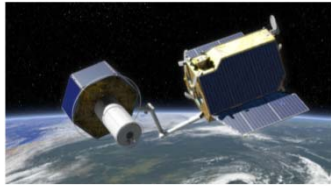


## Robotic Technologies for controlled satellite deorbiting

Gerhard Grunwald  
Institute of Robotics and Mechatronics

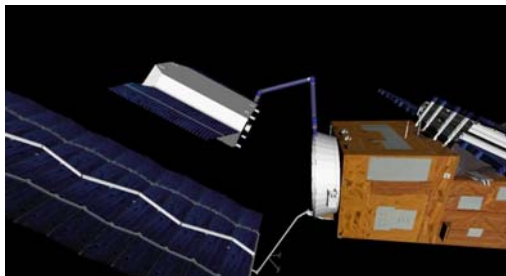


DLR

Knowledge for Tomorrow

DLR.de • Chart 2 Institute of Robotics and Mechatronics > G. Grunwald

## Controlled Deorbiting of a non cooperative satellite



- Chaser approaches the satellite
- Chaser synchronizes with the tumbling satellite
- **The robot is grasping the satellite**
- **The robot positions the chaser on satellite**
- Chaser deorbits the satellite



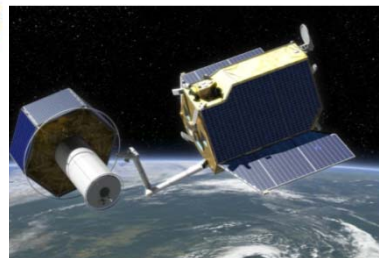
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## Robotic operational sequence „Grasping a satellite“

- The robot approaches the grasping point and grasps the satellite
  - Path Planning
  - Cartesian Control
  - Image Processing
  - Visual Servoing
- The robot decays the relative motion between two satellites
  - Path Planning
  - Cartesian Control
- The robot positions the chaser on satellite
  - Path Planning
  - Cartesian Control



## What is a robot?



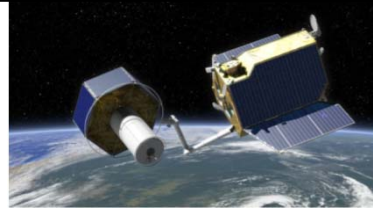
A robot is a **reprogrammable, multifunctional** manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a **variety** of tasks." –  
**Robotics Industry Association.**

Robotics is the intelligent connection of perception to action.

M. Brady 1984



## What is Space Robotics?



- Space robotics is the development of general purpose machines
  - that are capable of surviving (for a time, at least) the rigors of the space environment,
  - performing assembly, construction, maintenance, servicing, exploration or other tasks that **may or may not have been fully understood at the time of the design of the robot.**
- Humans control space robots from either a
  - “local” control console, essentially zero speed-of-light delay
  - “remotely” with non-negligible speed-of-light delays
- Space robots are generally designed to do multiple tasks, **including unanticipated tasks, within a broad sphere of competence.**

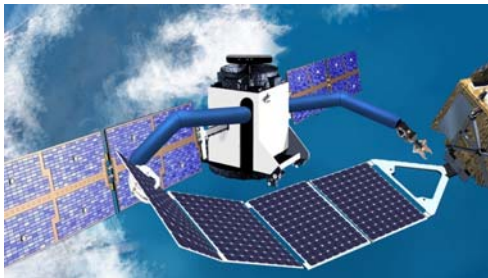
Brian Wilcox (JPL), Robert Ambrose (NASA), Vijay Kumar (UPenn)



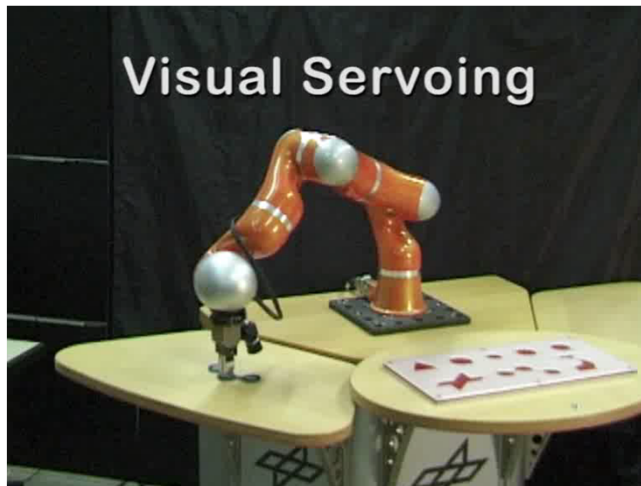
## On Orbit Servicing

Robotics will provide 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



### Maturity of the robotic technologies: Part1 On ground



Visual Servoing



### Maturity of the robotic technologies: Part1 On Ground





## Industrial Robots for Space Robotics

- Hardware in the loop Simulators for On Orbit Servicing Tasks including the grasping and deorbiting of a satellite



**EPOS**  
Test setup for approaching and docking



**DEOS-Simulator**  
Test setup for grasping and manipulation



## DEOS Sim

On-Orbit Servicing Simulator  
at DLR RMC



## Summary

- The robotic technologies for deorbiting a satellite are available
  - Proven on earth
  - Experienced in space
- Robotics will provide 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
- Robotics is an established high technology with a sound background
- Robotics has strong European industry, research, and services

