Automation and Robotics within the German Space Program

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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“

- Costs for space missions too high
- Space systems are single pieces (monolithic, not reusable)
- Missions generate space debris

„Challenge“

- Increase economic efficiency
- Create flexible + modular systems
- Sustainable space craft design
Our goals in space robotics

- Space-Robotics „Made in Germany“ = trademark of Germany’s space industry and academia
- Achieve and maintain a technological key position 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

Explore the solar system
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!
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
Intelligent Building Blocks for On-orbit Satellite Servicing

Building block catalogue

Concept inherent advantages

- 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

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Moon exploration as stepping stone to explore the solar system

Key elements

- Orbiter
  - Communication
  - Science

- Ground Control

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

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

- 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
TransTerrA – Exploration technology transfer

Robotic Space Exploration

- Exploration rover
- Supply Shuttle
- Base-Camps
- Ground Control

Developed for space

- Innovative MMI-concepts
- Logistics Chain
- Robot teams
- Semi-autonomy

Demonstrated in terrestrial applications

- Rehabilitation
- Maritime Resources
- Search & Rescue
SpaceBot Cup
Announced at the International Air Show 2012 in Berlin - to be held 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

**DEOS TDA**

**iBOSS**

**iSAT**

**DEOS Adaption**

**e.Deorbit**

**iSAT Servicing**

2012 2015 2017 2020 2023
Roadmap Exploration and Transfer

Technology Development

- Landing
- Mobility
- Sensing
- Controller S/W & H/W

Ground Control & Communication
- Self localization & Mapping
- Simulation & Test
- Guidance & Navigation

Analogue mission

Technology transfer

Thank you for your patience!