German Aerospace Center

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New German ROKVISS robot experiment on the ISS

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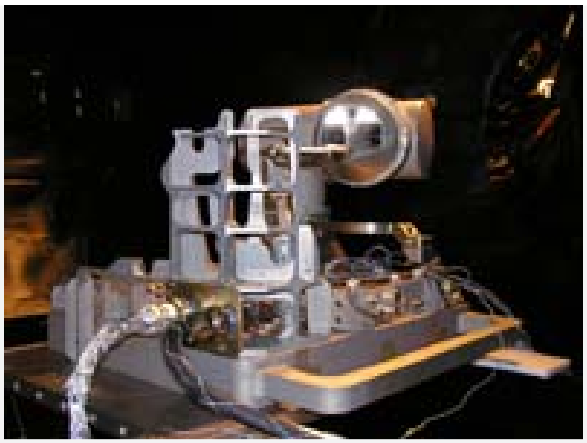
Testing intelligent hinged robot units for future manned and unmanned missions

The aim of the German ROKVISS (RObotic Components Verification on the ISS) experiment is to test highly integrated, modular robot components under the conditions experienced in space. The experiment has been developed by the German Aerospace Center (DLR) in the Oberpfaffenhofen-based Institute of Robotics and Mechatronics. At the same time, the experiment also serves to demonstrate various new control procedures in both automatic and so-called telepresence mode. The experimental flight unit will be installed on the International Space Station (ISS) in January 2005 following the launch of a Russian spaceship called Progress in December 2004. The experiment will be run on the station for about one year.



The intelligent lightweight hinged robot units from the ROKVISS experiment

The components used will form the basis for new lightweight robot elements which it is hoped will be used on future manned and unmanned space missions.

At its heart the system consists of a robot arm with two hinges, a 'metal finger' at the end of the arm, a stereo video camera and a mono camera. These elements are fitted on a basic platform on the outside of the Russian Service Module (SM) on the ISS. The base plate also accommodates electronic boxes for power distribution and image processing and a special experimental contour that is used for dynamic motion experiments on the robot and for tests on the hinge parameter settings. The robot's hinges and the cameras are controlled by a central experiment computer inside the ISS.

Control from Earth in telepresence mode

When in non-automatic mode, so-called telepresence mode, the experiment is run by an operator on the ground. This is only possible when the ISS is passing through the range of transmission and vision of the ground station in Weilheim, south-west of Munich. When in this range, a high-rate S-band link belonging to the ROKVISS ensures communication between the station and Earth and vice versa. The images taken by the stereo camera onboard the ISS are transferred to the operator's screen while the forces impacting on the robot and its hinge positions are also transferred at the same time. The forces can be sensed on the joystick used by the operator. The mono camera, secured to the head of the robot arm, can check the condition of the ISS at close range and take pictures of Earth.

Telepresence mode is only available during the phase of direct radio contact between Earth and the space station. The forces measured on the sensors' hinges are transferred directly to the operator's joystick. This mode requires an exacting up-and-down-link for the robot and video data. The maximum time delay for all data transfers is no greater than around 10 milliseconds.

Automatic mode is used during the phase in which there is no radio link from the station to Earth. During this time, the experiments are controlled by the experiment computer onboard the ISS and the experiment data saved for subsequent analysis.

ROKVISS –German aerospace skills

The project is being financed by DLR with funding from the German Ministry of Education and Research (BMBF). The hardware and software has been developed and built by EADS Space Transportation in Bremen, acting as the main contractor, and the DLR Institute of Robotics and Mechatronics in Oberpfaffenhofen, which is responsible for the robot components, running the experiments and scientific evaluation of the results. Kayser-Threde from Munich is assuming responsibility for the development and construction of the experiment's computer and power supply as well as providing the DLR institute with technical support. Hoerner & Sulger are supplying the camera equipment and electronic accessories. Project management is being handled by DLR's space agency. Implementation of this mission is based on an agreement between DLR's space agency, the Russian partner Roskosmos, RKK Energia and Munich-based Kayser-Threde, which is also acting as the main contractor for the S-band communication infrastructure.

ROKVISS – the ambitious space experiment

For reasons associated with cost and safety, robot applications in space require the use of lightweight elements which must offer a high degree of mobility and interactivity. The ratio of the load the robot has to move to its own weight should wherever possible be 1:1. The new robot concept developed by DLR is designed as a modular system, comprising the basic elements, the intelligent hinge drives and the electronics. The experiment aims to investigate and test highly integrated lightweight robot elements under the real conditions of space along with new control procedures for automatic operations and online control by an operator. System development is based on robot components already used on Earth.

ROKVISS – the complex and complete system

The ROKVISS system consists of several main components:

External flight unit
The basic platform is fitted to the outside of the ISS, on the Russian Service Module (SM) on what is known as the universal workstation. It was installed by the cosmonauts when they were working outside the station. The robot arm, along with its two highly integrated hinges, are fitted on the platform, at the end of which are the camera systems. The stereo camera transfers images of how the experiment is proceeding while the mono camera is used for observing at a distance. Other electronic units, such as power distribution and image processing, are also located on the platform.

These are joined by the S-band communication unit with antenna, telemetry and telecommand box as the data transmitting and receiving station for controlling the experiment. Kayser-Threde is the contractor responsible for this unit. The contour also fitted on the platform is used to run the experiments, i.e. to shut down paths and undertake contact operations in automatic and telepresence mode.

Internal flight unit
The ROKVISS onboard computer controls all the external flight unit's elements and therefore all the operations undertaken by the robot. It is also the link to the Russian control system and to the ROKVISS S-band communication unit.

Ground station
The flight system is controlled and monitored by the transmitting and receiving station of DLR's Space Operations Centre in Weilheim, southern Germany. The ROKVISS ground control unit is also situated here. This consists of a joystick with force feedback, the computers for path generation and image processing and a 3D virtual reality-based image projection unit.

ROKVISS – high levels of flexibility provided by the different operating modes

Telepresence mode
To repair satellites and perform other service tasks in space, it is absolutely essential that the operator can be included in the control circuit and a rapid data circuit is key to this. During the direct space-to-Earth data link, the robot experiment can be controlled directly from Earth. This mode requires what is known as a deterministic, very fast up-and-down link between the ISS and Earth-based control centre in order to transfer control and video signals. The signal time (physical runtime and time required to process the data) on this link should be kept to a minimum. In other words, operations are in real-time. When in this mode, there is direct force feedback between the station and Earth. When combined with

the stereo video images transferred from the station, the data gives the operator a real impression of the processes taking place on the robot system on the ISS.

Automatic mode
When in this mode, the robot is controlled automatically by the experiment computer. The data for automatic mode are saved on-board and transferred to the ground station for analysis once the experiment is complete. This is done during the next phase of radio contact following the experiment.

Prospects – what is the next step for space robotics after ROKVISS?

The main aim of the development project and experiment is to produce a blueprint for a new complex robot for use with service robots in space. An initial application for this is the TECSAS (Technology Satellite for the demonstration and verification of Space systems) mission. Once the feasibility investigation was completed, the definition phase of this project was begun in October 2004. The project is being run in conjunction with the Russian Space Agency, the Russian company Babakin Space Research Centre in Moscow, German companies and institutes and the Canadian Space Agency (CSA).

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