Compendium of Satellites and Satellite Launch Vehicles

The *Compendium of Satellites and Satellite Launch Vehicles* covers major satellites and satellite launch vehicles developed all over the world for varied applications. The satellites covered here are categorized into the following major categories:

A.Communication satellites
B. Weather Forecasting satellites
C. Remote Sensing satellites
D. Scientific satellites
E. Military satellites

The information provided includes brief technical details, applications, development agency, payload details and other relevant technical information about the satellite wherever applicable.

Satellite Tachnology: Principles and Applications Anil K.Maini and Varsha Agrawal

A. Communication Satellites

AAP-1 (Americom Asia Pacific-1) or GE-1A satellite or Worldsat-1 satellite

Americom Asia-Pacific (AAP) is a joint venture company of Lockheed Martin and SES Americom operating around 15 satellites, which provide communication services to America, Europe, over the Atlantic and Pacific oceans and Asia. AAP-1 (Fig.1) is a high-powered, all Ku-band FSS satellite providing broadcast program distribution, DTH, broadband data and VSAT services to China, Northeast Asia, Philippines and South Asia. In early 2004, the satellite was transferred to Worldsat LLC as Worldsat-1, but was renamed AAP-1 again in early 2005. In March 2007, the satellite was transfered to SES New Skies and named NSS-11**.**

Development Agency **:** Lockheed Martin Commercial Space Systems (LMCSS)
Launch **:** 02 October 2000 from Baikonur, Cosmodrome in Kazakhstan
Launch Vehicle **:** Proton-K
Orbit **:** GEO 108.2^{0}E
Weight **:** 3552kg
Payload **:** 28 Ku band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

Fig.1
AAP-1 satellite (Courtesy: Lockheed Martin)

Afristar satellite

WorldSpace Corporation of USA provides direct satellite digital audio and multi-media communication services to Africa, Middle East, Asia, Latin America and the Caribbean through its four satellites namely Afristar, Ameristar, Asiastar and Worldstar-4. Currently, Afristar and Asiastar are operational and both these satellites together broadcast audio, text and images to more than 4.6 billion people all over the world

Development Agency **:** Alcatel Space Industries, France and EADS Astrium
Launch **:** 28 October 1998 from Kourou in French Guiana, France
Launch Vehicle **:** Ariane-44L
Orbit **:** GEO 21^{0}E
Weight **:** 2750 kg
Payload **:** 3 L-band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

Agila series

Agila series of satellites are communication satellites of Philippines and are operated by Mabuhay Philippines satellite corporation. Agila series comprises of two satellites namely Agila-1 and Agila-2. Agila-1, formerly known as Palapa-B2P satellite, was launched in 1987. Agila-2, launched in 1997 provides telecommunication services to the Asia Pacific region and delivers broadcast television, telephone, and data services to Southeast Asian countries including Philippines, Hawaii, India, Pakistan, Bangladesh, Vietnam and China.

Agila-2

Development Agency : Space Systems Loral Company (SSL), USA
Launch : 19 August 1997 from Xichang Satellite Launch Center in Sichuan Province, China
Launch Vehicle : CZ-3B
Orbit : GEO 146^{0}E
Weight : 2820 kg
Payload : 24 standard C-band, 6 extended C-band and 24 Ku- band Transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Americom (AMC) series

AMC series of satellites provide a variety of satellite communication services to North and South America, Europe and the Pacific ocean region. 17 AMC satellites namely AMC-1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -15, -16, -18, -21 and -23 have been launched till date. AMC-1 provides high speed video and data services to United States, Alaska, Hawaii, Northern Mexico and Southern Canada. AMC-2 provides dedicated Ku-band services for television broadcasting to Canada, Hawaii and the Caribbean. AMC-3 provides C-band cable, radio and educational programming distribution services and Ku-band education, broadcast, business television and broadband internet services to CONUC, Hawaii and southern Canada. AMC-4 (Fig.2) serves North and South America. AMC-5 serves the SNG, VSAT, business television and broadband internet market in CONUS, Hawaii, Caribbean and Southern Canada. AMC-6 provides direct-to-home (DTH), media and entertainment distribution, enterprise and internet protocol (IP) services to North America. AMC-7 (Fig.3) and -8 provide distribution of cable, broadcast television and radio, telecommunication services, business television and broadband data distribution services throughout North America, Caribbean, Latin America, Europe and Asia. AMC-9 provides communication services to USA, Mexico and the Caribbean. AMC-10 (Fig.4) and -11 satellites provide cable television services to the North American region. AMC-12 provides communication services throughout the Atlantic region, including North America, the Caribbean, South America, Europe and Africa. AMC-15 (Fig.5) and -16 satellites are hybrid Ku/ Ka band satellites that provide satellite services to the North American region. AMC-23 is a hybrid C/Ku-band satellite serving customers throughout the Pacific region. In 2007 the satellite was spun-off from SES Americom to SAT-GE, when General Electric split off from SES. After this transaction, the satellite was renamed GE 23.

AMC-1, -2, -3 (GE-1, -2, -3)

Development Agency : Lockheed Martin Company, USA
Launch
AMC-1 : 8 September 1996
AMC-2 : 31 January 1997
AMC-3 : 4 September 1997
AMC-1 and -3 were launched from Cape Canaveral launch center, USA on Atlas-2A and Atlas-2AS respectively. AMC-2 was launched from Kourou in French Guiana, France on Ariane-44L
Orbit
AMC-1 : GEO 103º W
AMC-2 : GEO 85º W
AMC-3 : GEO 87º W
Weight
AMC-1 : 2783 kg
AMC-2 : 2648 kg
AMC-3 : 2845 kg
Payload : 24 C and 24 Ku band transponders each
Stabilization : 3-axis stabilization
Operational life : Deign life of 15 years

AMC-4, -6 (GE -4, -6)

Development Agency : Lockheed Martin Company. USA
Launch
AMC-4 : 13 November 1999
AMC-6 : 22 October 2000
AMC-4 was launched from Kourou in French Guiana, France on Ariane-44LP and AMC-6 was launched from Baikonour Cosmodrome in Kazakhstan on Proton-K
Orbit
AMC-4 : GEO 101º W
AMC-6 : GEO 72º W
Weight : 3900 kg each
Payload
AMC-4 : 24 C, 24 Ku band, 4 extended Ku band transponders
AMC-6 : 24 C and 28 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

AMC-5 (GE-5, ex Nahuel-1B)

Development Agency : Alcatel Space Industries, France
Launch : 28 October 1998 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 79º W
Weight : 1721 kg
Payload : 16 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

AMC-7 (GE-7),-8 (GE-8, Aurora-3)

Development Agency : Lockheed Martin Company, USA
Launch
AMC-7 **:** 14 September 2000
AMC-8 **:** 19 December 2000
Both these satellites were launched from Kourou in French Guiana, France on Ariane-5G
Orbit
AMC-7 **:** GEO 137º W
AMC-8 **:** GEO 139º W
Weight
AMC-7 **:** 1983 kg
AMC-8 **:** 2015 kg
Payload **:** 24 C Band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

AMC- 9 (ex GE-12)

Development Agency **:** Alcatel Space, France
Launch **:** 7 June 2003 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle **:** Proton-K
Orbit **:** GEO 79^{o}W
Weight **:** 4100 kg
Payload **:** 24 C and 24 Ku band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

AMC-10, -11, -18

Development Agency **:** Lockheed Martin Company, USA
Launch
AMC-10 **:** 5 February 2004
AMC-11 **:** 19 May 2004
AMC-18 **:** 8 December 2006
AMC-10 and -11 were launched from Cape Canaveral launch center, USA on Atlas-2AS. AMC-18 was launched from Kourou in French Guiana, France on Ariance 5ECA.
Orbit
AMC-10 **:** GEO 135º W
AMC-11 **:** GEO 131º W
AMC-18 **:** GEO 80º W
Weight
AMC-10, -11 **:** 2315 kg each
AMC-18 **:** 2081 kg
Payload **:** 24 C Band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

AMC-12 (Astra-4A, Star One-C12)

Development Agency : Alcatel Space, France
Launch : 3 February 2005 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 37.5°W
Weight : 4980 kg
Payload : 72 C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 16 years

AMC-15,-16

Development Agency : Lockheed Martin Company, USA
Launch
AMC-15 : 15 October 2004
AMC-16 : 17 December 2004
AMC-15 was launched from Baikonour Cosmodrome in Kazakhstan on Proton-M and AMC-16 was launched from Cape Canaveral launch center, USA on Atlas-5
Orbit
AMC-15 : GEO 105º W
AMC-16 : GEO 85º W
Weight
AMC-15 : 4020 kg
AMC-16 : 4065 kg
Payload : 24 Ku Band transponders and 12 Ka band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

AMC- 23

Development Agency : Alcatel Alenia Space, France (earlier Alcatel Space)
Launch : 29 December 2005 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 172° E
Weight : 4980 kg
Payload : 22 C band transponders and 26 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 16 years

AMC- 21

Development Agency : Alcatel Alenia Space, France and Orbital Sciences Corporation, USA
Launch : 14 August 2008 from Kourou in French Guiana, France
Launch Vehicle : Ariance-5ECA
Orbit : GEO 125° W
Weight : 2473 kg
Payload : 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 16 years

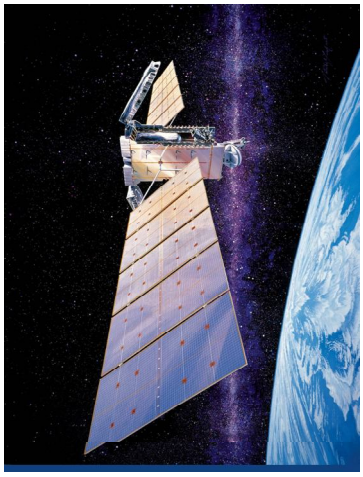


Fig.2
AMC-4 (Courtesy: Lockheed Martin)

Fig.3
AMC-7, -8 (Courtesy: Lockheed Martin)

Fig.4
AMC-10 (Courtesy: Lockheed Martin)

Fig.5
AMC-15 (Courtesy: Lockheed Martin)

AMOS series (Affordable Modular Optimized Satellite)

AMOS series of satellites are communication satellites from Israel. Currently, three satellites of the AMOS series namely AMOS-1, AMOS-2 and AMOS-3 have been launched. AMOS-1 satellite provided high quality broadcasting and communication services to Central Eastern Europe and the Middle East. In 2009 the satellite was sold to Intelsat, which will use it from an inclined orbit under the designation Intelsat 24. AMOS-2 (Fig.6) satellite provides television communication services to Israel, Europe and the United States. AMOS-3 satelite is a much more sophisticated satellite than its predecessors and has replaced the AMOS-1 satellte. AMOS-4 and -5 satellites are being planned to launched in the next two years.

AMOS-1 (Intelsat 24)

Development Agency **:** Israel Aircraft Industries
Launch **:** 15 May 1996 from Kourou in French Guiana, France

Launch Vehicle : Ariane-44L
Orbit : GEO 4º W
Weight : 961kg
Payload : 9 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 11 years

AMOS-2

Development Agency : Israel Aircraft Industries
Launch : 27 December 2003 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Soyuz-FG Fregat
Orbit : GEO 4º W
Weight : 1300 kg
Payload : 12 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

AMOS-3

Development Agency : Israel Aircraft Industries, Thales Alenia Space (France) and Telespazio Holdings (Italy)
Launch : 28 April 2008 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Zenit-3SLB
Orbit : GEO 4º W
Weight : 1250 kg
Payload : 12 Ku band transponders and 2 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 17 years

AMSC (American Mobile Satellite Corporation) series

AMSC series of satellites provide mobile satellite communication services to United States and Canada along with MSAT (Mobile Satellite System) satellites. The first satellite of the AMSC series (AMSC-1) was launched in the year 1995 to provide mobile satellite services to customers in North America. The satellite was leased to African Continental Telecommunications, Inc (ACTEL) and was named MSAT-2. AMSC-1 (Fig.7) and MSAT-1 each have the capability to support 2000 simultaneous radio channels. To continue its services, AMSC signed a contract with TMI Communications company to jointly own a satellite MSAT-1 (AMSC-2)

AMSC-1

Development Agency : Hughes Space and Communications Company, USA (now Boeing Satellite Systems)
Launch : 7 April 1995 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2A
Orbit : GEO 101^0W
Weight : 2550 kg
Payload : 10 L band transponders

Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

MSAT-1 (AMSC-2)

Development Agency : Hughes Space and Communications Company, USA (now Boeing Satellite Systems)
Launch : 20 April 1996 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : GEO 106.5^{0}W
Weight : 2830 kg
Payload : 10 L band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

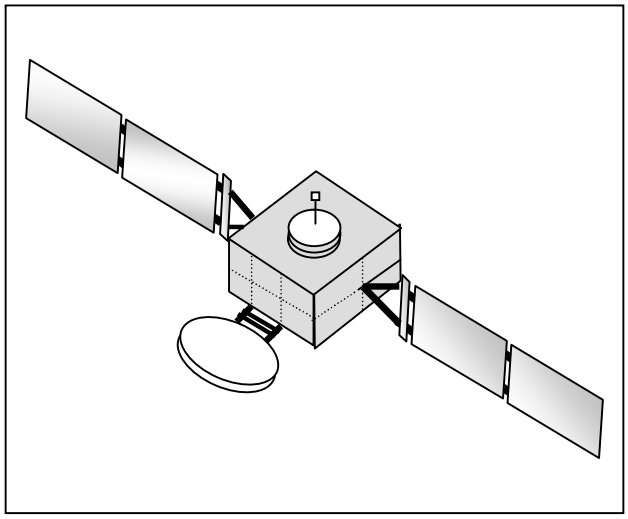


Fig.6
AMOS-2

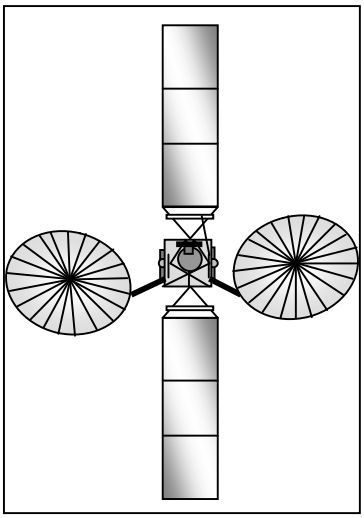


Fig.7
AMSC-1

Anik series

'Anik' is a domestic satellite system of Canada owned by Telesat. With the launch of Anik-A satellite on 9 November 1972, Canada became the first country to have a geostationary domestic communications satellite system. Telesat has successfully launched three Anik-A satellites, one Anik-B satellite, three Anik-C satellites, two Anik-D satellites, two Anik-E satellites (Fig.8) and four Anik-F satellites. Currently, Anik-F1, -F1R, -F2 and -F3 are operational.

Anik-F series

Anik-F series is sixth Anik series of satellites. Currently, it has four operational satellites, Anik-F1, -F1R, -F2 and -F3. Anik-F1 (Fig.9) satellite was designed to provide telecommunication services to North and South America. Anik-F1R (Fig.10) satellite will replace the Anik-F1 satellite; whose solar panels are not working properly. Anik-F2 (Fig.11) satellite provides internet and multimedia

services to North America. Anik-F3 provides communications services in C, Ku and Ka-bands over a large area covering North America.

Anik-F1

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 21 November 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 107.3°W
Weight : 4700 kg
Payload : 36 C band and 48 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Anik-F1R
Development Agency : Europe's space company Astrium Systems
Launch : 8 September 2005 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 107.3°W
Weight : 4100 kg
Payload : 24 C band and 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Anik-F2

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 17 July 2004 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 111.1°W
Weight : 5959 kg
Payload : 38 Ka band, 24 C band and 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Anik-F3

Development Agency : European company EADS Astrium
Launch : 9 April 2007 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 118.7°W
Weight : 4600 kg
Payload : 24 C band, 32 Ku band and 2 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Fig.8
Anik-E1, -E2 (Courtesy of TeleSAT CANADA)

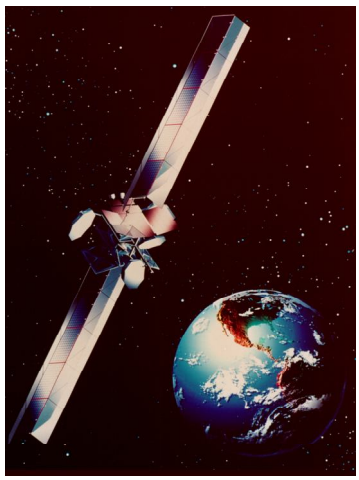


Fig.9
Anik-F1 (Courtesy of TeleSAT CANADA)

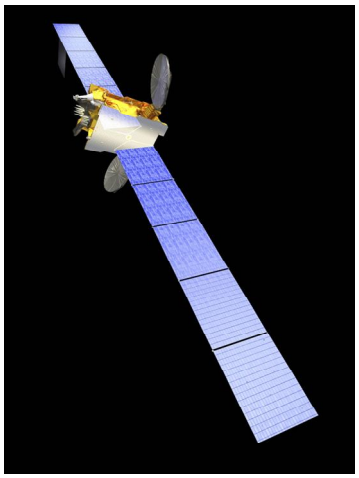


Fig.10
Anik-F1R (Courtesy of TeleSAT CANADA)

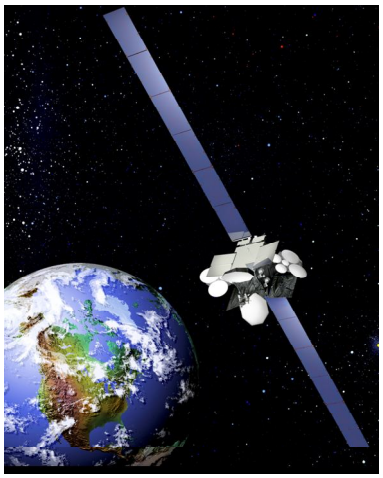


Fig.11
Anik-F2 (Courtesy of TeleSAT CANADA)

Apstar series

Apstar satellites belonging to APT Satellite Company are communication satellites from China. Apstar-1 was the first satellite to be launched in this series. Since then Apstar-1A, -2, 2R, -5 and -6 satellites have been launched. ApStar-2 satellite was designed to provide video, radio, data, and telephone transmission services to China, Japan, Vietnam, Russia, Eastern Europe, India and Australia. It was launched in the year 1995 but was destroyed in an explosion shortly after lift-off. To compensate for the loss of Apstar-2, Apstar-2R (Apstar-4 or Telstar-10) was launched in the year 1997. It provides regional voice, video and data services to the Asia-Pacific region, Europe, Russia, the Middle East and Africa.

Apstar-5 and Apstar-6 satellites are hybrid C/ Ku band satellites. Apstar-5 satellite replaced the Apstar-1 satellite in August 2004. It provides voice, video and data services to China, Hawaii, and East Asia, and C-band services to other parts of the Asia-Pacific region, including Australia and Hawaii. It also provides space-based internet backbone services for some of the major cities in Asia. Apstar-6 satellite replaced the Apstar-1A satellite in June 2005. It provides communication services to the Asia Pacific region including Hawaii. Moreover, it is the first civil satellite in China to be equipped with an anti-jamming system. Apstar-7 satellite is being planned to be launched in the year 2012 to provide reliable broadcasting and telecommunications services over the Asia Pacific Region, Africa, Middle East and a part of Europe.

Apstar-1, -1A (Fig.12)

Development Agency **:** Hughes Space and Communications, USA
(now Boeing Satellite Systems)
Launch
Apstar-1 **:** 21 July 1994
Apstar-1A **:** 3 July 1996
Both the satellites were launched from Xichang satellite launch center in Sichuan province, China on Chinese CZ-3
Orbit
Apstar-1 **:** GEO 138°E
Apstar- 1A **:** GEO 134°E
Weight **:** 1400 kg each
Payload **:** 24 active and 6 spare C band transponders each
Stabilization **:** Spin stabilized
Operational life **:** Both satellites have operational life of around 10 years

Apstar-2R (Apstar-4)

The transponder payload of Apstar-2R satellite was leased by by Loral Orion from APT Satellite Company Ltd.and was renamed Telstar-10.

Apstar-5

Part of the payload onboard the satellite is operated by Loral Skynet, who have designated the satellite as Telstar-18. Another part of the payload is operated by APT Satellite Inc. and they call it Apstar-5.

Development Agency **:** Space Systems Loral (SSL), USA
Launch **:** 29 June 2004 from Sea Launch
Launch vehicle **:** Zenit-3SL
Orbit **:** GEO 138°E
Weight **:** 4640 kg
Payload **:** 38 C band and 16 Ku band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

Apstar-6

Development Agency **:** Alcatel Space, France

Launch : 12 April 2005 from Xichang Satellite Launch Center in China
Launch vehicle : CZ-3B
Orbit : GEO 134°E
Weight : 4680 kg
Payload : 38 C band and 12 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Arabsat series

The Arab Satellite Communications Organization (Arabsat), formed in 1976 by the Arab league countries, is a domestic satellite communication system providing satellite communication services to the Arab world. Till date four generation of Arabsat satellites have been launched. Arabsat-1 series comprising of five C-band satellites (Arabsat-1A, -1B, -1C, -1D and -1E) provided television, voice and data communication services to the countries of Arab league. Arabsat-1C, launched on 26 February 1992, was sold to the Indian Space Research Organization (ISRO) on 26 November 1997 after the failure of INSAT- 2D satellite. The second generation comprises of four satellites namely Arabsat-2A, -2B, -2C and -2D. They were developed to meet the increasing demand of traditional and new telecommunications services and to ensure the continuity of services. Third generation, comprising of one satellite (Arabsat-3A), further enhanced the Arabsat satellite system's capability. Fourth generation comprises of two operational satellites, Arabsat-4B and Arabsat-4AR. They will provide communication services to the Middle East region. Arabsat-4A satellite was lost during launch. The fifth generation of Arabsat satellites will be launched in the near future.

Arabsat-2A

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch : 9 July 1996 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 26°E
Weight : 2600kg
Payload : 22 C band and 12 Ku band transponders
Stabilization 3-axis stabilization
Operational life : Design life of 12 years but it started running in inclined orbit from August 2002 and its television broad cast activities have been transferred to Arabsat 2D.

Arabsat-2B

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch : 13 November 1996 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 30.5°E
Weight : 2600kg
Payload : 22 C band and 12 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Arabsat-2C/ PAS-5 (Fig.13)

Development Agency : Hughes Space and Communications, USA (now Boeing Satellite Systems)
Launch : 28 August 1997 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : GEO 26.2°E
Weight : 3600kg
Payload : 28 C band and 28 Ku band transponders but operates only in C band
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Arabsat-2D (Hotbird-5, Eurobird-2)

Arabsat has leased Eutelsat's Hotbird-5 satellite. It is named Arabsat-2D (Fig.14) and it will replace Arabsat-2A and the partially inoperational satellite Arabsat-3A. It is dedicated for direct TV broadcasting applications

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch : 9 October 1998 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2A
Orbit : GEO 25.8°E
Weight : 3000kg
Payload : 20 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Arabsat-3A

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch : 26 February 1999 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 26.0 °E
Weight : 2708 kg
Payload : 20 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years

Arabsat-4A (Badr-1) (Fig.15)

Development Agency : Europe's space company Astrium Systems and Alcatel Space, France
Launch : 28 February 2006 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : Failed
Weight : 3340 kg
Payload : 24 active C band and 16 active Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Arabsat-4B (Badr-4)

Development Agency : Europe's space company Astrium Systems and Alcatel Space, France
Launch : 08 November 2006 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 26°E
Weight : 3300 kg
Payload : 28 active Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Arabsat-4AR (Badr-6)

Development Agency : Europe's space company Astrium Systems and Alcatel Space, France
Launch : 7 July 2008 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 26°E
Weight : 3400 kg
Payload : 24 active C band and 20 active Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

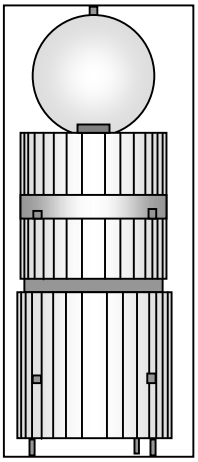


Fig.12
Apstar-1, -1A

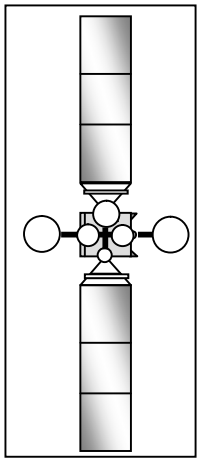


Fig.13
Arabsat-2C

Fig.14
Arabsat-2D

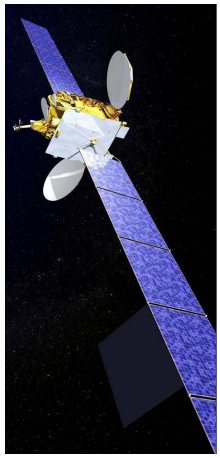


Fig.15
Arabsat-4A

(Fig.14 Courtesy: Eutelsat Fig.15 Courtesy: EADS SPACE)

AsiaSat series

AsiaSat, a regional satellite operator in Asia, provides broadcast and telecommunication services to the Asia Pacific region via its AsiaSat fleet of satellites. AsiaSat fleet comprises of AsiaSat 1, AsiaSat 2, AsiaSat 3S, AsiaSat 4 and AsiaSat 5 satellites. AsiaSat 3S, AsiaSat 4 and AsiaSat 5 are currently operational. The first satellite in the series, AsiaSat 1 was launched in the year 1990 and retired in 2003. AsiaSat launched its second satellite AsiaSat 2 in 1995. The satellite was sold to Israeli Spacecom Ltd. In late 2009 to be operated as Amos 5i.

The AsiaSat satellite program suffered a setback due to launch failure of AsiaSat 3 in 1997. AsiaSat 3S, identical to AsiaSat 3, was launched in the year 1999 to cover up for the loss. Addition of AsiaSat 4 in the year 2003 helped in further expanding satellite services for the Asia Pacific region. AsiaSat 5, a replacement satellite for AsiaSat 2, was launched in August 2009. AsiaSat 7 satellite, a backup satellite for Asiasat 5 satellite is being planned to be launched in the near future.

AsiaSat 2 (Amos 5i) (Fig.16)

Development Agency : Lockheed Martin Astro Space, USA
Launch : 28 November 1995 from Xichang Satellite Launch Center in China
Launch Vehicle : CZ-2E
Orbit : GEO 100.5°E
Weight : 3485 kg
Payload : 24 C band and 9 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years (Expected end of life in 2010)

AsiaSat 3S (Fig.17)

Development Agency : Hughes Space and Communication Company, USA (now Boeing Satellite Systems)
Launch : 21 March 1999 from Baikonur Cosmodrome in Kazakhstan
Launch Vehicle : Proton-D-1-e
Orbit : GEO 105.5°E
Weight : 3465 kg
Payload : 28 C band and 16 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

AsiaSat 4 (Fig.18)

Development Agency : Hughes Space and Communications Company, USA (now Boeing Satellite Systems)
Launch : 11 April 2003 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-IIIB
Orbit : GEO 122.2°E
Weight : 4042 kg
Payload : 28 C band and 20 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

AsiaSat 5

Development Agency : Space Systems Loral company, USA
Launch : 11 August 2009 from April 2003 from Baikonur Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 100.5°E
Weight : 3760 kg

Payload : 26 C band and 14 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

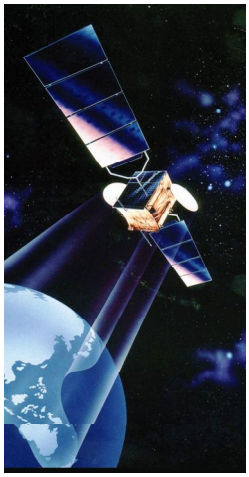


Fig.16
AsiaSat 2 (Courtesy: AsiaSat)

Fig.17
AsiaSat 3S (Courtesy: AsiaSat)

Fig.18
AsiaSat 4 (Courtesy: AsiaSat)

Asiastar satellite

Worldspace corporation of USA provides direct satellite digital audio and multi-media communications services to Africa, Middle East, Asia, Latin America and the Caribbean through its four satellites Afristar, Afristar 2, Asiastar and Worldstar-4. Currently, Afristar and Asiastar are operational and both these satellites together broadcast audio, text and images to more than 4.6 billion people all over the world. Afristar 2 satellite has been designed but its launch has been cancelled due to financial problems of the company. Launch of the Worldstar-4 satellite has also been cancelled.

Development Agency : Alcatel Space Industries, France and Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch : 21 March 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 105°E
Weight : 2750 kg
Payload : 96 L band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Astra series

Astra satellites provide broadband satellite communication services like TV, radio, broadband data and internet services in Europe. They are operated by SES Astra. Four series of Astra satellites have been launched namely Astra-1, Astra-2, Astra-3 and Astra-4. Currently, 12 Astra-1 satellites have been launched; Astra-1A, -1B, -1C, -1D, -1E, -1F, -1G, -1H, -1K, -1KR, -1L and -

1M. Astra-1K failed to reach the desired orbit due to launch vehicle failure and was deorbited. Astra-2 series has four operational satellites (Astra-2A, -2B, -2C and -2D). Both Astra-3 series and Astra-4 series have one operational satellite each namely Astra-3A and Astra-4A respectively. Astra-4A was initially a desgination for the 33 transponder payload on the AMC-12 satellite. As the AMC 12 satellite was transferred to New Skies Satellite, the **Astra 4A** designation has been allocated to the sub-Saharan Africa beam of Sirius 4. In April 2008, Sirus 2 war relocated to the 31.5° E position and renamed Astra 5A. The satellite failed in early January 2009 and was moved to a graveyard orbit.

Astra 3B, scheduled to be launched in 2010, will provide DTH broadcast services and two-way broadband services across Europe. Astra-1N and -4B satellites are scheduled to be launched in the year 2011. Astra-1N satellite will serve the German, French and Spanish markets, and provide customers with continuous operating and back-up satellite capacity at this location. Astra-4B satellite will serve customers in the Nordic and Baltic countries and the Sub-Saharan Africa.

Astra- 1C, -1D

Development Agency : Hughes Space and Communication Company, USA
(now Boeing Satellite Systems)
Launch
Astra-1C : 12 May 1993
Astra-1D : 1 November 1994
Both satellites were launched from Kourou in French Guiana. Astra-1C was launched on Ariane-42L and Astra-1D on Ariane-42P
Orbit
Astra-1C : GEO 19.2 °E
Astra-1D : GEO 23.5 °E
Weight
Astra-1C : 2790 kg
Astra-1D : 2924 kg
Payload : 18 active and 6 spare Ku band transponders each
Stabilization : 3-axis stabilization
Operational life : Astra 1C has a design life of 15 years
Astra 1D has design life of 12 years

Astra-1E, -1F

Development Agency : Hughes Space and Communication Company, USA
(now Boeing Satellite Systems)
Launch
Astra-1E : 19 October 1995
Astra-1F : 8 April 1996
Astra-1E was launched from Kourou in French Guiana, France on Ariane-42L and Astra-1F from Baikonour cosmodrome in Kazakhstan on Proton-K
Orbit : GEO 19.2 °E
Weight : 3010 kg each
Payload
Astra-1E : 18 active and 6 spare Ku band transponders
Astra-1F : 22 active and 8 spare Ku band transponders
Stabilization : 3-axis stabilization

Operational life : Astra-1E has a design life of 14 years and Astra-1F has design life of 15 years

Astra-1G, -1H, -2A, -2C

Development Agency : Hughes Space and Communication Company, USA (now Boeing Satellite Systems)
Launch
Astra-1G : 2 December 1997
Astra-1H : 18 June 1999
Astra-2A : 30 August 1998
Astra-2C : 16 June 2001
All the satellites were launched from Baikonour cosmodrome in Kazakhstan on Proton-K
Orbit
Astra-1G, -1H and -2C : GEO 19.2 °E
Astra-2A : GEO 28.2 °E
Weight
Astra-1G : 3379 kg
Astra-1H : 3700 kg
Astra-2A : 3635 kg
Astra-2C : 3643 kg
Payload
Astra-1G, -2A and-2C : 32 Ku band transponders each
Astra -1H : 32 Ku and 2 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : All the four satellites have a design life of 15 years

Astra-1KR

Development Agency : Lockheed Martin Company, USA
Launch : 20 April 2006 from Cape Canaveral launch center USA
Launch Vehicle : Atlas-5
Orbit : GEO 19.2°E
Weight : 4332 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Astra-1L

Development Agency : Lockheed Martin Company, USA
Launch : 5 May 2007 from Kourou in French Guiana, France
Launch Vehicle : Ariance-5ECA
Orbit : GEO 19.2°E
Weight : 4497 kg
Payload : 29 Ku and 2 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Astra-1M

Development Agency : Europe's space company EADS Astrium Systems
Launch : 5 November 2008 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 19.2°E
Weight : 5320 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Astra-2B

Development Agency : Europe's space company EADS Astrium Systems
Launch : 14 September 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 28.2°E
Weight : 3315 kg
Payload : 30 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Astra-2D, -3A

Development Agency: Hughes Space and Communications International was given the contract to build Astra-2D in August 1999. Hughes Space and Communications International was acquired by Boeing Satellite Systems in January 2000. Boeing Satellite Systems was given the contract to build Astra-3A satellite in August 2000.

Launch
Astra-2D : 19 December 2000
Astra-3A : 29 March 2002
Both the satellites were launched from Kourou in French Guiana, France
Launch Vehicle
Astra-2D : Ariane-5G
Astra-3A : Ariane-44L
Orbit
Astra-2D : GEO 28.2°E
Astra-3A : GEO 23.5°E
Weight
Astra-2D : 1420 kg
Astra-3A : 1500 kg
Payload
Astra-2D : 16 active and 2 spare Ku band transponders
Astra-3A : 20 active and 10 spare Ku band transponders
Stabilization : Spin stabilization
Operational life : Astra 2D has design life of 12 years and Astra 3A has design life of 10 years

Atlantic Bird series

Eutelsat Communications operates a fleet of satellites namely Atlantic Bird, Hotbird, Eurobird, Seasat and Eutelsat, providing communication services to Europe, the Middle East, and Africa, south-west Asia and North and South America. It offers TV and radio broadcasting services, corporate network solutions and a portfolio of IP applications including distribution of multimedia content, broadband internet access and internet backbone connections. Atlantic bird satellites comprise of 5 satellites namely Atlantic Bird-1, -2, -3, -4 and -4A. These satellites provide communication services to North and South America, Europe, North Africa and near Middle East.

Hot Bird 4 satellite was renamed Nilesat 103, when it was leased to Nilesat in September 2005. In June 2006 it returned to use by Eutelsat as Atlantic Bird 4. Hot Bird 10 satellite is initially comissioned as Atlantic Bird 4A at 7°W, but will revert to it's Hot Bird 10 designation when Atlantic Bird-7 satellite becomes operational. Atlantic Bird-7 satellite is scheduled to be launched in the year 2011.

Atlantic Bird-1

Development Agency : Alenia Spazio Company, Italy
Launch : 28 August 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 12.5°W
Weight : 2600 kg
Payload : 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational Life : Design life of 15 years

Atlantic Bird-2 (Fig.19)

Development Agency : Alcatel Space, France
Launch : 25 September 2001 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44P
Orbit : GEO 8.0°W
Weight : 3600 kg
Payload : 26 Ku band transponders
Stabilization : 3-axis stabilization
Operational Life : Design life of 15 years

Atlantic Bird-3 (Stellat-5)

Development Agency : Alcatel Space, France
Launch : 5 July 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : 5°W
Weight : 4100 kg
Payload : 10 C and 35 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years

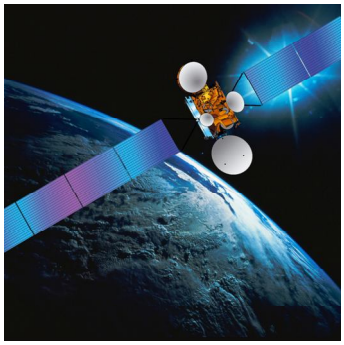


Fig.19
Atlantic Bird-2 (Courtesy: Eutelsat)

Aurora series

Aurora series of satellites, operated by Alascom, USA comprise of 3 satellites namely Aurora-1, -2 and -3. Aurora-3 satellite is currently operational.

Aurora-2 (Former Satcom C5)

Development Agency : The satellite was originally developed and operated by RCA Americom. RCA was sold to General Electric in 1986 and RCA Americom became GE Americom and the satellite construction division became GE Astro Space.
Launch : 29 May 1991 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Orbit : GEO 139°W
Weight : 1169 kg
Payload : 24 active and 4 spare C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years. The satellite was de-orbited in March 2001.

Aurora-3

AMC-8 satellite is used by Alascom as Aurora-3.

Bonum-1 satellite

BONUM-1 (Fig.20) satellite is operated by BONUM-1, a subsidiary of Media Most, a Moscow based private Russian group. The satellite provides satellite broadcasting television services to Russia.

Development Agency : Hughes Space and Communication Company, USA (now Boeing Satellite Systems)
Launch : 22 November 1998 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Orbit : GEO 36 °E

Weight : 1425 kg
Payload : 8 Ku Band transponders
Stabilization : Spin stabilized
Operational life : Design life of 11 years

Brasilsat series

Brasilsat series of satellites are operated by a Brazilian company named EMBRATEL Systems. These satellites provide telecommunications services like telephone, television, facsimile, data transmission and business networking services. The first generation of Brasilsat satellites, Brasilsat-A comprised of 2 satellites namely Brasilsat-A1 and -A2 launched in 1985 and 1986 respectively. Brasilsat-A satellites are out of service now. The second generation of Brasilsat satellites named Brasilsat-B is currently operational. Brasilsat-B comprises of four satellites namely Brasilsat-B1, -B2, -B3 and -B4.

Star One company is formed by partnership between Embratel systems and SES Global. Its fleet comprises of first generation Brasilsat satellite (Brasilsat-A2) and second generation Brasilsat satellites (Brasilsat-B1, -B2, -B3, -B4 satellites). Star One-C1, -C2 and -C12 satellites represent Star One's third generation satellites. Star One-C1 and -C2 satellites were launched in 2007 and 2008 respectively. 18 transponders on AMC-12 satellites are operated by Star One as Star One -C12.

Brasilsat-B1, -B2, -B3 and -B4 (Fig.21)

Development Agency : Hughes Space and Communication Company, USA
(now Boeing Satellite Systems)
Launch
Brasilsat-B1 : 10 August 1994
Brasilsat-B2 : 28 March 1995
Brasilsat-B3 : 4 February 1998
Brasilsat-B4 : 17 August 2000
All these satellites were launched from Kourou in French Guiana, France on Ariane-44LP
Orbit
Brasilsat-B1 : GEO 70°W
Brasilsat-B2 : GEO 65°W
Brasilsat-B3 : GEO 84°W
Brasilsat-B4 : GEO 92°W
Weight : 1757 kg each
Payload
Brasilsat-B1 and -B2 : 28 C Band and 1 X Band transponders each
Brasilsat-B3 and- B4 : 28 C Band transponders each
Stabilization : Spin stabilized
Operational life
Brasilsat-B1 and -B2 : Design life of 12 years
Brasilsat-B3 and -B4 : Design life of 12.6 years

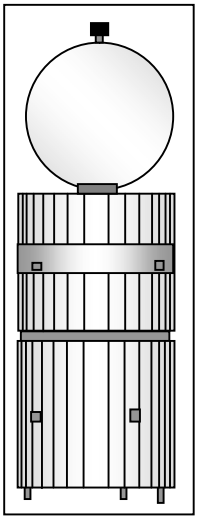


Fig.20
Bonum-1

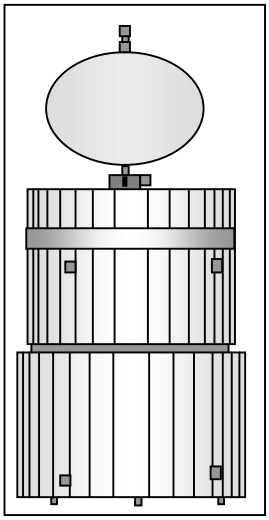


Fig.21
Brasilsat-B1, -B2, -B3, -B4

BSat series

BSat (Broadcasting Satellite), owned by Broadcasting Satellite System Corporation of Tokyo, is domestic satellite system from Japan providing broadcast services throughout Japan. They provide direct-to-home digital high-definition television services throughout Japan, relaying channels at higher resolution and in a wider-screen format than traditional analog systems. Uptil now two series of BSat satellites have been launched namely BSat-1 and BSat-2. BSat-1 series comprises of two satellites BSat-1a, -1b and BSat-2 series comprises of three satellites, BSat-2a, -2b, -2C. BSat- 2b, launched in July 2001 to serve as in-orbit backup, failed to reach the desired orbit. BSat-2C was launched in 2003 to compensate for its loss. The third generation BSat series will comprise of three satellites BSat-3a, -3b and -3c. BSat-3a was launched in the year 2007 while BSat-3b and -3c satellites will be launched in the years 2010 and 2011 respectively.

BSat-1a, -1b (Fig.22)

Development Agency : Hughes Space and Communications company, USA
(now Boeing Satellite Systems)
Launch
BSat-1a : 16 April 1997
BSat-1b : 28 April 1998
Both the satellites were launched from Kourou in French Guiana, France with B-Sat 1a on Ariane-44LP and B-Sat 1b on Ariane-44P
Orbit : GEO 110°E
Weight : 1236 kg each
Payload : 4 active and 4 spare Ku band transponders each
Stabilization : Spin stabilization
Operational life : Design life of 10 years

BSat-2a, -2b, -2c

Development Agency : Orbital Sciences Corporation, USA
Launch
BSat-2a : 8 March 2001
BSat-2b : 12 July 2001
BSat-2c : 11 June 2003
All the three satellites were launched from Kourou in French Guiana, France on Ariane-5G
Orbit
B-Sat-2a and -2c : GEO 110°E
BSat-2b : Launch failure
Weight : 1317 kg each
Payload : 4 active and 4 spare Ku band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

BSat-3a

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 14 August 2007 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 110°E
Weight : 1967 kg
Payload : 12 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years

CS series

CS satellites are communication satellites from Japan. CS satellites comprise of CS-1 series with one satellite named CS-1 (Sakura-1), CS-2 series with two satellites named CS-2a (Sakura-2a), -2b (Sakura-2b) satellites and CS-3 series with two satellites named CS-3a (Sakura-3a), -3b (Sakura-3b) satellites.

CS-3a (Sakura-3a) (Fig.23), -3b (Sakura-3b)

Development Agency : Mitsubishi Electric, Japan
Launch
CS-3a : 19 February 1988
CS-3b : 16 September 1988
Both the satellites were launched from Tanegshima Space Center in Japan on H-1
Orbit
CS-3a : GEO 132°E
CS-3b : GEO 136°E
Weight : 1100 kg each
Payload : 10 active and 5 spare Ka band, 2 active and 1 spare C band transponders each
Stabilization : Spin stabilization

Operational lifetime **:** Design life of 7 years

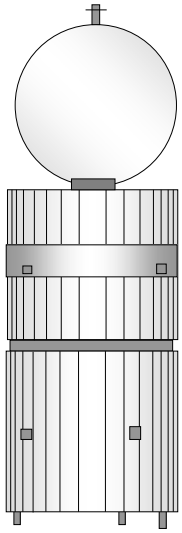


Fig.22
BSat-1a, -1b

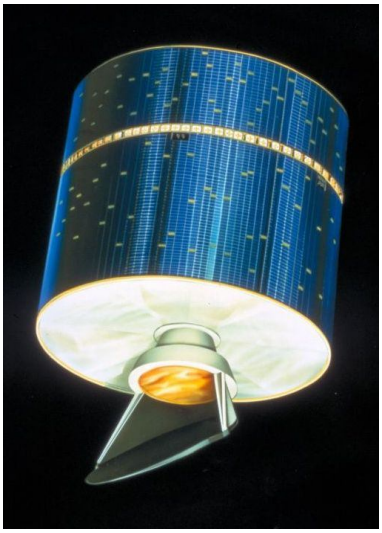


Fig.23
CS-3a (Courtesy: JAXA)

DirecTV series

DirecTV satellites, operated by DirecTV provide direct broadcast satellite (DBS) service to homes throughout North America since 1994. Currently DirecTV satellite fleet comprises of DirecTV -1, -2, -3, -1R, -4S, -5, -6, -7S, -8, -9S, -10, -11 and -12 satellites. DirecTV-1, -2, and -3 satellites deliver more than 200 channels of entertainment programming to subscribers that are equipped with digital home receiving units. DirecTV-1R satellite has replaced DirecTV-1 satellite, which remains as an in-orbit backup. DirecTV-4S satellite expanded the local channel offerings of DirecTV satellites in metropolitan markets. DirecTV-5 and -6, originally planned as Tempo-1 and Tempo-2 satellites, operated by Telecommunication Satellites Inc. (TCI), transmit more than 200 channels of high-fidelity broadcast programming to cable companies and home dishes. DirecTV-7S satellite is a high-power spot beam satellite that expands the services offered by DirecTV satellite system. DirecTV-8 satellite provides Ku band and Ka band services. DirecTV-10, -11 and -12 satellites provide broadcasting services to continental United States, Hawaii, and Alaska.

DirecTV-1 (DBS-1), -2 (DBS-2), -3 (DBS-3) (Fig.24)

Development Agency **:** Hughes Space and Communications company, USA
(now Boeing Satellite Systems)
Launch
DirecTV-1 **:** 17 December 1993
DirecTV-2 **:** 3 August 1994
DirecTV-3 **:** 10 June 1995
DirecTV-1 and -3 satellites were launched from Kourou in French Guiana, France on Ariane-44L and Ariane-42P respectively. DirecTV-2 satellite was launched from Cape Canaveral launch center, USA on Atlas-2A.
Orbit

DirecTV-1 : GEO 101°W
DirecTV-2 : GEO 101°W
DirecTV-3 : GEO 101°W
Weight : 2860 kg each
Payload : 16 Ku band transponders each
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

DirecTV-1R (DBS-4) (Fig.25)

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 9 October 1999 from SeaLaunch Platform in the Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 101°W
Weight : 3446 kg
Payload : 16 active and 4 spare Ku band transponders
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

DirecTV-4S (Fig.26)

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 26 November 2001 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 101.2°W
Weight : 4260 kg
Payload : 48 Ku band transponders
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

DirecTV-5, -6

Development Agency : Space Systems Loral company, USA
Launch
DirecTV-5 : 7 May 2002
DirecTV-6 : 8 March 1997
DirecTV-5 was launched from the Baikonour Cosmodrome in Kazakhstan on Proton-K and DirecTV-6 was launched from Cape Canaveral launch center, USA on Atlas-2A.
Orbit
DirecTV-5 : GEO 72.5°W
DirecTV-6 : GEO 110°W
Weight
DirecTV-5 : 3640 kg
Payload : 32 Ku band transponders each
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 12 years

DirecTV-7S, -9S

Development Agency : Space Systems Loral Company, USA
Launch
DirecTV-7S : 4 May 2004
DirecTV-9S : 13 October 2006 from
DirecTV-7S was launced from SeaLaunch Platform in the Pacific Ocean on Zenit-3SL and DirecTV-9S was launched from Kourou in French Guiana, France on Ariane-5ECA
Orbit
DirecTV-7S : GEO 119°W
DirecTV-9S : GEO 101.1°W
Weight
DirecTV-7S : 5483 kg
DirecTV-7S : 5535 kg
Payload : 54 Transponders
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

DirecTV-8

Development Agency : Space Systems Loral company, USA
Launch : 22 May 2005 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 101°W
Weight : 3711 kg
Payload : 36 Ku band transponders and a Ka band payload
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

DirecTV-10, -11, -12

Development Agency : Boeing Satellite Systems, USA
Launch
DirecTV-10 : 7 July 2007
DirecTV-11 : 19 March 2008
DirecTV-12 : 29 December 2009
DirecTV-10 and -12 satellites were launched from from Baikonour cosmodrome in Kazakhstan on Proton-M launch vehicle. DirecTV-11 satellite was launched from Sea Launch platform in the pacific ocean on Zenit-3SL.
Orbit
DirecTV-10 : GEO 102.8°W
DirecTV-11 : GEO 99.2°W
DirecTV-12 : GEO 76°W
Weight
DirecTV-10 : 5893 kg
DirecTV-11 : 5923 kg
DirecTV-12 : 5900 kg
Payload : 32 (+12) Ka-band and 55 (+15) Ka-band spot-beam transponders each
Stabilization : 3-axis stabilization
Operational lifetime : Design life of 15 years

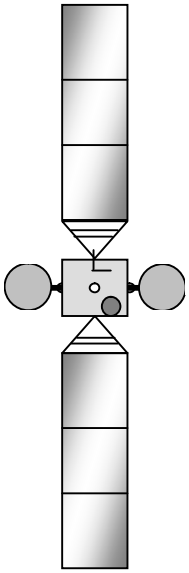


Fig.24
DirecTV-1, -2, -3

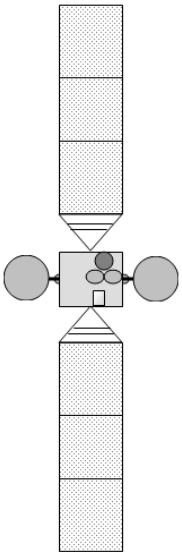


Fig.25
DirecTV-1R

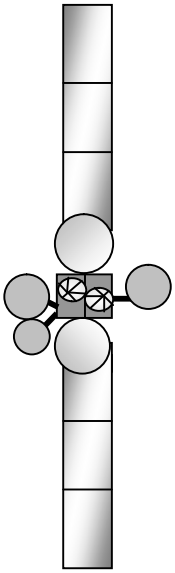


Fig.26
DirecTV-4S

eBird series

eBird satellite operated by Eutelsat is Europe's communication satellite series that provides internet protocol access network services to Scandinavia, Great Britain and Western and Eastern Europe. It was later renamed EuroBird 3**.**

eBird-1 (EuroBird 3.)

Development Agency **:** Boeing Space Systems, USA
Launch **:** 27 September 2003 from Kourou in French Guiana, France
Launch Vehicle **:** Ariane-5G
Orbit **:** GEO 33°E
Weight **:** 1530 kg
Payload **:** 20 active Ku band transponders
Stabilization **:** Spin stabilization
Operational lifetime **:** Design life of 10 years

Echostar series

Echostar satellites are operated by EchoStar Communications Corporation. Ten Echostar satellites namely Echostar-1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12 and -14, have been launched till date. The constellation of Echostar satellites provides Direct Broadband Satellite television services to America. Rainbow-1 satellite was purchased by EchoStar Communications Corporation in January 2005 from Cablevision. In March 2006, the satellite was renamed Echostar 12.

Echostar-1

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 28 Dec 1995 from Xichang launch center in China
Launch Vehicle : CZ-2E
Orbit : GEO 119 °W
Weight : 3287 kg
Payload : 16 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14-17 years

Echostar-2

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 10 September 1996 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : GEO 119°W
Weight : 2885 kg
Payload : 16 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14-17 years

Echostar-3 (Fig.27)

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 6 October 1997 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2AS
Orbit : GEO 61.5°
Weight : 3674 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14-17 years

Echostar-4

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 7 May 1998 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : Echostar 4 was launched to replace Echostar 1 at GEO 119°W. But due to satellite malfunction, it was not placed in that orbital slot
Weight : 3478 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Echostar-5

Development Agency : Space Systems Loral, USA
Launch : 23 September 1999 from Cape Canaveral launch center, USA

Launch Vehicle : Atlas-2AS
Orbit : GEO 110°W
Weight : 3602 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Echostar-6

Development Agency : Space Systems Loral company, USA
Launch : 14 July 2000 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2AS
Orbit : GEO 119°W
Weight : 3700 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Echostar-7 (Fig.28)

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 21 Feb 2002 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-3B
Orbit : GEO 119 °W
Weight : 4026 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Echostar-8

Development Agency : Space Systems Loral, USA
Launch : 22 August 2002 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : GEO 110 °W
Weight : 4660 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Echostar-9 (Telstar-13)

Development Agency : Space Systems Loral, USA
Launch : 8 August 2003 from the Sea Launch platform positioned on the equator on the pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 121°W
Weight : 4737 kg
Payload : 2 Ka**,** 32 Ku and 24 C band transponders
Stabilization : 3-axis stabilization

Operational life : Design life of 15 years

Echostar-10 (Fig.29)

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 15 February 2006 from the Sea Launch platform positioned on the Equator on the Pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 110°W
Weight : 4333 kg
Payload : 42 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Echostar-11

Development Agency : Space Systems Loral, USA
Launch : 16 July 2008 from the Sea Launch platform positioned on the Equator on the Pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 110°W
Weight : 5511 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Echostar-12

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 17 July 2003 from the Cape Canaveral launch center, USA
Launch Vehicle : Atlas-5
Orbit : GEO 61.5°W
Weight : 4328 kg
Payload : 36 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 18 years

Echostar-14

Development Agency : Space Systems Loral, USA
Launch : 20 March 2010 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 119°W
Weight : 6379 kg
Payload : 103 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

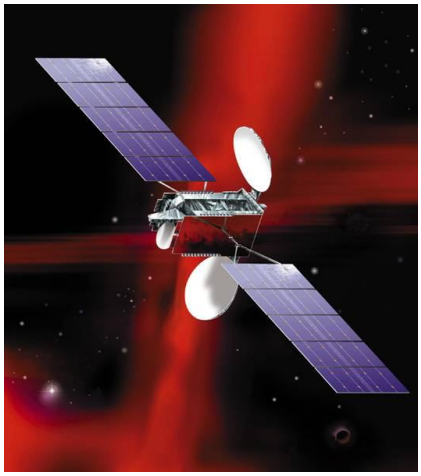


Fig.27
Echostar-3

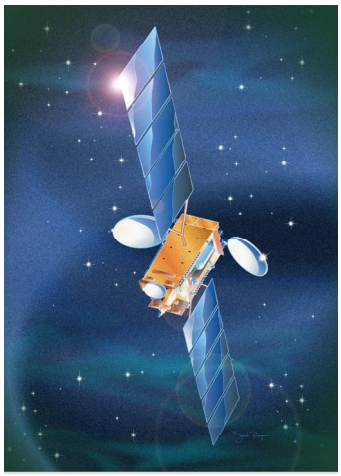


Fig.28
Echostar-7
(Courtesy: Lockheed Martin)

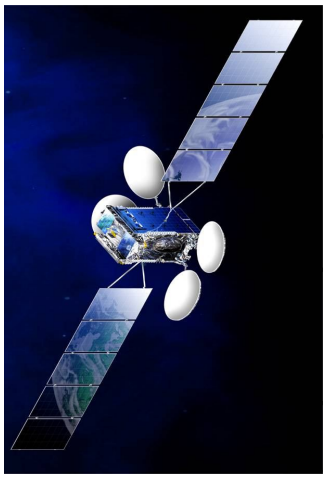


Fig.29
Echostar-10

Ekran series

Ekran and Ekran-M series of satellites are Russia's Direct Broadcasting communication satellites. Ekran series comprises of 17 satellites, Ekran-1 to Ekran-17, with the last satellite in the series Ekran-17 launched in the year 1988. Ekran-M series of satellites comprise of six satellites namely the Ekran-M 11L, Ekran-M 13L, Ekran-M 12L, Ekran-M 14L, Ekran-M 15L and Ekran-M 18L (Fig.30), each having only a single TV-relay channel, which is small compared to modern communications satellites equipped with dozens of transponders. Ekran M-18L, the last satellite of the Ekran M series, is currently operational. It provides TV and sound radio distribution services to communal antennas in Siberia and Far East Russia.

Ekran-M 4 (Ekran-M 18L)

Development Agency : NPO Prikladnoy Mekhaniki of Russia
Launch : 7 April 2001 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 99°E
Weight : 2100 kg
Payload : 1 active and 1 spare UHF transponders, C band uplink payload
Stabilization : 3-axis stabilization
Operational life : Design life of 9 years

Eurasiasat series

Eurasiasat-1 satellite, operated by Eurasiasat, provides high-powered Ku band BSS coverage from Western Europe to Central Asia, including Middle East and Russia, with an overlap over Turkey.

Eurasiasat-1 (Türksat 2A)

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch : 10 January 2001 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44P
Orbit : GEO 42°E
Weight : 3535 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eurobird series

Eutelsat communications operates a fleet of satellites namely Atlantic Bird, Hotbird, Eurobird, Seasat and Eutelsat, providing communication services to Europe, the Middle East and Africa, south-west Asia and North and South America. It offers TV and radio broadcasting services, corporate network solutions and a portfolio of IP applications including distribution of multimedia content, broadband internet access and internet backbone connections. Eurobird satellites provide direct broadcasting communication services to UK and business communication services to continental Europe.

Eurobird-1 (Fig.31)

Development Agency : Alcatel Space Industries, France
Launch : 8 March 2001 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 28.5°E
Weight : 3050 kg
Payload : 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eurobird-2

Hotbird-5 satellite was renamed as Eurobird-2, then as Arabsat-2D and currently it is renamed as Badr 2. .

Eurobird-3

eBird-1 satellite was renamed Eurobird-3.

Eurobird-4, -10

Hot Bird 3 was renamed Eurobird 10 in October 2006, Eurobird 4 in February 2009 and Eutelsat W75 in late 2009.

Eurobird-9

Hot Bird 2 was renamed Eurobird 9 in May 2007 and Eutelsat W48 in late 2009.

Eurobird-16

Hot Bird 4 was renamed Nilesat 103, when it was leased to Nilesat in September 2005. In June 2006 it returned to use by Eutelsat as Atlantic Bird 4. Latter it was renamed Eurobird-16.

Euobird-4A

Eutelsat-W1 satellite was renamed as Eurobird-4A.

Eurobird-9A

Hot Bird 7A was renamed Eurobird 9A in February 2009.

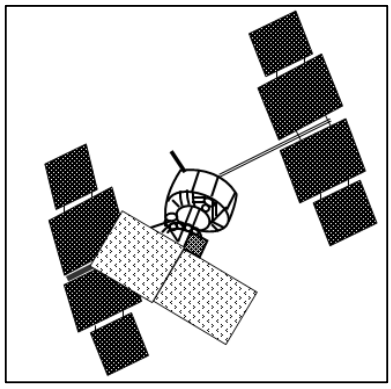


Fig.30
Ekran-M4

Fig.31
Eurobird-1 (Courtesy: Eutelsat)

Europe*Star series

Europe*Star series of satellites comprises of Europe*Star-1 and Europestar-B. Europe*Star-1 provides broadband services to Europe, Southern Africa, the Middle East, the Indian subcontinent and South East Asia. Europe*Star-B provides point-to-point connections such as internet backbone circuits, TV and telephony services to Europe.

In July 2005, Europe*Star-1 satellite was sold to Panamsat in July 2005, who renamed it as PAS-12. Latter Panamsat was acquired by Intelsat and the name of the PAS-12 satellite was changed to Intelsat 12 in February 2007.

Europe*Star-1 (PAS-12)

Development Agency : Alcatel Space, France and Space Systems Loral, USA
Launch : 29 October 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 47.5°E
Weight : 4167 kg
Payload : 30 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Europe*Star-B

Koreasat-1 satellite was sold to Europe*Star as Europe*Star-B.

Eutelsat series

Eutelsat Communications operates a fleet of satellites namely Atlantic Bird, Hotbird, Eurobird, Seasat and Eutelsat, providing communication services to Europe, the Middle East, and Africa, south-west Asia and North and South America. It offers TV and radio broadcasting services, corporate network solutions and a portfolio of IP applications including distribution of multimedia content, broadband internet access and internet backbone connections. Eutelsat satellite fleet comprises of Eutelsat-1F series, Eutelsat-2F and Eutelsat-W series of satellites. Eutelsat-1F and -2F series comprises of five satellites each (Eutelsat -1F1, -1F2, -1F3, -1F4, -1F5 and Eutelsat-2F1, -2F2, -2F3, -2F4 and -2F5). Eutelsat-W series comprises of Eutelsat-W1, -W2, -W2A, -W2M -W3, -W3A, -W4, -W48, -W5, -W7 and -W75, and satellites. Eutelsat-W satellites are also referred to as W-series satellites.

Eutelsat-2F1, -2F2, -2F3, -2F4, -2F5, -2F6
(Eutelsat-2F6 has been included in the Hot Bird satellite family as Hot Bird-1)

Development Agency **:** Aerospatiale Company, France (now Alcatel Space, France)
Launch
Eutelsat -2F1 **:** 30 August 1990
Eutelsat -2F2 **:** 16 January 1991
Eutelsat -2F3 **:** 7 December 1991
Eutelsat -2F4 **:** 10 August 1992
Futelsat -2F5 **:** 24 January 1994
Eutelsat -2F1, -2F2, -2F4 and -2F5 were launched on Ariane-44L from Kourou in French Guiana, France and Eutelsat-2F3 was launched from Cape Canaveral launch center, USA on Atlas-2
Orbit
Eutelsat-2F1 **:** GEO 76°E (last before being deorbited)
Eutelsat-2F2 **:** GEO 48°E
Eutelsat-2F3 **:** GEO 21.5°E (last before being deorbited)
Eutelsat-2F4 **:** GEO 12.5°W (last before being deorbited)
Eutelsat-2F5 **:** Launch Failure
Weight **:** 1878 kg each
Payload **:** 16 active Ku band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 12 years

Eutelsat-W1 (Eurobird-4A)

Eutelsat-W1 was originally built as Orion-2, but was later bought by Eutelsat as spare satellite and was called RESSAT (renamed Eutelsat-W1). It provides business communication services, internet-based services and television transmission throughout Europe, North Africa, the Middle East and central Asia. It was latter renamed Eurobird-4A.

Development Agency **:** Europe's space company Astrium Space
Launch **:** 6 September 2000 from Kourou in French Guiana, France

Launch Vehicle : Ariane-44P
Orbit : GEO 10°E
Weight : 3250 kg
Payload : 28 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eutelsat-W2, -W3, -W5 (Fig.32)

Eutelsat-W2, -W3 and -W5 satellites provide communication services over Europe, North Africa and Middle East. Eutelsat-W3 was renamed Eutelsat-W6 in November 2004.

Development Agency : Alcatel Space, France
Launch
Eutelsat-W2 : 5 October 1998
Eutelsat-W3 : 12 April 1999
Eutelsat-W5 : 20 November 2002
Eutelsat-W2 was launched on Ariane-44L from Kourou in French Guiana, France and Eutelsat-W3 and -W5 were launched from Cape Canaveral launch center, USA on Atlas-2AS and Delta-4M respectively
Orbit
Eutelsat-W2 : GEO 16°E
Eutelsat-W3 : GEO 21.5°E
Eutelsat-W5 : GEO 70.5°E
Weight
Eutelsat-W2 : 2965 kg
Eutelsat-W3 : 3180 kg
Eutelsat-W5 : 3170 kg
Payload : 24 active Ku band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eutelsat-W4

Eutelsat-W4 satellite provides communication services to Western Russia.

Development Agency : Alcatel Space, France
Launch : 24 May 2000 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-3A
Orbit : GEO 36°E
Weight : 2950 kg
Payload : 31 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eutelsat-W2A

Eutelsat-W2A satellite provides extended Ku-band capacity for video, broadband and telecommunications services in Europe, Africa and the Middle East, and boosts the C-band capacity available through Eutelsat's fleet for services across Africa.

Development Agency : Alcatel Alenia Space, France
Launch : 3 April 2009 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 10°E
Weight : 2950 kg
Payload : 46 Ku band and 10 C band transponders, S band payload
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Eutelsat-W2M

Eutelsat-W2M satellite offers fixed beam coverage to Europe, North Africa and the Middle East, as well as steerable beam coverage which can be re-oriented in orbit according to market requirements mainly towards Africa and central Asia.

Development Agency : Europe's EADS Astrium Systems and ISRO, India
Launch : 20 December 2008 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 15.8°E
Weight : 3460 kg
Payload : 32 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Eutelsat-W3A

Eutelsat-W3A provides telecommunications services including digital DVB broadcasting, multimedia, broadband access and pay-per-use bandwidth for corporate networks over a large zone covering Europe and Africa.

Development Agency : Europe's Space Company Astrium Systems
Launch : 15 March 2004 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 7°E
Weight : 4300 kg
Payload : 38 Ku band and 2 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Eutelsat-W7

Eutelsat-W7 satellite provides communication services to Europe, Russia, Africa, the Middle East and central Asia.

Development Agency : Alcatel Alenia Space, France
Launch : 24 November 2009 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 36°E
Weight : 5627 kg

Payload : 70 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Eutelsat W75

Hot Bird 3 was renamed Eurobird 10 in October 2006, Eurobird 4 in February 2009 and Eutelsat W75 in late 2009.

Eutelsat W48

Hot Bird 2 was renamed Eurobird 9 in May 2007 and Eutelsat W48 in late 2009.

Fig.32
Eutelsat-W2, -W3 and -W5 satellites (Courtesy: Eutelsat)

Ekspress series

The Ekspress-series of satellites have been operational in the Intersputnik system since the launch of Ekspress-1 satellite in October 1994. These satellites, developed by NPO PM (Russia), were launched for the purpose of replacing the Gorizont satellites. The second Ekspress satellite, Ekspress-2, had been operational at 80° East from September 1996 to May 2000 and was replaced with a new generation Ekspress-A (Ekspress-A1, -A1R, -A2 and -A3) series of satellites. Ekspress-A satellites provide fixed satellite services including television and radio programming, telephony, data, video conferencing and internet services.

Recent addition to the fleet of Ekspress-A satellites are the Ekspress-AM and Ekspress-MD series of satellites. They provide domestic communication services to Russia. Seven Ekspress-AM satellites namely Ekspress-AM1, -AM2, -AM3, -AM11 and -AM22, -AM 33 and -AM44 satellites have been launched. One satellite in Ekspress-MD series, Ekspress-MD 1, has been launched. They provide interactive TV broadcasting, radio broadcasting and multi-media broadcasting services. Future launches include Ekspress-AT 1 and Ekspress-MD 2 satellites.

Ekspress-A1, -A1R, -A2 and -A3

Development Agency : NPO PM, Russia and Alcatel Espace, France
Launch
Ekspress-A1 : 27 October 1999
Ekspress-A1R : 10 June 2002
Ekspress-A2 : 12 March 2000

Ekspress-A3 **:** 24 June 2000
All the satellites were launched by Proton-DM 01 from Baikonur cosmodrome in Kazakhstan
Orbit
Ekspress-A1 **:** Failed to reach orbit
Ekxpress-A1R **:** GEO 40°E
Ekspress- A2 **:** GEO 80°E
Ekxpress-A3 **:** GEO 11°W
Weight **:** 2600 kg each
Payload **:** 12 C band and 5 Ku band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 10 years

Ekspress-AM1, -AM2, -AM3, -AM11, -AM22

Development Agency
Ekspress-AM1 **:** NPO PM, Russia and NEC, Japan
Ekspress-AM2, -AM3, -AM11, -AM22
NPO PM, Russia and Alcatel Espace, France
Launch
Ekspress-AM1 **:** 30 October 2004
Ekspress-AM2 **:** 29 March 2005
Ekspress-AM3 **:** 24 June 2005
Ekspress-AM11 **:** 26 April 2004
Ekspress-AM22 **:** 28 December 2003
All the satellites were launched by Proton-K from Baikonur cosmodrome in Kazakhstan
Orbit
Ekspress-AM1 **:** GEO 40°E
Ekspress-AM2 **:** GEO 80°E
Ekspress-AM3 **:** GEO 40°E
Ekspress-AM11 **:** Disposable orbit as it was not working properly
Ekspress-AM22 **:** GEO 53°E
Weight **:** 2600 kg each
Payload
Ekspress-AM1 **:** 18 Ku band, 9 C band and 1 L band transponders
Ekspress-AM2 **:** 12 Ku band, 16 C band and 1 L band transponders
Ekspress-AM3 **:** 12 Ku band, 16 C band and 1 L band transponders
Ekspress-AM11 **:** 4 Ku band and 26 C band transponders
Ekspress-AM22 **:** 24 Ku band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 12 years

Ekspress-AM33, -AM44

Development Agency **:** NPO PM, Russia and Alcatel Espace, France
Launch
Ekspress-AM33 **:** 28 January 2008
Ekspress-AM44 **:** 11 February 2009
Both the satellites were launched by Proton-K from Baikonur cosmodrome in Kazakhstan
Orbit
Ekspress-AM33 **:** GEO 96.5°E

Ekspress-AM44 : GEO 11°W
Weight
Ekspress-AM33 : 2600 kg
Ekspress-AM44 : 2532 kg
Payload : 6 Ku band, 10 C band and 1 L band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Ekspress-MD 1

Development Agency : Alcatel Alenia Space, Italy and Khrunichev State Research and Production Space Centre, Russia
Launch : 11 February 2009 from Baikonur cosmodrome in Kazakhstan
Launch vehicle : Proton-M
Orbit : GEO 80°E
Weight : 1140 kg
Payload : 8 C band and 1 L band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

Galaxy series

Galaxy satellites was owned and operated by PanAmSat global satellite system provides satellite communication services to America, Europe, Africa, the Middle East and Asia and television, voice and data communication services to America. PanAmSat has been acquired by Intelsat in 2006. The first Galaxy satellite Galaxy-1, launched in 1983, revolutionized the U.S. television industry by delivering TV channels to cable service providers throughout the country. Since then Galaxy-1, -1R1, -1R2, -2, -3, -4, -5, -6, -7, -8i, -8iR, -3C, -3R, -4R, -10R, -9, -10, -10R, -11, -12, -13, -14, -15, -16, -17, -18, -19, -23, -25, -26, -27 and -28 satellites have been launched.

Galaxy-3R (Galaxy-8)

Galaxy-3R (Fig.33) satellite provides video and telecommunication services to USA. It can also provide Ku-band services to Latin America.

Development Agency : Hughes Space and Communication Company, USA (now Boeing Satellite Systems)
Launch : 14 December 1995 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2A
Orbit : GEO 95°W
Weight : 3069 kg
Payload : 24 active and 6 spare C band transponders and 24 active and 6 spare Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 8 years

Galaxy-9 (Fig.34)

Galaxy-9 is an in-orbit spare satellite.

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 23 May 1996 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-II
Orbit : GEO 91°W
Weight : 1397 kg
Payload : 24 active and 6 spare C band transponders
Stabilization : Spin stabilization
Operational life : Design life of 12 years

Galaxy-8i

Galaxy-8i satellite provides communication services to Mexico, Central and South America and Caribbean.

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 8 December 1997 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2AS
Orbit : GEO 95°W
Weight : 3537 kg
Payload : 32 active and 8 spare Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-10

Galaxy-10 satellite provides analog and digital television and other satellite communication services to USA

Development Agency : Hughes Space and Communications company, USA (now Boeing Satellite Systems)
Launch : 26 August 1998 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-III
Orbit : GEO 123°W
Weight : 3876 kg
Payload : 24 active and 6 spare C band transponders and 24 active and 6 spare Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Galaxy-11 (Fig.35)

Galaxy-11 satellite provides video and telecommunication services to North America and Brazil

Development Agency : Hughes Space and Communications Systems, USA (now Boeing Satellite Systems)
Launch : 21 December 1999 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L

Orbit : Initially GEO 99°W then shifted to 91° W
Weight : 4477 kg
Payload : 24 active and 6 spare C band transponders, 40 active and 10 spare Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-10R

Galaxy-10R satellite provides analog and digital television and other satellite communication services to USA

Development Agency : Hughes Space and Communications Systems, USA (now Boeing Satellite Systems)
Launch : 24 January 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42L
Orbit : GEO 123°W
Weight : 3475 kg
Payload : 24 C band and 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-4R

Galaxy-4R (Fig.36) satellite provides broadcast and telecommunication services to North America and back-up service to Latin America.

Development Agency : Hughes Space and Communication Systems, USA (now Boeing Satellite Systems)
Launch : 18 April 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42L
Orbit : GEO 99°W
Weight : 3668 kg
Payload : 24 C band and 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-3C

Galaxy-3C satellite provides communication services to United States and Latin America

Development Agency : Boeing Satellite Systems, USA
Launch : 15 June 2002 from the Sea Launch platform in the Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 95°W
Weight : 4810 kg
Payload : 24 active C band and 53 active Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-12

Galaxy-12 satellite provides cable, HDTV, video-on-demand and other digital services to North America

Development Agency : Orbital Sciences Corporation, USA
Launch : 8 April 2003 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 125°W
Weight : 1760 kg
Payload : 24 C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-13

The satellite (Fig.37) carries a total of 48 active transponders, 24 in Ku-band and 24 in C-band. The Ku-band payload is named Horizons-1 and is jointly owned by PanAmSat and JSAT. It offers a variety of digital video, internet and data services to United States and Asia. The C-band portion of the satellite is known as Galaxy-13. It serves the domestic U.S. cable industry.

Development Agency : Boeing Satellite Systems, USA
Launch : 30 September 2003 from Sea Launch Platform in Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 127°W
Weight : 4060 kg
Payload : 24 active and 8 spare C band transponders and 24 active and 8 spare Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-14

Galaxy-14 satellite provides digital video programming, High-Definition television (HDTV), Video on Demand (VOD) and IPTV services to the United States.

Development Agency : Orbital Sciences Corporation, USA
Launch : 13 August 2005 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Soyuz-FG
Orbit : GEO 125°W
Weight : 2087 kg
Payload : 24 C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-15

Galaxy-15 satellite provides digital video programming, High-Definition television (HDTV), Video on Demand (VOD) and IPTV services to the United States

Development Agency : Orbital Sciences Corporation, USA
Launch : 13 October 2005 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5GS
Orbit : GEO 133°W
Weight : 2033 kg
Payload : 24 C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-16, -18

Galaxy-16 and -18 satelites serve United States, Alaska, Hawaii, Puerto Rico, Canada and Mexico.

Development Agency : Space Systems Loral, USA
Launch
Galaxy-16 : 18 June 2006
Galaxy-18 : 21 May 2008
Both the satellites were launched from launched from Sea launch platform by Zenit-3SL
Orbit
Galaxy-16 : GEO 99°W
Galaxy-18 : GEO 123°W
Weight
Galaxy-16 : 4640 kg
Galaxy-18 : 4642 kg
Payload : 24 C band and 24 Ku band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-17

Development Agency : Alcatel Alenia Space, France
Launch : 5 May 2007 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 91°W
Weight : 4100 kg
Payload : 24 C band and 24 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Galaxy-19

Intelsat changed the name of the Intelsat Americas 9 satellite to Galaxy 19 in February 2007.

Galaxy-23

Intelsat changed the name of the Intelsat Americas 13 satellite to Galaxy 23 in February 2007.

Galaxy-25, 26, 27

Intelsat changed the name of the Intelsat Americas 5, 6 and 7 satellites to Galaxy 25, 26 and 27 respectively in February 2007.

Galaxy-28

Intelsat changed the name of the Intelsat Americas 8 satellite to Galaxy 28 in February 2007.

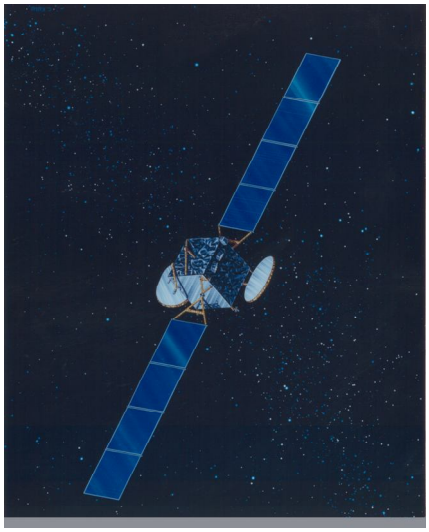


Fig.33
Galaxy-3R (Courtesy: Intelsat)

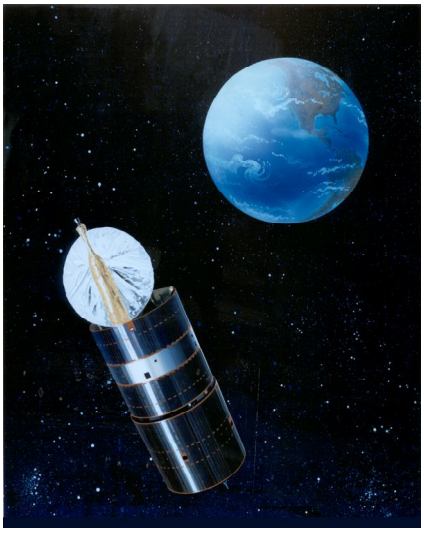


Fig.34
Galaxy-9 (Courtesy: Intelsat)

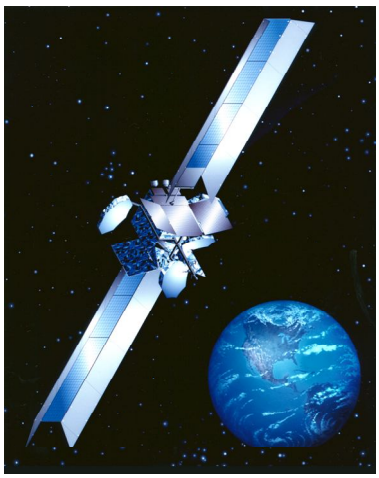


Fig.35
Galaxy-11 (Courtesy: Intelsat)

Fig.36
Galaxy-4R (Courtesy: Intelsat)

Fig.37
Galaxy-13 (Courtesy: Intelsat)

Gals series

Gals satellites are Russian communication satellites providing a variety of direct broadcasting communication services. These satellites are operated by Intercosmos, Russia. Two Gals satellites have been launched. These include Gals-1 and -2.

Development Agency **:** NPO Prikladnoi Mekhaniki (NPO-PM), Russia
Launch
Gals-1 **:** 20 January 1994
Gals-2 **:** 17 November 1995
Both these satellites were launched from Baikonour Cosmodrome in Kazakhstan on Proton-K
Orbit
Gals-1 **:** GEO 70°E
Gals-2 **:** GEO 70°E
Weight **:** 2500 kg each
Payload **:** 3 Ku band transponders each
Stabilization **:** 3-axis stabilization
Operational lifetime **:** Design life of 7 years

Garuda series

Garuda series of satellites, operated by Asia Cellular Satellite (ACeS) are Indonesia's communication satellites. Garuda-1, the first satellite of the ACeS system of satellites, serves the GEO satellite-based mobile telephone communications market in Asia. The second ACeS satellite, Garuda-2, was to serve as a back-up to Garuda-1 satellite, but its launch was latter cancelled.

Garuda-1

Development Agency **:** Lockheed Martin Missiles and Space, USA
Launch **:** 12 February 2000 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle **:** Proton-K
Orbit **:** GEO 123°E
Weight **:** 4500 kg
Payload **:** 88 active and 22 spare L band transponders
Stabilization **:** 3-axis stabilization
Operational lifetime **:** Design life of 12 years

Gonets series

Gonets are communication satellites from Russia operated by SmolSat. Three series of Gonets satellites namely the Gonets-D series, Gonets-D1 series and Gonets-D1M series have been launched. Gonets-D series comprised of Gonets-D 1 (Kosmos 2199) and Gonets-D 2 (Kosmos 2201) satellites. These satellites are no longer in service now. Gonets-D1 series comprises of 12 satellites, Gonets-D1 1 to Gonets-D1 12. Gonets-D1M are upgraded versions of Gonets-D1 satellites. One satellite, Gonets-D1M 1 has been launched in this series.

Gonets-D1 1 to Gonets-D1 12

Development Agency : NPO PM, Russia
Launch
Gonets-D1 1, -D1 2, -D1 3
19 February 1996
Gonets-D1 4, -D1 5, -D1 6
14 February 1997
Gonets-D1 7, -D1 8, -D1 9
28 December 2000
Gonets-D1 10, -D1 11, -D1 12
28 December 2001
All these satellites were launched from Plesetsk Cosmodrome in Russia on Tsiklon-3
Orbit
Gonets-D1 1 6, -D1 10, -D1 11, -D1 12
LEO Circular, 82.6^0 Mean Altitude of 1400 km
Gonets-D1 7, -D1 8, -D1 9
Launch Failure
Weight
Gonets-D1 1, -D1 2, -D1 3
250 kg each
Gonets-D1 4, -D1 5, -D1 6, -D1 7, -D1 8, -D1 9, -D1 10, -D1 11, -D1 12
225 kg each
Payload **:** 16 Ku band transponders each
Stabilization **:** Gravity gradient stabilization
Operational life **:** Design life of 5 years

Gonets-D1M 1

Development Agency : NPO PM of Russia
Launch **:** 21 December 2005 from Plesetsk Cosmodrome in Russia
Launch vehicle **:** Kosmos-3M
Orbit **:** LEO Circular, 82.6^0 Mean Altitude of 1400 km
Weight **:** 280 kg
Stabilization **:** Gravity gradient stabilization
Operational life **:** Design life of 5 years

Gorizont series

Gorizont satellites, operated by intersputnik, are Russian communication satellites. These satellites provide civilian and military telephone, telegraph, facsimile, TV and radio services. They also supports maritime and international communications. Till date 33 Gorizont satellites have been launched. These include Gorizont-1 to Gorizont-33.

Gorizont-31, -32, -33

Development Agency : NPO PM, Russia
Launch
Gorizont-31 **:** 25 January 1996

Gorizont-32 **:** 25 May 1996
Gorizont-33 **:** 6 June 2000
All the three satellites were launched from Baikonour Cosmodrome in Kazakhstan on Proton-K
Orbit
Gorizont-31 **:** GEO 140°E
Gorizont-32 **:** GEO 14°W
Gorizont-33 **:** GEO 145°E
Weight **:** 2300±25 kg
Payload **:** 6 C Band and 1 Ku Band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3 years

GSat series

GSat satellites, operated by Indian Space Research Organization (ISRO) are Indian experimental satellites. Till date three GSat satellites namely GSat-1, -2 and -3 have been launched on board the developmental test flights of India's Geosynchronous Satellite Launch Vehicle (GSLV). GSat-1 and -2 satellites are used for demonstrating digital audio broadcast, internet services, compressed digital TV experiments and developmental communication. They are also used to prove new spacecraft elements like Newton Reaction Control Thrusters, Fast Recovery Star Sensors and Heat Pipe Radiator Panels to validate them before using them in the operational ISRO satellites like IRS and INSATs. GSAT-3 or EDUSAT is the first Indian satellite built exclusively for serving the educational sector. It is mainly intended to meet the demand for an interactive satellite based distance education system for the country.

The launch of GSat-4 in April 2010 failed as the launch vehicle failed to deliver the satellite. GSat-5, -6, -7 and -8 are INSAT-4D, -4E, -4F and -4G satellites respectively scheduled for launch in the next 5 years.

GSat-1 (Fig.38)

Development Agency **:** ISRO, India
Launch **:** 18 April 2001 from Sriharikota Space Center (SHAR), India
Launch Vehicle **:** GSLV-D1
Orbit **:** Failed to reach the intended orbit
Weight **:** 1540 kg
Payload **:** 3 C Band and 2 S Band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3-5 years

GSat-2 (Fig.39)

Development Agency **:** ISRO, India
Launch **:** 8 May 2003 from Sriharikota Space Center (SHAR), India
Launch Vehicle **:** GSLV-D2
Orbit **:** GEO 48°E
Weight **:** 1800 kg
Payload **:** 4 C-Band and 2 Ku-band transponders, MSS payload, Total Radiation Dose Monitor (TRDM), Surface Charge Monitor (SCM), Solar X-

ray Spectrometer (SOXS), Coherent Radio Beacon Experiment (CRABEX)

Stabilization : 3-axis stabilization
Operational life : Design life of 3-5 years

GSat-3 (Fig.40)

Development Agency : ISRO, India
Launch : 20 September 2004 from Sriharikota Space Center (SHAR), India
Launch Vehicle : GSLV-D2
Orbit : GEO 74°E
Weight : 1950 kg
Payload : 6 Ku band and 6 extended C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years

GSat-4 (HealthSat)

Development Agency : ISRO, India
Launch : 15 April 2010 from Sriharikota Space Center (SHAR), India
Launch Vehicle : GSLV-D2
Orbit : Launch Failed
Weight : 2220 kg
Payload : Ka band transponder and GAGAN navigation payload
Stabilization : 3-axis stabilization
Operational life : Design life of more than 7 years

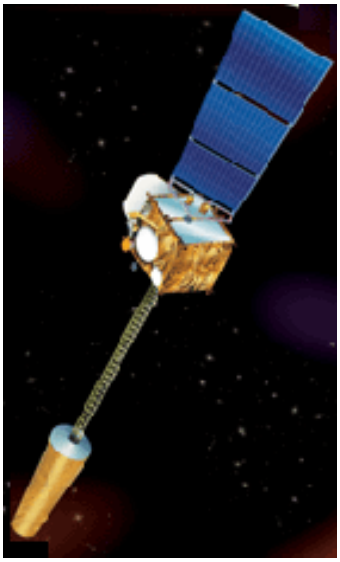


Fig.38
GSat-1 (Courtesy: ISRO)

Fig.39
GSat-2 (Courtesy: ISRO)

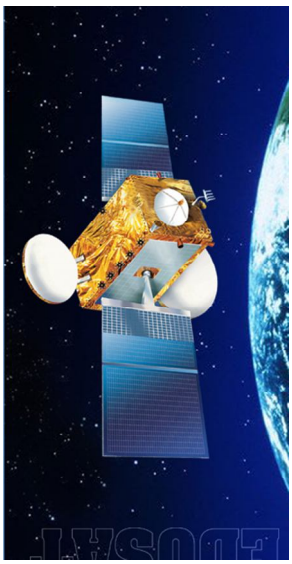


Fig.40
GSat-3 (Courtesy: ISRO)

GStar series

GStar satellites, operated by SES Americom Systems, are USA's communication satellites. Till date four GStar satellites namely GStar-1, -2, -3 and -4 have been launched.

GStar-4

Development Agency : GE Astro Space
(now Lockheed Martin Commercial Space Systems, USA)
Launch : 20 November 1990 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : GEO 125°W (Moved to 105°W two years after launch)
Weight : 1270 kg
Payload : 16 Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years. The satellite was de-orbited in February 2004

Hispasat series

Hispasat satellites are Spain's communication satellites operated by Hispasat. Four Hispasat satellites namely Hispasat-1a, -1b, -1c and -1d have been launched. Hispasat-1a and -1b provide civil and military communication services, offering services to telecommunications operators and radio broadcasting both in Europe, North Africa and America. These satellites have X-band payload, which are used by the Spanish ministry of defence for communicating with Spanish forces. Hipsasat-1c and -1d provide civil communication services. Figure 41 and 42 show Hispasat-1c and -1d satellites respectively during construction. Figure 43 shows Hispasat satellites in orbit. Hispasat-1e and -AG1 satellites are scheduled to be launched in the near future.

Hispasat-1a, -1b

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch
Hispasat-1a : 10 September 1992
Hispasat-1b : 22 July 1993
Both the satellites were launched from Kourou in French Guiana, France on Ariane-44LP and Ariane-44L respectively
Orbit : GEO 30°W
Weight
Hispasat-1a : 2194 kg
Hispasat-1b : 2120 kg
Payload : 3 active and 1 spare X Band and 12 active and
6 spare Ku Band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

Hispasat-1c, -1d

Development Agency : Alcatel Space Systems, France
Launch
Hispasat-1c : 3 February 2000
Hispasat-1d : 18 September 2002
Both the satellites were launched from Cape Canaveral launch center, USA on Atlas-2AS
Orbit : GEO 30°W
Weight
Hispasat-1c : 3113 kg
Hispasat-1d : 3250 kg
Payload
Hispasat-1c : 24 Ku Band transponders
Hispasat-1d : 28 Ku Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Fig.41
Hispasat-1c construction (Courtesy: Hispasat)

Fig.42
Hispasat-1d construction

Fig.43
Hispasat satellite in orbit
(Courtesy: Hispasat)

Hot Bird series

Eutelsat Communications operates a fleet of satellites namely Atlantic Bird, Hotbird, Eurobird, Seasat and Eutelsat, providing communication services to Europe, the Middle East, Africa, south-west Asia and North and South America. It offers TV and radio broadcasting services, corporate network solutions and a portfolio of IP applications including distribution of multimedia content, broadband internet access and internet backbone connections. Hot Bird series of satellites provide analogue and digital television, radio and multimedia services to Europe, North Africa and large areas of the Middle East. The first satellite to be launched in this series was Hot Bird-1 in 1995 (Eutelsat 2-F6 satellite is included in the Hotbird satellite family as Hotbird-1). Since then seven Hotbird satellites namely Hot Bird-2, -3, -4, -5, -6, -7 and -7A have been launched. The next satellite to be launched in this series is Hot Bird-8 in the near future.

Hot Bird-1

Eutelsat 2-F6 was included in the Hotbird satellite family as Hotbird-1.

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch : 28 March 1995 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 13°E
Weight : 1780 kg
Payload : 16 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 11 years

Hot Bird-2, -3, -4, -5 (Fig.44)

Arabsat has leased Eutelsat's Hotbird-2 satellite. It was renamed Arabsat-2D. Hotbird-4 was renamed Nilesat-103, when it was leased to Nilesat in September 2005.

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch
Hot Bird-2 : 21 November 1996
Hot Bird-3 : 2 September 1997
Hot Bird-4 : 27 February 1998
Hot Bird-5 : 9 October 1998
Hot Bird-2 and -5 were launched from Cape Canaveral launch center, USA on Atlas-2A and Hot Bird-3 and -4 were launched from Kourou in French Guiana, France on Ariane-44LP and Ariane-42LP respectively
Orbit
Hot Bird-2, -3, -4 : GEO 13°E. Hotbird-4 was later moved to 7°W
Hot Bird -5 : GEO 26°E
Weight
Hot Bird-2, -3, - 4 : 2900 kg each
Hot Bird-5 : 3000 kg
Payload
Hot Bird-2 : 26 Ku band transponders

Hot Bird-3 : 32 Ku band transponders
Hot Bird-4 : 28 Ku band transponders
Hot Bird-5 : 22 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Hot Bird-6

Development Agency : Alcatel Space Systems, France
Launch : 21 August 2002 from Cape Canaveral launch center in USA
Launch Vehicle : Atlas-5
Orbit : GEO 13°E
Weight : 3990 kg
Payload : 28 Ku and 4 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Hot Bird-7 (Failed during launch)

Development Agency : Europe's Space Company Astrium Systems
Launch : 11 Dec 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5
Orbit : Planned to be at GEO 13°E
Weight : 3400 kg
Payload : 40 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

HotBird-7A (Fig.45)

Hotbird-7A was launched to compensate for the loss of Hotbird-7 satellite.

Development Agency : Alcatel Alenia Space, France
Launch : 11 March 2006 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5
Orbit : GEO 13°E
Weight : 4100 kg
Payload : 38 Ku band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Hot Bird-8, -9, -10

Hot Bird -8, -9 and -10 are identical satellites launched with an aim to provide television, radio and interactive services to Europe, North Africa and the Middle East. Hot Bird 10 satellite is initially comissioned as Atlantic Bird 4A, but will revert to it's Hot Bird 10 designation when the Atlantic Bird 7 satellite becomes operational.

Development Agency : European company EADS Astrium

Launch
Hot Bird-8 **:** 4 August 2006
Hot Bird-9 **:** 20 December 2008
Hot Bird-10 **:** 12 February 2009
Hot Bird-8 was launched from Baikonour Cosmodrome in Kazakhstan on Proton-M and Hot Bird-9 and -10 were launched from Kourou in French Guiana, France on Ariane-5ECA.
Orbit
Hot Bird-8, 9 **:** GEO 13°E
Hot Bird -10 **:** GEO 7°W
Weight **:** 4875 kg each
Payload **:** 64 active Ku band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

Fig.44
Hotbird-2, -3, - 4, - 5 (Courtesy: Eutelsat)

Fig.45
Hotbird-7A (Courtesy: Eutelsat)

ICO series

ICO satellites (Fig.46), owned by ICO global communications, were developed to provide global mobile communication services using a constellation of 10 operational satellites and a global ground telecommunication network. The satellites were to be placed in medium earth orbit (MEO) at 45° inclination. The system once operational would have provided a wide range of satellite based mobile telecommunication services through handheld and fixed phones. Two satellites, ICO-F1 and ICO-F2 were launched in the year 2000 and 2001 respectively out of which the launch of ICO-F1 failed. The plan to launch a constellation of MEO satellites has been replaced by the concept of using geostationary satellites. One geostationary satellite ICO-G1 has been launched in the year 2008.

ICO-F1

Development Agency **:** Boeing Satellite Systems, USA
Launch **:** 12 March 2000 from Sea Launch
Launch Vehicle **:** Zenit-3SL
Orbit **:** Launch Failure
Weight **:** 2750kg
Payload **:** Integrated S and C band payload

Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 12 years

ICO-F2

Development Agency **:** Boeing Satellite Systems, USA
Launch **:** 19 June 2001 from Cape Canaveral launch center, USA
Launch Vehicle **:** Atlas-IIAS
Orbit **:** MEO, 45° Inclination, Mean Altitude of 10390 km
Weight **:** 2750kg
Payload **:** Integrated S and C band payload
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 12 years

ICO-G1

Development Agency **:** Space Systems Loral, USA
Launch **:** 14 April 2008 from Cape Canaveral launch center, USA
Launch Vehicle **:** Atlas-5
Orbit **:** GEO
Weight **:** 6634 kg
Payload **:** S band transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

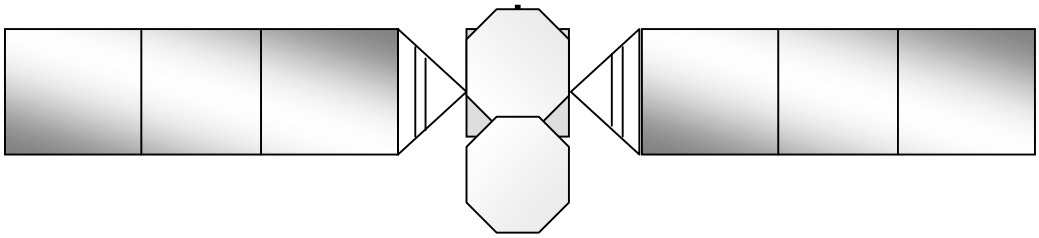


Fig.46
ICO series

Inmarsat

Inmarsat is the world's first global mobile satellite communication operator that offers a range of voice and multimedia communication services to ship owners and managers, journalists and broadcasters, health and disaster-relief workers, land transport fleet operators, airlines, airline passengers and air traffic controllers, government workers, national emergency and civil defence agencies, and peacekeeping forces. Inmarsat fleet comprises of Inmarsat-2, -3 and -4 series of satellites. Inmarsat-2 series comprises of four satellites (Inmarsat-2F1, -2F2, -2F3 and -2F4) and Inmarsat-3 series comprises of five satellites (Inmarsat -3F1, -3F2, -3F3, -3F4 and -3F5). Inmarsat-4 series is the fourth generation of Inmarsat communication system. Inmarsat-4 series comprises of three satellites namely Inmarsat-4F1, -4F2 and -4F3. .

Inmarsat-2

Inmarsat-2 (Fig.47) consists of four satellites Inmarsat-2F1, -2F2, -2F3 and -2F4

Development Agency : Inmarsat by British Aerospace (now part of Matra Marconi, France). Subcontractors included Hughes Aircraft company (US), Fokker (Netherlands), Matra (France), MBB (Germany), NEC (Japan) and Spar (Canada). -2 satellites were built by an international consortium headed

Launch

Inmarsat-2F1 : 30 October 1990
Inmarsat-2F2 : 8 March 1991
Inmarsat-2F3 : 16 December 1991
Inmarsat-2F4 : 15 April 1992

Inmarsat-2F1 and -2F2 were launched from Cape Canaveral launch center, USA by Delta-6925 and Inmarsat-2F3 and -2 F4 were launched from Kourou in French Guiana, France by Ariane-44L

Orbit (Launch Orbit)

Inmarsat-2F1 : GEO 65^0E (1990-1996), 179°E (1996-1999)
Inmarsat-2F2 : GEO 15^0W (1991-1996), 55°W (1997-1999)
Inmarsat-2F3 : GEO 178^0E (1992-1997), 65°E (1997-1999)
Inmarsat-2F4 : GEO 55^0W (1992-1997), 17°W (1997-1999)

Weight

Inmarsat-2F1, -2F2 and -2F4
1385 kg each
Inmarsat-2F3 : 1310 kg
Stabilization : 3-axis stabilization
Payload : 4 active L-band and 1 active C-band transponders
Operational Life : Design life of 10 years

Inmarsat-3

Inmarsat-3 (Fig.48) consists of five satellites namely Inmarsat-3F1, Inmarsat-3F2, Inmarsat-3F3, Inmarsat-3F4 and Inmarsat-3F5. These satellites provide voice and data communication services worldwide to mobile terminals as small as pocket-size messaging units on ships, aircraft and vehicles.

Development Agency : Lockheed Martin Astro Space (now Lockheed Martin Missiles & Space), USA and the European Marconi Space (now EADS Astrium)

Launch

Inmarsat-3F1 : 3 April 1996
Inmarsat-3F2 : 6 September 1996
Inmarsat-3F3 : 17 December 1996
Inmarsat-3F4 : 3 June 1997
Inmarsat-3F5 : 4 February 1998

Inmarsat-3F1 and -3F3 were launched from Cape Canaveral launch center, USA by Atlas-2A, Inmarsat-3F2 from Baikonur Cosmodrome in Kazakhstan by Proton-K and Inmarsat-3F4 and -3F5 were launched from Kourou in French Guiana, France by Ariane-44L

Stabilization : 3-axis stabilization

Orbit

Inmarsat-3F1 : GEO 64^0E
Inmarsat-3F2 : GEO 15.5^0W
Inmarsat-3F3 : GEO 179^0E

Inmarsat-3F4 : GEO 54^{0}W
Inmarsat-3F5 : GEO 25^{0}E
Weight
Inmarsat-3F1 : 2068 kg
Inmarsat-3F2, -3F3, -3F4, -3F5
1021 kg each
Payload : 22 L band transponders and C-band uplink

Inmarsat-4

Inmarsat-4 (Fig.49) satellites support the new Broadband Global Area Network (B-GAN) for internet and intranet solutions, video on demand, video conferencing, fax, email, telephone and high speed LAN access.
Development Agency : European company EADS Astrium
Launch
Inmarsat-4F1 : 11 March 2005
Inmarsat-4F2 : 8 November 2005
Inmarsat-4F3 : 18 August 2008
Inmarsat-4F1 was launched from Cape Canaveral launch center, USA by Atlas-5. Inmarsat-4F2 was launched from Sea launch platform by Zenit-3SL. Inmarsat-4F3 was launched from Baikonur Cosmodrome in Kazakhstan by Proton-M.
Stabilization : 3-axis stabilization
Orbit
Inmarsat-4F1 : GEO 65°E
Inmarsat-4F2 : GEO 53°W
Inmarsat-4F3 : GEO 98°W
Weight
Inmarsat-4F1 : 5959 kg
Inmarsat -4F2 : 5958 kg
Inmarsat -4F3 : 5960 kg
Operational life : Design life of 13 years

Fig.47
Inmarsat-2 (Courtesy: Inmarsat)

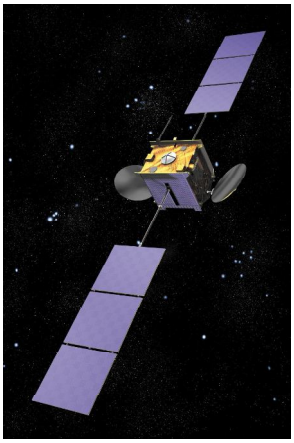


Fig.48
Inmarsat-3 (Courtesy: Inmarsat)

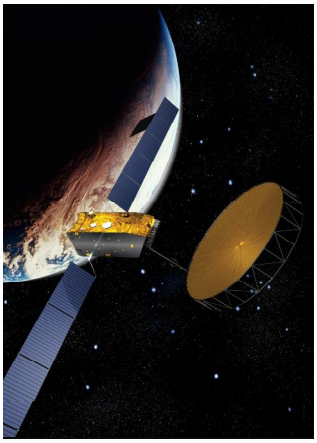


Fig.49
Inmarsat-4 (Courtesy: Inmarsat)

Iridium satellites

The concept of a satellite constellation that would provide constant global communication services from any point to any other point on the Earth was conceived in the year 1990. The original design comprised of 77 satellites, and hence the constellation was given the name Iridium (element iridium has an atomic number of 77). Later on, it was decided that the constellation will have only 66 satellites.

All the 66 satellites were launched by 1998. However, due to technological problems, the Iridium services became expensive and hence it seemed that the Iridium constellatiom will not work. But, in early November 2000, Iridium Satellite LLC took charge of Iridium satellites from Iridium LLC. Iridium satellites (Fig.50) will now continue to provide satellite communications to the U.S. government with plans to re-launch affordable satellite communications services to certain industries that have a need for satellite communications. Iridium Satellite LLC launched global voice services in March 2001 and added internet connectivity in June 2001. Seven additional spare satellites were launched in 2002 to ensure the system's long-term performance. The Iridium satellite service is ideally suited for industries such as maritime, aviation, Government/Military, emergency/humanitarian services, mining, forestry, oil & gas and heavy construction. Iridium currently provides services to the U.S. Department of Defence under a multi-year contract.

Development Agency : Motorola Satellite Communication, USA and Lockheed Martin Systems, USA
Launch : 95 Iridium satellites have been launched from 1997 to 2002
Orbit : The 66 main satellites orbit in 86.4° near circular (e = 0 0002939) orbits at an altitude of 780 kilometers above the Earth's surface in six orbital planes spaced 30 degrees apart with 11 satellites in each orbital plane.
Payload : Satellites transmit to each other and the ground stations through Ka-band frequencies and to customers through L-band frequencies.
Weight : 730 kg each
Operational life : Design life of 5 years

Fig.50
Iridium satellites (Courtesy: Iridium Satellite LLC)

INSAT series

Owned by the Indian Space Research Organization (ISRO), INSAT is one of the largest domestic communication satellite systems in the world providing services in the area of telecommunications, television broadcasting, mobile satellite services and meteorology including disaster warning. INSAT is a joint venture of the Department of Space (DOS), Department of Telecommunications (DOT), Indian Meteorological Department (IMD), All India Radio (AIR) and Doordarshan. Making a modest beginning with the launch of INSAT-1A in 1982, INSAT satellite program has come a long way in the last two decades. INSAT-1B, -1C and -1D followed INSAT-1A. They were followed by INSAT-2, INSAT-3 and INSAT-4 series of satellites.

INSAT-1 series

Four U.S.-built INSAT-1 satellites were launched between 1982 and 1990 to support Indian domestic communications and Earth observation requirements.

INSAT-1A

Development Agency : Ford Aerospace, USA
Launch : 10 April 1982 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-3914
Orbit : GEO 74^0E
Weight : 1152kg
Payload : 12 C-band and 2-S Transponders and VHRR meteorological payload
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years but abandoned in Sept 1982

INSAT-1B

Development Agency : Ford Aerospace, USA
Launch : 30 August 1983 from Cape Canaveral launch center, USA
Launch Vehicle : Shuttle Challenger
Orbit : GEO 74^0E (1983-1992), 92°E (1992-1993)
Weight : 1152kg
Payload : 12 C-band and 2-S Transponders and VHRR Meteorological payload
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years abandoned in Sept 1983

INSAT-1C

Development Agency : Ford Aerospace, USA
Launch : 21 July 1988 from Kourou in French Guiana, France
Launch Vehicle : Ariane-3
Orbit : GEO 93.5^0E
Weight : 1190 kg
Payload : 12 C-band and 2-S Transponders and VHRR Meteorological payload
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years but abandoned in Nov 1989

INSAT-1D

Development Agency : Ford Aerospace, USA
Launch : 12 June1990 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-4920
Orbit : GEO 83^{0}E (1990-1999), 74°E (1999-2000)
Weight : 1190kg
Payload : 12 C-band and 2-S Transponders
Stabilization : 3-axis stabilization
Operational life : Design life of seven years

INSAT-2 series

INSAT-2 series comprises of INSAT-2A, -2B, -2C, -2DT and -2E satellites.

INSAT-2A

Development Agency : Indian Space Research Organization, India
Launch : 10 July 1992 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 74^{0}E
Weight : 1900kg
Payload: : 12 C-band, 6 extended C band and 2 S Band transponders, 1 Data Relay Transponder, 1 Search and Rescue Transponder and Very High Resolution Radiometer (VHRR) meteorological payload operating in visible and infrared band
Stabilization : 3-axis stabilization
Operational life : Design life of seven years

INSAT-2B

Development Agency : Indian Space Research Organization, India
Launch : 22 July 1993 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 93.5^{0}E
Weight : 1931kg
Payload : 12 C Band, 6 Extended C Band and 2 S Band transponders , 1 Data Relay Transponder, 1 Search and Rescue Transponder and Very High Resolution Radiometer (VHRR) meteorological payload operating in visible and infrared band
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years

INSAT-2C

Development Agency : Indian Space Research Organization, India
Launch : 7 Dec 1995 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 93.5^{0}E
Weight : 2106kg

Payload : 12 C-band, 6 extended C-band, 3 Ku-band, 2 S-band BSS and 1-S band Mobile Service Transponders, 1C band mobile communication feeder link
Stabilization : 3-axis stabilization
Operational life : Design life of 7 years

INSAT-2DT

INSAT-2D, launched on 4 June 1997, became in-operable in October 1997 following a power bus anomaly. To partly augment the capacity of the INSAT system consequent to its loss, an in-orbit satellite, ARABSAT-1 was acquired by ISRO from ARABSAT Organization in November 1997

Development Agency : Indian Space Research Organization, India
Launch : 26 February 1992 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 55^0E
Weight : 2070kg
Payload : 25 C-band and 1 S band BSS Transponders
Stabilization : 3-axis stabilization

INSAT-2E (Fig.51)

Development Agency : Indian Space Research Organization, India
Launch : 3 April 1999 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : GEO 83^0E
Weight : 2550kg
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years
Payload : 12 C band, 5 extended C band transponders, Very High Resolution Radiometer (VHRR) and CCD camera . 11 of the C-band transponders have been leased to the INTELSAT Organsation.

INSAT-3 series

INSAT-3 series comprises of INSAT-3B, -3C, -3A and -3E satellites

INSAT-3B (Fig.52)

The launch of INSAT-3B has been advanced to precede that of INSAT-3A to cater to the immediate requirement of extended C- Band capacity that was depleted due to INSAT-2D failure.

Development Agency : Indian Space Research Organization, India
Launch : 21 March 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 83^0E
Weight : 2050kg
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

Payloads : 12 Extended C-band, 3 Ku-band and 1 S band Mobile Service Transponders and 1 Ku Beacon

INSAT-3C (Fig.53)

Development Agency : Indian Space Research Organization, India
Launch : 24 January 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-4
Orbit : GEO 74^0E
Weight : 2750kg
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years
Payloads : 24 Normal C-band, 6 extended C band, 2 S band BSS transponders and a Mobile service transponder operating in S-band for up-link and C-band for down-link and mobile communication

INSAT-3A (Fig.54)

Development Agency : Indian Space Research Organization, India
Launch : 10 April 2003 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5
Orbit : GEO 93.5^0E
Weight : 2950kg
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years
Payloads : Communication Payloads of 12 C-band transponders, 6 ext. C-band transponders, 6 Ku-band transponders, 1 S-band transponder and Satellite Aided Search And Rescue (SAS&R) transponder, Meteorological payload of VHRR operating in the visible band, thermal infrared and water vapour bands, CCD camera operating in the visible and short wave infrared bands and 1 Data Relay (DR) transponder

INSAT-3E (Fig.55)

Development Agency : Indian Space Research Organization, India
Launch : 27 September 2003 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5
Orbit : GEO 55^0E
Weight : 2750 kg
Payload : 24 C Band and 12 Extended C Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

INSAT-4 series

Four satellites have been launched in the INSAT-4 series namely INSAT-4A, -4B, -4C and -4CR. Four satellites namely INSAT-4D, -4E, -4F and -4G are being planned to be lauched in the near future. Figure 56 shows the image of INSAT-4A during construction and figure 57 shows the satellite in orbit.

INSAT-4A, -4B

Development Agency : Indian Space Research Organization, India
Launch
INSAT-4A : 21 December 2005
INSAT-4B : 11 March 2007
Both the satellites were launched from Kourou in French Guiana, France. INSAT-4A was launched by Ariane-5GS and INSAT-4B was launched by Ariane-5ECA.
Orbit
INSAT-4A : GEO 83°E
INSAT-4B : GEO 93.5°E
Weight
INSAT-4A : 3081 kg
INSAT-4B : 3028 kg
Payload : 12 C Band and 12 Ku Band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

INSAT-4C, -4CR

Development Agency : Indian Space Research Organization, India
Launch
INSAT-4C : 10 July 2006
INSAT-4CR : 2 September 2007
Both the satellites were launched from Sriharikota launch center in India on GSLV Mk.1.
Orbit
INSAT-4C : Launch failure
INSAT-4CR : GEO 74°E
Weight
INSAT-4C : 3081 kg
INSAT-4CR : 2168 kg
Payload : 12 Ku Band transponders each
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

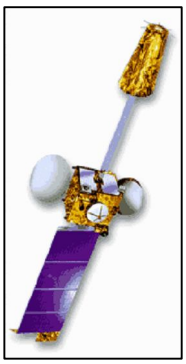


Fig.51
INSAT-2E

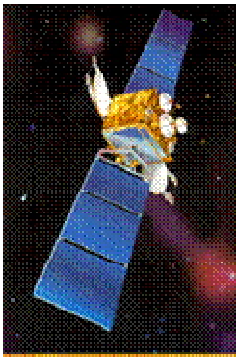


Fig.52
INSAT-3B

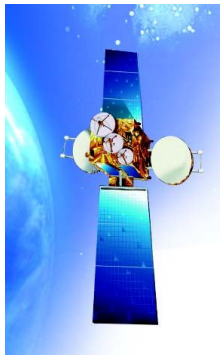


Fig.53
INSAT-3C

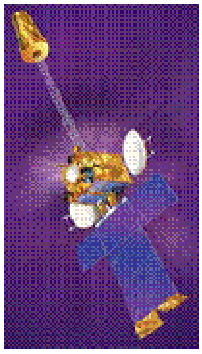


Fig.54
INSAT-3A

(Courtesy: ISRO)

Fig.55
INSAT-3E

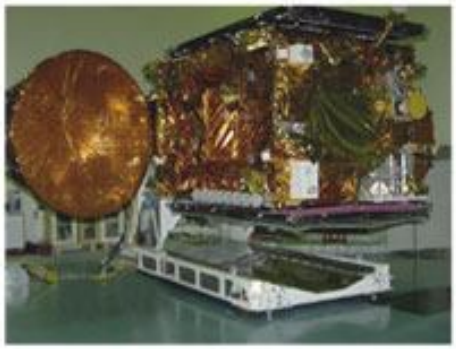


Fig.56
INSAT-4A during construction
(Courtesy: ISRO)

Fig.57
INSAT-4A

Intelsat satellites

International Satellite Organization (INTELSAT) was established in the year 1971, consisting of about 140 countries. It operates a fleet of satellites that provide global satellite public telecommunication and broadcasting services to its member countries. From a few hundred telephone circuits and a handful of members in 1965, INTELSAT has grown to a present-day system with more members than the United Nations and the capability of providing hundreds of thousands of telephone circuits. INTELSAT provides services to the entire globe, not just the industrialized nations. Intelsat became a private company on 18 July 2001, 37 years after the formation of INTELSAT. Till date, Intelsat has launched Intelsat-1, -2, -3, -4, -4A, -5, -5A, -6, -7, -7A, -8, -8A, -9 and -10 series of satellites. Salient features of these series are submarizd as under:

Satellite series	No. of satellites	Stabilization	Payload	Launch
Intelsat-1	1	Spin	1 transponder	1965
Intelsat-2	4	Spin	2 transponders	1966-1967
Intelsat-3	8	Spin	2 transponders	1968-1970
Intelsat-4	8	Spin	12 C band transponders	1971-1975
Intelsat-4A	6	Spin	20 C band transponders	1975-1978
Intelsat-5	8	3-axis	21 C band and 4 Ku band transponders	1981-1984
Intelsat-5A	6	3-axis	26 C band and 6 Ku band transponders	1985-1989
Intelsat-6	5	Spin	38 C band and 10 Ku band transponders	1989-1991
Intelsat-7	6	3-axis	26 C band and 10 Ku band transponders	1993-1996
Intelsat-7A	3	3-axis	26 C band and 14 Ku band transponders	1995-1996
Intelsat-8	4	3-axis	38 C band and 6 Ku band transponders	1997
Intelsat-8A	2	3-axis	28 C band and 3 Ku band transponders	1998
Intelsat-9	7	3-axis	44 C band and 12 Ku band transponders	2001-2003
Intelsat-10	1	3-axis	45 C band and 16 Ku band transponders	2004

Intelsat also operates a few satellites leased from other companies. Intelsat leased Telstar-5, -6, -7 and -8 satellites from Space Systems Loral and operates them as Intelsat Americas-5, -6, -7, -8 and -9 respectively. In February 2007, Intelsat Americas satellites were redesignated as Galaxy series. Intelsat Americas-5, -6, -7, -8 and -9 were renamed Galaxy-25, -26, -27, -28 and -29. C-

band payload of Telstar-13 was also leased by Intelsat and it operates as Intelsat Americas-13. Intelsat changed the name of the Intelsat America 13 satellite to Galaxy 23 from February 2007. Intelsat also leased Sinosat-1 satellite and operates it as Intelsat APR-1. Intelsat acquired Panamsat in 2005 and changed the name of PAS satellites to Intelsat in February 2007. Intelsat leased Sinosat-1 satellite and operates it as Intelsat APR-1. 11 of the C band transponders of INSAT-2E satellite have been leased to the Intelsat organsation which operates them as Intelsat-APR2 satellite.

Intelsat-6

Intelsat-6 series (Fig.58) comprises of five satellites Intelsat-601, -602, -603, -604 and -605

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Satellite Systems)
Launch
Intelsat-601 : 29 October 1991
Intelsat-602 : 27 October 1989
Intelsat-603 : 14 March 1990
Intelsat-604 : 23 June 1990
Intelsat-605 : 14 August 1991
Intelsat-601, -602 and -605 were launched from Kourou in French Guiana, France by Ariane-44L and Intelsat-603 and -604 were launched from Cape Canaveral launch center, USA by Titan-3
Orbit
Intelsat-601 : GEO 27°W (1992-1997) 34°°W (1997-1999)
Intelsat-602 : GEO 37°W (1989-1990) 24°W (1990-1991) 55°E (1991) 60°E (1992) 63°E (1992-1997) 62°E (1997-1999)
Intelsat-603 : GEO 34°W (1992-1997) 24°W (1997-1999)
Intelsat-604 : GEO 38°W (1990) 27°W (1990-1992) 60°E (1992-1999)
Intelsat-605 : GEO 24°W (1991-1997) 27°W (1997-1999)
Payload : 38 C band 10 Ku band transponders each
Weight
Intelsat-601 : 4330 kg
Intelsat-602, -603, -604 : 4215 kg each
Intelsat-605 : 4296 kg
Operational life : Design life of 13 years

Intelsat-K

Intelsat-K was leased to New Skies Ltd. which operates it as NSS-K satellite.

Intelsat-7, -7A series

Intelsat -7 and -7A program, comprising of nine high powered satellites, provide global dissemination of voice, video, and data transmission services.

Intelsat-7

The Intelsat-7 (Fig.59) consists of six satellites, Intelsat-701, Intelsat-702, Intelsat-703, Intelsat-704, Intelsat-705 and Intelsat-709. Intelsat-703 was leased to New Skies, Ltd. and was renamed as NSS-703.

Development Agency : Space Systems Loral, USA
Launch
Intelsat-701 : 22 October 1993
Intelsat-702 : 17 June 1994
Intelsat-703 : 6 October 1994
Intelsat-704 : 10 Jan 1995
Intelsat-705 : 22 March 1995
Intelsat-709 : 15 June 1996
Intelsat-701, -702 and -709 were launched from Kourou in French Guiana, France. Intelsat-701, -702 were launched by Ariane-44LP and Intelsat-709 by Ariane-44P. Intelsat-703, -704 and -705 were launched from Cape Canaveral launch center, USA by Atlas-2AS.
Orbit
Intelsat-701 : GEO 121°E (1993), 174°E (1994-1997), 180°W (After 1997)
Intelsat-702 : GEO 38°W (1994) 1°W (1994-1996) 177°E (After 1996)
Intelsat-703 : GEO 177°E (1994-1996) 57°E (After 1996)
Intelsat-704 : GEO 66^0E
Intelsat-705 : GEO 50°W (1995-1996) 18°W (After 1996)
Intelsat-709 : GEO 310^0E
Payload : 26 C band 10 Ku band transponders each
Weight : 3695 kg each
Operational Life : Design life of 10-15 years

Intelsat-7A

The Intelsat-7A series (Fig.60) comprises of three satellites, Intelsat-706, Intelsat-707 and Intelsat-708, each of which had four additional Ku-band transponders than Intelsat-7 satellites to provide additional communications capacity and an additional solar array panel to deliver more power. Intelsat-708 was destroyed in a failed launch attempt.

Development Agency : Space Systems Loral, USA
Launch
Intelsat-706 : 17 May 1995
Intelsat-707 : 14 March 1996
Intelsat-708 : 14 February 1996
Intelsat-706 and -707 were launched from Kourou in French Guiana, France by Ariane-44LP. Intelsat-708 was launched from Xichang Satellite Launch Center, China by CZ-3B
Orbit
Intelsat-706 : GEO 307^0E
Intelsat-707 : GEO 359^0E
Intelsat-708 : Launch failure
Payload : 26 C band 14 Ku band transponders each
Weight : 4180 kg each
Operational Life : Design life of 10-15 years

Intelsat-8

Intelsat-8 series (Fig.61) consists of four satellites Intelsat-801, -802, -803 and -804. Intelsat-803 was leased to New Skies Ltd. and was renamed NSS-803. It was later again renamed as NSS 5.

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch
Intelsat-801 : 1 March 1997
Intelsat-802 : 25 June 1997
Intelsat-803 : 23 September 1997
Intelsat-804 : 22 December 1997
All the four Intelsat-8 satellites were launched from Kourou in French Guiana, France, with Intelsat-801 and -802 on Ariane-44P and Intelsat-803 and -804 on Ariane-42L.
Orbit
Intelsat-801 : GEO 47°E (1997) 62°E (1997) 64°E (1997-1998) 31°W (After 1998)
Intelsat-802 : GEO 174^0E
Intelsat-803 : GEO 21^0W. Latter shifted to 183°E
Intelsat-804 : GEO 64^0E
Payload : 38 C band 6 Ku band transponders each
Weight : 3245 kg each
Operational Life : Design life of 14-17 years

Intelsat-8A

Intelsat-8A series (Fig.62) consists of two satellites namely Intelsat-805 and Intelsat-806. Intelsat -806 was leased to New Skies, Ltd. and was renamed as NSS-806.

Development Agency : Lockheed Martin Space systems, USA
Launch
Intelsat-805 : 18 June 1998
Intelsat-806 : 27 February 1998
Both Intelsat 8A satellites were launched from Cape Canaveral launch center, USA by Atlas-2AS
Orbit
Intelsat-805 : GEO 55.5^0W
Intelsat-806 : GEO 40.5^0W
Payload : 28 C band and 3 Ku band transponders each
Weight : 3524 kg each
Operational Life : Design life of 14-17 years

Intelsat APR-1

Intelsat leased Sinosat-1 satellite and operates it as Intelsat APR-1.

Intelsat APR-2

11 of the C band transponders of INSAT-2E satellite have been leased to the INTELSAT Organsation which operates them as Intelsat APR-2 satellite.

Galaxy-25, -26, -27, -28 and -29

Telstar-5, -6, -7, -8 and -9 satellites were sold to INTELSAT which operated these satellites as Intelsat Americas-5, -6, -7, -8 and -9. Intelsat Americas-5, -6, -7, -8 and -9 are renamed Galaxy-25, -26, -27, -28 and -29 in February 2007.

Intelsat-9 series

Intelsat-9 satellites (Fig.63) were launched to replace Intelsat-6 satellites. They provide enhanced voice, video, and data transmission services across the globe. The increased power and efficiency of the new Intelsat-9 satellites provide better coverage and stronger signals to improve the digital communication services, employ smaller Earth stations, and provide specialized Intelsat communications services. Intelsat-9 satellites serve the Indian and the Atlantic Ocean regions.

Development Agency : Space Systems Loral, USA
Launch
Intelsat-901 : 9 June 2001
Intelsat-902 : 30 Aug 2001
Intelsat-903 : 30 March 2002
Intelsat-904 : 23 Feb 2002
Intelsat-905 : 5 June 2002
Intelsat-906 : 6 September 2002
Intelsat-907 : 15 Feb 2003
All Intelsat-9 satellites were launched from Kourou in French Guiana, France by Ariane-44L except for Intelsat-903 which was launched from Baikonour cosmodrome in Kazakhstan by Proton-K
Orbit
Intelsat-901 : GEO 18^0W
Intelsat-902 : GEO 62^0E
Intelsat-903 : GEO 34.5^0W
Intelsat-904 : GEO 60^0E
Intelsat-905 : GEO 24.5^0W
Intelsat-906 : GEO 64^0E
Intelsat-907 : GEO 27.5^0W
Weight : 4725 kg each
Stabilization : 3-axis stabilization
Payload : 44 C band and 12 Ku band transponders each
Operational life : Design life of 13 years

Intelsat-10 02

Development Agency : Europe's company EADS Astrium
Launch : 16 June 2004 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 1^0W
Weight : 5575 kg
Payload : 45 C band and 16 Ku Band transponders
Stabilization : 3-axis stabilization

Operational life **:** Design life of 13 years

Fig.58
Intelsat-6

Fig.59
Intelsat-7
(Courtesy: Intelsat)

Fig.60
Intelsat-7A

Fig.61
Intelsat-8

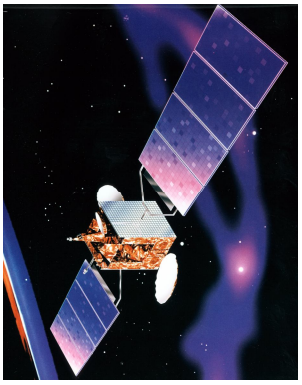


Fig.62
Intelsat-8A
(Courtesy: Intelsat)

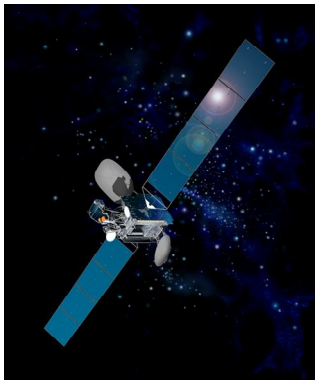


Fig.63
Intelsat-9

JCSat series

JCSat satellite system, operated by Japan Communications Satellite Company (JCSAT), now Japan Satellite Systems, Inc. (JSAT), is Japan's first commercial communications satellite system. It became operational in the year 1989 with the launch of JCSAT-1 on March 6 1989. JCSat-1 satellite was followed by JCSat-2, -3, -4, -5, -6, -8, -9, 10, -11, -12 and -110 satellites.

JCSat-3 (Fig.64) and -4 (Fig.65) were launched in the year 1995 and 1997 respectively to meet the growing demands of communication business in Asia, Australia, New Zealand, India and Hawaii. JCSat-5 (Fig.66) and -6, launched in 1997 and 1999 respectively, meet increased customer demand for multimedia and Internet access and carry voice, data and television signals to Japan. JCSat-8 (Fig.67), launched in 2002, replaces JCSAT-2 and provides coverage to Japan, East Asia, Australia and Hawaii. JCSat-10 provides communications services throughout Japan and Asia. JCSat-11 satellite failed to launch and JCSat-12 is a replacement satellite for JCSat-11. JCSat-110 (N-Sat 110, Superbird-5(D)) (Fig.68) telecommunications satellite, launched in 2000, is used for providing direct TV broadcast services to Japan and nearby regions.

JCSat-2, -3, -4, -5,- 6, -8

Development Agency : Hughes Space Systems, USA (now Boeing Satellite Systems)
Launch
JCSat-2 : 1 January 1990
JCSat-3 : 29 August 1995
JCSat-4 (JCSat-R) : 17 February 1997
JCSat-5 (JCSat-1B) : 3 December 1997
JCSat-6 : 16 February 1999
JCSat-8 (JCSat-2A) : 29 March 2002
JCSat-2, -3, -4, -6 satelltes were launched from Cape Canaveral launch center, USA. JCSat -2 was launched on Commercial Titan-3 and JCSat -3, -4 and -6 on Atlas 2AS. JCSat-5 and -8 were launched from Kourou in French Guiana, France by Ariane-44P and Ariane-44L respectively.
Orbit
JCSat-2 and -8 : GEO 154°E
JCSat-3 : GEO 128°E
JCSat-4 and -6 : GEO 124°E
JCSat-5 : GEO 150°E
Weight
JCSat-2 : 2280 kg
JCSat-3, -4, -5 : 1841 kg each
JCSat-6 : 2900 kg
JCSat-8 : 3800 kg
Stabilization : 3-axis stabilization
Payload
JCSat-2, -5, -6 : 32 Ku Band transponders each
JCSat-3, -4 : 12 C and 28 Ku Band transponders
JCSat-8 : 16 C and 16 Ku Band transponders
Operational Life
JCSat-2, -3, -4 : Design life of 10-12 years
JCSat-5, -6, -8 : Design life of 12, 14.5 and 11 years respectively

JCSat-9 (JCSat-5A)

Development Agency : Lockheed Martin, USA
Launch : 16 June 2004 from Sea launch platform in the pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 132°E
Weight : 4401 kg
Payload : 20 C band, 20 Ku band and 1 S band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

JCSat-10 (JCSat-3A), -11, -12 (JCSat-RA)

Development Agency : Lockheed Martin, USA
Launch
JCSat-10 : 11 August 2006
JCSat-11 : 5 September 2007
JCSat-12 : 21 August 2009

JCSat-10 and -12 were launched from Kourou in French Guiana, France by Ariane-5ECA. JCSat-11 was launched from Baikonour cosmodrome in Kazakhstan on Proton-M.

Orbit
JCSat-10, -12 : GEO 128°E
JCSat-11 : Launch failure
Weight
JCSat-10 : 4048 kg
JCSat-11, -12 : 4000 kg each
Stabilization : 3-axis stabilization
Payload : 30 Ku band and 12 C band transponders each
Operational Life : Design life of 15 years

JCSat-110

JCSat-110 is the same as N-Sat 110 and Superbird-5(D)

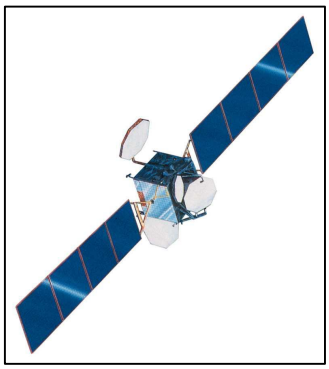


Fig.64
JCSat-3

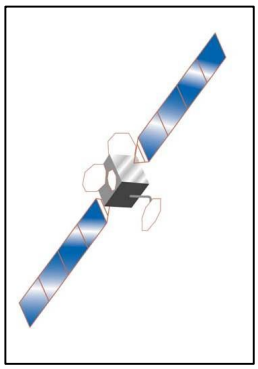


Fig.65
JCSat-4

Fig.66
JCSat-5

(Courtesy: JSAT Corporation)

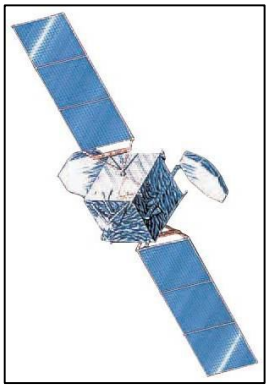


Fig.67
JCSat-8

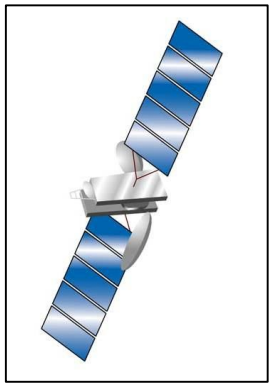


Fig.68
JCSat-110

(Courtesy: JSAT Corporation)

Koreasat series

Koreasat series of satellites, operated by Korea Telecom, are South Korea's communication satellites providing both fixed and direct broadcast services. Till date four satellites, Koreasat-1, -2, -3 and -5, have been launched in this series. Koreasat-6 scheduled to be launched in the near future will provide direct broadcasting services and FSS services to Korea.

Koreasat-1 (Mugunghwa-1, Europestar-B), -2 (Mugunghwa-2)

Development Agency : Martin Marietta, USA (Lockheed Martin, USA)
Launch
Koreasat-1 : 5 August 1995
Koreasat-2 : 14 January 1996
Both the satellites were launched from Cape Canaveral launch center, USA on Delta-7925
Orbit
Koerasat-1 : 116^0E (1995-1999)
Koreasat-2 : 113^0E
Stabilization : 3-axis stabilization
Payload : 12 FSS Ku and 3 BSS Ku Band transponders each
Weight
Koreasat-1 : 1464 kg
Koreasat-2 : 600 kg
Operational Life : Design life of 10 years

Koreasat-3 (Fig.69)

Development Agency : Lockheed Martin, USA
Launch : 4 September 1999 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : GEO 116^oE
Stabilization : 3-axis stabilization
Payload : 24 Ku Band (FSS), 6 Ku Band (DBS) and 3 Ka Band transponders
Weight : 2790 kg
Operational Life : Design life of 15 years

Koreasat-5

Development Agency : Alcatel Alenia Space, France
Launch : 28 August 2006 from Sea launch Platform in the pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 113°E
Stabilization : 3-axis stabilization
Payload : 24 Ku band, 8 SHF band and and 4 Ka band transponders
Weight : 4465 kg
Operational Life : Design life of 15 years

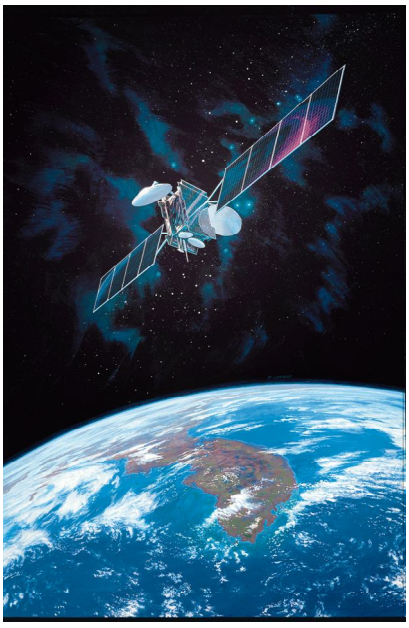


Fig.69
Koreasat-3 (Courtsey: Lockheed Martin)

LMI-1 satellite

LMI-1 is a Russian communication satellite providing fixed service telephony and direct broadcast television services to Russia. In addition to its Russian coverage, it provides telecommunications services to the Commonwealth of Independent States (CIS), Eastern and Central Europe, Asia and Africa.

Development Agency : Lockheed Martin, USA
Launch : 26 September 1999 from Baikonur Cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : GEO 75^0E
Stabilization : 3-axis stabilization
Payload : 28 C and 16 Ku Band transponders
Weight : 3740 kg
Operational Life : Design life of 15 years

Luch series

Luch satellites are Russian data communication satellites that provide communication services to the Mir space station, Buran space shuttle, Soyuz-TM spacecraft, military satellites and the TsUPK ground control center. They also provide mobile fleet communication services to the Soviet Navy. Luch series comprises of five Luch satellites and one Luch-2 satellite. Last Luch satellite was launched in 1994. Luch 4, 5A and 5B satellites are being planned to be launched in the near future.

Luch (Altiar-13L), -2 1 (Gelios-11L)

Development Agency : NPO-PM of Russia
Launch
Luch : 16 December 1994
Luch-2 1 : 11 October 1995
Both the satellites were launched from Baikonour cosmodrome, Kazakhstan on Proton-K
Orbit
Luch : GEO 95^{0}E (1994-1997), 16°W (1997-1999)
Luch-2 1 : GEO 77^{0}E
Stabilization : 3-axis stabilization
Payload : 3 transponders
Weight : 2400kg each
Operational life : Design life of 5 years

Measat series

Measat system, owned by Binariang Sdn. Bhd. is Malaysia's regional satellite communication system. MEASAT system provides direct-to-user (DTU) services, including the television and educational communication services in Malaysia and the general regional communications services including telephony, television, data transmission, and business in an area reaching from India to Hawaii and from Japan to East Australia. Currently, four Measat satellites namely Measat-1, -2, -3, and -3a have been launched.

Measat-1 and -2 (Fig.70)

Development Agency : Hughes Space Systems, USA (now Boeing Satellite Systems, USA)
Launch
Measat-1 : 13 January 1996
Measat-2 : 13 November 1996
Both of these satellites were launched from Kourou in French Guiana, France on Ariane-44L
Orbit
Measat-1 : GEO 91.5^{0}E
Measat-2 : GEO 148^{0}E
Stabilization : Spin stabilization
Payload
Measat-1 : 12 C and 5 active Ku band transponders
Measat-2 : 12 C and 11 Ku Band transponders
Weight : 1450 kg each
Operational Life : Design life of 12 years

Measat-3

Development Agency : Boeing Space Systems, USA
Launch : 11 December 2006 from Baikonur Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 91.5°E
Stabilization : 3-axis stabilization
Payload : 24 C band and 24 Ku band transponders

Weight : 4765 kg
Operational Life : Design life of 15 years

Measat-3a

Development Agency : Lockheed Martin, USA
Launch : 21 June 2009 from Baikonur Cosmodrome in Kazakhstan
Launch Vehicle : Zenit-3SLB
Orbit : GEO 91.5°E
Stabilization : 3-axis stabilization
Payload : 12 C band and 12 Ku band transponders
Weight : 2367 kg
Operational Life : Design life of 15 years

Molniya satellites

Molniya satellites provide telecommunication and television services to the states of former Soviet Union. Molniya satellites use a highly inclined elliptical orbit known as Molniya orbit, as Russian cities are at high latitudes where it is impractical to use geostationary satellites. Molniya orbit is a 12 hour period orbit with a perigee of 1470 km and apogee of 38900 km and inclined at an angle of 63.4°. Hence, the satellite remains almost stationary over high northern latitudes for about eights. Thus, by carefully placing thress to four satellites in molniya orbit, continuous communication can be maintained.

Molniya satellite was first launched on April 23, 1965. Till now Molniya-1 series having 87 satellites, Molniya-2 series having 17 satellites, Molniya-3 series (Fig.71) having 53 satellites and Molniya-3K series having 2 satellited have been launched. Molniya-1 series provided military and government communication services while Molniya-2 provided television and military communication services. Molyniya-3 series of satellites provide television, telephone and telegraph communication services.

Molniya 3-48, 3-49, 3-50, 3-51, 3-52, 3-53

Development Agency : NPO-PM of Russia
Launch
Molniya 3-48 : 24 October 1996
Molniya 3-49 : 1 July 1998
Molniya 3-50 : 8 July 1999
Molniya 3-51(3K, 1K) : 20 July 2001
Molniya 3-52 : 25 October 2001
Molniya 3-53 : 19 June 2003
All the satellites were launched from Plesetsk cosmodrome in Russia on Molniya-M
Orbit : Molniya
Weight
Molniya 3-48, 3-49, 3-50, 3-53
1600 kg each
Molniya 3-51, 3-52 : 1900 kg each
Payload : 3 6/4 band transponders

Operational life **:** Design life of 4 years

Molniya 3K-11L (#1), 3K-12L (#2)

Development Agency **:** NPO-PM of Russia
Launch
Molniya 3K-11L **:** 20 July 2001
Molniya 3K-12L **:** 21 June 2005
Both the satellites were launched from Plesetsk cosmodrome in Russia on Molniya-M
Orbit **:** 900 km × 39000 km, 65°

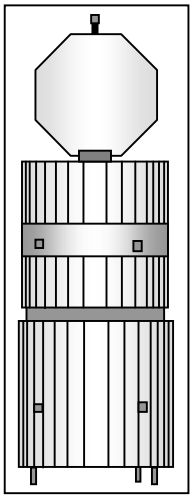


Fig.70
Measat-1, -2

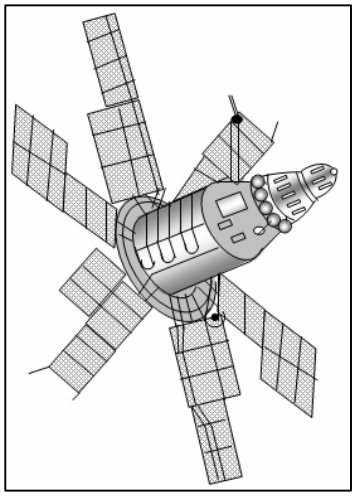


Fig.71
Molniya-3

Nimiq series

Nimiq series of satellites are communication satellites operated by Telesat Canada. Telesat has launched five satellites namely Nimiq-1 (Fig.72), Nimiq-2 (Fig.73), Nimiq-3, Nimiq-4 and Nimiq-5. These satellites provide DTH services, high-definition television, pay-per-view, specialty channels and interactive television services to Canada. Telesat has leased two satellites, DirecTV-2 and DirecTV-3 from DirecTV Inc. DirecTV-3 satellite was leased in the year 2004. It was used as a backup for Nimiq-2 and was renamed Nimiq-2i. It was moved in 2004 to serve as backup for Nimiq-1 and was renamed Nimiq-3. It was again moved in 2006 near Nimiq-2 to serve as its backup. DirecTV-2 satellite was co-located with Nimiq-1 and was renamed Nimiq-4i.

Nimiq-1 and -2

Development Agency **:** Lockheed Martin Commercial Space Systems, USA
Launch
Nimiq-1 **:** 20 May 1999
Nimiq-2 **:** 29 December 2002
Both these satellites were launched from Baikonour Cosmodrome is Kazakhstan with Nimiq 1 on Proton-K and Nimiq 2 on Proton-M

Orbit
Nimiq-1 : GEO 91^{0}W
Nimiq-2 : GEO 82^{0}W
Payload
Nimiq-1 : 32 Ku Band transponders
Nimiq-2 : 32 Ku and 2 Ka Band transponders
Weight : 3600 kg each
Operational Lifetime : Design lifetime of 12 years

Nimiq-4

Development Agency : Europe's EADS Astrium company
Launch : 19 Septmber 2008 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 82^{0}W
Payload : 32 Ku and 8 Ka Band transponders
Weight : 4850 kg
Operational Lifetime : Design lifetime of 15 years

Nimiq-5

Development Agency : Space Systems Loral, USA
Launch : 17 Septmber 2009 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 72.7°W
Payload : 32 Ku Band transponders
Weight : 4745 kg
Operational Lifetime : Design lifetime of 15 years

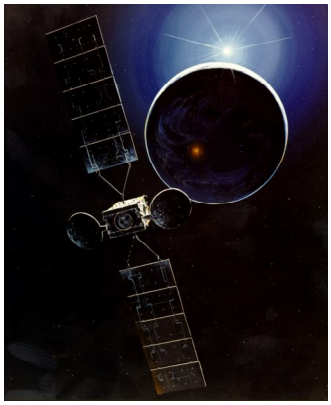


Fig.72
Nimiq-1 (Courtesy: TeleSAT CANADA)

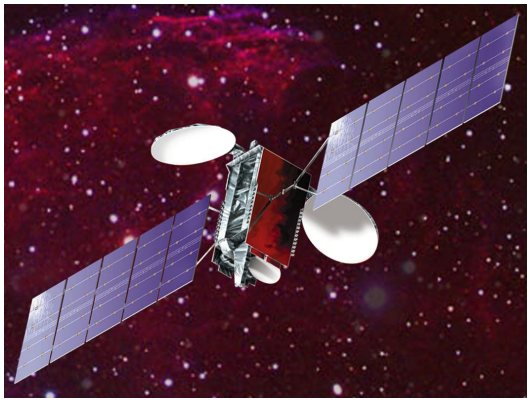


Fig.73
Nimiq-2 (Courtesy: TeleSAT CANADA)

New Skies Satellites (NSS)

New Skies, Ltd. owns and operates a fleet of geostationary communications satellites that offer high-power, global coverage for the delivery of video, internet, voice and data transmission

services. New Skies Satellites has launched five satellites namely NSS-6, NSS-7, NSS-8, NSS-9 and NSS-12 and has leased five satellites from Intelsat namely NSS-513, NSS-703, NSS-K, NSS-5, and NSS-806. It has acquired two satellites, NSS-10 and NSS-11, from SES Americom. It plans to launch SES 4 satellite in the year 2011.

NSS-703

Intelsat-703 was leased to New Skies, Ltd. and was renamed as NSS-703.

NSS-K

Intelsat-K was leased to New Skies Ltd., which operates it as NSS-K satellite.

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 9 June 1992 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2A
Orbit : GEO 338.5^{0}E
Weight : 2836 kg
Stabilization : 3-axis stabilization
Payload : 16 Ku band transponders
Operational life : Design life of 10 years

NSS-5 (Previously named NSS-803)

Intelsat-803 was leased to New Skies, Ltd. as NSS-803. It was latter renamed as NSS-5.

NSS-806

Intelsat-806 was leased to New Skies, Ltd. as NSS-806

NSS-7

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 16 April 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-4
Orbit : GEO 338^{0}E
Weight : 4700 kg
Payload : 36 C Band and 36 Ku Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

NSS-6

Development Agency : Lockheed Martin Commercial Space Systems, USA
Launch : 18 December 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 95^{0}E
Weight : 4750 kg
Payload : 50 Ku Band transponders

Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

NSS-8

Development Agency : Boeing Space Systems, USA
Launch : 30 January 2007 from Sea launch Platform in the pacific ocean
Launch Vehicle : Zenit-3SL
Orbit : Launch failure
Weight : 5920 kg
Payload : 56 (+10) C Band, 36 (+6) Ku Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 16 years

NSS-9

Development Agency : Orbital Sciences Corporation (OSC), USA
Launch : 12 February 2009 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 183°E
Weight : 2230 kg
Payload : 28 active C band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

NSS-12

Development Agency : Space Systems Loral, USA
Launch : 29 October 2009 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 57°E
Weight : 5620 kg
Payload : 40 C band and 48 Ku band active transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

NSS-10

In March 2007, the AMC-12 satellite was transfered to SES New Skies and named NSS-10**.**

NSS-11

In March 2007, the AAP-1 satellite was transfered to SES New Skies and named NSS-11**.**

Nilesat satellites

Egypt became the first African country to have its own direct TV broadcast satellite, when it launched Nilesat-101 satellite in the year 1998. Second satellite of the series, Nilesat-102, was

launched in 2000. Nilesat system broadcasts more than 150 digital TV channels and provides additional services such as data transmission, turbo internet and multicasting applications. Nilesat-201 satellite is being planned to be launched in the near future.

Nilesat-101

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch : 28 April 1998 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44P
Orbit : GEO 7^0W
Weight : 1840 kg
Payload : 12 Ku-Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Nilesat-102

Development Agency : Europe's EADS Astrium Systems
Launch : 17 September 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 7^0W
Weight : 1827 kg
Payload : 12 Ku-Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Nilesat-103

Hotbird-4 was renamed Nilesat-103, when it was leased to Nilesat in September 2005. In June 2006 it returned to use by Eutelsat as Atlantic Bird 4.

NStar series

NStar satellites, owned by Nippon Telegraph and Telephone (NTT) Mobile Communication Network, provide a variety of fixed and mobile domestic communications services to customers throughout Japan. The first satellites to be launched in this series were NSTAR-A and -B, which had replaced the CS series of satellites. They also provided significant new services, which range from providing alternate routes for telephony, to emergency communications, to marine and terrestrial mobile services, and ISDN. After NStar-A and -B, NStar-C was launched in the year 2002 to enhance the services of the NStar series of satellites.

NStar-A, -B (Fig.74)

Development Agency : Space Systems Loral, USA
Launch
NStar-A : 29 August 1995
NStar-B : 5 February 1996
Both the satellites were launched from Kourou in French Guiana, France on Ariane-44P
Orbit

NStar-A : GEO 132^{0}E
NStar-B : GEO 130^{0}E
Weight : 3400 kg each
Stabilization : 3-axis stabilization
Payloads : 1 S-band payload, 11 Ka-band, 8 Ku-band and 6 C-band transponders each
Operational life : Design life of 10 years

NStar-C

Development Agency : Lockheed Martin Systems, USA and Orbital Sciences Corporation (OSC), USA
Launch : 5 July 2002 from Kourou in French Guiana, France
Launch vehicle : Ariane-5
Orbit : GEO 136^{0}E
Weight : 1620 kg
Stabilization : 3-axis stabilization
Payloads : 20 S band and 1C band transponders
Operational life : Design life of 10 years

NStar-D

The S-band payload and a part of the C-band payload of the JCSat-5A satellite is operated as NStar-D to replace the NStar-A satellite.

Fig.74
NStar-A, -B (Courtesy: JSAT Corporation)

Optus series

Optus satellites, operated by Optus communication Pvt. Ltd., are Australian communication satellites. Four series of Optus satellites have been launched namely the Optus-A, Optus-B, Optus-C and Optus-D series. Optus-A was initially operated by Australia's national satellite company, AUSSAT under the name Aussat-A. They were Australia's first national communication satellites providing Direct Broadcasting services. Optus-A series comprises of three satellites namely Optus-A1 (Aussat-A1), Optus-A2 (Aussat-A2) and Optus-A3 (Aussat-A3). Currently, Optus-A3 is operational and Optus-A1 and -A2 are out of service. Optus-B series of satellites (earlier known as Aussat-B) comprises of three satellites namely Optus-B1, Optus-B2 and Optus-B3. They are three times more powerful than the Optus-A satellites. Optus-B2 satellite exploded

during launch. The Optus-B satellites enhance existing satellite communications services throughout Australia. The third series of Optus satellites, Optus-C, comprises of a single satellite Optus-C1 which provides commercial services in Ku-band for the Optus Ltd. and military communications at UHF, X and Ka-bands for the Australian Department of Defence. It provides regional coverage to Australia, New Zealand and the Asia-Pacific region, and global coverage from India to Hawaii. Optus-D series satellites provide fixed communications and direct television broadcasting services to Australia and New Zealand.

Optus-A3 (Earlier named Aussat-A3) (Fig.75)

Development Agency : Hughes space systems, USA (now Boeing satellite systems)
Launch : 16 September 1987 from Kourou in French Guiana, France
Launch vehicle : Ariane-3
Orbit : GEO 156^0E
Weight : 1620 kg
Stabilization : Spin stabilization
Payloads : 15 Ku band transponders
Operational life : Design life of 10 years

Optus-B1, -B2, -B3 (Fig.76)

Development Agency : Hughes Space Systems, USA (now Boeing Systems)
Launch
Optus-B1 : 13 August 1992
Optus-B2 : 21 December 1992
Optus-B3 : 27 August 1994
All the three satellites were launched on CZ-2E from Xichang Satellite Launch Center in Sichuan Province, China
Orbit
Optus-B1 : GEO 160^0E
Optus-B2 : Launch failure
Optus-B3 : GEO 156^0E (changed to 152°E)
Weight : 2858 kg each
Stabilization : 3-axis stabilization
Payloads : 15 Ku-band and 1 L-band transponders Ka-band beacon, laser retroreflector
Operational life : Design life of 10-14 years

Optus-C1

Development Agency : Mitsubishi Electric Corporation, Japan and Space Systems Loral, USA
Launch : 11 June 2003 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 156^0E
Weight : 4725 kg
Stabilization : 3-axis stabilization
Payloads : 24 Ku-band, 4 Ka-band, 4 X-band and 6 UHF Transponders
Operational life : Design life of 15 years

Optus-D1

Development Agency : Mitsubishi Electric Corporation, Japan and Space Systems Loral, USA
Launch : 13 October 2006 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 160°E
Weight : 2299 kg
Stabilization : 3-axis stabilization
Payloads : 24 Ku-band Transponders
Operational life : Design life of 15 years

Optus-D2, -D3

Development Agency : Hughes Space Systems, USA (now Boeing Systems)
Launch
Optus-D2 : 5 October 2007
Optus-D3 : 21 August 2009
Both the satellites were launched from Kourou in French Guiana, France. Optus-D2 satellite was launched on Ariane-5GS and Optus-D3 satellite on Ariane-5ECA
Orbit
Optus-D2 : GEO 152°E
Optus-D3 : GEO 156°E
Weight
Optus-D2 : 2401 kg
Optus-D3 : 2501 kg
Stabilization : 3-axis stabilization
Payloads : 24 Ku-band transponders each
Operational life : Design life of 15 years

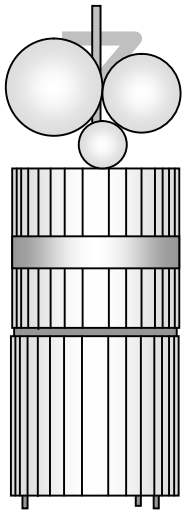


Fig.75
Optus-A3

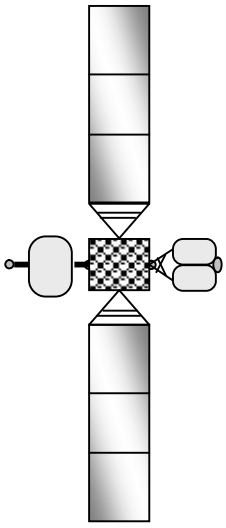


Fig.76
Optus-B1, -B3

Orbcomm satellites

Orbcomm is a commercial satellite based wireless data and messaging system providing services on a global scale. The whole constellation comprises of 36 satellites orbiting in LEO orbits. Till date Orbcomm-FM1 to Orbcomm-FM41 satellites have been launched. Second generation of Orbcomm satellites are slated to be launched in the near future.

Orbcomm-FM1 to FM28, FM30 to FM36 (Orbcomm-1 series)

Development Agency : Orbital Sciences Corporation, Virginia
Launch
Orbcomm-FM1, -FM2 : 3 April 1995
Orbcomm-FM3, -FM4 : 10 February 1998
Orbcomm-FM5 to 12 : 23 December 1997
Orbcomm-FM13 to 20 : 2 August 1998
Orbcomm-FM21 to 28 : 23 September 1998
Orbcomm-FM30 to 36 : 4 December 1999
Orbcomm-FM1 and -FM2 were launched on Pegasus-H from Vandenberg Air Force Base in California, USA. Orbcomm-FM3 and -FM4 were launched on Taurus-2210 from Vandenberg Air Force Base in California, USA. Orbcomm-FM5 to FM36 were launched on Pegasus-XL HAPS from Wallops Island
Orbit : Orbcomm-FM1 and -FM2 satellites are in Polar orbit with a mean radius of 785 km. Rest of the satellites are in inclined orbit in 3 planes with 8 equidistantly spaced satellites in each plane, 780 km circular, 45° inclination
Weight : 45 kg each
Stabilization : 3-axis stabilization
Payload : 17 data processors and seven antennas
Receive - 2400 bps at 148 - 149.9 MHz.
Transmit - 4800 bps at 137 - 138 MHz and 400.05 - 400.15 MHz
Operational life : Design life of 4 years

Orbcomm-FM29, -FM37 to -FM41 (Orbcomm-QL series)

Development Agency : Orbital Sciences Corporation (Virginia, USA), OHB-System (Germany) and PO Polyut (Russia)
Launch
Orbcomm-FM29, -FM37 to -FM41 : 19 June 2008
All the satellites were launched from Kapustin Yar launch center in Russia on Kosmos-3M launch vehicle.
Orbit
Orbcomm-FM29 : 661 km × 672 km, 48.45°
Orbcomm-FM37 to –FM41 : 661 km × 672 km, 48.45°
Weight
Orbcomm-FM29 : 80 kg
Orbcomm-FM37 to –FM41 : 115 kg each
Operational life : Design life of 8-10 years

Orion Series

Orion satellite system is a communication system from USA comprising of Orion-1 telecommunications satellite. Launched in November 1994, it serves Europe, the United States and parts of Canada and Mexico, providing video for broadcast and business television, high-speed internet access, multimedia and data networking services. In 1998, Orion Network Systems, Inc., the operator of Orion satellites, was acquired by Loral and Orion-1 was renamed as Telstar-11, now operated by Loral Skynet. Orion- 3 launch on May 4, 1999 was unsuccessful due to underperformance by the rocket booster and the satellite was left in a useless orbit. Orion-3 would have provided business communications services in the Asia pacific region.

Orion-2 satellite was launched on 19th October 1999 and was latter renamed as Telstar-12.

Palapa series

Palapa satellite system is the domestic satellite system from Indonesia. It provides communication link between thousands of Indonesian islands. It also provides coverage for the most of Asia and parts of Australia and New Zealand. The Palapa system, operated by Satelindo company of Indonesia, began with the launch of Palapa-A1 in the year 1976 followed by Palapa-A2 in 1977. Then came the second series of Palapa satellites, Palapa-B series consisting of Palapa-B1, -B2P, -B2R (Fig.77) and -B4 satellites. Palapa-B2 was planned to be launched under this series but it failed and hence Palapa-B2P was launched in 1987. Palapa-B2 was refurbished and relaunched in 1990 under the name Palapa-B2R. Palapa-B4, the last satellite of Palapa-B series was launched in 1990. Palapa-B series was followed by Palapa-C series, comprising of Palapa-C1 and Palapa-C2 satellites (Fig.78). Palapa-C1 satellite was renamed HGS 3, later Anatolia 1 and in 2002 Paksat 1. Latest satellite to be launched is the Palapa-D1 satellite in the Palapa-D series. The launch vehicle undeperformed and left the satellite in a too low transfer orbit. Palapa D1 was able to maneuvere itself into the planned GEO, but with a reduced lifetime.

Palapa -B2R, -B4

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Satellite Systems)
Launch
Palapa-B2R : 13 April 1990
Palapa-B4 : 14 May 1992
Both these satellites were launched from Cape Canaveral launch center, USA with Palapa-B2R on Delta-6925 and Palapa-B4 on Delta-7925
Orbit
Palapa-B2R : GEO 108^{0}E
Palapa-B4 : GEO 118^{0}E
Weight : 692 kg each
Stabilization : spin stabilization
Payloads : 24 active and 6 spare C Band transponders each
Operational life : Design life of 8 years

Palapa-C1, -C2

Development Agency : Hughes Space and Communication Systems, USA

(now Boeing Space Systems)

Launch
Palapa-C1 **:** 1 February 1996
Palapa-C2 **:** 16 May 1996

Palapa-C1 was launched from Cape Canaveral launch center, USA on Atlas-2AS and Palapa-C2 was launched from Kourou on Ariane-44L

Orbit
Palapa-C1 **:** GEO 113 ^{0}E (1996) 150°E (1996-1999)
Palapa-C2 **:** GEO 113 ^{0}E
Weight **:** 3000 kg each
Stabilization **:** 3-axis stabilization
Payloads **:** 24 active and 6 spare C band, six active and 2 spare extended C band, 4 active and 2 spare Ku Band transponders each
Operational life **:** Design life of 14 years

Palapa –D1

Development Agency **:** PT Satelit Palapa Indonesia (SATELINDO)
Launch **:** 31 August 2009 from Xichang Satellite Launch Center in Sichuan Province, China
Launch vehicle **:** CZ-3B
Orbit **:** GEO 113°E
Weight **:** 4100 kg
Stabilization **:** Spin stabilization
Payloads **:** 24 standard C Band, 11 extended C Band and 5 Ku Band transponders
Operational life **:** Design life of 15 years

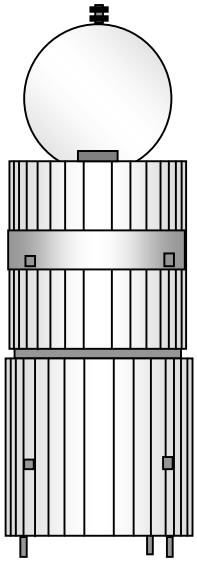


Fig.77
Palapa-B2R

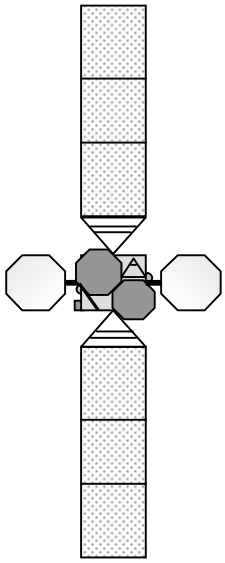


Fig.78
Palapa-C1, -C2

PAS series

PAS satellites are operated by PanAmSat, USA. PanAmSat has been acquired by Intelsat n 2006. These satellites provide communication services to America, Europe, Africa, the Middle East and Asia. PAS-1, the first satellite in this series was launched in the year 1988. PAS satellite fleet currently comprises of PAS-2, -3R, -4, -6B, -6, -7, -8, -9, -10, -1R and -12 satellites. PanAmSat was acquired by Intelsat and it changed the name of the PAS satellites to Intelsat from 1st February 2007.

PAS-2, -3R, -4

PAS-2, -3R and -4 (Fig.79) satellites provide video and data services over the Pacific, Atlantic and Indian ocean regions respectively.

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch
PAS-2 : 8 July 1994
PAS-3R : 12 January 1996
PAS-4 : 3 August 1995
All the three satellites were launched from Kourou in French Guiana, France with PAS-2 and -3 on Ariane-44L and PAS-4 on Ariane-42L
Orbit
PAS-2 : GEO 191°W later shifted to GEO 169 ^{0}E
PAS-3R : GEO 43.1^{0}W
PAS-4 : GEO 72^{0}E
Weight : 2920 kg each
Stabilization : 3-axis stabilization
Payloads
PAS-2 : 20 C-band and 20 Ku-band transponders
PAS-3R : 20 C-band and 20 Ku-band transponders
PAS-4 : 20 C-band and 30 Ku-Band transponders
Operational life : Design life of 15 years

PAS-5 (Arabsat-2C), -6B, -9, -10

PAS-5 satellite was leased to Arabsat in May 2002. PAS-6B satellite provides DTH services to South America. PAS-9 satellite provides communication services to America, Caribbean and Western Europe. PAS-10 satellite provides coverage to China, India, Middle East, South Africa and Europe. Fig.80 shows the artists view of these satellites.

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch
PAS-5 : 28 August 1997
PAS-6B : 21 December 1998
PAS-9 : 28 July 2000
PAS-10 : 14 May 2001

PAS-5 and -10 were launched on Proton-K from Baikonour Cosmodrome in Kazakhstan, PAS-6B on Ariane-42L from Kourou in French Guiana, France, PAS-9 on Zenit-3SL from Sea launch Platform in the pacific ocean

Orbit

PAS-5 : GEO 26.2^{0}E
PAS-6B : GEO 43^{0}W
PAS-9 : GEO 58^{0}W
PAS-10 : GEO 68.5^{0}E

Payload

PAS-5 and -9 : 24 active and 4 spare C band and 24 active and 4 spare and transponders
PAS-6B : 32 Ku-band transponders
PAS-10 : 32 C-band and 32 Ku-band transponders

Weight

PAS-5 : 3600 kg
PAS-6B : 3470 kg
PAS-9 : 3659 kg
PAS-10 : 3739 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

PAS -6, -7, -8

PAS-6 satellite provides digital television services to South America. PAS-7 satellite provides coverage to China, India, Middle East, South Africa and Europe. PAS-8 satellite serves Australia, Hawaii, Northwest coast of US and portions of far east.

Development Agency : Space Systems Loral, USA

Launch

PAS-6 : 8 August 1997
PAS-7 : 16 September 1998
PAS-8 : 4 November 1998

PAS-6 and -7 were launched by Ariane-44P and -44LP respectively from Kourou in French Guiana, France. PAS-8 was launched by Proton-K from Baikonour cosmodrome in Kazakhstan.

Orbit

PAS-6 : GEO 43^{0}W
PAS-7 : GEO 68.5^{0}E
PAS 8 : GEO 166^{0}E

Weight

PAS-6 : 3420 kg
PAS-7 : 3838 kg
PAS-8 : 3800 kg

Payload

PAS-6 : 36 Ku-band transponders
PAS-7 : 14 C-band and 30 Ku-band transponders
PAS-8 : 24 C-band and 24 Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years. PAS-6 became inoperational in the year 2004.

PAS-1R

PAS-1R satellite (Fig.81) provides services to America, the Caribbean, Europe and Africa.

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch : 15 November 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G
Orbit : GEO 45^{0}W
Weight : 4792 kg
Stabilization : 3-axis stabilization
Payload : 36 C Band and 36 Ku Band transponders
Operational life : Design life of 15 years

PAS-12

In July 2005, Europestar-1 satellite was sold to Panamsat and the satellite was renamed as PAS-12. It was renamed Intelsat-12 in 2007.

PAS-11

PAS-11 satellite has been renamed Intelsat-11.

Development Agency : Orbital Sciences Corporation, USA
Launch : 5 October 2007 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5GS
Orbit : GEO 43.1°W
Weight : 2491 kg
Stabilization : 3-axis stabilization
Payload : 16 C Band and 18 Ku Band transponders
Operational life : Design life of 15 years

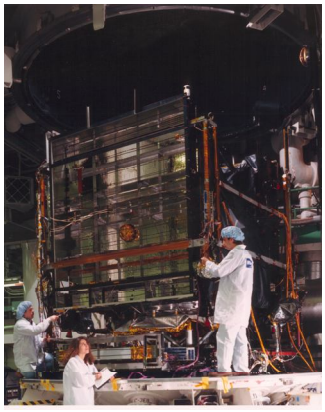


Fig.79
PAS-4

Fig.80
PAS-5, -6B, -9, -10
(Courtesy: Intelsat)

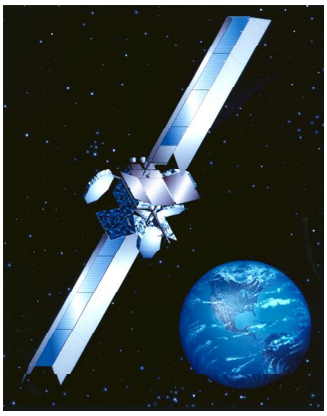


Fig.81
PAS-1R

Satcom series

Satcom satellites, owned by Comsat General Corporation, are USA's communication satellites. The satellites started their services in the year 1975 with the launch of Satcom-1 satellite. Satcom-1 satellite was followed by Satcom-2 satellite in 1976, Satcom-3 in 1979, Satcom-3R in 1981, Satcom-4 and -5 in 1982, Satcom-1R, -2R and -4R in 1983, Satcom-K2 in 1985, Satcom-K1 in 1986, Satcom-C1 in 1990, Satcom-C5 in 1991 and Satcom-C3 and -C4 in 1992.

Satcom -C3, -C4

Development Agency : GE Astro in California, USA
Launch
Satcom-C3 : 11 September 1992
Satcom-C4 : 21 August 1992
Satcom-C3 was launched from Kourou in French Guiana; France on Ariane-44L and Satcom-C4 was launched from Cape Canaveral launch center, USA on Delta-7925
Orbit
Satcom-C3 : GEO 131^{0}W
Satcom-C4 : GEO 135^{0}W
Payload : 24 active and 4 spare C-band transponders each
Weight : 1169 kg each
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Satmex series

Satmex satellites are Mexican communication satellites. Till date, 5 Satmex satellites namely Satmex-1, -2, -3, -4 and -5 have been launched. Currently, Satmex-3, -4 and -5 are operational and Satmex-6 has been planned for launch in the near future

Satmex-3 (same as Solidaridad-1)

Satmex-4 (same as Solidaridad-2)

Satmex-5 (Fig.82)

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch : 6 December 1998 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42L
Orbit : GEO 116.8^{0}W
Payload : 24 C Band and 24 Ku Band transponders
Weight : 4135 kg
Stabilization : 3-axis stabilized
Operational Lifetime : Design life of 15 years

Satmex-6

Development Agency : Space Systems Loral, USA

Launch : 27 May 2006 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 113°W
Payload : 36 C Band and 24 Ku Band transponders
Weight : 5456 kg
Stabilization : 3-axis stabilized
Operational Lifetime : Design life of 15 years

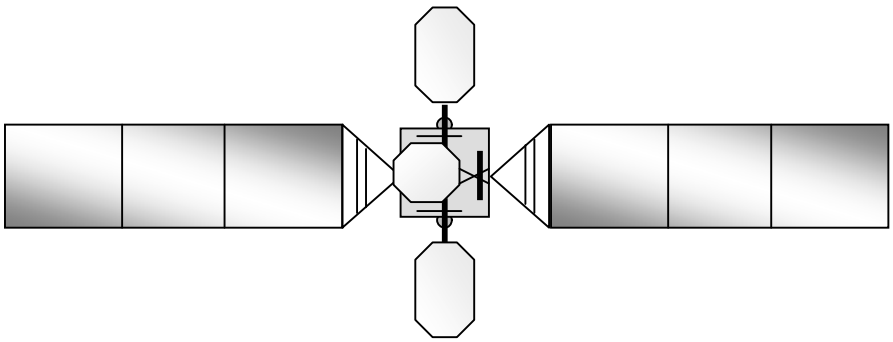


Fig.82
Satmex-5

SBS series

SBS (Satellite Business Systems) satellites are American communication satellites that provide integrated voice, data, electronic mail, and video communications services. The SBS series became operational with the launch of SBS-1 in the year 1980. Since then, five more SBS satellites namely SBS-2, SBS-3, SBS-4, SBS-5 and SBS-6 have been launched.

SBS -5, -6

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch
SBS-5 : 8 September 1988
SBS-6 : 12 October 1990
Both the satellites were launched from Kourou in French Guiana, France with SBS-5 on Ariane-3 and SBS-6 on Ariane-44L
Payload
SBS-5 : 14 Ku-band transponders
SBS-6 : 30 Ku-band transponders
Orbit
SBS-5 : GEO 123^0W
SBS-6 : GEO 74^0W, initially launched at 95^0W
Weight
SBS-5 : 1241 kg
SBS-6 : 2478 kg
Stabilization : Spin stabilization

Operational life **:** Design life of 10 years

SESAT series

The SESAT (Siberia - Europe SATellite) satellites, operated by Eutelsat, provide a wide range of telecommunications services to areas extending from the Atlantic Ocean to Eastern Russia, including a large part of Siberia and to areas within the Indian sub-continent. SESAT contributes to the development of international, regional and domestic services, such as thin route telephony, corporate and specialized data services and long distance trunk telephony. SESAT series comprises of SESAT-1 and -2 satellites.

SESAT-1

Development Agency **:** NPO Prikladnoi Mekhaniki (NPO-PM), Russia and Alcatel Space industries, France
Launch **:** 17 April 2000 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle **:** Proton-K
Orbit **:** GEO 36^0E
Payload **:** 18 Ku Band transponders
Weight **:** 2500 kg
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 10 years

SESAT-2 (Fig.83)

12 Ku-band transponders on Ekspress- AM22 satellite were leased to Eutelsat and are referred to as SESAT-2.

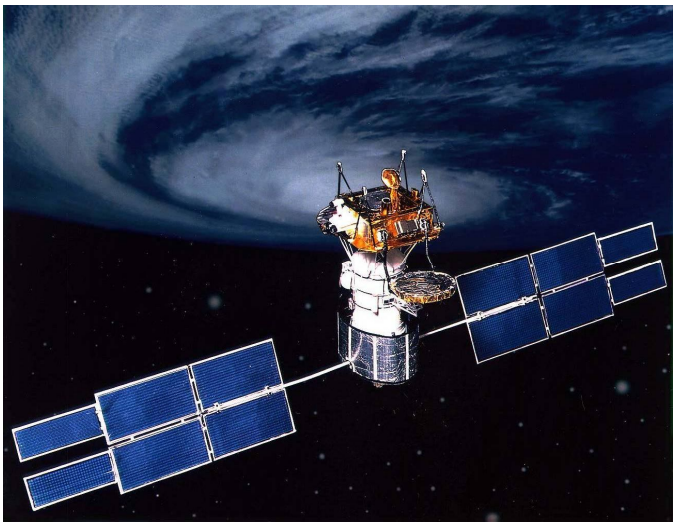


Fig.83
Sesat 2 (Courtesy: Eutelsat)

Sinosat series

Sinosat satellites are Chinese communication satellites. Three satellites namely Sinosat-1, -2 and -3 have been launched. Sinosat-1 satellite was leased to Intelsat and now operates as Intelsat APR-1. Sinosat-2 and -3 satellites serve the need for TV broadcasting, DirectPC and broadband multimedia systems in China as well as the neighboring areas.

Sinosat-1 (Intelsat APR-1)

Development Agency	**:** Aerospatiale, France (now Alcatel Space, France)
Launch	**:** 18 July 1998 from Xichang Satellite Launch Center in Sichuan Province, China
Launch Vehicle	**:** CZ-3B
Orbit	**:** GEO 110.5^0E
Payload	**:** 24 C-band and 14 Ku-band transponders
Weight	**:** 2820 kg
Stabilization	**:** 3-axis stabilization
Operational Life	**:** Design life of 15 years

Sinosat-2

Development Agency	**:** China Academy of Space Technology (CAST), China
Launch	**:** 28 October 2006 from Xichang Satellite Launch Center in Sichuan Province, China
Launch Vehicle	**:** CZ-3B
Orbit	**:** GEO 134°E
Payload	**:** 24 Ku-band transponders
Weight	**:** 5100 kg
Stabilization	**:** 3-axis stabilization
Operational Life	**:** Design life of 15 years

Sinosat-3

Development Agency	**:** China Academy of Space Technology (CAST), China
Launch	**:** 31 May 2007 from Xichang Satellite Launch Center in Sichuan Province, China
Launch Vehicle	**:** CZ-3A
Orbit	**:** GEO 125°E
Payload	**:** 24 Ku-band transponders
Weight	**:** 2200 kg
Stabilization	**:** 3-axis stabilization
Operational Life	**:** Design life of 15 years

Sirius Satellite Radio Constellation

Sirius Satellite Radio system (previously known as CD Radio) is a satellite constellation, providing digital radio services to North America. The constellation became fully operational in November 2000 with the launch of third Sirius Radio satellite. These satellites are operated by Sirius

Satellite Radio Inc. (earlier known as CD Radio). Four satellites namely Sirius-FM1, -FM2, -FM3 and –FM5 have been launched.

Sirius-FM1, -FM2, -FM3

Development Agency : Space Systems Loral, USA
Launch
Sirius-FM1 (Radiosat-1) : 30 June 2000
Sirius-FM2 (Radiosat-2) : 5 September 2000
Sirius-FM3 (Radiosat-3) : 30 November 2000
All the Sirius satellites were launched from Baikonour Cosmodrome in Kazakhstan by Proton-K
Payload : 1 S-band Transponder each
Weight : 3800 kg
Stabilization : 3-axis stabilization
Orbit : Constellation operates in Tundra orbit (an elliptical 24 hour orbit ranging from a perigee of 23975 km to an apogee of 46983 km inclined at 63.4 degrees)

Sirius-FM5 (Radiosat-5)

Development Agency : Space Systems Loral, USA
Launch : 30 June 2009 from Baikonour Cosmodrome in Kazakhstan
Launch vehicle : Proton-M
Payload : 1 X/S-band Transponder
Weight : 5820 kg
Stabilization : 3-axis stabilization
Orbit : GEO
Operational Life : Design life of 15 years

Sirius Satellites

Sirius satellites provide broadcasting and broadband services to Nordic, Baltic, Central and East European countries. These satellites are operated by SES SIRIUS AB (earlier named NSAB). The first satellite of the constellation was Sirius-1. Marcopolo-1 satellite was acquired by NSAB in the year 1993 and renamed Sirius-1 (latter renamed to Sirius-W). It became inoperational in the year 2003. Sirius-2 was the largest telecom satellite ever built in Europe at the time of its launch. It provides analog and digital DTH transmissions as well as video and data communication services. Sirius-3 satellite provides direct-to-home television services to the Scandinavian region. Sirius-4 satellite Sirius 4 provides replacement capacity for Sirius-2 and -3 satellites in the Nordic and Baltic markets as well as to enhance coverage in Eastern Europe and Russia.

Sirius-2

Development Agency : Aerospatiale, France (now Alcatel Space, France)
Launch : 12 November 1997 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 4.8^0E
Payload : 32 Ku Band Transponders
Weight : 1240 kg

Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Sirius-3 (Fig.84)

Development Agency : Hughes Space and Communication Systems, USA (now Boeing Space Systems)
Launch : 5 October 1998 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 5^0E
Payload : 15 Ku Band Transponders
Weight : 1465 kg
Stabilization : Spin stabilization
Operational life : Design life of 12 years

Sirius-4

Development Agency : SES Sirius AB, Sweden
Launch : 17 November 2007 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 4.8°E
Payload : 52 Ku Band and 2 Ka Band Transponders
Weight : 4385 kg
Stabilization : Spin stabilization
Operational life : Design life of 15 years

Solidaridad series

Solidaridad series of satellites, operated by Satmex Inc. (formerly owned by Telecomunicaciones de Mexico (Telecomm)), are second generation Mexican satellites providing C, L and Ku-band communication services to Mexico and C-band and Ku-band coverage to the southwestern United States. Two Solidaridad satellites have been launched till date, Solidaridad-1 and -2.Sat

Solidaridad-1, -2 (Fig.85)

Development Agency : Hughes Space and Communications Systems, USA (now Boeing Space Systems)
Launch
Solidaridad-1 : 19 November 1993
Solidaridad-2 : 7 October 1994
Both the satellites were launched from Kourou in French Guiana, France on Ariane-44LP and Ariane-44L respectively
Orbit
Solidaridad-1 : GEO 109.2^0W
Solidaridad-2 : 113.5^0W
Payloads : 18C, 16 Ku-band and 1L-band transponders
Weight : 2276 kg each
Operational Lifetime : Design life of 14 years. Solidaridad 1 satellite failed in 2000 and its users were transferred to other Satmex satellites.

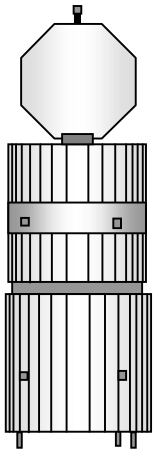


Fig.84
Sirius-3

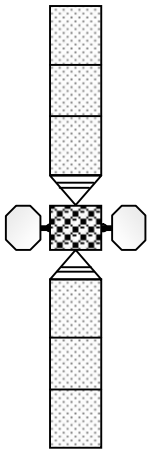


Fig.85
Solidaridad-1, -2

Stellat-5

Stellat-5 satellite was sold to Eutelsat and was renamed Atlantic Bird-3.

Stensat

Stensat satellite, operated by Amateur Radio of USA, is USA's experimental satellite weighing only 200 gm.

Development Agency : Stensat group
Launch : 26 January 2000 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Minotaur
Orbit : LEO, Sun-synchronous
Mean altitude of 749 km * 805 km, 100.22°
Payloads : Single channel mode "J" FM voice repeater
Weight : 200gm
Operational Life : Design life of 1 year

Superbird series

Superbird satellites are owned and operated by Space Communication Corporation (SCC), a Japanese satellite communication service company. The first Superbird satellite was Superbird-A launched in the year 1989. Superbird-A satellite was followed by Superbird-B, -A1, -B1, -C, -4 (-B2), -5 (-D), -6 (-A2) and -7 (-C2) satellites. Superbird-5 satellite is also referred to as JCSAT 110.

Superbird -A1, -B1

Development Agency : Space Systems Loral, USA
Launch
Superbird-A1 : 2 December 1992
Superbird-B1 : 26 February 1992
Superbird-A1 and -B1 were launched from Kourou in French Guiana, France on Ariane-42P and Ariane-44L respectively
Orbit
Superbird-A1 : GEO 158^0E
Superbird-B1 : GEO 162^0E
Payload : 23 Ku-band, 3 Ka-band and 2 X-band transponders each
Weight
Superbird-A1 : 2800 kg
Superbird-B1 : 2560 kg
Stabilization : 3-axis stabilization
Operational Life : Design life of 10 years

Superbird-C (Fig.86)

Development Agency : Hughes Space and Communication Systems, USA (now Boeing Space Systems)
Launch : 28 July 1997 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2AS
Orbit : GEO 144^0E
Payload : 24 Ku-band transponders
Weight : 3100 kg
Stabilization : 3-axis stabilization
Operational Life : Design life of 10 years

Superbird-4 (Superbird-B2) (Fig.87)

Development Agency : Hughes Space and Communication Systems, USA (now Boeing Space Systems)
Launch : 18 February 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 162^0E
Payload : 23 active Ku band and 6 Ka band transponders, 1 steer able Ku band spot beam
Weight : 4057 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years

Superbird-5 (Superbird-D, JCSat-110)

Development Agency : Lockheed Martin Systems, USA
Launch : 7 October 2000 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42L
Orbit : GEO 110^0E
Payload : 24 Ku-band transponders

Weight : 3530 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Superbird-6 (-A2)

Development Agency : Boeing Space Systems, USA
Launch : 14 August 2008 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2AS
Orbit : GEO 158^0E
Payload : 23 active Ku-band transponders
Weight : 3100 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 13 years

Superbird-7 (-C2)

Development Agency : Mitsubishi Electric, Japan
Launch : 15 April 2004 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 144°E
Payload : 28 Ku-band transponders
Weight : 4820 kg
Stabilization : 3-axis stabilization
Operational life : Design life of greater than 15 years

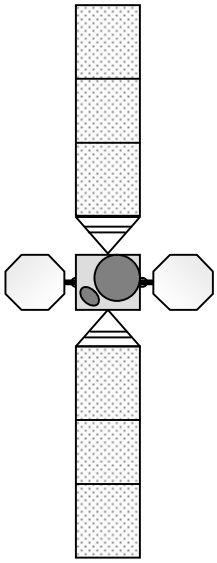


Fig.86
Superbird-C

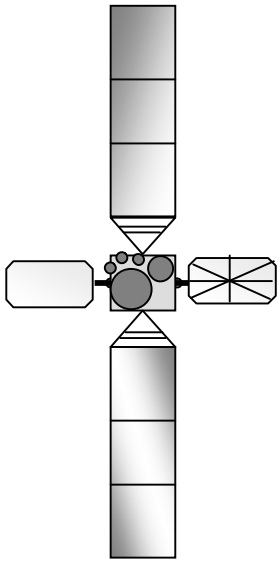


Fig.87
Superbird-4

TDF series

TDF satellites are French communication satellites. Two TDF satellites have been launched till date. TDF-1 launched in 1988 is out of service now. Currently TDF-2 satelite, launched in 1990, is operational

TDF-2

Development Agency : Aerospatiale, France (Alcatel Space, France)
Launch : 24 July 1990 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44L
Orbit : GEO 36^0E
Weight : 2100 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 8 years

TDRS series

The Tracking and Data Relay Satellite System (TDRSS) is a communication signal relay system from USA, which provides tracking and data acquisition services between low earth orbiting satellites and NASA/customer control and/or data processing facilities. TDRS satellites comprise the space segment of the TDRSS system. The TDRS satellite constellation comprises of three (two operational and one spare) satellites. Two generation of TDRS satellites have been launched. First generation, (Fig.88) comprises of seven satellites namely TDRS-A, -B, -C, -D, -E, -F and –G. Second generation (Fig.89) comprises of three satellites namely TDRS-H, -I and -J. TDRS-A, -B, -C, -D, -E and -F satellites constitute the basic TDRS program, TDRS-G, the replacement program and the TDRS-H, -I and -J satellites constitute the replenishment program.

TDRS-A (-1), -B (-2), -C (-3), -D (-4), -E (-5), -F (-6), -G (-7)

Development Agency : TRW Space and Electronics, USA
Launch
TDRS-A : 4 April 1983
TDRS-B : 28 January 1986
TDRS-C : 26 September 1988
TDRS-D : 13 March 1989
TDRS-E : 2 August 1991
TDRS-F : 13 January 1993
TDRS-G : 13 July 1995
The above TDRS satellites were launched from Cape Canaveral launch center, USA. TDRS-A and -B were launched on space shuttle Challenger, TDRS-C, -D and -G on space shuttle Discovery, TDRS-E on space shuttle Atlantis and TDRS-F on space shuttle Endeavor
Orbit
TDRS-A : GEO 67°W (1983), 41°W (1983-1989), 79°W (1989-1990), 170°W (1990-1993), 85°E (1994-1995), 49°W (1996)
TDRS-B : Launch failure

TDRS-C : 151°W (1988), 171°W (1989-1990), 174°W (1990-1991), 62°W (1991-1994), 171°W (1994-1995), 85°E (1995-1999)
TDRS-D : GEO 41°W
TDRS-E : GEO 174^{0}W
TDRS-F : GEO 150°W (1993), 138°W (1993), 46^{0}W (1994 to till date)
TDRS-G : GEO 150°W (1995-1996), 171° W (1996 to till date)
Weight
TDRS-A, -B : 2268 kg
TDRS-C, -E : 2200 kg each
TDRS-D, -G : 2120 kg each
TDRS-F : 2530 kg
Payloads : S band, Ku Band and C band payloads each
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

TDRS-8 (-H), -9 (-I), -10 (-J)

Development Agency : Hughes Space and Communication Systems, USA (now Boeing Space Systems)
Launch
TDRS-H : 30 June 2000
TDRS-I : 8 March 2002
TDRS-J : 4 December 2002
All the three satellites were launched from Cape Canaveral launch center, USA on Atlas-2A
Orbit
TDRS-H : GEO 171°W
TDRS-I : GEO
TDRS-J : GEO 41°W
Payload : S band, Ku Band and Ka band payloads each
Weight : 3192 kg each
Stabilization : 3-axis stabilization
Operational life : Design life of 11 years

Fig.88
1st generation TDRS satellites (Courtesy: NASA)

Fig.89
2nd generation TDRS satellites (Courtesy: NASA)

Telstar series

Telstar satellites are used for varied applications ranging from cable and DTH television to internet applications, to news gathering, distance learning, business learning and telephony

Telstar-1 was the first active communication satellite of the world. It was launched by Delta Rocket from Cape Canaveral on July 10, 1962, and transmitted the first direct television pictures from the United States to Europe, becoming the first satellite to relay signals from the Earth to a satellite and back. Telstar-2, launched on May 7, 1963, replaced Telstar-1 and became the first satellite to provide transatlantic television transmission services. They were followed by Telstar -301, -302, -303, -401, -402, -5, -6, -7, -8, -10, -11, -12, -13, -14 and -18 satellites. Currently, Telstar -5, -6, -7, -8, -10, -11, -12, -13, -14 and -18 satellites are operational.

Telstar-5, - 6, -7

Telstar-5, -6 and -7 satellites were sold to Intelsat in July 2003, who operates these satellites as Intelsat Americas-5, -6 and -7.

Development Agency : Space Systems Loral, USA
Launch
Telstar-5 : 24 May 1997
Telstar-6 : 15 Feb 1999
Telstar-7 : 25 September 1999
Telstar-5 and -6 were launched by Proton-K from Baikonour Cosmodrome in Kazakhstan and Telstar-7 was launched by Ariane-44L from Kourou in French Guiana, France
Orbit
Telstar-5 : GEO 97^0W
Telstar-6 : GEO 93^0W
Telstar-7 : GEO 129^0W
Weight
Telstar-5 : 3600 kg
Telstar-6 : 3763 kg
Telstar-7 : 3790 kg
Payloads
Telstar-5 and -6 : 24 C-band and 28 Ku-band transponders each
Telstar-7 : 24 C-band and 24 Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Telstar-8

Telstar-8 was sold to Intelsat in July 2003, who operates it as Intelsat Americas-8.

Development Agency : Space Systems Loral, USA
Launch : 23 June 2005 from Sea launch platform
Launch vehicle : Zenit-3SL
Orbit : GEO 89°W
Weight : 5493 kg
Payloads : 22 C-band, 36 Ku-band and 24 Ka-band transponders

Stabilization : 3-axis stabilization

Telstar-10 (Amstar-2R)

Development Agency : Space Systems Loral, USA
Launch : 17 October 1997 from Xichang Satellite Launch center in Sichuan Province
Launch vehicle : CZ-3B
Orbit : GEO 76.5^{0}E
Weight : 3700 kg
Payloads : 28 C-band and 15 Ku-band transponders
Stabilization : 3-axis stabilization

Telstar-11 (Orion-1)

Orion Network Systems Inc. was acquired by Loral in 1998. Orion-1 satellite was integrated into Loral's satellite fleet and was renamed Telstar-11.

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch : 29 November 1994 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-2A
Orbit : GEO 37.5^{0}W
Weight : 2361 kg
Payloads : 34 Ku-band transponders
Stabilization : 3-axis stabilization

Telstar-12 (Orion-2)

Orion-2 satellite was renamed Telstar -12.

Development Agency : Space Systems Loral, USA
Launch : 19 October 1999 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 15^{0}W
Weight : 3814 kg
Payloads : 38Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Telstar-13

C-band payload on the EchoStar-9 satellite was owned and operated by Loral Skynet, as Telstar -13. Loral sold Telstar-13 to Intelsat organisation in July 2003, which operates the C-band payload as Intelsat Americas-13 (IA-13).

Telstar-14

Development Agency : Space Systems Loral, USA
Launch : 11 January 2004 from Sea Launch Platform

Launch Vehicle : Zenit-3SL
Orbit : GEO 63^{0}W
Weight : 4694 kg
Payloads : 41 Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 15 years

Telstar-18

Telstar-18 satellite is also known as Apstar-5. Part of the payload on the satellite is operated by Loral Skynet, which calls the satellite Telstar-18. Another part of the payload is operated by APT satellite Inc. which calls it Apstar-5.

Thaicom series

Thaicom series of satellites are owned by Shin Satellite Public Company of Thailand (earlier known as Shinawatra Satellite). Thaicom is Thailand's first dedicated communication satellite system. Five Thaicom satellites have been launched till date namely Thaicom-1A, -2, -3, -4 and -5.

Thaicom-1A (formerly Thaicom-1), -2

Thaicom-1A (Fig.90) and Thaicom-2 satellites are first generation Thaicom satellites. They provide C-band communication services to Thailand, Laos, Myanmar, Vietnam, Malaysia, Philippines, Korea, Japan and east coast of China. They also provide Ku-band services to Thailand for direct broadcasting applications. Thaicom-1 satellite was renamed Thaicom-1A in June 1997 when it was relocated to 120°E from 78.5°E.

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch
Thaicom-1A : 17 December 1993
Thaicom-2 : 8 October 1994
Both the satellites were launched from Kourou in French Guiana, France on Ariane-44L
Orbit
Thaicom-1A : GEO 78.5°E (1993-1997) 120^{0}E (1997-till date)
Thaicom-2 : GEO 78.5^{0}E
Weight : 1080 kg each
Payloads : 10 active C-band and 2 active Ku-band transponders each
Stabilization : Spin stabilization
Operational life : Design life of 15 years

Thaicom-3

Thaicom-3 satellite provides communication services to Central Europe, Africa, eastern Asia and Australia.

Development Agency : Aerospatiale, France (now Alcatel Space, France)
Launch : 16 April 1997 from Kourou in French Guiana, France

Launch Vehicle : Ariane-44LP
Orbit : GEO 78.5^{0}E
Weight : 2652 kg
Payloads : 25 C-band 14 Ku-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Thaicom-4 (iPstar-1)

Thaicom-4 satellite, also known as iPstar-1 provides multimedia, data and direct-to-desktop services to Asia, India and Australia

Development Agency : Space Systems Loral, USA
Launch : 11 August 2005 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5GS
Orbit : GEO 78.3^{0}E
Weight : 6505 kg
Payloads : 87 Ku band 10 Ka band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Thaicom-5

Development Agency : Alcatel Alenia Space, France (earlier Alcatel Space)
Launch : 25 May 2006 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5ECA
Orbit : GEO 78.5°E
Weight : 2766 kg
Payloads : 24 C Band 14 Ku Band Transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 14 years

Thor series

Thor satellites, owned and operated by Telenor satellite services, provide direct broadcasting communication services to Norway. Five Thor satellites namely Thor-1, -2, -3, -5 and -6 have been launched. These satellites deliver television and telephony/data services to Scandinavia and Northern Europe, with western offshore beams to the Faroes, Iceland, and Greenland. In 1992 Marco Polo-2 satellite owned by British satellite broadcasting limited was acquired by Telenor and given the name Thor-1.

Thor-1 (Marco Polo-2)

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch : 17 August 1990 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-6925
Orbit : GEO 31°W (1990-1992), 0.8^{0}W (1992 onwards)
Payloads : 5 active Ku-band transponders

Weight : 1250 kg
Stabilization : Spin stabilization
Operational life : Design life of 10 years

Thor-2, -3 (Fig.91)

Development Agency : Hughes Space and Communication Systems, USA
(now Boeing Space Systems)
Launch
Thor-2 : 21 May 1997
Thor-3 : 10 June 1998
Both the satellites were launched from Cape Canaveral launch center on Delta-7925
Orbit : GEO 1^0W
Weight
Thor-2 : 1467 kg
Thor-3 : 1451 kg
Payloads
Thor-2 : 15 Ku-band transponders
Thor-3 : 14 Ku-band transponders
Stabilization : Spin stabilization
Operational life : Design life of 12 years

Thor-5

Thor-5 satellite, earlier named Thor-2R, provides improved coverage in the Nordic countries, Europe and the Middle East.

Development Agency : Orbital Sciences Corporation, USA
Launch : 11 February 2008 from from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-M
Orbit : GEO 0.8°W
Payloads : 24 Ku-band transponders
Weight : 1960 kg
Stabilization : Three-axis stabilization
Operational life : Design life of 15 years

Thor-6

Thor-6 satellite provides broadcasting services to Central and Eastern Europe.

Development Agency : Thales Alenia Space (France)
Launch : 29 October 2009 from Kourou in French Guiana, France
tLaunch Vehicle : Ariane-5ECA
Orbit : GEO 0.8°W
Payloads : 36 active Ku-band transponders
Weight : 3050 kg
Stabilization : Three-axis stabilization
Operational life : Design life of 15 years

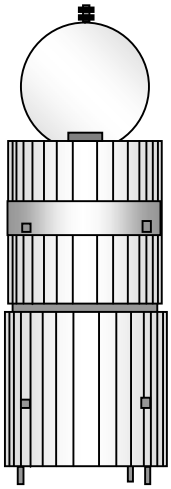


Fig.90
Thaicom-1A

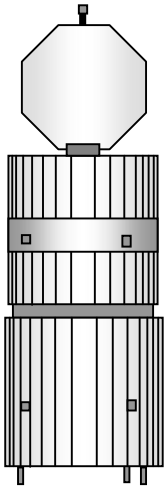


Fig.91
Thor-2, -3

Thuraya series

Thuraya satellites, operated by Thuraya satellite telecommunications company are United Arab Emirates's communication satellites providing GSM-compatible mobile telephone services. Three Thuraya satellites namely Thuraya-1, -2 and -3 have been launched.

Thuraya-1

Development Agency : Hughes space and communication systems, USA (now Boeing Space Systems)
Launch : 20 October 2000 from Sea launch Platform in the Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 44^0E Latter shifted to 28.5°E after the launch of Thuraya 2.
Weight : 5250 kg
Payloads : 128 L Band active elements and 2 active C Band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Thuraya-2

Development Agency : Boeing Space Systems, USA
Launch : 10 June 2003 from Sea launch Platform in the Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 44^0E
Weight : 5250 kg
Payloads : 128 L-band active elements and 2 active C-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

Thuraya-3

Development Agency : Boeing Space Systems, USA
Launch : 15 January 2008 from Sea launch Platform in the Pacific Ocean
Launch Vehicle : Zenit-3SL
Orbit : GEO 98.5°E
Weight : 5177 kg
Payloads : 128 L-band active elements and 2 active C-band transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 12 years

TV Sat series

TV Sat satellites are Germany's communication satellites that provide Direct TV Broadcasting services to Europe. Till date two TV Sat satellites have been launched namely TV Sat-1 in 1987 and TV Sat-2 in 1989. TV Sat-1 satellite became inoperational in 1989 due to failure of one of its solar panels. Currently, TV Sat-2 is operational

.

TV Sat-2

Development Agency : Aerospatiale, France (now Alcatel Space, France)
Launch : 8 August 1989 from Kourou in French Guiana, France
Launch Vehicle : Ariane-44LP
Orbit : GEO 19^0W
Weight : 2136 kg
Payload : 5 active and 1 spare Ku-band transponder
Stabilization : 3-axis stabilization
Operational life : Design life of 8 years

XM series

XM satellites, operated by XM Satellite Radio Inc. (XMTM), are USA's communication satellites providing digital audio radio programming services directly to automobiles, homes and portable radios from coast to coast. Currently, the XM-series comprises of four satellites namely XM-1 (Roll), XM-2 (Rock), XM-3 (Rhythm) and XM-4 (Blues). .

XM-1 (XM Roll), -2 (XM Rock) (Fig.92)

Development Agency : Boeing Space Systems, USA
Launch
XM-1 : 8 May 2001
XM-2 : 18 March 2001
Both the satellites were launched from the Sea Launch platform in the pacific ocean on Zenit-3SL
Orbit
XM-1 : GEO 85^0W
XM-2 : GEO 115^0W
Weight : 4682 kg each
Payloads : 13.3 KW Digital Audio Radio active 2-S Band transponders

Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

XM-3 (XM Rhythm), -4 (XM-Blues)

Development Agency **:** Boeing Space Systems, USA
Launch
XM-3 **:** 01 March 2005
XM-4 **:** 30 October 2006
Both the satellites were launched from Sea Launch platform in pacific ocean on Zenit-3SL
Orbit
XM-3 **:** GEO
XM-4 **:** GEO
Weight
XM-3 **:** 4703 kg
XM-4 **:** 5193 kg
Payloads **:** 13.3 kW digital audio radio active 2 S-band transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

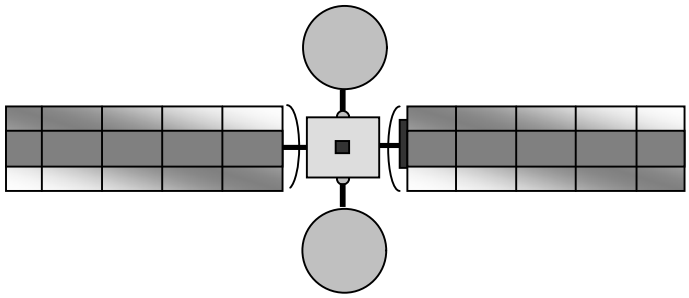


Fig.92
XM-1, -2

B. Remote Sensing Satellites

ADEOS satellite (renamed Midori)

ADEOS (Advanced Earth Observation Satellite) is Japan's remote sensing satellite operated by NASDA. ADEOS satellite monitors global environmental changes such as maritime meteorological conditions, atmospheric ozone, and gases that promote global warming. ADEOS-1 satellite was launched on 11 August 1996 but it became inoperational on June 30, 1997 because of the structural damage in its solar array paddle. ADEOS-2 satellite (Fig.93) was launched to take over ADEOS-1's observation mission.

ADEOS-2 (Midori-2)

Development Agency : Mitsubishi Electric, Japan
Launch : 14 December 2002 from Tanegashima, Japan
Launch Vehicle : H-2A
Orbit : LEO, near Polar Sun synchronous 803km circular orbit, 98.6°
Weight : 3730 kg
Stabilization : 3-axis stabilization
Payload : Advanced Microwave Scanning Radiometer (AMSR), Global Imager (GLI), Sea Winds (SeaWinds), Polarization and Directionality of the Earth's Reflectance (POLDER), Improved Limb Atmospheric Spectrometer-II (ILAS-II)
Operational Lifetime : Design life of 5 years

Aqua satellite

Aqua (formerly EOS PM-1) (Fig.94) satellite is a part of NASA's EOS (Earth Observing System) program, launched to perform multidisciplinary study of the Earth's interrelated processes of atmosphere, oceans, and land-surface and examine their relationship to Earth system changes. It will in particular collect information about the Earth's water cycle, including evaporation of water from the oceans, water vapor in the atmosphere and clouds, precipitation process, soil moisture, sea and land ice and snow cover on the land. In nutshell, Aqua satellite performs both remote sensing as well as scientific missions related to study of earth.

Aqua satellite is a part of Afternoon or "A-Train" satellite constellation.The constellation currently comprises of Aqua, Aura, PARASOL, CloudSat and CALIPSO satellites. PARASOL exited the A-Train orbit in December 2009. Expected upcoming missions are Glory, a NASA mission due to be launched in 2010, and GCOM-W1, a JAXA mission due to be launched in 2011. After these two missions join, the A-Train will be led by GCOM-W1, followed by Aqua, then CloudSat, CALIPSO, Glory, and, in the rear, Aura.

Development Agency : TRW Space and Electronics of USA
Launch : 4 May 2002 from Vandenberg Air Force Base
Launch Vehicle : Delta-7920
Orbit : LEO, near Polar Sun synchronous 676 km * 687 km, 98.2°
Weight : 2934 kg
Stabilization : 3-axis stabilization
Payload : Advanced Microwave Scanning Radiometer-EOS (AMSR/E), Moderate Resolution Imaging Spectro-radiometer (MODIS), Advanced Microwave

Sounding Unit (AMSU), Atmospheric Infrared Sounder (AIRS), Humidity Sounder for Brazil (HSB), Clouds and the Earth's Radiant Energy System (CERES)

Operational Lifetime : Design life of 6 years

Aura satellite

Aura satellite (formerly EOS Chemistry-1) (Fig.95) studies the Earth's atmosphere, ozone, air quality and climate. It performs both remote sensing as well as scientific missions related to study of earth. Aura satellite is a part of Afternoon or "A-Train" satellite constellation.

Aqua satellite is a part of Afternoon or "A-Train" satellite constellation.The constellation currently comprises of Aqua, Aura, PARASOL, CloudSat and CALIPSO satellites. PARASOL exited the A-Train orbit in December 2009. Expected upcoming missions are Glory, a NASA mission due to be launched in 2010, and GCOM-W1, a JAXA mission due to be launched in 2011. After these two missions join, the A-Train will be led by GCOM-W1, followed by Aqua, then CloudSat, CALIPSO, Glory, and, in the rear, Aura.

Development Agency : Northrop Grumman Space Technology (TRW Space)
Launch : 15 July 2004 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-7920
Orbit : LEO, near Polar orbit, altitude 705 km, 98.2°
Weight : 2967 kg
Stabilization : 3-axis stabilization
Payload : High Resolution Dynamics Limb Sounder (HIRDLS), Microwave Limb Sounder (MLS), Ozone Monitoring Instrument (OMI), Tropospheric Emission Spectrometer (TES)
Operational Lifetime : Design life of 6 years

Fig.93
Adeos-2 (Courtesy: JAXA)

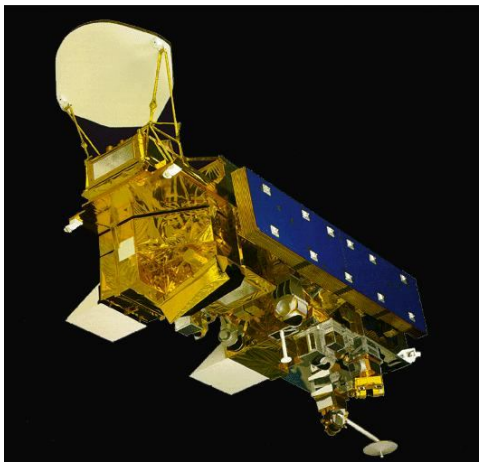


Fig.94
Aqua (Courtesy: NASA)

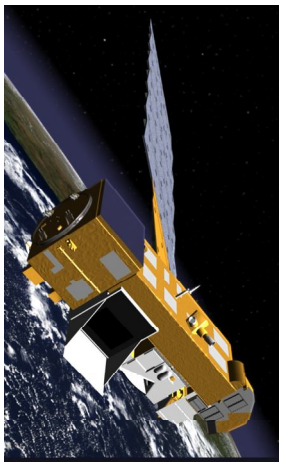


Fig.95
Aura (Courtesy: NASA)

Bird 1 satellite

Bird 1 (Bi-spectral Infra-red Detection) is a German technology demonstrator remote sensing satellite. It is a demonstrator of innovative remote sensing technology dedicated to fire recognition by small satellites. It also carries out the investigation of hot spots (forest fires, volcanic activities, burning oil wells or coal seams), of vegetation condition and their changes and real-time discrimination between smoke and water clouds and cloud analysis.

Development Agency : German Aerospace Center (DLR)
Launch : 22 October 2001 from Sriharikota launch center in India
Launch Vehicle : PSLV
Orbit : LEO Sun synchronous at altitude of 551 * 580km, 97.8°
Weight : 92 kg
Payload : A bi-spectral infrared Hot Spot Recognition System (HSRS) and a Wide-Angle Optoelectronic Stereo Scanner (WAOSS)
Stabilization : 3-axis stabilization
Operational life : Design life of 1 year

CartoSat series

CartoSat series of satellites are Indian remote sensing satellites. Three satellites have been launched in the series namely CartoSat-1, -2 and -2A. CatroSat-2B satellite is scheduled to be launched in the near future. CartoSat-1 satellite is also referred to as IRS-P5 satellite.

CartoSat-1

Same as IRS-P5 satellite.

CartoSat-2, -2A

Cartosat-2 is an advanced remote sensing satellite with a single panchromatic camera capable of providing scene-specific spot imageries for cartographic applications. Cartosat-2 suffered from some problems after launch. To compensate for its loss,an improved Cartosat 2A was launched in 2008.

Development Agency : Indian Space Research Organization (ISRO)
Launch
Cartosat-2 : 10 January 2007
Cartosat-2A : 28 April 2008
Both the satellites were launched from SHAR center in Sriharikota. CartoSat-2 was launched on PSLV-C7 and CartoSat-2A was launched on PSLV-C9
Orbit
CartoSat-2A : LEO circular Sun synchronous (suffered problems after launch)
CartoSat-2A : LEO circular Sun synchronous, Mean altitude of 635 km, 97.94°
Weight
CartoSat-2 : 650 kg
CartoSat-2A : 690 kg
Stabilization : 3-axis stabilization
Payloads : Both satellites have a panchromatic camera

Operational Life **:** Design life of 5 years

Cbers satellite

Cbers (China Brazil Earth Resources Satellite) is a joint Brazil-China co-operative program for the development of two remote sensing satellites. The CBERS satellites will enhance and complement the existing remote sensing systems and will provide more detailed information on the Earth environment and resources. Three Cbers satellites namely Cbers-1 (ZY-1A), Cbers-2 (ZY-1B) (Fig.96) and Cbers-2B (ZY-1B2) have been launched till date. The initial agreement has been expanded to launch two more satellites of the same kind, CBERS-3 and -4, in the second stage.

Cbers-1, -2 and -2B

Development Agency **:** INPE-National Institute for Space Research and Brazilian Space Agency from Brazil and Chinese Academy for Space Technology (CAST) from China.
Launch
Cbers-1 **:** 14 October 1999
Cbers-2 **:** 21 October 2003
Cbers-2B **:** 19 September 2007
All the three satellites were launched on CZ-4B from Taiyuan Satellite launch center in China
Orbit **:** LEO Circular Sun synchronous 778km mean altitude, 98.5°
Weight **:** 1450 kg each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 2 years
Payload
Cbers-1, -2 **:** High resolution CCD camera, Infrared multi-spectral scanner camera (IRMSS camera), Wide field imager camera (WFI camera)
Cbers-2B : High resolution CCD camera, High resolution panchromatic camera (HRC), Wide field imager camera (WFI camera)

Envisat satellite

Envisat (Environment Satellite) (Fig.97) is European space agency's (ESA) advanced polar-orbiting Earth observation satellite. It is a successor of ERS-1 and ERS-2 satellites and supports Earth science research and monitoring of the evolution of environmental and climatic changes.

Development Agency **:** EADS Astrium company, Europe
Launch **:** 1 March 2002 from Kourou launch center in French Guiana, France
Launch Vehicle **:** Ariane-5G
Orbit **:** LEO Circular Sun synchronous 796km altitude, 98.54^0
Weight **:** 8211 kg
Stabilization **:** 3-axis stabilization
Payload **:** Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), Global Ozone Monitoring by Occultation of Stars (GOMOS), Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY), Medium Resolution Imaging Spectrometer (MERIS), Advanced Along Track Scanning Radiometer (AATSR), Advanced

Synthetic Aperture Radar (ASAR), Radar Altimeter 2 (RA-2), Microwave Radiometer (MWR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), Laser Retro-Reflector (LRR).

Operational life : Design life of 5 years

EO-1 (New Millennium 2) satellite

Earth Observing-1 (EO-1) satellite (Fig.98) is the first satellite of NASA's New Millennium Program (NMP). It was launched on November 21, 2000 as part of a one-year technology validation/ demonstration mission to test new technology over a short time frame, and confirm that it was suitable for a long term satellite mission, such as the next generation of Landsat satellites. EO-1 satellite mission was also aimed at lowering the costs and enhancing the performance of future Earth science missions. Other satellites of the NMP program include Deep Space 1 and 2, Earth Observing 3 (EO-3), Space Technology 5, 6, 7 and 8. EO-1 satellite is also a part of NASA's EOS (Earth Observing System) program. It successfully completed its mission in November 2001 and as the end of the mission approached, the EO-1 mission was further extended. Under the Extended Mission provisions, image data acquired by EO-1 are archived and distributed by the USGS EROS Data Center (EDC).

Development Agency : Swales Aerospace, USA
Launch : 21 November 2000 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-7320
Orbit : Polar Circular Sun synchronous orbit, altitude of 705 km, 98.7^0
Weight : 529kg
Stabilization : 3-axis stabilization
Payload : Hyper-spectral Imager (Hyperion), ALI (Advanced Land Imager) multi-spectral sensor and Atmospheric Corrector
Operational lifetime : Design life of 2 years

Fig.96
Cbers-2
Courtesy: INPE

Fig.97
Envisat
Courtesy: ESA-DENMAN PRODUCTIONS

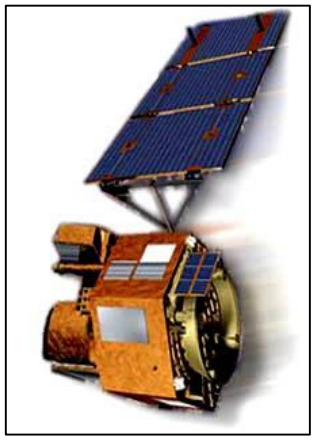


Fig.98
EO-1
Courtesy: NASA

EROS series

EROS (Earth Resources Observation Satellite) is a series of Earth observation satellites owned and operated by ImageSat International of Israel. Earlier, eight satellites were planned to be launched but now the EROS series will comprise of three satellites, EROS-A, -B and -C. EROS-A and -B satellites have been launched and EROS-C satellite is scheduled for launch in the year 2010.

EROS-A

Development Agency : Israel Aircraft Industries and Electro Optical Industries (ELOP), Israel
Launch : 5 December 2000 from Svobondy Cosmodrome in Russia
Launch Vehicle : Start-1
Orbit : LEO Circular Sun synchronous Mean altitude of 480 km, 97.33^{o}
Weight : 250 kg
Stabilization : 3-axis stabilization
Payload : CCD camera
Operational life : Design life of 6 years

EROS-B

Development Agency : Israel Aircraft Industries and Electro Optical Industries (ELOP), Israel
Launch : 25 April 2006 from Svobondy Cosmodrome in Russia
Launch Vehicle : Start-1
Orbit : LEO Circular Sun synchronous Mean altitude of 500 km
Weight : 350 kg
Stabilization : 3-axis stabilization
Payload : CCD/ TDI camera (Charged Coupled Device/ Time Delay Integration Camera)
Operational life : Design life of 10 years

ERS series

ERS series of satellites are Remote sensing satellites developed by the European space agency as a family of multi-disciplinary Earth observation satellites. They have collected a wealth of valuable data on the Earth's land surfaces, oceans, and polar caps and they monitor natural disasters such as severe flooding or earthquakes in remote parts of the world. On a global scale they have expanded the understanding of the interaction between the oceans and atmosphere, ocean currents and changes in the Arctic and Antarctic ice and hence climate trends can be predicted more accurately. The ERS satellites have also kept a close eye on agricultural areas, forests, coastlines and marine pollution. Two ERS satellites have been launched namely ERS-1 (Fig.99) and -2 (Fig.100).

ERS-1

Development Agency : Matra Marconi (renamed EADS Astrium), UK and European Aerospace Company Dornier Systems
Launch : 17 July 1991 from Kourou in French Guiana, France
Launch Vehicle : Ariane-40

Orbit : LEO Circular Sun synchronous Mean Altitude of 780 km, 98.5^0
Weight : 2157kg
Stabilization : 3-axis stabilization
Payload : Active Microwave Instrument (AMI) combining functions of SAR and Wind Scatterometer, Radar altimeter (RA), Along-track scanning radiometer (ATSR), Microwave sounder, Precise Range and Range-Rate Equipment (PRARE), Laser Retro-reflector array
Operational life : Design life of 3 years (Inoperational since March 2000).

ERS-2

Development Agency : Matra Marconi (renamed Astrium), UK and European Aerospace company Dornier Systems
Launch : 21 April 1995 from Kourou in French Guiana, France
Launch Vehicle : Ariane-40
Orbit : LEO Circular Sun synchronous, Mean altitude 785 km, 98.5^0
Weight : 2515 kg
Stabilization : 3-axis stabilization
Payload : Active Microwave Instrument (AMI) combining functions of SAR and Wind Scatterometer, Radar altimeter (RA), Along-track scanning radiometer (ATSR), Microwave sounder, Precise Range and Range-Rate Equipment (PRARE), Laser Retro-reflector array, Global Ozone Monitoring Experiment (GOME)
Operational life : Design life of 3 years

Fig.99
ERS-1 (Courtesy: ESA)

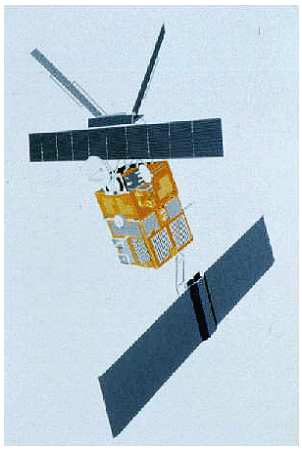


Fig.100
ERS-2 (Courtesy: ESA)

Haiyang series (HY)

Haiyang is China's first marine satellite series and is used to monitor ocean and sea water colour and temperature through remote sensing technology. Two satellites namely, HY-1A and HY-1B have been launched and they provide information on marine organisms, landforms under shallow water, water temperatures and ocean pollutants by observing data such as the optical

characteristics of seawater, chlorophyll density, sea surface temperature, suspended sand content, yellow materials, and maritime contamination. They provide real-time data that is beneficial for the fishing industry and study of ocean resources.

Development Agency : Chinese Academy of Space Technology (CAST)
Launch
HY-1A : 15 May 2002
HY-1B : 11 April 2007
Both the satellites were launched from Taiyuan Satellite Launch Center, China. HY-1A was launched on Long March-4B and HY-1B was launched on Long March-2C-III.
Orbit : LEO Circular Polar Sun synchronous
Mean altitude of 798 km 98.8°
Weight : 360kg
Stabilization : 3-axis stabilization
Payload : 10-band IR ocean color scanner and a 4-band CCD camera.
Operational life
HY-1A : Design life of 2 years
HY-1B : Design life of 3 to 5 years

ICESAT satellite

ICESAT (Ice, Cloud & Land Elevation Satellite) (Fig.101), formerly known as EOS-LAM (Earth Observation System-Laser Altimetry Mission), is a part of NASA's EOS (Earth Observing System) program. It measures changes in the thickness of ice sheets in Antarctica and Greenland.

Development Agency : Ball Aerospace, USA
Launch : 13 January 2003 from Vandenberg Air Force base in California, USA
Launch Vehicle : Delta-7320
Orbit : LEO Sun synchronous 586 km * 594 km, 94.0°
Weight : 970 kg
Stabilization : 3-axis stabilization
Payload : Geoscience Laser Altimeter System (GLAS)
Operational life : Design life of 5 years

Ikonos

Ikonos satellites are USA's high resolution Earth imaging satellites. They are the first satellites in the world to have resolution of one meter. Launch of first satellite in this series, Ikonos-1 on 27 April 1999, was a failure. The Ikonos-2 satellite (Fig.102), an identical twin of Ikonos-1 was launched later in the same year to cover up for the loss of Ikonos-1. The resolution of one meter helps them to distinguish between objects such as trucks, roads, pipelines, individual trees, crops, large equipment, boats, ships etc. having dimensions of a meter of more. Ikonos-2 has provided a reliable stream of image data that has become a standard for commercial high-resolution satellite data products.

Ikonos-2

Development Agency : Lockheed Martin Missiles & Space, USA

Launch : 24 September 1999 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Athena-2
Orbit : LEO Circular Near Polar Sun synchronous Mean Altitude of 681 km, 98.1^0
Weight : 720 kg
Stabilization : 3-axis
Payload : 1 sensor operating in the panchromatic (0.45 - 0.90 microns) mode as well as multi-spectral mode (Blue 0.45 - 0.52, Green 0.52 – 0.60, Red 0.63 - 0.69, Near IR 0.76 - 0.90 micron)
Operational life : Design life of 7 years

Fig.101
ICESAT (Courtesy: NASA)

Fig.102
Ikonos-2 (Courtesy: GeoEye)

IRS Series

The Indian remote sensing satellites are the main-stay of National Natural Resources Management system (NNRMS) of India, providing operational remote sensing data services. IRS system was established with the launch of IRS-1A in March 1988. IRS-1A satellite was followed by IRS-1B, IRS-1E (P1) and IRS-P2 satellites launched in 1991, 1993 and 1994 respectively. Then came IRS-1C, IRS-1D, IRS-P3, IRS-P4, IRS-P5 and IRS-P6 satellites. Slated for future launch are IRS-2 series (OCEANSAT-2/CLIMATSAT-1/ATMOS-1) and the IRS-3 series. IRS-2 series will be an integrated mission that will cater to global observation of climate, ocean and atmosphere. IRS-3 series will have all weather capabilities with multi-frequency and multi polarization microwave payloads and other passive instruments.

IRS-1C

Development Agency : Indian Space Research Organization (ISRO)
Launch : 28 December 1995 from Baikonur cosmodrome in Kazakhstan
Launch Vehicle : Molniya rocket of Russia
Orbit : LEO near Circular Sun-synchronous 805km * 817km, 99^0
Weight : 1250kg

Stabilization : 3-axis stabilization
Payloads : Panchromatic cameras operating in 0.5-0.75 micron band, LISS-III cameras operating in four bands (0.52-0.59, 0.62-0.68, 0.77-0.86 and 1.55-1.70 micron) and Wide field sensor working in 0.62-0.68 and 0.77-0.86 micron bands
Operational life : Design life of 3 years

IRS-P3

Development Agency : Indian Space Research Organization (ISRO)
Launch : 21 March 1996 from SHAR center in Sriharikota
Launch Vehicle : PSLV-D3
Orbit : LEO circular Sun-synchronous, Mean altitude of 817 km, 98.68^0
Weight : 920 kg
Stabilization : 3-axis stabilization
Payloads : Wide Field Sensor (WiFs) operating in three bands of 0.62-0.68, 0.77-0.86, 1.55-1.69 micron, Modular Opto-electric Scanner (MOS), X-ray astronomy experiment
Operational Life : Design life of 1 year

IRS-1D

Development Agency : Indian Space Research Organization (ISRO)
Launch : 29 September 1997 from SHAR center in Sriharikota
Launch Vehicle : PSLV-D4
Orbit : Satellite entered in elliptical orbits instead of circular, with an apogee and perigee of 831km and 737km respectively
Weight : 930kg
Stabilization : 3-axis stabilization
Payloads : same as IRS-1C
Operational Life : Design life of 3 years

IRS-P4 (OceanSat-1)

IRS-P4 (Fig.103) is the first Indian remote sensing satellite built for ocean applications

Development Agency : Indian Space Research Organization (ISRO)
Launch : 26 May 1999 from SHAR center in Sriharikota
Launch Vehicle : PSLV
Orbit : LEO circular Sun synchronous, Mean altitude of 720 km, 98.28^0
Weight : 1050 kg
Stabilization : 3-axis stabilization
Payloads : OCM (Ocean Colour Monitor) with 8 spectral bands and MSMR (Multi-frequency Scanning Microwave Radiometers) operating at 6.6, 10.65, 18.0 and 21 GHz frequencies
Operational Life : Design life of 5 years

IRS-P6 (Resourcesat-1)

IRS-P6 (Fig.104) is the first Indian remote sensing Satellite built for ocean Applications

Development Agency : Indian Space Research Organization (ISRO)
Launch : 17 October 2003 from SHAR center in Sriharikota
Launch Vehicle : PSLV-C5
Orbit : LEO Circular Sun synchronous Mean Altitude 821 km, 98.76^0
Weight : 1360kg
Stabilization : 3-axis stabilization
Payloads : A high resolution Linear Imaging Self Scanner (LISS-4) operating in three spectral bands in the Visible and Near Infrared Region (VNIR), a medium resolution LISS-3 camera operating in three spectral bands in VNIR and one in Short Wave Infrared (SWIR) band, an Advanced Wide Field Sensor (AWiFS) operating in three spectral bands in VNIR and one band in SWIR and a Solid state recorder
Operational Life : Design life of 5 years

IRS-P5 (Cartosat 1)

IRS-P5 (Cartosat-1) (Fig.105) satellite is mainly intended for cartographic applications.

Development Agency : Indian Space Research Organization (ISRO)
Launch : 5 May 2005 from SHAR center in Sriharikota
Launch Vehicle : PSLV-C6
Orbit : LEO circular Sun synchronous, Mean altitude of 618 km, 98.87^0
Weight : 1560 kg
Stabilization : 3-axis stabilization
Payloads : 2 Panchromatic cameras (PAN fore and PAN after) operating in 0.50 to 0.85 µm band and Solid state recorder
Operational Life : Design life of 5 years

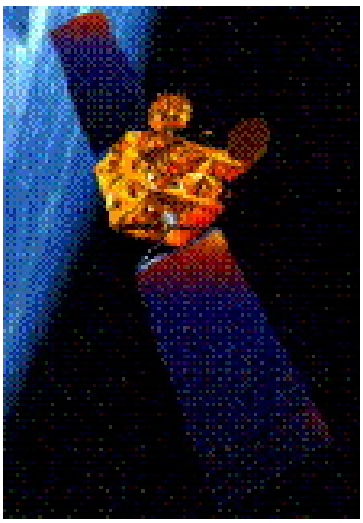


Fig.103
IRS-P4 (Courtesy: ISRO)

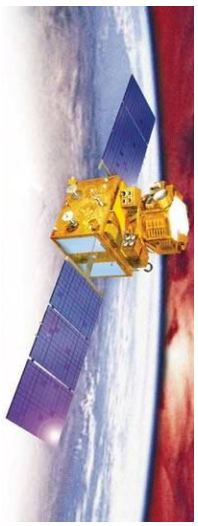


Fig.104
IRS-P6 (Courtesy: ISRO)

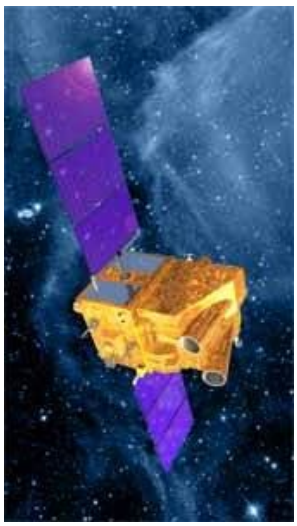


Fig.105
IRS-P5 (Courtesy: ISRO)

Kompsat series

Kompsat (Korea Multi-purpose Satellite) satellites are Korean multi-purpose satellites with remote sensing being their major mission objective. Currently, Kompsat-1 and -2 satellites have been launched and Kompsat-3 and -5 satellites are slated for launch in the near future. Kompsat-1 was designed for cartography, biological oceanography applications and studying the effects of radiation environment on microelectronics. Kompsat-2 satellite provides high-resolution images of the Korean peninsula for the production of maps and digital elevation models, applications for which include land use planning and disaster and risk management.

Kompsat-1 (Arirang-1)

Development Agency : Korean Aerospace Research Institute (KARI) and TRW Space and Electronics, USA
Launch : 21 December 1999 from Vandenberg Air Force base in California, USA
Launch Vehicle : Taurus-2110
Orbit : LEO, near Circular Sun-Synchronous, 685 km, 98.28°
Weight : 469 kg
Stabilization : 3-axis stabilization
Payload : Electro-Optical Camera (EOC), Ocean Scanning Multi-spectral Imager (OSMI), Space Physics Sensor (SPS)
Operational lifetime : Design life of 3 years

Kompsat-2 (Arirang-2)

Development Agency : Korean Aerospace Research Institute (KARI) and Europe's EADS Astrium Systems
Launch : 28 July 2006 from from Plesetsk Cosmodrome in Russia
Launch Vehicle : Rokot-KM
Orbit : LEO, near Circular Sun-Synchronous, 685 km, 98.13°
Weight : 800 kg
Stabilization : 3-axis stabilization
Payload : Multi-spectral camera (MSC)
Operational lifetime : Design life of 3 years

Landsat Program

The Landsat program is USA's remote sensing satellite program launched with the objective of observing the Earth on a global basis. It is the longest running enterprise for acquisition of imagery of the earth from space. Landsat imagery is a unique resource for global change research and applications in agriculture, water resources, urban growth, geology, forestry, regional planning, education and national security. Scientists use Landsat satellites to gather remotely sensed images of the land surface and surrounding coastal regions for global change research, regional environmental change studies and other civil and commercial purposes.

The first Landsat satellite, Landsat-1 was launched in 1972. A total of seven Landsat satellites have been launched till date. The first generation of Landsat satellites comprised of three satellites namely Landsat-1, -2 and -3 originally called ERTS for Earth Resources Technology Satellite. They were developed and launched by NASA between July 1972 and March 1978 and

were decommissioned by 1983. The second generation of Landsat satellites, Landsat-4 and -5 were launched in 1982 and 1984 respectively. Then, Landsat-6 was launched, but failed shortly after its launch in October 1993. Landsat-7 was launched in the year 1999 to cover up for the loss of Landsat-6. Future plans include the launch of Landsat-8 in the year 2011.

Landsat-7

Landsat-7 (Fig.106) is a part of NASA's Earth science enterprise and offers the unique capability to seasonally monitor important small scale processes on a global level. It provides well-calibrated, multi-spectral, moderate resolution, substantially cloud-free, sun-lit digital images of the Earth's continental and coastal areas with global coverage on a seasonal basis

Development Agency : Lockheed Martin, USA
Launch : 15 April 1999 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-II
Orbit : Polar Circular Sun synchronous orbit Mean altitude of 705 km, 98.2^0
Weight : 1973 kg
Stabilization : 3-axis stabilization
Payload : Enhanced Thematic Mapper + (ETM+) which is an eight-band, multispectral scanning radiometer operating in the spectral bands of 0.520-0.900 micron (panchromatic band), 0.45-0.52 micron (blue), 0.53-0.61 micron (green), 0.63-0.69 micron (red), 0.75-0.9 micron (near IR), 1.55-1.75 micron (mid IR), 2.09-2.37 micron (mid IR) and 10.4-12.5 micron (thermal IR)
Operational Life : Design life of 5 years

MTI (Multi-spectral Thermal Imager) Satellite

MTI satellite is a space-based research and development project sponsored by the U.S. Department of Energy (DOE), launched with the primary objective to demonstrate advanced multi-spectral and thermal imaging, image processing, and associated technologies that could be used in future systems for detecting and characterizing facilities producing weapons of mass destruction. The data collected by the satellite can be used for both military as well as civil applications such as to support current and future treaty monitoring system, to develop future Department of Defense operations support and targeting systems, to support the Global Change Research Program, hazardous waste site characterization and surveying, resource exploration, and crop health and yield assessment.

Development Agency : Los Alamos National Laboratory USA, Sandia National Laboratory USA, Savannah River Technology Center USA, US Air Force Research Laboratory, Ball Aerospace (USA), Raytheon (USA) and TRW (USA)
Launch : 12 March 2000 from Vandenberg Air Force base in California, USA
Launch Vehicle : Taurus-1110
Orbit : Polar circular Sun synchronous orbit
Mean altitude of 555 km, 97^0
Weight : 610kg
Stabilization : 3-axis stabilization
Payload : Multiband imager operating in 15 spectral bands, High Energy X-ray Spectrometer (HXRS)

Operational Life : Design life of 3 years

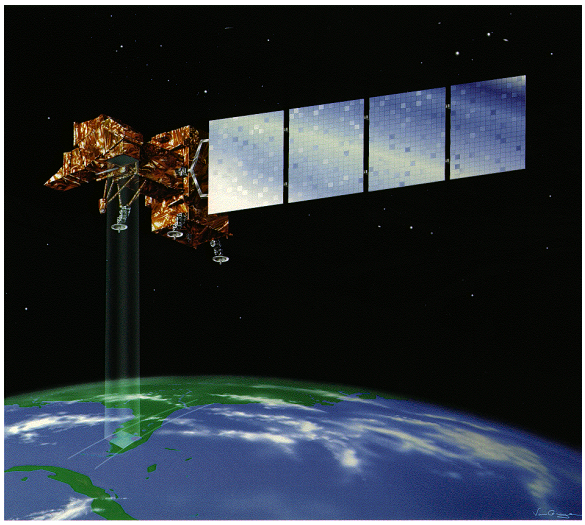


Fig.106
Landsat-7 satellite (Courtesy: NASA)

OceanSat series

OceanSat series of satellites are remote sensing satellites of India. Two satellites namely OceanSat-1 and -2 have been launched. OceanSat-1 satellite is also referred to as IRS-P4 satellite. OceanSat-2 is envisaged to provide service continuity for the operational users of OCM (Ocean Color Monitor) data as well as to enhance the application potential in other areas. The main objectives of OceanSat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water.

OceanSat-1

Same as IRS P4

OceanSat-2

Development Agency : Indian Space Research Organization (ISRO)
Launch : 23 September 2009 from SHAR center in Sriharikota
Launch Vehicle : PSLV-C14
Orbit : LEO circular Sun synchronous, Mean altitude of 720 km, 98.28°
Weight : 960 kg
Stabilization : 3-axis stabilization
Payloads : Ocean Colour Monitor (OCM), Scanning Scatterometer (SCAT) and Radio Occultation Sounder for Atmospheric Studies (ROSA)
Operational Life : Design life of 5 years

Orbview satellites

Orbview satellites are American remote sensing satellites operated by ORBIMAGE. Four Orbview satellites namely Orbview-1, -2, -3, -4 and -5 have been launched till date. OrbView-1 provides the world's first broad-area cloud-to-cloud lightening data and also offers meteorological research data for atmospheric monitoring and weather forecast applications. Orbview-2 (Seastar) (Fig.107) satellite provides quantitative data on global ocean bio-optical properties to the Earth science community. The imagery provided by the satellite is valuable for monitoring plankton and sedimentation levels in the oceans and assessing the health of land-based vegetation on a global basis, which is useful for a variety of applications such as fishing, agriculture, naval operations, scientific research and environmental monitoring. OrbView-3 and -4 satellites were designed to provide high-resolution imagery of the Earth. Orbview-4 satellite was lost during its launch. The images provided by Orbview-3 (Fig.108) are used for varied applications including environmental impact assessments for engineering companies; infrastructure planning for utilities and telecommunications; urban planning for city and county governments; crop health assessment for farmers; exploration for oil, gas and mineral companies; habitat monitoring for environmental agencies; surveillance and mission planning for national security agencies and real estate assessment and travel planning for consumers.

Orbview-5 satellite has been renamed GeoEye-1 after the fusion of OrbImage and Space Imaging as the new company GeoEye.

Orbview-1 (formerly Microlab-1)

Development Agency : Orbital Sciences Corporation, USA
Launch : 3 April 1995 from Vandenberg Air Force base in California, USA
Launch Vehicle : Pegasus-XL
Orbit : LEO Sun-synchronous mean altitude 740 km, 69.99°
Weight : 68 kg
Payload : Optical Transient Detector (OTD), an atmospheric monitoring instrument (GPS/MET).
Operational life : Design life of 5 years**.** Currently the satellite is operating in safe-hold mode and is used for station keeping

Orbview-2 (Seastar)

Development Agency : Orbital Sciences Corporation, USA
Launch : 1 August 1997 from Vandenberg Air Force Base, California, USA
Launch Vehicle : Pegasus-XL
Orbit : LEO circular near Polar Sun synchronous, Mean altitude of 700 km, 98.22°
Weight : 309 kg
Payload : Sea-viewing Wide Field-of-view Sensor (SeaWiFS)
Operational life : Design life of 7.5 years

Orbview-3

Development Agency : Orbital Sciences Corporation, USA
Launch : 26 June 2003 from Vandenberg Air Force Base in California, USA

Launch Vehicle : Pegasus-XL
Orbit : LEO circular Near Polar Sun synchronous, Mean altitude 470 km, 97°
Weight : 304 kg
Stabilization : 3-axis stabilization
Payload : 1 camera operating in the panchromatic and 4 channel multi-spectral mode
Operational life : Design life of 5 years

Orbview-5

Development Agency : General Dynamics (formerly Spectrum Astro), USA, Kodak/ITT Industries, USA and Boeing Launch Services, USA
Launch : 6 Septermber 2008 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta II
Orbit : LEO circular Near Polar Sun synchronous, Mean altitude 684 km, 98°
Weight : 1955 kg
Stabilization : 3-axis stabilization
Payload : 1 camera operating in the panchromatic and multi-spectral mode
Operational life : Design life of 7 years

Fig.107
Orbview-2 (Courtesy: GeoEye)

Fig.108
Orbview-3 (Courtesy: GeoEye)

Quickbird series

Quickbird satellites are remote sensing satellites from USA, owned and operated by Digital Globe. Three satellites namely Quickbird-1, Quickbird-2 and Quickbird-4 have been launched under the Quickbird series of satellites. Quickbird-1 and Quickbird-4 were lost during launch. Quickbird-2 is the highest resolution commercial satellite in operation that can image objects as

small as 60 cm. Thus, the data collected by Quickbird-2 contributes greatly to mapping, agricultural and urban planning, weather research and military surveillance.

Quickbird-2

Development Agency : Ball Aerospace & Technologies, USA
Launch : 18 October 2001 from Vandenberg Air Force base in California, USA
Launch Vehicle : Delta-7320
Orbit : LEO Circular Near Polar Sun synchronous, Mean altitude 450 km, 97.2^0
Weight : 980 kg
Stabilization : 3-axis stabilization
Payload : BGIS 2000 sensor (Ball's Global Imaging System) operating in the panchromatic mode and 4-band multi-spectral mode
Operational life : Design life of 5 years

Radarsat

Radarsat is Canada's first advanced Earth observation satellite project owned and operated by Canadian Space Agency (CSA). Radarsat satellites focus on the use of radar sensors to provide unique information about the Earth's surface through most weather conditions and even darkness, which can be used in monitoring the environment and managing the Earth's natural resources. Currently the Radarsat series comprise of Radarsat-1 (Fig.109) and -2 satellites with Radarsat constellation comprising of three satellites planned for launch in the near future.

Radarsat-1

Development Agency : Spar Aerospace (now a part of EMS Technologies), Canada and Ball Aerospace, USA
Launch : 4 November 1995 from Vandenberg Air Force Base, in California, USA
Launch Vehicle : Delta-7920
Orbit : LEO near Polar Sun synchronous, 793 km × 821 km, 98.6°
Weight : 2750kg
Stabilization : 3-axis stabilization
Payload : Synthetic Aperture Radar (SAR) operating in C-band
Operational life : Design life of 5 years

Radarsat-2

Development Agency : MacDonald, Dettwiler and Associates Ltd. (MDA), Canada and Alenia Spazio, Italy
Launch : 14 December 2007 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Soyuz-FG Fregat
Orbit : LEO near Polar Sun synchronous, 783 km × 787 km, 98.6°
Weight : 2300 kg
Stabilization : 3-axis stabilization
Payload : Synthetic Aperture Radar (SAR) operating in C-band
Operational life : Design life of more than 7 years

Fig.109
Radarsat-1(Courtesy: Canadian Space Agency)

Resurs satellites

Resurs satellites are passive remote sensing satellites from Rusia comprising of three families of satellites namely Resurs-F, Resurs-O and Resurs-DK. Resurs-F satellites, similar to Kosmos reconnaissance satellites, have short operational lives. Resurs-F system of satellites comprises of Resurs-F1 series, -F2 series, -F3 series, -F1M series and -F2M series. Resurs-O system is analogous to American Landsat satellite program. Resurs-O satellites are primarily used for coastal waters' surveillance, detection of industrial pollution sources and agricultural monitoring. Till date, four Resurs-O satellites have been launched. These include Resurs-O1 1, -O1 2, -O1 3, and -O1 4 satellites in 1985, 1985, 1994 and 1998 respectively.

One satellite has been launched in the Resurs-DK series (Resurs-DK 1). It is mainly designed to image and transmit data on information for Earth natural resources study, data on echology and emergency, sea surface status, ice situation, meteorological conditions in Earth polar regions, as well as to support digital data exchange between ground users. Resurs-P1 and –P2 satellites are scheduled to be launched in the near future.

Resurs-DK 1

Development Agency : TsSKB Progress, Russia
Launch : 15 June 2006 from Baikonur cosmodrome in Kazakhstan
Launch Vehicle : Soyuz-U
Orbit : LEO Circular Polar Sun synchronous, 360 km × 604 km, 70°
Weight : 6550 kg
Stabilization : 3-axis stabilization
Payload : Visible cameras operating in panchromatic and multi-spectral mode, Arina (for detection of high energy electrons and protons) and PAMELA (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics)
Operational life : Design life of 5 years

Risat-2 satellite

RISAT-2 is an Indian Radar Imaging Satellite with all weather capability to take images of the earth. This Satellite will enhance ISRO's capability for Disaster Management applications.

Risat-2

Development Agency : Indian Space Research Organization (ISRO)
Launch : 20 April 2009 from SHAR center in Sriharikota
Launch Vehicle : PSLV-CA
Orbit : LEO circular Sun synchronous, Mean altitude of 550 km, 41°
Weight : 300 kg
Stabilization : 3-axis stabilization
Payloads : Synthetic aperture radar (SAR) operating in the X-band

SAC series

Three satellites have been launched in SAC series. These include SAC-A, SAC-B and SAC-C. SAC-A is a technology demonstrator satellite to test and characterize the performance of new technologies and systems for use in future satellites. SAC-B is a scientific satellite to study solar physics and astrophysics.

SAC-C (Fig.110) satellite is an international mission between NASA, the Argentine commission on space activities (CONAE), the French space agency, Brazilian space agency, Danish space research institute and Italian space agency to study the structure and dynamics of the Earth's atmosphere, ionosphere and geomagnetic field. It provides multi-spectral images of the Earth in order to monitor the condition and dynamics of the terrestrial and marine biosphere and environment. It utilizes new GPS based techniques to globally measure atmospheric phenomena for the study of weather, seasonal, inter-annual and long term climatic changes, enhance the understanding of the Earth's magnetic field and related Sun-Earth interactions, measure high energy radiation environment, trapped particle intensities and energy distribution and correlate them with the degradation of advanced electronic components.

SAC-D (Aquarius) satellite is being planned to be launched in the near future.

SAC-C satellite

Development Agency : CONAE, NASA, Argentine company INVAP, French Space Agency, Brazilian Space Agency, Danish Space Research Institute and Italian Space Agency
Launch : 21 November 2000 From Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-7320
Orbit : LEO Circular Near PolarSun synchronous, Mean altitude 702km, 98.2^0
Weight : 475kg
Stabilization : 3-axis stabilization
Payload : Mulitspectral Medium Resolution Scanner (MMRS), High Resolution Technological Camera (HRTC), Influence of Space Radiation on

Advanced Components (ICARE) experiment, Italian Star Tracker (IST), Whale Tracker Experiment, Italian Navigation Experiment (INES), Data Collection System, Digital Transponder, High Sensitivity Camera (HCS), GPS Occultation and Passive Reflection Experiment (GOLPE), Scalar Helium Magnetometer (SHM)

Operational life : Design life of 4 years

SPOT satellites

SPOT is French satellite program for Earth Observation with Belgium and Sweden as its partners. The system is designed by French space agency (CNES) and operated by its subsidiary, Spot Image. SPOT's first satellite named SPOT-1 was launched in 1986. In total five SPOT satellites have been launched till date. These include SPOT-1, SPOT-2, SPOT-3, SPOT-4 and SPOT-5. SPOT-1, -2 and -3, launched in 1986, 1990 and 1993 respectively, each carried two identical HRV (High Resolution Visible) imaging instruments and two tape recorders for imaging data. They had a design life of 3 years and are out of service now. Currently, two of the SPOT satellites, SPOT 4 and SPOT 5, are operational. SPOT satellites provide Earth observation products for such diverse applications as agriculture, cartography, cadastral mapping, environmental studies, urban planning, telecommunications, surveillance, forestry, land use/land cover mapping, natural hazard assessments, flood risk management, oil and gas exploration, geology and civil engineering.

SPOT-4 (Fig.111)

Development Agency : Matra Marconi, France (now Europe's EADS Astrium Systems)
Launch : 24 March 1998 from Kourou in French Guiana, France
Launch Vehicle : Ariane-4
Orbit : Polar circular, near Polar Sun synchronous, Mean altitude of 822km, 98.7^0
Weight : 2755 kg
Stabilization : 3-axis stabilization
Payload : Two high Resolution Visible Infrared (HRVIR) push broom imaging instruments working in two modes: Multi-spectral mode operating in 0.50-0.59 µm (Green), 0.61-0.68µm (Red), 0.78-0.89µm (NIR), 1.58-1.75 µm (SWIR) bands and Panchromatic mode operating in 0.61-0.68 µm band. HVRIR includes a new vegetation monitoring instrument operating in the same bands as HRVIR.
Operational life : Design life of 5 years

SPOT-5 (Fig.112)

Development Agency : Europe's EADS Astrium Systems
Launch : 4 May 2002 from Kourou in French Guiana, France
Launch Vehicle : Ariane-42P
Orbit : Polar Circular Near-Polar Sun synchronous, Mean altitude of 822km, 98.3^0
Payload : Two HRG (High Geometric Resolution) imaging instruments working in two modes: Multispectral mode operating in 0.50-0.59 µm (Green),

0.61-0.68µm (Red), 0.78-0.89µm (NIR), 1.58-1.75 µm (SWIR) bands and Panchromatic mode operating in 0.48-0.71 µm band

Weight : 3000 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years

SAC-C
(Courtesy: NASA)

SPOT-4
(Courtesy: CNES/ill.D.DUCROS)

SPOT-5
(Courtesy: CNES/ill.D.DUCROS)

Sunsat satellite

Sunsat is South Africa's first satellite in space. It is a multi-purpose satellite, built by students of a South African university designed with mission objectives of imaging, world wide store-and-forward email communications and satellite engineering research, study of the earth magnetic field, gravity field, atmosphere and ionosphere plus inter-comparison of GPS and SLR precision orbits. The primary purpose of SUNSAT is to take low cost, high resolution photographs of South Africa, which can be used to determine the type and density of vegetation on ground.

Development Agency : University of Stellenbosch, South Africa
Launch : 23 February 1999 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-II
Orbit : Elliptical Sun synchronous Polar Orbit 620km * 850km, 93^0
Weight : 64kg
Stabilization : 3-axis stabilization
Payload : High resolution CCD camera (Pushbroom imager) operating in green, red and near-infrared bands, magnetometer, GPS receiver, Amateur radio communications system supporting UHF, VHF, S/L bands
Operational life : Design life of 4-5 years but it failed on 19 January 2001

TOMS-EP (Total Ozone Mapping Spectrometer- Earth Probe)

TOMS-EP (Fig.113) is the third mission in NASA's TOMS program, which provides long-term observations of the global distribution of the Earth's ozone layer and measurements of sulphur-

dioxide released in volcanic eruptions. Previous missions included the Nimbus-7 launched in 1978 and the Soviet Meteor-3 launched in 1991. Originally intended for launch in 1994, TOMS-EP was delayed by failures of the first two Pegasus XL launch vehicles. Because of this delay, it will fly simultaneously with ADEOS-TOMS satellite and hence it was placed into a lower orbit (altitude 500 km) than the original planned orbit (altitude 950 km) to prevent it from gathering redundant information. But ADEOS satellite failed in 1997. Orbit of TOMS-EP was raised to an altitude of 640 km. TOMS-EP satellite is currently facing calibration problem.

TOMS-EP

Development Agency : TRW Space & Electronics, USA
Launch : 2 July 1996 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Pegasus-XL
Orbit : LEO Near-Polar Near-Circular Sun synchronous, 705 km * 746 km, 98.3^0
Weight : 295 kg
Payload : TOMS-3 instrument (Total Ozone Mapping Spectrometer) having an average resolution of 62km. It measures total ozone by observing both incoming solar energy and backscattered ultraviolet (UV) radiation at six wavelengths.
Stabilization : 3-axis stabilization
Operational life : Design life of 2 years

Fig.113
TOMS-EP (Courtesy: NASA)

TRMM (Tropical Rainfall Measuring Mission) Satellite

TRMM satellite (Fig.114) is a joint mission between NASA and the National Space Development Agency (NASDA), Japan. It is the first mission dedicated to measuring tropical and subtropical rainfall. The data collected by TRMM satellite are used by atmospheric scientists and weather forecasters to better understand how rainfall happens so as to enable them to improve their forecasts. It also helps in designing weather models, in disaster management, determining air quality, in water management, aviation safety, public health and invasive species.

Development Agency : NASA Goddard Space Flight Center

Launch : 27 November 1997 from Tanegashima Space Center in Japan
Launch Vehicle : H-2
Orbit : LEO Sun synchronous 350 km, 35^0
Latter raised to 400 km altitude
Weight : 3512 kg
Stabilization : 3-axis stabilization
Payload : Precipitation Radar (PR), TRMM Microwave Imager (TMI), Visible Infrared Scanner (VIRS), Clouds and the Earth's Radiant Energy System (CERES), Lightening Imaging Sensor (LIS)
Operational life : Design life of 3 years**.** The mission life has been extended and is still operational

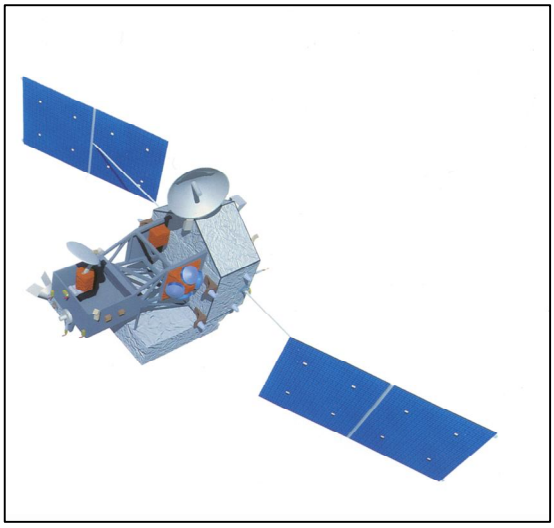


Fig.114
TRMM satellite (Courtesy: NASA)

Yaogan series

Yaogan series of satellites are Chinese remote sensing satellites. Till date Yaogan-1, -2, -3, -4, -5, -6, -7, -8, -9A, -9B and -9C satellites have been launched.

Yaogan -1, -3 (JB- 5 1, JB- 5 2)

Development Agency : Shanghai SAST group
Launch
Yaogan-1 : 27 April 2006
Yaogan-3 : 11 November 2007
Both the satellites were launched from Taiyuan space center. Yaogan-1 was launched on CZ-4B and Yaogan-3 on CZ-4C launch vehicle
Orbit : LEO Near-Polar Near-Circular Sun synchronous
Mean altitude 636 km, 97.9°
Weight
Yaogan-1: 2700 kg

Stabilization : 3-axis stabilization

Yaogan -2, -4, -7 (JB- 6 1, JB- 6 2, JB- 6 3)

Development Agency : Shanghai SAST group
Launch
Yaogan-2 : 25 May 2007
Yaogan-4 : 1 December 2008
Yaogan-7 : 9 December 2009
All the three satellites were launched from Jiquan Satellite Launch Center on CZ-2D launch vehicle
Orbit : LEO Near-Polar Near-Circular Sun synchronous, 639 km × 663 km, 97.9°
Stabilization : 3-axis stabilization

Yaogan -5 (JB- 8 1)

Development Agency : Shanghai SAST group
Launch : 15 December 2008 from Taiyuan space center
Launch vehicle : CZ-4B
Orbit : LEO Near-Polar Near-Circular Sun synchronous, Mean altitude 628 km, 97.3°
Weight : 2700 kg
Stabilization : 3-axis stabilization

Yaogan -6 (JB- 7 1)

Development Agency : Shanghai SAST group
Launch : 22 April 2009 from Taiyuan space center
Launch vehicle : CZ-2C-III
Orbit : LEO Near-Polar Near-Circular Sun synchronous, 493 km × 501 km, 97.8°
Stabilization : 3-axis stabilization

Yaogan -8

Development Agency : Shanghai SAST group
Launch : 15 December 2009 from Taiyuan space center
Launch vehicle : CZ-4C
Orbit : LEO Near-Polar Near-Circular Sun synchronous, 1200 km × 1212 km, 100.5°
Stabilization : 3-axis stabilization

Yaogan -9A, -9B, 9C

Development Agency : Shanghai SAST group
Launch
All the three satellites were launched on 5th March 2010 from Jiquan Satellite Launch Center on CZ-4C launch vehicle
Orbit : LEO Near-Polar Near-Circular Sun synchronous,

1089 km × 1107 km, 63.4°
Stabilization **:** 3-axis stabilization

ZiYuan series

Ziyuan satellites are China's remote sensing satellites. Two series of ZiYuan satellites namely ZiYuan-1 and -2 have been launched.

ZiYuan-1 series

Two ZiYuan-1 satellites have been launched namely ZiYuan-1A and -1B also known as CBERS-1 and CBERS-2 respectively.

ZiYuan-2 series

ZiYuan-2 series of satellites are used for both civilian and military observation applications. The military code name for these satellites is Jian Bing-3 (JB-3). Three ZiYuan-2 series satellites namely ZiYuan-2A, -2B and -2C have been launched.

Development Agency **:** Chinese Academy of Space Technology (CAST)
Launch
Ziyuan-2A (JB-3 1) **:** 1 September 2000
Ziyuan-2B (JB-3 2) **:** 27 October 2002
ZiYuan-2C (JB-3 3) **:** 6 November 2004
All the three satellites were launched from Taiyuan Satellite Launching Center (TSLC) in the northern Shanxi Province on CZ-4B
Orbit **:** LEO Near-Circular Near-Polar Sun synchronous
Ziyuan-2A **:** 490 km * 493 km, 97.3^0
Ziyuan-2B **:** 470 km * 483 km, 97.4^0
Ziyuan-2C **:** 479 km * 504 km, 97.3^0
Payload **:** High Resolution CCD Cameras and infrared multi-spectral scanner each
Operational life **:** Design life of 2 years

C. Weather Forecasting Satellites

Advanced TIROS-N (ATN) NOAA satellites

ATN NOAA series of satellites mark the fourth generation of polar weather satellites in the Polar Operational Environmental Satellite (POES) program. The first satellite in this series was NOAA 8, launched on 23 March 1983. A total of 12 satellites have been launched in this series. These inlcude NOAA-8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18 and -19 satellites. NOAA-19 was the last satellite to be launched in this series. Fig.115 shows the image of NOAA-17 satellite.

NOAA-15 (NOAA K), -16 (NOAA L), -17 (NOAA L), -18 (NOAA N) and -19 (NOAA N')

Development Agency : Lockheed Martin Astro, USA
Launch
NOAA-15 : 13 May 1998
NOAA-16 : 21 September 2000
NOAA-17 : 24 June 2002
NOAA-18 : 20 May 2005
NOAA-19 : 6 February 2009
All these satellites were launched from Vandenberg Air Force Base in California, USA. NOAA -15, -16 and -17 were launched on Titan-2 and NOAA-18 and -19 were launched on Delta-7320.
Orbit
NOAA-15 : LEO Sun-synchronous 847 * 861 km, 99°
NOAA-16 : LEO Sun-synchronous 807 * 824 km, 99°
NOAA-17 : LEO Sun-synchronous 853 * 867 km, 99°
NOAA-18 : LEO Sun-synchronous mean altitude 854 km, 98.74°
NOAA-19 : LEO Sun-synchronous mean altitude 870 km, 98.73°
Stabilization : 3-axis stabilization
Weight
NOAA-15, -16, -17 : 1479 kg each
NOAA-18, -19 : 1419 kg each
Payload
NOAA -15, -16, -17 : AMSU-A (Advanced Microwave Sounding Unit-A), AMSU-B (Advanced Microwave Sounding Unit-B), AVHRR-3 (Advanced Very High Resolution Radiometer-3), HIRS-3 (High Resolution Infrared Sounder-3), OCI, SARSAT (Search and Rescue Transponders), APT (Automatic Picture Transmission), HRPT (High Resolution Picture Transmission), DSB (Direct Sounder Broadcast), SEM (Space Energy Monitor), SBUV-2 (Solar Backscatter Ultraviolet Radiometer), ARGOS, DCS (Data Collection System)
NOAA-18 : AMSU, MHS, AVHRR-4, DCS, BDA, ESA, HIRS, IMP, IMS, MEPED, NEA, SAD, SAR, SBA, SBUV, SLA, SOA, SRA, TED, UDA, VRA
NOAA-19 : HIRS-4, AMSU-A, MHS, AVHRR-3, SBUV-2, SEM, ADCS (Advanced Data Collection System), DDR (Digital Data Recorder)
Operational life
NOAA-18 : Design life of minimum 3 years
NOAA-19 : Design life of minimum 2 years

Feng Yun 2 series

Feng Yun 2 (FY-2) is China's geostationary meteorological program. Five satellites have been launched in FY-2 series namely FY-2A, FY-2B, FY-2C, FY-2D and FY-2E. FY-2F satellite is being planned to be launched in the near future.

FY-2A

Development Agency	: Shanghai Institute of Satellite Engineering
Launch	: 10 June 1997 from Xichang launch center
Launch Vehicle	: CZ-3
Orbit	: GEO 105°E (1997-2000), 85°E (2000 onwards)
Stabilization	: Spin stabilization
Payload	: VISSR (Visible and Infrared Spin-scan Radiometer), Wefax (analogue), DCS (Data Collection Service) capability and a digital S-band fservice (CCITT G3)
Operational life	: Design life of 3 years. Retired in April 2000

FY-2B

Development Agency	: Shanghai Institute of Satellite Engineering
Launch	: 25 June 2000 from Xichang launch center
Launch Vehicle	: CZ-3A
Orbit	: GEO 105°E
Stabilization	: Spin stabilization
Payload	: VISSR (Visible and Infrared Spin-scan Radiometer), Wefax (analogue), DCS (Data Collection Service) capability and a digital S-band fax service (CCITT G3)
Weight	: 1250 kg
Operational life	: Design life of 3 years

FY-2C

Development Agency	: Shanghai Institute of Satellite Engineering
Launch	: 19 October 2004 from Xichang launch center
Launch Vehicle	: CZ-3A
Orbit	: GEO 105°E
Stabilization	: Spin stabilization
Payload	: Improved VISSR (Visible and Infrared Spin-scan Radiometer), LRIT (Low Rate Information Transmission), DCS (Data Collection Service) capability
Operational life	: Design life of 3 years

FY-2D, -2E

Development Agency	: Shanghai Institute of Satellite Engineering
Launch	
FY-2D	: 8 December 2006
FY-2E	: 23 December 2008

Both the satellites were launched from Xichang launch center on CZ-3A launch vehicle
Orbit
FY-2D **:** GEO 86.5°E
FY-2E **:** GEO 123.5°E
Stabilization **:** Spin stabilization
Weight **:** 1369 kg each
Operational life **:** Design life of 3 years

Geostationary Operational Environmental Satellites (GOES)

GOES satellite system, USA's geostationary weather forecasting satellite system launched by NASA, has remained an essential cornerstone of weather observation and forecasting for 25 years. It grew out of the successful use of experimental geostationary weather satellites named SMS-1 and -2 satellites. The first GOES satellite, GOES-1 (A), was launched in the year 1975. Since then fifteen GOES satellites have been launched, with GOES-15 launched in 2010, being the latest. GOES satellites provide the kind of continuous monitoring necessary for intensive data analysis. They circle the Earth in a geosynchronous orbit and hence provide continuous information on severe weather conditions such as tornadoes, flash floods, hail storms, and hurricanes.

GOES satellite imagery is also used to estimate rainfall during the thunderstorms and hurricanes for flash flood warnings and also to estimate snowfall accumulations and overall extent of snow cover. Such data helps meteorologists to issue winter storm warnings and spring snow melt advisories. GOES satellite sensors also detect ice fields and map the movements of sea and lake ice. The GOES program maintains two satellites operating in tandem to provide observational coverage of 60 percent of the Earth. One of the GOES satellite is positioned at 75ºW (GOES East) and the other is positioned at 135ºW longitude (GOES West). Each satellite views almost a third of the Earth's surface. GOES East monitors North and South America and most of the Atlantic Ocean, while GOES West looks down at North America and the Pacific Ocean basin. In addition to observations, the GOES West satellite has been used to create and operate PEACESAT (Pan-Pacific Educational and Cultural Experiments by Satellite). PEACESAT provides satellite telecommunication services to serve the educational, economic development, medical and cultural needs of many Pacific island nations and territories.

Currently, three second generation and three third-generation GOES satellites, GOES-10 (K), GOES-11 (L), GOES-12 (M), GOES-13 (N), GOES-14 (O) and GOES-15 (P) are operational.

GOES -10, -11, -12 (Fig.116)

Development Agency **:** Space Systems Loral, USA
Launch
GOES-10 (K) **:** 25 April 1997
GOES-11 (L) **:** 3 May 2000
GOES-12 (M) **:** 23 July 2003
All the GOES satellites were launched from Cape Canaveral launch center, USA with GOES-10 satellite was launched by Atlas-1 and GOES-11 and -12 satellites were launched by Atlas-2A
Orbit
GOES-10 **:** GEO 135^0W
Weight

GOES-10 : 2105 kg
GOES-11 : 2217 kg
GOES-12 : 2219 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years
Payload : GEOS satellites carry environmental, data collection and data broadcast payloads. Environmental payloads comprise of 5 channel Imager, 19 channel Sounder and Space Environment Monitor (SEM). The imager operates in one visible band of 0.52- 0.72 micron, and four IR bands of 3.78-4.03, 6.47-7.02, 10.2-11.2 and 11.5-12.5 micron. The 19 channel sounder or radiometer operates in four bands of visible, Long Wave IR, Medium Wave IR and Short Wave IR. SEM comprises of Energetic Particle Sensor (EPS), X-Ray Sensor (XRS), High Energy Proton and Alpha Particle Detector (HEPAD) and a magnetometer. SEM payloads are used for monitoring the near Earth space environment or solar weather. GOES 12 imager instead of having the 11.5-12.5 band has a 12.9-13.7 micron band. Data collection payloads comprise of Data Collection System (DCS). Data Broadcast payload comprises of Processed Data Relay (PDR), Weather Facsimile Transponders (WEFAX), Search and Rescue (SAR) and Sensor data and Multiuse Data Link (MDL) transponders

GOES-13, -14, -15

Development Agency : Boeing Space Systems, USA
Launch
GOES-13 (N) : 24 May 2006
GOES-14 (O) : 27 June 2009
GOES-15 (P) : 4 March 2010
All the GOES satellites were launched from Cape Canaveral launch center on Delta-4M+ launch vehicle
Orbit
GOES-13 : GEO 75°W
GOES-14 : GEO 135°W
GOES-15 : GEO 105°W
Weight : 3133 kg each
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years
Payload : Imager, sounder, solar X-ray imager and space environment monitor (SEM) payloads. All the three satellites have one downlink and five uplink channels in the S-band, eight downlink channels in the L-band and one downlink and two uplink channels in the UHF band.

Fig.115
NOAA-17 (Courtesy: NOAA and NASA)

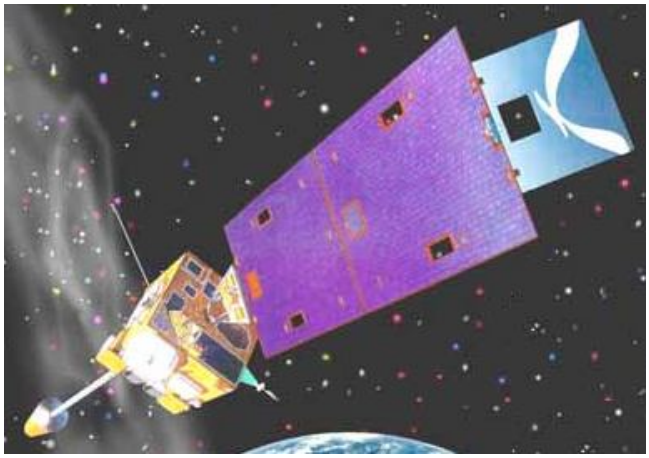


Fig.116
GOES satellites (Courtesy: NASA)

Himawari series (GMS – Geostationary Meteorological Satellite series)

Himawari satellites are Japan's geostationary meteorological satellites. These satellites are a part of the World Weather Watch (WWW) project of the World meteorological organization. First Himawari satellite named Himawari (GMS) was launched in the year 1977. A total of seven Himawari satellites namely Himawari (GMS), Himawari-2 (GMS-2), Himawari-3 (GMS-3), Himawari-4 (GMS-4), Himawari-5 (GMS-5), Himawari-6 (MTSat 1R) and Himawari-7 (MTSat 2) have been launched till date.

Himawari-5 (GMS-5)

Development Agency : NEC (Nippon Electric Corporation), Japan and Hughes Space and Communications Company, USA (now Boeing Satellite Systems)
Launch : 18 March 1995 from Tanegshima launch center, Japan
Launch Vehicle : H-2
Orbit : GEO 140°E
Payload : Visible and infrared spin scan radiometer (VISSR), search and rescue experiment payload
Stabilization : Spin stabilization
Weight : 747 kg
Operational life : Design life of 5 years

Himawari-6 (MTSat 1R)

Development Agency : Space Systems Loral, USA
Launch : 26 February 2005 from Tanegshima launch center, Japan
Launch Vehicle : H-2A
Orbit : GEO 140°E
Payload : Japanese Advanced Meteorological Imager (JAMI)
Stabilization : Three-axis stabilization

Weight : 2900 kg
Operational life : Design life of 10 years

Himawari-7 (MTSat 2)

Development Agency : Mitsubishi Electric, Japan and Boeing Satellite Systems, USA
Launch : 18 February 2006 from Tanegshima launch center, Japan
Launch Vehicle : H-2A
Orbit : GEO 145°E
Payload : Five channel imaging telescope
Stabilization : Three-axis stabilization
Weight : 4650 kg
Operational life : Design life of 10 years

Fig.117
GMS-5 satellite (Courtesy: JAXA)

Meteor series

Meteor are meteorological satellites from Russia. The program comprises of Meteor-1, -2, -3, -3M and –M series of satellites. Currently the first satellite of Meteor-3M series named Meteor-3M1 is operational. Second Meteor-3M satellite and Meteor-M series of satellites will be launched in the near future. One satellite, Meteor-M 1, of the Meteor-M series has been launched. The second satellite of the series, Meteor-M 2, will belaunched in the near future.

Meteor-3M1

Meteor-3M1 satellite is a joint mission of NASA and Russian Aviation and Space Agency. NASA's payload SAGE-III was carried by the Meteor-3M1 satellite

Development Agency : Elektromekhanika Research Institute (VNIIEM), Istra
Launch : 10 December 2001 from Bakionour cosmodrome in Kazakhstan
Launch Vehicle : Zenit-2

Orbit : LEO, Sun-synchronous mean altitude of 1012 km, 99.6°
Weight : 2500 kg
Payload : SAGE III (Strategic Aerosol and Gas Experiment), spherical retroreflector and other weather monitoring instruments
Stabilization : 3-axis stabilization
Operational life : Design life of 3 years

Meteor-M 1

Development Agency : Elektromekhanika Research Institute (VNIIEM), Istra
Launch : 17 September 2009 from Bakionour cosmodrome in Kazakhstan
Launch Vehicle : Soyuz-2-1b-Fregat
Orbit : LEO, Sun-synchronous, 814 km × 820 km, 98.8°
Weight : 2700 kg
Payload : MSU-MR (Global and regional for cloud cover mapping), KMSS (multichannel scanning unit for Earth surface monitoring), MTVZA (imager/sounder for Atmospheric temperature and humidity profiles, sea surface wind), Severjanin (SAR for Ice monitoring)
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years

Meteosat satellites

Meteosat satellite network is a European weather satellite system, currently operated by EUMETSAT (European Organization for Meteorological Satellites). Meteosat satellites aid the forecasters in swift recognition and prediction of various weather phenomena such as thunder storms, fog, rain, depressions, wind storms and so on. Meteosat satellites provide improved weather forecasts to Europe, Middle East and Africa. They also play a vital role in contributing to the global network of weather satellites that continuously monitor the globe.

Meteosat system of satellites became operational in the year 1977 with the launch of Meteosat-1. The system was maintained and operated by ESA (European space agency). Two generation of Meteosat satellites have been launched till date. The first generation of Meteosat satellites comprise of seven satellites, namely Meteosat-1, -2, -3, -4, -5, -6 and -7 (Fig.118). All of the first generation satellites were developed by ESA. However the maintenance of these satellites was given to European organization for Meteorological satellites (EUMETSAT) in the year 1995. The second generation satellites (MSG) (Fig.119) are an enhanced follow-on to the first generation satellites. They are jointly developed by ESA and EUMETSAT. Two satellites have been launched in this series, MSG-1 on 28 August 2002 and MSG-2 on 21 December 2005. MGS-1 (Meteosat-8) is used as a back-up satellite since the launch of MSG-2 (Meteosat-9). Two more satellites in the series are being planned to be launched in the near future.

Meteosat-5, -6, -7

Development Agency : Aerospatiale Company, France (now Alcatel Space, France)
Launch
Meteosat-5 : 3 March 1991
Mateosat-6 : 20 November 1993
Meteosat-7 : 2 September 1997

All the three satellites were launched from Kourou in French Guiana France on Ariane-44LP

Orbit

Meteosat-5 : GEO 63°E
Meteosat-6 : GEO 10°E
Meteosat-7 : GEO 0°
Weight : 282kg
Stabilization : Spin stabilization
Payload : Meteosat Visible and Infrared Imager (MVIRI) instrument
Operational life : Design life of more than 10 years

Meteosat-8 (MSG-1), -9 (MSG-2)

Development Agency : Alcatel Space Industries, France

Launch

Meteosat-8 (MSG-1) : 29 January 2004
Mateosat-9 (MSG-2) : 21 December 2005

All these satellites were launched from Kourou in French Guiana France on Ariane-44LP

Orbit

Meteosat-8, -9 : GEO 0°
Weight : 282kg
Stabilization : Spin stabilization
Payload : Meteosat Visible and Infrared Imager (MVIRI) instrument, Geostationary Earth Radiation Budget (GERB) instrument
Operational life : Design life of 7 years

METSAT series

METSAT (Meteorological Satellite) satellites are the first exclusive Indian meteorological satellite built by ISRO. So far, meteorological services had been combined with telecommunication and television services in the INSAT system. Currently METSAT-1 (Fig.120) is operational with METSAT-2 to be launched in the near future. METSAT will be a precursor to the future INSAT system that will have separate satellites for meteorology and telecommunication & broadcasting services. This will enable larger capacity to be built into INSAT satellites, both in terms of transponders and their radiated power, without the design constraints imposed by meteorological instruments.

METSAT-1 (Kalpana-1)

Development Agency : Indian Space Research Organization (ISRO)
Launch : 12 September 2002 from Sriharikota launch center, India
Launch Vehicle : PSLV
Orbit : GEO 74^0E
Weight : 1055 kg
Stabilization : 3-axis stabilization
Payload : 3-band VHRR instrument, Data Relay Transponder

Operational life **:** Design life of 5-7 years

Fig.118
First generation Meteosat
(Copyright 2005 © EUMETSAT)

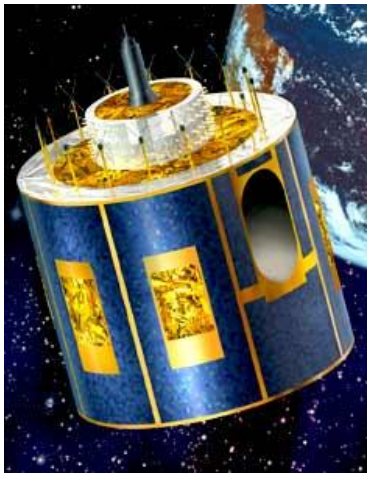


Fig.119
MSG series
(Courtesy: EADS SPACE)

Fig.120
METSAT-1
(Courtesy: ISRO)

D.Scientific Satellites

ACE (Advanced Composition Explorer)

ACE (Fig.121) is NASA's satellite mission designed to identify matter that comes near the earth from the sun, the space between planets and the Milky Way galaxy. These observations help the scientists to better understand the formation and evolution of the solar system. ACE also serves as a space weather station and provides advanced warning of geomagnetic storms that can overload power grids, disrupt communications, and present a hazard to astronauts

Development Agency : John Hopkins Applied Physics Lab (APL), USA
Launch : 25 August 1997 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7920
Orbit : L1 Halo solar orbit (In this orbit the Earth's gravitational pull is equal to that of the sun) around a gravitationally stable L1 Libration point between the Earth and the Sun
Weight : 785 kg
Stabilization : Spin stabilization
Payload : Cosmic Ray Isotope Spectrometer (CRIS), Solar Wind Ionic Composition Spectrometer (SWICS), Solar Wind Ions Mass Spectrometer (SWIMS), Electron Proton and Alpha Monitor (EPAM), Solar Wind Electron Proton and Alpha Monitor (SWEPAM), Magnetometer (MAG), Solar Isotope Spectrometer (SIS), Ultra Low Energy Isotope Spectrometer (ULEIS), Solar Energetic Particle Ionic Charge Analyzer (SEPICA), Real Time Solar Wind (RTSW)
Operational lifetime : Design life of 2-5 years

ACRIMSAT (Active Cavity Radiometer Irradiance Monitor Satellite)

ACRIMSAT (Fig.122) is NASA's scientific satellite launched to ascertain the extent of solar radiation variability and to measure the total amount of sunlight falling on Earth's atmosphere, oceans and land, and improve predictions of long-term climate change. The data collected by ACRIMSAT is correlated with possible global warming data, ice-cap shrinkage data and ozone layer depletion data.

Development Agency : Orbital Sciences Corporation (OSC), USA
Launch : 20 December 1999 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Taurus
Orbit : LEO Near-Circular Near-Polar sun-synchronous, 683 km * 724 km, 98.13^0
Weight : 120 kg
Stabilization : Spin stabilization
Payload : Active Cavity Radiometer Irradiance Monitor (ACRIM III)
Operational lifetime : Design life of 5 years

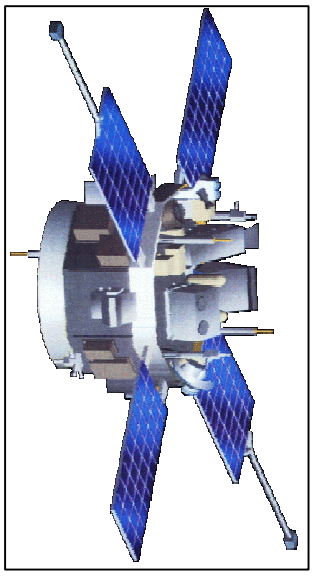


Fig.121
ACE satellite (Courtesy: NASA)

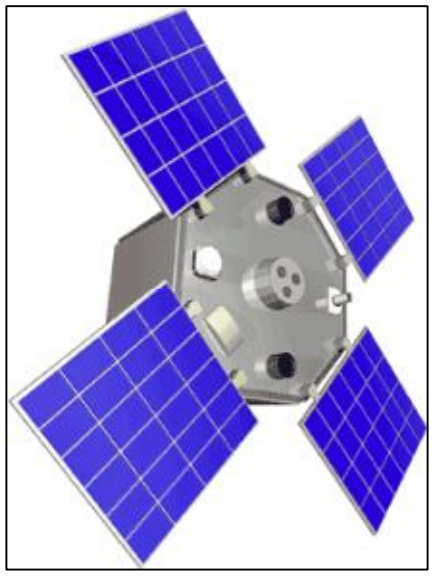


Fig.122
ACRIMSAT satellite (Courtesy: ACRIM Project, JPLNASA)

Badr series

Badr is Pakistan's operational microsatellite project comprising of Badr-A and Badr-B satellites. Currently, Badr-B satellite is operational. The main mission objectives of Badr-B programme include indigenous development of low cost satellites and creation of necessary infrastructure for future development in this field. Acquisition of earth observation is another objective.

Badr-B

Development Agency : Pakistan's Space Agency (SUPARCO)
Launch : 10 December 2001 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Zenit-2
Orbit : LEO near-circular, near-circular, Sun-synchronous
996 km * 1015 km, 99.7°
Weight : 68.5 kg
Stabilization : Gravity Gradient single-axis stabilization
Payload : CCD camera, Radiation dosimeter, Store and Forward Experiment (SAFE)
Operational lifetime : Design life of more than 2 years

BeppoSAX

BeppoSAX is the Italian space program with participation of the Netherlands agency for aerospace programs. It is an X-ray mission covering more than three decades of energy - from 0.1 to 300 keV - with a relatively large effective area, medium energy resolution and imaging capabilities in the range of 0.1-10 keV. The satellite performs X-ray imaging of the sources

associated with Gamma-ray bursts and determining their positions with an unprecedented precision and monitoring the X-ray afterglow of Gamma-ray bursts. Due to poor and degrading spacecraft conditions, the BeppoSAX mission ended on April 30 2002.

Development Agency : Alenia Spazio, Italy and Telespazio, Italy
Launch : 30 April 1996 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-1
Orbit : LEO, Circular, Sun-synchronous
Mean Altitude of 590 km, 3.9°
Weight : 900 kg
Stabilization : 3-axis stabilization
Payload : Narrow Field Instruments (NFI) [Four X-ray telescopes working in conjunction with Low Energy Concentrator Spectrometer (LECS) or Medium Energy Concentrator Spectrometer (MECS), High pressure Gas Scintillator Proportional Counter (HPGSPC), Phoswich Detection System (PDS)] and Wide Field Camera
Operational lifetime : Design life of 6 years

Calipso satellite

Calipso satellite is a part of Afternoon or "A-Train" satellite constellation.The constellation currently comprises of Aqua, Aura, PARASOL, CloudSat and CALIPSO satellites. PARASOL exited the A-Train orbit in December 2009. Expected upcoming missions are Glory, a NASA mission due to be launched in 2010, and GCOM-W1, a JAXA mission due to be launched in 2011. After these two missions join, the A-Train will be led by GCOM-W1, followed by Aqua, then CloudSat, CALIPSO, Glory, and, in the rear, Aura.

Development Agency : Alcatel Space, France
Launch : 28 April 2006 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Delta-7420
Orbit : LEO Sun synchronous 676 km * 687 km, 98.2°
Weight : 560 kg
Stabilization : 3-axis stabilization
Payload : LIDAR**,** Imaging Infrared Radiometer (IIR) and a Wide field Camera (WFC)
Operational life : Design life of 3 years

Cloudsat satellite

Cloudsat satellite is a part of Afternoon or "A-Train" satellite constellation.The constellation currently comprises of Aqua, Aura, PARASOL, CloudSat and CALIPSO satellites. PARASOL exited the A-Train orbit in December 2009. Expected upcoming missions are Glory, a NASA mission due to be launched in 2010, and GCOM-W1, a JAXA mission due to be launched in 2011. After these two missions join, the A-Train will be led by GCOM-W1, followed by Aqua, then CloudSat, CALIPSO, Glory, and, in the rear, Aura.

Development Agency : Ball Aerospace, USA
Launch : 28 April 2006 from Vandenberg Air Force Base in California, USA

Launch Vehicle : Delta-7420
Orbit : LEO Sun synchronous at altitude of 705km, 98.2°
Weight : 999 kg
Stabilization : 3-axis stabilization
Payload : Cloud Profiling Radar (CPR)
Operational life : Design life of 22 months

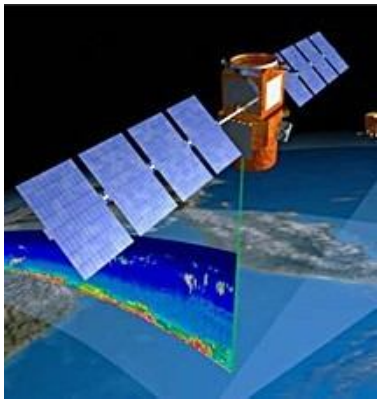


Fig.123
Calipso (Courtesy: NASA)

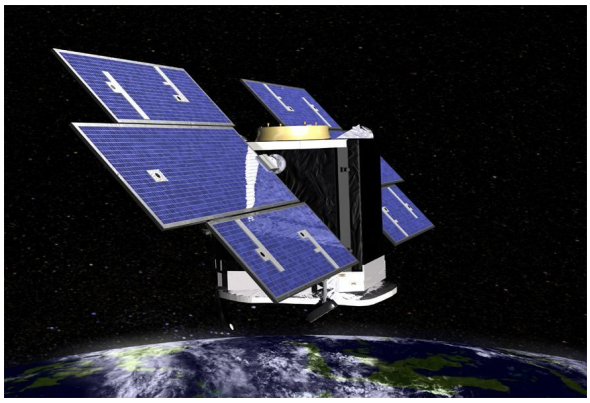


Fig.124
Cloudsat (Courtesy: NASA/JPL)

CHAMP (CHAllenging Minisatellite Payload) satellite

CHAMP, a German satellite operated by GFZ Postdam, is one of the three satellites of the European scientific mission launched for geo-scientific and atmospheric research applications. Its mission objective is to generate precise gravity and magnetic field measurements allowing the scientists to detect the spatial variations of both the fields.

Development Agency : Daimler Chrysler Aerospace Jena Optronik GmbH (DJO), Dornier Satellitensysteme GmbH (former DSS, now Astrium) and Raumfahrt und Umwelttechnik GmbH (RST)
Launch : 15 July 2000 from Plesetsk Cosmodrome in Russia
Launch Vehicle : Cosmos-3M
Orbit : LEO Circular, near-Polar, non-Sun synchronous, Mean Altitude of 454 km, 87.27^0
Weight : 522 kg
Stabilization : 3-axis stabilization
Payload : Laser Retro Reflector (LRR), Overhauser Magnetometer (OVM), Fluxgate Magnetometer (FGM), Digital Ion Drift Meter (DIDM), Electrostatic STAR Accelerometer, GPS Receiver TRSR-2, Advanced Stellar Compass
Operational lifetime : Design life of 5 years

Chandra X-ray Observatory

The Chandra X-ray Observatory (Fig.125) is part of NASA's fleet of 'Great Observatories' along with the Hubble space telescope, the Spitizer space telescope and the de-orbited Compton

gamma ray observatory. Chandra X-ray observatory, formerly named as Advanced X-ray Astrophysics Facility (AXAF), is designed to make astrophysical observations of celestial objects from normal stars to quasars, understand the nature of physical processes which take place within astronomical objects, and understand the history and evolution of the universe. The observatory has made it possible for the scientists to study even the extremely faint X-ray sources, sometimes strongly absorbed in crowded fields.

Development Agency : TRW Space & Electronics, USA
Launch : 23 July 1999 from Cape Canaveral launch center, USA
Launch Vehicle : Space shuttle Columbia (STS-93)
Orbit : Highly eccentric Earth Orbit
10 000 * 140 161 km, 28.45^0, 64 hour and 18 minutes Period
Weight : 4800 kg
Stabilization : 3-axis stabilization
Payload : X-ray telescope, AXAF Charged Coupled Imaging Spectrometer (ACIS), High Resolution Camera (HRC), High Energy Transmission Grating Spectrometer (HETG), Low Energy Transmission Grating Spectrometer (LETG)
Operational lifetime : Design life of 5 years

Cluster satellites

Cluster (Fig.126) is a magnetospheric research project operated by ESA, consisting of a constellation of four identical satellites. Cluster is a part of International Solar-Terrestrial Physics (ISTP) program. ISTP is a joint program of NASA, the European Space Agency (ESA), and the Institute of Space and Astronuatical Science (ISAS) of Japan. Other missions of the ISTP program include Geotail, WIND, POLAR and SOHO satellites. The Cluster mission is currently investigating the small-scale structure (in three dimensions) of the Earth's plasma environment, such as those involved in the interaction between the solar wind and the magnetospheric plasma, in global magnetotail dynamics, in cross-tail currents. It is also investigating formation and dynamics of the neutral line and that of plasmoids. Two series of Cluster satellites comprising of four satellites each have been launched. The first four Cluster satellites (Cluster-FM1, -FM2, -FM3 and -FM4) were lost in the Ariane 5 flight failure in the year 2006. Cluster-II satellites were launched to replace the orginal Cluster mission satellites.

Cluster-II mission (Cluster-FM5, -FM6, -FM7, -FM 8)

Development Agency : Europe’s space company EADS Astrium
Launch : Cluster-II satellites were launched from Baikonour cosmodrome in Kazakhstan on Soyuz-U launch vehicle. Cluster-FM6, -FM7 were launched on 16 July 2000 and -FM5, -FM8 were launched on 9 August 2000.
Orbit : Elliptical polar orbit, 19 000 * 119 000 km, 57 hour period
Weight : 1200 kg each
Stabilization : Spin stabilization
Payload : Fluxgate Magnetometer (FGM), Electron Drift Instrument (EDI), Active Spacecraft Potential Control experiment (ASPOC), Spatio-Temporal Analysis of Field Fluctuation experiment (STAFF), Electric Field and Wave experiment (EFW), Digital Wave Processing experiment (DWP),

Waves of High frequency and Sounder for Probing of Electron density by Relaxation experiment (WHISPER), Wide Band Data instrument (WBD), Plasma Electron And Current Experiment (PEACE), Cluster Ion Spectrometry experiment (CIS), Research with Adaptive Particle Imaging Detectors (RAPID)

Operational lifetime : Design life of 9 years

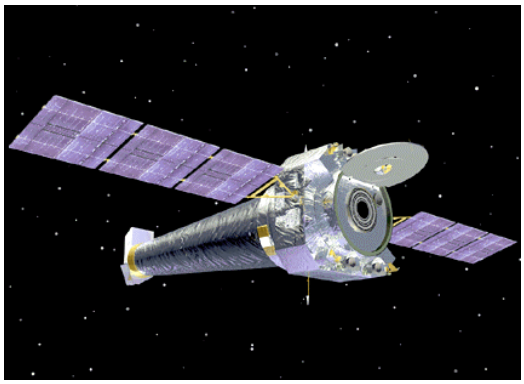


Fig.125
Chandra X-ray observatory (Courtesy: NASA)

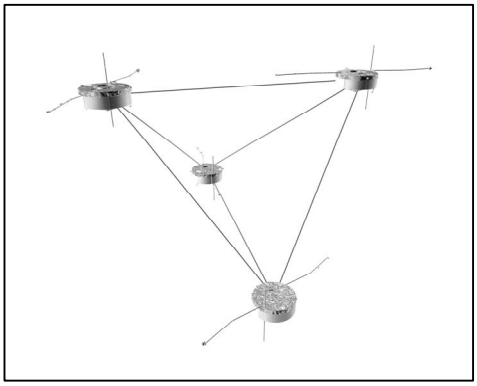


Fig.126
Cluster satellites (Courtesy: ESA)

Compass or Kompas satellite

Compass (Complex Orbital Magneto-Plasma Autonomous Small Satellite) satellite of Russia was launched for detection of the effects of tectonic breakings of Earth on its environment. It studies the response of different layers of Eearth's atmosphere to changes in the state of zone of tectonic activity, which is used for prediction of natural catastrophes. It also studies the possibility of the development/detection of the concealed/latent layers of useful minerals - including oil and gas.

Development Agency : GRT sKB Makeyev, Russia
Launch : 10 December 2001 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Zenit-2
Orbit : LEO, near-Polar, near-circular, Sun-synchronous
1018 km * 996 km, 99.7^0
Weight : 80 kg
Stabilization : 3-axis stabilization
Operational life : Design life of 1-2 years

Compton Gamma Ray Observatory (CGRO)

The Compton Gamma Ray Observatory (CGRO) (Fig.127) was the second mission of NASA's Great Observatories program. Its mission was to study the sources and astrophysical processes like nuclear reactions, elementary particle production and decay, Compton scattering and so on that produce gamma ray radiation in the energy range of 30 keV to 30 GeV. Compton was safely deorbited and re-entered the Earth's atmosphere on June 4, 2000.

Development Agency : TRW Space & Electronics, USA

Launch : 5 April 1991 from Cape Canaveral launch center, USA
Launch Vehicle : Space Shuttle Atlantis
Orbit : LEO orbit, mean altitude 450 km, 28.5^0
Weight : 15620 kg
Stabilization : 3-axis stabilization
Payload : Burst And Transient Source Experiment (BATSE), the Oriented Scintillation Spectrometer Experiment (OSSE), the Imaging Compton Telescope (COMPTEL) and the Energetic Gamma Ray Experiment Telescope (EGRET).
Operational lifetime : Operated for 9 years

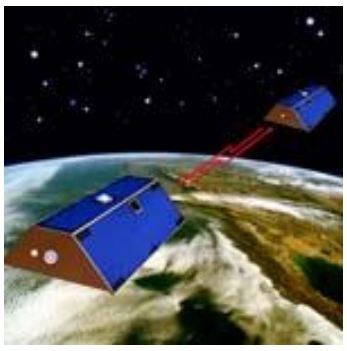
ESSP-2 (Earth System Science Pathfinder 2) or Gravity Recovery and Climate Experiment (GRACE) series

ESSP-2 or GRACE mission is a joint project between NASA's ESSP program and the German DLR, comprising of two twin satellites, ESSA-2A and ESSA-2B (Fig.128). The objective of the GRACE mission is to make detailed measurements of Earth's gravity field by accurately measuring the distance between them using GPS and a microwave ranging system.

ESSA-2A (GRACE-1, Tom), -2B (GRACE-2, Jerry)

Development Agency : Europe's space company EADS Astrium Systems and Space Systems Loral, USA
Launch : Both the satellites were launched on 17 March 2002 from Plesetsk Cosmodrome in Russia
Launch Vehicle : Rockot-KM
Orbit : LEO, Circular Near-Polar, mean Altitude of 480 km, 89^0.
Both the satellites are 170 to 180 km apart
Weight : 380 kg each
Payload : K-band Ranging System (KBR), Ultra Stable Oscillator (USO), SuperSTAR Accelerometers (ACC), Star Camera Assembly (SCA), Coarse Earth and Sun Sensor (CES), Center of Mass Trim Assembly (MTA), Black-Jack GPS Receiver and Instrument Processing Unit (GPS) and Globalstar Silicon Solar Cell Arrays (GSA).
Operational lifetime : Design life of 5 years

Fig.127
CGRO (Courtesy: NASA)



Fig,128
GRACE satellites (Courtesy: JPL/ NASA)

Fermi Gamma Ray Space Telescope (FGST)

FGST is a gamma ray observatory from NASA that makes observations of celestial gamma-ray sources in the energy band extending from 10 MeV to more than 100 GeV. It is a follow on to CGRO mission.

Development Agency : Spectrum Astro, USA
Launch : 11 June 2008 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7920H
Orbit : LEO circular, mean altitude of 550 km, 28.5°
Weight : 4450 kg
Stabilization : 3-axis stabilization
Payload : Large Area Telescope (LAT)
Operational lifetime : Design life of 5 years

Formosat, ROCSAT (Republic of China Satellite) series

ROCSAT series of satellites are Taiwan's satellites operated by the Taiwanese National Space Program Office (NSPO). ROCSAT-1, ROCSAT-2 satellites and ROCSAT-3 constellation of satellites have been launched.

Formosat-1 (ROCSAT-1)

ROCSAT-1 satellite performs experiments in the areas of ocean color imaging, space telecommunication and solar-terrestrial physics. It was renamed Formosat-1 in December 2004

Development Agency : TRW Space and Electronics, USA
Launch : 27 January 1999 from Cape Canaveral launch center, USA
Launch Vehicle : Athena-1
Orbit : LEO, Sun-synchronous, near circular, 588 km * 601 km, 35.0°
Weight : 400 kg
Stabilization : 3-axis stabilization
Payload : One Experimental Communication Payload, one Ocean Color Imager (OCI) and one Ionospheric Plasma and Electrodynamics Instrument (IPEI)
Operational lifetime : Design life of 2-4 years

Formosat-2 (ROCSAT-2)

ROCSAT-2 is a regional remote sensing satellite designed to collect data to be used for natural disaster evaluation, agricultural applications, urban planning strategy, environmental monitoring, and ocean surveillance. In addition to the remote sensing payload, the satellite's payload also includes an auroral observation instrument for scientific applications. It was renamed Formosat-2 in December 2004.

Development Agency : Europe's space company EADS Astrium Systems
Launch : 20 May 2004 from Vandenberg Air Force base in California, USA
Launch Vehicle : Taurus-3210

Orbit : LEO, mean altitude 891 km, 99.1°
Weight : 764 kg
Stabilization : 3-axis stabilization
Payload : Black and white Imager, Color Imager and lightning detector
Operational lifetime : Design life of 5 years

Formosat-3 (ROCSAT-3)

ROCSAT-3/ COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) program is an international collaboration between Taiwan and USA. The program comprises of a constellation of six microsatellites (ROCSAT-3A, -3B, -3C, -3D, -3E, -3F or COSMIC-1, -2, -3, -4, -5, -6 respectively) to provide data for weather forecast applications and scientific applications like ionospheric and gravity research.

Development Agency : Orbital Sciences Corporation (OSC), USA
Launch : All the six satellites were launched on 15 April 2006 from Vandenberg Air Force base in California, USA
Launch Vehicle : Minotaur-1
Orbit : LEO, mean altitude 700 km, 72°
Weight : 70 kg each
Payload : GPS Occulation Receiver (GOX), Tiny Ionospheric Photometer (TIP) and Tri-band Beacon (TBB)
Operational lifetime : Design life of 5 years

FUSE (Far Ultraviolet Spectroscopic Explorer) or MIDEX-0

FUSE satellite or MIDEX-0 satellite (Fig.129) is a joint US-Canada-France project that represents the next generation, high-orbit, ultraviolet space observatory covering the wavelength range of 90.5-119.5 nm. It was developed and is being operated for NASA by the John Hopkins University. Only one previous mission, Copernicus, has operated in the far-ultraviolet region of the electromagnetic spectrum. However, FUSE will provide sensitivity of about ten thousand times greater than that of Copernicus. The primary objective of FUSE is to use high-resolution spectroscopy at far ultraviolet wavelengths to study the origin and evolution of the lightest elements (hydrogen and deuterium) created shortly after the big bang, and the forces and processes involved in the evolution of galaxies, stars and planetary systems.

Development Agency : John Hopkins University Applied Physics Laboratory, USA and Orbital Sciences Corporation (OSC), USA
Launch : 24 June 1999 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7320
Orbit : LEO, near circular Sun-synchronous, 753 km * 769 km, 25^0
Weight : 1334 kg
Stabilization : 3-axis stabilization
Payload : Far Ultra Violet telescope and spectrometer, Fine Error Sensor (FES)
Operational lifetime : Design life of 3-5 years

GALEX (Galaxy Evolution Explorer) or SMEX-7

GALEX (Fig.130) is USA's scientific satellite operated by NASA. Its mission objective is to perform UV imaging and spectroscopic surveys to map the global history and probe the causes of star formation and its evolution over the red-shift range. It also explores the origin and evolution of galaxies, stars and heavy elements using an onboard ultraviolet telescope.

Development Agency : Orbital Sciences Corporation (OSC), USA
Launch : 28 April 2003 from Cape Canaveral Air Force station, USA
Launch Vehicle : Pegasus-XL
Orbit : LEO, Sun-synchronous, near-circular 690 km * 702 km, 29°
Weight : 312 kg
Stabilization : 3-axis stabilization
Payload : 50 cm Modified Ritchey-Chretien Telescope
Operational lifetime : Design life of 2-3 years

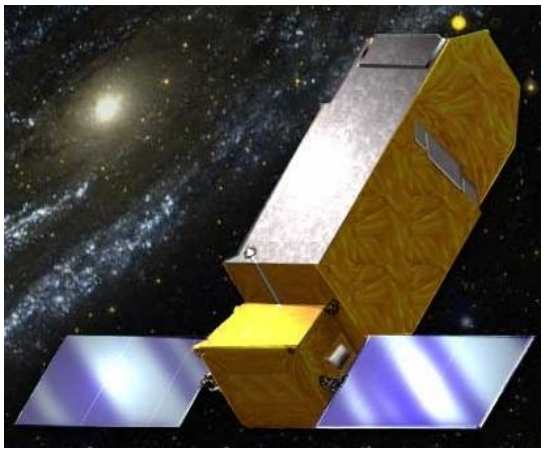


Fig.129
FUSE satellite (FUSE project at JHU)

Fig.130
GALEX satellite(Courtesy: NASA)

Genesis (Discovery-5)

Genesis (Fig.131) is one of NASA's Discovery program missions (Discovery-5). Discovery missions include Mars Pathfinder (Discovery-1), NEAR (Discovery-2), Lunar Prospector (Discovery-3), Stardust (Discovery-4), Genesis (Discovery-5), CONTOUR (Discovery-6), Deep Impace (Discovery-7), MESSENGER (Discovery-8), Dawn (Discovery-9) and Kepler (Discovery-10). Genesis mission objectives were to collect samples of the solar wind and to obtain precise measurement of solar wind abundances and solar elemental abundances. For this purpose it was inserted into an halo orbit around the Earth-Sun L-1 point. It collected samples during 29 month mission period and reentered the earth's atmosphere on 8 September 2004 to be captured in mid air by a helicopter over the desert of Utah. But the capsule crashed in the Utah desert. Scientists are currently examining the samples to find the usable samples.

Development Agency : Lockheed Martin Astronautics, USA

Launch : 8 August 2001 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7326
Orbit : L1 Earth sun Halo orbit
Weight : 636 kg
Stabilization : 3-axis stabilization
Payload : Collector arrays, concentrator, solar wind monitors
Operational lifetime : Design life of 3-4 years

Geotail satellite

Geotail is a satellite whose primary objective is to study the structure and dynamics of Earth's magnetotail. The satellite was developed and is operated by Japan's Institute of Space and Astronautical Science (ISAS), one of the predecessor bodies of JAXA. Geotail is a part of International Solar-Terrestrial Physics (ISTP) program. ISTP is a joint program of NASA, the European Space Agency (ESA), and the Institute of Space and Astronuatical Science (ISAS) of Japan. Other missions of the ISTP program include CLUSTER, WIND, POLAR and SOHO satellites.

Development Agency : Japanese Institute for Space and Astronautical Science (ISAS)
Launch : 24 July 1992 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-6925
Orbit : Launched into Elliptical orbit Perigee 8 Radius of earth (Re), Apogee 210 Re. Currently 9 Re * 30 Re
Weight : 1009 kg
Stabilization : Spin stabilization
Payload : Plasma Wave Investigation (PWI), Energetic Particles and Ion Composition (EPIC), Electric Field Detector (EFD), Magnetic Fields Measurement (MGF), Low Energy Particles (LEP), Comprehensive Plasma Instrument (CPI), High Energy Particles (HEP)
Operational lifetime : Design life of 4 years

HALCA (Highly Advanced Laboratory for Communication and Astronomy) or VSOP (Very Large Baseline Interferometry Space Observatory Programme) - former MUSES B

The HALCA satellite (Fig.132), operated by Japan's Institute of Space & Astronautical Science (ISAS), is the world's first radio astronomy scientific satellite that is dedicated to Very-Long Baseline Interferometery (VLBI) observations. It provides very high-resolution observations of deep-space objects. The angular resolution of HALCA satellite is 300 times the resolution of the Hubble space telescope. Based on the success of these experiments, space VLBI satellite development projects had been underway in the United States, Russia and Japan.

Development Agency : NEC Corporation of Japan
Launch : 12 February 1997 from Uchinoura Space Center in Japan
Launch Vehicle : M-5
Orbit : Elliptical, 524 * 21320 km, 31.2^0
Weight : 800 kg
Stabilization : 3-axis stabilization
Payload : 8-meter radio telescope

Operational lifetime **:** Design life of 3 years

HESSI (High Energy Solar Spectroscopic Imager) or SMEX 6

HESSI renamed to RHESSI (Reuven Ramaty High Energy Solar Spectroscopic Imager) (Fig.133) is NASA's small explorer satellite that explores the basic physics of particle acceleration and explosive energy release in solar flares. It takes high resolution images of solar flares in the X-rays and gamma rays band.

Development Agency **:** Spectrum Astro Inc., Germany and University of California, USA
Launch **:** 5 February 2002 from Cape Canaveral launch center, USA
Launch Vehicle **:** Pegasus-XL
Orbit **:** LEO sun-synchronous, Mean altitude 600 km, 38°
Weight **:** 293 kg
Stabilization **:** Spin stabilization
Payload **:** X-ray and gamma-ray imaging spectrometer
Operational lifetime **:** Design life of 2-3 years

Fig.131
Genesis (Courtsy: JPL/ NASA)

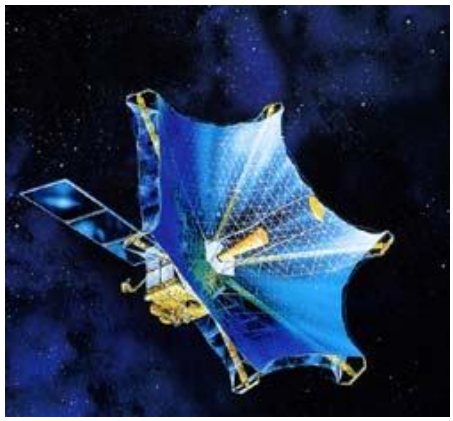


Fig.132
HALCA satellite (Courtesy: JAXA)

Fig.133
RHESSI (Courtesy: NASA)

HETE (High Energy Transient Explorer)

The HETE program began in 1989 with an aim to search for gamma ray bursts (GRBs). Two HETE satellites namely HETE-1 and HETE-2 have been launched till date. HETE-1 was destroyed during its launch in 1996. It was followed up by HETE-2, which was launched in the year 2000. HETE-2 satellite program (Fig.134) is collaborative effort between USA, Japan, France and Italy, headed by the center for space research at MIT. It detects and localizes gamma-ray bursts (GRBs). The suite of instruments onboard the satellite allows simultaneous observations of GRBs to be made in soft and medium X-ray and gamma-ray bands. HETE-2 computes the location of GRBs and transmits the coordinates as soon as they are calculated. These coordinates are distributed to ground-based observers for detailed study of the initial phases of GRBs. HETE-2 also performs a survey of the X-ray sky.

HETE-2

Development Agency : Massachusetts Institute of Technology (MIT), USA and AeroAstro, USA
Launch : 9 October 2000 from Kwajalein Missile Range facility in the Republic of the Marshall Islands
Launch Vehicle : Pegasus-H
Orbit : LEO, Circular pointing in anti-solar direction, Mean Altitude of 625 km, 1.9^0
Weight : 124 kg
Payload : 2 X-ray detectors: Wide-Field X-ray Monitor (WXM) and a Soft X-ray Camera (SXC), a set of wide-field gamma ray spectrometer (French Gamma Ray Telescope (FREGATE))
Operational lifetime : Design life of 2 years

Hubble Space Telescope

Hubble space telescope (HST) (Fig.135) was the first mission of NASA's 'Great Observatories' program. Other missions included the Chandra X-ray telescope, the Spitizer space telescope and the Compton gamma ray observatory (CGRO). The Hubble space telescope, a long term observatory, is a co-operative program of ESA and NASA. HST is a very large telescope with an aperture of 1/24 and an effective focal length of 57.6m orbiting in LEO orbit at an altitude of 610-620 km. It makes observations in the near UV-visible-IR wavelength bands. Hubble observations have helped in partially confirming the theory that most galaxies have a black hole in their nucleus. The current model of the accelerating universe has taken inputs from the images provided by HST. HST observations have confirmed that there are planets revolving around stars other than the Sun. It has imaged large portions of the universe and strengthened the belief of scientists that the universe is uniform over large scales.

Development Agency : Lockheed Martin Missiles and Space, USA
Launch : 24 April 1990 from Cape Canaveral launch center, USA
Launch Vehicle : Space Shuttle Discovery (STS-31)
Orbit : LEO, Circular Mean Altitude of 590 km, 28.5^0
Weight : 11 110 kg
Stabilization : 3-axis stabilization
Payload : Currently the instruments on-board the Hubble Space Telescope are Wide Field/Planetary Camera 2 (WFPC-2), Space Telescope Imaging Spectrograph (STIS), Near Infrared Camera and Multi-Object Spectrometer (NICMOS) , Fine Guidance Sensors (FGS) and Advanced Camera for Surveys (ACS).
Previous Instruments include Wide Field/ Planetary camera (WFPC-1), Faint Object Camera (FOC), Faint Object Spectrograph (FOS) and Goddard high resolution spectrograph (GHRS)
Operational lifetime : Design life of 15 years with in-orbit servicing every 2.5 years

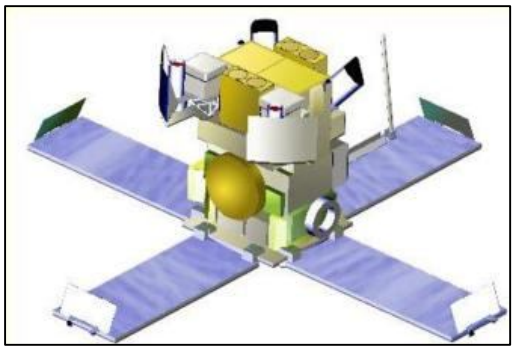


Fig.134
HETE-2 satellite (Courtesy: JESUS NOEL VILLASENOR/ MIT)

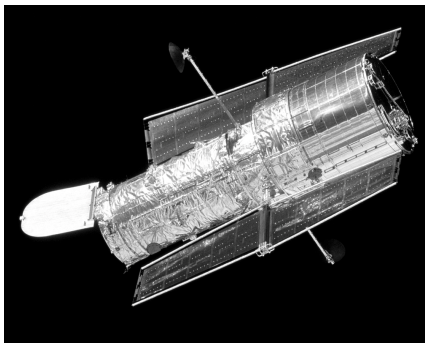


Fig.135
HST (Courtesy: STScI/ NASA)

IMAGE (Imager for Magnetopause to Aurora Global Exploration) or MIDEX-1

IMAGE satellite, developed by NASA, is a mission dedicated to imaging the Earth's magnetosphere, the region of space controlled by the Earth's magnetic field and containing plasmas of both solar and terrestrial origin.

Development Agency : Lockheed Martin Missiles and Space, USA
Launch : 25 March 2000 from Vandenberg Air Force Base, USA
Launch Vehicle : Delta-7326
Orbit : Elliptical Polar, 1000km * 45922 km, 90^0
Weight : 494 kg
Stabilization : Spin stabilization
Payload : Low-Energy Neutral Atom (LENA) imager, Medium-Energy Neutral Atom (MENA) imager, High-Energy Neutral Atom (HENA) imager, Extreme Ultraviolet Imager (EUV), Far Ultraviolet Imager (FUV), Radio Plasma Imager (RPI)
Operational lifetime : Design life of 3-5 years

Integral (International Gamma Ray Astrophysics Laboratory)

Integral mission is conceived as an observatory led by ESA with contributions from Russia (PROTON launcher) and NASA (Deep Space Network ground station). The mission is dedicated to the fine spectroscopy and fine imaging of celestial gamma-ray sources in the energy range 15 keV to 10 MeV with concurrent source monitoring in the X-ray (3-35 keV) and optical (V-band, 550 nm) energy ranges.

Development Agency : Alenia Spazio, Italy
Launch : 17 October 2002 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : Elliptical Polar, 10.000 km × 153.000 km, 51,6° (at beginning)
31.000 km × 153.000 km, 86,5° (after 5 years)
Weight : 4100 kg
Stabilization : Three-axis stabilization
Payload : SPI Spectrometer, Imager IBIS, OMC (optical monitoring camera) and

JEM-X X-ray monitor
Operational lifetime : Design life of 2 years, extendable to 5 years

Jason-1

Jason-1 is a France-USA joint oceanography mission after the Topex/ Poseidon mission, which will study the ocean surface topography and will provide information on the ocean circulation and its effect on the global climate. It will also study the ties between the oceans and atmosphere, monitor events such as El Niño conditions and ocean eddies and hence improves global climate forecasts and predictions. It will provide coverage of 90 percent of the world's oceans over a ten-day cycle.

Development Agency : Alcatel Space Industries, France
Launch : 7 December 2001 from Vandenberg Air Force Base, USA
Launch Vehicle : Delta-7920
Orbit : Prograde LEO orbit, mean altitude 1336 km, 66^0
Weight : 494 kg
Stabilization : 3-axis stabilization
Payload : POSIEDON-2 Altimeter, JMR Radiometer and three location systems comprising of Dosris (Doppler location), LRA (Laser Tracking) and TRSR (GPS location)
Operational lifetime : Design life of 5 years

MAP (WMAP, MIDEX 2)

MAP (Microwave Anisotrophy Probe) (Fig.136) is USA's scientific satellite providing information on cosmology. It is operated by NASA and is a follow up mission to COBE mission. Its main objective is to measure relative cosmic microwave background temperature accurately over the full sky with high angular resolution and sensitivity. MAP was re-christened Wilkinson Microwave Anisotropy Probe (WMAP) in February 2003.

Development Agency : NASA Goddard Space Flight Center and Swales Aerospace, USA
Launch : 30 June 2001from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7425
Weight : 840 kg
Stabilization : spin stabilization
Orbit : Initial orbit (182km * 292492km, 28.7° phasing orbit)
Final orbit (L2 (1 -10° Lissajous orbit)
Payload : 2 passively cooled microwave radiometers
Operational lifetime : Design life of 3 years

Odin

Odin is a Swedish satellite designed for both astronomy and aeronomy applications. The astronomy mission objectives are to study the physics and the chemistry of the interstellar medium by observing emission from giant molecular clouds and nearby dark clouds, detection of protostars, comets, height distribution of trace elements in the atmospheres of Jupiter and Saturn, studies of the dynamics and chemical composition of outflows and estimates of star formation

activity. The aeronomy mission is to study scientific problem areas in the stratosphere and mesosphere by making measurements of various trace species.

Development Agency : Swedish space corporation
Launch : 20 February 2001 from Svobodny space center, Russia
Launch Vehicle : Start-1
Weight : 250 kg
Stabilization : 3-axis stabilization
Orbit : LEO circular, Sun synchronous, Mean Altitude of 625.7 km, 97.8°
Payload : Optical Spectrograph and IR Imaging System (OSIRIS), Submillimeter Radiometer (SMR), Gregorian antenna
Operational lifetime : Design life of 2 years

PARASOL (Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a LIDAR) satellite

Parasol is a microsatellite developed by CNES to study the radiative and microphysical properties of clouds and aerosols by measuring the directionality and polarization of light reflected by the Earth-atmosphere system.

Development Agency : French space agency (CNES)
Launch : 18 December 2004 from Kourou in French Guiana, France
Launch Vehicle : Ariane-5G+
Weight : 120 kg
Stabilization : 3-axis stabilization
Orbit : LEO circular, Mean Altitude of 705 km
Payload : Imaging radiomter called POLDER (Polarization and Directionality of the Earth's Reflectances)
Operational lifetime : Design life of 2 years

POLAR satellite

The POLAR satellite (Polar Plasma Laboratory) (Fig.137) is the second satellite to be launched under NASA's Global Geo-space Science (GGS) program. The other satellite of the GGS program is the WIND satellite. The GGS program is a major component of the ISTP Science Initiative that will help fill critical gaps in the scientific understanding of solar and plasma physics. Other satellites of the ISTP program (International Solar Terrestrial Physics program) are Geotail, Cluster and SOHO satellites. POLAR satellite measures solar wind entry, ionospheric output, and the depositions of energy into the neutral atmosphere at high latitudes. Imaging instruments make possible the measurement of visible, ultraviolet and X-ray spectra of the polar caps.

Development Agency : Lockheed Martin Astronautics, USA
Launch : 24 February 1996 from Vandenberg Air Force Base, USA
Launch Vehicle : Delta-7925
Orbit : Highly elliptical orbit 5100 km * 51000 km, 86°, period 18 hours
Weight : 1250 kg
Stabilization : Spin stabilization

Payload : Toroidal Imaging Mass-Angle Spectrograph (TIMAS) , Plasma Waves Investigation (PWI), Hot Plasma Analyzer (Hydra), Comprehensive Energetic-Particle Pitch-Angle Distribution (CEPPAD), Charge and Mass Magnetospheric Ion Composition Experiment (CAMMICE), Polar Ionospheric X-ray Imaging Experiment (PIXIE), Electric Fields Investigation (EFI), Ultraviolet Imager (UVI), Visible Imaging System (VIS), Thermal Ion Dynamics Experiment (TIDE), Magnetic Fields Experiment (MFE)

Operational lifetime : Design life of 3-4 years

QuikSCAT (Quick Scatterometer)

QuikSCAT (Fig1.38) is a NASA satellite that is providing climatologists, meteorologists and oceanographers with daily, detailed snapshots of the winds swirling above the world's oceans. It covers around 90% of the ocean surface.

Development Agency : Ball Aerspace, USA
Launch : 19 June 1999 from Vandenberg Air Force Base, California USA
Launch Vehicle : Titan-23G
Weight : 970 kg
Stabilization : 3-axis stabilization
Orbit : LEO, Circular, Near-Polar Sun-synchronous, Mean Altitude of 800 km, 98.6^0
Payload : SeaWinds scatterometer
Operational lifetime : Design life of 2-3 years

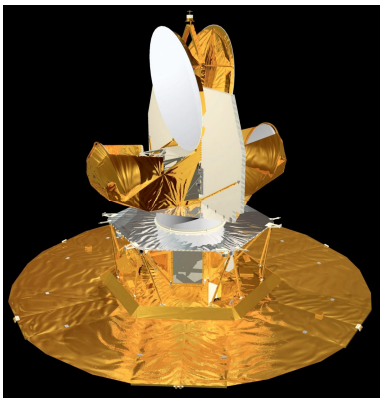


Fig.136
MAP Probe (Courtesy: NASA)

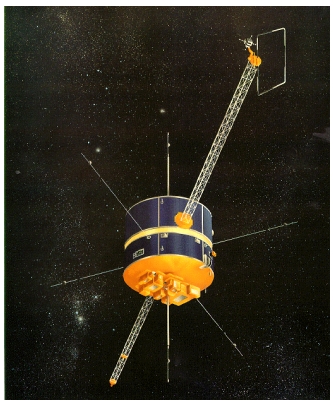


Fig.137
POLAR spacecraft (Courtesy: NASA)

Fig.138
QuikSCAT (Courtesy: NASA)

Rossi X-ray Timing Explorer (RXTE)

RXTE (Fig.139) is NASA's mission with the primary objective to study the temporal and broad-band spectral phenomena associated with stellar and galactic systems containing compact objects in the energy range of 2 to 200 KeV, and in time scales from microseconds to years. It is used to explore fast and ultra-fast X-ray variability in relatively bright sources and provide X-ray spectra of these variable sources on very short timescales.

Development Agency : NASA Goddard Space Flight Space Center
Launch : 30 December 1995 Cape Canaveral launch center, USA
Launch Vehicle : Delta-7920
Weight : 3035 kg
Stabilization : 3-axis stabilization
Orbit : LEO, Circular, Mean altitude of 580 km, 23^0
Payload : Proportional Counter Array (PCA) comprising of 5 xenon gas proportional counters, co-pointed with detectors on the High Energy X-Ray Timing Experiment (HEXTE) and the All-Sky Monitor (ASM)
Operational lifetime : Design life of 5 years

SORCE (Solar Radiation and Climate Experiment)

SORCE makes precise and accurate measurements of the Total Solar Irradiance (TSI). These measurements will be connected with previous TSI measurements to maintain a long-term record of solar influences on the Earth.

Development Agency : Orbital Sciences Corporation (OSC), USA
Launch : 25 January 2003 from Cape Canaveral launch center, USA
Launch Vehicle : Pegasus-XL
Weight : 315 kg
Stabilization : 3-axis stabilization
Orbit : LEO, Circular, Mean altitude of 645 km, 40°
Payload : Total Irradiance Monitor (TIM), Spectral Irradiance Monitor (SIM), two identical Solar Stellar Irradiance Comparison Experiments (SOLSTICE) and XUV Photometer System (XPS).

Stardust

Stardust (Fig.140) is the fourth NASA Discovery mission and the first U.S. space mission dedicated solely to the exploration of a comet. The primary goal of Stardust is to collect dust and carbon-based samples during its closest encounter with comet named Wild 2. It will also bring back samples of interstellar dust, including recently discovered dust streaming into our solar system from the direction of Sagittarius

Development Agency : Lockheed Martin Astronautics, USA
Launch : 7 February 1999 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-II
Weight : 380 kg
Stabilization : 3-axis stabilization
Orbit : Three loops around the Sun to meet comet Wild-2 (Heliocenteric orbit). The sample material capsule from Stardust returned to Earth on January 15, 2006 in Utah's Great Salt Lake desert
Payload : Aerogel Sample Collectors, Comet and Interstellar Dust Analyzer (CIDA), Navigation Camera (NavCam), Dust shield and monitors (Whipple Shield, Dust Flux Monitors (DFM))
Operational lifetime : Design life of 7 years

Terra Satellite (former EOS AM)

Terra (Fig.141) is a multi-nation (USA-Canada-Japan) NASA scientific research satellite in orbit around the Earth. It provides global data on the state of the atmosphere, land and oceans, as well as their interactions with solar radiation and with one another. The Terra project is responsible for the design, fabrication, test, launch, and on-orbit checkout of the instruments and spacecraft for the first EOS mission

Development Agency : Lockheed Martin Missiles and Space, USA
Launch : 18 December 1999 from Vandenberg Air Force station in California USA
Launch Vehicle : Atlas-2AS
Orbit : LEO, Near circular, near Polar Sun synchronous, 700km * 737km, 98.2^0
Weight : 5040kg
Stabilization : 3-axis stabilization
Payload : Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER), Clouds and the Earth's Radiant Energy Systems (CERES), Multi-angle Imaging Spectro-Radiometer (MISR), Moderate-resolution Imaging Spectro-radiometer (MODIS), Measurements of Pollution in the Troposphere (MOPITT)
Operational life : Design life of 6 years

THEMIS (Time History of Events and Macroscale Interactions during Substorms)

THEMIS mission, comprising of five probes, studies the magnetospheric substorm instability, a dominant mechanism of transport and explosive release of solar wind energy within Geospace. THEMIS will elucidate which magnetotail process is responsible for substorm onset at the region where substorm auroras map (~10 R_e).

Development Agency : Swales Aerospace, USA
Launch : 17 February 2007 from from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Orbit :
#1 : 1.6 R_e x 34.0 R_e, 3.9°; later lunar orbit
#2 : 1.2 R_e x 19.9 R_e, 9.8°; later lunar orbit
#3, #4 : 1.6 R_e x 11.6 R_e, 7°
#5 : 1.3 R_e x 13.1 R_e, 12°
Weight : 126 kg each
Stabilization : Spin stabilization
Payload : Instrument Data Processing Unit (IDPU), Electric Field Instruments (EFI), Flux Gate Magnetometer (FGM), Search Coil Magnetometers (SCM), Electrostatic Analyzer (ESA) and Solid State Telescope (SST)
Operational life : Design life of 2 years

TIMED (Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics) satellite

NASA's TIMED satellite (Fig.142) was designed to obtain a global picture of the mesosphere and lower thermosphere/ionosphere.

Development Agency : John Hopkins University Applied Physics Laboratory, USA
Launch : 7 December 2001 from Vandenberg Air Force Base, California, USA
Launch Vehicle : Delta-7920
Weight : 587 kg
Stabilization : 3-axis stabilization
Orbit : LEO Circular Mean Altitude of 625 km, 74^0
Payload : The Global Ultraviolet Imager (GUVI), Solar Extreme Ultraviolet Experiment (SEE), TIMED Doppler Interferometer (TIDI), A multichannel radiometer known as SABER (Sounding of the Atmosphere using Broadband Emission Radiometry)
Operational lifetime : Design life of 2 years

Fig.139
RXTE (Courtesy: NASA)

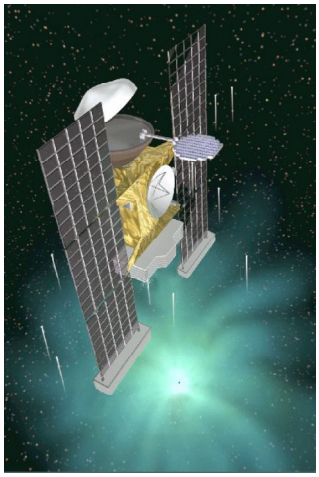


Fig.140
Stardust (Courtesy: NASA)

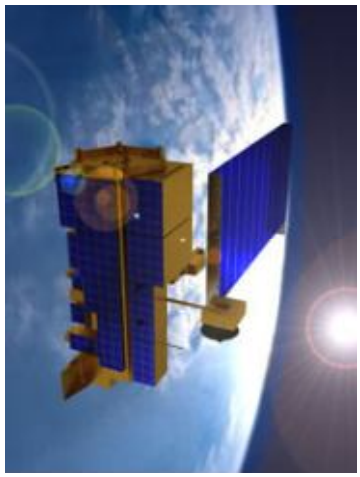


Fig.141
Terra (Courtesy: NASA)

WIND satellite

WIND satellite (Fig.143), together with Geotail, Polar, SOHO, and Cluster projects, constitute a cooperative scientific satellite project designated as International Solar Terrestrial Physics (ISTP) program, which aims at gaining improved understanding of the physics of solar terrestrial relations. The main purpose of the WIND spacecraft is to measure the incoming solar wind, magnetic fields and particles and observe the Earth's foreshock region.

Development Agency : Lockheed Martin Astro, USA
Launch : 1 November 1994 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Orbit : For the first nine months of operation, Wind was placed in a lunar swing-by elliptical orbit with apogee from 80 to 250 Earth radii and perigee of between 5 and 10 Earth radii. Wind was then inserted into a L1 halo orbit
Weight : 5040kg
Stabilization : Spin stabilization

Payload : Hot Plasma and Charged Particles (3D Plasma), Transient Gamma Ray and EUV Spectrometer (TGRS), Magnetic Fields Instrument (MFI), Plasma and Radio Waves (WAVES), Solar Wind Experiment (SWE), Solar Wind and Suprathermal Ion Composition Studies (SWICS/STICS), Gamma Ray Burst Detector (KONUS), Energetic Particle Acceleration, Composition and Transport (EPACT)

Operational life : Design life of 3-5 years

Fig.142
TIMED satellite (Courtesy: NASA)

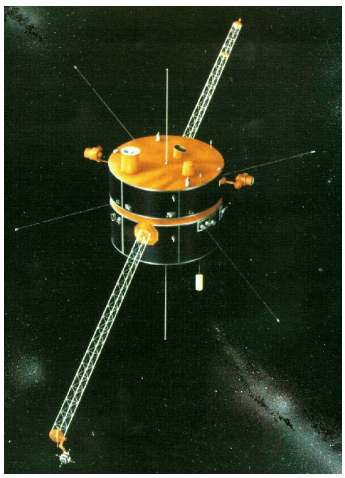


Fig.143
WIND satellite (Courtesy: NASA)

XMM-Newton (X-ray Multi-Mirror Mission)

XMM-Newton satellite of ESA is dedicated to astrophysical spectroscopy with a scientific objective to perform high-throughput spectroscopy of cosmic X-ray sources over a range of energies from around 0.1keV to 12keV. The XMM-Newton mission will help scientists solve a number of cosmic mysteries, ranging from the enigmatic black holes to the origins of the universe itself.

Development Agency : Dornier Satellite Systems, Germany
Launch : 10 December 1999 from Kourou in French Guiana in France
Launch Vehicle : Ariane-504
Weight : 3800 kg
Stabilization : 3-axis stabilization
Orbit : 48 hour Elliptical, 7000 km * 114 000 km, 40^0
Payload : 3 European Photon Imaging Cameras (EPIC), 2 Reflection Grating Spectrometer (RGS) and Optical Monitor (OM), particle detector, the EPIC Radiation Monitor System (ERMS)
Operational lifetime : Nominal 2 years - extended to 31 March 2010

Planetary missions

Cassini-Huygens mission

The Cassini-Huygens mission comprises of two elements: The Cassini orbiter (Fig.144) and the Huygens probe (Fig.145). The Cassini orbiter orbits around planet Saturn and the Huygens probe was designed to make in-situ observations of the Saturnian satellite Titan, by entering its atmosphere. The Cassini Orbiter's mission has an objective of carrying out detailed studies of Saturn and its rings and satellites, with a special focus on Titan. The principal objectives of the Orbiter are to determine the three-dimensional structure and dynamical behavior of the rings of Saturn, determine the composition of the satellite surfaces and their geological history, measure the three-dimensional structure and dynamic behavior of Saturn's magnetosphere, study the dynamical behavior of Saturn's atmosphere at cloud level, study the time variability of Titan's clouds and hazes and characterize its surface on a regional scale. The Huygens probe determined the physical characteristics of Titan's atmosphere, its chemistry and photochemistry, characterized the meteorology of Titan and examined the physical state, topography, and composition of the surface. Cassini-Huygens mission is a joint NASA-ESA mission with NASA designing the Cassini orbiter and ESA being responsible for the Huygen's probe. Cassini-Huygens mission was launched in the year 1997, reached Saturn in June 2004 and entered orbit around Saturn on July, 1 2004. Huygens was separated from Cassini on 25 December 2004 and landed successfully on Titan on 14 January 2005. The probe transmitted images and data both during decent and after landing on the surface. Huygens operated for about 2 hours after landing.

Development Agency : NASA's Jet Propulsion Laboratory, USA (Cassini), Alcatel Space, France (Huygens)
Launch : 15 October 1997 from Cape Canaveral launch center, USA. It reached Saturn in June 2004.
Launch Vehicle : Titan-4B
Orbit : Planetary orbit around Saturn (Cassini)
Weight : 5172 kg during launch
Stabilization : 3-axis stabilization
Payload : Cassini orbiter has 12 instruments and the Huygens probe had six. Cassini carried the following instruments: Composite Infrared Spectrometer (CIRS), Imaging Science Subsystem (ISS), Ultraviolet Imaging Spectrograph (UVIS), Visible and Infrared Mapping Spectrometer (VIMS), Cassini Plasma Spectrometer (CAPS), Cosmic Dust Analyzer (CDA), Ion and Neutral Mass Spectrometer (INMS), Magnetometer (MAG), Magnetospheric Imaging Instrument (MIMI), Radio and Plasma Wave Science (RPWS), Radar, Radio Science (RSS). Huygens carried the following instruments: Huygens Atmospheric Structure Instrument (HASI), Doppler Wind Experiment (DWE), Descent Imager/Spectral Radiometer (DISR), Gas Chromatograph Mass Spectrometer (GCMS), Aerosol Collector and Pyrolyser (ACP), Surface-Science Package (SSP)
Operational lifetime : Cassini has design life of 4 years after reaching Saturn

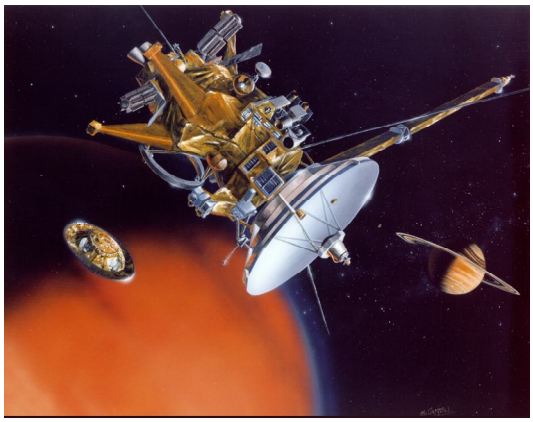


Fig.144
Cassini/ Huygens mission (Courtesy: NASA)

Fig.145
Huygens Probe (Courtesy: NASA)

Deep Impact mission

Deep Impact (Fig.146) is a part of NASA's Discovery mission. Its mission objectives are to study the interior of a comet. The Deep Impact fly-by mission releases the impactor spacecraft to the comet. When the impactor spacecraft hits the comet, the flyby spacecraft uses its instruments to perform optical imaging and infrared spectral mapping of the structure and composition of the crater's interior and the ejected material blasted into space. The primary mission ended in August 2005 and the spacecraft was put on a trajectory to come back to earth.

Development Agency : Ball Aerospace, USA and Jet Propulsion Laboratory, NASA
Launch : 12 January 2005 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Weight : 1020 kg
Orbit : Heliocentric
Payload : High Resolution Instrument (HRI) and the Medium Resolution Instrument (MRI)
Operational lifetime : Design life of 8 months

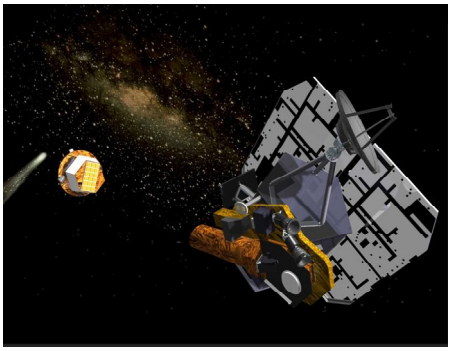


Fig.146
Deep Impact (Courtesy: NASA)

Galileo mission

The Galileo mission was launched with an aim to study the planet Jupiter. It consists of two spacecraft; an orbiter (Fig.147) and an atmospheric descent probe (Fig.148). The objectives of the Galileo orbiter were to investigate the circulation and dynamics of the Jovian atmosphere and to characterize the morphology, geology, composition, gravitational and magnetic fields and physical state of Jupiter's satellites. The science goals of the Galileo probe were to determine the chemical composition and structure of the Jovian atmosphere, investigate the nature of cloud particles and the location and structure of cloud layers, to examine the Jovian radiative heat balance and nature of Jovian lightning activity. The Galileo satellite was launched from space shuttle Atlantis during the STS-34 mission in 1989. It took five years to reach Jupiter, where it has remained for 9 years. The probe was released from the orbiter 147 days prior to its entry into the Jovian atmosphere on 7 December 1995. Galileo was deorbited at the end on the mission to avoid contaminating the moon Europa. It burned up in the Jupiter atmosphere on 21 September 2003.

Development Agency : NASA's Jet Propulsion Laboratory, USA
Launch : 18 October 1989 from Cape Canaveral launch center, USA
Launch Vehicle : Space Shuttle Atlantis (STS-34)
Orbit : Planetary orbit around Jupiter
Weight : 5172 kg during launch
Stabilization : Dual spin stabilization
Payload : Orbiter instruments: Remote sensing instruments (Camera, near-Infrared mapping spectrometer, Photopolarimeter-radiometer, Ultraviolet spectrometer/extreme ultraviolet explorer) Instruments studying magnetic fields and charged particles (Magnetometer, Energetic particle detector, Plasma investigation, Plasma wave subsystem, Dust-detection subsystem), Engineering Experiment (Heavy ion counter), Radio Science(Celestial mechanics, Propagation)
Descent Probe instruments: Atmospheric structure, Neutral mass spectrometer, Helium abundance, Nephelometer, Net flux radiometer, Lightning and radio emissions/energetic particles, Doppler wind experiment)
Operational lifetime : Operated till September 2003

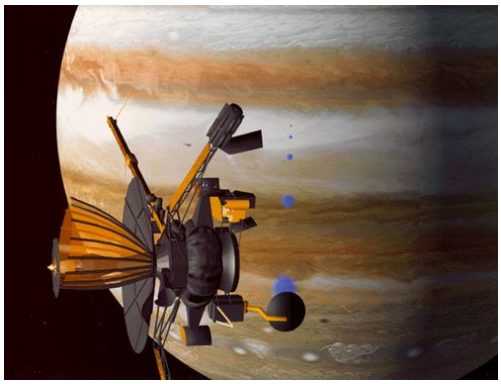


Fig.147
Galileo orbiter (Courtesy: NASA)

Fig.148
Galileo Descent probe (Courtesy: NASA)

Lunar Prospector

Lunar Prospector (Fig.149) is one of NASA's Discovery mission satellite (Discovery 3). The objectives of Lunar Prospector mission are to study the lunar crust and its atmosphere, map the magnetic and gravitational fields of moon and to study the moon's core.

Development Agency : Lockheed Martin Missiles and Space, USA
Launch : 7 January 1998 from Cape Canaveral launch center, USA
Launch Vehicle : Athena-II
Orbit : LEO orbit around moon, Initial altitude 100km which was lowered to 40km in December 1998. After the end of its mission (on 31 July 1999) the spacecraft was crashed on the lunar surface to look for water ice on moon.
Weight : 295 kg
Stabilization : Spin stabilization
Payload : Neutron Spectrometer (NS), Gamma Ray Spectrometer (GRS), Magnetometer/Electron Reflectometer (Mag/ER), Doppler Gravity Experiment (DGE), Alpha Particle Spectrometer (APS)
Operational lifetime : Design life of 1 year

Mars Exploration Rovers

The Mars exploration rover mission is a part of NASA's Mars exploration program, a long-term project of robotic exploration of Mars with the mission objective to search and characterize a wide range of rocks and soil to find clue of water activity on Mars. Twin robots, the Mars exploration rovers (Rover A and Rover B) (Fig.150) were launched for the purpose in the year 2003.

Development Agency : Jet Propulsion Laboratory, NASA
Launch
Rover A (Spirit) : 10 June 2003 on Delta-II (7925)
Rover B (Opportunity) : 7 July 2003 on Delta- II (7925H)
Both these rovers very launched from Cape Canaveral launch center, USA. Rover A and B reached Mars on 3 January 2004 and 24 January 2004 respectively.
Weight : 130 kg each
Payload : Both the rovers have following instruments: Panoramic camera (Pancam), Miniature Thermal Emission spectrometer (MiniTES), Mössbauer spectrometer (MB), Alpha Particle X-ray spectrometer (APXS), magnets, Microscopic imager (MI) and Rock Abrasion Tool (RAT)
Operational lifetime : Design life of 3 months (But they are still operational)

Mars Express mission

Mars Express mission consists of an orbiter, the Mars Express orbiter (Fig.151) and a lander, Beagle-2. The mission's main objective is to search for sub-surface water from orbit and deploy a lander onto the Martian surface (Beagle 2). Seven scientific instruments onboard the orbiting spacecraft perform a series of remote sensing experiments on the Martian atmosphere, the planet's structure, geology and composition. The mission objectives of Beagle-2 are to perform exobiology and geochemistry research. Beagle-2 lander was successfully released towards the

surface of the planet on the 19 December 2003, 5 days before orbit insertion. Mars Express was successfully inserted into a Mars orbit on 25 December 2003.

Development Agency : Europe's EADS Astrium
Launch : 2 June 2003 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Soyuz Fregat
Orbit : Elliptical orbit around Mars 258 km * 11560 km 86.3°
Weight : 1223 kg
Stabilization : 3-axis stabilization
Payload : **Orbiter:** High Resolution Stereo Camera (HRSC), Energetic Neutron Atoms Analyzer (ASPERA), Planetary Fourier Spectrometer (PFS), Visible and Infrared Mineralogical Mapping Spectrometer (OMEGA), Sub-Surface Sounding Radar Altimeter (MARSIS), Radio Science Experiment (MaRS), Ultraviolet and Infrared Mars Atmospheric Spectrometer (SPICAM)
Lander (Beagle-2): rock corer-grinder, a stereo camera, a microscope, a wind sensor, a X-ray spectrometer and a gamma-ray Mössbauer spectrometer
Operational lifetime : 31 October 2007 (Extended Mission)

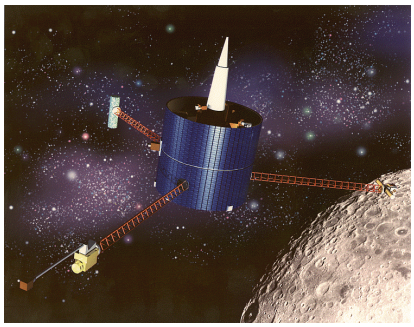


Fig.149
Lunar Prospector (Courtesy: NASA)

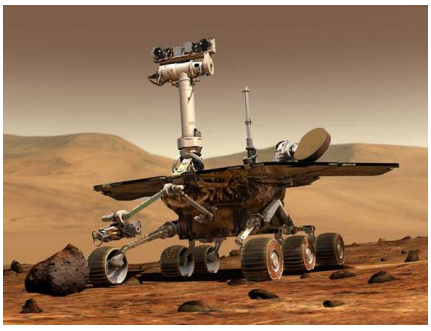


Fig.150
Mars exploration rovers(Courtesy: NASA/JPL)

Mars Global Surveyor

NASA's Mars Global Surveyor (MGS) mission (Fig.152) is the oldest Mars spacecraft mission currently in operation. It was the first successful mission launched to Mars after the Viking mission in 1976. The objectives of the mission include high resolution imaging of the planet's surface, studies of the topography and gravity, presence of water on Mars, the weather and climate of Mars, the composition of the surface and atmosphere, and the existence and evolution of the Martian magnetic field. It was successfully put into orbit around Mars on 11 September 1997. On 31 January 2001, MGS completed the mapping phase of the mission, which lasted for one Martian year (two Earth years). During this phase, the MGS instruments systematically monitored and made measurements of the planet's surface and atmosphere. The spacecraft is now in its extended mission and its current mission extension ends in September 2006.

Development Agency : NASA Jet Propulsion Laboratory and Lockheed Martin Astronautics, USA
Launch : 7 November 1996 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925A

Weight : 1060 kg
Stabilization : 3-axis stabilization
Orbit : Planetary orbit around Mars
Initial orbit (Elliptical 54 021 km * 258 km)
Final orbit (Near circular Polar Sun-synchronous)
Mean altitude of 378 km
Payload : Mars Orbiter Camera (MOC), Thermal Emission Spectrometer (TES), Mars Orbiter Laser Altimeter (MOLA), Magnetometer (Electron Reflectometer) and Radio Science (Gravity Field Experiment)
Operational lifetime : Design mission life of 6 years

Mars Odyssey

2001 Mars Odyssey (Fig.153) is an orbiting spacecraft designed to study the planet Mars. Its mission objectives are to determine the composition of the planet's surface, to detect water and shallow buried ice and to study the radiation environment. The primary science mission continued through August 2004 and Odyssey is currently in its extended mission. Odyssey also serves as a communications relay for the Mars Exploration Rovers (Spirit and Opportunity) and future missions

Development Agency : Lockheed Martin Aeronautics, USA
Launch : 7 April 2001from Cape Canaveral launch center, USA.
It reached Mars on 24 October 2001.
Launch Vehicle : Delta-II (7925)
Weight : 725 kg
Stabilization : 3-axis stabilization
Orbit : Planetary orbit around Mars
Initial orbit (Elliptical orbit, 200 * 500 km)
Final orbit (LEO, Circular Polar Sun-synchronous)
Mean altitude of 400 km
Payload : Gamma Ray Spectrometer (GRS), Thermal Emission Imaging System (THEMIS), Martian Radiation Environment Experiment (MARIE)
Operational lifetime : Design life of 3 years to orbit Mars

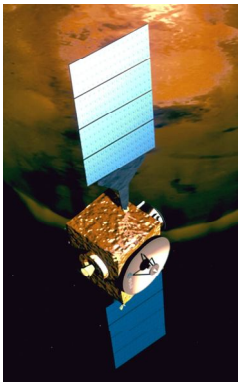


Fig.151
Mars Express Orbiter
(Courtesy: ESA)

Fig.152
Mars Global Surveyor
(Courtesy: NASA)

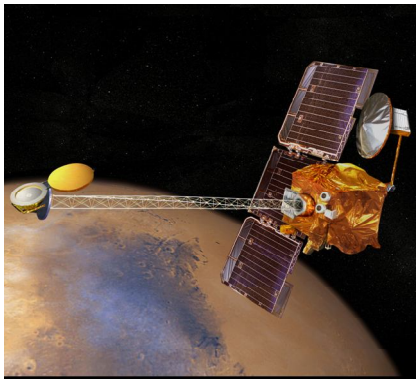


Fig.153
Mars Odyssey
(Courtesy: NASA)

Mars Reconnaissance Orbiter

Mars Reconnaissance Orbiter (Fig.154) is an orbiter mission to Mars designed to study in detail the Martian terrain. It is equipped with cameras to zoom in for extreme close-up photography of the Martian surface and also carries a sounder to find subsurface water and look for safe and scientifically worthy landing sites for future exploration. Science observations will take place over one Martian year after which the orbiter will be used as a communications relay.

Development Agency : Lockheed Martin Space systems, USA
Launch : 12 August 2005 from Cape Canaveral launch center, USA.
It reached Mars on 11 March 2006.
Launch Vehicle : Atlas-5
Weight : 2180 kg
Stabilization : 3-axis stabilization
Orbit : Planetary orbit around Mars
Initial orbit (Highly elliptical orbit)
Final orbit (LEO Polar orbit 250 * 320 km)
Payload : **Science Instruments:**
Cameras: HiRISE (High Resolution Imaging Science Experiment), CTX (Context Camera, *MARCI* (Mars Color Imager)
Spectrometer: CRISM (Compact Reconnaissance Imaging Spectrometer for Mars)
Radiometer: MCS (Mars Climate Sounder)
Radar: SHARAD (Shallow Radar)
Engineering Instruments:
Electra UHF Communications and Navigation Package, Optical Navigation Camera, Ka-band Telecommunications Experiment Package
Science Facility Experiments:
Gravity Field Investigation Package, Atmospheric Structure Investigation Accelerometers
Operational lifetime : Design life of one Martian year

MESSENGER (MERrcury Surface, Space ENvironment, GEochemistry and Ranging mission)

MESSENGER (Fig.155) was the seventh mission of NASA's Discovery program designed to understand the forces that have shaped the planet Mercury. With MESSENGER's discoveries, scientists will better understand how the planet was formed, how it evolved and how it interacts with the Sun. Gravity assist by the planet Venus and three Mercury flybys, along with several course correction maneuvers, will position MESSENGER to reach its orbit around Mercury in March 2011. MESSENGER is scheduled to stay in orbit at Mercury for one Earth year, finishing its data collection in March 2012.

Development Agency : Hopkins University Applied Physics Laboratory, USA
Launch : 3 August 2004 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925H
Weight : 1108 kg

Stabilization : 3-axis stabilization
Orbit : Highly elliptical planetary orbit around Mercury, 200km * 15193 km, 80°
Payload : Mercury Dual Imaging System (MDIS), Gamma-Ray and Neutron Spectrometer (GRNS), X-Ray Spectrometer (XRS), Magnetometer (MAG), Mercury Laser Altimeter (MLA), Mercury Atmospheric and Surface Composition Spectrometer (MASCS), Energetic Particle and Plasma Spectrometer (EPPS), Radio Science (RS)
Operational lifetime: Operational life of one 1 year and total life of 8 years

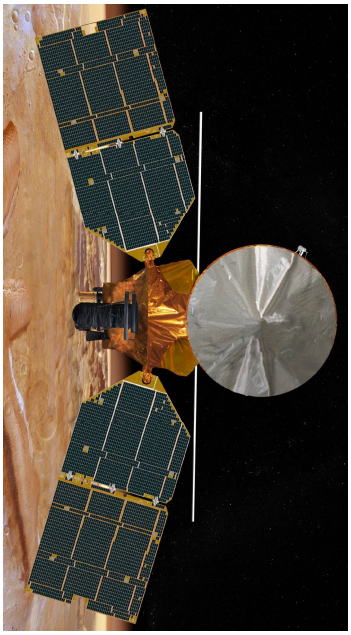


Fig.154
Mars Reconnaissance Orbiter (Courtesy: NASA/JPL)

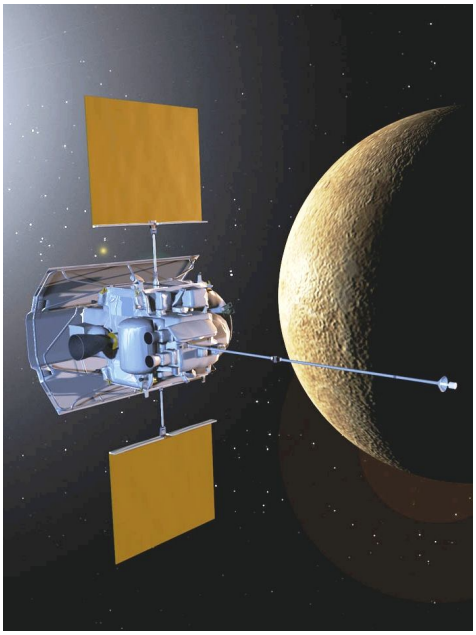


Fig.155
MESSENGER (Courtesy: NASA)

NEAR (Discovery-2, Shoemaker)

NEAR (Near Earth Asteroid Rendezvous) (Fig.156) is NASA's space mission to rendezvous and orbit around a near earth asteroid (433 Eros). The primary scientific goals are to measure the asteroid's bulk properties (size, shape, volume, mass, gravity field and spin state), surface properties (elemental and mineral composition, geology, morphology and texture) and internal properties (mass distribution and magnetic field). On the cruise to Eros, it flew by asteroid 253 Mathilde on 27 Jun 1997 and flew by earth on 23 January 1998. NEAR spacecraft failed to insert itself into Eros orbit in January 1999. NEAR was inserted into orbit around the asteroid on the second attempt on 14 February 2000. After reaching orbit, NEAR was renamed NEAR-Shoemaker.

Development Agency : John Hopkins University Applied Physics Lab of USA
Launch : 17 February 1996 from Cape Canaveral launch center, USA
Launch Vehicle : Delta-7925
Weight : 818 kg
Stabilization : 3-axis stabilization

Orbit : Initially the orbit was circular with a radius of 200 km. The radius of the orbit was decreased to 50 × 50 km orbit on 30 April 2000 and decreased to 35 × 35 km on July 14, 2000. The orbit was raised over succeeding months to a 200 × 200 km orbit and then slowly decreased and altered to a 35 × 35 km retrograde orbit on December 13, 2000. The mission ended with a touchdown in the "saddle" region of Eros on February 12, 2001

Payload : Multi-spectral Imager (MSI), X-Ray/ Gamma Ray Spectrometer (XGRS), Near Infrared Spectrograph (NIS), Near Laser Range-fnder (NLR), Radio Science

Operational lifetime : 1 year mission life

New Horizons

New Horizons is a mission designed to fly by Pluto and its moon Charon and transmit images and data back to Earth. It will then continue on into the Kuiper Belt where it will fly by a number of Kuiper Belt Objects and return further data. The primary objectives are to characterize the global geology and morphology of Pluto and Charon, map the surface composition of Pluto and Charon, and characterize the neutral atmosphere of Pluto and its escape rate.

Development Agency : John Hopkins University Applied Physics Lab, USA and Southwest Research Institute (SwRI)

Launch : 19 January 2006 from Cape Canaveral launch center, USA

Launch Vehicle : Atlas-5 (551)

Weight : 478 kg

Stabilization : 3-axis stabilization

Orbit : Fly-by mission

Payload : LEISA (Visible and infrared imager/spectrometer), Alice (Ultraviolet imaging spectrometer), REX (Radio Science EXperiment) - passive radiometer, LORRI (Long Range Reconnaissance Imager) - telescopic camera, SWAP (Solar Wind Around Pluto) - Solar wind and plasma spectrometer, PEPSSI (Pluto Energetic Particle Spectrometer Science Investigation) - Energetic particle spectrometer, SDC (Student Dust Counter) - measures the space dust peppering New Horizons during its voyage

Operational lifetime : Design life of 10 – 15 years

Nozomi (former Planet-B)

Nozomi (Fig.157) is Japan's Mars orbiting aeronomy mission designed to study its upper atmosphere and its interaction with the solar wind and to develop technologies for use in future planetary missions. It will measure the structure, composition and dynamics of the ionosphere, aeronomy effects of the solar wind, atmospheric constituents, the intrinsic magnetic field, the penetration of the solar-wind magnetic field, the structure of the magnetosphere, and dust in the upper atmosphere and in orbit around Mars. Nozomi was due to arrive at Mars around the middle of December 2003, but it failed to inject itself into orbit around Mars due to unrecoverable malfunction. In spite of the failed Mars mission, Nozomi remains in a heliocentric orbit to continue monitoring solar activity

Development Agency : Institute of Space and Aeronautical Science (ISAS), University of Tokyo
Launch : 4 July 1998 from Uchinoura Space Center (USC), Japan
Launch Vehicle : M-5
Weight : 540 kg
Stabilization : Spin stabilization
Orbit : Currently heliocentric planned orbit (Highly eccentric Mars orbit)
Payload : Mars Imaging Camera (MIC), Magnetic Field Measurement (MGF), Probe for Electron Temperature (PET), Electron Spectrum Analyzer (ESA), Ion Spectrum Analyzer (ISA), Electron and Ion Spectrometer (EIS), Extra Ultraviolet Scanner (XUV), Ultraviolet imaging Spectrometer (UVS), Plasma Wave and Sounder (PWS), Low Frequency plasma wave Analyzer (LFA), Ion Mass Imager (IMI), Mars Dust Counter (MDC), Neutral Mass Spectrometer (NMS), Thermal Plasma Analyzer (TPA)

SOHO

SOHO (Fig.158) is a part of International Solar-Terrestrial Physics (ISTP) program. ISTP is a joint program of NASA, the European Space Agency (ESA), and the Institute of Space and Astronuatical Science (ISAS) of Japan. Other missions of the ISTP program include Geotail, WIND, POLAR and Cluster satellites. The mission objective of SOHO is to study the Sun from its deep core to the outer corona and to study the solar wind. Together with two other ESA missions, Cluster and Ulysses, SOHO is studying the Sun-Earth interaction from different perspectives.

Development Agency : Ball Aerspace, USA
Launch : 2 December 1995 from Cape Canaveral launch center, USA
Launch Vehicle : Arlas-IIAS
Weight : 1850 kg
Stabilization : 3-axis stabilization
Orbit : Halo orbit around the L1 Lagrange point
Payload : Coronal Diagnostic Spectrometer (CDS), Charge, Element, and Isotope Analysis System (CELIAS), Comprehensive Suprathermal and Energetic Particle Analyzer (COSTEP), Extreme ultraviolet Imaging Telescope (EIT), Energetic and Relativistic Nuclei and Electron experiment (ERNE), Global Oscillations at Low Frequencies (GOLF), Large Angle and Spectrometric Coronograph (LASCO), Michelson Doppler Imager/Solar Oscillations Investigation (MDI/SOI), Solar Ultraviolet Measurements of Emitted Radiation (SUMER), UltraViolet Coronograph Spectrometer (UVCS), Variability of Solar Irradiance and Gravity Oscillations (VIRGO)
Operational lifetime : Design life of 2 years (Mission extended till March 2007)

Fig.156
NEAR spacecraft (Courtesy: NASA)

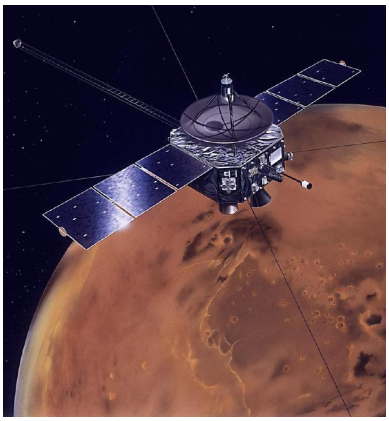


Fig.157
Nozomi spacecraft (Courtesy: JAXA)

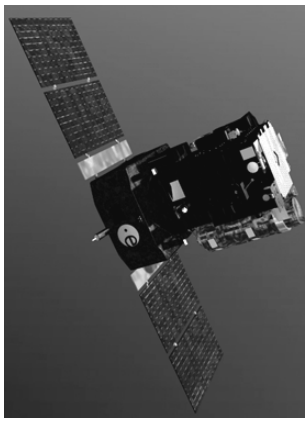


Fig.158
SOHO(Courtesy: ESA & NASA)

Venus Express

Venus Express is ESA's first mission to Earth's nearest planetary neighbour, Venus. The mission objectives are to study the atmosphere, the plasma environment, and the surface of Venus in great detail.

Development Agency **:** Europe's EADS Astrium
Launch **:** 9 November 2005 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle **:** Soyuz-FG Fregat
Orbit **:** 24-hour elliptical, quasi-polar orbit around Venus
Weight **:** 1270 kg
Stabilization **:** 3-axis stabilization
Payload **:** ASPERA-4 (Analyser of Space Plasmas and Energetic Atoms), MAG (Magnetometer), PFS (Planetary Fourier Spectrometer), SPICAV (Spectroscopy for Investigation of Characteristics of the Atmosphere of Venus), VeRa (Venus Radio Science), VIRTIS (Visible and Infrared Thermal Imaging Spectrometer) and VMC (Venus Monitoring Camera)
Operational lifetime **:** 31 December 2012 (Extended Mission)

E. Military Satellites

Military Communication Satellites

Defence Satellite Communication Systems (DSCS) series

DSCS satellites are US military communication satellites providing high security data and voice communication services to US Department of Defence. Till date, three series of DSCS satellites have been launched. These include DSCS-1, -2 and -3. The DSCS-1 or the IDCSP (Initial Defence Communication Satellite Program), comprising of 27 satellites provided the Pentagon with its first geosynchronous military communication satellite system. DSCS-2, comprising of 16 satellites, provided secure voice and data communications for the US military. DSCS-3 are geostationary communication satellites that provide a robust anti-jam, nuclear hardened capability that supports US Department of Defence (DoD) worldwide requirements, White House and diplomatic communications. It provides uninterrupted high priority secure voice and high-data rate communication services such as the exchange of wartime information between defence officials and battlefield commanders. DSCS-3 series comprises of 14 satellites, DSCS-3 1 to -3 14.

DSCS-3 series

DSCS-3 4 (A2, USA-44), -3 5 (B14, USA-78), -3 6 (B12, USA-82), -3 7 (B9, USA-93)

Development Agency : Lockheed Martin Missiles and Space, USA
Launch
DSCS-3 4 : 4 September 1989
DSCS-3 5 : 16 February 1992
DSCS-3 6 : 2 July 1992
DSCS-3 7 : 19 July 1993
DSCS-3 4 was launched on Titan-34D, DSCS-3 5, -3 6 and -3 7 were launched on Atlas-2. All these satellites were launched from Cape Canaveral launch center, USA
Orbit : GEO
Weight : 1235 kg each
Payload : Six independent Super High Frequency (SHF) transponders, one special purpose single channel transponder operating in both SHF and UHF bands, three receive antennas and five transmit antennas
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

DSCS-3 8 (B10, USA-97), -3 9 (B7, USA-113), -3 10 (B13, USA-134), -3 11 (B8, USA-148), -3 12 (B111, USA-153), -3 13 (A3, USA-167), -3 14 (B6, USA-170)

Development Agency : Lockheed Martin Missiles and Space, USA
Launch
DSCS-3 8 : 28 November 1993
DSCS-3 9 : 31 July 1995
DSCS-3 10 : 25 October 1997
DSCS-3 11 : 21 January 2000
DSCS-3 12 : 20 October 2000
DSCS-3 13 : 11 March 2003
DSCS-3 14 : 29 August 2003

All these satellites were launched from Cape Canaveral launch center, USA. DSCS-3 8 was launched on Atlas-2, DSCS-3 13, -3 14 on Delta 4M and DSCS-3 9, -3 10, -3 11 and -3 12 on Atlas-2A

Orbit : GEO
Weight : 1235 kg each
Payload : Six independent Super High Frequency (SHF) transponders and one special purpose single channel transponder operating in both SHF and UHF bands
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

Geizer (Potok series)

Potok satellites (code named Geizer) are Russian military communication satellites. Potok was one element of the second generation global command and control system (GKKRS). Ten Potok satellites have been launched. Potok handled communications between ground stations and the Yantar-4KS1 and Yantar-4KS1M electroptical reconnaissance satellites.

Potok-10

Development Agency : Applied Mechanics NPO-Lavochkin of Russia
Launch : 4 July 2000 from Baikonour cosmodrome in Kazakhstan
Launch Vehicle : Proton-K
Orbit : GEO 80^0E
Weight : 2400 kg
Stabilization : 3-axis stabilization
Payload : Slav-2 and Sintez transponders (C band)
Operational life : Design life of 5 years

Globus series

The Globus series of satellites represent second generation of Russian military communication satellites, replacing older Raduga ("Rainbow") satellites. They are also referred to as Raduga-1 series of satellites. Eight satellites have been launched in the series including Raduga-1 1, -1 2, -1 3, -1 4, -1 5, -1 6, -1 7 and -1 8.

Raduga-1 4, -1 5, -1 6, -1 7, 1 8

Development Agency : Applied Mechanics NPO-PM of Russia
Launch
Raduga-1 4 : 28 February 1999
Raduga-1 5 : 28 August 2000
Raduga-1 6 : 6 October 2001
Raduga-1 7 : 27 March 2004
Raduga-1 8 : 28 February 2009
All the satellites were launched on Proton-K from Baikonour cosmodrome in Kazakhstan
Orbit
Raduga-1 4 : GEO 35°E
Raduga-1 5 : GEO 50^0E

Raduga-1 6 **:** GEO
Raduga-1 7 **:** GEO 85°E
Raduga- 1 8 **:** GEO
Weight
Raduga-1 5, 1 8 **:** 2400 kg
Raduga-1 6, -1 7 **:** 2000 kg each
Payload **:** "Tor" C band transponders working at 20, 42 and 44 GHz
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3 years

Leasat series (Syncom-4)

Leasat or Syncom-4 (Fig.159) series of satellites are US military communication satellites providing world-wide communication services to mobile air, surface, subsurface and fixed earth stations of the Navy, Marine Corps, Air Force and Army. Five Leasat satellites namely Leasat-1, -2, -3, -4 and -5 been launched till date. Leasat-1, -2 were launched in 1984 followed by Leasat-3, -4 in 1985 and Leasat-5 in 1990.

Leasat-5 (Syncom-4 5)

Development Agency **:** Hughes Space Systems, USA (now Boeing Systems)
Launch **:** 9 January 1990 from Cape Canaveral launch center, USA
Launch Vehicle **:** Space Shuttle Columbia
Orbit **:** GEO 177^0W
Weight **:** 7711 kg
Payload **:** Five antennas (Two UHF helices, one Transmit and one Receive), two X-band horns (one beacon, one receive), 12 UHF repeaters
Stabilization **:** Spin stabilization
Operational life **:** Design life of 7 years

Fig.159
Leasat satellite (Courtesy: NASA)

MILSTAR series

MILSTAR (Military Strategic and Tactical Relay) is a tactical and strategic multiservice satellite system designed to provide survivable communication services for U.S. forces worldwide. They provide voice, data, imagery and video communication services to users on foot, ships, submarines and aircraft. Two series of MILSTAR namely the satellites MILSTAR-1 and MILSTAR-2 series have been launched. The third series more popularly known as the AEHF (Advanced Extreme High Frequency) system represents the next generation of highly secure military satellites. The first satellite of the AEHF system is scheduled to be launched in the year 2010.

MILSTAR-1 series

MILSTAR-1 series (Fig.160) comprises of two satellites- MILSTAR-1 1 (MILSTAR-1) and -1 2 (MILSTAR-2)

Development Agency : Lockheed Martin Missiles and Space, USA and TRW, USA
Launch
MILSTAR-1 1 : 7 February 1994
MILSTAR-1 2 : 6 November 1995
Both these satellites were launched from Cape Canaveral launch center, USA on Titan-4A
Orbit
MILSTAR-1 1 : GEO 120^0W
MILSTAR-1 2 : GEO 4^0E
Weight : 5150 kg each
Payload : LDR and Crosslink payloads
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

MILSTAR-2 series

MILSTAR-2 series (Fig.161) comprises of three satellites, MILSTAR-2 2 (MILSTAR-4), -2 3 (MILSTAR 5) and -2 4 (MILSTAR-6). MILSTAR-2 1 (MILSTAR-3), launched on 30 April 1999 was a launch failure. The MILSTAR-2 satellites have extended the communications capabilities of MILSTAR satellites to higher data rates

Development Agency : Lockheed Martin Missiles and Space, USA, TRW, USA and Boeing Space Systems, USA
Launch
MILSTAR-2 F2 : 27 February 2001
MILSTAR-2 F3 : 15 January 2002
MILSTAR-2 F4 : 8 April 2003
All the three satellites were launched from Cape Canaveral launch center, USA on Titan-4B
Orbit : GEO
Weight
MILSTAR-2 F2 : 4670 kg
MILSTAR-2 F3, -2 F4 : 4500 kg
Payload : LDR, MDR and Crosslink payloads
Stabilization : 3-axis stabilization

Operational life **:** Design life of 12 years

Fig.160
MILSTAR-1 (Courtesy: USAF)

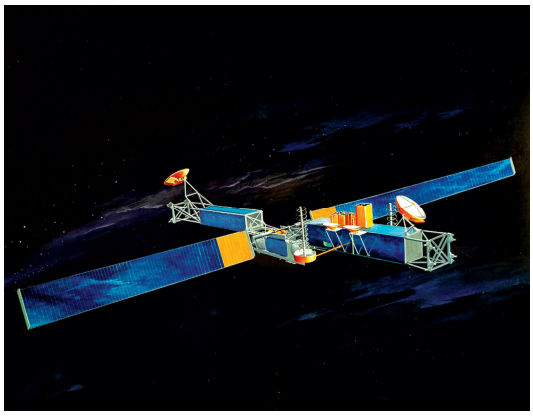


Fig.161
MILSTAR-2 (Courtesy: USAF)

Satellite Data System (SDS) series

SDS satellites are used to relay images from optical and digital reconnaissance satellites. They also provide relay communication services to US Air Force units that are out of range of GEO comsats. They are also used for nuclear blast detection. Three generation of SDS satellites have been launched. The first generation SDS series comprised of six satellites launched between 1976 and 1987. The second generation SDS satellites carry an infrared missile launch detection sensor in addition to the communication payloads. Second generation SDS series comprises of four satellites launched between 1989 and 1996. Third generation SDS satellites comprise of four satellites. They have been reportedly code named ‘Quasar’.

SDS-3 1, -3 2, -3 3, -3 4

Development Agency **:** Boeing Satellite Systems, USA
Launch
SDS-3 1 **:** 29 January 1998
SDS-3 2 **:** 6 December 2000
SDS-3 3 **:** 11 October 2001
SDS-3 4 **:** 31 August 2004
SDS-3 5 **:** 10 December 2007
All the satellites were launched from Cape Canaveral launch center, USA. SDS-3 1 was launched on Atlas 2A, SDS-3 2, -3 3, -3 4 satellites were launched on Atlas-2AS and SDS-3 5 was launched on Atlas-5 (401)
Orbit
SDS-3 1, -3 4, -3 5 **:** Molniya
SDS-3 2, -3 3 **:** GEO
Payload **:** HERITAGE infrared missile launch detection sensor, four dish antennas

SICRAL series

SICRAL (Sistema Italiana de Communicazione Riservente Allarmi) is the first national Italian system for satellite military telecommunications. Currently, it comprises of SICRAL-1 and -1B satellites, with SICRAL-2 scheduled to be launched in the near future.

SICRAL-1, -1B

Development Agency
SICRAL-1 **:** Italian companies Alenia Spazio, Fiat Avio and Telespazio
SICRAL-1B **:** Thales Alenia Space, France
Launch
SICRAL-1 **:** 7 February 2001
SICRAL-1B **:** 20 April 2009
SICRAL-1 was launched from Kourou in French Guiana, France on Ariane-44L. SICRAL-1B was launched from SeaLaunch Platform in the Pacific Ocean on Zenit-3SL launch vehicle
Orbit
SICRAL-1 **:** GEO 16.2°E
SICRAL-1B **:** GEO 11.8°E
Weight
SICRAL-1 **:** 2596 kg
SICRAL-1B **:** 3038 kg
Payload **:** 9 SHF, EHF and UHF transponders
Stabilization **:** 3-axis stabilization
Operational life
SICRAL-1 **:** Design life of 10 years
SICRAL-1B **:** Design life of 13 years

Skynet series

Skynet satellites provide strategic and tactical communication services for the United Kingdom's Armed forces. Till date, four Skynet series of satellites namely Skynet-1, -2, -4 and -5 have been launched. Skynet-1 series comprised of two satellites namely Skynet-1A and -1B. Skynet-2 series also comprised of two satellites namely Skynet-2A and -2B. Skynet-4series is the third generation Skynet satellites comprising of six satellites namely Skynet-4A, -4B, -4C, -4D, -4E and -4F. These satellites provide links between land, sea and airborne terminals, with protection of oral messages and high-speed digital transmissions.

Three satellites, Skynet-5A, -5B and -5C, have been launched in the Skynet-5 series. Fourth satellite of the Skynet-5 series, Skynet-5D, is scheduled to be launched in the year 2013. Skynet-5 series provide the next generation of secure global military satellite communications services for the British Ministry of Defence.

Skynet-4 series

Development Agency
Skynet-4A, -4B, -4C **:** British Aerospace
Skynet-4D, -4E, -4F **:** Matra Marconi, France (now Europe’s EADS Astrium)
Launch

Skynet-4A **:** 1 January 1990
Skynet-4B **:** 11 December 1988
Skynet-4C **:** 30 August 1990
Skynet-4D **:** 10 January 1998
Skynet-4E **:** 26 February 1999
Skynet-4F **:** 7 February 2001

Skynet-4A and -4D were launched from Cape Canaveral launch center, USA with Skynet-4A on Titan-34D and Titan-4D on Delta 7000. Skynet-4B, -4C, -4E and -4F were launched from Kourou in French Guiana, France. Skynet-4B, -4C were launched on Ariane-44LP and Skynet-4E and -4F were launched on Ariane-44L

Orbit
Skynet-4A **:** GEO 6^0E
Skynet-4B, -4C **:** GEO 1^0W
Skynet-4D, -4E **:** GEO 53^0E
Skynet-4F **:** GEO 6^0E
Weight **:** 1500 kg each
Payload
Skynet-4A, -4B, -4C **:** 4 SHFand 2 UHF Transponders each
Skynet-4D, -4E, -4F **:** 4 SHF, 2 UHF and 2 C-band Transponders each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 6 years

Skynet-5 series

Development Agency **:** EADS Astrium, Europe and , Paradigm Secure Communications, UK
Launch
Skynet-5A **:** 11 March 2007
Skynet-5B **:** 14 November 2007
Skynet-5C **:** 12 June 2008

All the three satellites were launched from Kourou in French Guiana, France on Ariane-5ECA launch vehicle.

Orbit **:** GEO
Weight
Skynet-5A **:** 4700 kg
Skynet-5B **:** 4635 kg
Skynet-5C **:** 4638 kg
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 15 years

Strela series

The Strela communication satellite system consists of a constellation of medium orbit store-dump satellites that provide survivable communication services to Soviet military and intelligence forces. Till date Strela-1, -1M, -2, -2M and -3 series of satellites have been launched. Strela-3 series is currently operational.

Strela-3 series

The Strela-3 system, which began missions in 1985, has satellites in two orbital planes; spaced 90 degrees apart. Each plane apparently contains 10-12 satellites. 141 Strela-3 satellites have been launched till date.

Strela-3 #128, #129, #130, #131, #132, #133, #134, #135, #136, #137, #138, #139, #140, #141
Development Agency **:** NPO-PM, Russia
Launch
Strela-3 #128, #129, # 130 **:** 28 December 2001
Strela-3 #131, #132 **:** 8 July 2002
Strela-3 #133, #134 **:** 19 August 2003
Strela-3#135, #136 **:** 23 September 2004
Strela-3#137, #138, #139 **:** 23 May 2008
Strela-3#140, #141 **:** 6 July 2009
Launch Vehicle
Strela-3 #128, #129, # 130 **:** Tsiklon-3
Strela-3#131 - #136 **:** Kosmos 3M
Strela-3#137 - #141 **:** Rokot-KM
All the satellites were launched from Plesetsk launch center in North Russia
Orbit **:** LEO, Sun-synchronous, 1400 km × 1414 km, 82.6°
Weight **:** 225 kg each
Stabilization **:** Gravity Gradient stabilization
Operational life **:** Design life of 3 years

Ultra High Frequency Follow On series (UFO series)

UFO series upgraded the US Navy's Ultra-High Frequency (UHF) satellite communications network satellites replacing the Fleet Satellite Communications (FLTSATCOM) and the Leasat spacecraft. These satellites support the Navy's global communications network, serving ships at sea and a variety of other U.S. military fixed and mobile terminals. Four blocks of UFO satellites have been launched. These include Block-1 comprising of three satellites (UFO-1, -2, -3), Block-2 comprising of four satellites (UFO-4, -5, -6, -7), Block-3 comprising of three satellites (UFO-8, -9, -10) and Block-4 comprising of one satellite (UFO-11).

UFO -4, -5, -6, -7 (UHF-F0 Block 2)

Development Agency **:** Hughes Space Systems, USA (now Boeing Satellite Systems)
Launch
UFO-4 **:** 29 January 1995
UFO-5 **:** 31 May 1995
UFO-6 **:** 22 October 1995
UFO-7 **:** 25 July 1996
All these satellites were launched on Atlas-2 from Cape Canaveral launch center, USA
Orbit **:** GEO
Weight **:** 1360 kg each
Payload **:** UHF, SHF, EHF transponders
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 4 years

UFO-8, -9, -10 (UHF-F0 Block 3)

Development Agency : Hughes Space Systems, USA (now Boeing Satellite Systems)
Launch
UFO-8 : 16 March 1998
UFO-9 : 20 October 1998
UFO-10 : 23 November 1999
UFO-8 was launched on Atlas-2, UFO-9 and -10 were launched on Atlas-2A. All the three satellites were launched from Cape Canaveral launch center, USA
Orbit : GEO
Weight : 1541 kg each
Payload : UHF, EHF, GBS transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 4 years

UFO-11 (UHF-F0 Block 4) (Fig.162)

Development Agency : Boeing Satellite Systems, USA
Launch : 18 December 2003 from Cape Canaveral launch center, USA
Launch Vehicle : Atlas-3B
Orbit : GEO
Weight : 1360 kg
Payload : UHF, EHF, transponders
Stabilization : 3-axis stabilization
Operational life : Design life of 4 years

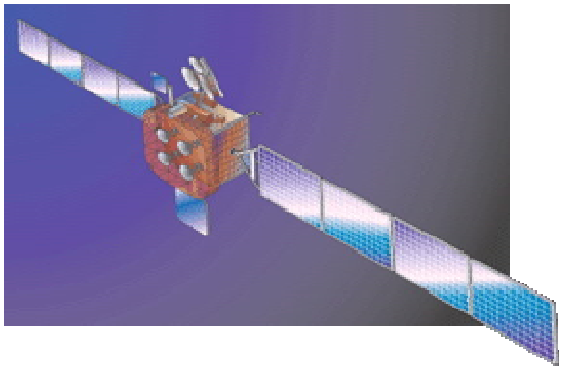


Fig.162
UFO-11 (Courtesy: Aerospace Corporation)

Early Warning Satellites

Defence Support Program (DSP) series

Defence Support Program (DSP) satellites are a key part of North America's early warning system. These satellites detect missile launches, space launches and nuclear detonations. The first launch of a DSP satellite took place in the early 1970s and since that time, these satellites have provided an uninterrupted early warning capability to the United States. Till date DSP Block-1 or Phase-I (DSP-1, -2, -3 and -4 satellites) , Block-2 or Phase-II (DSP-5, -6 and -7 satellites), Block-3 or Phase II-MOS/PIM (DSP-8, -9, -10 and 11 satellites), Block-4 or Phase-II Upgrade (DSP-12 and -13 satellites) and Block-5 or Phase-III (Fig.163) (DSP-14, -15, -16, -17, -18, -19, -20, -21, -22 and -23) series of satellites have been launched. DSP-23 Phase-III satellite is scheduled for launch in near future.

Fig.163
DSP Block 5 (Courtesy: USAF)

DSP-18, -19, -20, -21, -22, -23

Development Agency : TRW Space and Electronics, USA
Launch
DSP-18 : 23 February 1997
DSP-19 : 9 April 1999 (Failure)
DSP-20 : 8 May 2000
DSP-21 : 6 August 2001
DSP-22 : 14 February 2004
DSP-23 : 11 November 2007
All these satellites except DSP-23 were launched on Titan-4B. DSP-23 was launched on Delta-4H. All the satellites were launched from Cape Canaveral launch center, USA
Orbit : GEO
Weight : 2386 kg each
Payload : Telescope with 6000 element IR array, nuclear explosion detectors, particle detection monitors.

Stabilization **:** Spin stabilization
Operational life
DSP-18 **:** Design life of 5 years
DSP-20, -21,-22, -23 **:** Design life of 7-9 years

Oko series

Russia's ballistic missile early warning network comprises of two series of satellites namely the Oko satellites and Prognoz satellites. The constellation was designed with nine operational Oko and seven operational Prognoz satellites. 86 Oko satellites have been launched till Dec 2005.

Oko-81, -82, -83, -84, -85, -86

Development Agency **:** Lavochkin, Russia
Launch
Oko-81 **:** 9 April 1997
Oko-82 **:** 14 May 1997
Oko-83 **:** 7 May 1998
Oko-84 **:** 27 December 1999
Oko-85 **:** 1 April 2002
Oko-86 **:** 24 December 2002
All these satellites were launched on Molniya-M from Plesetsk launch site in the northern Russia.
Orbit **:** Molniya, Apogee of 39 700 km, Perigee of 600km, Inclination of 63^0
Weight **:** 2400 kg each
Payload **:** Infrared sensors, telescopes
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3-5 years

Military Earth Observation satellites

Geosat Follow On series (GFO series)

GFO satellite is used by US navy to provide continuous world wide oceanographic data for ships at sea and for navy facilities on shore, directly supporting naval operations such as ship routing, anti-submarine warfare and amphibious operations.

GFO-1

Development Agency : Ball Aerospace, USA
Launch : 10 February 1998 from Vandenberg Air Force Base in California, USA
Launch Vehicle : Taurus-2210
Orbit : LEO, Sun-synchronous 775 km x 878 km, 108^0
Weight : 410 kg
Payload : Precise radar altimeter (Resolution <5cm)
Stabilization : Spin stabilization
Operational life : Design life of 8 years

Okean-O 1

OKEON-O is a Russian-Ukrainian remote sensing satellite that enables monitoring of ocean salinity, waves and ice conditions.

Development Agency : Ukrainian Yuzhnoye company
Launch : 17 July 1999 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle : Zenit-2
Orbit : LEO, Sun-synchronous 664 km x 662 km, and inclination 98.1^0
Weight : 6150 kg
Stabilization : 3-axis stabilization
Payload : Electro-optical and radar sensors
Operational life : Design life of 3 years

Navigation satellites

GLONASS satellite system (Uragan system)

GLONASS (Global Navigation Satellite System) is Russian navigation satellite system. The system is a counterpart to the US GPS system and shares the same principles in data transmission and positioning methods. It is managed for the Russian federation Government by the Russian space forces and the system is operated by the Coordination Scientific Information Center (KNITs) of the ministry of Defence of the Russian federation. The space segment of GLONASS is formed by 24 satellites (21 operational and 3 on-orbit spares) located in three orbital planes in a circular orbit of altitude 19 100 km and with an inclination of 64.8°. The three orbital planes are separated by 120°, and the satellites within the same orbital plane are separated by 45°.

The first GLONASS satellites were launched in 1982. The GLONASS system was declared fully operational on 24 September 1993. Since then, two series of GLONASS satellites namely GLONASS and GLONASS-M have been launched. The third generation satellites of GLONASS system named GLONASS-K are scheduled for launch in the near future.

GLONASS series (Uragan series) (Fig.164)

87 satellites have been launched in this series till December 2005.

Uragan-72 (Kosmos-2362), -73 (Kosmos-2363), -74 (Kosmos-2364), -75 (Kosmos-2374), -76 (Kosmos-2375), -77 (Kosmos-2376), -78 (Kosmos-2382), -79 (Kosmos-2381), -80 (Kosmos-2394), -81 (Kosmos-2395), -82 (Kosmos-2396), -83 (Kosmos-2402), -84 (Kosmos-2403), -85 (Kosmos-2411), -86 (Kosmos-2412), -87 (Kosmos-2417)

Development Agency : Russian company NPO PM
Launch
Uragan-72, -73, -74 : 30 December 1998
Uragan -75, -76, -77 : 13 October 2000
Uragan -78, -79 : 1 December 2001
Uragan -80, -81, -82 : 25 December 2002
Uragan -83, -84 : 10 December 2003
Uragan -85, -86 : 26 December 2004
Uragan -87 : 25 December 2005
All the satellites were launched on Proton-K from Baikonour Cosmodrome in Kazakhstan
Orbit : In 3 planes MEO Circular Mean altitude of 19 100 km, 64.8^0
Weight : 1300 kg
Payload : L-band navigation payload
Stabilization : 3-axis stabilization
Operational life : Design life of 3 years

Glonass-M (Uragan-M) series

Glonass-M series satellites (Fig.165) are second generation Russian Navigation satellites.

Uragan-M#1 (Kosmos-2382), -M#2 (Kosmos-2404), -M#3 (Kosmos-2413), -M#4 (Kosmos-2418), -M#5 (Kosmos-2419), -M#6 (Kosmos-2424), -M#7 (Kosmos-2425), -M#8 (Kosmos-2426), M#9 (Kosmos-2431), M#10 (Kosmos-2432), M#11 (Kosmos-2433), M#12 (Kosmos-2434), M#13 (Kosmos-2435), M#14 (Kosmos-2436), M#15 (Kosmos-2442), M#16 (Kosmos-2443), M#17 (Kosmos-2444), M#18 (Kosmos-2447), M#19 (Kosmos-2448), M#20 (Kosmos-2449), M#21 (Kosmos-2456), M#22 (Kosmos-2457), M#23 (Kosmos-2458), M#24 (Kosmos-2459), M#25 (Kosmos-2460), M#26 (Kosmos-2461)

Development Agency : Russian company NPO PM
Launch
Uragan-M#1 **:** 1 December 2001
Uragan-M#2 **:** 10 December 2003
Uragan-M#3 **:** 26 December 2004
Uragan-M#4, -M#5 **:** 25 December 2005
Uragan-M#6, -M#7, -M#8 **:** 25 December 2006
Uragan-M#9, -M#10, -M#11 **:** 26 October 2007
Uragan-M#12, -M#13, -M#14 **:** 25 December 2007
Uragan-M#15, -M#16, -M#17 **:** 25 September 2008
Uragan-M#18, -M#19, -M#20 **:** 25 December 2008
Uragan-M#21, -M#22, -M#23 **:** 14 December 2009
Uragan-M#24, -M#25, -M#26 **:** 1 March 2010
Uragan-M#1 to –M#11 were launched on Proton-K and Uragan-M#12 to –M#26 were launched on Proton-M. All the satellites were launchd from Baikonour Cosmodrome in Kazakhstan
Orbit **:** In 3 planes MEO Circular Mean altitude of 19 100 km, 64.8°
Weight **:** 1480 kg
Payload **:** L-band navigation payload
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 5-7 years

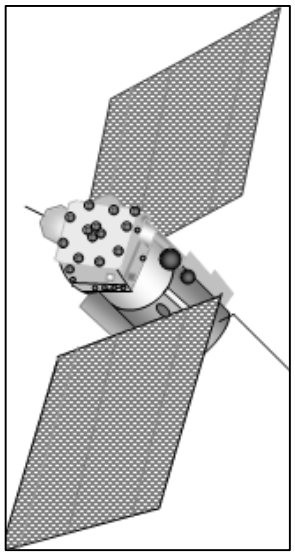


Fig.165
GLONASS

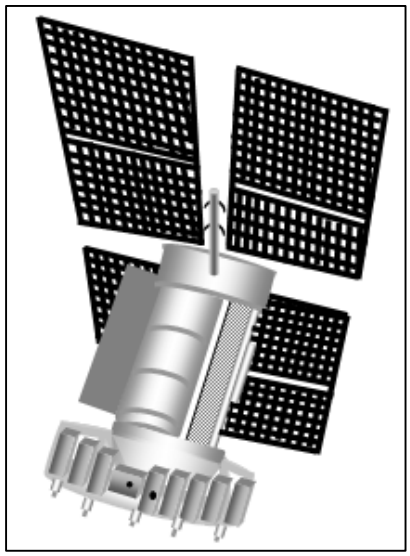


Fig.164
GLONASS-M

Navstar system (GPS system)

GPS system is US satellite based navigation system developed by the US Department of Defence (DoD). Originally envisioned as primarily a military system, GPS is now a dual-use system, used for both military as well as civilian applications. GPS navigation system employs a constellation of 24 satellites and ground support facilities to provide three dimensional position, velocity and timing information to all the users worldwide 24 hours a day. The GPS receivers calculate their location on the basis of ranging, timing and position information transmitted by GPS satellites (The GPS satellites transmit information at two frequencies, 1575.42 MHz (L1) and 1227.6 MHz (L2)).

The first GPS satellite was launched on 22 February 1978. It marked the beginning of first generation GPS satellites, referred to as Block-I satellites. Eleven satellites were launched in this block and were mainly used for experimental purposes. These satellites were out of service by the year 1995. The second generation of GPS satellites comprised of Block-II and Block-IIA satellites. Block-IIA satellites were advanced versions of Block-II satellites. A total of 28 Block-II and Block-IIA satellites (nine satellites in the Block-II series and nineteen satellites in the Block-IIA series) were launched over the span of 8 years, from 1989 to 1997. GPS system was declared fully functional on 17 July 1995 ensuring the availability of at least 24 operational, non-experimental GPS satellites.

Currently, third generation GPS satellites, referred to as Block-IIR satellites, are being launched. The first satellite in this series was launched in the year 1997. 21 satellites are planned to be launched in this block. Till Dec 2009, 13 Block-IIR satellites had been launched. One of the potential advantages of Block-IIR satellites over previous satellites is that they have reprogrammable satellite processors enabling up-gradation of satellites while in orbit. These satellites can calculate their own positions using inter-satellite ranging techniques. Moreover, they had more stable and accurate clocks on-board them as compared to the Block-II and -IIA satellites. Block-IIR satellites have three rubidium atomic clocks (having accuracy of one second in 300 000 years), whereas Block-II and -IIA satellites have two cesium atomic clocks (having accuracy of one second in 160 000 years) and two rubidium atomic clocks (having accuracy of one second in 300 000 years). Eight of the planned Block-IIR satellites have been improved further and are named Block-IIR-M satellites. These satellites will carry a new military code on both the frequencies (L1 and L2) and a new civilian code on the L2 frequency. The dual codes will provide increased resistance to jamming and the new civilian code will provide better accuracy to civilian users by increasing capability to compensate for atmospheric delays. Eight Block-IIR-M satellites has been launched till June 2010. .

Block-IIR satellites will be followed by Block-IIF satellites. 12 Block-IIF satellites are being planned to be launched by the year 2011. These satellites will have a third carrier signal, L5, at 1176.45 MHz. They will also have larger design life, fast processors with more memory and a new civilian code. GPS-III phase of satellites are in the planning stage. These satellites will employ spot beams, enabling the system to have better position accuracy (less than a meter). They will be positioned in three orbital planes having non-recurring orbits.

Navstar IIR (GPS-IIR) (Fig.166)

Navstar-IIR (Navigation System using Timing And Ranging) is the third evolutionary stage of the second generation of the Navstar GPS satellites. Block-IIR satellites provided dramatic

improvements over previous blocks as they could determine their own position by performing inter-satellite ranging with other Navstar-IIR vehicles. They also had reprogrammable satellite processors enabling problem fixes and upgrades in flight, increased satellite autonomy, and radiation hardness.

Development Agency : General Electric Atrospace, USA (now Lockheed Missiles and Space)
Launch
Navstar-IIR 1 : 16 January 1997
Navstar-IIR 2 : 23 July 1997
Navstar-IIR 3 : 7 October 1999
Navstar-IIR 4 : 11 May 2000
Navstar-IIR 5 : 16 July 2000
Navstar-IIR 6 : 10 November 2000
Navstar-IIR 7 : 30 January 2001
Navstar-IIR 8 : 29 January 2003
Navstar-IIR 9 : 31 March 2003
Navstar-IIR 10 : 21 December 2003
Navstar-IIR 11 : 20 March 2004
Navstar-IIR 12 : 23 June 2004
Navstar-IIR 13 : 6 November 2004
All the satellites were launched on Delta-7925 from Cape Canaveral launch center, USA
Orbit : 20200 km × 20200 km, 55.0°
Weight : 2032 kg each
Payload : Antennas to transmit L-band frequencies: L1 = 1575.42 MHz and L2 = 1227.6 MHz and precise atomic clocks
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

GPS-IIR-M (Navstar-IIR-M)

Block-IIR-M satellites are improved GPS-IIR satellites and will carry a new military code on both the frequencies (L1 and L2) and a new civilian code on the L2 frequency. Eight GPS-IIR-M satellites have been launched till June 2010.

Navstar-IIR-M (GPS-IIR-M)

Development Agency : General Electric Astrospace, USA (now Lockheed Missiles and Space)
Launch
Navstar-IIR-M 1 : 26 September 2005
Navstar-IIR-M 2 : 25 September 2006
Navstar-IIR-M 3 : 17 November 2006
Navstar-IIR-M 4 : 17 October 2007
Navstar-IIR-M 5 : 20 December 2007
Navstar-IIR-M 6 : 15 March 2008
Navstar-IIR-M 7 : 24 March 2009
Navstar-IIR-M 8 : 17 August 2009
All the satellites have been launched from Cape Canaveral launch center, USA on Delta-7925.
Orbit : 20200 km × 20200 km, 55.0°
Weight : 2032 kg each

Payload : Antennas to transmit L-band frequencies: L1 = 1575.42 MHz and L2 = 1227.6 MHz and precise atomic clocks
Stabilization : 3-axis stabilization
Operational life : Design life of 10 years

Fig.166
GPS IIR satellite (Courtesy: Lockheed Martin)

Reconnaissance & Surveillance satellites

Advanced Orion series (Mentor series)

These satellites are geostationary signal intelligence satellites operated by US Air Force. They replaced the Magnum / Orion series of satellites. Mission objectives of Mentor satellites is to intercept communication transmissions especially line-of-sight microwave links and missile telemetry interception from the Soviet Union and China. Three satellites namely Mentor-1, -2, -3 have been launched.

Launch
Mentor-1 **:** 14 May 1995
Mentor-2 **:** 8 May 1998
Mentor-3 **:** 9 September 2003
Mentor-1 was launched on Titan-4A and Mentor-2 and -3 were launched from Titan-4B. All the three satellites were launched from Cape Canaveral launch center, USA
Orbit **:** GEO
Stabilization **:** 3-axis stabilization
Payload **:** Large dish antenna

Arkon-1 series

The Arkon-1 series is a new area reconnaissance satellite of Russia having resolution of the order of 2 to 10 m. It has an unusually high (1510-2747km) orbit for a photo-reconnaissance satellite. Till date, four Arkon-1 satellites have been launched in the years 1983, 1989, 1997 and 2002.

Development Agency **:** NPO Lavochkin, Russia
Launch
Araks-1 (Kosmos-2344): 6 June 1997
Araks-2 (Kosmos-2392): 25 July 2002
Both the satellites were launched on Proton-K from Baikonour Cosmodrome in Kazakhstan
Orbit **:** LEO, Sun-synchronous 1500 km × 1836 km, 64.4°
Weight
Araks-1 **:** 6000 kg
Araks-2 **:** 2600 kg
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 2 years

Helios series

Helios program is Europe's military optical reconnaissance satellite system. Two series of Helios satellites namely Helios-1 and -2 have been launched.

Helios-1 series

Two satellites have been launched in this series namely Helios-1A and -1B

Development Agency : Matra Marconi Space, Europe
Launch
Helios-1A : 7 July 1995
Helios-1B : 3 December 1999
Both the satellites were launched on Ariane-40 from Kourou in French Guiana, France
Orbit : LEO, Sun-synchronous 672 × 676km, 98.1°
Weight : 2500 kg each
Payload : Panchromatic, high resolution and wide-angle optical instruments
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years

Helios-2 series

One satellite (Helios-2A) has been launched in this series. Second satellite of the series named Helios-2B is planned be launched in the year 2008.

Helios-2A

Development Agency : EADS Astrium, Europe
Launch : 18 December 2004 from Kourou in French Guiana, France
Launch vehicle : Ariane-5G
Orbit : LEO, Sun-synchronous, mean altitude of 680 km, 98.1°
Weight : 4200 kg
Payload : Imagers in visible and infrared bands
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years

KH series (Key Hole satellites)

The KH (KeyHole) designation is used to refer to all photographic American reconnaissance satellites. They are operated by National Reconnaissance Office (NRO). 13 KH series satellites have been launched. KH-1 satellites are sometimes referred to as USA's first 'Spy' satellites. The satellites launched initially had resolution of the order of 10 m and lifetime of around a week, which was later improved to 3m and 19 days respectively in the KH-4B series. KH-1 to KH-4 series of satellites was codenamed CORONA.

The SAMOS and the CORONA programs were the first generation of the intelligence imagery satellites that returned high-resolution images to Earth using re-entry capsules. Other first generation satellites included the ARGON and the LANYARD series of satellites. ARGON was the code name given to the KH-5 satellites, designed for large-scale mapmaking. LANYARD satellites or the KH-6 satellites were used for gathering important intelligence information. 12 KH-5 and three KH-6 satellites were launched. KH-6 series was followed by KH-7, KH-8 and KH-9 series. All the satellites from KH-1 to KH-9 were film based 'Close-look PHOTOINT' satellites that returned high-resolution images to Earth using small re-entry capsules and were part of Key-Hole series of satellites. They orbited in low earth orbits at an altitude of around 200km. Around 150 satellites were launched in KH-1 to KH-9 programs during the period 1960 to 1972.

The use of PHOTOINT satellites employing return capsules was discontinued in the early 1980s. Satellites that took wide-area images were advanced version of IMINT satellites and transmitted images back to earth via an electronic telemetry link. These satellites were the 'Electro-optical' satellites. The first electro-optical satellite series was KH-11 code named Crystal/ Kennan, first launched in December 1976. Nine satellites were launched under the series in a span of 12 years from 1976 to 1988. KH-11 satellites orbited in higher orbits as compared to their predecessors. They had the capability to take visible, near-IR and thermal-IR images. KH-11 series was followed by Advanced KeyHole or KH-12 series of satellites. Five satellites have been launched under this series, from 1992 to 2005. KH-12 satellites provided real-time images in the visible, near-IR and thermal IR bands. KH-13 series is a potential successor to the KH-12 reconnaissance satellites. Not much information is not available on KH-13 satellites.

KH-12 series

Development Agency : Lockheed Martin Missiles and Space, USA
Launch
KH-12 1 (USA 86) : 28 November 1992
KH-12 2 (USA 116) : 5 December 1995
KH-12 3 (USA 129) : 20 December 1996
KH-12 4 (USA 161) : 5 October 2001
KH-12 5 : 19 October 2005
All the satellites were launched from Vandenberg Air Force Base in California, USA. KH-12 1, 12 2 and 12 3 were launched on Titan-4A, KH-12 4, 12 5 was launched on Titan-4B
Orbit : Near-polar, sun-synchronous orbit
KH-12 1 : 198 km x 207 km, 62^0
KH-12 2 : 256 km x 911 km, 97.7^0
KH-12 3 : 153 km x 949 km, 97.9^0
Weight : 19 600 kg each
Payload : Optical sensors operating in the visible, near IR and thermal IR bands and electronic cameras
Stabilization : 3-axis stabilization
Operational life : Design life of 10-12 years

KH-13 series (EIS series, 8X series)

Development Agency : Lockheed Martin Missiles and Space, USA
Launch : 22 May 1999 from Vandenberg Air Force Base in California, USA
Launchvehicle : Titan-4B

Lacrosse (Onyx) series

Lacrosse satellites, operated by National Reconnaissance Office of USA are radar reconnaissance satellites. Till December 2005, five Lacrosse satellites have been launched namely Lacrosse-1, -2, -3, -4 and -5**.**

Lacrosse 4 (Onyx 4)

Development Agency : Lockheed Martin Astronautics, USA
Launch

Lacrosse-4 **:** 17 August 2000
Lacrosse-5 **:** 30 April 2005
Lacrosse-4 was launched from Vandenberg Air Force Base in California, USA and Lacrosse-5 was launched from Cape Canaveral launch center. Both the satellites were launched on Titan-4B.
Orbit **:** LEO, Sun-synchronous
Lacrosse-4 **:** Mean altitude 690km, 68°
Lacrosse-5 **:** Mean altitude 714km, 57°
Payload **:** Synthetic Aperture Radar (SAR)
Weight **:** 14500kg each
Operational life **:** Design life of 9 years

Neman series (Yantar-4KS1M)

Neman satellites are Russian electro-optical reconnaissance satellites. Till date nine satellites have been launched in this series. These include Neman-1 to Neman-9.

Neman-9 (Cosmos 2370)

Development Agency **:** Photon company of Russia
Launch **:** 3 May 2000 from Baikonour Cosmodrome in Kazakhstan
Launch Vehicle **:** Soyuz-U
Orbit **:** LEO, Sun-synchronous 200km × 270km, 64.9^0
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3-5 years

Tselina series

Tselina satellites are Russian ELINT satellites, comprising of Tselina-O, -D, -R and -2 series. Tselina-2 series is the latest of the Tselina series of satellites.

Tselina-2

22 Tselina satellites have been launched, Tselina-2 1 to Tselina-2 22

Tselina-2 21, -2 22 (Fig.167)

Development Agency **:** Yuzhone company of Russia
Launch
Tselina-2 21 **:** 3 February 2000
Tselina-2 22 **:** 10 June 2004
Both the satellites were launched from Baikonour Cosmodrome in Kazakhstan on Zenit-2
Orbit **:** LEO, Sun-synchronous, Mean altitude 850km, 71^0
Weight **:** 3200 kg each
Stabilization **:** 3-axis stabilization
Operational life **:** Design life of 3 years

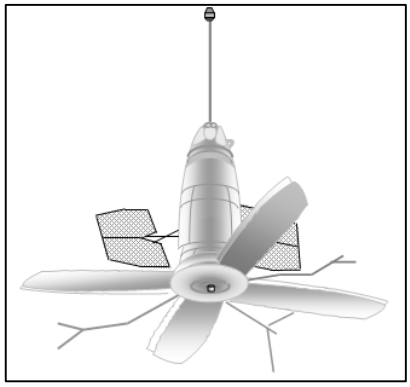


Fig.167
Tselina-2

US-PM series

US-PM satellites are passive ocean surveillance satellites. Till date, 12 satellites namely US-PM1 to US-PM12 have been launched in this series.

Cosmos-2367 (Kosmos-2367, US-PM10), Cosmos-2383 (Kosmos-2383, US-PM11), Cosmos-2408 (Kosmos-2408, US-PM12)

Development Agency : Arsenal design Bureau of Russia
Launch
US-PM10 : 24 December 1999
US-PM11 : 21 December 2001
US-PM12 : 28 May 2004
All the three satellites were launched on Tsyklon-2 from Baikonour Cosmodrome in Kazakhstan
Orbit : LEO, Sun-synchronous, mean altitude 420 km, 65^0
Weight : 3300 kg each
Payload : Radio-Technical Reconnaissance system and systems for electronic camouflage and self protection
Stabilization : 3-axis stabilization
Operational life : Design life of 5 years

Unmanned Launch Vehicles

Ariane Launch Vehicles

Ariane Launch vehicles, operated by Arianespace of France launch satellites in to the low earth orbit, Ssun-synchronous orbit and the geostationary transfer orbit from Kourou in French Guiana, France. The first inaugural flight of Ariane was way back in the year 1979, when Ariane-1 launched the CAT-1 satellite in GTO orbit. After Ariane-1, came in Ariane-2, Ariane-3, Ariane-4 and Ariane-5 series of launch vehicles. Ariane-1 was a three stage rocket with a lift-off mass of 210 000 kg. It was capable of launching one satellite or two small satellites into geostationary orbit. Ariane- 2 and -3 are also 3-atage launch vehicles similar to Ariane-1 but had larger payload capacity. Ariane-3 also had two strap-on solid rocket boosters.

Ariane-4

Ariane-4, known as the 'workhorse' of the Ariane family, comprises of six medium to heavy lift launch vehicles namely Ariane-40, -42P, -44P, -42L, -44L and -44LP, with Ariane-44L being the most powerful Ariane-4 variant. Ariane-4 has proved ideal for launching satellites for communications and Earth observation, as well as for scientific research. Since its inaugural flight in June 1988, the Ariane-4 completed more than 120 successful launches and had captured nearly 50 percent of the commercial GTO market. The Ariane-4 family builds upon a three stage liquid core vehicle (Ariane-40) having six Viking-5C engines in the first stage, one Viking-4B engine in the second stage and one HM7B engine in the third stage. The Ariane-42P adds two PAP-12 solid strap-on motors while the Ariane-42L adds two Viking-6 liquid strap-on boosters. The Ariane-44P and Ariane-44L use four solid and liquid boosters respectively. The Ariane-44LP uses two solid and two liquid strap on boosters. Currently, the Ariane-4 is being phased out in favour of the Ariane-5 launcher.

Ariane-40 (Fig.168)

Comprises of three variants namely Ariane-40 H10, -40 H10+ and -40 H10-3

Configuration : Core Vehicle
Launch mass : 240 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-40 H10 : 1900 kg in GTO
Ariane-40 H10+ : 2020 kg in GTO
Ariane-40 H 10-3 : 2105 kg in GTO

Ariane-42P (Fig.169)

Comprises of Ariane-42P H10, -42P H10+ and -42P H10-3

Configuration : Core Vehicle plus two solid strap-on motors
Launch mass : 339 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-42P H10 : 2600 kg in GTO
Ariane-42P H10+ : 2740 kg in GTO
Ariane-42P H10-3 : 2930 kg in GTO

Ariane-44P (Fig.170)

Comprises of Ariane-44P H10, -44P H10+ and -44P H10-3

Configuration : Core Vehicle plus four solid strap-on motors
Launch mass : 358 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-44P H10 : 3000 kg in GTO
Ariane-44P H10+ : 3290 kg in GTO
Ariane-44P H10-3 : 3465 kg in GTO

Ariane-42L (Fig.171)

Comprises of Ariane-42L H10, -42L H10+ and -42L H10-3

Configuration : Core Vehicle plus two liquid strap-on motors
Launch mass : 400 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-42L H10 : 3200 kg in GTO
Ariane-42L H10+ : 3350 kg in GTO
Ariane-42L H 10-3 : 3480 kg in GTO

Ariane-44LP (Fig.172)

Comprises of Ariane-44LP H10, -44LP H10+ and -44LP H10-3

Configuration : Core Vehicle plus two solid and two liquid strap-on motors
Launch mass : 420 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-44LP H10 : 3700 kg in GTO
Ariane-44LP H10+ : 4030 kg in GTO
Ariane-44LP H 10-3 : 4220 kg in GTO

Ariane-44L (Fig.173)

Comprises of Ariane-44L H10, -44L H10+ and -44L H10-3

Configuration : Core Vehicle plus four liquid strap-on motors
Launch mass : 470 000 kg
Launch site : Kourou in French Guiana, France
Payload Launching Capability
Ariane-44L H10 : 4200 kg in GTO
Ariane-44L H10+ : 4460 kg in GTO
Ariane-44L H 10-3 : 4720 kg in GTO

Fig.168 Ariane-40 | Fig.169 Ariane-42P | Fig.170 Ariane-44P | Fig.171 Ariane-42L | Fig.172 Ariane-44LP | Fig.173 Ariane-44L
(Courtesy: ESA/CNES/ARIANESPACE-Jecnice Optique.CJG)

Ariane-5

Ariane-5 launch vehicles comprise of a central core stage with two solid strap-on motors. On top of this, different upper stage configurations are integrated. They have capability to launch larger satellites for communications, Earth observation and scientific research into geostationary orbits and Sun-synchronous orbits at reduced costs while maintaining high reliability. The original version is named Ariane-5G (Generic) having the payload capability to launch satellites of 6200kg to geostationary transfer orbit. The first successful launch by Ariane-5 took place on 30 October 1997 while its first operational flight occurred in December 1999, when it launched ESA's X-ray Multi-Mirror (XMM). Other operational variants of Ariane-5 are 5G+, 5GS, 5ES and 5ECA. .

Ariane-5G

Launch mass **:** 710 000 kg
Launch site **:** Kourou in French Guiana, France
Payload Launching Capability
5900 kg in GTO

Ariane-5G+

Launch site **:** Kourou in French Guiana, France
Payload Launching Capability
6950 kg in GTO

Ariane-5GS (Fig.175)
Launch mass **:** 750 000 kg
Launch site **:** Kourou in French Guiana, France
Payload Launching Capability
6800 kg in GTO

Ariane-5ES
Launch mass **:** 760 000 kg
Launch site **:** Kourou in French Guiana, France
Payload Launching Capability
8000 kg in GTO

Ariane-5ECA (Fig.174)

Launch mass **:** 776 650 kg
Launch site **:** Kourou in French Guiana, France
Payload Launching Capability
9600 kg in GTO

Fig.174
Ariane-5 ECA

Fig.175
Ariane-5GS

(Courtesy: ESA-D.DUCROS)

Athena Launch Vehicles

Athena is a core component of the Lockheed Martin launch vehicle family, which also includes the Titan-IV, Titan-II, MSLS, Atlas and Proton vehicles. Athena launch vehicle is available in two versions namely Athena-1 and Athena-2. The Athena program began in January 1993. The first operational mission of Athena-1 successfully launched the NASA Lewis satellite into orbit from Vandenberg Air Force Base (VAFB), USA on 22 August 1997. The first misson of Athena-2 was on 6 January 1998. It successfully launched NASA's Lunar Prospector spacecraft from Cape Canaveral Air Station (CCAS), USA.

Athena-1

Athena-1 formerly known as Lockheed Martin Launch Vehicle 1 (LMLV-1) was designed to carry 4 small satellite payloads for NASA and the Air Force.

Configuration **:** Solid motor first stage (Castor-120) + solid motor second stage (Orbus-21D) + liquid motor OAM (Orbit Adjust Module)
Launch mass **:** 66 300 kg
Payload Launching Capability
795 kg in 185 km LEO

Athena-2 (formerly known as LMLV-2/ LLV-2)

Configuration **:** Solid motor first and second stages (Castor-120) + solid motor third stage (Orbus-21D) + liquid motor OAM (Orbit Adjust Module)
Launch mass **:** 120 700 kg
Payload Launching Capability
1985 kg in 185 km LEO

Atlas Launch Vehicles

Atlas launch vehicle family evolved from the Atlas Intercontinental Ballistic Missile (ICBM) program of the U.S. Air Force. Atlas became one of the most important boosters for the Air Force, NASA and Department of Defence orbital payloads. It was first used as a non-strategic missile launcher in December 1958 for Project SCORE (Signal Communications Orbit Relay Equipment). Since the launch of the first Atlas launch vehicle in 1958, around 600 flights have occurred till date. The Atlas launch vehicle comprises of four basic families including the Atlas-I, Atlas-II (II, IIA and IIAS), the Atlas-III (IIIA and IIIB) and the Atlas-V (400 and 500 series). These launch vehicles were manufactured by Lockheed Martin Astronautics, USA

Atlas-I

Configuration **:** Pressure stabilized booster + Centaur-1/2 (2xRL-10A-3-3A)
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
2340 kg in GTO

Atlas-II

Atlas-II family includes Atlas-II, -IIA and -IIAS developed in the mid 1980's to launch commercial satellites in LEO and GEO orbits. Atlas-II retired in March 1998 and -IIA in 4 Dec 2002. The last successful flight of Atlas-IIAS occurred on 31 August 2004.

Atlas-II

Configuration **:** Pressure stabilized booster + Centaur-2 (2xRL-10A-3-3A)
Launch mass **:** 187 600 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
2810 kg in GTO

Atlas-IIA

Configuration **:** Pressure stabilized booster + Centaur-2 (2xRL-10A-4)
Launch mass **:** 185 427 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
3180 kg in GTO

Atlas-IIAS

Configuration **:** Pressure stabilized booster + 4x Castor IVA strap ones
+ Centaur-2 (2xRL-10A-4)
Launch mass **:** 233 750 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
3833 kg in GTO

Atlas-III launch vehicle

Atlas-III launch vehicle is an improved version of Atlas-II family of launch vehicles. It comprises of Atlas-IIIA and Atlas-IIIB families.

Atlas-IIIA

Configuration **:** Pressure stabilized booster + Centaur-2 (1xRL-10A-4-2)
Launch mass **:** 220 672 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
4060 kg in GTO

Atlas-IIIB SEC

Configuration **:** Pressure stabilized booster + Centaur-2 (1xRL-10A-4-2)
Launch mass **:** 225 392 kg
Launch site **:** Cape Canaveral launch center, USA

Payload Launching Capability
4193 kg in GTO

Atlas-IIIB DEC

Configuration **:** Pressure stabilized booster + stretched Centaur-2 (2xRL-10A-4-2)
Launch mass **:** 225 392 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
4609 kg in GTO

Atlas-V series

Atlas-V series, built by Lockheed Martin, currently comprises of Atlas-V 400 (Fig.176) series and Atlas-V 500 (Fig.179) series. The Heavy Atlas-V(HLV) (Fig.178) is under development.

Atlas-V 400 series

Atlas-V 400 series in turn comprises of Atlas-V 401, -V 411,-V 421 and -V 431 series of launch vehicles.

Atlas-V 401

Configuration **:** Common core + Centaur (1xRL-10A-4-2)
Launch mass **:** 334 045kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
Maximum of 4950 kg in GTO

Atlas-V 411

Configuration **:** Common core + 1 SRB (strap-on booster) + Centaur (1xRL-10A-4-2)
Launch mass **:** 374 120 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
Maximum of 5950 kg in GTO

Atlas-V 421

Configuration **:** Common core + 2 SRB (strap-on booster) + Centaur (1xRL-10A-4-2)
Launch mass **:** 414 920 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
Maximum of 6830 kg in GTO

Atlas-V 431

Configuration **:** Common core + 3 SRB (Strap-on Booster) + Centaur (1xRL-10A-4-2)

Launch mass **:** 461 180 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
Maximum of 7640kg in GTO

Atlas-V 500 series

Atlas-V500 series comprises of Atlas-V 501, -V 502, -V 511,- V 512, -V 521, -V 522, -V 531, -V 532, -V 541, -V 542, -V 551, -V 552 and Atlas-V HLV (Heavy) series. Four launches have taken place till April 2010 by Atlas-V 500 series of launch vehicles. Two launch missions were carried out by Atlas-V 521 and one each by Atlas-V 551 and Atlas-V 501.

Atlas-V 521

Configuration **:** Common core + 2 SRBs (Strap-on Booster) + Centaur (1xRL-10A-4-2)
Launch mass **:** 418 725 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
6285 in GTO

Atlas-V 551

Configuration **:** Common core + 5 SRBs (Strap-on Booster) + Centaur (1xRL-10A-4-2)
Launch mass **:** 541 195 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
8670kg in GTO

Atlas-V 501

Configuration **:** Common core + Centaur (1xRL-10A-4-2)
Launch mass **:** 337 290 kg
Launch site **:** Cape Canaveral launch center, USA
Payload Launching Capability
3970 kg in GTO

Cosmos series (Kosmos series)

Cosmos family of launch vehicles are two-stage Russian launch vehicles derived from the R-12 and R-14 ballistic missiles. These launch vehicles were developed for launching satellites not requiring the more powerful R-7-based (Soyuz-type) boosters. Cosmos and Cosmos-2 series consisted of an R-12 first stage and a high-performance second stage that burned a unique liquid oxygen/UDMH propellant combination. These were used to launch Cosmos and Intercosmos satellites until being phased out in 1977. They were superseded by Cosmos-1, Cosmos-3, and Cosmos-3M based on the R-14 booster.

Fig.176
Atlas-V 400

Fig.177
Atlas-V 500

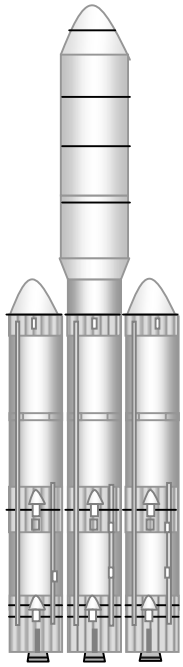


Fig.178
Heavy Atlas-V HLV

Cosmos-3M

Cosmos-3M is a two stage, liquid fueled launch vehicle operational since the early 1960s. It has made more than 400 launches. Production of Cosmos-3M has halted since 1995.

Configuration **:** 2 stage liquid engines
Launch mass **:** 109 000 kg
Launch site **:** Plesetsk launch center in Russia
Payload Launching Capability
1500 kg in LEO

Cyclone Launch Vehicle (Tsyklon)

Cyclone (Tsyklon) is a Soviet/Ukrainian-designed expandable launch system, primarily used to put Cosmos and Meteor class satellites into low earth orbit. It is based on the R-36 intercontinental ballistic missile. There are two major variants of the Cyclone namely the Cyclone-2 and Cyclone-3. Cyclone-2 has been operational since the year 1967, where as Cyclone-3 has been operational since 1977.

Cyclone-2

Configuration **:** 2 stages liquid engine

Launch mass : 182 000 kg
Launch site : Baikonour Cosmodrome in Kazakhstan
Payload Launching Capability
3350 kg in LEO orbit 200km 51°, 2820kg LEO orbit 200km 65°

Cyclone-3 (Tsiklon-3)

Configuration : 3 stage liquid engine
Launch mass : 186 000kg to 190 000kg
Launch site : Plesetsk launch center in Russia
Payload Launching Capability
4100 kg in LEO 200km, 66° orbit

Delta Launch Vehicles

Delta launch vehicle was developed by the US government in response to Soviet Union's launch of Sputnik in 1957. Delta was derived from the Thor intermediate range ballistic missile, developed in the mid 1950s for the US Air Force. The first successful Delta launch was the Echo-1 satellite on 12 August 1960. Through the years Delta became larger, capable of carrying heavier satellites to higher orbits. The capability increased from 45 kg to a 185 km circular LEO orbit to 21 892 kg to 407km circular LEO and 12 757 kg to GTO using Delta-IV. The main Delta series include Delta-II, -III and -IV.

Delta-II

Delta-II launch vehicles have been in service since 1989. It has launched a range of US government, scientific and commercial payloads. There are several variants of Delta-II series namly the Delta-7300, Delta-7400 and Delta-7900 series. Delta-7300 series comprises of Delta-7320 (Fig.179) and Delta-7326. Delta-7400 series comprises of Delta-7420, Delta-7425 (Fig.180) and Delta-7426. Delta-7900 series comprises of Delta-7920, Delta-7925 (Fig.181), Delta-7926, Delta-7920H and Delta-7925H.

Delta-7320

Configuration : Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 3 GEMS (solid strap-on motors)
Launch mass : 151 700 kg
Launch Site : Cape Canaveral launch center, USA or Vandenberg Air Force Base, USA
Payload Launching Capability
2865 kg in LEO

Delta-7326

Configuration : Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 3 GEMS (solid strap-on motors) +stage 3 (star 37FM)
Launch mass : 155 000 kg
Launch Site : Cape Canaveral launch center, USA or Vandenberg Air Force Base, USA

Payload Launching Capability
898 kg in GTO

Delta-7420 (-2420)

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 4 GEMS (solid strap-on motors)
Launch mass **:** 165 000 kg
Payload Launching Capability
3094 kg to LEO
Launch Site **:** Mostly from Cape Canaveral launch center, USA

Delta-7425 (-2425)

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 4 GEMS (solid strap-on motors) +stage 3 (star 48B)
Launch mass **:** 171 420 kg
Payload Launching Capability
1102 kg in GTO
Launch Site **:** Cape Canaveral launch center, USA

Delta-7426 (-2426)

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 4 GEMS (solid strap-on motors) +stage 3 (star 37FM)
Launch mass **:** 171 420 kg
Payload Launching Capability
1102 kg in GTO
Launch Site **:** Cape Canaveral launch center, USA

Delta 7920

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 9 GEMS (solid strap-on motors)
Launch mass **:** 231 670kg
Launch Site **:** Mostly Vandenberg Air Force Base, USA
Payload Launching Capability
5090kg in LEO

Delta-7925

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 9 GEMS (solid strap-on motors) +stage 3 (star 48B)
Launch mass **:** 231 670 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
1882 kg in GTO

Delta-7925H (-2925H)

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 9 GEMS (solid strap-on motors) +stage 3 (star 48B)
Launch mass **:** 231 670 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
2030kg in GTO

Delta-7920H

Configuration **:** Core Vehicle (stage 1 (RS-27A) + stage 2 (AJ-10-118K)) + 9 GEMS (solid strap-on motors)
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
5815kg in LEO

Fig.179
Delta 7320

Fig.180
Delta 7425

Fig.181
Delta 7925

Delta-III

The Delta-III launch vehicle, designed by Boeing Expendable Launch System, USA was intended as an upgraded version of Delta-II launch vehicle for launching satellites in GTO. Although the Boeing system is planning to phase out the Delta-III in favour of the Delta-IV launch vehicle

Delta-8930 (Delta-3940)

Configuration **:** Stretched Core Vehicle (stage 1 (RS-27A) + stage 2 (RL-10B2)) + 9 GEMS (solid strap-on motors) + Cryogenic upper stage
Launch mass **:** 301450 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
3810 kg in GTO

Delta-IV

The Delta-IV was developed under the US Air Force EELV contract. There are several variants of the Delta-IV launch vehicle namely the Delta-IVM (Fig.182), Delta-IVM+ (4, 2) (Fig.183), Delta-IVM+ (5, 2) (Fig.184), Delta-IVM+ (5,4) (Fig.185) and Delta-IVH (Fig.186). Delta-IVM, Delta-4M+ (4, 2), Delta-IVM+ (5, 4) and Delta-IVH have been used till April 2010 to launch satellites.

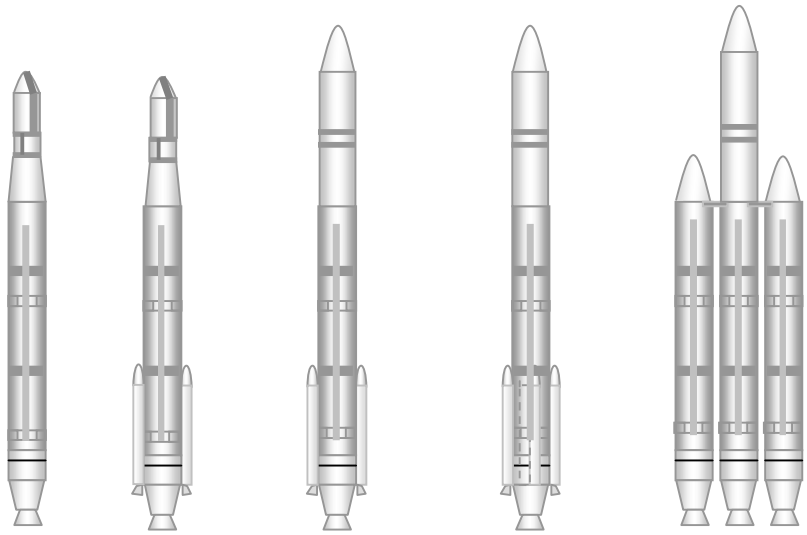


Fig.182 Delta-IVM | Fig.183 Delta-IVM+ (4, 2) | Fig.184 Delta-IVM+(5,2) | Fig.185 Delta-IVM+ (5,4) | Fig.186 Delta-IV heavy

Delta-IVM

Configuration **:** Core Vehicle (stage 1 (RS-68)) +4m fairing (RL-10B-2)
Launch mass **:** 256 000 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
3900 kg in GTO

Delta-IVM+(4,2)

Configuration **:** Core Vehicle (stage 1 (RS-68)) +2 GEMS+ 4m fairing (RL-10B-2)
Launch mass **:** 297 000 kg
Launch Site **:** Cape Canaveral launch center, USA

Payload Launching Capability
5300 kg in GTO

Delta-IVM+(5,4)

Configuration **:** Core Vehicle (stage 1 (RS-68)) + 4 GEMS+ 4m fairing (RL-10B-2)
Launch mass **:** 345 000 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
6555 kg in GTO

Delta-IVH

Configuration **:** Core Vehicle (stage 1 (RS-68)) +2 Core boosters (RS-68)+ 5m fairing (stretched RL-10B-2)
Launch mass **:** 732 000 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
12400 kg in GTO

Geostationary Launch Vehicle (GSLV)

GSLV series (Fig.187) of launch vehicles developed and operated by Indian Space Research Organization (ISRO) are capable of launching satellites of 2500 kg class to GTO orbit. It is a three stage launch vehicle, with the first stage being a solid rocket augmented by four liquid fueled strap-on boosters. The second stage is a liquid fueled stage and the third stage is the cryogenic stage.

GSLV Mk.-1

Launch mass **:** 402 000 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
5000 kg in LEO, 2900 kg in LPEO and 1500 kg in GTO

GSLV Mk.-1(2)

Launch mass **:** 402 000 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
5000 kg in LEO, 2900 kg in LPEO and 1900 kg in GTO

GSLV Mk.-2

Launch mass **:** 402 000 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
2500 kg in GTO

H-2A Launch Vehicle

H-2A is a family of liquid-fuelled expendable launch vehicle system with the capability of launching satellites into geostationary orbit. It is manufactured by Mitsubishi and ATK Thiokol for the Japan Aerospace Exploration Agency (JAXA). First successful test flight was done in August 2001. Different models of H-2A have been developed: H-2A-202 (Fig.188), H-2A-2022 (Fig.189), H-2A-2024 (Fig.190) and H-2A-204 (Fig.191).

H-2A-202

Configuration **:** Core vehicle (stage 1 (liquid engine LE-7A) + stage 2 (liquid engine LE-5B)) plus 2 SRBs (Solid rocket boosters)
Launch mass **:** 285 000 kg
Launch Site **:** Tanegashima launch center in Japan
Payload Launching Capability
4150 kg in GTO

H-2A-2024

Configuration **:** Core vehicle (stage 1 (liquid engine LE-7A) + stage 2 (liquid engine LE-5B)) plus 2 SRBs (Solid rocket boosters) plus 4 SSB (Strap-on boosters)
Launch mass **:** 350 000 kg
Launch Site **:** Tanegashima launch center in Japan
Payload Launching Capability
4500 kg in GTO

H-2A-2022

Configuration **:** Core vehicle (stage 1 (liquid engine LE-7A) + stage 2 (liquid engine LE-5B)) plus 4 SRBs (Solid rocket boosters)
Launch mass **:** 316 000 kg
Launch Site **:** Tanegashima launch center in Japan
Payload Launching Capability
4250 kg in GTO

H-2A-204

Configuration **:** Core vehicle (stage 1 (liquid engine LE-7A) + stage 2 (liquid engine LE-5B)) plus 2 SRBs (Solid rocket boosters) plus 2 SSB (Strap-on boosters)
Launch mass **:** 445 000 kg
Launch Site **:** Tanegashima launch center in Japan
Payload Launching Capability
6000 kg in GTO

Fig.187
GSLV (Courtesy: ISRO)

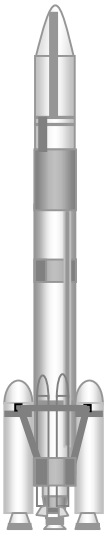


Fig.188
H-2A-202

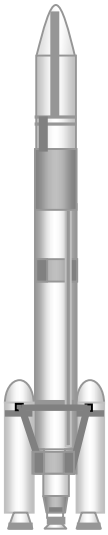


Fig.189
H-2A-2022

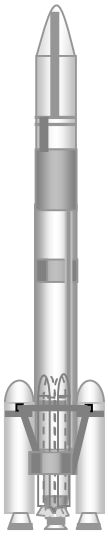


Fig.190
H-2A-2024

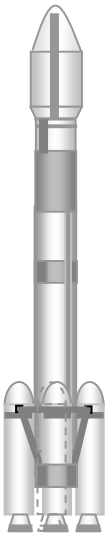


Fig.191
H-2A-204

Long March Launch Vehicles

Long March launch vehicles, operated by China great wall industry corporation, were developed to launch China's satellites into various orbits. Long March launch vehicles are also known as ChangZheng or CZ series. Four series of Long March satellites have been launched. These include Long March -1, -2, -3 and -4. Long March-5 series is in the development phase.

LM-2 series

Different variants of Long March-2 are Long March-2, -2C, -2E, -2D and -2F. Long March-2 is the base model of the Long March-2 family. The first Long March-2 rocket was launched in 1974 and its production ended in 1979. LM-2 launch vehicles were developed by China academy of launch vehicle technology (CALT). The first launch of LM-2C and -2E took place in 1982 and 1990 respectively. LM-2E is designed to send satellites to GEO orbits. LM-2D was first launched in 1992. LM-2F was derived from LM-2E and is a dedicated space launch vehicle for Shen Zhon space ship in the Chinese manned space programme.

Long March LM- 2C

LM-2C is China's first operational space launch vehicle that formed the basis of LM-2, LM-3 and LM-4 family of launch vehicles. LM-2C/SD, a variant of LM-2C was developed to meet the dual launch requirement for the Motorola Iridium mobile satellite telecommunication network. It had a newly designed upper stage, the "Smart Dispenser" (SD) for dual satellites launch. Another variant of the vehicle was revealed in May 2001. It has a CTS upper stage. This was a further development of the SD and was a three-axis stabilized upper stage consisting of a spacecraft adapter and an orbital maneuver system. It was capable of putting 1400 kg of payload into a 900 km Sun-synchronous orbit.

LM-2C

Configuration : 2 stage liquid engine (1st stage YF-6 rocket motor) + 2nd stage (YF-24 rocket motor)
Launch mass : 213 000 kg
Launch Site : Mostly from Jiquan Satellite Launch Center
Payload Launching Capability
3360 kg in LEO (500 km)

LM-2C/SD

Configuration : 2 stage liquid engine ((1st stage YF-6 rocket motor) + 2nd stage (YF-24 rocket motor) plus 'Smart Dispenser' (HTPB solid rocket motor)
Launch mass : 213 000 kg
Launch Site : Taiyuan Satellite Launch Center
Payload Launching Capability
1465 kg in 630 km LEO

LM-2D

LM-2D developed by China academy of launch vehicle technology (CALT) is mainly used for launching different spacecraft for LEO missions.

Configuration : 2 stage core vehicle (1st stage YF-21B liquid motor) + (2nd stage one YF-22 and a YF-23 swiveling venire motor) + McDonnell Douglas PAM-D upper stage
Launch mass : 232 700 kg
Launch Site : Jiuquan Satellite Launch Centre (JSLC)
Payload Launching Capability
3700kg to LEO

Long March 2E (Fig.192)

Configuration : 2 stage core vehicle (1st stage YF 6 liquid engine) + (2nd stage one F-22 and a YF-23 swiveling venire motor) + four strap on stages (YF-5 motors). In May 2001 it was announced that another upper stage (ETS), an solid rocket motor, will be added
Launch mass : 460 000 kg
Launch Site : XiChang Satellite Launch Center
Payload Launching Capability
9500 kg in LEO 200 km, 3500 kg in GTO

Long March 2F

Configuration : 2 stage core vehicle (1st stage YF 6 liquid engine) + (2nd stage one F-22 and a YF-23 swiveling venire motor) + four strap on stages (YF-5 motors)

Launch mass : 460 000 kg
Launch Site : XiChang Satellite Launch Center
Payload Launching Capability
8400 kg in LEO 185 km, 3500 kg in GTO

LM-3

LM-3 is a three stage launch vehicle, the third stage being a cryogenic upper stage. It is used to launch satellites into geostationary transfer orbit. LM-3 variants include LM-3, -3A, -3B and -3C. LM-3 was introduced in 1984 to provide China with its initial GEO mission capability. The last two missions occurred in 1997 and 2000 respectively. LM-3 has been reportedly replaced by LM-3A.

LM-3A

LM-3A (Fig.193) is a three-stage launch vehicle, especially dedicated for launching different satellites for GTO missions. It became functional in February 1994. LM-3A has a greater geosynchronous transfer orbit capability, greater flexibility for attitude control and better adaptability to a variety of launch missions.

Configuration : 3 stage launch vehicle (1st stage (YF-21 liquid motor) + 2nd stage (liquid motor YF-22 + YF-23 swiveling venire motor) + 3rd stage (YF-75 liquid rocket motor)
Launch mass : 240 000 kg
Launch Site : Xichang Satellite Launch Center
Payload Launching Capability
6500 kg in LEO 200 km, 2600 kg in GTO

LM-3B

The LM-3B (Fig.194) is presently China's most powerful, most advanced, and most sophisticated space launch vehicle. The first flight of the LM-3B took place in 1996

Configuration : 3 stage vehicle (1st stage (YF-6 rocket motor) + 2nd stage (YF-24 rocket motor consisting) + 3rd stage (YF-75 liquid rocket motor) and 4 boosters strapped on the first stage (YF-5 thrust chambers motors)
Launch mass : 426 000 kg
Launch Site : Xichang Satellite Launch Center
Payload Launching Capability
5100 kg to GTO

LM-3C

LM-3C (Fig.195) is similar to the LM-3B, but with only two strap-on boosters. So far the LM-3C has not undergone any launch mission.

Configuration : 3 stage vehicle (1st stage (YF-6 rocket motor) + 2nd stage (YF-24 rocket motor consisting) + 3rd stage (YF-75 liquid rocket motor) and 2 boosters strapped on the first stage (YF-5 thrust chambers motors)
Launch mass : 345 000 kg

Launch Site **:** Xichang Satellite Launch Center
Payload Launching Capability
3800 kg to GTO

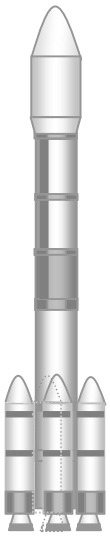


Fig.192
LM-2E

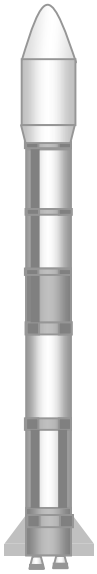


Fig.193
LM-3A

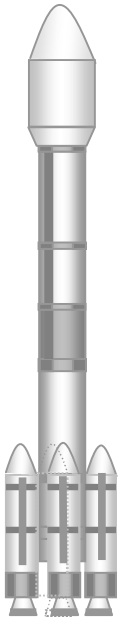


Fig.194
LM-3B

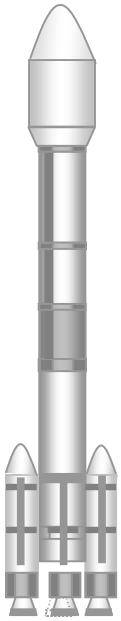


Fig.195
LM-3C

LM-4

LM-4 series of launch vehicles are designed and developed by Shanghai academy of space flight technology (SAST). It is the third currently operational series in LM family and is mainly used for sun-synchronous orbit missions. The LM-4 was originally designed as a backup launch vehicle for CALT's LM-3 to launch China's communications satellites. As the LM-3 successfully launched China's first communications satellite DFH-2, the mission of the LM-4 was shifted to launch Sun-synchronous orbit meteorological satellites. The variants of LM-4 family include LM-4A, LM-4B and LM-4C. LM-4A has been employed only twice till date (September 1988 and 1990) for inserting payloads into Sun-synchronous orbits. LM-4B is an improved variant derived from the LM-4A with almost identical design. Primary modifications include larger fairing size, digital electronic control system and improved rocket motors. The LM-4C, first flown in 2007, had an upgraded second-stage engine that could be restarted in space.

LM-4A

Configuration **:** 3 stage vehicle (1^{st} stage (YF-21B rocket motor) + 2^{nd} stage (YF-24F rocket motor) + 3^{rd} stage (YF-40 rocket))
Launch mass **:** 241 000 kg
Launch Site **:** Tai Yuan Satellite Launch Center
Payload Launching Capability
2790 kg to SSO, 1419 kg to GTO, 4595 kg to LEO

LM-4B

Configuration : 3 stage vehicle (1st stage (YF-21B rocket motor) + 2nd stage (YF-24F rocket motor) + 3rd stage (YF-40 rocket))
Launch mass : 249 000 kg
Launch Site : Tai Yuan Satellite Launch Center
Payload Launching Capability
2200 kg to LEO

LM-4C

Configuration : 3 stage vehicle (1st stage (YF-21B rocket motor) + 2nd stage (YF-24F rocket motor) + 3rd stage (YF-40 rocket))
Launch mass : 250 000 kg
Launch Site : Tai Yuan Satellite Launch Center
Payload Launching Capability
2800 kg to LEO

Minotaur Launch Vehicle

Minotaur also known as Orbital Suborbital Program (OSP) launch vehicle was developed by orbital sciences corporation of USA to provide low cost, reliable space launch capability for small-satellites. Minotaur is a 4 stage vehicle and is a combination of Minuteman-2 ICBM system and the Pegasus launch vehicle. Minotaur-IV, a new variant of Minotaur launch vehicle is currently under construction to launch the U.S. Air Force's space-based surveillance system (SBSS) satellite in 2010.

Configuration : 4 stages of solid motors
Launch mass : 36 200 kg
Launch Site : Vandenberg Air Force Base, California USA
Payload Launching Capability
340 kg in LEO 407km

Pegasus

Pegasus is a space launch vehicle developed by Orbital sciences corporation. It is a three stage vehicle with a fourth optional HAPS (hydrazine auxiliary propulsion system) stage. Pegasus is capable of placing small payloads into low altitude orbits. The first successful Pegasus launch occurred on 5 April 1990. Pegasus-XL introduced in 1994 has increased payload capability. The standard Pegasus has been discontinued.

Pegasus

Configuration : 3 stage vehicle ((1st stage (solid engine Orion 50S) + 2nd stage (solid engine Orion 50) + 3rd stage (solid engine Orion 38))
Launch mass : 18 500 kg
Launch Site : Edwards Air Force Base in USA
Payload Launching Capability

400 kg in LEO

Pegasus-HAPS

Configuration : 4 stage vehicle (1st stage (solid engine Orion 50S) + 2nd stage (solid engine Orion 50) + 3rd stage (solid engine Orion 38) + 4th stage (HAPS))
Launch mass : 18 500 kg
Launch Site : Edwards Air Force Base in USA
Payload Launching Capability
425 kg in LEO

Pegasus-H

Configuration : 3 stage vehicle (1st stage (solid engine Orion 50S) + 2nd stage (solid engine Orion 50) + 3rd stage (solid engine Orion 38))
Launch mass : 18 500 kg
Launch Site : Vandenberg Air Force Base in California, USA, Cape Canaveral launch center, USA, Kwajalein Atoll
Payload Launching Capability
400 kg in LEO

Pegasus-XL

Configuration : 3 stage vehicle (1st stage (solid engine Orion 50SXL) + 2nd stage (solid engine Orion 50XL) + 3rd stage (solid engine Orion 38))
Launch mass : 23 130 kg
Launch Site : Mostly Vandenberg Air Force Base in California, USA
Payload Launching Capability
475 kg in LEO 185 km

Pegasus-XL HAPS

Configuration : 4 stage vehicle (1st stage (solid engine Orion 50SXL) + 2nd stage (solid engine Orion 50XL) + 3rd stage (solid engine Orion 38) + 4th stage (HAPS))
Launch mass : 23 000 kg
Launch Site : Mostly Wallops Island
Payload Launching Capability
500 kg in LEO

Proton Launch Vehicle

Proton, the heavy lift work horse of the Russian launch vehicle fleet, was originally developed in 1965 as a two stage intercontinental ballistic missile capable of lifting the heaviest warheads in Russia's arsenal. The Russian scientists modified the original Proton-2 stage booster into a 3-stage configuration, known as Proton-K, for heavy, LEO missions to an altitude of 200 km and in a 4-stage configuration, Proton-K Block-D and Proton-K Block-DM, for high altitude semi-synchronous (GLONASS), geosynchronous, and deep-space missions, such as lunar and

planetary probes. Proton-K is a three stage vehicle with 1st stage having 6 strap-on liquid boosters, 2nd stage comprising of four liquid sustainer engines and 3rd stage comprising of one liquid engine. Proton-K Block-D and Block-DM launch vehicle comprise of an additional 4th stage of liquid motor. Block-D launch vehicles are without an independent navigation and guidance unit and are used for deep-space missions and the Block-DM comprises of such a unit and is used mostly for Earth orbital missions. The latest in the Proton series of launch vehicles is the Proton-M, having a fourth stage different from Block-DM launch vehicles.

Proton-K

Proton-K launch vehicles have been used to launch satellites during the period 1968-2000.

Configuration : 3 stages of liquid motors with first stage having 6 motors, second stage having 4 motors and third stage having 1motor
Launch mass : 670 800 kg
Launch Site : Baikonour cosmodrome in Kazakhstan
Payload Launching Capability
19 760 kg in 186 km, 51.6° LEO

Proton-K Block-D series

It comprises of Block-D, -D-1, -D-2, -DM, -DM-2, -DM1, -DM-2M, -DM3, -DM4, -DM-5 and -DM2. They all have identical three stage core vehicle but different upper 4th stage. Proton-K Block-D (8K82K 11S824) launch vehicle was used for launching missions to Venus, Mars and satellites around Earth in the 1960s and 1970s. Proton-K Block-D-1 (8K82K 11S824M) was used to launch satellites in the 1970s to late 1980s. Proton-K Block D-2 (8K82K 11S824F) has launched three satellites, two in the year 1988 and one in 1996. Proton-K Block-DM (8K82K 11S86) was used during the period 1974 to 1990. Proton-K Block-DM-2 (8K82K 11S861) has launched more than 100 satellites since 1982. Block-DM-1 (8K82K 11S861) and -DM4 ((8K82K 11S861-01) have launched one satellite each in the year 1996 and 1997 respectively. Block-DM-2M launch vehicle has launched nine satellites in a span of eight years, between 1994 to 2002. Block-DM3 (8K82K 11S861-01) has been operational since 1996. Block-DM-5 (8K82K 17S40) has launched two satellites till date in the years 1997 and 2002 respectively. Block-DM2 (8K82K 17S40) has been operational since 1997 and has launched four satellites till date.

Configuration : 3 stage core + different upper 4th stage
Launch mass : 689 200 kg
Launch Site : Baikonour cosmodrome in Kazakhstan

Proton-M series

Proton-M, sometimes identified Proton-KM, featured several modifications, which were designed to increase payload and reliability of the vehicle, compared to the previous version of the rocket, known as Proton-K. For the first time, a digital flight control system replaced traditional analog hardware onboard Proton. It allowed more efficient propellant consumption during the flight and, as a result, the delivery of bigger payloads into orbit. The rocket has become even more powerful due to the use of new version of the RD-253 engines on its first stage. Most Proton-M launches have used a Breez-M upper stage to propel the spacecraft into a higher orbit. Launches have also been made with Block-DM upper stages, namely the Block DM-2 when launching GLONASS

spacecraft. Lauch of two Yamal satellites, is scheduled using Proton-M with a Block DM-3 upper stage.

Proton Breeze series

It comprises of Proton K Breez M (8K82K 14S43) and Proton-M Breez-M (8K82KM 14S43) series of launch vehicles.

Proton-K Breez-M

Configuration **:** 4 stage vehicle (3 stage Proton core + 4th Breez M stage)
Launch mass **:** 712 800 kg
Launch Site **:** Baikonour cosmodrome in Kazakhstan
Payload Launching Capability
21 000 kg to LEO 185 km 51.6°

Proton-M Breeze-M

Configuration **:** 4 stage vehicle
Launch mass **:** 712 800 kg
Launch Site **:** Baikonour cosmodrome in Kazakhstan
Payload Launching Capability
4500 kg in GTO

Polar Satellite Launch Vehicle (PSLV)

The PSLV launch vehicles were developed by Indian Space and Research Organization (ISRO) to launch its own remote sensing satellites (IRS series) into sun-synchronous orbits. PSLV is a four stage core vehicle with additional strap-on solid boosters. The core vehicle possesses an unusual design consisting of two solid-propellant stages (1st and 3rd stages) and two liquid stages (2nd and 4th stages). The maiden flight of PSLV with IRS-I E satellite on 20 September 1993 was a failure. The first successful flight of PSLV was on 15 October 1994 which launched the IRS-P2 satellite into the prescribed Sun-synchronous orbit.

PSLV-1 (Fig.196)

Configuration **:** 4 stage core vehicle + 6 strap-on boosters
Launch mass **:** 294 200 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
3250kg to LEO

PSLV-2 (Fig.197)

Configuration **:** 4 stage core vehicle + 6 strap-on boosters
Launch mass **:** 294 200 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability

3250kg to LEO

PSLV-3

Configuration **:** 4 stage core vehicle + 6 strap-on boosters
Launch mass **:** 294 200 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
3250 kg to LEO

PSLV-CA

Configuration **:** 4 stage core vehicle
Launch mass **:** 230 000 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
2100 kg to LEO, 1100 kg to SSO

PSLV-XL

Configuration **:** 4 stage core vehicle + 6 strap-on boosters
Launch mass **:** 316 000 kg
Launch Site **:** Sriharikota launch center, India
Payload Launching Capability
1750 kg to SSO

Fig.196
PSLV-1 (Courtesy: ISRO)

Fig.197
PSLV-2 (Courtesy: ISRO)

Shtil Launch Vehicle

Shtil launch vehicle is a converted SLBM (submarine launched ballistic missile) used for launching artificial satellites in LEO orbit. It is a three stage liquid engine launch vehicle. Shtil family of launch vehicles comprise of Shtil-1 and Shtil-2. Shtil-1 has carried out two flights and Shtil-2 is still under development

Shtil-1

Configuration **:** 3 stages of liquid propellants
Launch mass **:** 40 000 kg
Launch Site **:** Delta IV class missile submarine
Payload Launching Capability
430 kg in LEO 200km

Start Launch Vehicle

The Start program, operated by ZAO Puskovie Uslugi of Russia and by the United Start Corporation of USA, consists of two launch vehicles, the Start-1 and the Start. Start-1, a four stage vehicle, is one of the smallest launch vehicles in the world having a capacity of lifting 632 kg satellite to a LEO altitude of 200 km. The Start launch vehicle is similar to the Start-1, though it is a five stage vehicle. They are the only launch vehicles in the world to use solid propellant for all stages.

Start-1

Configuration **:** 4 stages of solid motors
Launch mass **:** 46 000 kg
Launch Site **:** Svobodny launch center and Plesetsk launch center
Payload Launching Capability
632 kg in LEO 200km, 52°

Start

Configuration **:** 5 stages of solid motors
Launch mass **:** 59 000 kg
Launch Site **:** Svobodny launch center and Plesetsk launch center
Payload Launching Capability
645 kg in LEO 200km, 90°

Taurus Launch Vehicle

Taurus launch vehicle, developed by Orbital sciences corporation of USA, is a four stage vehicle derived from the Pegasus program. There are four variants of Taurus launch vehicle namely ARPA Taurus, standard Taurus, Taurus-XL and Taurus-XLS. ARPA Taurus is the smallest version and has carried out three launch flights. The standard Taurus is larger than ARPA Taurus and has undergone three flight missions. It has two versions namely Taurus-2110 and -2210. Taurus-XL has two versions Taurus-3110 and -3210 with capability of launching 1500 kg and

1276 kg payload respectively into 400km LEO orbit. Taurus-3210 has undergone one launch mission. Taurus-XLS, the largest vehicle among the Taurus variants with a capability to launch 2180 kg of payload in LEO, is a study phase vehicle. When added with a perigee kick motor, Taurus can launch satellites into geostationary transfer orbit (GTO).

ARPA Taurus (Taurus-1110)

Configuration : 4 solid motor stages (1st stage (TU-903) + 2nd stage (Orion50S) + 3rd stage (Orion 50) + 4th stage (Orion 38))
Launch mass : 68 930 kg
Launch Site : Vandenberg Air Force Base in California, USA
Payload Launching Capability
1220kg in LEO 400km, 28.6°

Standard Taurus (Taurus-2110)

Configuration : 4 solid motor stages (1st stage (Castor 120) + 2nd stage (Orion50S) + 3rd stage (Orion 50) + 4th stage (Orion 38))
Launch mass : 73 000 kg
Launch Site : Vandenberg Air Force Base in California, USA
Payload Launching Capability
1259kg in LEO 400km, 28.6°, 889 kg in 400km sun-synchronous

Standard Taurus (Taurus-2210)

Configuration : 4 solid motor stages (1st stage (Castor 120) + 2nd stage (Orion50S) + 3rd stage (Orion 50) + 4th stage (Orion 38))
Launch mass : 73 000 kg
Launch Site : Vandenberg Air Force Base in California, USA
Payload Launching Capability
1047kg in LEO 400km, 28.6°, 695 kg in 400km sun-synchronous

Taurus-XL (Taurus-3110)

Configuration : 4 solid motor stages (1st stage (Castor-120) + 2nd stage (Orion50S-XL) + 3rd stage (Orion-50XL) + 4th stage (Orion-38))
Launch mass : 77 960 kg
Launch Site : Vandenberg Air Force Base in California, USA
Payload Launching Capability
1450 kg in LEO 400km, 28.6°, 1054 kg in 400km sun-synchronous

Taurus-XL (Taurus-3210)

Configuration : 4 solid motor stages (1st stage (Castor-120) + 2nd stage (Orion50S-XL) + 3rd stage (Orion-50XL) + 4th stage (Orion-38))
Launch mass : 77 960 kg
Launch Site : Vandenberg Air Force Base in California, USA
Payload Launching Capability

1276kg in LEO 400km, 28.6°, 882 kg in 400km sun-synchronous

Titan Launch Vehicle

The Titan launch vehicle family was developed by the United States Air Force to meet its medium lift requirements in the 1960s. Titan launch vehicles have been used to launch unmanned military spacecraft, ranging from heavy photoreconnaissance platforms in low earth orbit to geosynchronous communications, missile launch detection and ELINT satellites. Titan launch vehicle comprises of Titan-I, -II, -III and -IV series of launch vehicles.

Titan-I series

Titan-I series of rockets were operational in the late 1950s till mid 1960s.

Titan-II series

Titan-II, built by Lockheed Martin Astronautics, is a two-stage liquid fueled booster, designed to provide a small-to-medium weight class capability. It is able to lift approximately 1900 kg into a polar LEO orbit. Various versions of Titan-II vehicle include Titan-II GLV, Titan-II (23)G, Titan-II (23)G Star-37S-ISS and Titan-II (23)G Star-37XFP-ISS. Titan-II GLV and Titan-II (23)G are two stage vehicles and Titan-II (23)G Star-37S-ISS and Titan-II (23)G Star-37XFP-ISS have an additional third stage. Titan-II GLV has carried out 12 satellite launch missions in the 1960s. Titan-II (23)G, Titan-II (23)G Star-37S-ISS and Titan-II (23)G Star-37XFP-ISS carried out their first mission in 1988, 1997 and 1993 respectively.

Titan-II (23)G

Configuration **:** 2 stage liquid engine (1st stage (2xLR87) + 2nd stage (LR91))
Launch Site **:** Vandenberg Air Force Base in California, USA

Titan-II (23)G Star-37XFP-ISS

Configuration **:** 3 stage liquid engine (1st stage (2xLR87) + 2nd stage (LR91) + 3rd stage (Star 37S/ISS))
Launch Site **:** Vandenberg Air Force Base in California, USA

Titan-II (23)G Star-37S-ISS

Configuration **:** 3 stage liquid engine (1st stage (2xLR87) + 2nd stage (LR91) + 3rd stage (Star 37XFP/ISS))
Launch Site **:** Vandenberg Air Force Base in California, USA

Titan-3 series

Titan-3 launch vehicles have the following variants namely Titan-3A, Titan-3B Agena-D, Titan-3(23)B Agena D, Titan-3(33)B Agena D, Titan-3(24)B Agena D, Titan-3(34)B Agena D, Titan-3C, Titan-3(23)C, Titan-3D, Titan-3E Centaur-D1T, Titan-3E Centaur-D1T Star-37E, Titan-34D, Titan-

34D IUS, Titan-34D Transtage and Commercial Titan-3. Titan-3 series of launch vehicles have been operational from 1964 to 1992 and have carried out more than 250 launch missions.

Titan-4 series

Titan-4 series is built by Lockheed Martin Astronautics to launch US government satellites. Titan-4 can be launched with no upper stage for LEO satellites, or with a Centaur or Inertial Upper Stage (IUS) to deliver satellites directly to GEO.

Titan-403A, -404A, -405A

Configuration : 2 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91)) plus 2 strap on boosters
Launch mass : 906 000 kg
Launch Site
Titan-403A, 404A : Vandenberg Air Force Base in California, USA
Titan-405A : Cape Canaveral launch center, USA
Payload Launching Capability
17 110 kg in LEO 1000 km

Titan-402A IUS

Configuration : 4 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91) + 3rd stage (IUS stage 1 Orbus 21) + 4th stage (IUS stage 2 Orbus 6E)) plus 2 strap on boosters
Launch Site : Cape Canaveral launch center, USA
Launch mass : 910 000kg
Payload Launching Capability
4944 kg in GTO

Titan-401 A Centaur-T

Configuration : 3 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91) + 3rd stage (Centaur T 2xRL-10-3)) plus 2 strap on boosters
Launch Site : Cape Canaveral launch center, USA
Launch mass : 868 000kg
Payload Launching Capability
4536 kg in GEO

Titan-403B, -404B, -405B

Configuration : 2 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91)) plus 2 strap on boosters
Launch mass : 906 000 kg
Launch Site : Vandenberg Air Force Base in California, USA and Cape Canaveral launch center, USA
Payload Launching Capability
21 900 kg in LEO 1000 km and 17 650 kg in SSO

Titan-402B IUS

Configuration **:** 4 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91) + 3rd stage (IUS stage 1 Orbus 21) + 4th stage (IUS stage 2 Orbus 6E)) plus 2 strap on boosters
Launch mass **:** 910 000 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
2760 kg in GEO

Titan-401B Centaur T

Configuration **:** 3 stage vehicle (1st stage (2xLR-87) + 2nd stage (LR-91) + 3rd stage (Centaur T 2xRL-10-3)) plus 2 strap on boosters
Launch mass **:** 868 000 kg
Launch Site **:** Cape Canaveral launch center, USA
Payload Launching Capability
5773 kg in GEO

Zenit Launch Vehicles

The Zenit launch vehicle operated by Yuzhnoye state design office of Ukraine was originally designed to place large spy satellites into LEO polar orbits. Currently, there are two Zenit configurations namely the two stage Zenit- and the three stage Zenit-3SL. Both are highly automated launch vehicles having large payload capability as well as the ability to launch in all types of weather, making them the ideal launch vehicle for the Sea launch international consortium.

Zenit-2

The first flight of Zenit-2 was way back in 1985 and it has carried out about 50 launch missions till date.

Configuration **:** 2 stage liquid motors
Launch mass **:** 459 000 kg
Launch Site **:** Baikonour cosmodrome in Kazakhstan
Payload Launching Capability
13740 kg in LEO and 11380 kg in SSO

Zenit-2 SLB (Zenit-2M)

One flight has been carried out by Zenit-2M launch vehicle in the year 2007.

Configuration **:** 2 stage liquid motors
Launch mass **:** 440 000 kg
Launch Site **:** Baikonour cosmodrome in Kazakhstan
Payload Launching Capability
12030 kg in LEO

Zenit-3SL

Configuration **:** 3 stage liquid motors
Launch mass **:** 469 000 kg
Launch Site **:** Sea Launch Platform
Payload Launching Capability
7000 kg to LEO, 5250 kg to GTO

Zenit-3SLB (Zenit-3M)

Configuration **:** 3 stage liquid motors
Launch mass **:** 460 000 kg
Launch Site **:** Sea Launch Platform
Payload Launching Capability
5000 kg to LEO, 3600 kg to GTO