



The international participation in Herschel and Planck

The European Space Agency's Herschel far-infrared and submillimetre space observatory and the Planck space telescope are two of the most ambitious and technologically challenging missions ever conceived and built in Europe.

Herschel, equipped with the largest mirror ever launched into space (3.5 m diameter), three advanced scientific instruments and a complex cryogenic system to keep the instrument detectors at temperatures close to absolute zero (down to 0.3K), will observe a mostly uncharted part of the electromagnetic spectrum in order to study the birth and the evolution of stars and galaxies. Planck, featuring two highly sophisticated instruments and a combined passive-active cooling system to keep some of the detectors as cool as 0.1K, is designed to map tiny irregularities in fossil radiation left over from the very first light in the Universe (the Cosmic Microwave Background, or CMB), emitted shortly after the Big Bang.

The industrial participation

The Herschel and Planck satellites were developed under a common engineering programme by an industrial team led by Thales Alenia Space (Cannes, France) on ESA's behalf. The joint development process was aimed at optimising resources, by using the same industrial teams and shared design of spacecraft components whenever possible.

A host of subcontractors spread all over Europe, and a few in the United States, contributed to the two spacecraft. The major ones are: Astrium (Friedrichshafen, Germany), which provided the Herschel payload module; Astrium (Toulouse, France), which provided the Herschel telescope; and Thales Alenia Space (Turin, Italy), which provided the service modules for both satellites.

The following companies are also part of the Herschel and Planck industrial consortium: RUAG Aerospace Austria (Austria), Centre Spatial de Liège and Thales Alenia Space Belgium (Belgium); Terma and Ticra (Denmark); Patria, Space Systems Finland and VTT (Finland); Air Liquide (France); Linde, Teldix, EADS Eurocopter, Kayser-Threde (Germany); Captec, McGinley Space and System International (Ireland); Rafael (Israel); Galileo Avionica and Top Rel (Italy); Dutch Space (EADS Astrium), ETS, Satellite Services BV and Terma (The Netherlands); Prototec and Kongsberg (Norway); Skysoft, Critical Software and Altrantec (Portugal); EADS Casa, SENER, Thales Alenia Space España, Tecnologica, GMV and Rymosa (Spain); RUAG Aerospace Sweden AB (Sweden); APCO and Oerlikon (Switzerland); MSP, Datasat, AEA Technology, EADS Astrium UK, RAL, BOC Edwards (UK); ATK, Northrop Grumman (USA).

The Planck telescope was manufactured by Astrium (Friedrichshafen, Germany) on behalf of ESA and the DTU Space (Copenhagen, Denmark), with the Danish part funded by the Danish Natural Science Research Council.

The instruments consortia

Large academic and industrial consortia from around the world designed and manufactured Herschel and Planck's instruments under national funding.



Herschel

The **Photodetector Array Camera and Spectrometer (PACS)**, a camera and a low- to medium-resolution spectrometer for wavelengths up to about 205 microns, was designed and built by a consortium of 14 science institutes in 6 European countries (Austria, Belgium, France, Germany, Italy, Spain) led by the Max Planck Institute for Extraterrestrial Physics (Germany), which also hosts the PACS instrument control centre. The major part of the funding for PACS comes from DLR and MPG (Germany), BELSPO/PRODEX (Belgium), CNES and CEA (France), ASI (Italy), Ministerio de Ciencia y Tecnología (Spain), and the Ministry of Science and Research (Austria).

The **Spectral and Photometric Imaging Receiver (SPIRE)**, a camera and a low- to medium-resolution spectrometer for wavelengths longer than 200 microns, was designed and built by a consortium of scientists and institutes led by Cardiff University (UK), with major participation from the UK, France, USA, and other contributions from Italy, Canada, Spain, Sweden, China. The SPIRE instrument control centre is located at the Rutherford Appleton Laboratory (UK). The major funding for SPIRE comes from STFC (UK), CNES, CEA and CNRS (France), NASA (USA), and from ASI (Italy), CSA (Canada), Ministerio de Educación y Ciencia (Spain), Stockholm Observatory (Sweden), and the Chinese Academy of Sciences and the National Astronomical Observatories (China). Additional funding support for some instrument and data processing activities has been provided by ESA.

The **Heterodyne Instrument for the Far Infrared (HIFI)**, a very-high-resolution spectrometer, was designed and built by a consortium of 25 institutes in 13 countries led by the SRON Netherlands Institute for Space Research (The Netherlands, also hosting the HIFI instrument control centre), with major contributions from the Netherlands, Germany, USA and France. The major funding for SPIRE comes from SRON (Netherlands), DLR (Germany), NASA (USA), CNES and CNRS (France), with smaller contributions from Canada, Sweden, Spain, Switzerland, Italy, Poland, Ireland, Greece and Taiwan.

An additional centre for analysis and processing of the Herschel data is the NASA Herschel Science Center, part of the USA contribution to the mission, located at the California Institute of Technology Infrared Processing and Analysis Center, Pasadena, California, USA.

Planck

The **Low Frequency Instrument (LFI)**, an array of 22 tuned radio receivers that will image the sky at three frequencies between 30 GHz and 70 GHz, was designed and built by a consortium of more than 50 institutes from more than 10 countries in Europe and in America, led by the Istituto di Astrofisica Spaziale e Fisica Cosmica in Bologna (Italy). The data processing centre and the operations centre for the LFI are located at the Osservatorio Astronomico di Trieste, Italy.

The major funding for LFI comes from ASI and INAF (Italy), in addition to contributions from NASA (USA), Tekes and Millilab (Finland), STFC and Jodrell Bank (UK), the INTA Spanish Space Agency, IAC and University of Santander (Spain), and from Norway, Switzerland, Canada, Germany and ESA. Major industrial contribution is due to Thales Alenia Space (Milan, Italy).

The **High Frequency Instrument (HFI)**, an array of 52 bolometric detectors also in the focal plane of the Planck telescope that will image the sky at six frequencies between 100 GHz and 857 GHz, was designed and built by a consortium of 25 institutes from Europe and North America led by the Institut d'Astrophysique Spatiale in Orsay (France), with major contributions from France, the UK and the USA. The data processing centre and the operations centre for the HFI are located at the Institut d'Astrophysique de Paris, France, and Institut d'Astrophysique Spatiale d'Orsay, France, respectively. The major funding to HFI comes from CNES and CNRS [INSU, IN2P3] (France), NASA (USA), STFC (UK), with smaller contributions from CSA (Canada), DLR (Germany), ESA, Italy, Ireland and Spain.

The NASA contribution to the Planck mission also includes the delivery of a catalogue of cosmic objects, called the Early Release Compact Source Catalogue, to the Planck data processing centres in Europe six months after completion of the first sky survey. Major industrial contribution is due to Air Liquide-DTA (Grenoble, France).