

# ARCHIVED REPORT

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## Herschel and Planck

### Outlook

- The Ariane 5 launch vehicle carrying Herschel and Planck blasted off from the Kourou Spaceport at 2:12 p.m. EST (18:12 GMT) on May 14, 2009
- Before the launch, Herschel and Planck were more than 20 percent over budget and months behind schedule

### Orientation

**Description.** The Herschel (formerly called FIRST) observatory is a giant space telescope. Planck is an observational science mission.

**Sponsor.** The European Space Agency (ESA).

**Status.** The Herschel and Planck spacecraft were launched on May 14, 2009, aboard an Ariane 5 ECA launcher.

**Total Produced.** Herschel and Planck have both been produced and launched.

**Application.** Herschel's main objective is to discover how the first galaxies were formed and how they evolved. Planck will help researchers understand the origin and evolution of the universe.

**Price Range.** The total cost for the Herschel and Planck mission is EUR1.6 billion (\$2 billion).

### Contractors

#### Prime

<b>Thales Alenia Space</b>	<a href="http://www.thaleson-line.com/space">http://www.thaleson-line.com/space</a> , 26 ave JF Champollion, BP 1187, Toulouse, 31037 France, Tel: + 33 05 34 35 36 37, Fax: + 33 05 61 44 49 90, Prime
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#### Subcontractor

<b>Air Liquide</b>	<a href="http://www.airliquide.com/en">http://www.airliquide.com/en</a> , 75 Quai D'Orsay, Paris, 75321 France, Tel: + 33 014 062 5555 (Dilution Coolers)
<b>Astrium</b>	<a href="http://www.space.eads.net">http://www.space.eads.net</a> , PO Box 801109, Munich, 81663 Germany, Tel: + 49 89 607 0, Fax: + 49 89 607 264 81 (Payload Module)
<b>BOOSTEC Industries</b>	<a href="http://www.boostec.com">http://www.boostec.com</a> , Zone Industrielle, Bazet, 65460 France, Tel: + 33 056 233 4500, Fax: + 33 056 233 4505 (Herschel Silicon Carbide Mirror)

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<b>Danish Space Research Institute, DSRI</b>	<a href="http://www.dsri.dk">http://www.dsri.dk</a> , Juliane Maries Vej 30, Copenhagen, DK-2100 Denmark, Tel: + 45 3532 5830, Fax: + 45 3536 2475 (Planck Mirrors)
<b>Institut d'Astrophysique Spatiale (CNRS)</b>	<a href="http://www.ias.fr">http://www.ias.fr</a> , Université Paris-Sud, bâtiment 121, Orsay, 91405 France, Tel: + 33 16 985 8500, Fax: + 33 16 985 8675 (Design and Construction of HIFI Instrument)
<b>Northrop Grumman Space Technology</b>	<a href="http://www.as.northropgrumman.com">http://www.as.northropgrumman.com</a> , 1 Space Park, Redondo Beach, CA 90278 United States, Tel: + 1 (310) 812-4321, Fax: + 1 (310) 813-7548 (Space Inertial Reference Unit)
<b>RUAG Space AB</b>	<a href="http://www.ruag.com/en/Space/Space_Home">http://www.ruag.com/en/Space/Space_Home</a> , Solhusgatan 11, Göteborg, 405 15 Sweden, Tel: + 46 31 735 00 00, Fax: + 46 31 735 40 00 (Tracking Equipment)
<b>Thales Alenia Space Italia</b>	<a href="http://www.thalesgroup.com/Markets/Space/Home/">http://www.thalesgroup.com/Markets/Space/Home/</a> , Via Saccomuro, 24, Rome, 00131 Italy, Tel: + 39 06 41511, Fax: + 39 06 4190675 (Service Modules)

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## Technical Data

**Design Features.** The Herschel Space Observatory, known as Herschel (formerly the Far Infrared and Submillimeter Space Telescope, or FIRST), is a cornerstone of the ESA's Horizon 2000 Scientific Program and provides photometry and spectroscopy in the 80- to 670-micron range. The spacecraft is named after William Herschel, an Anglo-German astronomer who discovered infrared light in 1800.

The Herschel spacecraft is approximately 9 meters (30 ft) high and 4.5 meters (15 ft) wide, with a launch mass of about 3,250 kilograms (7,165 lb). It carries the infrared telescope and three scientific instruments, and operate for approximately three years.

Herschel features a 3.5-meter radiatively cooled Cassegrain telescope and a payload of three instruments contained inside a superfluid helium cryostat. Instruments provisionally chosen include:

- Heterodyne Instrument for FIRST (HIFI), which combines the high spectral resolving power capability (0.3 to 300 km/s) of the radio heterodyne technique with the low noise detection offered by superconductor-insulator-superconductor (SIS) and hot electron bolometer (HEB) mixers.
- Photoconductor Array Camera and Spectrometer (PACS), which employs two 25 x 16 Ge:GA detector arrays covering the 80- to 130-micron and 130- to 210-micron bands. PACS performs photometry simultaneously in the two bands, providing full beam sampling at 90 and 180 microns, respectively.
- Spectral and Photometric Imaging Receiver (SPIRE), which is a bolometer detector array

instrument that provides broadband photometry simultaneously in bands centered on 250, 350, and 500 microns.

Herschel was launched on an Ariane 5 in 2009 along with its smaller sibling, Planck, a cosmic background radiation field spacecraft. Formerly called COBRAS/SAMBA, Planck will join Herschel at the second Lagrangian point of the Earth-Sun system.

The Planck spacecraft was produced by a European team led by Alcatel Space. The goal of the mission is to observe the cosmic microwave background. Planck is a 1.5-year (2009 to 2011, approximately), far-infrared, all-sky survey mission that operates in nine wavebands, with frequencies from 30 GHz to 857 GHz and an angular resolution of 30 to 5 arcmin. The spacecraft carries two instruments that are designed to measure the temperature of background radiation and detect differences as small as a few micro-kelvins.

The Low Frequency Instrument (LFI) comprises 56 tuned receivers or detectors that are operated at -253°C (equivalent to 20° above absolute zero). The receivers act as transistor radios and amplify the signal collected by the telescope (which serves as the antenna). The detected signal is then stored in an onboard computer for analysis. The instrument works in three frequency channels: 30, 44, and 70 GHz.

The High Frequency Instrument (HFI) consists of 48 bolometric detectors that convert radiation to heat. The heat is measured by a thermometer and converted into a real temperature by the computer. The detectors work in six frequency channels ranging between 100 and 857 GHz and are operated at -272°C.

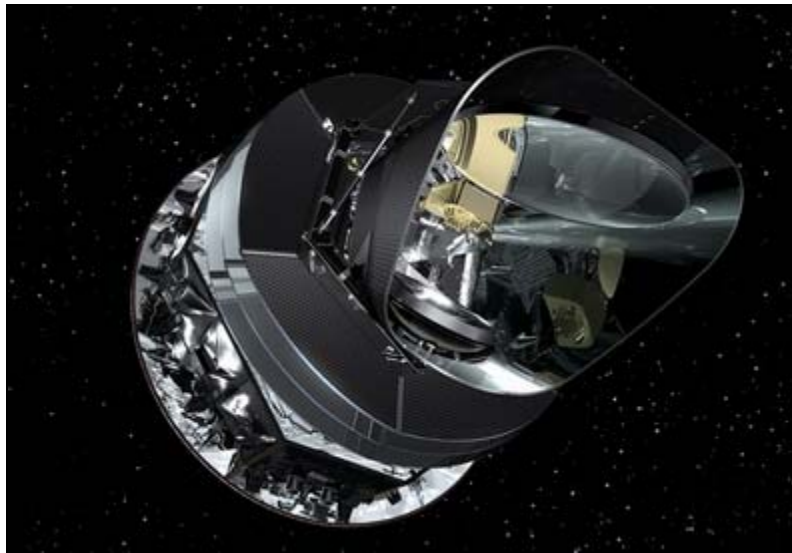
## Herschel and Planck

For the instruments to maintain their temperatures, a system of refrigerators was placed on board the spacecraft.



Artist's Depiction of Herschel

Source: ESA



Artist's Depiction of Planck

Source: ESA

## Program Review

**Background.** In 1999, the ESA's Science Program Committee formally approved the three instruments slated to ride aboard the Herschel Space Observatory.

As proposed by the scientific community in 1998, Herschel's payload consists of two cameras and a high-resolution spectrometer. Nearly 40 institutes, mainly

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European with some U.S. participation, designed and built the spacecraft's instruments.

Herschel was implemented in parallel with the ESA's Planck program by a common project team.

Planck, formerly called COBRAS/SAMBAS, was approved in 1996 as the third mission in the ESA's Horizon 2000 program. Later, the mission was renamed Planck after Max Planck, a German scientist who won the Nobel Prize for physics in 1918.

Originally, the ESA hoped to launch Planck in 2003. However, budgetary constraints pushed the launch date back to 2009. Herschel and Planck were launched together in the carrier position (Planck carries the Herschel mission inside the Ariane 5 ECA payload adapter). An industry team led by Thales Alenia Space designed the spacecraft.

### *Alcatel Awarded Herschel and Planck Contracts*

In March 2001, a European industrial consortium led by Alcatel Space (now Thales Alenia Space) was awarded a contract to build the Herschel and Planck spacecraft. Astrium GmbH of Germany and Italy's Alenia Spazio were also assigned as main contractors for the two development programs.

**SES Wins Computer Contract.** Saab Ericsson Space supplied computer equipment for Herschel and Planck under a EUR16 million contract announced in April 2002. SES designed and produced computer equipment for satellite tracking, positioning, orientation, and telecommand. The computer systems were based on the European ERC-32 processors and operate at 20-MHz clock frequency. Several application-specific integrated circuits (ASICs) help reduce weight, volume, and power consumption. Spares were built for use on future missions.

**Austrian Aerospace Wins Aperture Cover Contract.** In August 2002, Astrium selected Austrian Aerospace (AAE) to supply the telescope aperture cover on Herschel's payload module. This payload module is a huge cryostat vessel that provides the cooling for an infrared telescope housed inside. The aperture cover is essentially a door that closes and seals the cryostat during the long on-ground test and preparation period. The inner side of the cryostat (and the door) is kept at approximately -268°C and under vacuum conditions; on the outer side are conditions of ambient pressure and temperature. The main function of the door during the on-ground period is gas- and temperature-tight to prevent loss of the expensive helium cooling gas.

### *Telescope Takes Shape*

In December 2003, the prime contractor for the Herschel telescope, EADS Astrium, successfully manufactured the flight primary mirror silicon carbide (SiC) blank for the Herschel telescope. It consists of 12 segments that have been brazed together to form a monolithic blank, which have been ground, polished, and coated to become the primary mirror for the flight telescope. Delivery of the completed telescope was scheduled for 2005, but delays with instrument development pushed delivery to 2009.

**MOIS Software for Herschel and Planck.** In July 2003, Rhea System SA won a contract to provide its MOIS software for assembly, integration, and testing, as well as flight procedure development, for the Herschel and Planck spacecraft. MOIS software is used on many European missions, including Smart-1, Mars Express, MSG, and the future Rosetta mission.

**Northrop Grumman Awarded SIRU Contract.** The Navigation Systems Division of Northrop Grumman was awarded a contract in September 2003 to provide two scalable Space Inertial Reference Units (SIRUs) for the Herschel spacecraft. The SIRU supplies angle and velocity information to the satellite's attitude control system. The key component of the SIRU is Northrop Grumman's hemispherical resonator gyro, which has no mechanical components to wear out. Financial details of the award were not disclosed.

### *Integration of Planck's Two Instruments*

The focal plane units of the two Planck instruments HFI and LFI were integrated into a single assembly in November 2006. The High Frequency Instrument (HFI) focal plane unit was inserted into the dedicated opening in the center of the Low Frequency Instrument (LFI) focal plane unit.

At this time, the HFI was already assembled with its cryogenic cooling pipework in a dedicated support structure, while the LFI focal plane unit was connected to the back-end electronics by a set of waveguides. In this complicated configuration, the two instruments were integrated into a single assembly.

The complex integration was conducted by a team of four engineers of AAS-I (formerly Laben). It took about four hours to perform the integration, during which time the two instruments were often as close as 1 millimeter from each other at different locations. The descent of HFI into LFI was precisely controlled to the millimeter to prevent any contact between the two instruments. The successful integration gave way to the mating and alignment of the combined HFI/LFI instruments with the Planck telescope integrated on the flight model spacecraft.

## Herschel and Planck

Following the successful conclusion of a Launch Readiness Review in May 2009, the Ariane 5 carrying Herschel and Planck was declared ready to launch on May 14. The launch vehicle blasted off from the Kourou

Spaceport at 2:12 p.m. EST (18:12 GMT). The first radio signals from the spacecraft reached ground stations at 2:49 p.m. EST (18:49 GMT). Both spacecraft reached their designated locations at L2 in mid-June.

## Funding

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The European Space Agency and its project partners provide the funding for the Herschel and Planck missions.

## Timetable

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<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Mar	2001	Alcatel chosen to lead industry team
May	2009	Herschel and Planck launched on Ariane 5 ECA
Jun	2009	Herschel and Planck reach L2

## Forecast Rationale

Herschel and Planck successfully launched in 2009, an important accomplishment for ESA.

The cost to design and build Herschel and Planck grew significantly during the life of the program. The final cost, estimated to be \$2 billion, was about twice that originally anticipated. A May 2005 report indicated that Europe's complicated relationship with contractors, civil agencies, and research laboratories had hampered the development process. The Herschel and Planck payloads in particular posed a tremendous challenge to Europe's industrial complex.

Despite the cost growth, the program can be considered a success. ESA designed, built, and launched satellites that will provide significant data to scientists worldwide. Herschel is expected to remain operational for three years, while Planck will be operational for one and a half years.

With both satellites manufactured and launched, the program has shifted its focus, and this report will be archived next year. Scientists at ground stations will now collect and interpret data sent from the spacecraft. ESA will move on to developing new scientific spacecraft.

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