PSLV-C1/IRS-1 D MISSION

OBJECTIVES

- *To launch the operational remote sensing satellite IRS - 1D weighing 1200 kg into 817 km polar sunsynchronous orbit.*
- *To demonstrate first operational mission of PSLV with enhanced payload capability achieved through uprating of propulsion systems and optimising the strapon firing sequence.*

SPECIFICATIONS

Orbit	-	**Polar Sunsynchronous Circular (SSPO)**
Altitude	-	**817±35 km.**
Inclination	-	**98.731±0.2 deg.**
Eccentricity	-	**0.001104**
Orbital period	-	**101.35 min.**
Nominal Launch time	-	**10.20 hrs.**
Launch azimuth	-	**140 deg.**

REALISATION

The mission is accomplished through the integrated and coordinated functioning of the following main elements

- **LAUNCH VEHICLE**
- **SPACECRAFT**
- **LAUNCH RANGE FACILITIES**
- **TELEMETRY, TELECOMMAND AND TRACKING SYSTEMS**

All the ISRO centres are actively engaged in the realisation of the mission

- **Vikram Sarabhai Space Centre, Thiruvananthapuram**

  Lead centre with the major responsibility of Launch Vehicle design, project management, mission planning , Integration & checkout.

- **Liquid Propulsion Systems Centre, Valiamala, Mahendragiri and Bangalore**

  Design, realisation and testing of liquid propulsion systems including control powerplants

- **ISRO Satellite Centre, Bangalore**

  Design, realisation, testing and integration of satellite systems

- **Shriharikota Range**

  Vehicle assembly and launch operation, manufacturing and testing of large solid propellant boosters

- **Space Applications Centre, Ahmedabad**

  Realisation of payloads for the satellite

- **ISRO Telemetry Tracking Centre, Bangalore, SHAR & Thiruvananthapuram**

  Provide telemetry and tracking support for the mission

- **ISRO Inertial Systems Unit, Thiruvananthapuram**

  Realisation of Inertial Navigation Systems for Launch Vehicle and Satellite

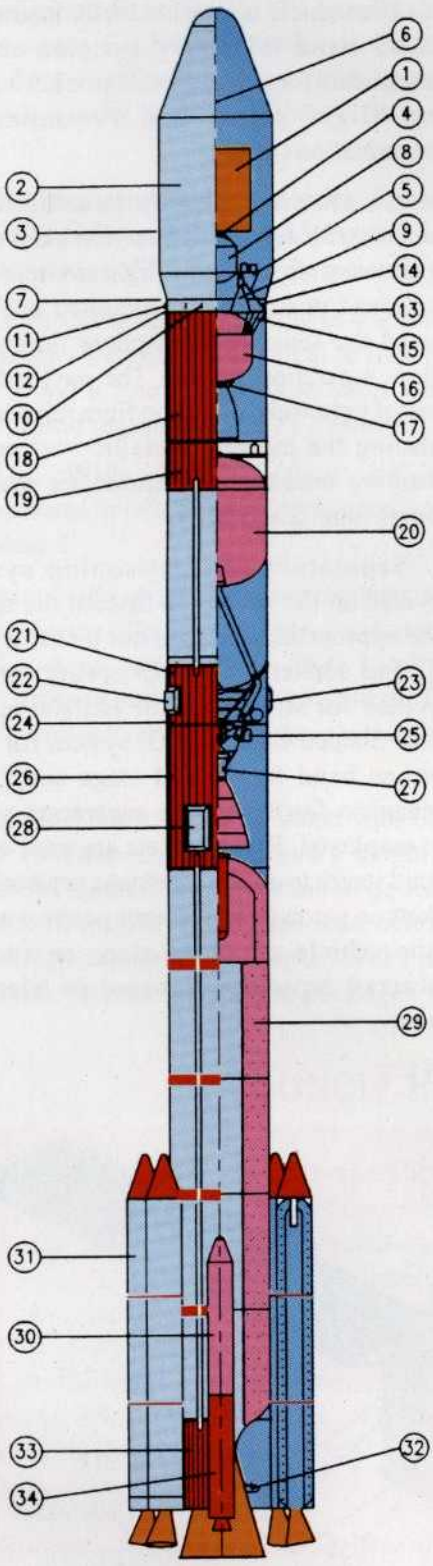
In addition to the ISRO Centres a large number of major and minor industries also contribute in the realisation of the vehicle and spacecraft systems

VEHICLE

Vehicle height	-	**44.4 m**
Lift off mass	-	**294 t**
Maximum vehicle diameter at heatshield	-	**3.2 m**
Vehicle envelope diameter at base	-	**5.1 m**

In this fourth flight, the Polar Satellite Launch Vehicle, PSLV - C1, is deployed on its first operational mission of lauching Indian remote sensing satellite IRS-1D into sunsynchronous polar orbit. The launching of this satellite demonstrates the country's total self reliance in this vital application area. The payload capability of the PSLV has been enhanced to 1200kg in this mission to meet the requirement of the operational IRS-1D satellite. This has been achieved mainly through increase in the first and second stage propellant loading, altering the sequence of ignition of the strapons and reduction in inert mass of the fourth stage.

The PSLV with an overall height of 44.4 metres and lift off mass of 294 tonnes is configured as a four stage vehicle with alternate solid and liquid propulsion modules. The first stage motor of PSLV-C1 carries 138t, of solid propellant and measures 2.8m in diameter. The motor case is made of indigenously produced high strength steel. The first stage thrust is augmented by six 1.0m diameter solid propellant strapon motors. Four of these strapon motors, are ignited on the ground and the remaining two in flight considering the requirement of maximising payload. The solid booster uses indigenously produced propellant, a combination of Hydroxyl Terminated polybutadiene (HTPB) fuel and Ammonium Perchlorate Oxidiser. The second stage, uses the indigenously developed Vikas engine, and carries over 40t of liquid propellant - Unsymmetrical Dimethyl Hydrazine as the fuel and N2O4 as the oxidiser. The third stage uses kevlar epoxy motor case and carries 7t of solid propellant (HTPB). It has a contoured and submerged nozzle. The fourth stage uses 2t of liquid propellant - MON



1. PAYLOAD
2. HEATSHIELD
3. PAYLOAD SEPARATION PLANE
4. PAYLOAD ADAPTOR
5. EQUIPMENT BAY
6. HEATSHIELD SEPARATION PLANE VERTICAL
7. HEATSHIELD SEPARATION PLANE HORIZONTAL
8. FOURTH STAGE PROPELLANT TANK
9. FOURTH STAGE ENGINE (2)
10. ANTENNAE
11. REACTION CONTROL THRUSTER (6)
12. THIRD STAGE SEPARATION PLANE
13. SECOND STAGE SEPARATION PLANE
14. INTER STAGE 3/4
15. THIRD STAGE ADAPTOR
16. THIRD STAGE MOTOR
17. FLEX NOZZLE CONTROL SYSTEM
18. INTER STAGE 2/3U
19. INTER STAGE 2/3L
20. SECOND STAGE PROPELLANT TANK
21. INTER STAGE 1/2U
22. RETRO ROCKET (4)
23. ULLAGE ROCKET (4)
24. FIRST STAGE SEPARATION PLANE
25. GIMBAL CONTROL SYSTEM
26. INTER STAGE 1/2L
27. SECOND STAGE ENGINE
28. RETRO ROCKET (8)
29. FIRST STAGE MOTOR
30. SITVC INJECTANT TANK (2)
31. STRAP-ON MOTOR (6)
32. SITVC SYSTEM
33. BASESHROUD
34. ROLL CONTROL ENGINE (2)

POLAR SATELLITE LAUNCH VEHICLE

and MMH and has two high performace engines of 7kN thrust.

PSLV is guided and controlled in all the three axes from lift - off to spacecraft injection by the Navigation, Guidance and Control system (NGC) housed in the equipment bay. The closed loop guidance scheme resident in the on-board computer ensures the required accuracy in the injection conditions. The three axes attitude stabilisation of the vehicle is achieved by the autonomous control systems provided in each stage.

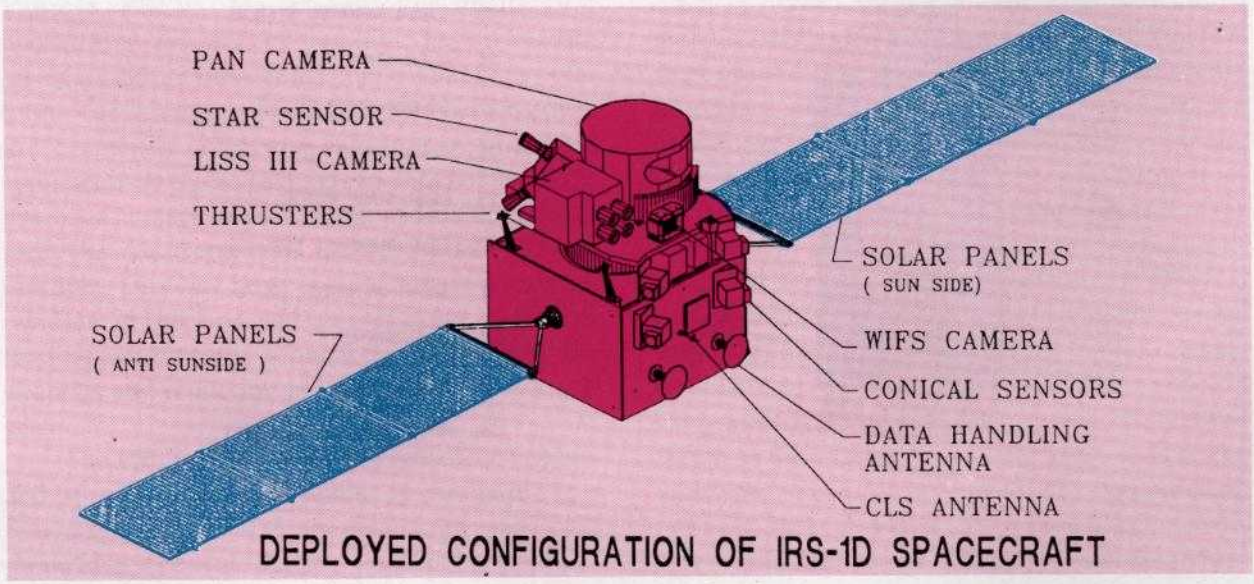
The first stage is provided with Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw control . Two Swivellable Roll Control Thrusters (RCT) are used for roll control. After the first stage burnout, and before the second stage control takes over, RCT engines are used for yaw and roll control and a set of four Reaction Control Thrusters (RCT) are used for pitch control. Second stage has Engine Gimbal Control (EGC) for pitch and yaw and Hot Gas Reaction Control system (HRCS) for roll control. The third stage has Flex Nozzle Control (FNC) for the pitch and yaw control during thrust phase. The fourth stage is controlled during thrust phase by gimballing its two engines for pitch, yaw and roll. A Reaction Control System (RCS) with six thrusters is provided on fourth stage for coast phase control of both third and fourth stages.

The vehicle is provided with instrumentation, PCM-S band telemetry systems and C-band transponders for performance monitoring, tracking, range/flight safety and Preliminary Orbit Determination (POD).

An aluminium alloy heatshield of 3.2m diameter with acoustic protection blankets protects the spacecraft from hostile flight environment during the ascend phase and is separated and jettisoned beyond the sensible atmosphere through a linear bellow separation system. The payload adaptor is made of light weight Carbon fibre reinforced plastic replacing the existing metallic version . All the remaining interstage structures are made of high strength aluminium alloy.

Separation and jettisoning systems are provided on the vehicle to discard the spent stages at the appropriate time without boundary collision. Ball and socket joint with spring thrusters are provided for strapon motor jettisoning. Flexible Linear Shaped Cord (FLSC) system for first stage, Merman band for second stage and 'Ball lock' mechanism for third stage separation systems are also employed. Retro rockets are used on first and second stages to ensure safe stage separation. Ullåge rockets on second stage ensures positive acceleration of the vehicle at second stage engine ignition. Spacecraft separation is based on Merman band system.

SPACECRAFT



DEPLOYED CONFIGURATION OF IRS-1D SPACECRAFT

The indigenously built IRS-1D spacecraft is the in orbit spare for IRS-1C which is already in service. The satellite weighing 1200 kg will have payloads similar to that of IRS-1C as listed below.

i) A high resolution Panchromatic Camera (PAN) with a resolution of 5.6 meters and additional off nadir viewing capability.

ii) LISS - 3 Cameras operating in 4 spectral bands - 3 bands are identical to IRS-1A/ 1B and a fourth band is in short wave infrared region of 1550 - 1750 nm.

iii) The Wide Field Sensor (WiFS) operates in two bands namely band 3 and band 4.

The spacecraft consists of a mainframe and a payload platform. The mainframe consists of mechanical system, power, TTC, Data handling system and Attitude and orbit control system. The payload platform accommodates the paylods and some sensors.

The satellite has a cuboidal shape with base dimensions 1650mm x 1550mm and a height of 2300mm in the stowed configuration. The main platform is built around a stiffened load bearing cylinder with honeycomb horizontal decks and vertical panels. While subsystem packages are mounted on the inside of the honeycomb panels the payloads are fixed on a special top deck thermally isolated from the main body through a CFRP cylinder. The interface with the vehicle is through a merman band joint of 937mm diameter. The interface ring is rivetted to the load bearing stiffened cylinder.

Two deployable suntracking solar arrays on each side with 3 panels each of 1.1m x 1.46m generating 813 w of power cater to the power requirements while two 21 AH batteries take care of the eclipse periods. Telemetry, Tracking and Command system is configured around S-band coherent transponder. Telemetry system monitors all the housekeeping data and the data can be transmitted both in real time and playback mode simultaneously in conjunction with an onboard tape recorder.

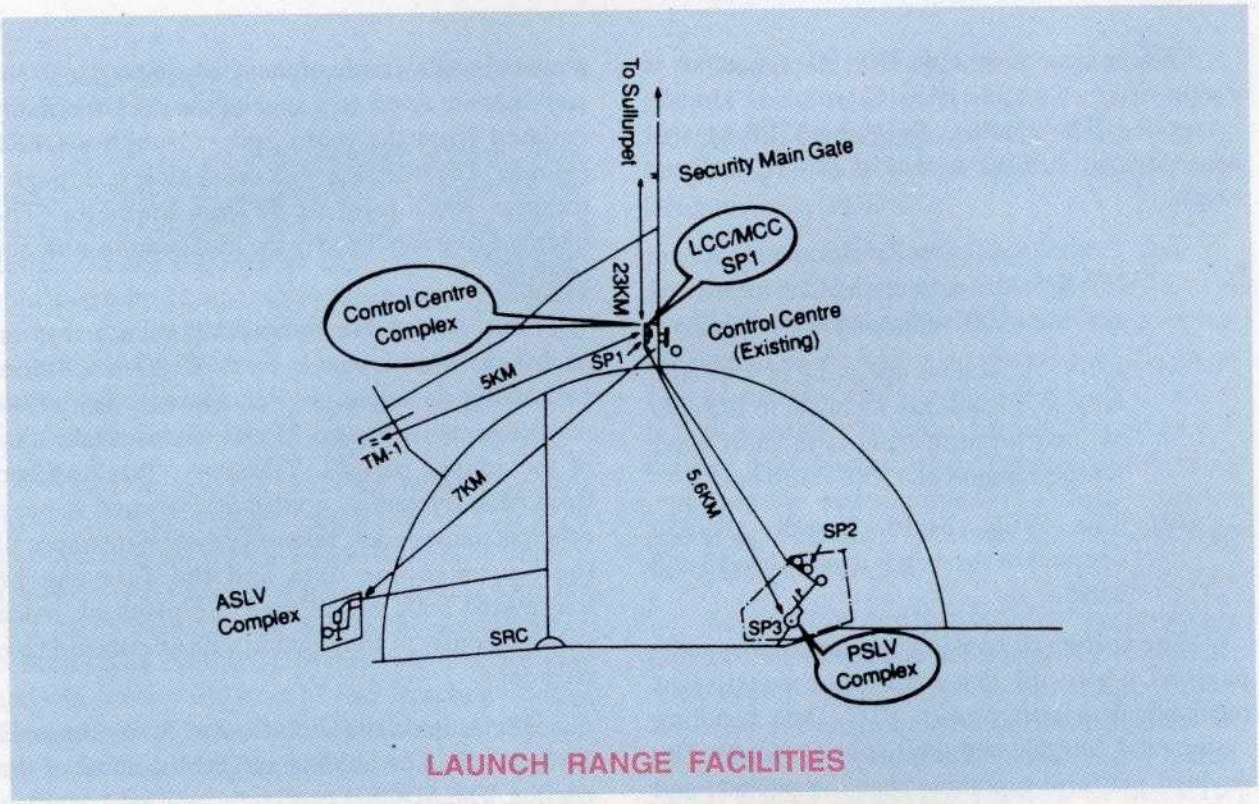
The Attitude and Orbit Control System ensures the 3 axis attitude holding and orbit control of the satellite. The AOCS is configured around 4 reaction wheels and magnetic torquers for momentum dumping backed up by monopropellant hydrazine thrusters. The satellite is also capable of orbital velocity correction upto 40m/s by using the 11 Newton thruster.

LAUNCH RANGE FACILITIES

The final vehicle and spacecraft preparations, integration, checkout and the lunching of the vehicle are carried out at Launch Range facilities at Sriharikota Range (SHAR). The SHAR complex located at 80 km north east of Chennai (lat.13.73, long.80.24) is ideally located at the east coast of India. It has all the required facilities for the launch of space vehicles both in low earth as well as polar orbits. The main elements of the PSLV launch complex are the following.

* Mobile Service Tower (MST), Umbilical Tower (UT) & Launch pedestal
* Solid Motor Preparation Facility
* Subsystem preparation facility for all interstages, PS2, heatshield and spacecraft
* Liquid propellant storage and transfer facility
* Hardware storage facility for interstages
* Launch Control Centre (LCC) & Mission Control Centre (MCC)
* Range Instrumentation and support facility

The vehicle is vertically integrated over the launch pedestal which is located above the jet



LAUNCH RANGE FACILITIES

deflector and the two exhaust ducts enable smooth flow of the exhaust gases. The umbilical tower provides interface structure through which all the required fluid servicing lines and electrical checkout lines are attached to the vehicle and disconnected at lift-off. At the time of vehicle integration, the 75m tall Mobile Service Tower is positioned around the launch pedestal and the Umbilical Tower and provides the access and protective enclosure for the vehicle integration. It also provides handling systems and clean environment for the vehicle and satellite assembly. The tower can be moved on a rail system to a safe distance of 100m from the vehicle before launch.

Located 5km away from the launch pad, the LCC has facilities for the remote checkout and launch of the vehicle. The LCC houses all the vehicle control consoles, filling consoles as well as checkout and automatic launch systems. It is connected to the launch pad through fibre optic data links and the data is fed in real time to computers as well as specialists' consoles in the appropriate form.

The Mission Control Centre located adjacent to LCC has consoles for the mission executives who authorise the launch based on readiness of all the systems. The vehicle performance is displayed in large display boards graphically in real time. The range safety console is manned by the Range Safety Officer who is authorised to terminate the vehicle in case of a vehicle malfunction which can pose danger to men and materials on ground.

The major Range Instrumentation and support Facilities are -

- Tracking systems like Precision 'C' band and 'S' band radars
- Telecommand System
- Support System like Intercommunication, CCTV System, Data Links, Range Timing System, Real Time Systems and Specialist display System; and
- Metereology and Technical photography

TELEMETRY, TELECOMMAND AND TRACKING SYSTEMS

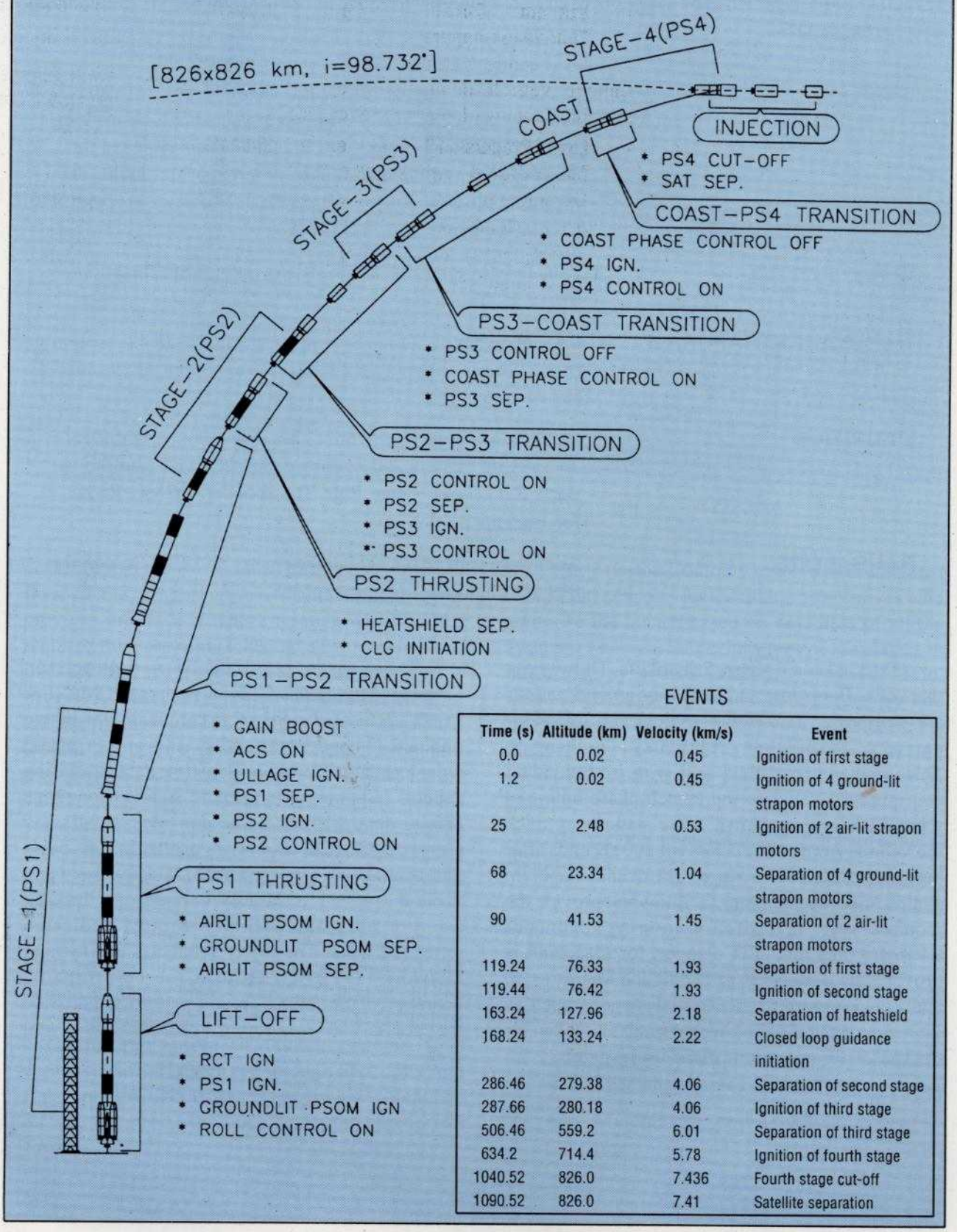
Ground systems and Ground stations play a very important role in confirmation of the mission, ensuring Range and flight safety and enabling post flight data analysis. Telemetry Tracking and Telecommand (TTC) support to PSLV is provided by a network of ground stations which track the vehicle and acquire the telemetry data during launch.

SHAR - I	Acquisition of Telemetry carriers TMI and TM2 of vehicle, data recording, prepocessing and transmission to mission computer for Range Safety and Specialist Display in real time. Ranging with satellite transponder. Acquisition of satellite data recording preprocessing and transmission to Satellite Control Centre, Bangalore.
SHAR - II	Launch base total redundant station doing same function as SHAR 1
THIRUVANANTHAPURAM	Immediate Range Station Serving as space diversity reception to ensure continuous data even during flame attenuation periods.
MAURITIUS	Down Range Station with three carrier reception capability of all Satellite carriers and ranging capability with satellite 'S' Band Range and Range Rate Transponder. PCMC Radar for tracking the vehicle.
BANGALORE	Additional backup for Vehicle Telemetry and TTC Station for IRS-1D support during initial phase.

During launch phase, Sriharikota, Thiruvananthapuram, Bangalore and Mauritius ground stations are configured to receive vehicle and telemetry carriers. SHAR has Telemetry Tracking & Telecommand facilities and with its redundant configuration, cater to the launch phase upto 680 seconds. Mauritius Down range station can track the vehicle from 656 seconds till 200 seconds after burnout of the fourth stage. Thiruvananthapuram station has only telemetry facilities and provide the required space diversity for ensuring continuous telemetry data link. TTC support for spacecraft is provided by Bangalore, Lucknow and Mauritius. In addition, support from external stations such as Bearslake, Pokerflat and Welheim are also taken for the spacecraft operations in the initial phase.

Tracking is provided by two Precision Coherent Monopulse C-Band Radars (PCMC-1 & PCMC-2) located at SHAR in conjunction with two onboard C-band transponders and one PCMC-3 radar located at Mauritius. Real time data processing support is provided by ground stations for range safety, data display at the consoles at Mission Control Centre and for preliminary orbit determination. The data transmission between ground stations is largely carried out through satellite links and partially through dedicated terrestrial links. The ISRO Telemetry & Tracking Network (ISTRAC) ensures the co-ordinated operation of the various ground stations and provide the necessary services during the mission in this vital area.

PSLV–C1 FLIGHT PROFILE



EVENTS

Time (s)	Altitude (km)	Velocity (km/s)	Event
0.0	0.02	0.45	Ignition of first stage
1.2	0.02	0.45	Ignition of 4 ground-lit strapon motors
25	2.48	0.53	Ignition of 2 air-lit strapon motors
68	23.34	1.04	Separation of 4 ground-lit strapon motors
90	41.53	1.45	Separation of 2 air-lit strapon motors
119.24	76.33	1.93	Separtion of first stage
119.44	76.42	1.93	Ignition of second stage
163.24	127.96	2.18	Separation of heatshield
168.24	133.24	2.22	Closed loop guidance initiation
286.46	279.38	4.06	Separation of second stage
287.66	280.18	4.06	Ignition of third stage
506.46	559.2	6.01	Separation of third stage
634.2	714.4	5.78	Ignition of fourth stage
1040.52	826.0	7.436	Fourth stage cut-off
1090.52	826.0	7.41	Satellite separation

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