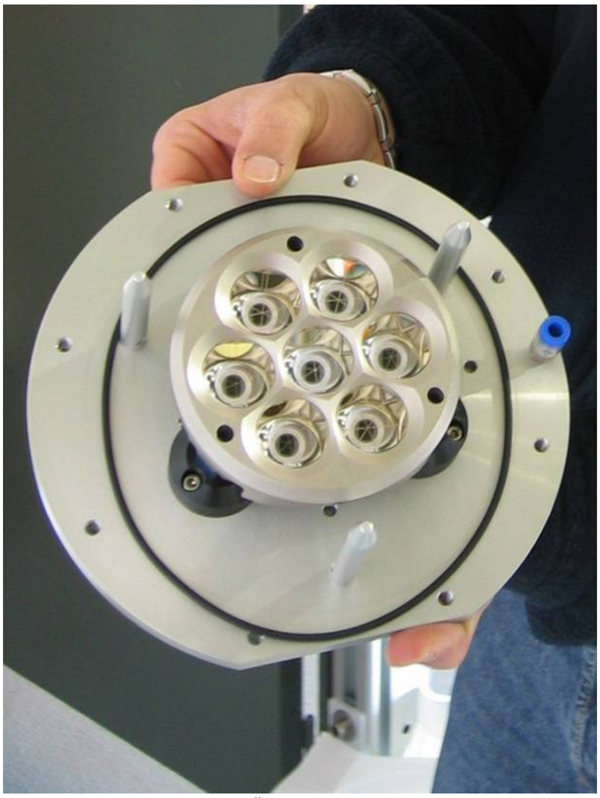
Rendezvous and Docking Technology

From a distance of around 30 km from the ISS the ATV will use relative GPS in order to close in on the ISS up to a distance of 249 m. Hereafter the ATV will use a brand new European-built technology called a videometer, together with additional data from telegoniometers, to successfully rendezvous and dock with Russian Zvezda Service Module of the International Space Station.



Retroreflectors (Image: ESA)

Elements of the ATV's rendezvous and docking system known as retroreflectors are located on the aft end of Zvezda. The videometer on the front of the ATV emits pulsed laser beams, which are passively reflected by these retroreflectors resulting in unique light patterns. The videometer analyses the image formed by the pattern of light spots. This image processing provides the ATV with its relative position and orientation to the ISS, thus allowing it to identify, approach and mate to Zvezda's docking mechanism.

Two sets of different patterns of retroreflectors are installed at very precise locations on the Zvezda Service Module. One is a large 1.5 m sided triangular shape and the other a smaller pyramidal shape 8.5 cm in height.

On the mobile platform simulating Zvezda (right), a set of retroreflectors are facing sensors mounted on an articulated industrial robotic arm simulating the ATV (left). The relative motion between the two is identical to the one expected when the ATV docks with the ISS. (Image: ESA)

Each of the 26 retroreflectors, which looks like a small 2.5 cm cube, has the capability to reflect the laser beam exactly in the direction it was sent from. The precision of these optical devices is such that the reflection of the beam does not deviate by more than 3 mm over a distance of 300 m.

The Jules Verne videometer. (Image: ESA)

Engineers monitor ATV rendezvous testing at Europe's largest ship hull test facility, 100 km west of Paris in 2006. (Image: ESA)

The Jules Verne videometer is designed and manufactured by Sodern, a subsidiary of EADS, in Limeil-Brévannes, a Paris suburb. All ATV spacecraft will have two identical videometers, installed 20 cm apart on the front of the ATV. Both are active during rendezvous with one acting as a back-up.

To add redundancy and a safety margin to the critical rendezvous operations, a secondary sensor - called a telegoniometer, which is totally independent and parallel to the videometer – will also be used. The telegoniometer, which works in a similar way as a radar, will continuously calculate the distance and direction from the ATV to the ISS.

ESA and EADS managers observing ATV rendezvous testing in August 2006. From left to right: Nicolas Chamussy, ATV Programme Manager for EADS, Jean-Jacques Dordain, Director General of ESA, John Ellwood, ESA's ATV Project Manager, Michael Menking, V.P. Orbital and Reusable Systems at EADS, Daniel Sacotte, ESA Director of Human Spaceflight and ESA astronaut Jean-François Clervoy, senior advisor to the ATV programme. (Image: ESA)

Like the two videometers, two telegoniometers (one back-up), located on the ATV front cone, emit laser pulses (at a different wavelength to the videometers) towards the retroflectors on the ISS. The travel time of the pulses, which are reflected back, gives the distance between the two spacecraft. The direction from the ATV to the ISS is given by the orientation of the telegoniometers' two built-in mirrors, which rotate to aim the laser towards the retroreflectors.

The distance and direction information from the telegoniometer can be compared to that obtained via image processing using the videometer. However, only the videometer can compute the orientation of the ISS. Activated at the same 250 m distance from the ISS, the telegoniometer's radar-like pulses provide 10 000 hits per second, whereas the camera-like videometer illuminates its objective from once per second to 10 times per second as it approaches its target.

Artist's impression of the ATV targetting a laser beam at the ISS. (Image: ESA/D.Ducros)

In support of these two independent systems, each with its own back-up, additional data/ monitoring capabilities are also provided by the Russian Kurs radar-based system within the final 3 ½ km to docking with visual imagery provided by a video camera on Zvezda for the final 500 m. Imagery is also available from US cameras in a distance from 1 km to 250 m from the Station.