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Designs on space

The lifecycle of a satellite

The Skynet 5 satellite blasts off into space on board an Ariane 5 rocket in November 2007.

There are thousands of man-made satellites orbiting the Earth. Some are only a few hundred kilometres above us and complete one orbit roughly every 90 minutes. Geostationary satellites are located around 40 000 kilometres from the surface of the Earth, completing an orbit of the Earth every 24 hours. Other spacecraft are exploring the solar system. With so many spacecraft out there, have you ever wondered how a satellite is made? Victoria Hodges, a satellite engineer, explains.

Key words

satellite

orbit

design

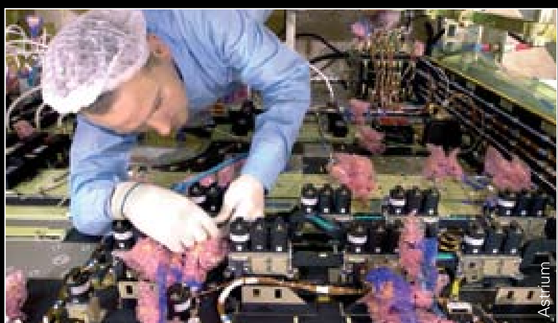
construction

From concept to design

Typically there are four main stages in the lifecycle of a satellite. At the end of each stage and before the next can commence the project will go through a series of technical reviews in order to ensure that the stage has been properly completed and that the project team are ready to move on.

The first stage is the Concept Exploration. During this phase the initial mission concept feasibility will be studied and a preliminary design will be produced. The preliminary design must take into account the requirements provided by the customer.

The second stage is the Detailed Design Phase. At this point, the customer may provide more detailed requirements as the design of the mission and the satellite becomes more advanced. By the end of this phase a "baseline" solution for the mission will have been produced. This provides the starting point for the next stage. However, before the next stage can start, the design must pass through another series of reviews.



An engineer assembles part of the payload on a satellite

Box 1: Satellite Systems

Power – for Earth-orbiting satellites the power is generated by large solar panels and then distributed around the satellite via the power distribution system. Power is also stored on board the satellite in rechargeable batteries, enabling the satellite to draw extra power when required and providing power when the satellite enters eclipse (when the satellite travels behind the Earth so that the Earth blocks the satellite's view of the Sun).

Thermal – the thermal control system controls the temperature of the satellite systems, so that they can continue to operate normally. The electronics used on board a satellite generally work around room temperature, but the temperature in space is much less than this. Looking out into deep space and in eclipse the temperature can be as low as -270°C; however, in view of the Sun the temperature can be up to 180°C. Insulation is provided by thermal blankets (made up of many layers of a polymer called Mylar interspersed with layers of netting) wrapped around parts inside the satellite and around the outside. Other methods of controlling the temperature of a satellite include paints and surface coatings, heat pipes (a bit like central heating) and radiators used to release excess heat out into space.

Attitude and Orbit Control – this system is responsible for controlling the attitude (orientation) of the satellite and maintaining its orbit. This is vitally important. For example, in order to communicate with the ground stations on Earth, the satellite antennas must be pointing at the Earth and in order to generate power, the solar arrays must be pointing toward the Sun. Star trackers provide information on where the satellite is pointing and actuators such as small thrusters and wheels then provide a torque in order to rotate the satellite when necessary.

Communications – the communications system allows two way communications between the satellite and the ground station on Earth. The satellite receives messages from the ground called telecommands and sends back information and data called telemetry. Communications are sent using Radio Frequency electromagnetic waves via the communications antennas mounted on the outside of the spacecraft.

On-Board Computer – the on-board computer is the brain of the satellite. It processes all of the information received from both the ground stations and the satellite itself. The computer sorts the information into different categories and then in the case of commands received from the ground, it communicates the commands to the appropriate systems. The computer also collects telemetry from the different systems and groups it into packets to be sent via the communications system to the ground station.

Manufacture

In the third stage, Manufacture and Test, the overall satellite design is finalised and the manufacture begins. The different parts of a satellite are often supplied by a number of suppliers. The role of the satellite manufacturer is to bring all of the pieces of the jigsaw together in the correct way in order to build the satellite. We call this work the Satellite Assembly and Integration.

Satellites must be assembled in clean environments called “clean rooms”. Engineers working in the clean rooms wear overcoats, hats and gloves in order to prevent any dust or particles from getting inside the satellite as this can cause damage to the electronics and other satellite systems. So how clean are the clean rooms? Well, in a Class 100 clean room, there can be up to 100 particles >0.5µm in diameter (that is 1000 times smaller than 1mm!) for every cubic ft. The air outside contains roughly 3 million particles like this for every cubic ft, so it’s very clean!

A satellite is comprised of systems. Each system has a different function and generally they fall into one of two categories: Satellite Bus Systems and Payload Systems.

The **Satellite Bus** is the part of the satellite that provides all of the essential functions required by the satellite in order to stay in orbit and support the Payload. The Bus systems comprise the Power Generation and Distribution, Thermal Control, Satellite Communications, the Attitude and Orbit Control, the On Board Computer and many others. Some of these systems are described in more detail in Box 1.

The **Payload** is the mission-specific part of the satellite. For example the payload on a scientific satellite might be a telescope and the associated detectors and processors to collect the scientific data. Payloads often have their own dedicated on board computers in addition to the one provided by the satellite bus. This is usually due to the high volume of data that needs to be collected and stored before being communicated to the ground.

Testing, testing

The satellite must undergo a rigorous set of tests to ensure that it can survive both the launch and the harsh space environment – see Box 2.

Satellite integration into launcher fairing

Once the satellite has passed each of the tests, it will be transported to the launch site to be integrated into the launcher fairing. Final tests will be carried out to check the health of all of the satellite systems and the satellite’s own fuel tanks will be filled and tested for any leaks. The satellite and launcher will then be made ready for launch.

Into space

The final stage is Launch and Operations. 3,2,1, zero – we have lift off... finally the satellite will blast off from the launch site and be propelled into space. Once the satellite has been released from the launcher, it will manoeuvre itself into the desired orbit and, after a few months of initial in-orbit testing, it will begin its nominal mission. At the end of its mission the satellite must be disposed of. Satellites in a low-Earth orbit are de-orbited and burn up in the atmosphere, satellites in the Geostationary orbit are manoeuvred out into graveyard orbits further away from the Earth.

Astrium is dedicated to providing civil and defence space systems and services. In 2007, Astrium had 12 000 employees in France, Germany, the United Kingdom, Spain and the Netherlands, and achieved a turnover of €3.5 billion.

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Box 2 Testing

Electromagnetic Compatibility (EMC) Test

Electromagnetic interference generated by the spacecraft systems can be propagated along the power lines and even radiated outwards by the units. EMC testing is carried out first to measure these interference levels and to ensure that the spacecraft systems can operate normally in the presence of these and slightly higher interference levels.

Thermal Vacuum Test

This test is to show that the satellite can cope with the temperature and pressure variations in space and that the systems will still operate normally. The satellite is sealed into a Thermal Vacuum Chamber. The conditions inside the chamber are then varied so that the satellite experiences the extremes of temperature and pressure that it may encounter in space. During this time the systems on board the satellite will be monitored. Thermal testing can take many weeks to complete.

Vibration Test

The vibration test is designed to simulate the conditions that the satellite will encounter during launch. The satellite is mounted to a “Shaker Table” which then begins to shake at different frequencies, simulating the launch conditions.

1. The Inmarsat 4 satellite enters the thermal vacuum chamber

2. Testing a satellite’s electrical systems (EMC test).

3. A satellite undergoes vibration testing