Automation and Robotics within the German Space Program

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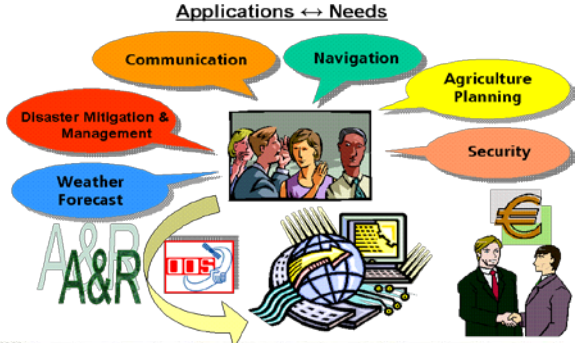
DLR

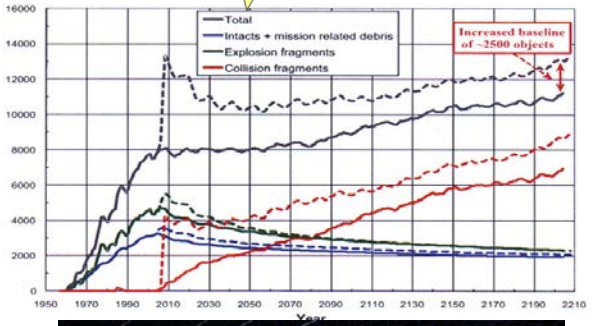
The German Space Robotics Program

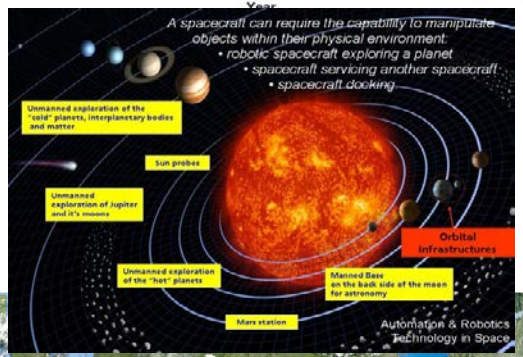
- Motivation
- Challenges and goals
- Core areas and current activities
- Roadmap

Setting the scene - Motivation

- **Hundreds of satellites populate** the Earth **orbits from LEO to GEO** in order to respond to increasing needs of society for tele-communication and navigation, weather forecasts, transnational agriculture planning etc..
- Space flight follows **“throw away mentality” -** Existing satellites **are not prepared** for any intervention
- International agreements [IADC] call for **removal of satellites** from their orbits at EOL - **many don’t**.
- **Cascading effect** increases space debris even w/o any launches – **prevention measures are not enough** maintain save access to space
- Mastering the **capabilities for OOS** are major **stepping stones** on the way to explore the Solar System.







Challenges to space flight in the 21st century

„Problem“		„Challenge“
▪ Costs for space missions to high	→	Increase economic efficiency
▪ Space systems are single pieces (monolithic, not reusable)	→	Create flexible + modular systems
▪ Missions generate space debris	→	Sustainable space craft design

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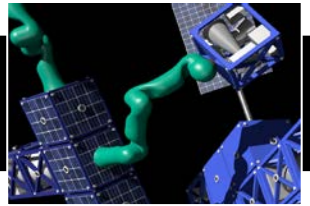
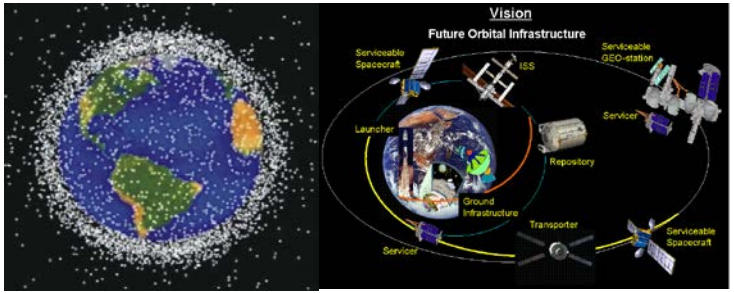
Our goals in space robotics

- Space-Robotics „Made in Germany“ = trademark of Germanys space industry and academia
- Achieve and maintain a technological key position in in future cooperative international space projects
- Support technology transfer from and to terrestrial applications, foster innovations
- Set-up international rules to enforce responsible and considerate treatment of space assets (CoC)

Core areas of the space robotics program

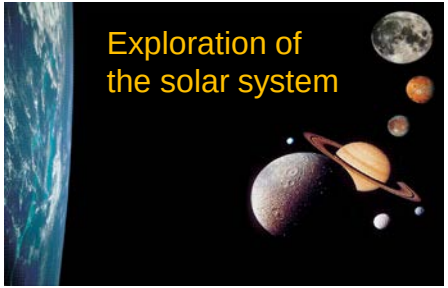
Orbital infrastructure





Disposal of space debris; serviceable satellites and stations

Exploration



Moon exploration as stepping stone to the solar system

Technology transfer

Transfer of Technology from and to Space-Robotics

DLR's approach to OOS

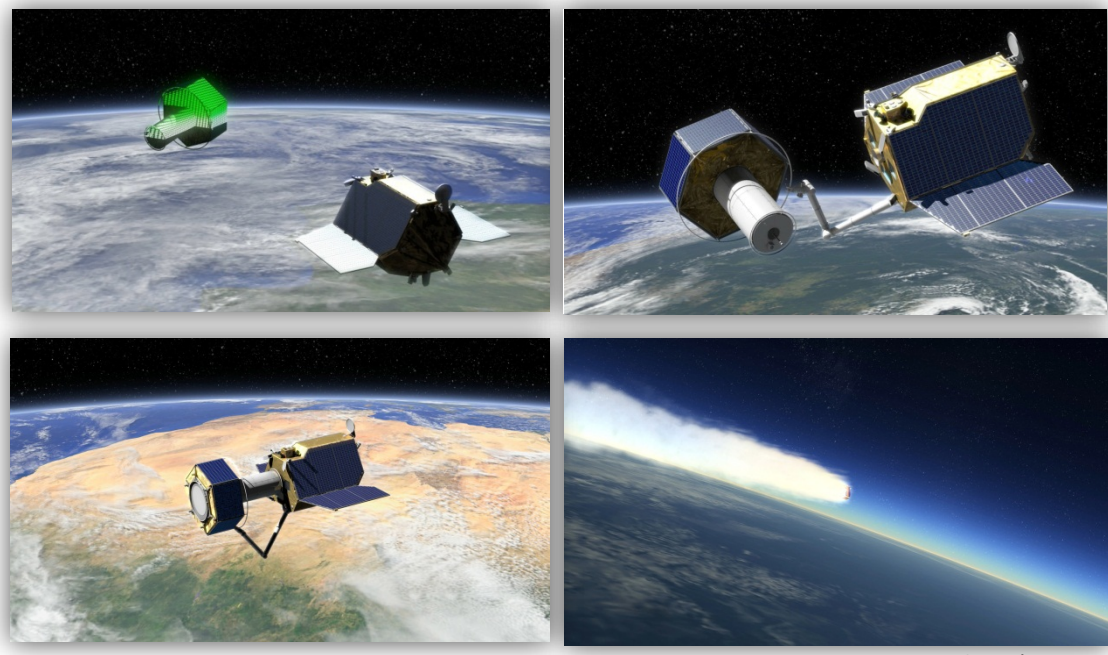
- **Demonstrate the availability of technology**
  Verify procedures and techniques for rendezvous, capture, maintenance and removal of an uncontrollable satellite from its operational orbit
  ➡ **DEOS** (Deutsche Orbitale Servicing-Mission)

- Translate the increasing needs of society and lessons learned from DEOS into **technical and technological requirements for** the extension and operation of **next generations orbital infrastructure**

- **Create serviceability / maintainability through "cooperative" satellite design**, standardization, modularity.

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



More detailed information in separate presentation !

Vision – Future satellite design

Market analyses predict increasing demand for smaller and economically viable satellites

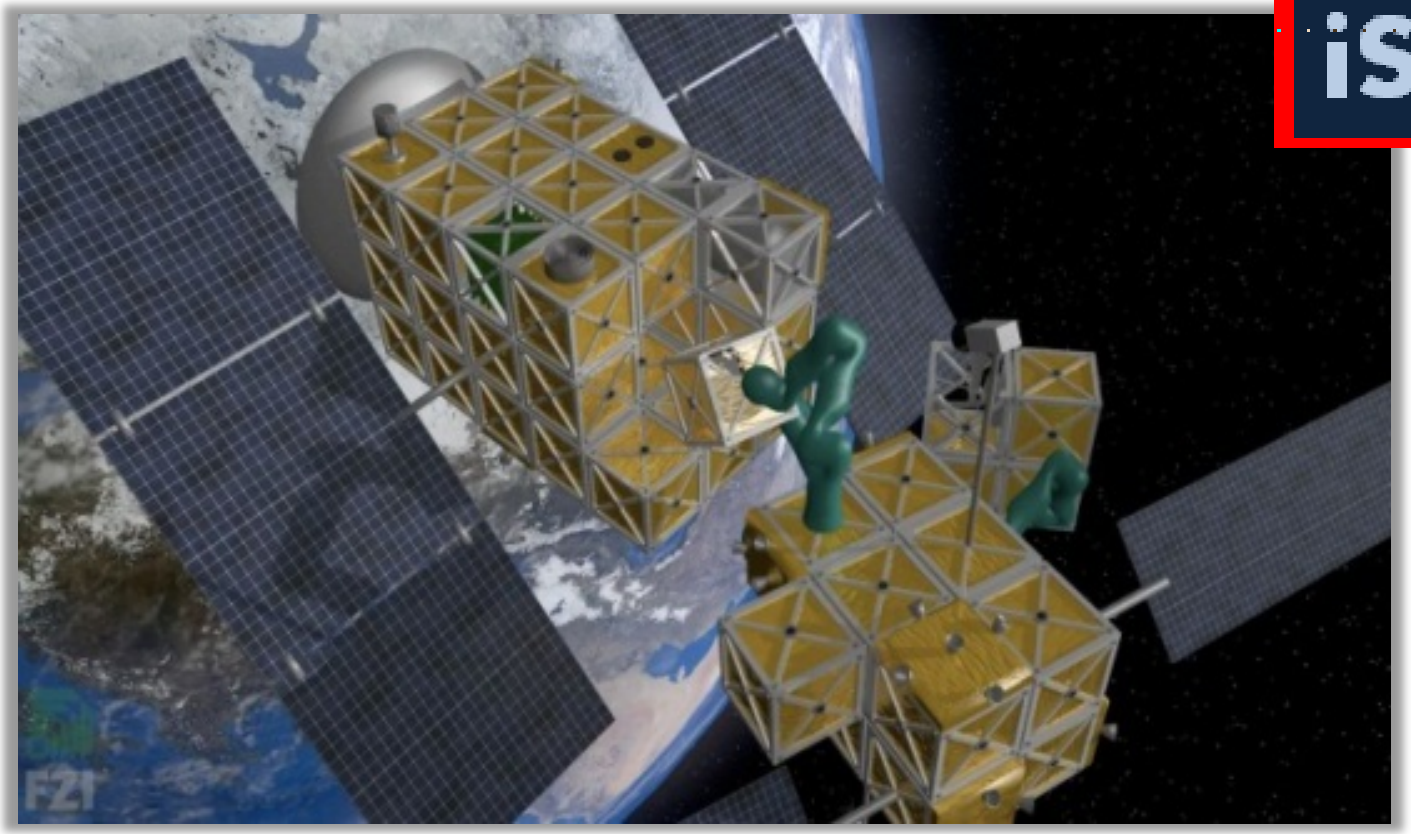
Future satellites are

- **Adjustable to customers desires**
- **Adjustable to mission needs**
- **Easy to maintain**
- **Resource-saving**
- **Debris avoiding**
- **Cost-efficient**

New design philosophy

- Platform- and payload-design based on qualified and standardized building blocks provided with “intelligent” interfaces for mechanical, electrical, data and thermal coupling
- Mission configurations will be generated through varying combinations of those building blocks
- Handle lifetime of platform and payloads separately
- Service provider operates platform, payload owner focuses on core business
- Reconfiguration of platform and payload suite during lifetime depending on changing mission requirements

iSAT



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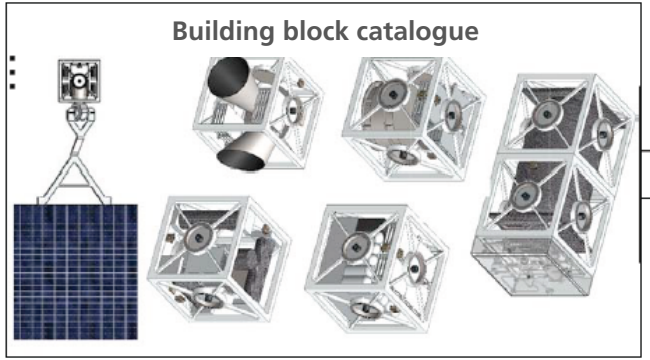
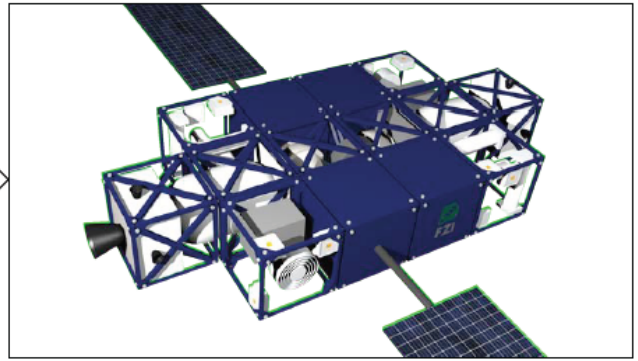
Concept inherent advantages

iBOSS

Intelligent Building Blocks for On-orbit Satellite Servicing





iSAT

Intelligent multi purpose SATellite

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- Reduction of development time and costs
- Increased maintainability through building block based flexible and modular spacecraft design
- Remarkably increased reliability through inherent redundancy
- Mitigation of mission risk per user and unit
- High flexibility and fast reaction to customer wishes and needs
- Fast deployment of technological innovations
- Increased satellite life expectancy
- Market potential for qualified off-the-shelf modules

Moon exploration as stepping stone to explore the solar system

Key elements

Orbiter

- Communication
- Science

Ground Control

→ Return of Samples →

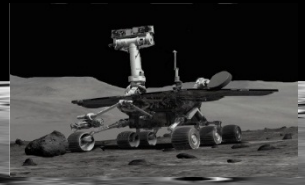
← Return of Samples ←

Lander

- Soft and precise landing
- Science
- Re-launch capability

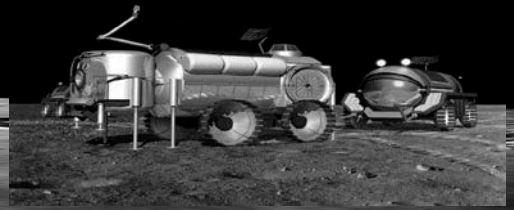
Mobile Robot

- Mobility / Autonomy
- Assembly / installation
- Science
- Resource supply



Lab

- Science
- In situ resource utilization



RIMRES

Reconfigurable integrated multiple-robot exploration system

Assembly of robotic agents with varying properties based on standardized components for mobility, manipulation, power supply, communications etc.

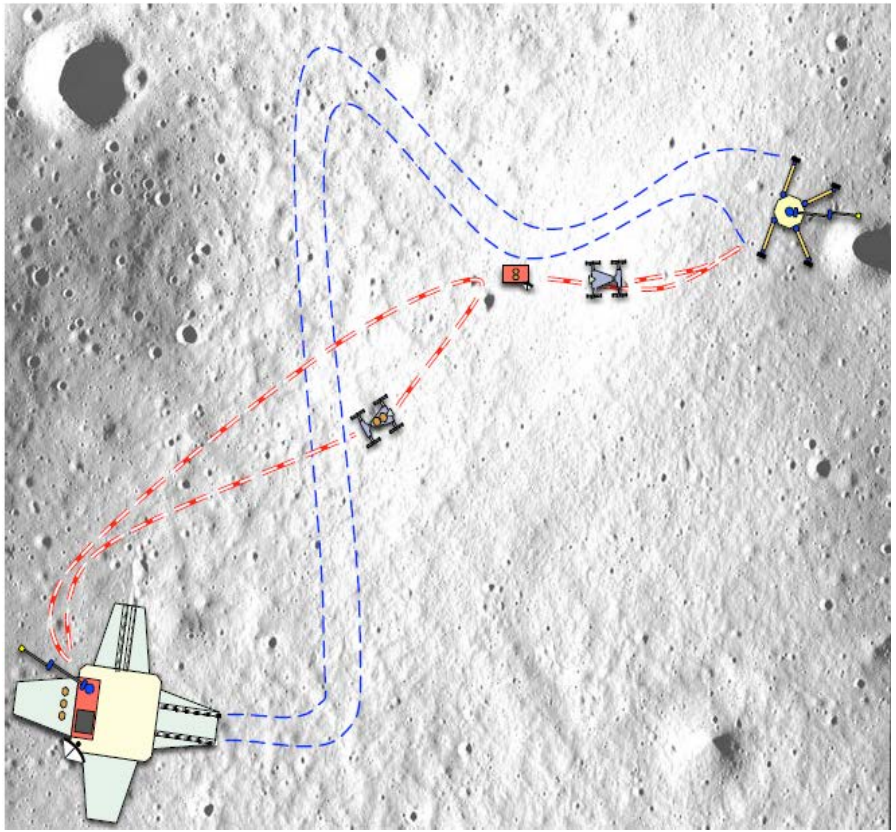
- **Highly modular system concept**
- **Compilation of a robot team out of robotic agents based on mission objectives and requirements**
- **Inherent redundancy through modularity**

Source: DFKI

Analogue mission

Demonstrate exploration capability of a robotic team in representative terrestrial environment by:

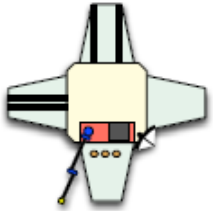
- Set-up of tele-robotic ground control station
- Set-up representative communication links with unpredictable latencies
- Verify mission planning and re-planning
- Demonstrate mobility concepts with respect to geological and geophysical properties
- Demonstrate adjustable system autonomy



Source: DFKI

Rover

Crawler/Climber



Lander

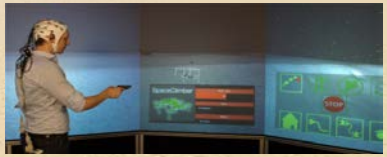
Base camp

TransTerrA – Exploration technology transfer

Exploration rover

Supply Shuttle

Base-Camps



Ground Control

Developed for space

Robotic Space Exploration

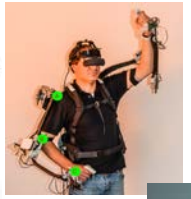
Innovative MMI-concepts

Logistics Chain

Robot teams

Semi-autonomy

Rehabilitation



Maritime Ressources

Search & Rescue

……

Demonstrated in terrestrial applications

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SpaceBot Cup

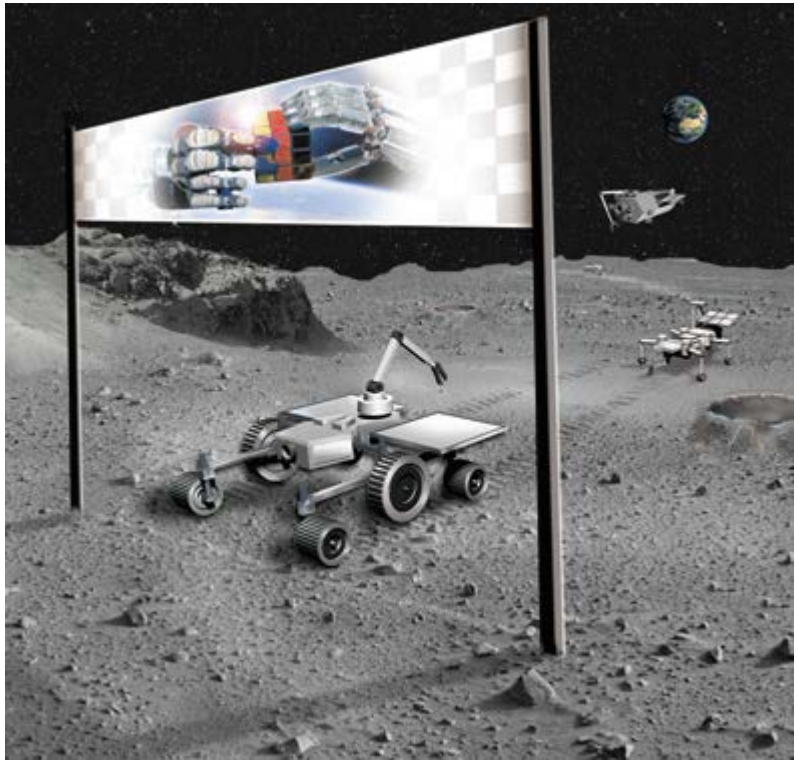
Announced at the International Air Show 2012 in Berlin - to be hold in November 2013

Robot contest based upon a typical planetary exploration scenario

Competition of German teams from academia and small & mid-sized companies

New impulses through know-how transfer between Space-Robotics and terrestrial disciplines

Innovation in Space and on Earth through networking



For more information:
www.dlr.de/rd/spacebotcup

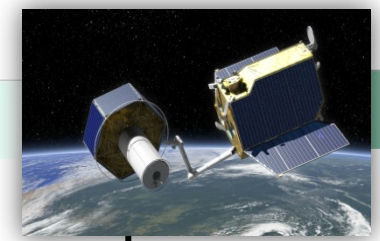
Roadmap On-Orbit Servicing

Focus:
Capturing, De-Orbiting

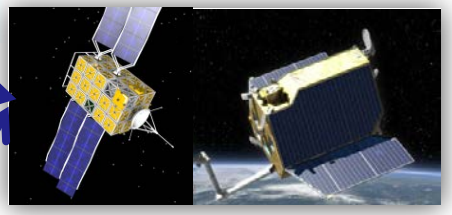
e.Deorbit

DEOS TDA

IDEOS



DEOS Adaption



iBOSS

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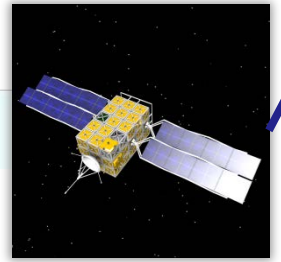

iSAT Servicing

Focus:
Servicing

2012 2015 2017 2020 2023

Roadmap Exploration and Transfer