The ESA A&R technology R&D

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Outline

- The R&D funding schemes (GSP, TRP, CTP, GSTP, ARTES…)
- Robotics Missions at ESA
  - Where, which, when…
  - Some needs in detail
- Looking beyond missions
- Conclusions

The ESA R&D Funding Schemes

There are several programmes at ESA dedicated to funding R&D they are mostly defined to be complementary in terms of Technology Readiness Level (TRL). The ESA-wide programmes are:

Level 1: Technology concept and/or application formulated. GSP

Level 2: Analytical & experimental critical function and/or characteristic proof-of-concept. TRP

Level 3: Component and/or breadboard validated in laboratory environment.

Level 4: Component and/or breadboard validated in relevant environment. GSTP

Level 5: System/subsystem model or prototype demo in a relevant environment (ground or Space).

Level 6: System prototype demonstration in a space environment. GSTP5

Level 7: Actual system completed and "Flight qualified" through test and demonstration (ground or space).

Level 8: Actual system "Flight proven" through successful mission operations.

The ESA R&D funding schemes

- **TRP and GSTP are since few years ruled by the "end-to-end" process that aims at maximising technology return to ESA missions. Every 3 years**
  - Project directorates state needs for their missions
  - Technology gatekeepers make proposals for R&D activities to satisfy their needs
  - Project directorates and TRP/GSTP programme managers decide which activities get funded
  - Hence most of TRP and GSTP money funds activities related to missions in the planning
  - A small part is allocated to R&D not immediately connected to missions
- **GSP has instead**
  - every 2 years an call for ideas open to all ESA
  - The GSP programme management decide which proposals get funded
  - Most of funded activities have no connection to missions in the planning

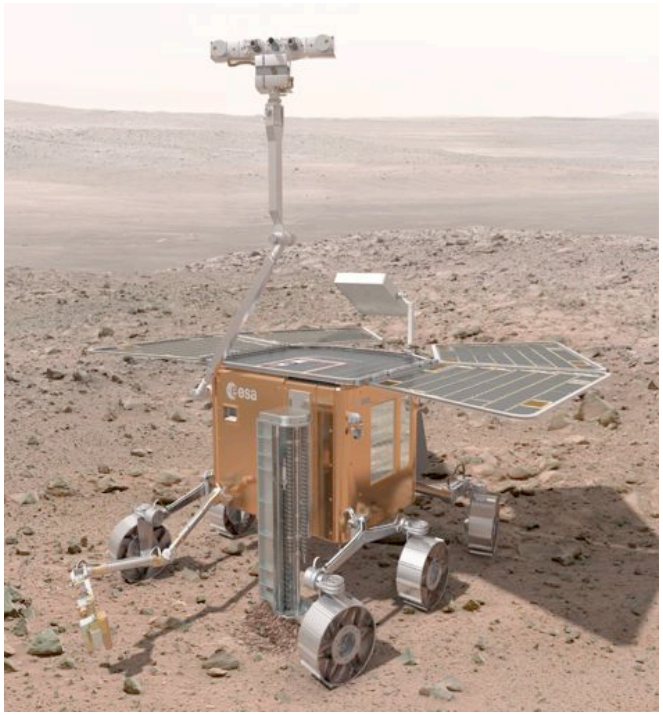
Where are the Robotics Missions at ESA?

- **Robotics for exploration: since mid of 2008 we have a new organization at ESA:**
  - Directorate of Science and Robotics Exploration (D/SRE): dealing with exploration missions without humans (this is the sense of "robotics")
    - Robot explorers: 'solo' robots, intelligent/autonomous
  - Directorate Human Spaceflight and Exploration (D/HSF): dealing with human-based exploration
    - Robot agents: robots teleoperated by crew
    - Robot assistants: robots that perform tasks together with crew being commanded by crew
- **Robotics for Satellite Servicing: as the main "customers" of satellite servicing are GEO telecom satellites the subject is being reluctantly pursued by the Directorate of Telecommunication and Integrated Applications (D/TIA)**

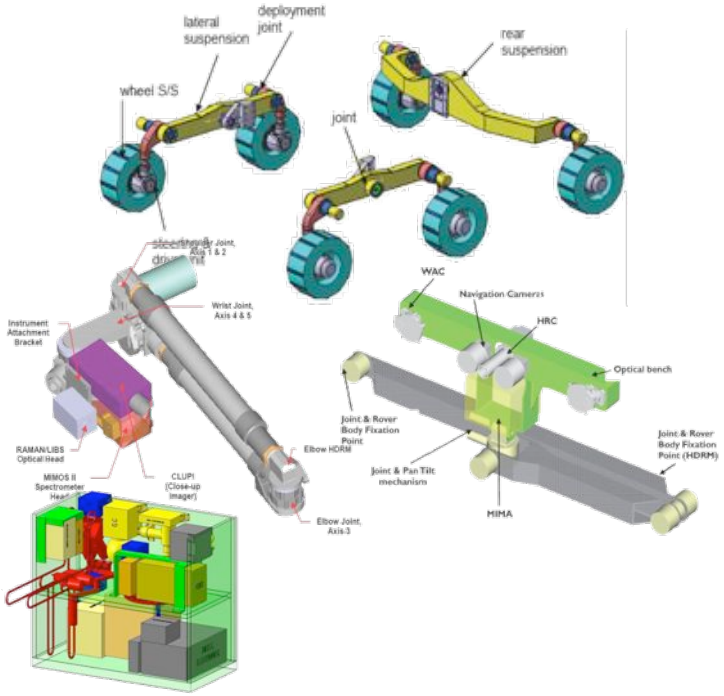
Which are the robotics missions at ESA?

- **Robotics Exploration**
  - ExoMars: overview of the mission provided by a paper from A.Elfving in session 3. Many developments within ExoMars are presented in session 3 and 4
  - The "Cosmic Vision 2015-2025" missions (Marco Polo, TANDEM) addressed by a paper from P. Falkner in session 1
  - MoonNext and MarsNext faith uncertain
- **Human Exploration (with robots)**
  - ERA
  - Eurobot: still going on with the ground prototype development (see paper from P. Schoonejans et al. next in session) and maybe resurging at the Ministerial conference
- **Satellite Servicing**
  - OLEV now being pursued as commercial endeavour with ESA support. See paper from C. Kaiser et al. in session 13

When?



- **ExoMars delayed to 2016 for financial reasons**
  - Delay unfortunate, but may give time for new technology to be readied
  - R&D building blocks under preparation that could be used in ExoMars:
    - (TRP) MEMS motion control chip (see presentation from F. Brühn in session 16) running
    - (TRP) MEMS IMU started
    - (TRP) Autonomous Controller initiated
    - (TRP) Control Station for Autonomy planned for 2009
    - (GSTP) Rover System Design, Simulation and Verification Tool (see presentation from C.Kapellos et al. in session 9) running



ExoMars will employ a Rover, carrying the Pasteur exobiology payload and a drill to collect subsurface samples down to 2-m depth. The Humboldt a geophysics & environment payload () is proposed on the landing platform.

BB example: motion control chip

Each wheel has 3 active degrees of freedom ⇨ 18 drives

The robot arm system has 5 DOF + rock-abrasion tool and focussing mechanism of the close-up imager ⇨ 7 drives

Camera mast 2 DOF, Stereable antenna 2 DOF. 4 drives

Drill box positioned by 2-DOF positioner ⇨ 2 drives

Drill assembles a drill string and provides controlled rotation and translation ⇨ 4 drives

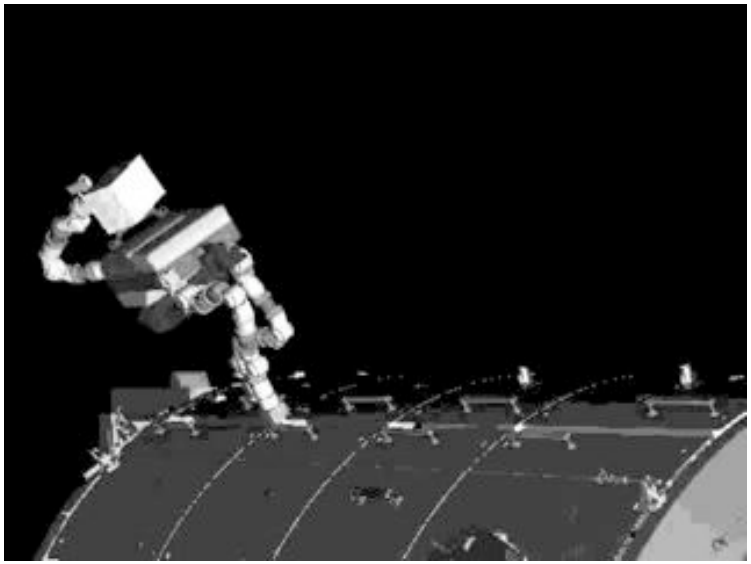
Drill tool with sample acquisition capabilities. 2 drives

SPDS has a total of ⇨ 8 drives

TOTAL 45 DRIVES! ⇨ many, many cables (~12 kg)

Need to minimise cable mass and feed-through

When?



- **Eurobot demo flight proposed for ministerial, if approved a flight in 2013 might be possible**
  - R&D building blocks under preparation that could be used in Eurobot
    - (GSTP) Telemanipulation Extension to the DREAMS Ground Control Station (see presentation from C.Kapellos et al. in session 12) running
    - (Internal funding) Human Arm Exoskeleton (see presentation from A. Schiele et al. in session 7) running
    - (TRP) dexterous robot hand started
    - (TRP) Hand Exoskeleton planned
    - (TRP) Heavy duty chassis planned

When?

- **OLEV may become a reality in three years as the vehicle is being developed for a paying customer (EUTELSAT)**
  - The technology seeds for OLEV have been sow long ago at ESA in the development of RVD equipment and algorithms, and at DLR in the development of a grasping tool

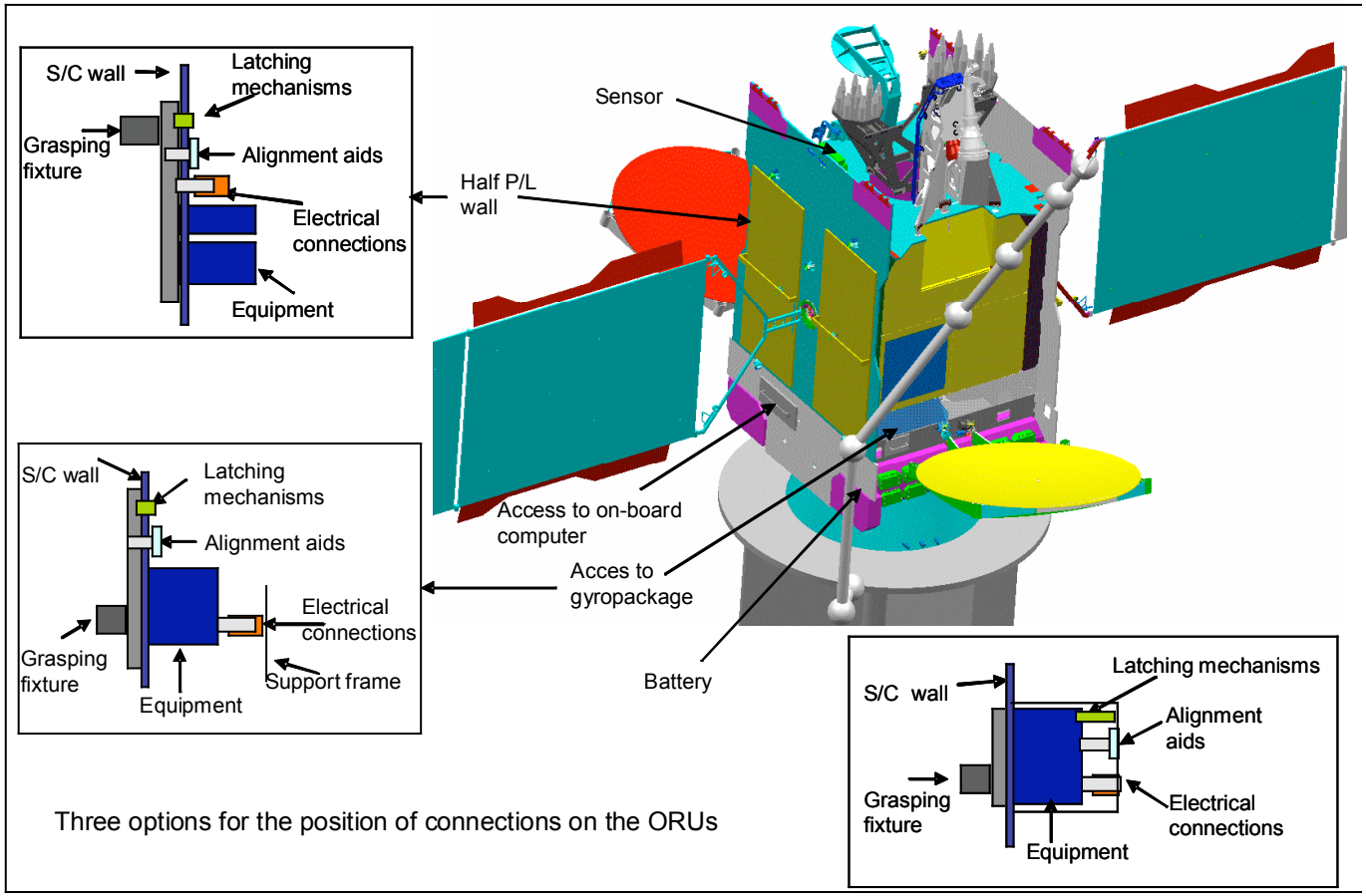
Looking beyond missions

With the contribution from the GSP and the small part of TRP and GSTP not allocated to support missions we can fund more speculative activities such as:

- (GSP) Alternative landing systems that can make smart use of re-entry energy (see presentations from M. Graziano et al. and T.Lutz et al. in session 5) running
- (TRP) design of modifications of existing GEO telecom satellites to make them suitable for servicing and refuelling (see presentations of C.Cougnet and C. Heemskerk et al. in session 13) running
- (TRP/GSTP) A MEMS technology strawman for a Near-Earth Objects Micro Explorer (NEOMEX) running
- A student robotics competition to design rovers capable of returning a soil sample from the bottom of a crater (see mini-workshop on Friday)

BB example on satellite servicing

ESA is studying how to modify an existing commercial telecom platform (EUROSTAR 3000)



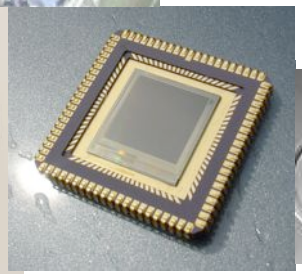
Three options for the position of connections on the ORUs

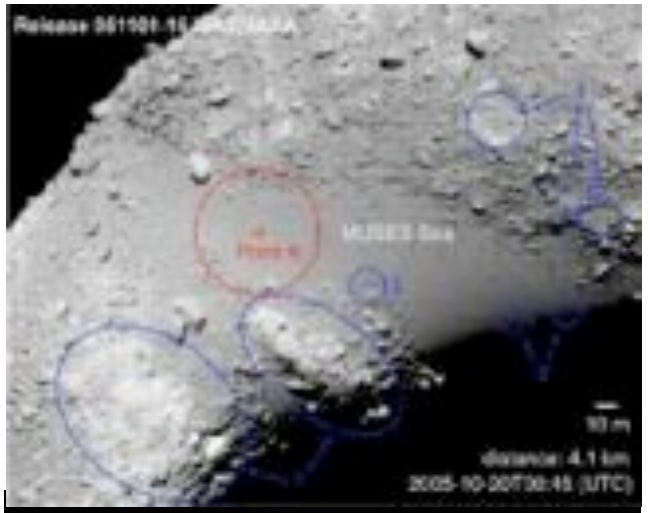
Strawman mission: NEO Micro Explorer

- Objective: To perform close-up scientific investigations on several sites on a Near Earth Object.
- Constraints: Extreme mass-limitation, 5 kg platform, 2-4 kg payload of 10-15 W
- Challenge: use microsystems integrated in a system to gain performance with respect to mass.

NEOMEx will demonstrate all critical functions

of a S/C in an integrated manner





The Lunar Robotics Challenge

- 8 teams of Engineering students tasked to create robots to fetch soil samples from the bottom of a crater







Conclusions

- ESA has an ambitious number of missions which will need to make use of robotics and AI technologies
- We have prepared/are preparing a number of research and development activities which should maximise the probability that their results will be used
- Within the flexibility (and limitations) of ESA programmes, new technology and applications are being pursued, beyond the needs of current (or planned) missions.