German Aerospace Center

DLR ROKVISS robotic arm returns from space

28 September 2011

The ROKVISS (Robotik-Komponenten-Verifikation auf der ISS - Robotic Components Verification on the ISS) technology experiment developed by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has returned to Earth after six years in space. The DLR Institute of Robotics and Mechatronics took delivery of the robotic arm in Oberpfaffenhofen a few weeks ago. The results from the initial functional tests are now available; ROKVISS dealt with operations on the exterior wall of the International Space Station (ISS) without any problems - to the absolute delight of the experts.

"It is almost unbelievable; the robotic system is functioning just as well as it did on the first day - no rattles, no unusual noises from the gearbox, and the joints are moving completely smoothly. It is as though ROKVISS had never left the laboratory," reports project leader Klaus Landzettel from the DLR Institute of Robotics and Mechatronics. The surface of ROKVISS is also intact; there are no signs of impacts or other damage. Only the colour of the 50 centimetre / 7 kilogram robotic arm has changed – from grey to light brown in one place.

Expectations exceeded

ROKVISS was brought back to Earth and delivered by the Russian spacecraft component manufacturer RKK Energia and the Central Research Institute of Robotics and Technical Cybernetics in Saint Petersburg, which also participated in the investigation and analysis of the robotic system. This work was carried out under a close German-Russian collaboration.

However, before the DLR researchers could switch ROKVISS on, they needed to reassemble the robotic arm (which had been partially dismantled for the return journey) and carry out initial functional tests to check the electronic system. The preparation phase was expected to last two days, but in just two hours the system was ready for operation. "The success of the ROKVISS mission far exceeded our expectations," concludes Landzettel.

Return on Soyuz

One peculiarity of the mission was the transportation method used; ROKVISS was included in the payload of a Soyuz spacecraft, alongside astronauts returning to Earth. As the case provided was too small for the entire robotic arm, it had to be disassembled into several parts by the ISS crew. To accomplish this, DLR researchers devised precise instructions for the astronauts to remove ROKVISS during extravehicular excursion and then disassemble the joints step by step in a specific order. Once it was taken apart, the robotic arm fitted exactly into the 47 × 16 × 16 centimetre transportation container.

The future of robotics

The results of the current tests confirm that the techniques developed by the DLR Institute of Robotics and Mechatronics are ideally suited for use in space. The technology used in the robotic arm, which was controlled via a joystick with force feedback, has been proven in over 500 trials on the ISS. Future missions will now benefit from this reliable system. This is particularly applicable to the Deutsche Orbital Servicing Mission (DEOS), planned for 2015 and designed to capture defective satellites with a robotic arm and dispose of them in a controlled manner. The researchers can also use the knowledge acquired from ROKVISS to prepare the humanoid robot Justin for use in space.

Significance for science

ROKVISS is the first complex mechatronic system to be returned to Earth after long-term use in space and be available for subsequent investigation. During its six-year period in space, DLR researchers developed and executed measurement processes to detect changes in the robotic system because installing a robotic arm on the exterior wall of the ISS meant exposing it to temperature fluctuations of -20 to +60 degrees Celsius, 16 times a day. Furthermore, the vacuum of space causes difficulties with the thermal control of the overall system.

The developers can now go one step further and see the effects of the shift from Earth's atmosphere to a vacuum. Are certain effects reversed when the system re-enters the atmosphere from space? This primarily concerns materials and the inner workings of the robotic system - transmission friction and the lubricants and adhesives used. Additional tests on ROKVISS are planned in the coming weeks, when the technology experiment will be fully disassembled into its individual components and analysed together with Russian colleagues.

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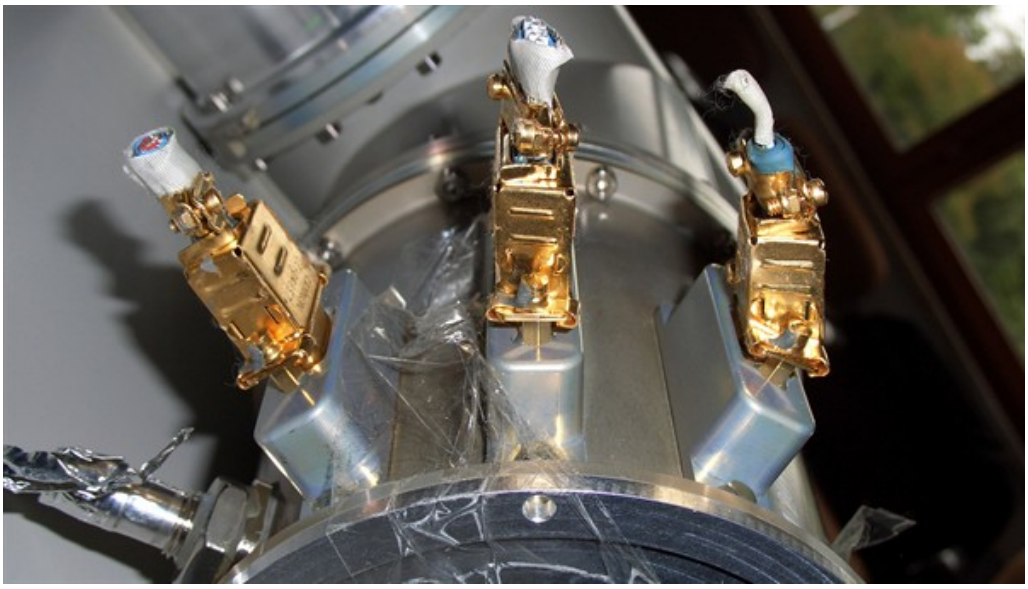
Connectors on ROKVISS



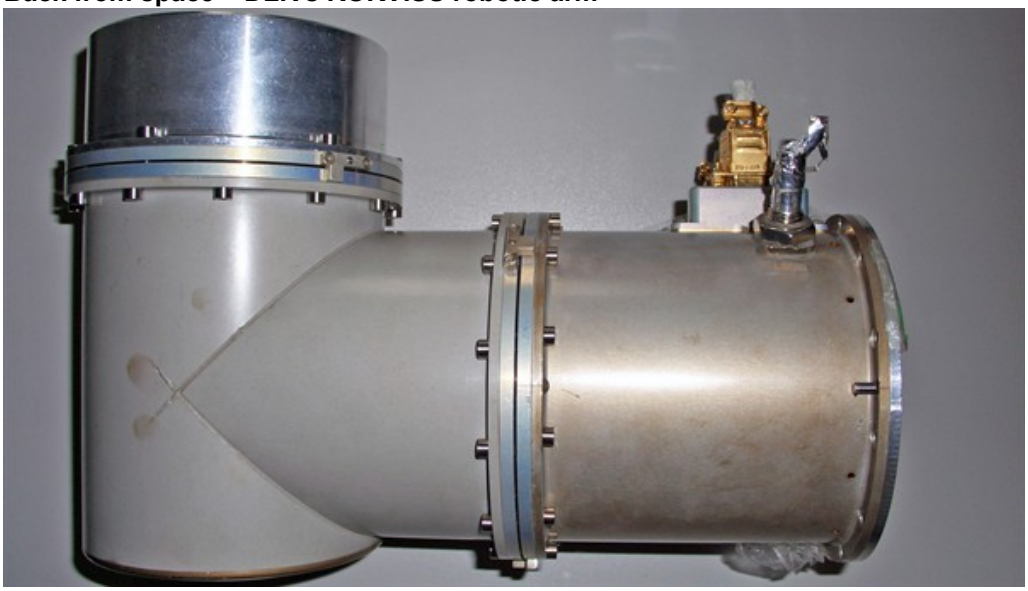
DLR's ROKVISS robotic arm is equipped with four connectors – for heater power, data, power for the arm itself and video data (from right to left in the image). For its transport back to Earth, the astronauts were instructed to cut the cables – to simplify dismantling aboard the ISS.

Delivery of ROKVISS to DLR Oberpfaffenhofen

Alexander Silinenko (right), from the Central Research Institute of Robotics and Technical Cybernetics in Saint Petersburg, hands ROKVISS to Klaus Landzettel (left) from the DLR Institute of Robotics and Mechatronics. Also present are representatives of the spacecraft component manufacturer RKK Energia, Moscow, which was responsible for dismantling ROKVISS and transporting it back to Earth in a Soyuz spacecraft.

Credit: DLR (CC-BY 3.0).

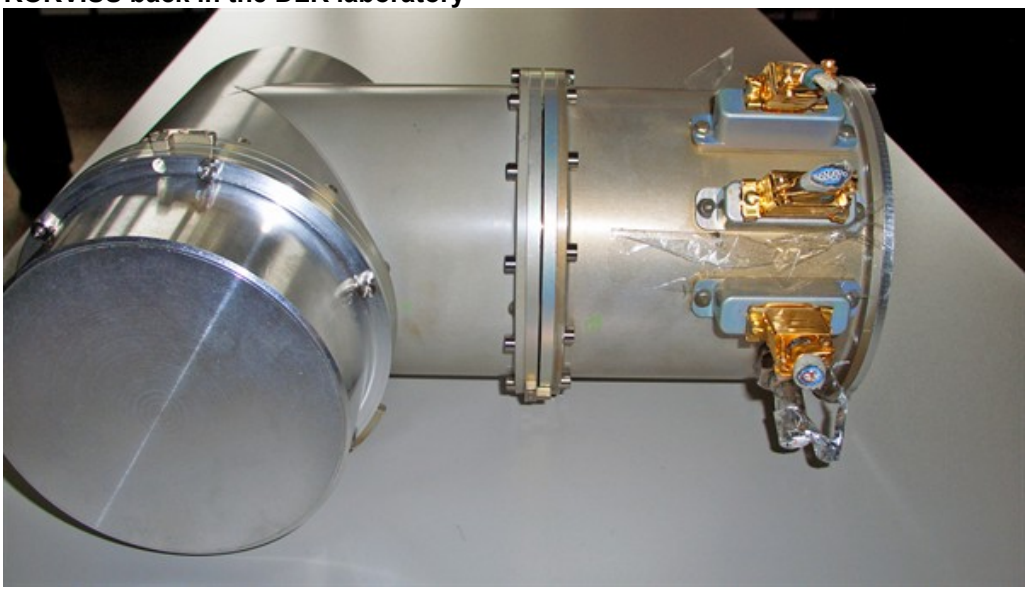
Back from space – DLR's ROKVISS robotic arm



DLR's ROKVISS robotic arm has returned to Earth after six years in space. Tests currently being performed at the DLR Institute of Robotics and Mechatronics show the system to be functioning as well as it did when new.

Credit: DLR (CC-BY 3.0).

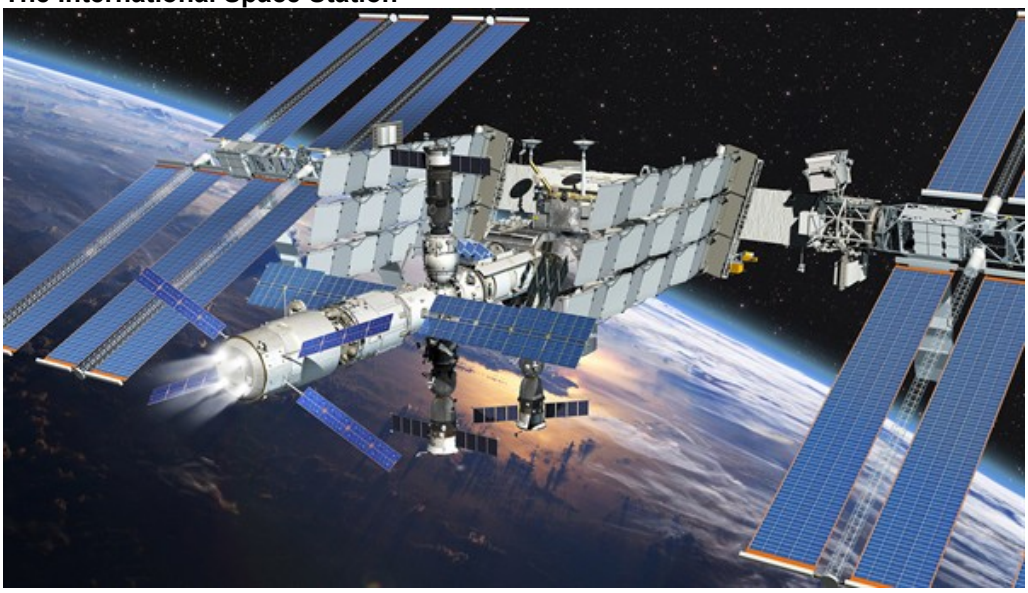
ROKVISS back in the DLR laboratory



DLR's ROKVISS robotic arm shows no signs of external damage. The results of tests now being conducted confirm that the technologies developed by the DLR Institute of Robotics and Mechatronics are well suited for use in space.

Credit: DLR (CC-BY 3.0).

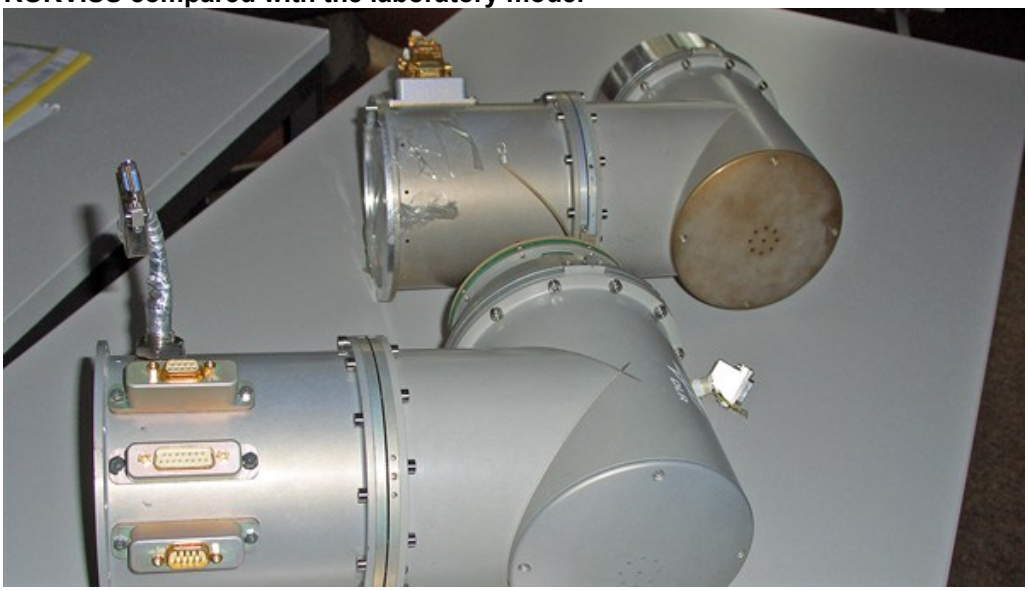
The International Space Station



The experimental ROKVISS system spent six years in use on the exterior of the International Space Station. In more than 500 successful test operations, the DLR project team at Oberpfaffenhofen had the robotic arm perform a variety of motion sequences; it was controlled using a joystick with force feedback.

Credit: ESA.

ROKVISS compared with the laboratory model



ROKVISS models compared – the robot arm returned from space (rear) and the laboratory model (front). Only the brownish discoloration of the 'real' ROKVISS shows its use on the exterior of the ISS.

Credit: DLR (CC-BY 3.0).

Transport container

The technology experiment was returned to Earth as payload on a Soyuz spacecraft – packed in this container. A cardboard model of ROKVISS can be seen in its interior. DLR researchers devised a way to disassemble the robotic arm so it would fit exactly into this small transport container.

Credit: DLR (CC-BY 3.0).

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