DLR‘s Robotic Technologies for Space Debris Mitigation and On-Orbit Servicing

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On Orbit Servicing and Space Debris

Space Robot Assistance

Planetary Exploration
On Orbit Servicing

Robotics provides a scalable technology:
- from simple tasks like
deorbiting
space debris removal
- over maintenance and repair
- to complex assembly assistance functions
new ISS?
future manned Mars spacecraft
Space Debris Mitigation and on Orbit Servicing

Robot technology can handle both
- service and repair
- space debris mitigation

DLR DEOS mission
Space debris in LEO: Increase of future population

- Cascading effect starts to increase space debris even w/o any launches

→ Only way to limit increase is to actively remove objects from LEO

(source: NASA)
ROTEX - The first remotely controlled Robot in Space (1993)

IEEE Judith A. Resnik Award

1994 – JOHANNES DIETRICH
Inst. Robotics & Syst. Dynamics - Wessling, Germany

'For development of a successful high-performance, rugged, multi-sensor, miniaturized robotic gripper for use in the outer space environment.'
GETEX / ETS-VII 1999

- Target (0.4t)
- Chaser (2.5t)
- Launched by H-II rocket on Nov. 28, 1997
Dynamic Motion Experiment
How does an Robot interact with the Satellite and affect its attitude control?
Preparing light weight Robots and Hands for Space Application

Requirements:
- low weight
- low energy consumption
- In size and agility comparable humans (antropomorph)
JUSTIN System:
Weight: 45 kg
DoF: 43
Control Loop: 1kHz

Head:
DLR 3D Modeller
Stereo Camera
Laser Scanner and Stripe Projector
3 DoF

2 DLR Light Weight Arms (left and right)
7 DoF each

Torso:
4 Joints / 3 actuated

2 DLR Hands in left and right configuration
12 DoF each
ROKVISS
Roboter Komponenten Verifikation auf der ISS
Technology Validated in ROKVISS 6 Year Mission on ISS

Final highlights

- Remote control „from home“
- return of the robot down to earth for wear analysis
The DEOS Mission

Mission statement
- Locate and approach a client satellite
- Capture a tumbling, non-cooperative satellite using a manipulator mounted on a free flying service-satellite
- Demonstrate servicing tasks: refuel, module exchange etc.
- De-orbiting of the coupled satellites within a pre-defined re-entry corridor
Robotics Sub-System

- Observation of client motion
- Identification of dynamic parameters
- Motion estimation
- Path-planning
- Path-control including visual-servoing
- Decay the motion between servicer and client
Hardware in the Loop Simulatoren

EPOS – simulation for approaching

DEOS-Simulator

simulation of grasping and manipulation
Communication paths and corresponding round trip times

- **Relais satellite in GEO**: 20 ms
- **Spacecraft in GEO**: 250 ms
- **Spacecraft in LEO**: 500 ms
- **Spacecraft in LEO**: 20 ms
Tele-Presence Operation with Time Delay
ENVISAT
Possible Capture Methods  (Subset only)

Antenna  Structure  Adaptor
DEOS (Start 2017) – main DLR OOS Mission
Is a Swift, Low-Cost Mission Feasible?

**Small, swift** project based on DEXHAND and BIROS possible as precursor mission?
(small arm, drag sail and tether for de-orbiting)
THANK YOU FOR YOUR ATTENTION!