AUTOMATION AND ROBOTICS IN SPACE FOR SATELLITE SERVICING AND EXPLORATION AT KAYSER-THREDE

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1. INTRODUCTION

Kayser-Threde is active in Space A & R since more than a decade.

The projects encompass science and technology topics for on-orbit servicing and exploration such as

- Dextrous robots on the Space Station and small satellites
- Commercial satellite servicing
- A & R for unmanned and manned missions to moon and mars

Recent projects are shortly described below.

2. PROJECTS

2.1. TEF (Technology Exposure Facility)

TEF stands for a robotically serviced "Technology Exposure Facility" on the ISS.

TEF was first studied and proposed to the European Space Agency by Kayser-Threde in about 1995. While the robot arm then was based upon a Tecnospazio-Italia design, the end-effector, gripping tool, hold down mechanism and S/W architecture was designed by Kayser-Threde with the Institute for Robotics and Mechatronic DLR-RM of the German Space Research Institution DLR. This project unfortunately did not realize.

A follow-on study, called MISSISS, was performed in a team with EADS-ST, Bremen and DLR-RM.

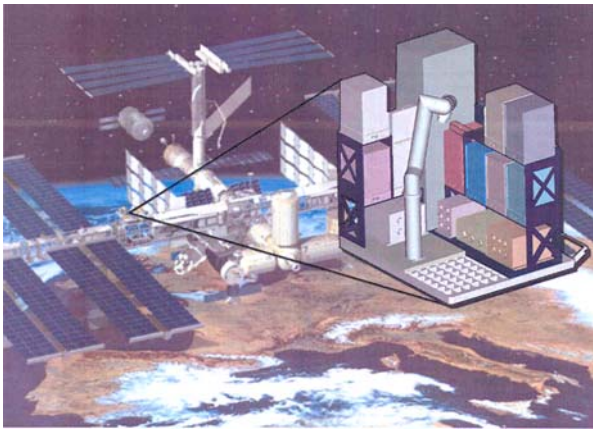

FIG. 1 Study of the robotically serviced Technology Exposure Facility on the ISS by Kayser-Threde

2.2. ROKVISS (Robotik Komponenten Verifikation auf der ISS)

ROKVISS is based upon a Kayser-Threde proposal to DLR to fly a technology and public outreach demonstration project on the Russian segment of the ISS using the DLR-RM developed lightweight robotic joints (called ROTEC at that time). ROKVISS is mounted on an external structure on the ISS-Russian Segment with an independent communication unit (CUP = "Communication Unit for Payloads") under a separate contract between Rosaviakosmos/RSC Energia and DLR/Kayser-Threde.

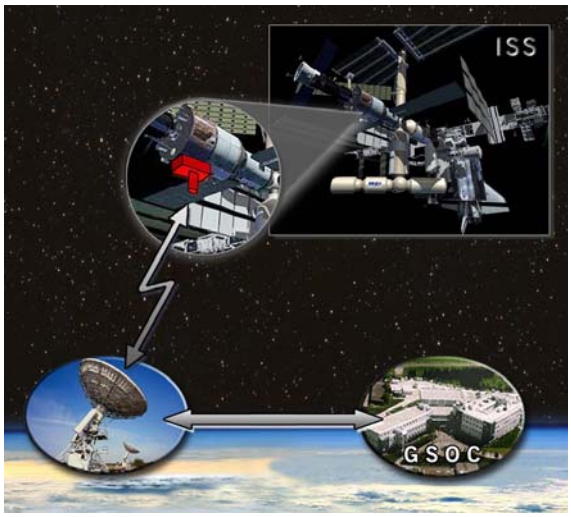

FIG. 2 ROKVISS Configuration: Space and Ground Segment

Kayser-Threde major tasks in ROKVISS are

- Support and supervision of DLR-RM in design, PA/QA, parts procurement and quality, safety and manufacturing questions regarding the ROKVISS joints
- Design and manufacturing of Power Distribution Unit for robot and vision system
- Design and manufacturing of Onboard Computer (OBC)
- Design and development of onboard and ground software for real-time communication link between ISS and Weilheim ground station: 4Mbit downlink, 256 kbit uplink, round trip time less than 20ms
- Interface responsibility to the platform incl. the communication infrastructure.

ROKVISS is in nominal operation since April 2005. Impressive results and excellent performance were achieved, see Ref [1], [2].

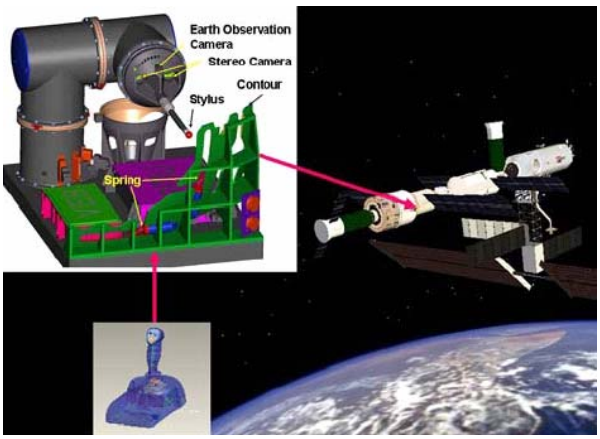

FIG. 3 ROKVISS Manipulator with the contour following experiment on the ISS

2.3. CX-OLEV

ConeXpress Orbital Life Extension Vehicle (CX-OLEV) is an orbital "tugboat" that will supply the propulsion, navigation and guidance to maintain a telecom satellite in its proper GEO slot for 10 or more additional years. CX-OLEV also can be used to rescue spacecrafts that have been placed in a wrong orbit by their launch vehicles, or which have become stranded in an incorrect orbital location during positioning manoeuvres.

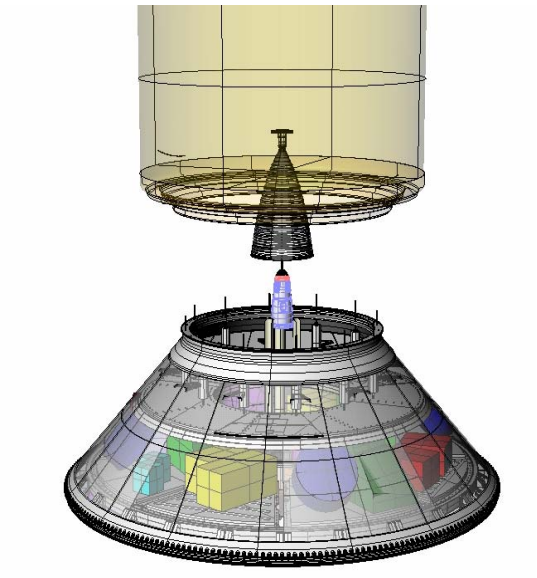

FIG. 4 CX-OLEV configuration: Client and CX-OLEV in parking position

Kayser-Threde is responsible for the docking payload of CX-OLEV, the heart of the system.

Kayser-Threde major tasks in CX-OLEV are

- Analysis of the docking scenario and establishment of requirements for the Docking Payload and the operational concept
- Engineering of the Docking Payload subsystems
- Vision System for docking monitoring with stereo cameras
- Target Illumination System to provide orbit independent visibility of the docking maneuver
- Capture Tool Deployment Mechanism used to deploy and retract the Capture Tool during docking
- Client Support Mechanism used to provide mechanical support of the client in the docked position
- Docking Payload Control Unit hardware and software
- Support and supervision of DLR-RM in design, PA/QA, parts procurement and quality, safety and manufacturing questions regarding the Capture Tool.

CX-OLEV is a public-private-project presently in phase B.

2.4. TECSAS

The Technology Satellite for demonstration and verification of Space system (TECSAS) shall demonstrate the availability and advanced maturity of servicing system technologies including approach and rendezvous, inspection fly around, capture and stabilization of the coupled satellite pair, manipulation of the target satellite, ground control via telepresence and autonomous operations, etc.

TECSAS is a joint DLR/CSA/Babakin project, presently in phase B with EADS-ST, KT, vH-S and DLR-RM in Germany.

FIG. 5 TECSAS Configuration (from BSC Mission Description Technical Note)

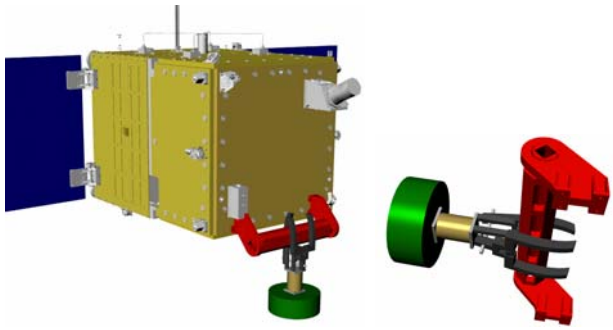

FIG. 6 TECSAS Gripper Concept with Quicksat handle

3. KAYSER-THREDE EXOBIOLOGY PAYLOADS IN LOW EARTH ORBIT

Kayser-Threde has developed respectively is developing at present various Exobiology Payloads in the low earth orbit.

The working horse for exobiology research is BIOPAN, which is a pan-like exposure facility and flies on a unmanned Russian retrievable FOTON spacecraft. Various samples are exposed to space environment by opening the lid in space. The 4th flight of BIOPAN took place in 2005. For details we refer to Ref. [3].

FIG. 7 BIOPAN (FOTON)

In addition, two exposure facilities are under construction to fly on the International Space Station ISS, EXPOSE (ISS) and a EXPOSE-RS on the Russian Segment, see Ref. [3].

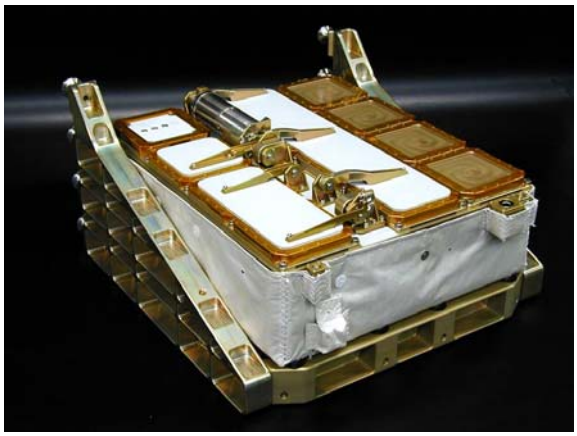

FIG. 8 EXPOSE (ISS)

For MARS an Exobiology Multi User Facility has been studical a few years ago, followed by a ExoMars Phase A study for the so-called PASTEUR ExoMars payload, see Ref. [s].

4. KAYSER-THREDE'S EXPLORATION ACTIVITIES

Kayser-Threde is also very active in A & R for planetary, i.e. Mars exploration. As example Kayser-Threde led the phase A ESA study Exobiology Package for Mars, the ESA study A & R for (Human) Mars Exploration with many subcontractors spread over Europe, and covering the whole range of A & R tools for planetary exploration, see Ref. [4].

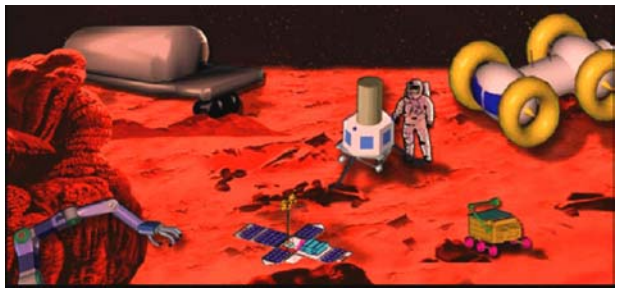

FIG. 9 and FIG. 10 Automation and Robotics for Human Mars Exploration, Ref. [4]

Other examples are recent studies for the envisaged Mars sample return mission:

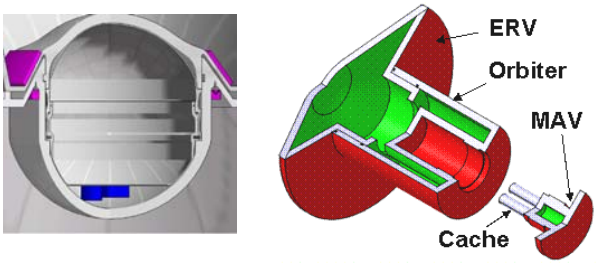

FIG. 11 Mars Sample Return Container (Sealing Technology)

Regarding the ExoMars Mission, Kayser-Threde aims to lead the PASTEUR Payload Integration in the frame of the planned ESA ExoMars Mission. Major interests also exist in the ROVER vehicle, in conjunction with various industrial and institutional partners in Germany, such as e.g. von Hoerner & Sulger, DLR Institute for Robotics and Mechatronic.

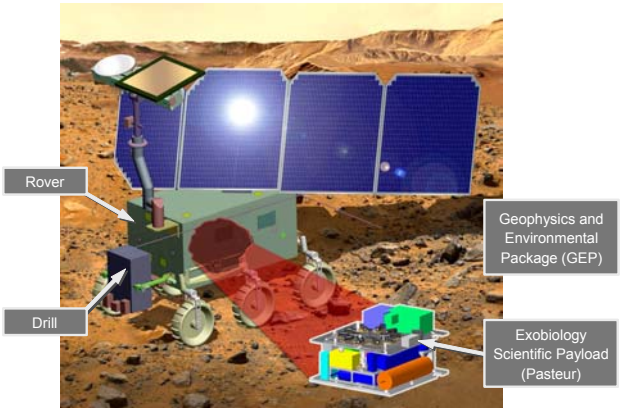

FIG. 12 The ROVER and PASTEUR Payload as studied by Kayser-Threde and MDA Canada for ExoMars

5. SUMMARY

A & R is a key element in the German Space programme. Kayser-Threde is well positioned for a leading function both for on-orbit servicing and Mars exploration.

The close cooperation with competent partners is a key element of these activities.

6. REFERENCES

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[4] Hofmann, P., Richter von, A.: Automation and Robotics for Human Mars Exploration (AROMA), 53rd International Astronautical Congress, Houston, USA, Oct. 10-19, 2002 (IAC-02-IAA.13.3.05)