ESA Robotics Overview

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Outline

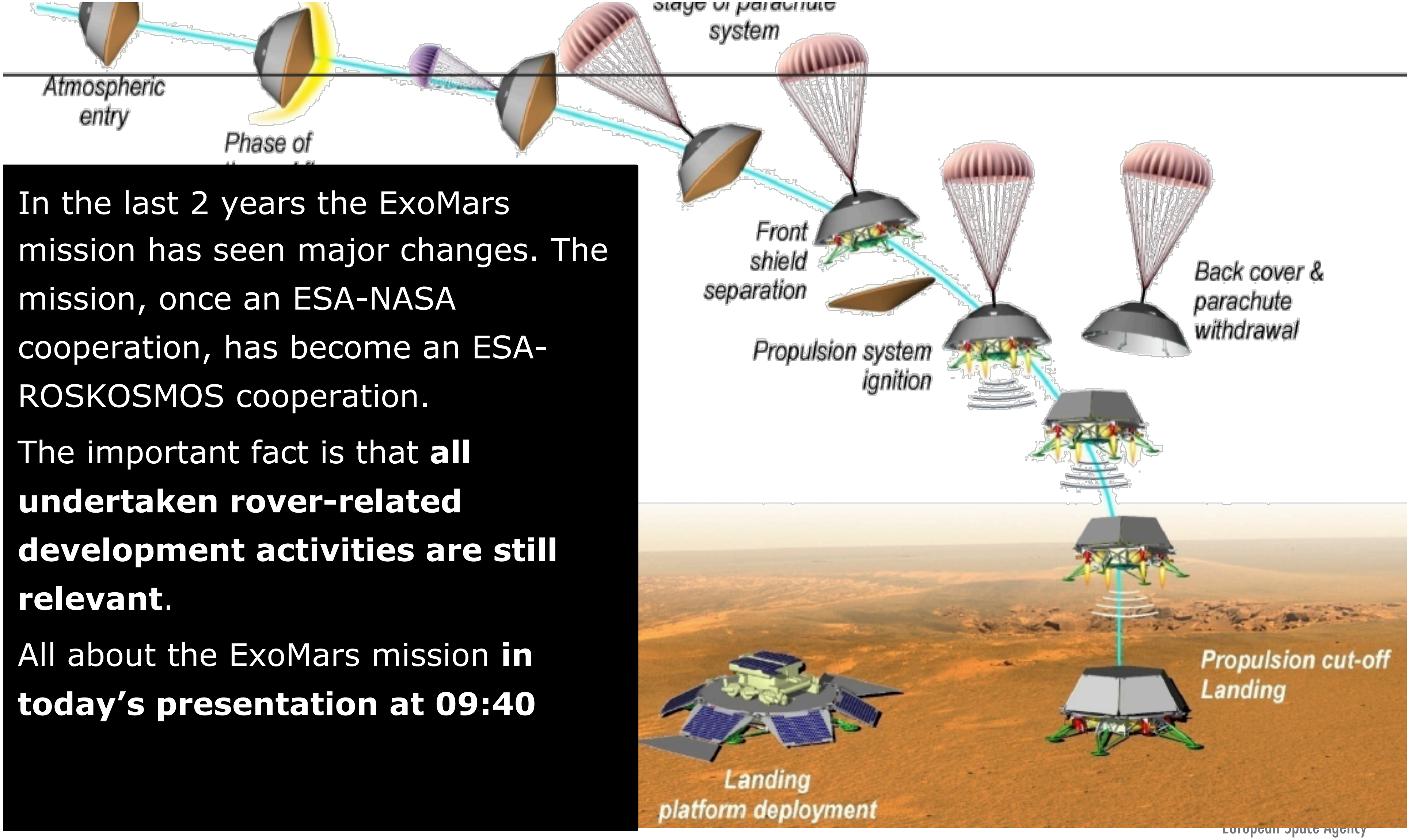
This presentation is an introduction to the last two years of developments in the field of space robotics at ESA with respect to:

- Planetary and Orbital missions (both in development and in study),
- technology plans, that were derived from mission needs, and
- technologies being currently developed

Many (but not all) of the subjects introduced will be addressed by dedicated presentation in the conference, this presentation intends to:

- provide an organic view of the different subjects
- summarise important conclusions
- provide references to the individual presentations

Planetary Missions



In the last 2 years the ExoMars mission has seen major changes. The mission, once an ESA-NASA cooperation, has become an ESA-ROSKOSMOS cooperation.

The important fact is that **all undertaken rover-related development activities are still relevant**.

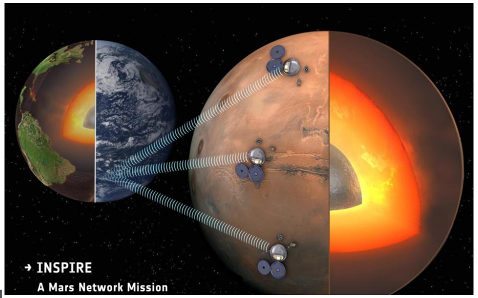
All about the ExoMars mission **in today's presentation at 09:40**

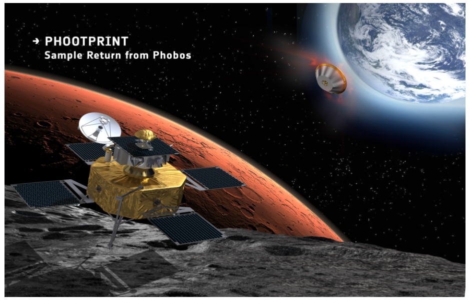
Planetary Missions

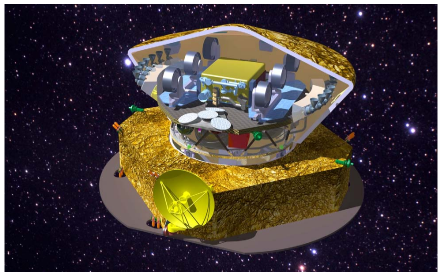
Following ExoMars, three other missions targeting the Martian system are being studied. All of them have important robotics elements:

- **INSPIRE**, a multi-lander mission to Mars needs a small deployment arm
- **PHOOTPRINT**, needs a large sampling arm to return samples from Mars moon Phobos
- **Mars Precision Lander features** a small, but remarkably performing sample fetching rover also equipped with a small robot arm
  Presentation on one of the SFR concepts in session Planetary Sampling I at 14:15

All about these missions in a **presentation on the Mars Robotics Exploration Programme (MREP) today at 10:15**



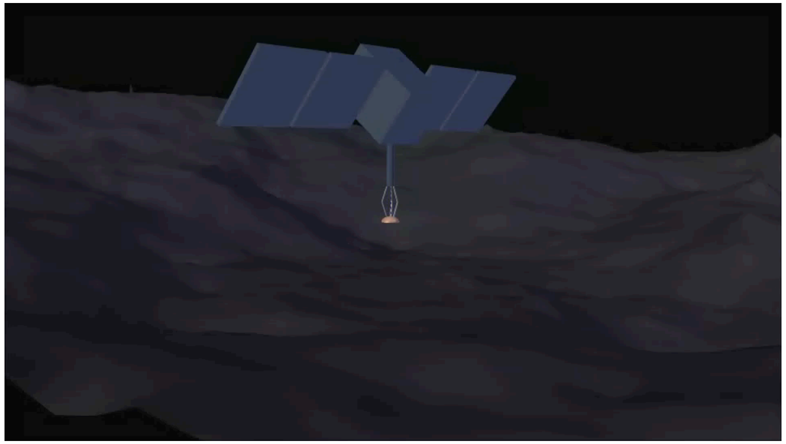




Planetary Missions

Mars is not the only destination of robotic probes:

- MarcoPolo-R aims at sample return from an asteroid. It will use a robotic sampling mechanism.
- Though the Lunar Lander mission did not receive funding at the last ministerial council, ESA still intends to target the Moon through participation to the ROSKOSMOS Luna-Resurs and Luna-Grunt missions. Drilling technology developed for ExoMars will be adapted for the Lunar-Resurs mission within the L-GRASP activity

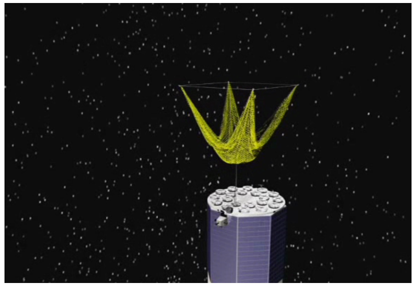


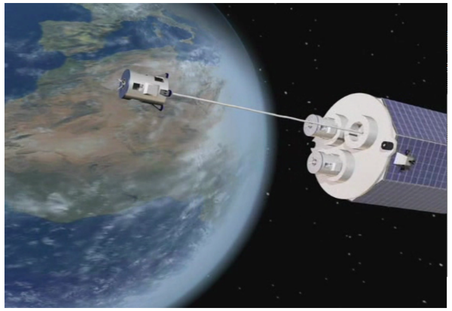
Orbital Robotics

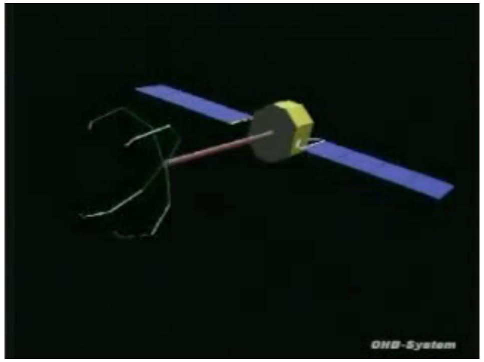
- The European Robot Arm (ERA) is finally approaching launch, a delta Qualification Review was recently completed. **All about ERA today at 11:00**
- The METERON telerobotics experiments are being developed by the Technical & Quality Management Directorate with support from the Human Spaceflight and Operation Directorate. Presentations on the technologies used by METERON are in
  - **Tomorrow's session Simulation / Modelling /Visualisation I at 09:50**
  - **Tomorrow's session Control & Estimation I at 12:25**
  - **Friday's session Human-Robot Interaction at 12:05 and 12:30**

Orbital Robotics

- Since few years ESA has studied the issue of de/re-orbiting spent satellites (ROGER studies in 2001)





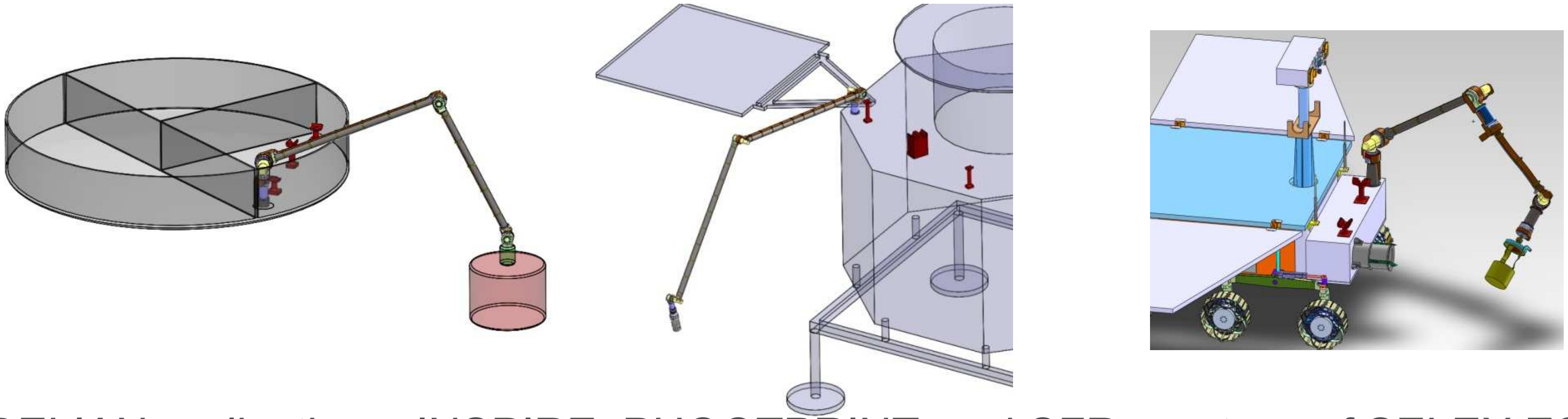


- Recently the subject of Active Debris Removal (ADR) has gained momentum, internationally and also at ESA. The CLEANSPACE initiative addresses the need of making space activities environmentally friendly. This includes also ADR. **All about CLEANSPACE in today's presentation at 11:25**

Technology: robot arms

Most of the planetary missions require lightweight robot arms. These differ from arms developed by ESA (e.g. DEXARM) in several key performance parameters.

ESA has started the development of DExtrous LIghtweight Arms for exploratioN (DELIAN). DELIAN targets the development of a family of robot joints that the realisation of diverse highly mass-constrained planetary robot arms



DELIAN realisations: INSPIRE, PHOOTPRINT, and SFR courtesy of SELEX ES

Technology for future rovers

- A sample fetching rover will require speeds of locomotion much higher than what possible today
- An improvement of an order of magnitude in terms of range/ speed is required.
- The SEEKER activity aimed at demonstrating that this increase is possible with state of the art terrestrial technology. See **SEEKER presentations in today's Navigation / localisation I at 15:45, 16:10, 16:35**
- It is clear that not a single technological solution may provide for such performance boost.
- Essentially these technological solutions aim at turning all energy available to the rover into distance travelled.
- ESA has activated a number of activities to address different solutions

Technology for future rovers

In turning energy into increased range and speed there are 2 possible areas of improvement:

1. Increase energy intake:
   1. Increase/maintain solar energy production
   2. Implement thermal energy production
2. Decrease energy losses
   1. Decrease energy spent in warming up
   2. Decrease energy losses in locomotion
   3. Decrease energy losses in computation

Technology for future rovers

In turning energy into increased range and speed there are 2 possible areas of improvement:

1. Increase energy intake:
   1. Increase/maintain solar energy production → **DUSTER**
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Dust Unseating from Solar-panels and Thermal-radiators by Exhaling Robot (DUSTER): These activities (2 parallel contracts) address the development of ultra-light robot to blow away dust from solar arrays and radiators.

Technology for future rovers

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Technology for future rovers

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The Motion Controller Chip has produced a prototype of a very compact robot joint controller that can survive at very low temperatures without need of warm-up energy. The MCC-X activity will address industrialisation of the prototype

MCC

Technology for future rovers

In turning energy into increased range and speed there are 2 possible
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Wheels are not the most efficient means to move in natural terrain. Yet we must use them. The Adaptable Wheels for Exploration (AWE) will develop wheels that can switch into different modes (e.g. stowed, steering, soft-soil, hard-soil)

AWE

Technology for future rovers

The tasks of Environment Perception, Localisation and Navigation require a lot of processing power and consequently energy. The SPARTAN, SEXTANT and COMPASS activities address the use of FPGA for increasing the efficiency of these tasks. **A presentation on SEXTANT is in today's session Navigation/localisation I at 17:00**

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SPARTAN
SEXTANT
COMPASS

Technology for future rovers

ESA continues to develop autonomous operation of rovers:

- The **Rover Autonomy Testbed (RAT)** activity targets the optimal assignment of teleoperation and autonomous functions depending on communication constraints
- The **Ground Control Station For Autonomy (3DROCS)** builds on the successful 3DROV development to provide an environment to operate rovers
- The **Mobile Autonomous Scientist for Terrestrial and Extraterrestrial Research (MASTER)** activity targets the development of an agent that based on training can detect salient scientific events
- The **GOAC TRL-increase Convenience-enhancements, Hardening and Application-extension (GOTCHA)** activity aims at continuing the development of the Goal-Oriented Autonomous Controller (GOAC)
- The **AUTONOMous Technologies for HighlY Mobile Rovers (AUTONOMY)** activity aims at developing ways to manage the high complexity of a rover locomotion system also to detect and avoid entrapment

Technology for future rovers

ESA has embarked into validation of rover systems through **field testing**.
A first field test took place in the SEEKER activity.

A second field test will take place in the SAFER activity. This specifically targets rehearsal of the ExoMars outcrop search-and-drill scenario.

The creation of the ESA Harwell site is an opportunity to establish a programme of recurring field tests.

Technology: ADR

The principle "robotic" problems in ADR are related to:

- Grasping the debris
- Maintaining safety of the compound (debris + chaser) during deorbitation

Considering that ESA is not the only Agency working on spacecraft servicing, ESA has chosen to concentrate only on some of the possible technologies (i.e. the ones not addressed by other agencies):

- Throw-nets: a complete programme of development and validation (includes parabolic and sounding rocket tests) has been initiated.
- "Octopus" arms: simulation and prototyping activities are envisaged
- Harpoons: continuation of development initiated by ASTRIUM UK

Conclusions

A long long standing mission finally getting launched.

A troubled mission getting out of the many mishaps it has experienced.

Telerobotics experiments flying to the ISS.

5 planetary missions, all featuring capital robotics elements, being studied.

ADR (which needs robotics) becoming a priority…

Is 2013, finally, the year of space robotics?