

## Columbus Development History

The following information provides an overview of different steps in the development of the Columbus Laboratory and related issues.

### 1995

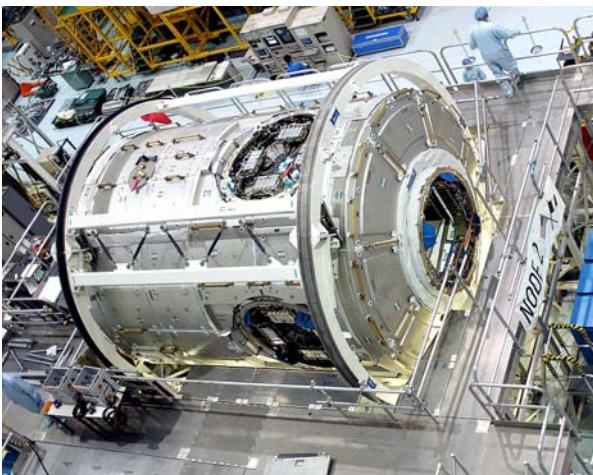
At the ESA Ministerial Council meeting in Toulouse in October the programme for European participation in the International Space Station is approved. This includes the Columbus Orbital Facility (Columbus Laboratory) and the Microgravity Facilities for Columbus.

### 1996

ESA signs the 658 million euro contract with prime contractor DASA (now part of EADS Astrium) to develop the Columbus laboratory.

### 1997

The Preliminary Design Review starts in October to evaluate the Columbus Orbital Facility system design. ESA propose attachment points for external research payloads. On 8 October the Columbus Orbital Facility Launch Barter Agreement is signed between ESA and NASA. Under this agreement ESA will provide additional hardware and services for the International Space Station to NASA, including Nodes 2 and 3 in exchange for the European laboratory module being launched on the US Space Shuttle.



Node 2 in the NASA Space Station Processing Facility. This module, which will be the attachment point of Columbus, formed part of a barter agreement with NASA for launching Columbus on Space Shuttle. (Image: NASA)

### 1998

The Columbus Preliminary Design Review is completed on schedule. This leads to the start of Critical Design Reviews for equipment and subsystems. Interfaces are defined with NASA

between Columbus and the Shuttle, the overall ISS and the payload racks which house for example the Columbus experiment facilities.

The Meteoroid and Debris Protection System panels for Columbus are tested up to impact velocities of 7 km/sec. Primary structure manufacturing is underway. The performance of the module's water loop was tested in late 1998.



Close up of Columbus with Meteoroid and Debris Protection System panels. One panel removed along with thermal blanket layer to reveal primary structure. (Image: EADS Astrium)

ESA Council decide that the Operations Control Centre for the Columbus Laboratory, together with the central node of the Communications Network will be located at the German Aerospace Center (DLR) facility in Oberpfaffenhofen in Germany.

### 1999

Cabin ventilation was verified in February 1999 on a mock-up of the Columbus interior, using the fans and ducting hardware. Fire-suppression tests were conducted in March 1999 on mechanical mock-ups of the relevant areas.

Earlier problems with the laboratory mass have now been resolved and the associated design changes incorporated. Data management interface tests between Columbus and the ISS are conducted successfully.

### 2000

A full-scale mockup of Columbus, with all external features incorporated, has been tested in the NASA/JSC Neutral Buoyancy Facility, and astronauts have verified that all planned and contingency EVA activities can be carried out.

**Columbus Development History**



Columbus Neutral Buoyancy testing at the Johnson Space Center in the USA in 2000.

Manufacture of the flight unit primary structure is complete and pressure and leakage testing have been successfully carried out. The subsystem critical design reviews are now complete. Following successful completion of the launch and on-orbit modal survey tests on the flight model, the test configuration has been disassembled and integration of the flight harnesses, ducting and plumbing has started.

**2001**

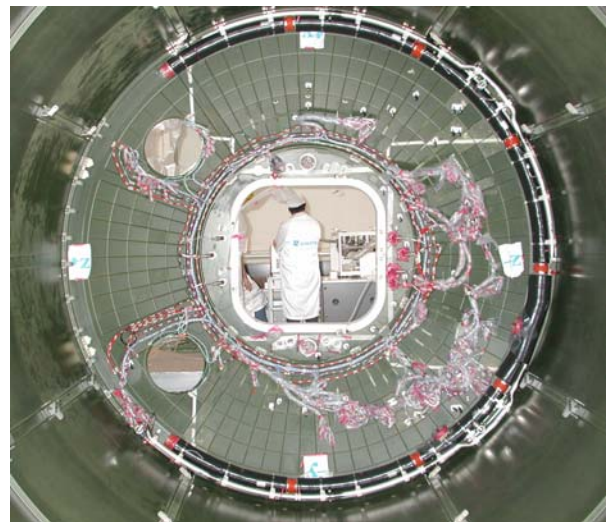
The system Critical Design Review and the independent NASA Safety Review II have been conducted successfully. The accommodation of the European external payloads on the Columbus External Payload Facility has been agreed with



Columbus External Payload Facility. (Image: EADS Astrium)

NASA. Under this agreement, ESA will free the three positions on the Express Pallet at the S3 truss site and retains exclusive rights to use the Columbus External Payload Facility location for approximately 4.5 years.

The Columbus flight-unit integration began at Alenia Spazio's (now part of Thales Alenia Space) premises in Turin in March 2001 with the integration of the Pre-integrated Columbus Assembly (PICA), which comprises all mechanical items, such as: primary and secondary structures; thermal-control system and environmental control & life-support system equipment; harness, ducting and plumbing; illumination, crew support equipment; and external protection like multi-layer insulation and micrometeoroid and debris-protection items.



Internal view of the Pre-integrated Columbus Assembly (PICA) during harness integration at Alenia Spazio in Turin in 2001.

The first test jointly performed with NASA and the ISS prime contractor Boeing on data communications exchange between Columbus and the rest of the ISS was successfully completed in June 2001. The ISS Assembly Sequence is updated in June though the Columbus launch remains scheduled in October 2004.



The Pre-integrated Columbus Assembly (PICA) being loaded into an Airbus Super Guppy for transport to Bremen in 2001.

**Columbus Development History**

After completion of the flight-unit mechanical integration phase at Alenia Spazio in Turin, the Pre-integrated Columbus Assembly is delivered to EADS Astrium in Bremen on 27 September for the start of flight-unit final integration. This involves integrating all functional elements into the Columbus module, including: power distribution units; communications equipment (including video and audio communication); data-management equipment, and flight-application software.



The Pre-integrated Columbus Assembly (PICA) being lowered onto the Columbus integration stand at EADS in Bremen after arrival from Alenia Spazio in Turin. (Image: EADS Astrium)

**2002**

Integration of almost all the internal functional components of the Columbus flight unit is now complete, and the closeout plate of the starboard end-cone has been installed and wired up. The first functional system testing on the flight unit has been performed successfully.

The Columbus Crew Trainer has been successfully integrated into the Columbus Mechanical Mock-Up at the European Astronaut Centre in Cologne and has been used to support the first ISS Advanced Crew Training session between 26 August and 6 September



Integration of functional components at EADS in 2002.

2002. This included hands-on training sessions, covering the systems and subsystems of the Columbus module and its four principle ESA experiment facilities.



Columbus mechanical mock-up at the European Astronaut Centre in Cologne, Germany. (Image: ESA)

The core members of the Flight Control Teams and the nomination of the lead Flight Directors for the Columbus launch mission have been defined.

**2003**

Grounding of the Shuttle fleet following the STS-107 Columbia accident on 1 February causes a long-term delay in the ISS assembly launch sequence.

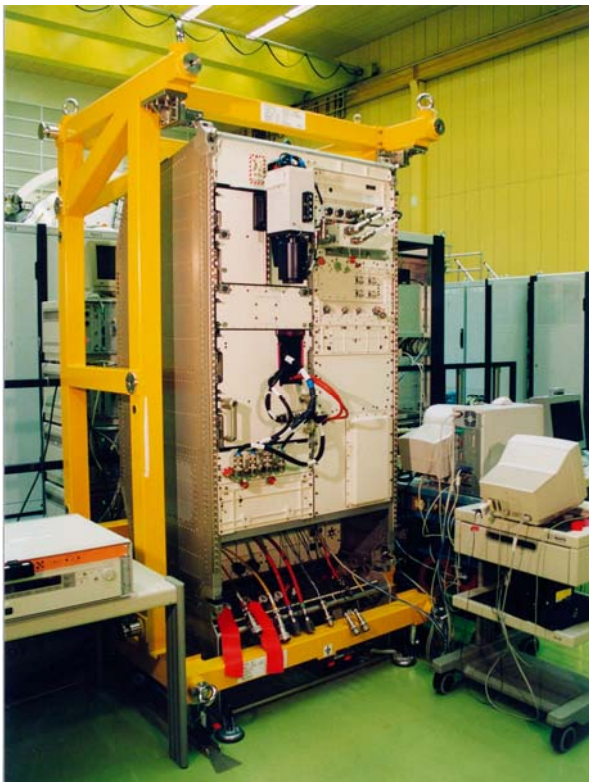
## Columbus Development History

On 31 March ESA sign a contract with DLR to develop the Columbus Control Centre.



Professor Achim Bachem, former member of the executive board of DLR (left) and Jorg Feustel-Buechl, ESA's former Director of Human Spaceflight (right) during the signing of the contract to develop the Columbus Control Centre.

Thermal and electromagnetic compatibility tests are performed successfully on the flight model of the Columbus Laboratory. Following completion of the qualification test campaign on the flight model of the Columbus laboratory, qualification and flight safety reviews are completed. The flight models



The Fluid Science laboratory during testing on the Rack Level Test Facility at EADS in Bremen, Germany. (Image: ESA)

of Biolab, the European Physiology Modules and the Fluid Science Laboratory are assembled. These successfully complete interface testing with Columbus using the Rack Level Test Facility at EADS Space Transportation (now EADS Astrium) in Bremen, Germany.

### 2004

Columbus testing has shown that the audible noise level is well below the requirement level, making it the quietest module for the ISS. The European Drawer Rack flight model interface testing with Columbus was successfully completed in February. The flight models of the experiment facilities have been delivered.

The External Payload Facility has been attached to the end-cone of the module. Training models of all experiment facilities have now been delivered to the European Astronaut Centre in Cologne.

ESA and EADS Space Transportation sign the contract, which covers initial ISS exploitation activities, in particular preparations for the operations of Columbus.



Columbus Control Centre. First joint simulation with NASA. September 2003. (Image: ESA)

Columbus operations preparation is progressing and a second table-top simulation is successfully performed at the Columbus Control Centre. System Validation Tests are completed in August with the Columbus Control Centre connected to the User Support and Operations Centres and the Columbus Laboratory flight module with the experiment facilities integrated.

All four active Columbus payload facilities have been integrated into the Columbus flight model, which has successfully completed both the individual payload Integrated Functional Testing and the Integrated System Test. Testing of the

**Columbus Development History**



Fisheye photo of Columbus with flight models of the European experiment facilities installed during testing in 2004.

first NASA payload rack installed in Columbus, the Human Resource Facility, was successfully completed in October. The inauguration of the Columbus Control Centre in Oberpfaffenhofen in Germany took place on 19 October.



Inauguration of the Columbus Control Centre on 19 October 2004. From left to right: Hiltrud Pieterek, ESA, Sigmar Wittig, former Chairman of the Executive Board of DLR, Otto Wiesheu, former Bavarian Minister, Jorg Feustel-Buechl, former ESA Director of Human Spaceflight, Klaus Wittmann, DLR, Joachim Kehr, DLR.

**2005**

All payload facilities have been removed from Columbus and returned to their developers for flight readiness completion, and the Columbus laboratory has entered a hibernation phase. Numerous training courses have been held at the European Astronaut Centre (EAC), including Columbus User-Level Training for ground support personnel (February), and for an international class of astronauts (March); and Columbus Payload Advanced Training for Facility Responsible Centre personnel and EAC biomedical engineers (March).

The final round of Columbus system acceptance testing is completed. Columbus has been weighed

and is some 350 kg below specification mass. The flight models of the European Physiology Module, Biolab, Fluid-Science Laboratory and the European Drawer Rack, including the Protein Crystallisation Diagnostic Facility, have been delivered to EADS in Bremen, Germany where they have been integrated into Columbus and have successfully completed interface testing.

The flight models of the two Columbus External Payloads, SOLAR and EuTEF, have been delivered and successfully integrated and interface tested on Columbus, and subsequently returned to their developers final integration testing. The first Columbus simulation in the Integrated Simulation Set-Up was performed in October. The simulation was run on the Columbus Trainer at EAC, with the Flight Control Team in the Columbus Control Centre commanding the module.

On 25 October, NASA confirm baseline of 18 more Shuttle flights to the ISS. Subsequent evaluation of ISS final configuration and assembly sequence establish feasibility of advancing the launch of Columbus and its payloads by two flights.



Space agency leaders take time from Heads of Agency meeting for a group photo on 2 March 2006 at the Kennedy Space Center. From left Virendra Jha (CSA), Anatoly Perminov (Roscosmos), ESA's Director General Jean-Jacques Dordain, Mike Griffin (NASA) and Keiji Tachikawa (JAXA) (Image: NASA)

**2006**

The Heads of Agency meeting takes place at the Kennedy Space Center in Florida on 2 March. In the subsequent press conference it is announced that 16 more Shuttle flights are needed to complete ISS assembly. ESA Director General Jean-Jacques Dordain also confirms the

**Columbus Development History**

advancement of the Columbus launch to flight seven in the sequence bringing the launch date forward to the second half of 2007.

Columbus is loaded into a container at EADS Astrium in Bremen, Germany and transferred into an Airbus 'Beluga' aircraft at Bremen airport on 28 May for delivery to the USA. After landing in Florida on 30 May, Columbus is delivered to the Kennedy Space Center on the following day.



Top: Columbus being loaded into an Airbus 'Beluga' in Bremen, Germany on 28 May 2006. (Image: EADS), Middle: Columbus arriving at Kennedy Space Center on 31 May 2006 and Bottom: ESA's ISS Programme Manager, Alan Thirkettle giving a speech during Columbus arrival ceremony (Images: NASA)

On 2 June a ceremony takes place at the Kennedy Space Center to welcome the new module. In August the Incoming inspection campaign is finished, which included a module leak check in the Operations and Checkout Building vacuum chamber at the Kennedy Space Center.



Columbus laboratory on a workstand in the Space Station Processing Facility of the Kennedy Space (Image: NASA)

**2007**

From January to April payload processing takes place at the Space Station Processing Facility of the Kennedy Space Center. All the payload facilities inside Columbus go through procedures to ready them for launch. Between April and August the European Transport Carrier, is integrated for launch and this includes integration of items to go to the ISS such as the European developed Flywheel Exercise Device. Flight trunnions are also installed. These are used to keep Columbus fixed in the Shuttle cargo during launch.

After September, water loop degassing takes place on Columbus and the module is pressurised. It is then placed in a canister ready for shipment prior to launch.