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Supplying the International Space Station

December 2007

Europe's new spaceship ready for ISS missions

The first of ESA's Automated Transfer Vehicles (ATVs) – named *Jules Verne* after the visionary 19th century science fiction writer – represents the most complex space vehicle ever developed in Europe.

From its first operational flight in 2008, Europe's most challenging spaceship to date will play a vital role in servicing the International Space Station (ISS).

Its essential mission will be as a cargo carrier, storage facility and as a 'tug' vehicle to raise the Space Station's orbit every so often.

The versatile craft is an essential European contribution to the regular operations of the Space Station, whose lifeblood comprises regular deliveries of experimental equipment and spare parts as well as food, air and water for the long-stay crews.

At present this role is largely fulfilled by the US Space Shuttle and Russian unmanned Progress craft but the retirement of the Shuttle in 2010 will give added importance to Europe's ATV.

Each of the new ATV craft – carrying up to nine tonnes of cargo on a mission typically lasting six months – will be launched by an Ariane-5 from Europe's spaceport in Kourou, French Guiana.

When the first ATV *Jules Verne* lifts off as planned in early 2008, ESA French astronaut Léopold Eyharts will be among the crew of the Space Station to oversee its arrival.

Equipped with its own propulsion and navigation systems, the ATV is a multi-functional spaceship, combining the fully automatic capabilities of an unmanned vehicle with human spacecraft safety requirements.

A high-precision navigation system will guide the ATV on a rendezvous trajectory towards the Space Station, where it will dock automatically to the Russian Service Module, about 14 days after launch.

It will remain there as a pressurised and integral part of the complex for up to six months until a controlled reentry into the Earth's atmosphere, where it will burn up and, in the process, dispose of waste material no longer needed on the Space Station.

"We are proud of the ATV," said Daniel Sacotte, ESA's Director of Human Spaceflight, Microgravity and Exploration.

"At around 20 tonnes, this will be by far the heaviest payload Ariane-5 has launched to date," he added.

"With the launch of the first ATV we are ready in Europe to reap the benefits of the investments we have been making in space."

Although people will not be carried by ATV, astronauts dressed in normal clothing will be able to access cargo and systems during the time it is docked.

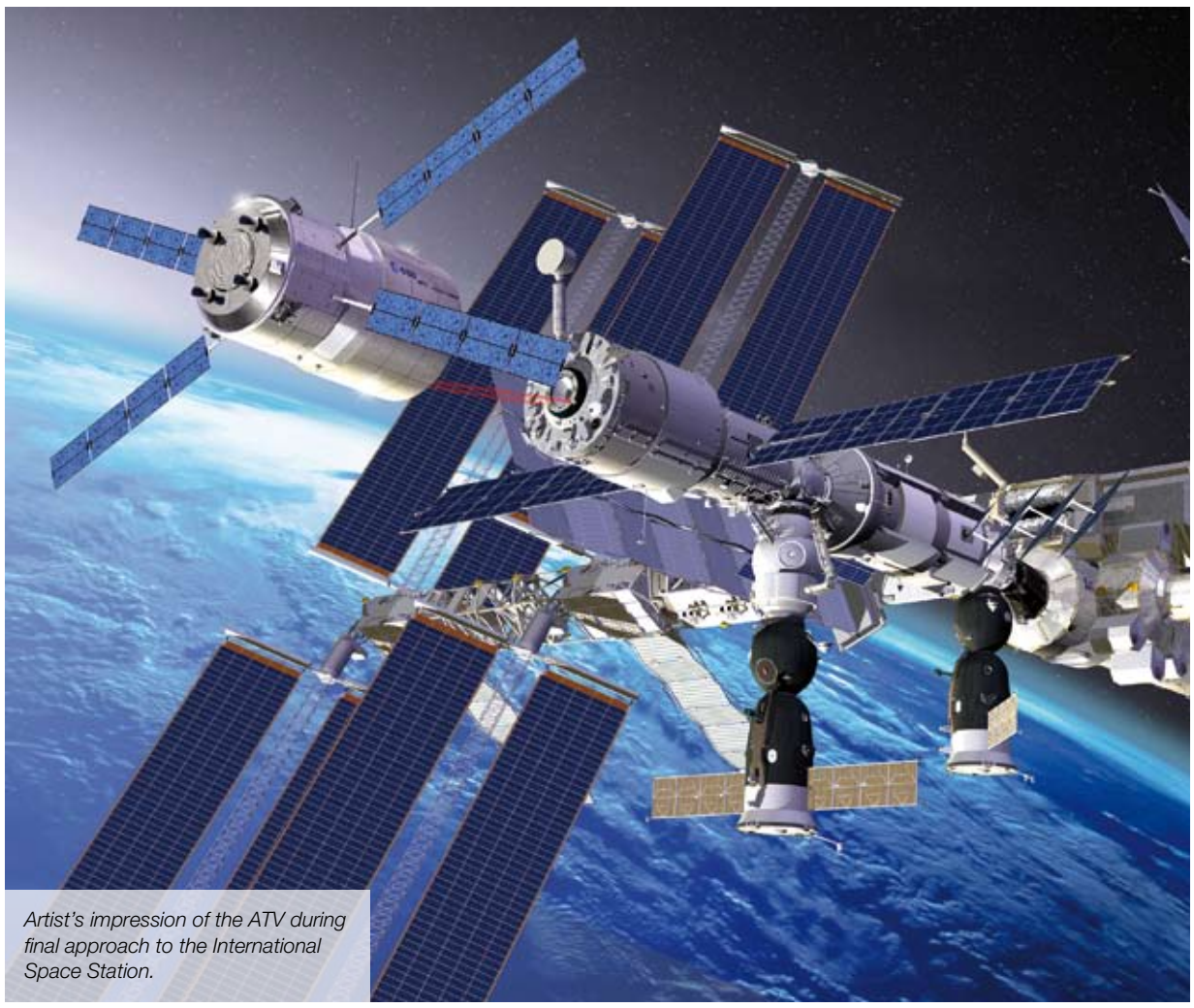
The 45 m³ pressurised volume of the ATV's Integrated Cargo Carrier is based on ESA's Columbus laboratory, which in turn is based on the Italian-built Multi-Purpose Logistics Module (MPLM).

Inside, it has room for up to eight racks loaded with modular storage cargo elements.

Its structure also incorporates several storage tanks for drinking water, refuelling propellant for the Space Station's own propulsion system, and air (oxygen and nitrogen) for the crew. The 'nose' of the cargo section contains the Russian-made docking equipment and the rendezvous sensors.

ESA's ISS programme manager Alan Thirkettle described the ATV "like a combination of a telecoms satellite, navigation vessel and a human spacecraft all rolled into one".

"As a logistics resupply vehicle for the Space Station, the ATV will be important from 2008 but it will be fundamental from 2011, once the Space Shuttle retires, when it will become the heavy lift vehicle for the ISS," he said.



Artist's impression of the ATV during final approach to the International Space Station.

Complex maiden flight for ESA's advanced cargo craft

The concept of a space tug or transfer vehicle for moving astronauts and equipment to different Earth orbits has been envisaged for decades by different space agencies – but the European-built Automated Transfer Vehicle is the most powerful spacecraft of its kind to date.

This highly advanced ESA-developed, new-generation spaceship has, by way of comparison, about three times the payload capability of its Russian counterpart – the Progress-M cargo vehicle.

Its cylindrical shape – 10.3 metres long and 4.5 metres in diameter – is covered with an insulating foil layer on top of meteoroid protection panels, whilst an X-shaped solar array resembles metallic blue wings and gives it the characteristic look of a dragonfly.

Internally, each ATV consists of two sections, the avionics/propulsion module (called the Service Module), and the Integrated Cargo Carrier, which links with the ISS.

Equipped with its own propulsion and navigation systems, the ATV is multi-functional, combining the fully automatic capabilities of an unmanned vehicle with human spacecraft safety requirements necessary for docking with the International Space Station.

The ATV Service Module has four main engines and 28 smaller ones for attitude control. After docking, it will perform Space Station attitude control and can also be used to desaturate the Station's gyroscopic attitude system and boost the complex's orbit to overcome the effects of residual atmospheric drag, or to perform debris-avoidance manoeuvres.

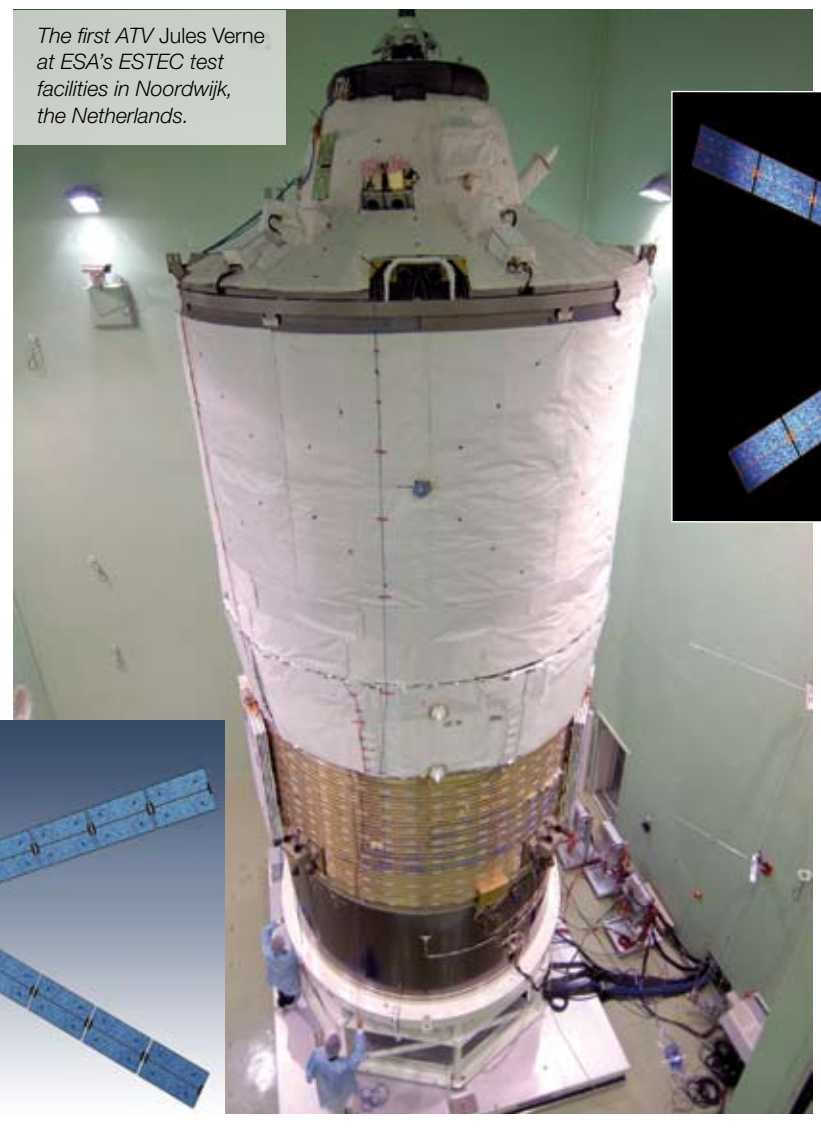
Each ATV will be launched from Europe's spaceport in French Guiana by an Ariane-5 and injected into a 51.6 degree orbit – the same as that of the Space Station.

The ATV will separate from its Ariane launcher 70 minutes after lift-off and activate its own navigation systems, becoming a fully automated spaceship on course for rendezvous with the ISS.

The maiden ATV flight will mark the first rendezvous and docking of a European spacecraft in orbit, and also the first European resupply mission to the Space Station.

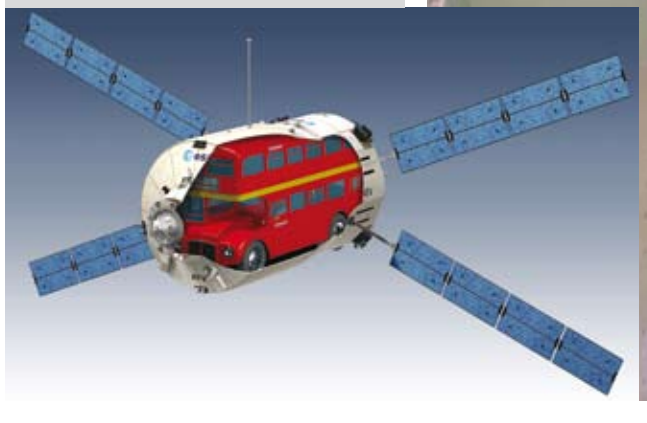
It is the most demanding and complex of five planned ATV missions and, to allow engineers to perform a series of detailed approach tests, it will be performed over 14 days – compared to 10 days for a normal mission.

Under the responsibility of the ATV Control Centre in Toulouse, France, the first mission will demonstrate that the ATV can automatically – and safely – fulfil all of its primary objectives: rendezvous with the ISS, resupply the orbital outpost and reboost its more-than-200-tonne structure.



The first ATV Jules Verne *at ESA's ESTEC test facilities in Noordwijk, the Netherlands.*

An artist's impression of how the ATV will appear in Earth orbit.



The ATV is about the size of a traditional London double-decker bus.

esa ATV - JULES VERNE

ATV's sophisticated mission control profile

During its final approach, the ATV flies along an accurate navigation path thanks to its innovative laser-based optical rendezvous sensors.

To compensate for the effects of atmospheric drag, the ATV's thrusters will be used to boost the Space Station's altitude at intervals of 10 to 45 days, as depicted in this artist's impression.

The purpose-built ATV Control Centre in Toulouse, France.

A typical Automated Transfer Vehicle mission will begin when the craft is launched into orbit by a specially modified Ariane-5.

After separation from Ariane, the ATV's navigation systems will be activated and engines fired to boost it into a transfer orbit – activities that will be monitored closely by the dedicated ATV Control Centre in Toulouse, France.

The cargo craft will come in sight of the International Space Station after up to 10 days in orbit when its computers will begin final approach manoeuvres over the next two orbits, eventually closing with the Space Station at a relative speed of a few centimetres a second whilst both vehicles orbit at around 28,000 kilometres an hour.

Docking will be fully automatic and, if there are any last minute problems, either the ATV's computers or the Space Station crew can trigger a pre-programmed sequence of anti-collision manoeuvres, fully independent of the main navigation system.

During the highly critical phases of an ATV flight – from launch to docking, and from departure to reentry – a 60-person team at the new ATV Control Centre will work in three adjacent control rooms closely monitoring the automatic approach procedures.

The French space agency (CNES) has responsibility for management of the Centre, coordinating and supporting all ATV operations on behalf of ESA.

The ATV's state-of-the-art automatic rendezvous system is made possible using a series of sensors. During the first part of its flight, a combination of Star Tracker and GPS data will be used.

The Star Tracker, able to recognise different constellations in the sky and use this information to calculate the spacecraft's orientation in space, and GPS – which gives positional information by measuring the angles between orbiting satellites – are the modern equivalents of centuries-old navigation techniques.

The spacecraft uses these to draw closer to the Space Station over a period of 10 days before switching to a different system for the high-precision docking, using a videometer's eye-like sensors combined with a completely separate parallel measurement system as a back-up to show that everything is going to plan.

The videometer will analyse images of its emitted laser beam, reflected by passive retro-reflectors located around the Russian docking port where the ATV will be attached.

The ATV Ariane-5 launch configuration.

During the last 20 metres of the final approach manoeuvre, the videometer will automatically recognise the retro-reflector's target patterns and then calculate the distance and direction to the docking port.

To add a safety margin, a secondary independent sensor – called a telegoniometer – will emit laser pulses at a different wavelength to the retro-reflectors. The travel time of the pulses gives the distance, whilst direction is given by the orientation of two built-in mirrors.

Describing the ATV as "the most complex and innovative spaceship" ever developed in Europe, John Ellwood, ESA's ATV project manager, said the cargo load on the first mission will be limited to five tonnes.

"We want to retain some flexibility for the various test manoeuvres that will be performed during the approach – in effect we will be doing a little 'dance' in front of the Space Station to demonstrate how accurate everything is," he explained.

With the ATV securely attached, astronauts can enter the cargo section and remove the payload – maintenance supplies, science hardware, parcels of food and family mail.

Its fuel and water supply tanks will be connected to the Space Station's own plumbing system and astronauts will manually release oxygen and nitrogen directly into the ISS.

ATVs will remain at the Space Station for up to six months, during which time the crew will steadily remove cargo and replace it with unwanted material.

Once its resupply mission is complete, the ATV hatch will be closed by the crew and later the spacecraft will be separated by ground command. Its engines will deorbit the spacecraft – not at the shallow angle used for the relatively gentle reentry of manned vehicles, but on a steep flight path to perform a controlled reentry under deliberately high forces of atmospheric drag, causing it to break up and burn high above the Pacific Ocean.

Spacecraft with built-in future potential

ESA's Automated Transfer Vehicle has been designed so that it can be the basis in the future for developing a wide variety of new space vehicles.

Several studies have looked at different scenarios, including replacing the pressurised cabin with a large cargo return craft and reentry shield which would be able to bring back cargo and valuable experiments.

Such a project could use the flight-proven concept of ESA's Atmospheric Reentry Demonstrator which flew successfully in 1998.

The ATV could also become a crew transport vehicle – which would require more complex modifications – whereby the pressurised cabin would be transformed into a manned reentry capsule for crew transportation.

This could be used, in a first phase, as a crew rescue vehicle for the Space Station, and later as a full up-and-down crew transport vehicle launched by Ariane-5.

Or there could be an unpressurised logistics carrier version for transporting several tonnes of equipment not requiring a pressurised environment.

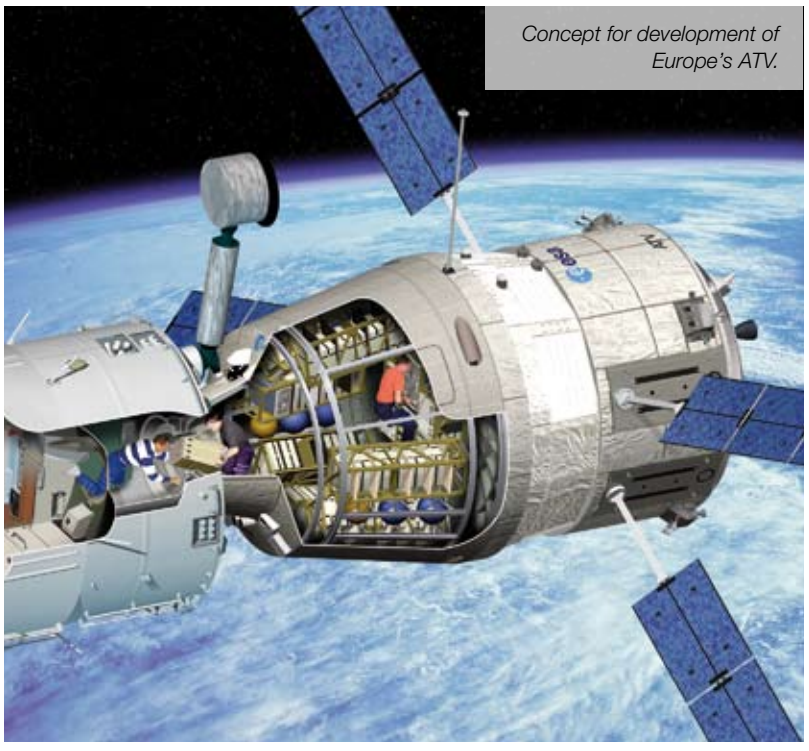
Another concept would involve equipping the core of an ATV with a small ejectable capsule able to return about 150 kg of cargo to Earth at the end of its mission.

The ATV could also be evolved into an unmanned free-flying laboratory able to dock periodically with the ISS for major servicing support. Such a free-flying, pressurised spaceship could also be used as a safe haven for an entire crew in case of an onboard ISS emergency.

Later, there might be the possibility of constructing a mini space station by equipping the ATV with two docking mechanisms – one in front and one in the back.

And further in the future, ATV could also be developed into a transfer vehicle for carrying tonnes of supplies and equipment – including space telescopes and planetary spacecraft – to lunar and Martian orbits.

Concept for development of Europe's ATV.



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European Space Agency, 8-10 rue Mario-Nikis, F-75738 Paris Cedex 15, France
For further information:
ESA Communication Department **tel:** +33 (1) 5369 7155 **email:** contactesa@esa.int

www.esa.int/atv
www.esa.int/spaceflight
www.esa.int/columbus

pictures & photos:
ESA/NASA
writing & design:
Clive Simpson

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