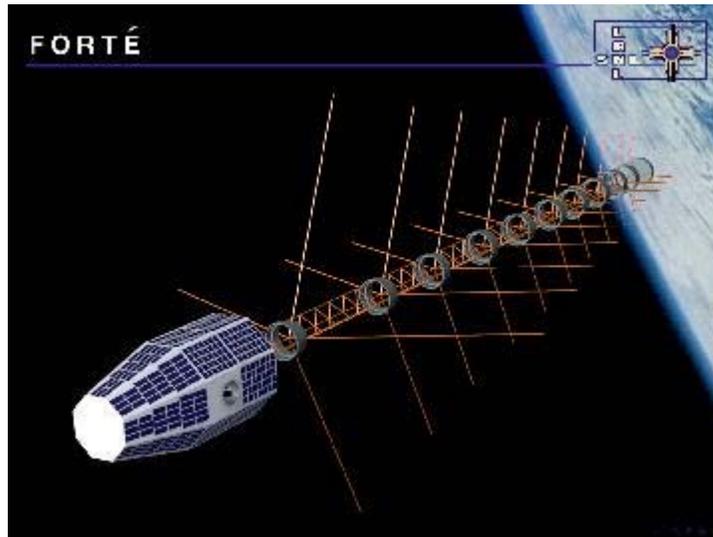
## Discoverer 14



Recovery of film canister by a C-119

**Discoverer 14** (also known as KH-1 9009) was a spy satellite used in the Corona program managed by DARPA and the United States Air Force. On 19 August 1960, usable photographic film images taken by the satellite were recovered by a C-119 recovery aircraft. This was the first successful recovery of film from an orbiting satellite and the first mid-air recovery of an object returning from Earth orbit.

# FORTE



Fast On-orbit Rapid Recording of Transient Events

The **Fast On-orbit Rapid Recording of Transient Events** (FORTE, occasionally stylized as FORTÉ) is a lightweight satellite which was launched at about 8:30 AM on August 29, 1997 into a circular 800-kilometer (500 mi) low Earth orbit which is inclined 70 degrees relative to the earth's equator, using a Pegasus XL rocket. It was developed and launched by the Sandia National Laboratory in cooperation with Los Alamos National Laboratory, as a testbed for technologies applicable to U.S. nuclear detonation detection systems used to monitor compliance with arms control treaties, and later to study lightning from space. The project was sponsored by the United States Department of Energy, and cost about US\$35 million. It utilizes optical sensors, RF sensors, and an "event classifier" in order to make observations, including monitoring Very High Frequency (VHF) lightning emissions in the ionosphere occurring from between 50 to 600 miles (80 to 970 km) above the surface of the Earth, and it will be a component of the VHF Global Lightning and Severe Storm Monitor (V-GLASS) system. Its primary mission is to record and analyze bursts of RF energy rising from the surface of the Earth. FORTE is 7-foot (2.1 m) tall, weighs 470-pound (210 kg), and is the first all-composite spacecraft, its framework being made entirely of graphite-reinforced epoxy. It consists of three decks with aluminum honeycomb cores, and composite facing to support the onboard instruments.

## Intruder

**Intruder**, also known as **IOSA** (**I**ntegrated **O**verhead **S**IGINT **A**rchitecture) is reported to be the codename for a spy satellite system to be operated by the United States National Reconnaissance Office, which will replace the current Mentor and Mercury systems. The

satellites were reported to have been under development in 1995. The Intruder system was designed to combine the electronic signals intelligence (ELINT) and communications intelligence (COMINT) roles of signals Intelligence (SIGINT) spacecraft, which had previously been performed by different satellites, the Rhyolite and Vortex series respectively.

It has been reported that *NRO L-26* may be the launch designation for the first Intruder satellite. NRO L-26 was scheduled to launch in 2005 on a Delta IVH from launch complex SLC-37B at the Cape Canaveral Air Force Station, but was delayed due to a number of issues. It launched on 17 January 2009, and subsequently designated USA-202.

## **KH-5 Argon**

### **KH-5 Argon**

#### **General Information**

<b>Manufacturer</b>	Lockheed
<b>Country of Origin</b>	United States
<b>Applications</b>	Reconnaissance Geodetic mapping
<b>Orbit regimes</b>	LEO
<b>Operator</b>	NRO
<b>Derived from</b>	RM-81 Agena

#### **Production**

<b>Status</b>	Retired
<b>Launched</b>	12
<b>Retired</b>	5
<b>Failed</b>	4
<b>Lost</b>	3

#### **Typical spacecraft**

<b>Average mass</b>	1,274 kg (2,810 lb)
<b>Equipment</b>	Optical cameras

556 x 556 km coverage

140 m resolution

**KH-5 ARGON** was a series of reconnaissance satellites produced by the United States from February 1961 to August 1964. The KH-5 operated similarly to the Corona series of satellites, as it ejected a canister of photographic film. At least 12 missions were attempted, but at least 7 resulted in failure. The satellite was manufactured by Lockheed. Launches used Thor-Agena rockets flying from Vandenberg Air Force Base, with the payload being integrated into the Agena.

## Payload

Different versions of the satellite varied in mass from 1150 kilograms to 1500 kg. At least two missions deployed ELINT subsatellites. Ground resolution for the satellite was 140 meters, with a swath of 556 km. The onboard camera had a focal length of 76 mm. The purpose of the system, which produced relatively low-resolution images compared to other spy satellites, was to provide imagery for mapmaking purposes. This was one of the tasks that had originally been planned for the Samos series of satellites equipped with the (quickly cancelled) "E-4" cameras. Each satellite took photographs for less than a week before returning its film.

The satellite was in use during the same period as the KH-2-KH-4A Corona and the KH-6 Lanyard satellites. Later satellites were the KH-4B and KH-7. Images from three of the successful missions returned the first images of Antarctica from space.

## Launches

Name	Launch Date	NSSDC ID	Alt Name	Alt Name	Mass (kg)	Decay Date	Notes
<b>KH-5 9014A</b>	1961-02-17	1961-005A	Discoverer 20	1961 Epsilon	1100	1962-07-28	Film capsule not ejected
<b>KH-5 9016A</b>	1961-04-08	1961-011A	Discoverer 23	1961 Lambda	1150	1962-04-16	Film capsule ejected into wrong orbit, not recovered
<b>KH-5 9018A</b>	1961-06-8	DISC24	Discoverer 24	1961-F05	1150	---	Failed to orbit
<b>KH-5 9020A</b>	1961-07-21	DISC27	Discoverer 27	1961-F07	1150	---	Failed to orbit
<b>KH-5 9034A</b>	1962-05-15	1962-018A	FTV 1126	1962 Sigma	1150	1962-06-20	Successful.
<b>KH-5 9042A</b>	1962-09-1	1962-044A	FTV 1132	1962 A Upsilon	1150	1962-10-01	Film capsule sank.

<b>KH-5 9046A</b>	1962-10- 9	1962- 053A	FTV 1134	1962 B Epsilon	1500	1962- 10-17	Successful.
<b>KH-5 9055A</b>	1963-04- 26	1963- F07	OPS 1008	1963-F07	1150	---	Failed to orbit
<b>KH-5 9058A</b>	1963-08- 29	1963- 035A	OPS 1561	1963-035	1000	1963- 09-30	Successful; deployed ELINT subsatellite
<b>KH-5 9059A</b>	1963-10- 29	1963- 042A	OPS 2437	1963-042	1500	1963- 11-29	Successful; deployed ELINT subsatellite
<b>KH-5 9065A</b>	1964-06- 13	1964- 030A	OPS 3236	1964-030	1500	1964- 07-14	Successful.
<b>KH-5 9066A</b>	1964-08- 21	1964- 048A	OPS 2739	1964-048	1500	1964- 09-20	Successful.