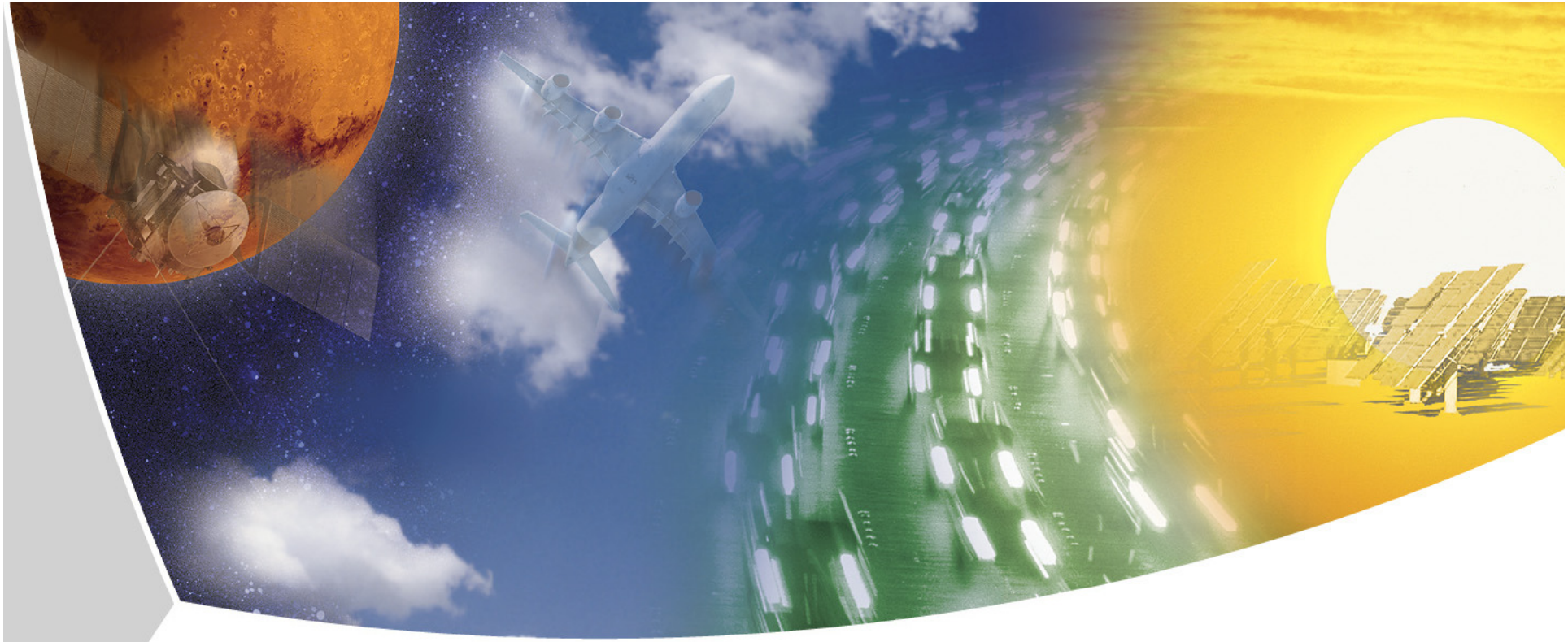

DLR‘s Robotic Technologies for Space Debris Mitigation and On-Orbit Servicing

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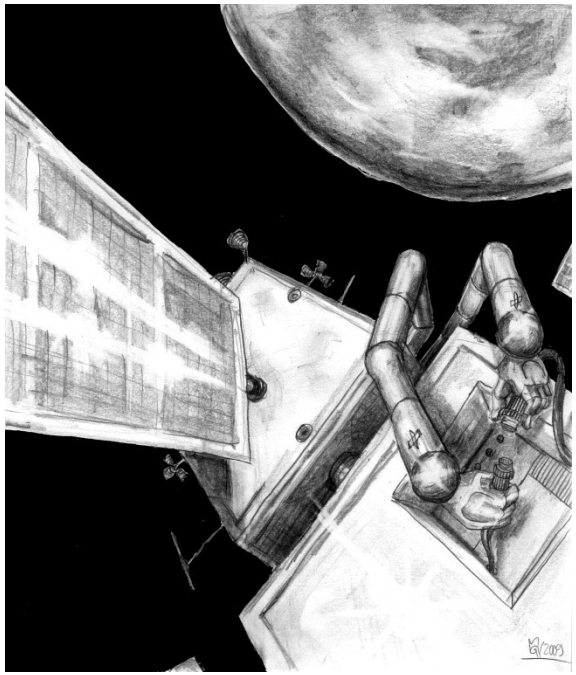
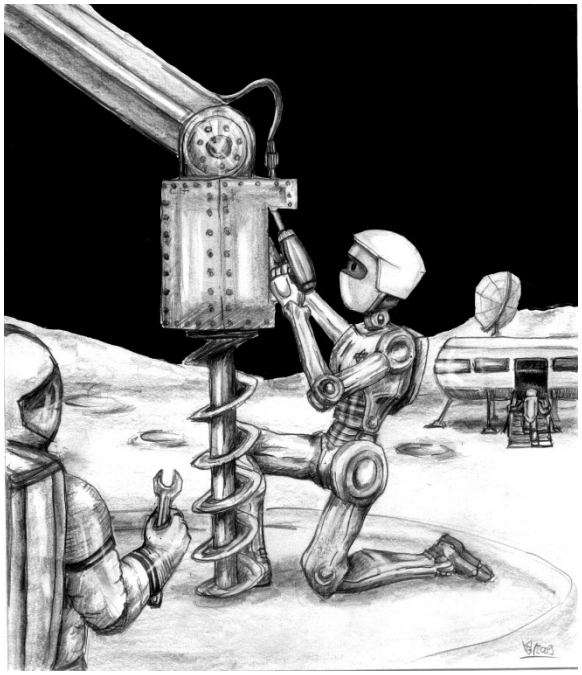
in der Helmholtz-Gemeinschaft

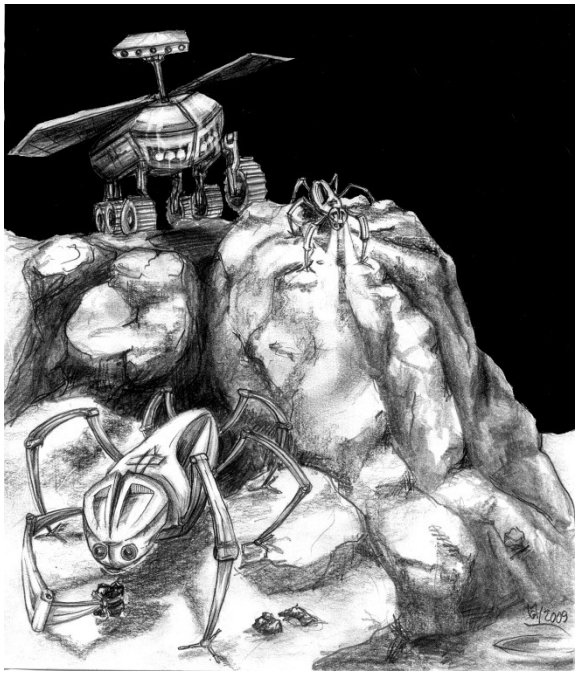
Space Robotics Application Scenarios at the German Aerospace Center (DLR)



On Orbit Servicing and Space Debris



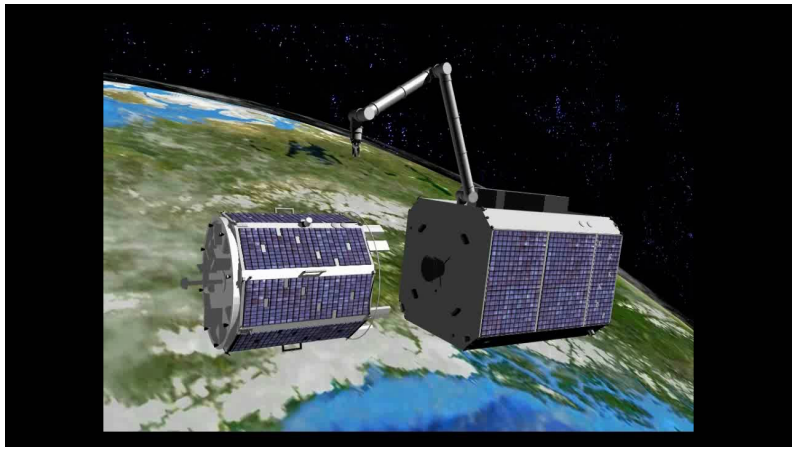
Space Robot Assistance

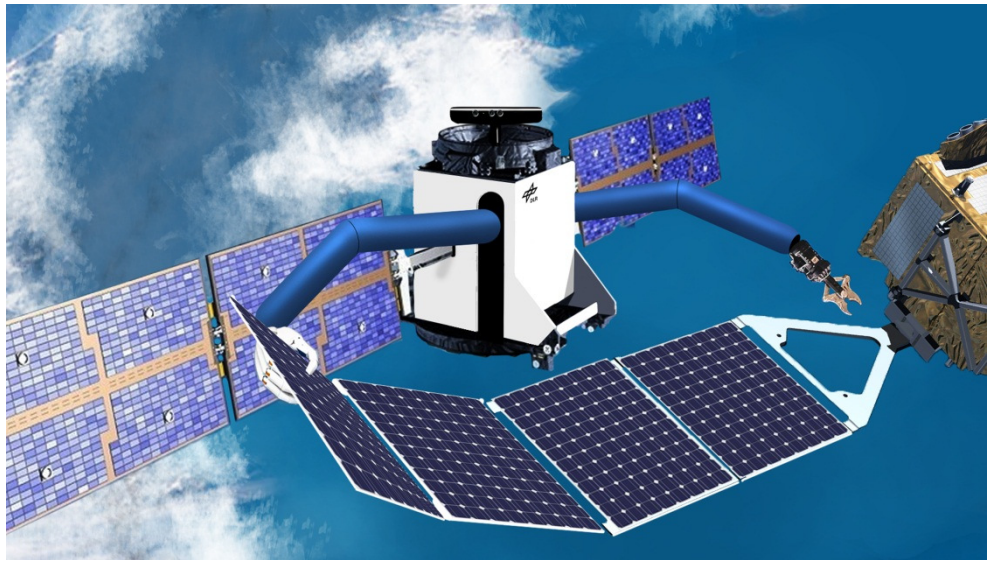


Planetary Exploration

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



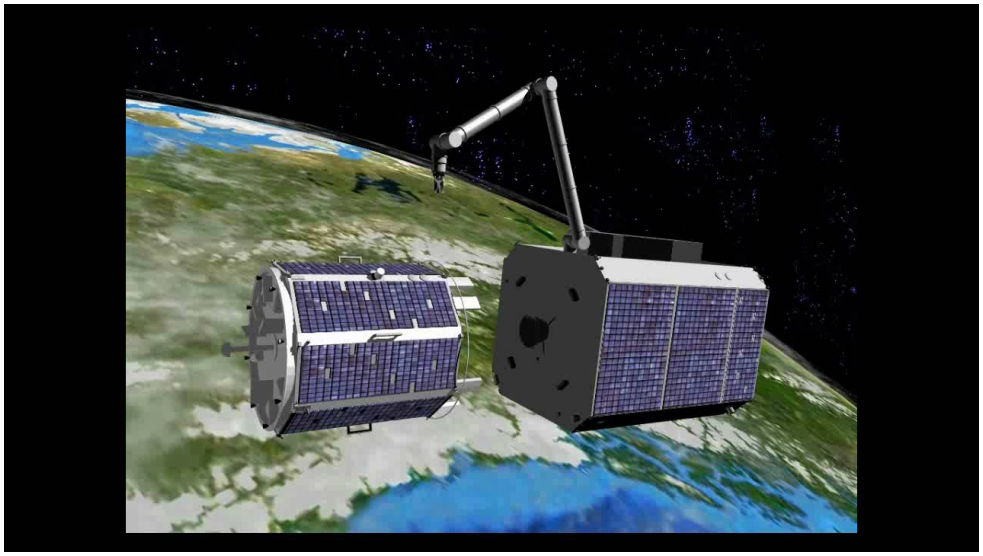


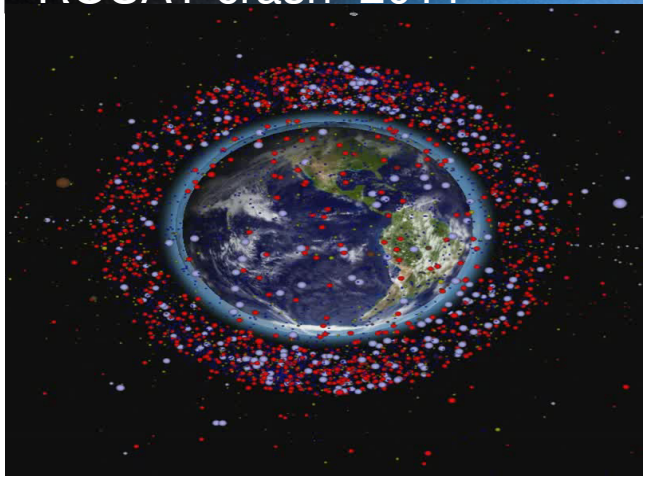
Space Debris Mitigation and on Orbit Servicing

Robot technology can handle both

- service and repair
- space debris mitigation

DLR DEOS mission

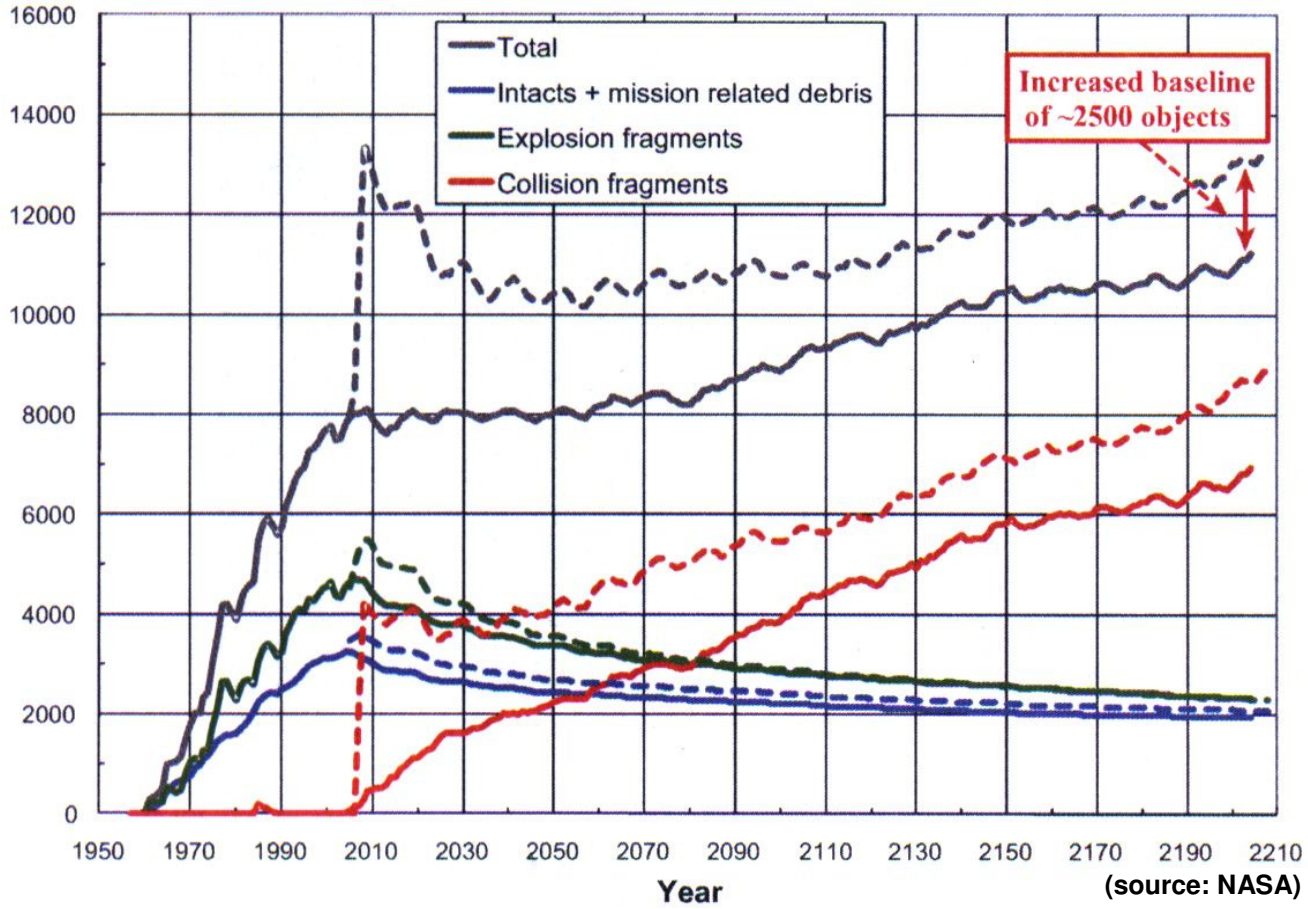




DLR

Space debris in LEO: Increase of future population

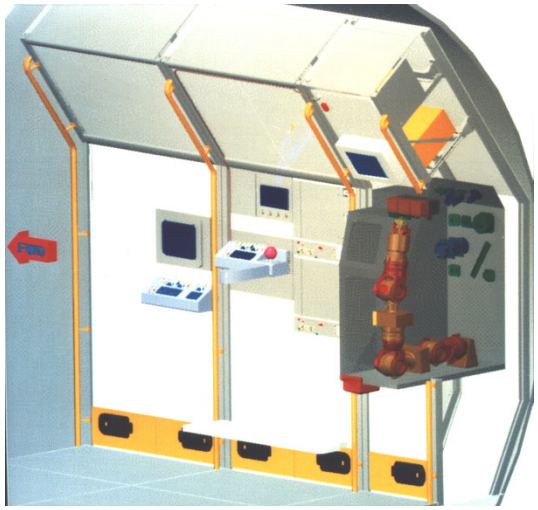
- Cascading effect starts to increase space debris even w/o any launches

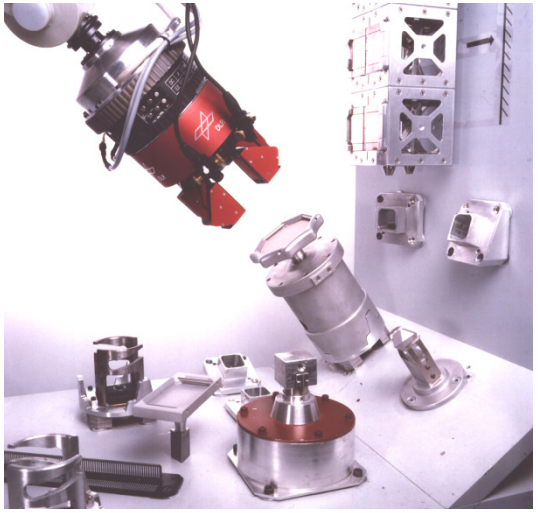


(source: NASA)

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

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

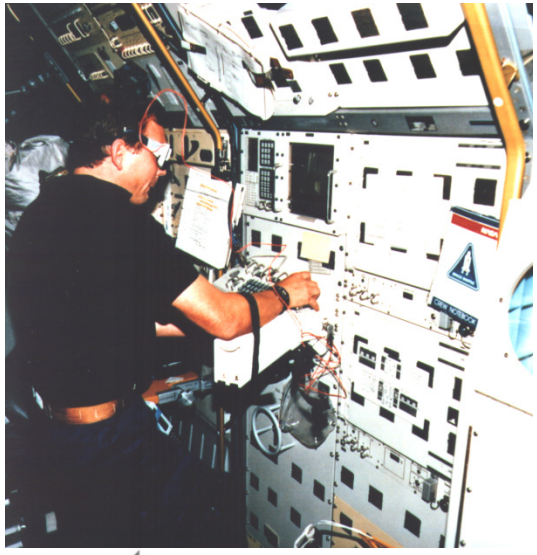


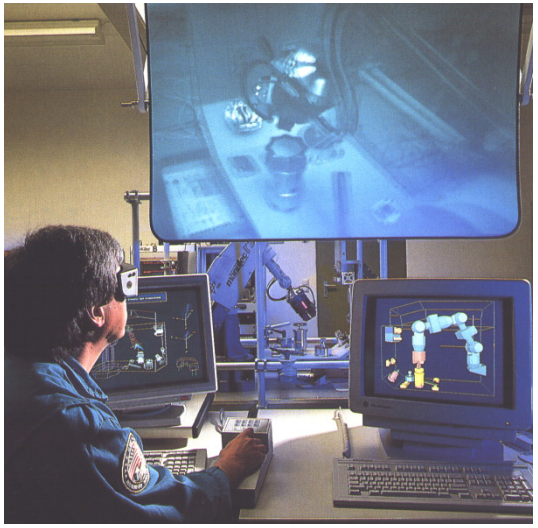


IEEE Judith A. Resnik Award

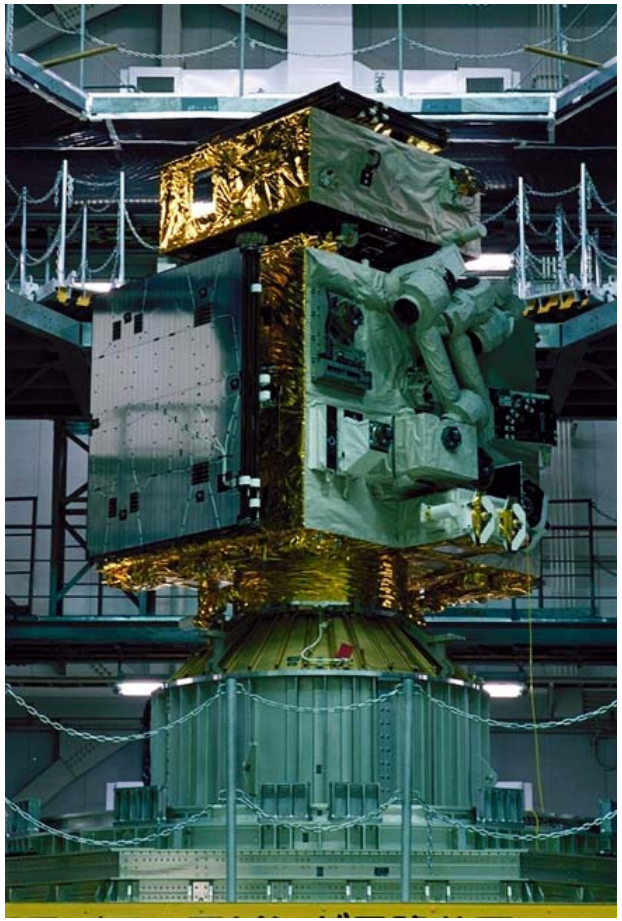
1994 – JOHANNES DIETRICH
Inst. Robotics & Syst. Dynamics - Wessling, Germany

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





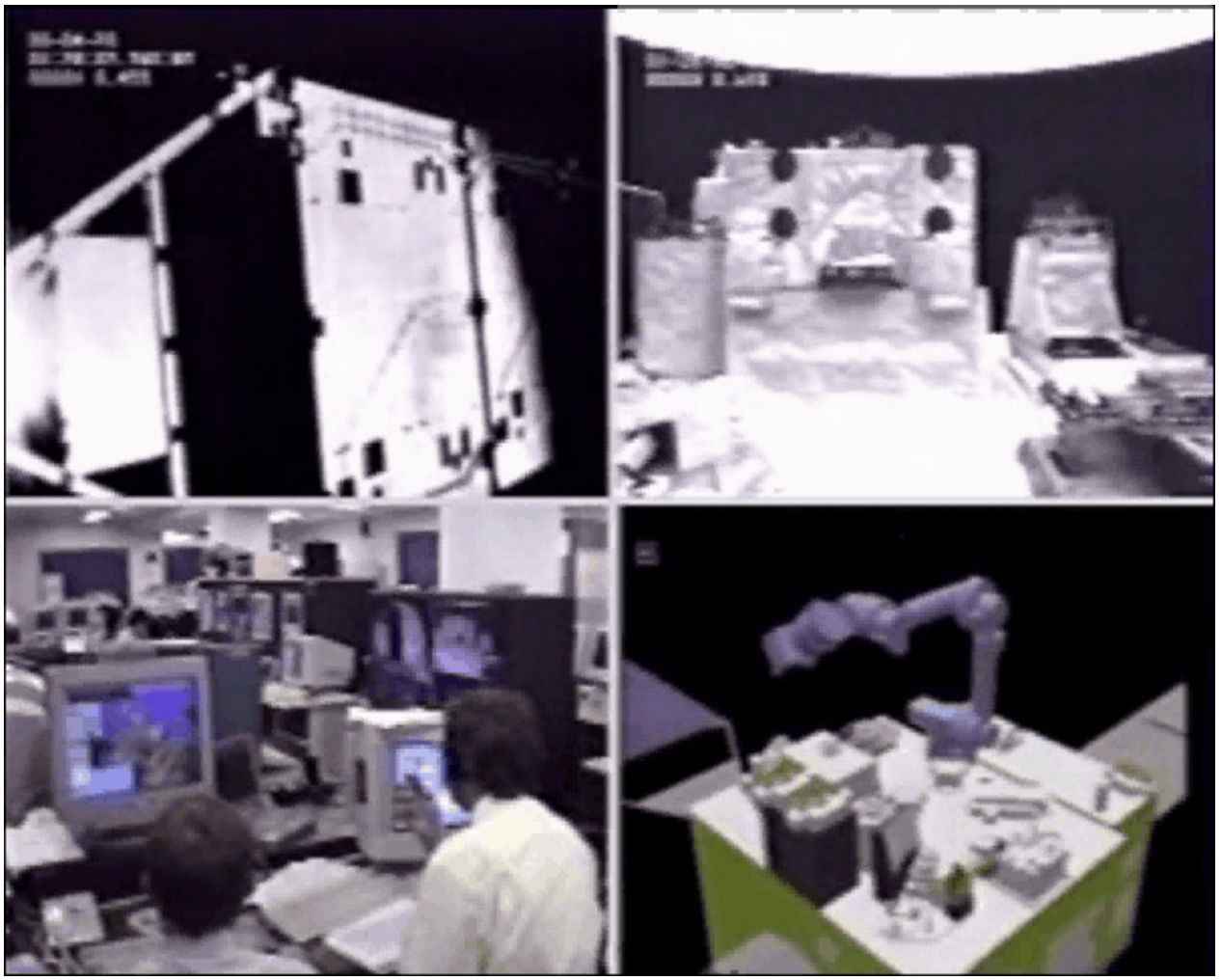
GETEX / ETS-VII 1999



- 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)

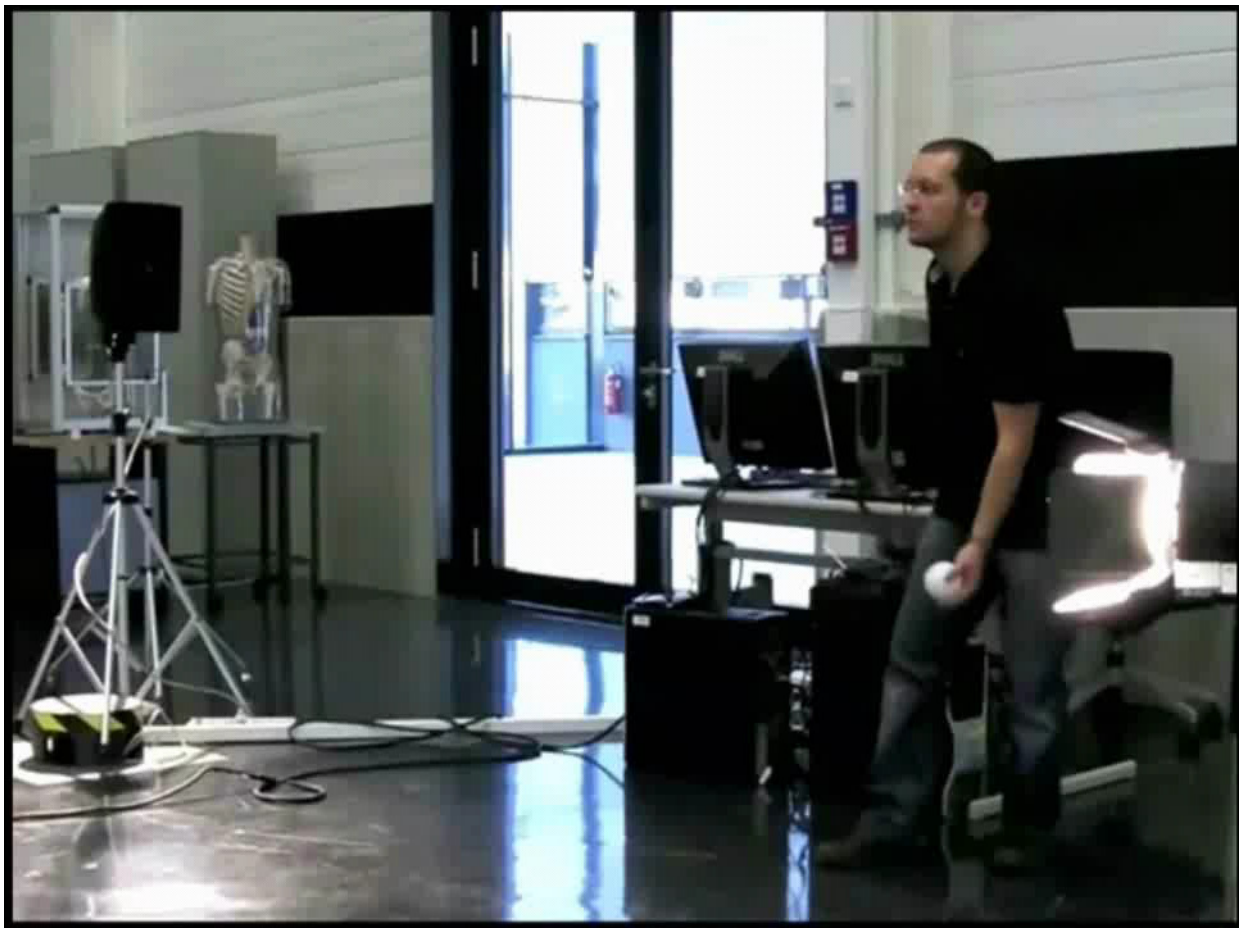
JUSTIN System:
Weight: 45 kg
DoF: 43
Control Loop: 1kHz

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

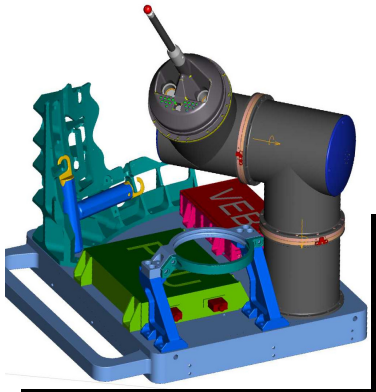
2 DLR Light Weight
Arms (left and right)
7 DoF each

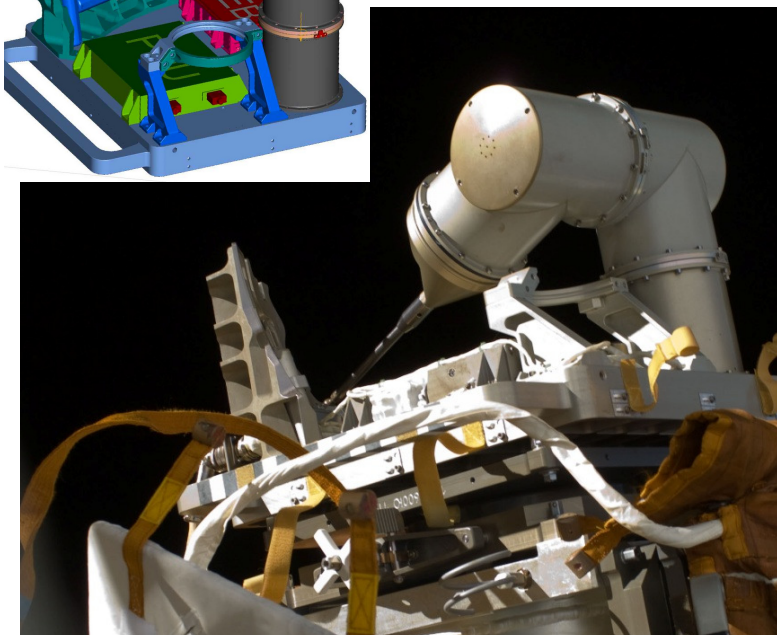
Torso:
4 Joints / 3 actuated

2 DLR Hands in left
and right configuration
12 DoF each



ROKVISS
Roboter Komponenten Verifikation auf der ISS

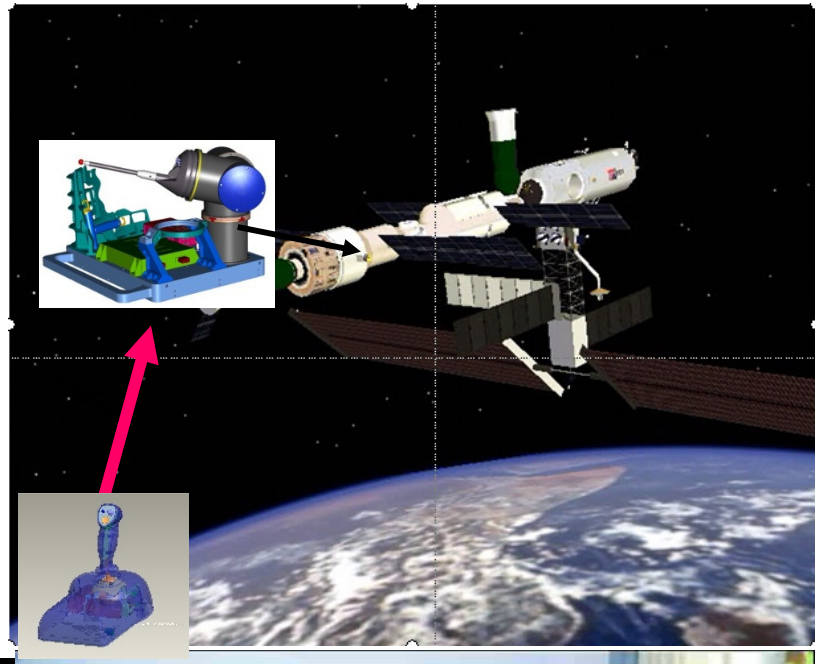




Technology Validated in ROKVISS 6 Year Mission on ISS

Final highlights

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

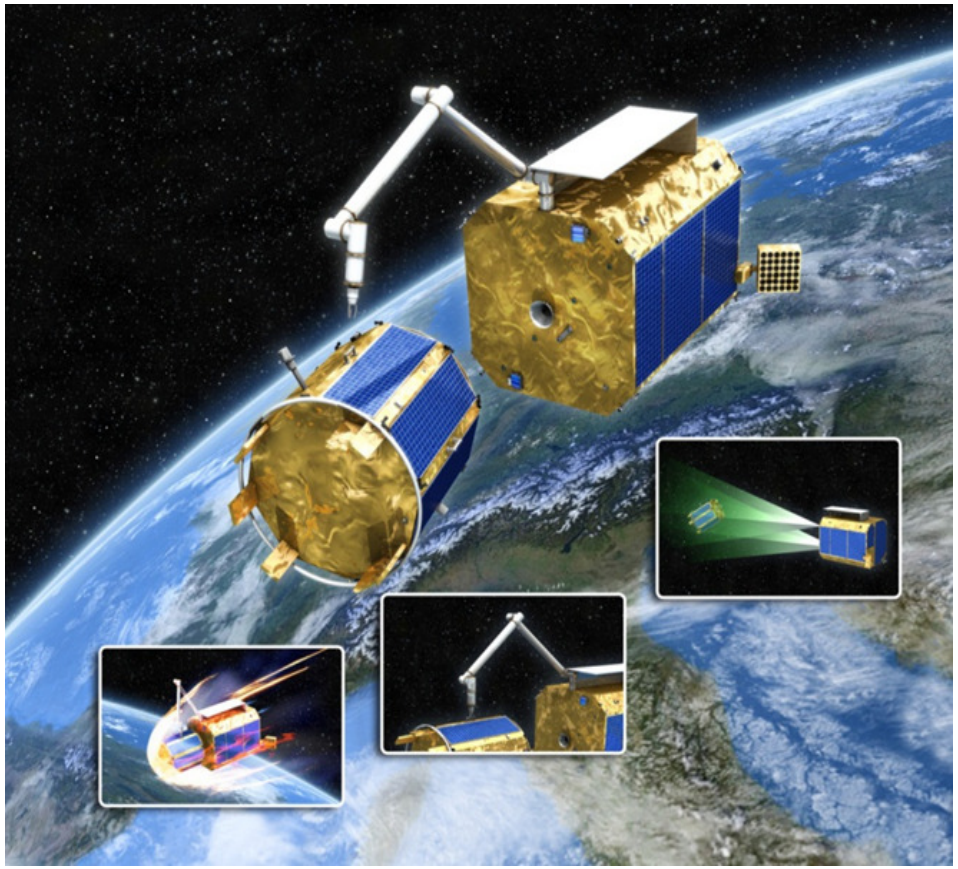


DLR

The DEOS Mission

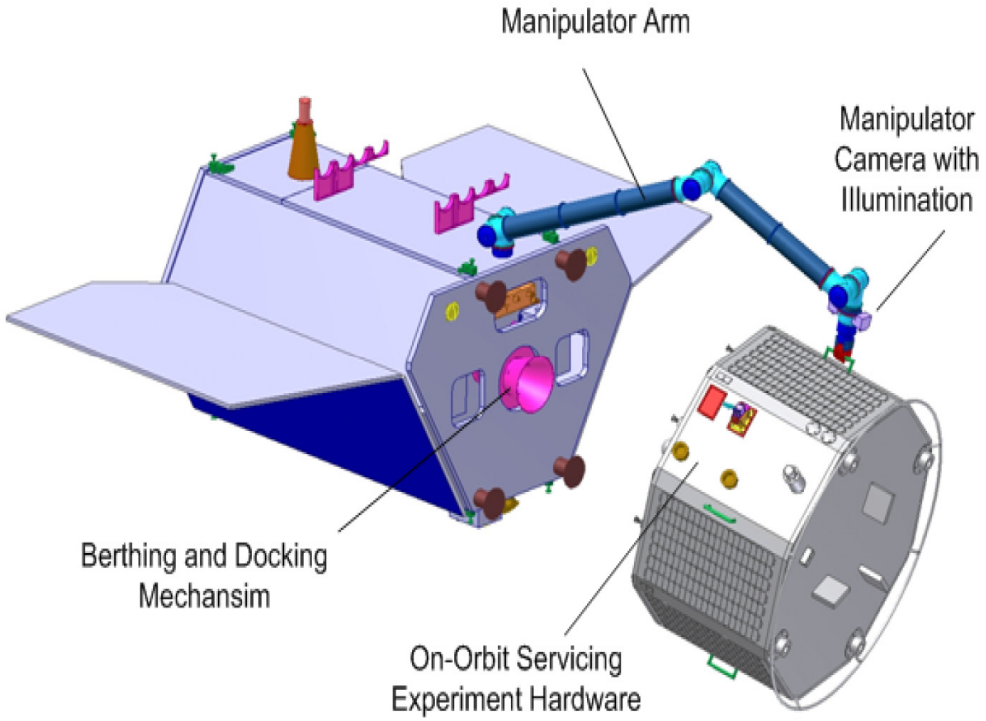
Mission statement

- **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**

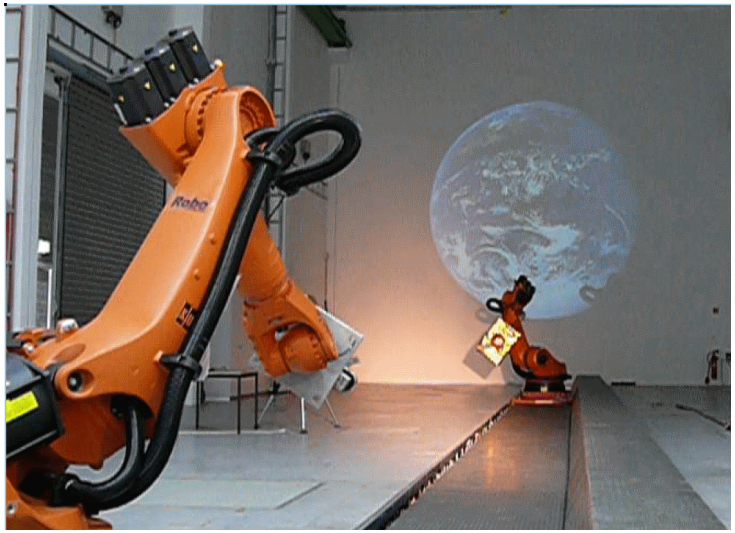


Robotics Sub-System

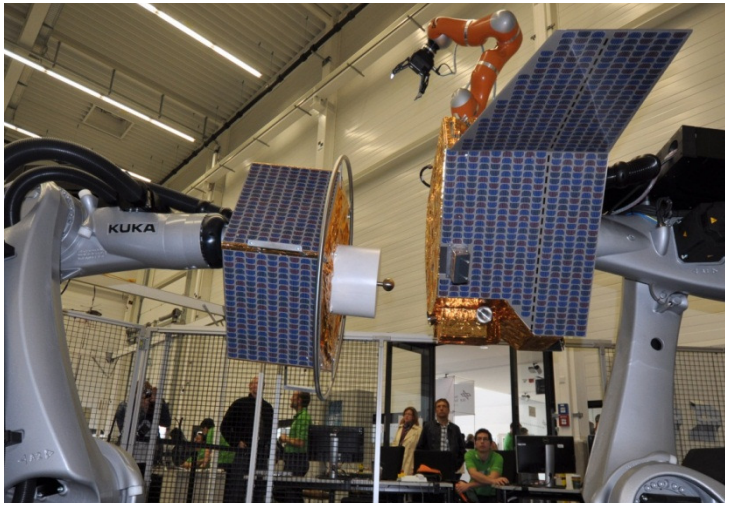
- Observation of client motion
- Identification of dynamic parameters
- Motion estimation
- Path-planning
- Path-control including visual-servoing
- Decay the motion between servicer and client



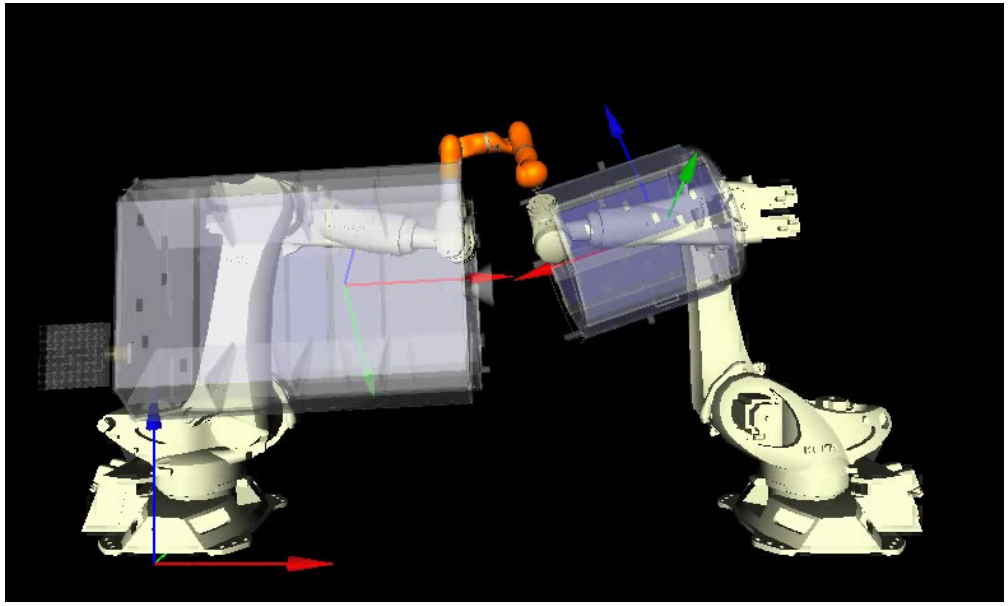
Hardware in the Loop Simulatoren



EPOS – simulation for approaching



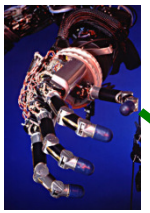
simulation of grasping and ‚manipulation



DEOS-Simulator

Communication paths and corresponding round trip times

Relais satellite in GEO



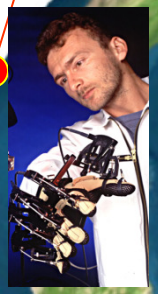
Spacecraft in GEO

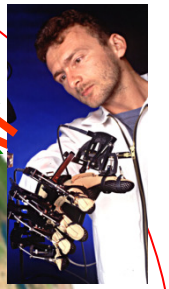
250 ms

500 ms

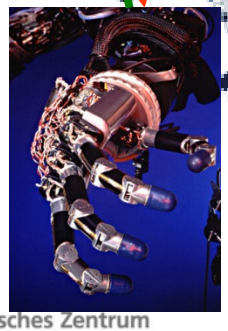
Spacecraft in LEO

20 ms

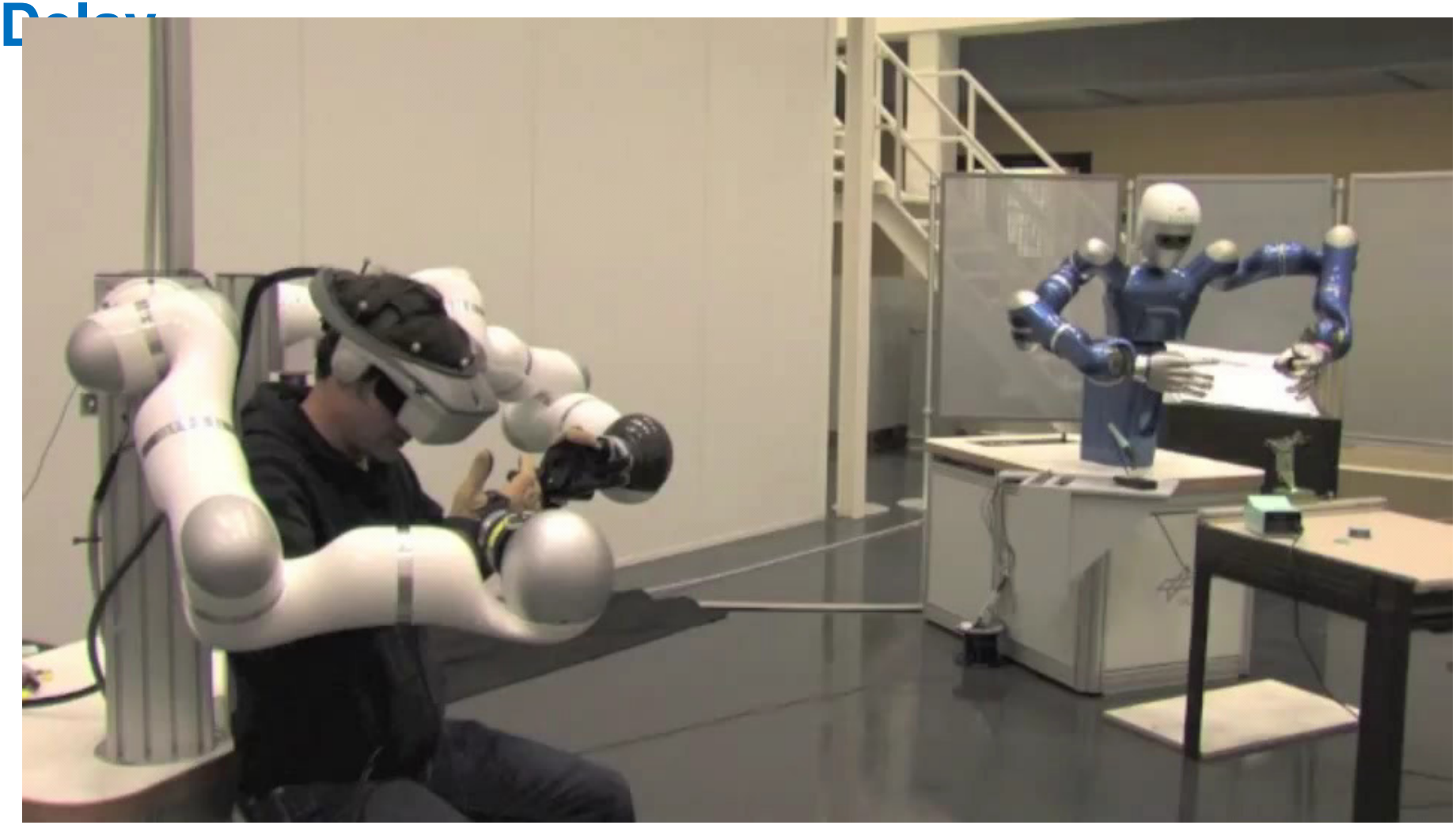




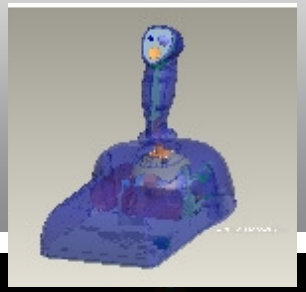
Spacecraft in LEO



Tele-Presence Operation with Time Delay

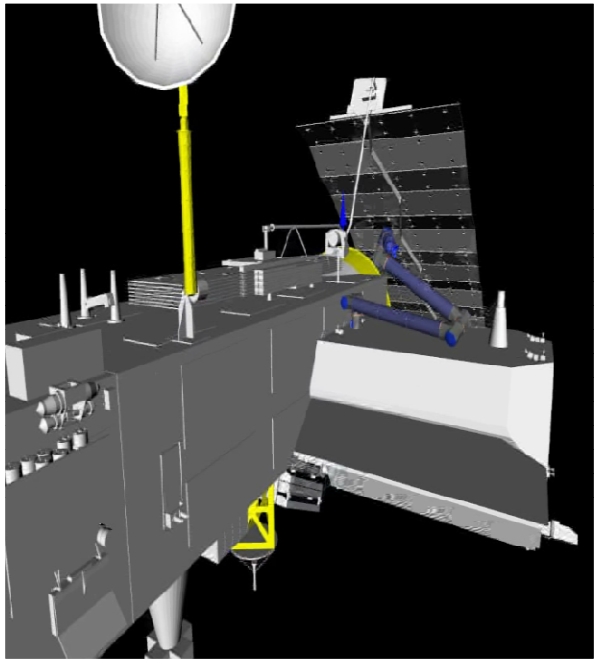


2014) METERON (Start 2015)

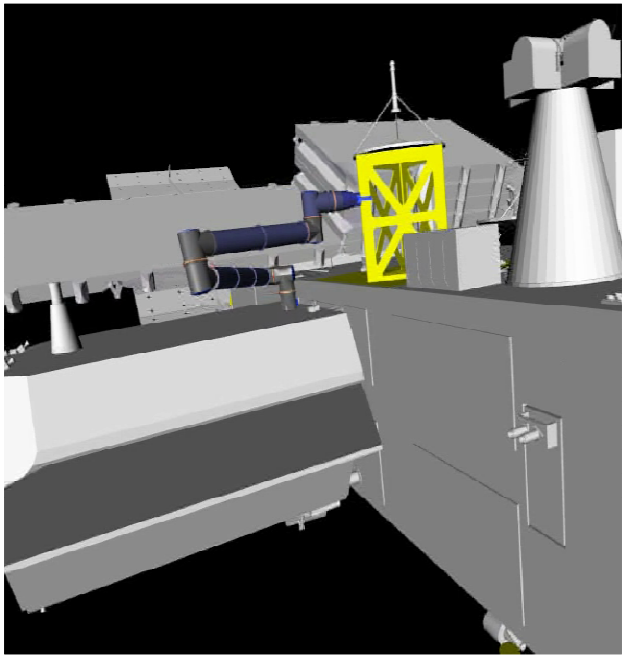


-**M**ars-**E**nd-**T**o-**E**nd-**RO**botic **N**etworking METERON

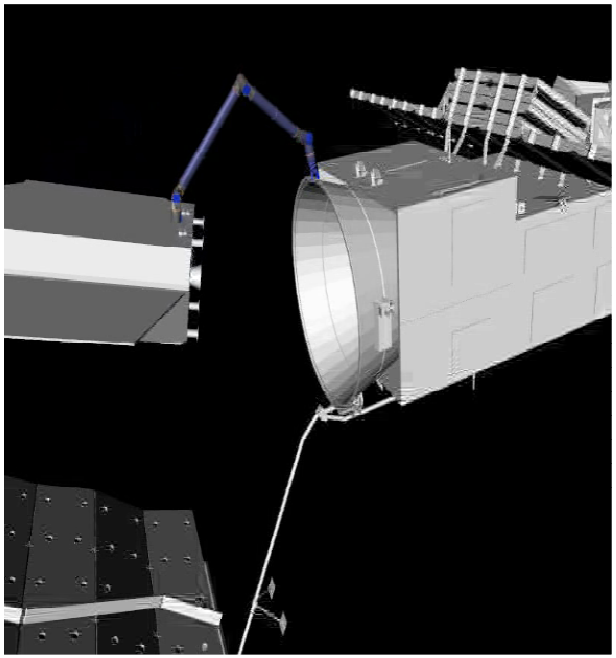
ENVISAT
Possible Capture Methods (Subset only)



Antenna

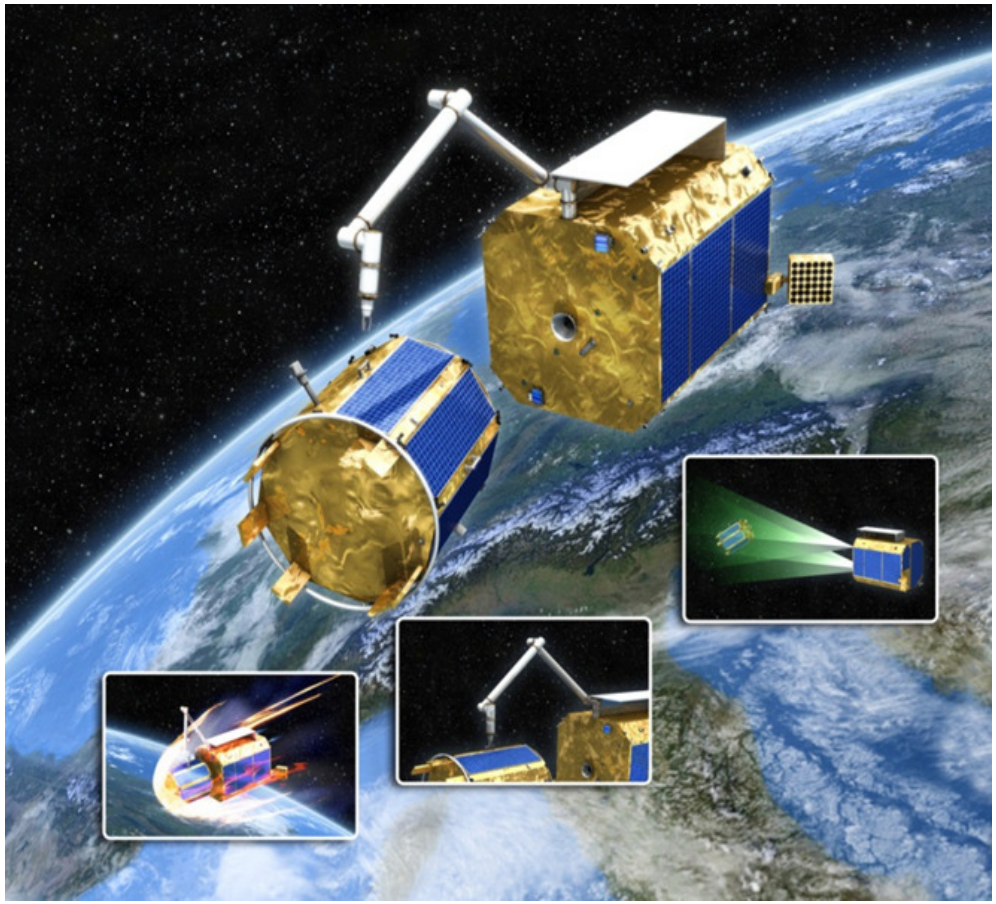


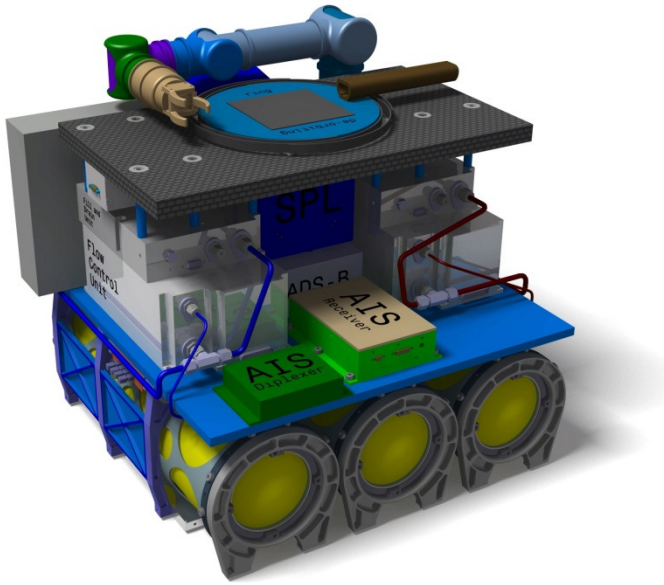
Structure



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!