

# A Satellite for the Galileo Mission

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**Abstract.** The Galileo System is based on a 30 spacecrafts constellation in MEO orbits, controlled and commanded in S-band link by a Ground Control Centre. The navigation service is achieved via transmission to the user of L-band signals comprising ranging codes and timing information.

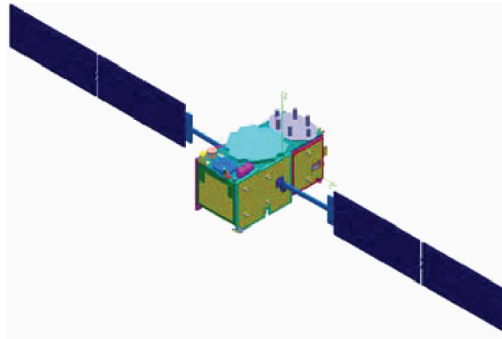
The timing signals are provided by precision on-board atomic clocks, implemented as two redundant pairs per satellite. Two different technologies are implemented - passive hydrogen maser and rubidium.

In addition to the navigation services, a Search & Rescue service is provided, which is implemented by a dedicated payload.

The specified lifetime for the Galileo satellites is 12 years while the overall specified lifetime of the Galileo System is 20 years. This means that a full replenishment of the satellite constellation will be required. In the frame of the IOV phase, 4 satellites will be produced and deployed in two different orbit planes in two dual launches using the Soyuz.

## 1 General Information

The Galileo constellation comprises of 30 satellites placed in MEO orbit, with 10 satellites placed in each of 3 orbital planes distributed evenly round the equator. The active constellation comprises of 27 satellites, with each plane containing a spare satellite which can be moved to replace any failed satellite within the same plane, thereby reducing the impact of failures upon quality of service. All satellites are identical in terms of design, performance capability and fuel load. The satellite flight configuration is shown in Fig. 1. The earth-pointing face is defined along the +Z axis. In launch configuration the solar arrays are stowed on the +/- Y sides of the satellite. The volume and outer shape of the satellite is compatible with the shroud dimensions of the selected launchers. Clearly visible on the earth-facing side of the satellite are the search and rescue and navigation payload antennas.



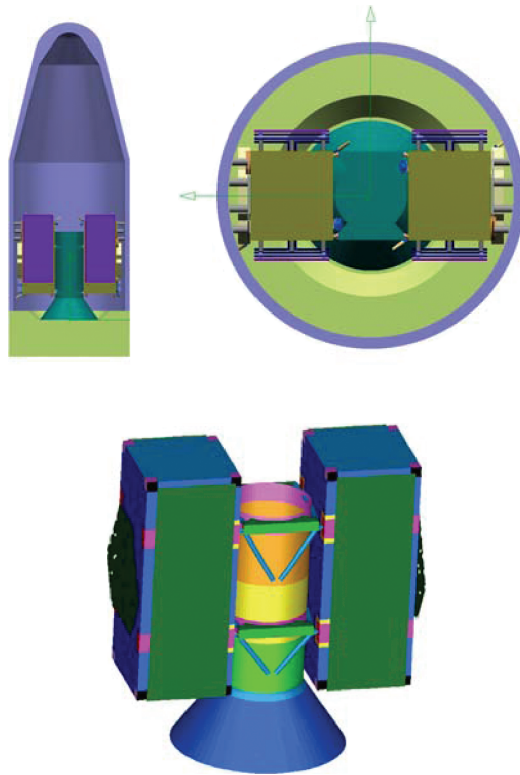
**Fig. 1.** Galileo satellite flight configuration.

The satellite is composed of the following subsystems:

- Payload Subsystem including the navigation payload and the SAR payload
- Structure Subsystem
- Thermal Control Subsystem (TCS)
- Electrical Power Subsystem (EPS) with the following units:
  - Solar Arrays (SA)
  - Solar Array Drive Mechanisms (SADM)
  - Battery
  - Power Conditioning and Distribution Unit (PCDU)
- Harness
- Avionics Subsystem with
  - on-board computer (Integrated Control and Data Handling Unit, ICDU)
  - Attitude and Orbit Control System, AOCS (based on earth sensors, sun sensors, gyros, reaction wheels and magnetic torquers),
  - Software (SW)
- Telemetry, Tracking and Command (TTC) Subsystem (with S-Band Transponder and two low-gain, omni-directional antennas)
- Propulsion Subsystem (mono-propellant system with one tank and 8 thrusters)
- Laser Retro-Reflector (LRR)
- Platform Security Unit (PFSU)

### **Launchers for IOV**

For IOV Launchers the launchers already selected is Soyuz, with dual launch. The configuration under fairing is shown in Fig. 2.



**Fig. 2.** Soyuz configuration for IOV.

## **2 Payload Architecture**

The Galileo satellites include two payloads, the Navigation payload and the Search and Rescue payload.

The overall payload block diagram is presented in Fig. 3, here under.

### **Navigation Payload**

The main functions of the navigation payload are:

- Provision of on-board timing signals
- Receipt & storage of up-linked navigation message data
- Receipt & storage of up-linked integrity data
- Assembly of navigation message in the agreed format
- Error correction coding of navigation message
- Generation of ranging codes



- Encryption of ranging codes as required
- Generation and modulation of L-Band carrier signals
- Broadcast of navigation signals

The timing signals are provided by high precision on-board clocks, implemented as two (cold) redundant pairs per satellite, each pair including two different technologies, the Passive Hydrogen Maser (PHM) which is the primary reference clock and the Rubidium Atomic Frequency Standard (RAFS), both of them being operated simultaneously. Due to the highly stable frequency stability requirements the clocks are mounted on a separate radiator panel, which is kept facing deep space using a yaw steering law controlled by the Avionics.

The whole clock ensemble is under the control of a dedicated (internally cold redundant) Clock Monitoring and Control Unit (CMCU) which performs the monitoring and switching functions (selection under Ground control) and generates a highly stable on-board reference frequency of 10.23 MHz which is distributed to the other payload units.

The navigation data (including integrity data, Search and Rescue data and other mission data) are contained in the C-band spread spectrum uplink signal which is received via the Cband mission receive antenna operating in RHCP polarisation (baseline solution is a small aperture axially corrugated circular waveguide horn). The Mission Receiver (MISREC) which includes the Mission Processor function (MISPROC), performs the receive function, the despread and demodulation functions in order to provide a data stream which is routed to the Payload Security Unit (PLSU) which performs COMSEC treatment of the incoming signal, and passed to the Navigation Signal Generator Unit (NGSU). The MISREC is an internally cold redundant unit.

The Navigation Signal and Generator Unit (NSGU) which includes internal cold redundancy, receives the up-linked navigation data and uses them to generate the navigation signals in the appropriate format, performs the PRN encoding and the modulation of the 3 navigation signals (E5a + E5b, E6 and L1) and passes them to the Frequency Generation and Upconversion Unit (FGUU) which performs the up- conversion into L-band of the 3 signals.

The FGUU includes internal cold redundancy.

The 3 L-band navigations signals are then routed to a 2:1 (E5a + E5b and E6 with respectively about 65 W and 70 W SSPA RF output power) or 3:2 (L1 with parallel amplification at about 50 W SSPA RF output power) SSPA redundancy ring. The two amplified L1 signals are routed to the navigation antenna and combined in free space while the two other signals are multiplexed (within the NAVOMUX) before being routed to the navigation antenna.

The Navigation transmit Antenna (NAVANT) which is operated in RHCP polarisation consists of a high and a low band beam-forming network and a dual band array of radiating elements which provides a global coverage iso-flux radiation pattern.

Test couplers are included in order to allow the testing of the different navigation payload sections during the payload and satellite AIT cycle.

The payload Remote Terminal Unit performs the communication functions between the payload and the avionics subsystem via the 1553B data bus as well as the acquisition of all payload units telemetry and the distribution of all commands to the

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