BHARATHIDASAN UNIVERSITY
Tiruchirappalli - 620 024
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Programme : 6 year Integrated M.Tech in Geological Technology and Geoinformatics

Course title : Principles of Remote Sensing
Course code : MTGT 0304

UNIT – V
Remote Sensing Satellites

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LANDSAT - HISTORY

The Landsat program was created in the United States in the heady scientific and exploratory times associated with taming the atom and going to the Moon. Apollo Moon - bound missions that inspired the Landsat program. During the early test bed missions for Apollo, photographs of Earth's land surface from space were taken for the first time.

In 1965, director of the U.S. Geological Survey (USGS), William Pecora, proposed the idea of a remote sensing satellite program to gather facts about the natural resources of our planet.

While weather satellites had been monitoring Earth's atmosphere since 1960 and were largely considered useful, there was no appreciation of terrain data from space until the mid-1960s.

When Landsat 1 was proposed, it met with intense opposition from the Bureau of Budget and those who argued high-altitude aircraft would be the fiscally responsible choice for Earth remote sensing. Concurrently, the Department of Defense feared that a civilian program such as Landsat would compromise the secrecy of their reconnaissance missions.

Additionally, there were also geopolitical concerns about photographing foreign countries without permission.

In 1965, NASA began methodical investigations of Earth Remote Sensing using instruments mounted on planes.

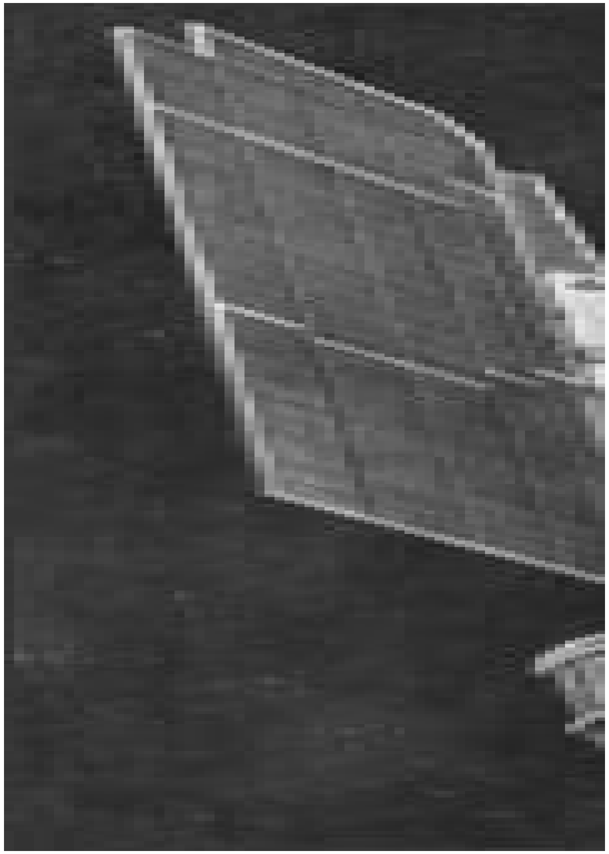
In 1966, the USGS convinced the Secretary of the Interior, Stewart L.Udall, to announce that the Dept. of the Interior (DOI) was going to proceed with its own Earth-observing Satellite program. This savvy political stunt forced the NASA to expedite the building of LANDSAT.

Finally, by 1970 NASA had a green light to build a satellite and within only two years, Landsat 1 was launched, heralding a new age of remote sensing of land from space.

Thor-Delta rocket prepared to launch Landsat 1, 1972.

Landsat 1

Landsat 1 was launched on July 23, 1972; at that time the satellite was known as the **Earth Resources Technology Satellite (ERTS).** It was the first Earth-observing satellite to be launched with the intent to study and monitor our planet's landmasses.



LANDSAT-1 (Instruments)

To perform the monitoring, Landsat 1 carried two instruments: a camera system built by the Radio Corporation of America (RCA) called the **Return Beam Vidicon (RBV)**, and the **Multispectral Scanner System (MSS)** built by General Electric (GE).

The RBV was supposed to be the prime instrument, but the MSS data were found to be superior. In addition, the RBV instrument caused an electrical transit that caused the satellite to briefly loose altitude control.

The MSS instrument was flown as the secondary and highly experimental instrument. But once scientists looked at the data, the roles switched. The MSS recorded data in four spectral bands - green, red, and two infrared bands.

To help understand the data and to explore the potential applications of this new technology, NASA oversaw 300 private research investigators. Nearly one third of these were international scientists.

These researchers came from a wide array of Earth science disciplines. They evaluated the usefulness of Landsat data to their respective fields.

Landsat 1 operated until January 1978, outliving its design life by five years. The Landsat 1 MSS acquired over 300,000 images providing repeated coverage of the Earth's land surfaces. The quality and impact of the resulting information exceeded all expectations.

LANDSAT 1 – Technical Details

- Launch Date: July 23, 1972
- Status: Decommissioned, January 6, 1978
- Sensors: RBV, MSS
- Altitude: nominally 900 km
- Inclination: 99.2°
- Orbit: Polar, Sun-synchronous
- Equatorial Crossing Time: nominally 9:42 AM mean local time (descending node)
- Period of Revolution : 103 mins; ~14 orbits/day
- Repeat Coverage : 18 days

LANDSAT 2

Launch Date: January 22, 1975
Status: Decommissioned, February 5, 1982
Sensors: RBV, MSS
Altitude: nominally 900 km
Inclination: 99.2°
Orbit: Polar, Sun-synchronous
Equatorial Crossing Time: nominally 9:42 AM
mean local time (descending node)
Period of Revolution : 103 minutes; ~14 orbits/day
Repeat Coverage : 18 days

Landsat 2 was launched on January 22, 1975, two and a half years after Landsat 1. Just prior to launch of ERTS-B (Landsat 2) NASA officially renamed the ERTS into "LANDSAT". The second Landsat was still considered an experimental project and was operated by NASA.

Landsat 2 carried the same sensors as its predecessor: the Return Beam Vidicon (RBV) and the Multispectral Scanner System (MSS). The RBV instrument was primarily used for engineering evaluation purposes while the MSS continued to systematically collect images of Earth.

In February of 1982 after seven years of service, Landsat 2 was decommissioned.

LANDSAT 3

Landsat 3 was launched on March 5, 1978, three years after Landsat 2. The third Landsat was still considered an experimental project and was operated by NASA until 1979.
Because of the Landsat program's technical and scientific success, it was declared operational in 1979 and operational responsibility shifted from NASA (a research and development agency) to the National Oceanic and Atmospheric Administration (NOAA), the agency charged with operating the weather satellites.

Landsat 3 carried the same sensors as its predecessors but the RBV instrument on-board Landsat 3 had an improved 30 m ground resolution and used two RCA cameras which both imaged in one broad spectral band (green to near-infrared; 0.505–0.750 μm) instead of three separate bands (green, red, infrared) like its predecessors.

The MSS continued to systematically collect images of Earth using four spectral bands. A fifth thermal band was also part of the Landsat 3 MSS, however, the channel failed shortly after launch. In March of 1983, Landsat 3 was decommissioned.

Sensor	Mission	Sensitivity (μm)	Resolution (m)
RBV	1, 2 3	0.475-0.575 0.580-0.680 0.690-0.830 0.505-0.750	80 80 80 30
MSS	1-5 3	0.5-.0.6 06-0.7 0.7-0.8 0.8-1.1 10.4-12.6 (Failed after launch)	79/82 79/82 79/82 79/82 240
TM	4, 5	0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90 1.55-1.75 10.4-12.5 2.08-2.35	30 30 30 30 30 120 30
ETM	6 (Failed)	Above TM Bands and Plus 0.50-0.90	30 (120m thermal band) 15
ETM+	7	Above TM Bands and Plus 0.50-0.90	30 (60m thermal band) 15

Band Landsat 1-3	Band Landsat 4 & 5	Spectral Range (µm)	EM Region	Generalised Application Details
4	1	0.5 - 0.6	Visible Green	Assessment of vegetation vigor, coastal water mapping
5	2	0.6 - 0.7	Visible Red	Chlorophyll absorption for vegetation differentiation
6	3	0.7 - 0.8	Near Infrared	Delineation of water bodies, biomass surveys
7	4	0.8 - 1.1	Near Infrared	Delineation of water bodies, biomass surveys

Radiometric characteristics of the ETM+ and TM sensors

Band Number	Spectral Range (in Microns)	EM Region	Generalised Application Details
1	0.45 - 0.52	Visible Blue	Coastal water mapping, differentiation of vegetation from soils
2	0.52 - 0.60	Visible Green	Assessment of vegetation vigor
3	0.63 - 0.69	Visible Red	Chlorophyll absorption for vegetation differentiation
4	0.76 - 0.90	Near Infrared	Biomass surveys and delineation of water bodies
5	1.55 - 1.75	Middle Infrared	Vegetation and soil moisture measurements; differentiation between snow and cloud
6	10.40- 12.50	Thermal Infrared	Thermal mapping, soil moisture studies and plant heat stress measurement
7	2.08 - 2.35	Middle Infrared	Hydrothermal mapping
8	0.52 - 0.90 (panchromatic)	Green, Visible Red, Near Infrared	Large area mapping, urban change studies

LANDSAT 4

Landsat 4 was launched on July 16, 1982. The Landsat 4 spacecraft was significantly different than that of the previous Landsats and it did not carry the RBV instrument.

In addition to the Multispectral Scanner System (MSS) instrument, Landsat 4 (and Landsat 5) carried a sensor with improved spectral and spatial resolution, *i.e.*, the new satellites could *see* a wider portion of the electromagnetic spectrum and also could see the ground in greater detail. This new instrument was known as the Thematic Mapper (TM).

The Landsat 4 TM instrument had seven spectral bands. Data was collected from the blue, green, red, near-infrared, mid-infrared (2 bands) and thermal infrared portions of the electromagnetic spectrum.

Within a year of launch, Landsat 4 lost the use of two of its solar panels and both of its direct downlink transmitters. So, the downlink of data was not possible until the Tracking and Data Relay Satellite System (TDRSS) became operational: Landsat 4 could then transmit data to TDRSS using its Ku-band transmitter and TDRSS could then relay that information to its ground stations.

While Landsat 4 was built and launched by NASA, NOAA initially oversaw the operations of the satellite. Landsat 4 operations were contracted out to the Earth Observation Satellite Company (EOSAT) corporation in 1984.

By 1998, the management of the Landsat 4 (and Landsat 5) operations contract was transferred from NOAA to the USGS; operations were continued by the private sector until mid-2001 when Space Imaging (formerly EOSAT) returned the operations contract to the U.S. Government.

Despite the numerous transfers of satellite operation, the USGS has remained responsible for long-term preservation of Landsat data in its National Satellite Land Remote Sensing Data Archive (NSLRSDA) in Sioux Falls, South Dakota.

LANDSAT 5

On March 1, 1984, NASA launched Landsat 5, the agency's last originally mandated Landsat satellite. Landsat 5 was designed and built at the same time as Landsat 4 and carried the same payload: the Multispectral Scanner System (MSS) and the Thematic Mapper (TM) instruments.

In 1987, the Landsat 5 TDRSS transmitter (Ku-band) failed. This failure made downlinking data acquired outside of the U.S. data acquisition circle (*i.e.*, range of U.S. ground receiving antennas) impossible; Landsat 5 has no on-board data recorder to record acquired data for later downlink.

The MSS instrument was turned off in August of 1995. The TM instrument is still in operation, some 24 years after its planned design life. Data is regularly acquired at stations in the U.S. and Australia for entry into the U.S. archive. A number of International Ground Stations download data for their local acquisition area.

In November 2005, Landsat 5 TM operations were suspended after problems with the solar array left the satellite unable to properly charge its on-board batteries. Working together, USGS and NASA engineers were able to devise a new method of solar array operations. And, on January 30, 2006 Landsat 5 resumed normal operations.

Landsat 6

On October 5, 1993 the EOSAT-owned Landsat 6 failed at launch after not reaching the velocity necessary to obtain orbit.

Landsat 6 carried an Enhanced Thematic Mapper (ETM). The ETM sensor would have collected data in the same seven spectral bands and at the same spatial resolutions as the TM instrument on Landsats 4 and 5. The ETM instrument also included an eighth band with a spatial resolution of 15 m. The eighth band was known as the sharpening band or Panchromatic band. It was sensitive to light from the green through near infrared wavelengths of the EM spectrum.

In 1993, with Landsats 4 and 5 both beyond their design lives, the loss of Landsat 6, and a nascent Landsat 7 program, it seemed that a data gap was eminent. Yet, Landsat-5 continued to operate (and operates to this day).

The government-owned Landsat 7 was successfully launched on April 15, 1999 from the Western Test Range of Vandenberg Air Force Base, California, on a Delta-II expendable launch vehicle. The Earth observing instrument on Landsat 7, the Enhanced Thematic Mapper Plus (ETM+), replicates the capabilities of the highly successful Thematic Mapper instruments on Landsats 4 and 5.

The ETM+ also includes additional features that make it a more versatile and efficient instrument for global change studies, land cover monitoring and assessment, and large area mapping than its design forebears.
These features are:

a panchromatic band with 15m spatial resolution
on-board, full aperture, 5% absolute radiometric calibration
a thermal IR channel with 60m spatial resolution
an on-board data recorder

Landsat 7 is the most accurately calibrated Earth-observing satellite, *i.e.*, its measurements are extremely accurate when compared to the same measurements made on the ground. Landsat 7's sensor has been called "the most stable, best characterized Earth observation instrument ever placed in orbit." Landsat 7's rigorous calibration standards have made it the validation choice for many coarse-resolution sensors.

Landsat 5

TM

Swath Width = 185 km

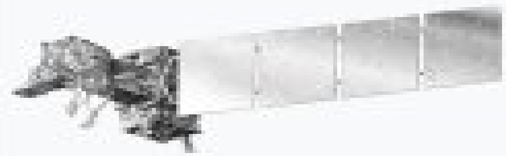
Repeat Cycle = 16 days

0.45–0.52 µm	30 m
0.52–0.60 µm	30 m
0.63–0.69 µm	30 m
0.76–0.90 µm	30 m
1.55–1.75 µm	30 m
10.4–12.5 µm	120 m
2.08–2.35 µm	30 m

Spectral Bands

Pixel Size

* Pointable +/- 32°



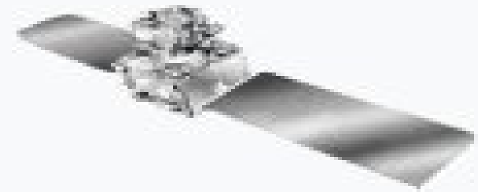
Landsat 7

ETM+

Swath Width = 185 km

Repeat Cycle = 16 days

0.45–0.52 µm	30 m
0.52–0.60 µm	30 m
0.63–0.69 µm	30 m
0.76–0.90 µm	30 m
1.55–1.75 µm	30 m
10.4–12.5 µm	60 m
2.08–2.35 µm	30 m
0.52–0.90 µm	15 m



IRS-P6

LISS-III

Swath Width = 141 km

Repeat Cycle = 24 days

0.52–0.59 µm	24 m
0.62–0.68 µm	24 m
0.77–0.86 µm	24 m
1.55–1.70 µm	24 m

AWiFS

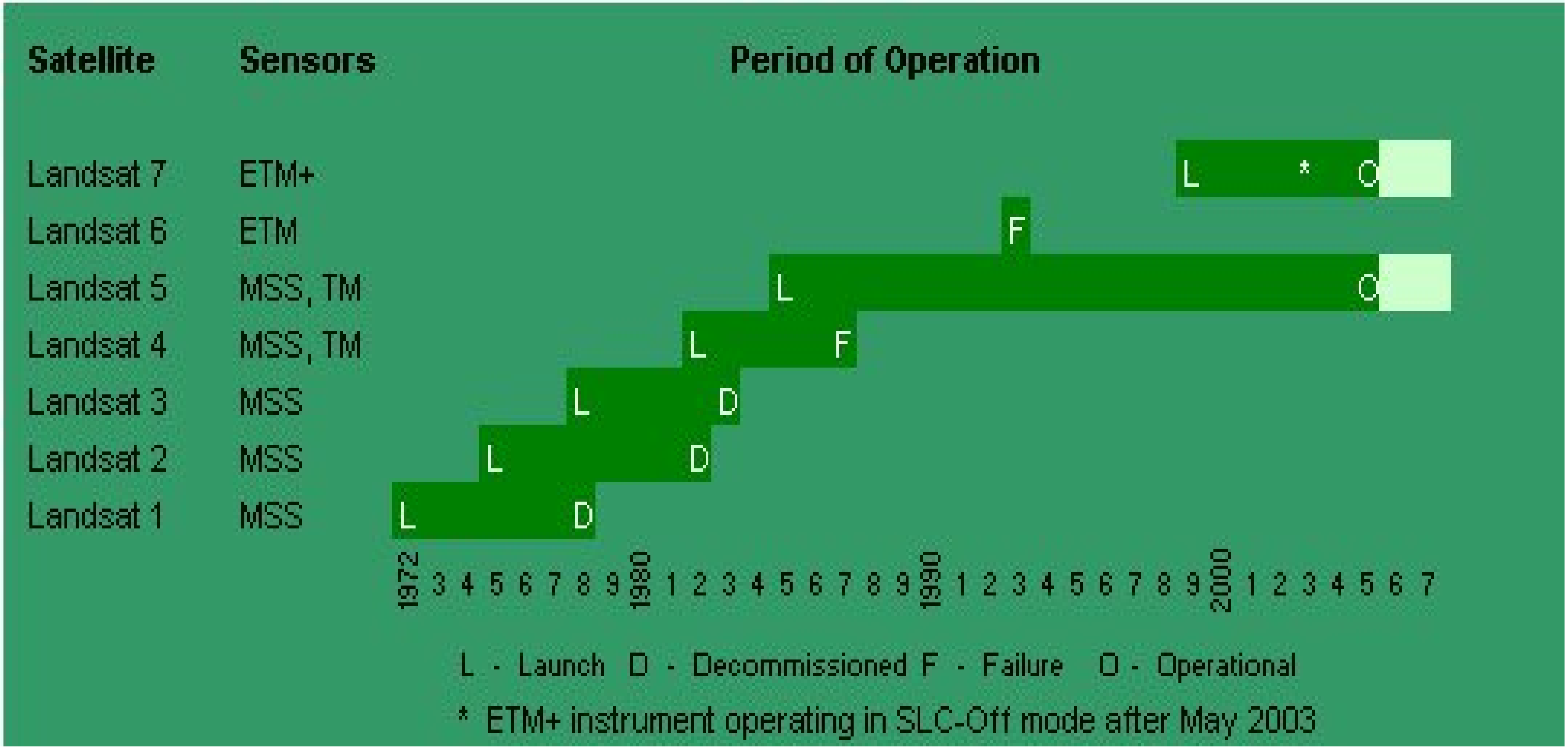
Swath Width = 740 km

Repeat Cycle = 4 days

0.52–0.59 µm	56 m
0.62–0.68 µm	56 m
0.77–0.86 µm	56 m
1.55–1.70 µm	56 m

Radiometric characteristics of the ETM+ and TM sensors

Number	Spectral Range (in Microns)	EM Region	Generalised Application Details
1	0.45 - 0.52	Visible Blue	Coastal water mapping, differentiation of vegetation from soils
2	0.52 - 0.60	Visible Green	Assessment of vegetation vigour
3	0.63 - 0.69	Visible Red	Chlorophyll absorption for vegetation differentiation
4	0.76 - 0.90	Near Infrared	Biomass surveys and delineation of water bodies
5	1.55 - 1.75	Middle Infrared	Vegetation and soil moisture measurements; differentiation between snow and cloud
6	10.40- 12.50	Thermal Infrared	Thermal mapping, soil moisture studies and plant heat stress measurement
7	2.08 - 2.35	Middle Infrared	Hydrothermal mapping
8	0.52 - 0.90 (panchromatic)	Green, Visible Red, Near Infrared	Large area mapping, urban change studies


Satellite
Sensors
Period of Operation
Landsat 7
ETM+
Landsat 6
ETM
Landsat 5
MSS, TM
Landsat 4
MSS, TM
Landsat 3
MSS
Landsat 2
MSS
Landsat 1
MSS
L * O
F
L O
L F
L D
L D
L D
1972 3 4 5 6 7 8 9 1980 1 2 3 4 5 6 7 8 9 1990 1 2 3 4 5 6 7 8 9 2000 1 2 3 4 5 6 7
L - Launch D - Decommissioned F - Failure O - Operational
* ETM+ instrument operating in SLC-Off mode after May 2003

Satellite Facts Satellites and Sensors

This table shows how these satellites and sensors relate to one other, as well as some basic features of each satellite and sensor.

Satellite	Sensor	Swath (km)	Spatial resolution (at nadir) (m)	No. of spectral bands	Potential Revisit time (days)
			OPTICAL		
Landsat	MSS	185	80	4	16
	TM	185	30; 120	7	16
	ETM+	185	15; 30; 60	8	16
Resources at-1 (IRS-P6)	LISS-III	141	23.5	4	24
	AWiFS	740	56	4	24
ALOS	PRISM	35	2.5	1	46
	AVNIR-2	70	10	4	46
TERRA	ASTER	60	15 - 90	14	variable
TERRA and Aqua	MODIS	2330	250 - 1000	36	1-2
NOAA	AVHRR	2399	1.1	7	1-2
			SYNTHETIC APERTURE RADAR (SAR)		
ERS	SAR	100	20	1	35
ALOS	PALSAR	30-250	10 - 100	1	46
RADARSAT	RADARSAT	50 - 500	8 - 100	1	2 - 4

The Landsat series of satellites have provided multispectral data of Earth's surface on a global basis, at a spatial resolution consistent with human-scale activities and concerns for over 35 years, but as the waning days of Landsat 5 and 7 meet the nascent days of LDCM, the possibility of a Landsat data gap looms large.

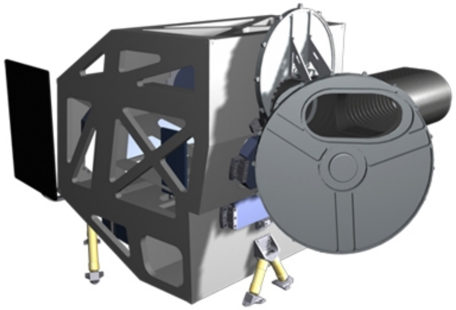
Landsat gave the world the first perspective of human-induced large-scale environmental changes such as the rapid expansion of desert cities like Dubai, the deforestation of the Amazon rainforest, and the disappearance of the Aral Sea.

Landsat-related research has led to the implementation of many socially beneficial applications, such as natural resources management, water management techniques, natural disaster relief planning, environmental management etc.

Landsat Data Continuity Mission (LDCM)

To extend this legacy of Landsat, plans are in the works for a December 2012 launch of the **Landsat Data Continuity Mission (LDCM)**, which will collect and archive data consistent with its predecessor Landsat satellites. NASA selected Ball Aerospace and Technology Corporation to build LDCM's Operational Land Imager (OLI) instrument, bringing the long-awaited Landsat follow-on mission closer to actualization.

Although there are no plans for a thermal instrument on LDCM-unlike Landsats 4, 5, and 7 - the satellite will include evolutionary advances in technology and performance. LDCM will have two new spectral bands, one tailored especially for detecting cirrus clouds and the other for coastal zone observation. Additionally, LDCM will be required to return 400 scenes per day to the USGS data archive (150 more than Landsat 7), increasing the probability of capturing cloud-free scenes for the global landmass.



Design concept of LDCM's Operational Land Imager instrument. Image credit: Ball Aerospace & Technology Corp.

Band Number	Band Name	Min. Lower Band Edge (nm)	Max. Upper Band Edge (nm)	Ground Sampling Distance (m)
1	Coastal/ Aerosol	433	453	28-30
2	Blue	450	515	28-30
3	Green	525	600	28-30
4	Red	630	680	28-30
5	NIR	845	885	28-30
6	SWIR 1	1560	1660	28-30
7	SWIR 2	2100	2300	28-30
8	Panchro matic	500	680	14-15
9	Cirrus	1360	1390	28-30

SPOT

PROGRAMME

SPOT (*Satellite Pour l'Observation de la Terre*, *French for "Earth observation satellite") is a high-resolution, optical imaging system operating from space. This programme is part of CNES's Earth observation strategy. Since 1986, the SPOT family of satellites has been viewing our planet and providing remarkably high-quality images.*

SPOT is the best-performing civil satellite of its generation. In spite of increasing competition, SPOT has become the worldwide standard in satellite imagery.

CNES -Centre National d'Etudes Spatiales

Founded in 1961, CNES is the government agency responsible for shaping & implementing France's space policy. Its task is to invent the space systems of the future, bring space technologies to maturity and guarantee France's independent access to space. CNES is a pivotal player in Europe's space programme, and a major source of initiatives and proposals that aim to maintain France and Europe's competitive edge.

CNES Headquarters – located in Paris

CNES administrative operations are directed from the CNES headquarters in Paris. It oversees the ministries and also defines strategic guidelines for the agency's technical centres.

Evry Space centre - the Launcher Directorate

The Launcher Directorate (DLA), in Evry, leads all developments for the Ariane programme, under contract to the European Space Agency (ESA)

Toulouse Space Centre (CST) - a technical and operational complex

Guiana Space Centre (CSG) – located in French Guiana

The CSG is dedicated to Europe's launcher programme. It coordinates all resources needed for launch infrastructures; launcher and payload preparation. The site was chosen in 1967 for its ideal location 5° north of the equator, which is ideal for launching

In 1978, the French government decided to launch an operational Earth observation programme. SPOT is one element of a series of projects designed to better understand and manage the planet.

SPOT data are serving a broad range of applications, including cartography, natural resource management and land planning and management.
Since SPOT 1, the governments of Belgium and Sweden have participated in the programme, each contributing 4% of the cost. This funding takes the form of participation by their respective industries in the production of satellite equipment or ground

Spot 1-3

*Launched from Kourou Launch Range in French Guiana on 21. Feb. 1986 by Ariane launch vehicle. It retired from full time service on 31.Dec.1990. **Spot 2** was launched on 21.Jan.1990, **Spot 3** was launched on 23.March 1998.*

Spot 1-3 had identical orbits and sensor systems.

Altitude – 832 km; Sun synchronous, , Temporal resolution 26 days

Equator crossing at 10.30 A.M. Payload consists of 2 identical High Resolution Visible (HRV) imaging systems.

SPOT

(Satellite Pour l'Observation de la Terre – Earth Observation Satellite)

Initiator	CNES
Origin	Studies for an Earth observation system carried out by CNES in the 1970s
Status	SPOT 4 and SPOT 5 currently operational
Participants	CNES, SSTC (Belgian scientific, technical and cultural services), Swedish Space Corporation (Swedish space agency)
Goals	Help to improve knowledge and management of our planet
Objectives	Explore Earth's resources; detect and forecast phenomena involving climatology and oceanography; monitor human activities and natural phenomena
Principal missions	SPOT 1 – 1986 / 1990 SPOT 2 – 1990 / 2009 SPOT 3 – 1993 / 1996 SPOT 4 – 1998

HRV Sensors

Each HRV sensor can acquire the images in panchromatic mode (P mode: a single wide band in the visible part of the spectrum) or multispectral mode (XS mode: the green, red, and infrared bands of the EMR). The two HRV sensors can function independently or in tandem in either XS or P mode. Each of the two HRV instruments can sweep a 60 km-wide swath. They thus acquire 60km x 60km images. The images' spatial resolution is 10m for the Panchromatic and 20m for the multispectral images.

The SPOT satellites' optical instruments can make oblique observations upto angles of 27° from the satellite's vertical axis by changing the direction of each optical instrument's entry mirror. These orientations are remote-controlled by the ground stations, thereby making it possible to observe

Spot 1-3 (2- HRV)

Mode	Bands	Spectral Resolution	Spatial Resolutio n
XS-Multispectral	XS 1	0,50 - 0,59 µm	20mx 20m
	XS 2	0,61 - 0,68 µm	
	XS 3	0,79 - 0,89 µm	
P-Panchromatic	PAN	0,51 - 0,73 µm	10mx 10m

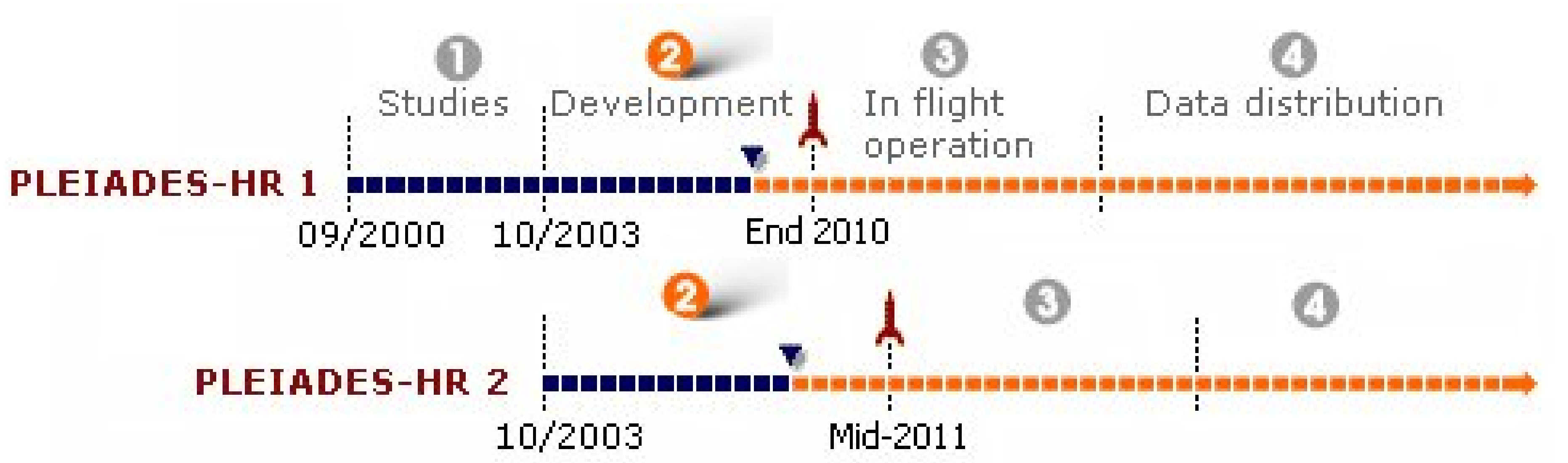
The Pleiades programme is intended to replace SPOT. Pleiades is the result of studies begun several years ago on the possibility of using smaller, cheaper satellites which are more agile offer better performance.

Different kind of sensor have been identified to meet virtually all optical and radar imaging needs . The system will be made up of several satellite constellations, each furnishing specific data. The first high-resolution satellites of this programme will be launched in 2010. They will complement the Italian radar satellite constellation within the French-Italian Orfeo system, which has both civil and military applications.

Pleiades program is the result of an in-depth study about the user needs evolution. A cooperation program was initiated between France and Italy, taking advantage of all the CNES Earth observation skills, to develop ORFEO, a dual Earth observation system with metric resolution, in which Pleiades (France) is the optic component and Cosmo-Skymed (Italy) is the radar component.

This component is made of two "small satellites" (mass of one ton) offering a spatial resolution at nadir of 0.7 m and a field of view of 20 km. Their great agility enables a daily access all over the world, which is a critical need for defense and civil security applications, and a coverage capacity necessary for the cartography kind of applications at scales better than those accessible to SPOT family satellites. Moreover, PLEIADES have stereoscopic acquisition capacity to meet the fine cartography needs, notably in urban regions, and to bring complete information given by aerial photography.

With respect to the constraints of the France-Italian agreement


1
Studies
2
Development
3
In flight operation
4
Data distribution
PLEIADES-HR 1
09/2000
10/2003
End 2010
2
3
4
PLEIADES-HR 2
10/2003
Mid-2011

The Pleiades project is part of ORFEO, a joint Franco-Italian initiative by the countries' national space agencies CNES and ASI, marking a major technological advance in optical earth observation systems. The dual-technology program addresses both military and civil needs for European users, including mapping, volcano monitoring, geophysical and hydrology studies, urban planning, etc. As prime contractor for the Pleiades system-in particular the ground segment-CNES selected Astrium as satellite prime contractor and Thales Alenia Space for the imaging instruments.

The Pleiades optical high-resolution imaging instruments offers enhanced resolution of 70 cm

European Space Agency - (ESA)

1945-50 After the Second World War, many European scientists had left Western Europe to work either in the US or the Soviet Union. Although Western European countries could still invest in research and space-related activities, European scientists realised that solely national projects would be unable to compete with the major superpowers.
1958 Pierre Auger (F) and Edoardo Amaldi (I), two prominent members of the Western European scientific community, recommend that European governments set up a 'purely scientific' joint organisation for space research taking CERN as a model.

1960 Scientists from ten European countries, the 'Groupe d'etudes europeen pour la Collaboration dans le domaine des recherches spatiales' (GEERS), with Harrie Massey (UK) as President and Auger as Secretary, set up a commission at which government representatives would decide on possibilities of European cooperation in space.

Europa at Euro Space Centre, Belgium1961 The 'Commission préparatoire européenne de recherches spatiales' (COPERS) defines a scientific programme, an 8-year budget and administrative structure for the envisaged European Space Research Organisation (ESRO). It agrees on the sites for ESRO's establishments.

1964 European nations decide to have two different agencies, one to develop a launch system, the European Launch Development Organisation (ELDO) and the other, the European Space Research Organisation (ESRO), to develop spacecraft.

1966 ESRIN set up as part of ESRO in Frascati, near Rome, Italy, and begins acquiring data from environmental satellites in the 1970s. ESRIN, now known as the ESA Centre for Earth Observation, is one of the five ESA specialised centres situated in Europe.

1967 European Space Operations Centre (ESOC) set up in Darmstadt, Germany. It has now operated more than 50 satellites in 40 years of history.

1968 After an initial period in Delft, ESTEC moves to its present site in Noordwijk, the Netherlands, in April 1968. More than 40 spacecraft, starting with ESRO-1, have been designed and placed into orbit with the backing of ESTEC expertise since the 1960s.

ESA's Ulf Merbold on Spacelab-11972 Although ESRO is establishing itself as a leader in space exploration, ELDO is dealing technological problems, cost overruns and political dispute. The idea of a new single European space organisation is first discussed. ELDO is eventually downsized and dismantled in 1974.

1973 ESRO and NASA agree to build Spacelab, a modular science package for use on Space Shuttle flights. Construction starts in 1974 and the first module was given to NASA in exchange for flight opportunities for European astronauts. Spacelab was used on 25 shuttle flights between 1983 and 1998.

1975 ESA is created in its current form, merging ELDO with ESRO. There are 10 founding members: Belgium, Germany, Denmark, France, United Kingdom, Italy, the Netherlands, Sweden, Switzerland and Spain. Ireland joins later in the year. ESA launches its first major scientific mission, Cos-B, a satellite monitoring gamma-ray emissions in the Universe. One of the most successful space missions ever, it operates for over six years, four years longer than planned.

1978 Canada becomes a Cooperating State. ESA joins NASA and the UK in launching IUE, the world's first high-orbit telescope, which operates very successfully for 18 years.

1979 Austria signs an Association Agreement with ESA. First Ariane launched.

1980 A French company, Arianespace, is formed to produce, operate and market the Ariane 5 rocket as part of ESA's Ariane programme. As the successor of ELDO, ESA had begun to build rockets for unmanned scientific and commercial payloads. Ariane takes mostly commercial payloads into orbit from 1984 onward. A more advanced launch system, Ariane 4, operates between 1988 and 2003 and establishes ESA as the world leader in commercial space launches in the 1990s.

1983 Ulf Merbold from Germany becomes first ESA astronaut to fly on US Space Shuttle, during STS-9 Spacelab mission.

1986 Giotto, ESA's first deep-space mission, studies Comets Halley and Grigg-Skejllerup.

1990s SOHO, Ulysses and the Hubble Space Telescope all jointly carried out with NASA. Recent scientific missions in cooperation with NASA include Cassini-Huygens, to which ESA contributes the successful Huygens probe.

1997 The first flight of Ariane-5 ends in failure, but later flights establish Ariane in the highly competitive commercial space launch market, with 25 successful launches by 2006.

2003 Mars Express orbiter and its lander, Beagle 2, launched. Mars Express, the first fully European mission to any planet, is playing a key role in an international exploration programme spanning the next two decades.

2005 The ESA Huygens probe lands on the surface of Titan, Saturn’s largest moon - the first ever to land on a world in the outer Solar System.

2007 The European Space Policy was signed on 22 May 2007, unifying the approach of the ESA with those of the individual European Union member states. Jointly drafted by the European Commission and ESA’s Director General, Jean-Jacques Dordain, it creates for the first time a common political framework for space activities in Europe.

2008 ESA's Columbus laboratory is launched on Space Shuttle Atlantis to the International Space Station (ISS). ESA now becomes a fully responsible partner in the operations and utilisation of the ISS and is thus entitled to fly its own astronauts for long-duration missions as members of the resident ISS crew. ATV *Jules Verne*, ESA's first Automated Transfer Vehicle, is also launched to take vital supplies to the ISS. The Czech Republic formally becomes ESA's 18th Member State on 12 November 2008.

2009 Herschel and Planck launched. ESA astronaut Frank De Winne joins the first ISS crew of six, and in October becomes the first European commander of an ISS expedition. ESA selects new astronauts, for the first time since 1992: two Italian, one French, one Dane, one German and one British. The new recruits will join the European Astronaut Corps and start their training to prepare for future missions to the International Space Station, and beyond.

The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.
ESA is an international organisation with 18 Member States. By coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country.

What does ESA do?

ESA's job is to draw up the European space programme and carry it through. ESA's programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe.

Who belongs to ESA?

Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Canada takes part in some projects under a Cooperation agreement.

Hungary, Romania, Poland, Estonia and Slovenia are 'European Cooperating States'. Other countries have signed cooperation agreements with ESA.

Where is ESA located?
ESA's headquarters are in Paris which is where policies and programmes are decided. ESA also has sites in a number of European countries, each of which has different responsibilities:

EAC, the European Astronauts Centre in Cologne, Germany;
ESAC, the European Space Astronomy Centre, in Villanueva de la Canada, Madrid, Spain;
ESOC, the European Space Operations Centre in Darmstadt, Germany;
ESRIN, the ESA centre for Earth Observation, in Frascati, near Rome, Italy;
ESTEC, the European Space Research and Technology Centre, Noordwijk, the Netherlands.

ESA also has liaison offices in Belgium, USA and Russia; a launch base in French Guiana and ground/tracking stations in various parts of the world.

How many people work for ESA?

There are around 2000 staff working for ESA, from all the Member States and include scientists, engineers, information technology specialists and administrative personnel.

Where do ESA's funds come from?

ESA's mandatory activities (space science programmes and the general budget) are funded by a financial contribution from all the Agency's Member States, calculated in accordance with each country's gross national product. In addition, ESA conducts a number of optional programmes. Each Member State decides in which optional programme they wish to participate and the amount they wish to contribute.

How big is ESA's budget?

ESA's budget for 2010 is €3745 million. ESA operates on the basis of geographical return, i.e. it invests in each Member State, through industrial contracts for space programmes, an amount more or less equivalent to each country's contribution.

How much does each European spend on ESA?

European per capita investment in space is very little. On average, every citizen of an ESA Member State pays, in taxes for expenditure on space, about the same as the price of a cinema ticket (in USA, investment in civilian space activities is almost four times as much).

How does ESA operate?

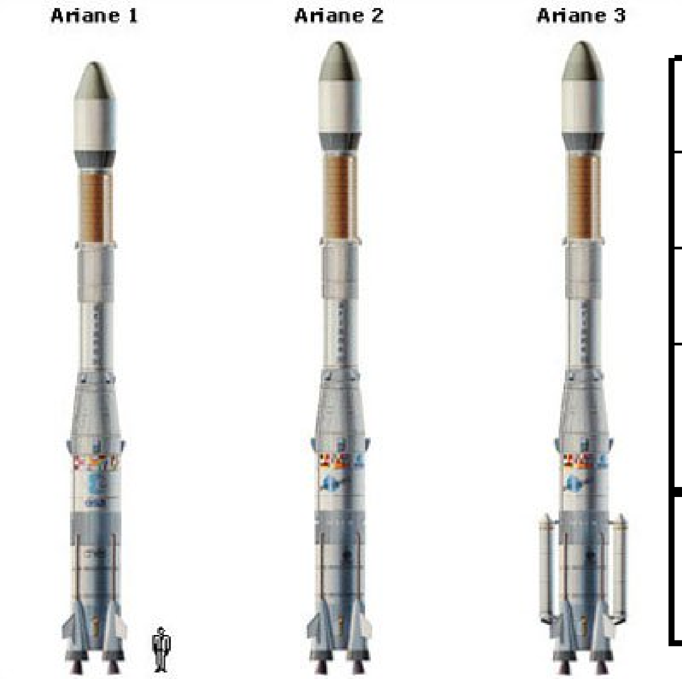
The Council is ESA's governing body and provides the basic policy guidelines within which ESA develops the European space programme. Each Member State is represented on the Council and has one vote, regardless of its size or financial contribution.

ESA is headed by a Director General who is elected by the Council every four years. Each individual research sector has its own Directorate and reports directly to the Director General. The present Director General of ESA is Jean-Jacques Dordain.

Work on the first Ariane launcher began as early as 1974 using the then new technology of combining liquid oxygen and liquid hydrogen. The first flight was scheduled for 15 December 1979. On that eventful day, in front of a large and expectant audience, countdown started and the motor underneath the launcher lit - and then went out.

Fortunately the fault was not serious and the launch was rescheduled for 23 December, but then bad weather and a few small problems led to yet another delay.

The next attempt proved to be third time lucky. On 24 December, at 14:14 hours local time, Ariane 1 blasted into space from Europe’s Spaceport in Kourou, French Guiana. Europe’s independent adventure in space had begun.



Main Data	Ariane 1	Ariane 2	Ariane 3
Height	47.4 m	49 m	49 m
Diameter	3.8 m	3.8 m	3.8 m
Liftoff mass	210 tons	219 tons	237 tons
Maximum Payload	1.83 tons	2.27 tons	2.67 tons

Ariane 1 was designed primarily to put two telecommunications satellites at a time into orbit, thus reducing costs. As the size of the satellites grew Ariane 1 began to give way to the more powerful Ariane-2 and Ariane-3 launchers.
Altogether, 11 successful Ariane-1 launches took place between 1979 and 1986, and five successful Ariane-2 flights between 1987 and 1989. Ariane 3 made a record 11 flights from 1984 to 1989, all of which were successful.
All three launchers were slightly different. The first and third stages of Ariane 2 and Ariane 3 were longer than those of Ariane 1, while Ariane 3 had strap-on boosters containing liquid or solid propellant, making it the most flexible and powerful of the three launchers, capable of launching a payload of 1.7 tonnes.

Ariane 4 launchers			
Main Data	**40**	**42P**	**44P**
Height	up to 58.72 m	up to 58.72	up to 58.72
Diameter*	3.8 m	3.8 m	3.8 m
Liftoff mass	240 tonnes	320 tonnes	350 tonnes
Max. payload mass**	2 tonnes	2.7 tonnes	3.1 tonnes
Main Data	**42L**	**44LP**	**44L**
Height	up to 58.72 m	up to 58.72 m	up to 58.72 m
Diameter *	3.8 m	3.8 m	3.8 m
Liftoff mass	360 tonnes	420 tonnes	470 tonnes
Max. payload mass**	3.3 tonnes	3.8 tonnes	4.3 tonnes

Ariane 4 was justly known as the 'workhorse' of the Ariane family. Since its first flight on 15 June 1988 until the last, on 15 February 2003, it made 113 successful launches.

The Ariane 4 proved ideal for launching communications and Earth observation satellites as well as those for scientific research. This launcher was extremely versatile. The first stage could hold two or four strap-on boosters, or none at all. This meant that it could lift into orbit satellites weighing from 2000 to nearly 4300 kg in GTO, nearly three times as much as the Ariane-3 launcher.

During its working life, Ariane 4 captured 50% of the market in launching commercial satellites, showing that Europe can more than hold its own in the commercial launch field.

Ariane 5 Evolution

Between 1996 and 2003 the Ariane 5 Generic launcher has made 16 launches from Europe's Spaceport. Depending on the payload, the configuration of the upper part of the launcher has been adapted for each launch to ensure the optimum accommodation of single, dual or, for Flight 162 on 27 September 2003, a triple payload.

Apart from the initial qualification flight which ended in failure 39 s after liftoff, and the 10th flight where a problem with the storable propellant stage (EPS) placed one satellite in an unrecoverable orbit, the Ariane 5 Generic launcher has demonstrated its robustness and reliability.

Ariane 5 Generic Plus (A5G+)

To improve the performance of the initial Ariane 5 version and to respond to evolution in market demand, a set of small but important changes have been introduced on a limited number of launchers. Launchers with these modifications are referred to as the Ariane 5 Generic Plus. These changes are:

introduction of the lighter P2001 nozzle on the EAP boosters

modifications to the EPS upper stage: increased capacity of the two MMH tanks (+ 300 kg of ergols); modified mixture ratio of the Aestus engine

modifications to the vehicle equipment bay (VEB): replacing the aluminium structure with a lighter composite version; a new separation system for the VEB and the main stage to reduce the shock created during separation; new electrical equipment and components

All these modifications have led to an increase in performance for a standard geostationary transfer orbit of 150 kg net payload.

The Ariane 5G+ operated flawlessly on the three launches made in 2004.

Ariane 5 Evolution

In the mid 1990s an analysis of the launch market was carried out. This showed that the majority of customers require launches into geosynchronous transfer orbit and identified the need for further upgrades of the Ariane launch capacity.
Decisions to modify and improve Ariane 5 launcher versions were taken leading to the development of the:
Ariane 5 ECA
Ariane 5 GS
Ariane 5 ES ATV

ERS-European Remote sensing Satellite

ERS 1

European Remote Sensing satellite (ERS) was the ESA's first Earth-observing satellite. It was launched On July 17, 1991 into a Sun synchronous Polar orbit at a height of 782–785 km. Mission ended on March 10, 2000.

ERS-1 carried an array of earth-observation instruments that gathered information about the Earth (land, water, ice and atmosphere) using a variety of measurement principles. These included:

RA (Radar Altimeter) is a single frequency nadir-pointing radar altimeter operating in the Ku band.

ATSR-1 (Along-Track Scanning Radiometer) is a 4 channel infrared radiometer and microwave sounder for measuring temperatures at the sea-surface and the top of clouds.

SAR (synthetic aperture radar) operating in C band can detect changes in surface heights with sub-millimeter precision.

Wind Scatterometer used to calculate information on wind speed and direction.

MWR is a Microwave Radiometer used in measuring atmospheric water, as well as providing a correction for the atmospheric water for the altimeter.

To accurately determine its orbit, the satellite included the PRARE (Precision Range and Range-Rate Equipment) and a Laser Retroreflector. The PRARE was non-operational since launch. The Retroreflector was used for calibrating the Radar Altimeter to within 10 cm.

Mission

The ERS-2 mission comprises the ERS-2 satellite, ground segment facilities at ESOC and other locations for data processing and archiving, and ground stations for telemetry and data receipt. The mission uses advanced microwave (radar) techniques to provide measurements of the Earth's atmospheric and surface properties regardless of cloud and sunlight conditions. This contributes to the scientific study and understanding of our climate and the environment.

Its successor, ERS-2, was launched on April 21, 1995, on an Ariane 4, from ESA's Guiana Space Centre near Kourou, French Guiana. Largely identical to ERS-1, it added additional instruments and included improvements to existing instruments including:

GOME (Global Ozone Monitoring Experiment) is a nadir scanning ultraviolet and visible spectrometer.

ATSR-2 included 3 visible spectrum bands specialized for Chlorophyll and Vegetation

RA - Radar Altimeter	Ku-band (13.8 GHz) nadir-pointing active microwave sensor designed to measure the time return echoes from ocean and ice surfaces.
ATSR - Along Track Scanning Radiometer (no longer used)	Comprises an Infra-Red Radiometer (IRR) and a Microwave Sounder (MWS). On ERS-2, the IRR is equipped with additional visible channels for vegetation monitoring.
GOME - Global Ozone Monitoring Experiment	A nadir-scanning ultraviolet and visible spectrometer for global monitoring of atmospheric Ozone; since summer 1996, ESA has been delivering three-day GOME global observations of total ozone, nitrogen dioxide and related cloud information.
MWR - Microwave Radiometer	Measures the integrated atmospheric water vapour column and cloud liquid water content, as correction terms for the radar altimeter signal.
SAR - Synthetic Aperture Radar	Provides two-dimensional spectra of ocean surface waves. In image mode the SAR provides high resolution two-dimensional images with a spatial resolution of 26 m in range (across track) and between 6 and 30 m in azimuth (along track). Image data is acquired for a maximum duration of approximately ten minutes per orbit.
WS - Wind Scatterometer	Obtains information on wind speed and direction at the sea surface for incorporation into models, global statistics and climatological datasets; operates by recording the change in radar reflectivity of the sea due to the perturbation of small ripples by the wind close to the surface.
PRARE - Precise Range And Range-Rate Equipment (no longer used)	A compact, space-borne, two-way, two-frequency microwave satellite tracking system.

Envisat (Environmental Satellite) is an Earth-observing satellite built by the European Space Agency. It was launched on the 1st March 2002 aboard an Ariane 5 into a Sun synchronous polar orbit at a height of 790 km (±10 km). It orbits the Earth in about 101 minutes with a repeat cycle of 35 days. It is the largest European satellite to date (late 2006), with total mass 8211 kg.
Envisat carries an array of nine Earth-observation instruments that gather information about the earth (land, water, ice, and atmosphere) using a variety of measurement principles.
Several of the instruments are advanced versions of instruments that were flown on the earlier ERS-1 and ERS-2 missions and other satellites.

ASAR (Advanced Synthetic Aperture Radar) operating in C band can detect changes in surface heights with sub-millimeter precision.

MERIS (MEdium Resolution Imaging Spectrometer) measures the reflectance of the Earth (surface and atmosphere) in the solar spectral range (390 to 1040 nm).

AATSR (Advanced Along Track Scanning Radiometer) can measure the temperature of the sea surface

RA-2 (Radar Altimeter 2) is a dual-frequency Nadir pointing Radar operating in the Ku band and S bands, it is used to define ocean topography, onitor sea ice and measure land heights.

MWR (Microwave Radiometer) for measuring water vapour in the atmosphere.

DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) for orbit determination to within 10 cm or less

GOMOS (Global Ozone Monitoring by Occultation of Stars) looks to stars as they descend through the Earth's atmosphere and change color, which also tells a lot about the presence of gases such as O3 (ozone), and allows for the first time a space-based measurement of the vertical distribution of these trace gases.

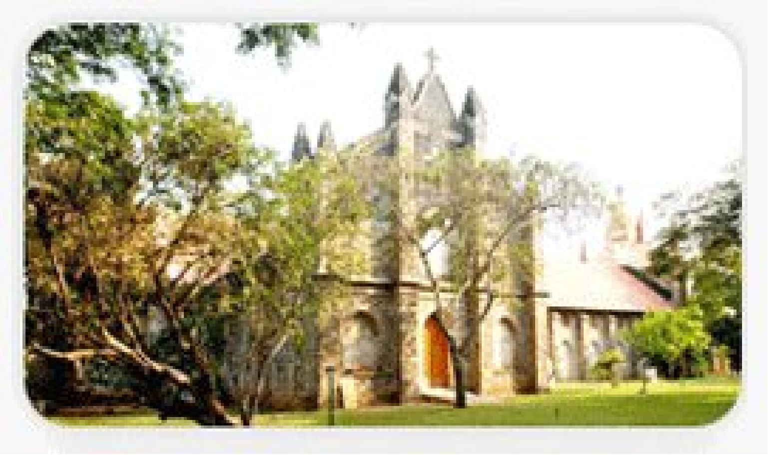
MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) is a spectrometer

SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) compares light coming from the sun to light reflected by the Earth, which provides information on the atmosphere through which the earth-reflected light has passed.

Dr.Vikram Sarabhai

Considered as the father of Indian Space Programme.

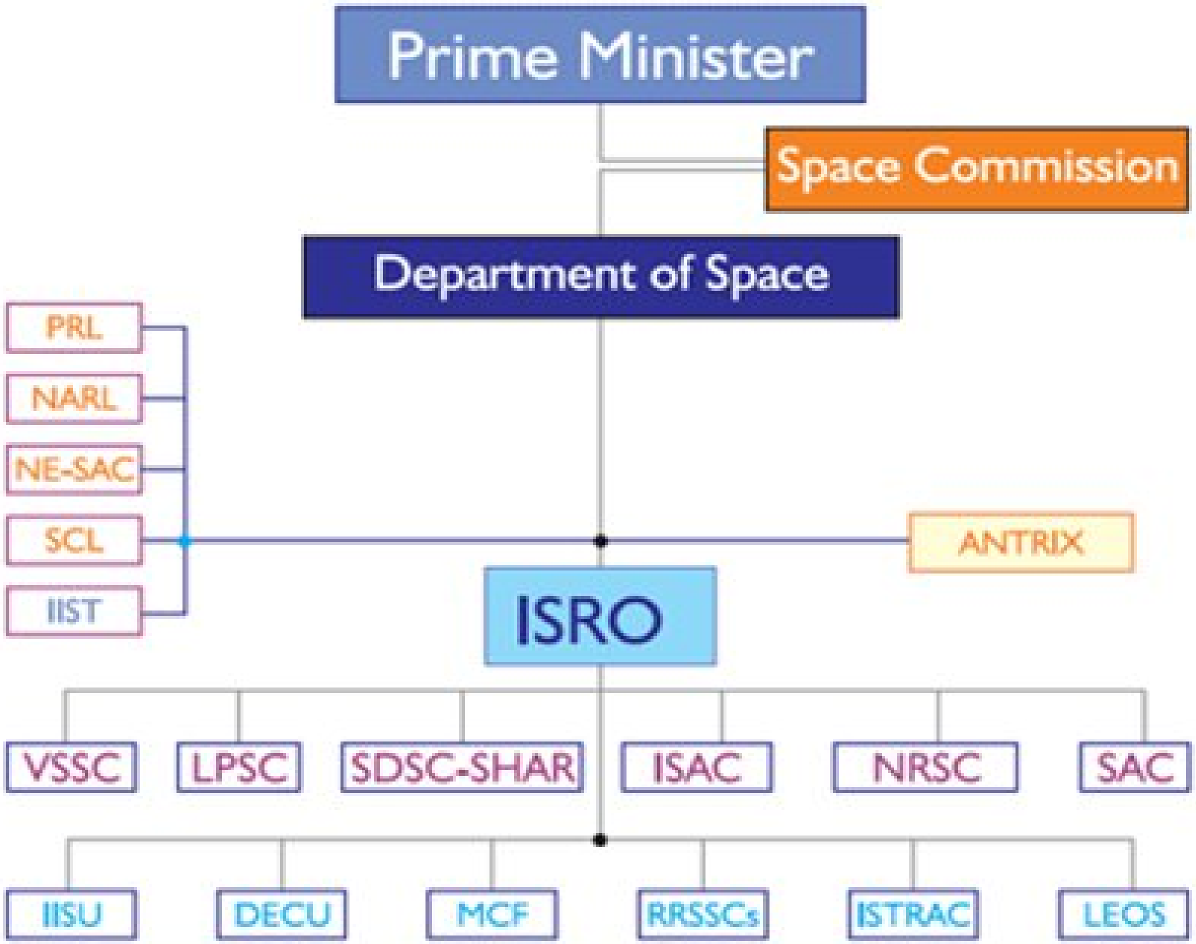
Space activities in India started during early 1960s with the scientific investigation of upper atmosphere and ionosphere over the magnetic equator that passes over Thumba near Thiruvananthapuram using small sounding rockets. Realising the immense potential of space technology for national development, Dr.Vikram Sarabhai, envisioned that this powerful technology could play a meaningful role in national development and solving the problems of common man.



Thumba Equatorial Rocket Launching Station (TERLS), a few meters from the coastline, St Mary Magdalene Church.

Accordingly, Indian Space Research Organisation (ISRO) has successfully operationalised two major satellite systems namely ***Indian National Satellites (INSAT)*** *for communication services and* ***Indian Remote Sensing (IRS) satellites*** *for management of natural resources; also,* ***Polar Satellite Launch Vehicle*** *(PSLV) for launching IRS type of satellites and* ***Geostationary Satellite Launch Vehicle*** *(GSLV) for launching INSAT type of satellites.*

The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes through, mainly ***Indian Space Research Organisation (ISRO), National Remote Sensing Centre*** *(NRSC),* ***Physical Research Laboratory*** *(PRL),* ***National Atmospheric Research Laboratory*** *(NARL),* ***North Eastern-Space Applications Centre*** *(NE-SAC) and*



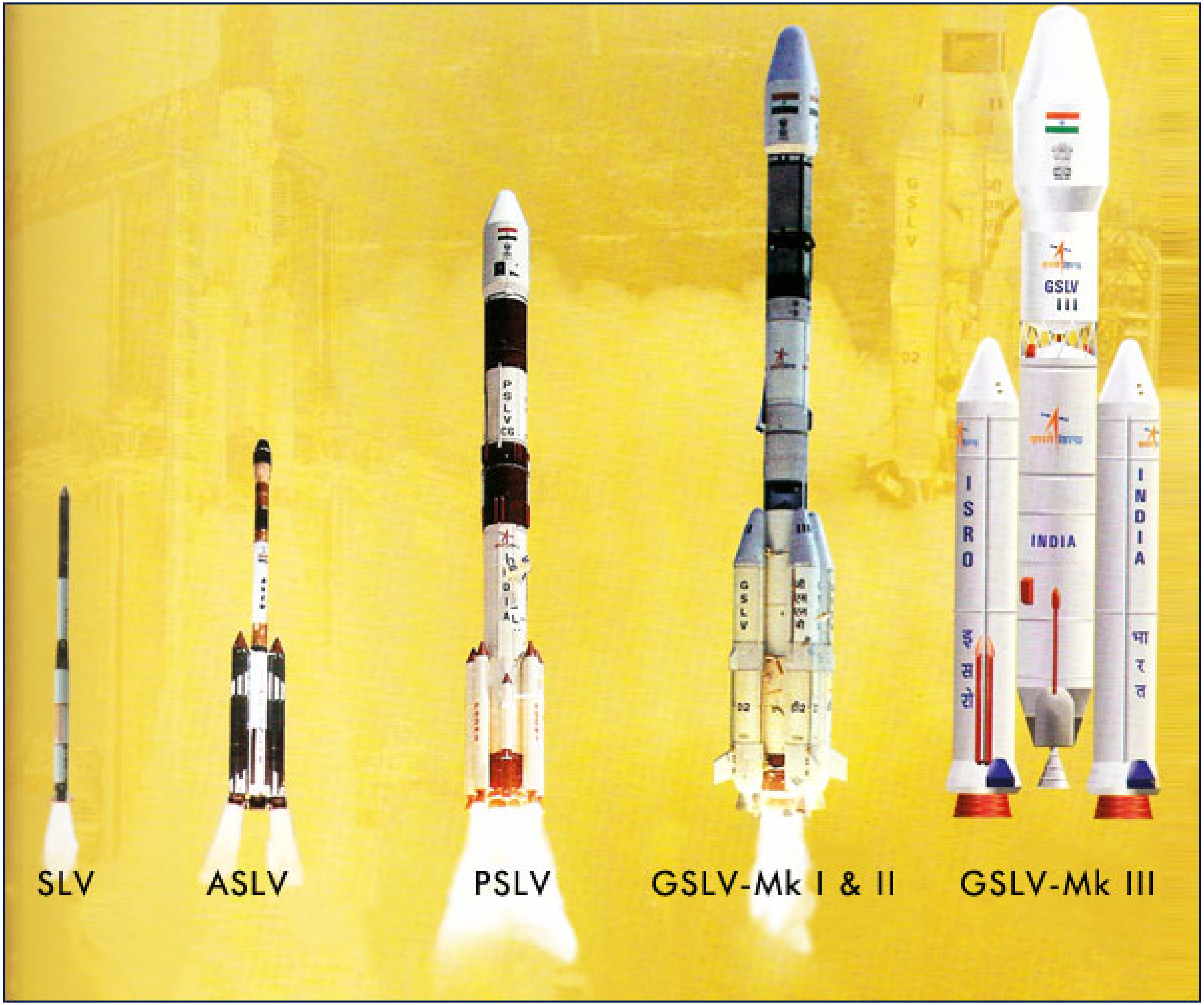
NRSC: National Remote Sensing Centre, **PRL:** Physical Research Laboratory, **NARL:** National Atmospheric Research Laboratory, **NE-SAC:** North Eastern Space Applications Centre, **SCL:** Semi-Conductor Laboratory, **ISRO:** Indian Space Research Organisation, **Antrix:** Antrix Corporation Limited, **VSSC:** Vikram Sarabhai Space Centre, **LPSC:** Liquid Propulsion Systems Centre, **SDSC:** Satish Dhawan Space Centre, **ISAC:** ISRO Satellite Centre, **SAC:** Space Applications Centre, **IISU:** ISRO Inertial Systems Unit, **DECU:** Development and Educational Communication Unit, **MCF:** Master Control Facility, **RRSSCs:** Regional Remote Sensing Service Centres, **ISTRAC:** ISRO Telemetry, Tracking and Command Network, **LEOS:** Laboratory for Electro-optic Systems, **IIST:** Indian Institute of Space Science and Technology

ISRO CENTRES

- Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram
- ISRO Satellite Centre (ISAC), Bangalore
- Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota
- Liquid Propulsion Systems Centre (LPSC) , Valiamala, Mahendragiri, Bangalore
- Space Applications Centre (SAC), Ahmedabad
- Development and Educational Communication Unit (DECU), Ahmedabad
- ISRO Telemetry, Tracking and Command Network (ISTRAC), Banglaore
- Master Control Facility (MCF), Bhopal
- Master Control Facility (MCF), Hassan
- ISRO Inertial Systems Unit (IISU), Thiruvananthapuram
- Laboratory for Electro-Optic Systems (LEOS), Bangalore

- National Remote Sensing Centre (NRSC), Hyderabad
- Indian Institute of Remote Sensing (IIRS), Dehradun
- Physical Research Laboratory (PRL) , Ahmedabad,
- National Atmospheric Research Laboratory (NARL) ,Gadanki
- Regional Remote Sensing Service Centres (RRSSC), Bangalore, Jodhpur, Kharagpur, Dehradun and Nagpur.
- North Eastern-Space Applications Centre (NE-SAC), Shillong
- Antrix Corporation Limited , Bangalore
- Semi-Conductor Laboratory (SCL), Chandigarh
- Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram

Launch Vehicles are used to transport and put satellites or spacecrafts into space. In India, the launch vehicles development programme began in the early 1970s. The first experimental Satellite Launch Vehicle (SLV-3) was developed in 1980.



ISRO's Launch Vehicle Development

Satellite Launch Vehicle-3 (SLV-3), *India's first experimental satellite launch vehicle was successfully launched on July 18, 1980 from SHAR Centre Sriharikota, when Rohini satellite, RS-1, was placed in orbit. SLV-3 was a 22 m long, all solid, four stage vehicle weighing 17 tons capable of placing 40 kg class payloads in low earth orbit.*

It employed an open loop guidance (with stored pitch programme) to steer the vehicle in flight along pre-determined trajectory. The first experimental flight of SLV-3, in August 1979, was only partially successful. Apart from the July 1980 launch, there were two more launches held in May 1981 and April 1983, orbiting Rohini satellites carrying remote sensing sensors.

*An Augmented version of this, **ASLV**, was launched successfully in 1992. India has made tremendous strides in launch vehicle technology to achieve self-reliance in satellite launch vehicle programme with the operationalisation of Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).*

PSLV represents ISRO's first attempt to design and develop an operational vehicle that can be used to orbit application satellites. While SLV-3 secured for India a place in the community of space-faring nations, the ASLV provided the rites of passage into launch vehicle technology for ISRO. And with PSLV, a new world-class vehicle has arrived. PSLV has repeatedly proved its reliability and versatility by launching 30 satellites / spacecrafts (14 Indian and 16 for international customers) into a variety of orbits so far.

***The Polar Satellite Launch Vehicle, usually** known by its abbreviation PSLV is the first operational launch vehicle of ISRO. PSLV is capable of launching 1600 kg satellites in 620 km sun-synchronous polar orbit and 1050 kg satellite in geo-synchronous transfer orbit. In the standard configuration, it measures 44.4 m tall, with a lift off weight of 295 tonnes.*

PSLV has four stages using solid and liquid propulsion systems alternately. The first stage is one of the largest solid propellant boosters in the world and carries 139 tonnes of propellant. A cluster of six strap-ons attached to the first stage motor, four of which are ignited on the ground and two are air-lit. The reliability rate of PSLV has been superb. There had been 15 continuously successful flights of PSLV, till September 2009. With its variant configurations, PSLV has proved its multi-payload, multi-mission capability in a single launch and its geosynchronous launch capability.

In the recent Chandrayaan-mission, another variant of PSLV with an extended version of strap-on motors, PSOM-XL, the payload haul was enhanced to 1750 kg in 620 km SSPO. PSLV has rightfully earned the status of workhorse launch vehicle of ISRO.

Geosynchronous Satellite Launch Vehicle (GSLV)-Mark I & II *,is capable of placing INSAT–II class of satellites (2000 – 2,500 kg) into Geosynchronous Transfer Orbit (GTO). GSLV is a three stage vehicle GSLV is 49 m tall, with 414 t lift off weight. It has a maximum diameter of 3.4 m at the payload fairing. First stage comprises S125 solid booster with four liquid (L40) strap-ons. Second stage (GS2) is liquid engine and the third stage (GS3) is a cryo stage. The vehicle develops a lift off thrust of 6573 kn. The first flight of GSLV took place from SHAR on April 18, 2001 by launching 1540 kg GSAT-1. It was followed by four more launches , GSLV-D2 on May 8, 2003 (GSAT-2 1825 kg), GSLV-F01 on September 20, 2004 (EDUSAT 1950 kg), GSLV-F02 on July 10, 2006 and GSLV-F04 on September 2, 2007 (INSAT-4CR 2130 kg).*

***The GSLV-III or Geosynchronous Satellite Launch Vehicle Mark III** , is a launch vehicle currently under development by the Indian Space Research Organization. GSLV Mk III is conceived and designed to make ISRO fully self reliant in launching heavier communication satellites of INSAT-4 class, which weigh 4500 to 5000 kg. It would also enhance the capability of the country to be a competitive player in the multimillion dollar commercial launch market.*

The vehicle envisages multi-mission launch capability for GTO, LEO, Polar and intermediate circular orbits. GSLV-Mk III is designed to be a three stage vehicle, with 42.4 m tall with a lift off weight of 630 tonnes. First stage comprises two identical S200 Large Solid Booster (LSB) with 200 tonne solid propellant, that are strapped on to the second stage, the L110 re-startable liquid stage. The third stage is the C25 LOX/LH2 cryo stage. The large payload fairing measures 5 m in diameter and can accommodate a payload volume of 100 cu m. The development work on Mk III is progressing as per schedule for a launch in 2011.

PSLV has 15 consecutively successful flights out of 16 launches

PSLV used for launching a total of 16 satellites for foreign customers under commercial agreements, demonstrating its multi-satellite launch capability

PSLV used to launch Space capsule Recovery Experiment (SRE-1), Chandrayaan-1 and ISRO's exclusive meteorological satellite, KALPANA-1, proving its versatility

GSLV with four successful flights of five launches can launch 2 to 2.5 tonne satellite into Geo-synchronous Transfer Orbit (GTO)

Successful testing of indigenously developed cryogenic upper stage on November 15, 2007.