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),
- technologies being currently developed and
- technology plans for the near future

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

2014 was the year of ROSETTA. The sampling system of ROSETTA has been presented at previous ASTRA conferences

in all phases of its conception, design and engineering. This **Tuesday at 09:50 in session 3A: Planetary sampling** see how it worked on 67P

Planetary Missions

In the last 2 years the ExoMars mission has completed its transition to an ESA-ROSKOSMOS cooperation.

The launch date approaches and phase C/D is in full swing.

The rover is proceeding from the drawing board to the lathe

All about the ExoMars mission **in today's presentation at 09:15**

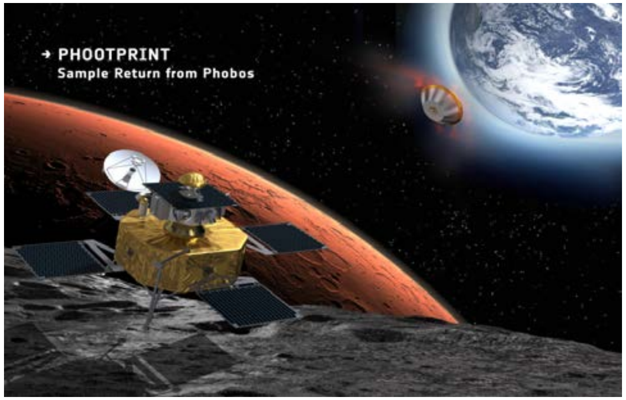
Furthermore there is an entire session dedicated to ExoMars developments **Today starting at 14:00**

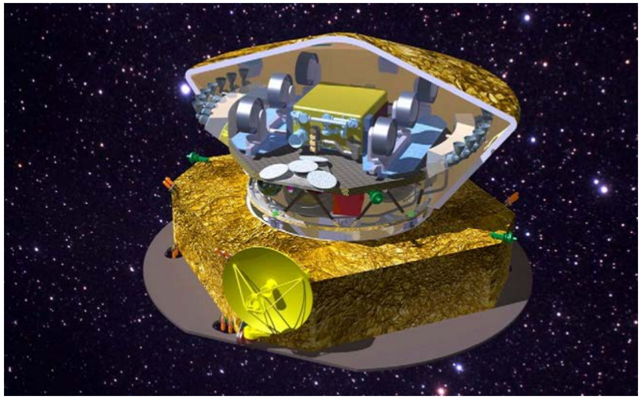
Planetary Missions

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

- **PHOOTPRINT**, needs a large sampling arm to return samples from Mars moon Phobos. See presentations on sampling tools on Tuesday at 8:30 and 9:00 and on robot arm on Tuesday at 15:55
- **Mars Precision Lander features** a small, but remarkably performing sample fetching rover also equipped with a small robot arm

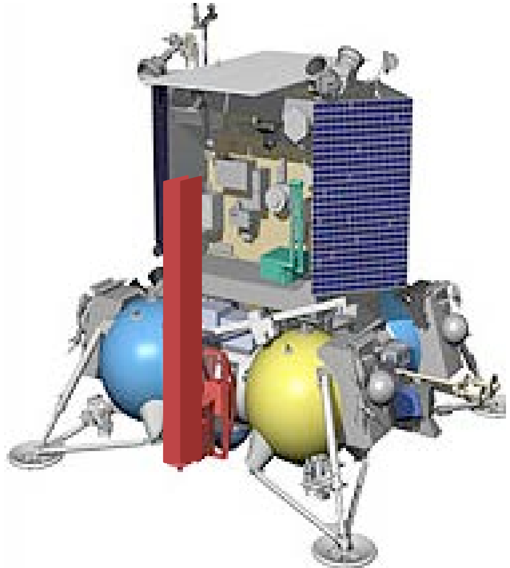
All about these missions in a **presentation on the Mars Robotics Exploration Programme (MREP) today at 09:55**





Planetary Missions

- ESA intends to target the **Moon** through participation to the ROSKOSMOS Luna-Resurs and Luna-Grunt missions. The missions have been subject of extensive Concurrent Design Facility (CDF) studies, which have identified the ESA possible contributions.
- For both missions ESA intends to contribute a sampling drill.
- Drilling technology initially developed for ExoMars is being adapted for the Moon. **See presentation on Tuesday at 9:25 and 10:15**



Orbital Robotics

- The European Robot Arm (ERA) while awaiting launch, is being subject of some refurbishing work. **All about ERA today at 10:15**
- 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 METERON experiments are in **Tomorrow's session 4A: Human-Robot Interaction I at 11:20 and 11:45**
- More presentations on METERON technologies also in **Tomorrow's session 4A: Human-Robot Interaction I at 12:35 and 5A: Human-Robot Interaction II at 14:00 and 14:25**

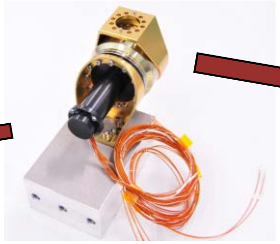
Orbital Robotics

- 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 10:35**
- **Also look at session 7A: Active Debris Removal on Wednesday morning for result of ADR tech. activities**

Technology for planetary sampling: robot arms and low-gravity gears

Most of the planetary missions require lightweight robot arms.

ESA proceeds with the development of DExtrous LIghtweight Arms for exploratioN (DELIAN). DELIAN targets the development of a family of robot joints that allow the realisation of diverse highly mass-constrained planetary robot arms. See **6A: Manipulators & End-Effectors at 15:55**



Sampling in a low gravity environment requires accurate management of the force exchanged with planetary surfaces. Following the breathtaking landing of Philae, ESA is investigating Active Landing Gears that can also manage force exchange during sampling. See session **9A at 14:50**

Technology for planetary sampling: sampling mechanisms

For the specifics of Low-gravity sampling three alternative sampling systems have/are been/being developed

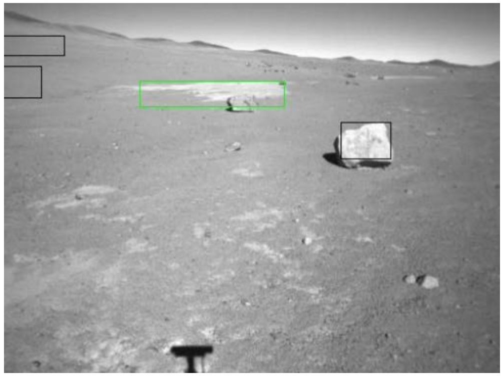
A rotary brush type one  see **3A: Planetary sampling at 8:30**

A corer type one  see **session 3A at 8:30**

A clamshell-grab one 

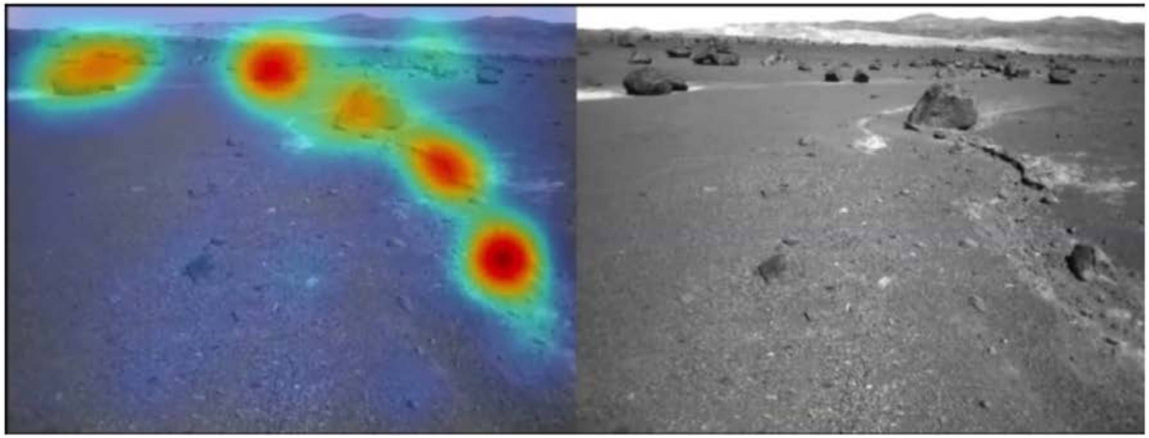
Technology for future rovers: global localisation

- A Martian sample fetching rover will require speeds of locomotion much higher than what possible today
- The rover will travel autonomously for large traverses (possibly up to a kilometre).
- Dead-reckoning no longer sufficient. ESA has been investigating global localisation based on a-priori known landmarks; see **8B: Localisation & Navigation at 11:20 and 12:10**



Technology for future rovers: autonomous science

- The rover will travel autonomously for large traverses (possibly up to a kilometre) it is unthinkable not to undertake some science. This will need to be done autonomously.
- The Mobile Autonomous Scientist for Terrestrial and Extraterrestrial Research (MASTER) activity has prototyped an agent that based on training can detect salient scientific events; see **7B: Planning & Autonomy at 9:25**



Technology for future rovers: autonomous control

Whether for Lunar or Martian exploration the way autonomous control is commanded from ground has been an important subject of development.

- The Rover Autonomy Testbed (RAT) activity has developed an integrated testbed that allows experimenting on the optimal assignment of teleoperation and autonomous functions depending on communication constraints; see **8A: Robotic Testbeds & Frameworks at 11:45**
- The Ground Control Station For Autonomy (3DROCS) has built on the successful 3DROV development to provide an environment to program rovers; see **9B: Simulation / Modelling / Visualisation at 15:40**

Technology for future rovers: validation of the system

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 took place in the SAFER activity. This specifically targeted rehearsal of the ExoMars outcrop search-and-drill scenario; see **1A: ExoMars at 14:00**

Plans – Technology for Rovers

The finding of how difficult is to bring back good samples of volatiles from the Moon south pole has hinted that in-situ analysis with a ExoMars-style rover may be a more viable option.

-> The activity **LUnar scenario Concept valIdation and Demonstration (LUCID**) will address the operation of rovers in permanently shadowed areas

Recent (bad) experience of the Curiosity rover with terrains of unexpected consistency shows that we still know very little about Martian soil.

-> the **stUdy on Negligible Dedicated Equipment on Rovers for Soil Testing and Appraisal of Navigable fielDs (UNDERSTAND)** aims at developing of experiments for the in-situ characterisation of Martian soils

Plans – Technology for Rovers

Space robot systems of the future will be required to perform ever more complex tasks requiring ever more complex hardware and software.

It is clear that for these systems a solid foundation for realising the control of complexity needs to be prepared.

-> the activity **Space Automation & Robotics General cONtroller (SARGON)** intends to develop a first prototype of Robot Control Operating System (RCOS) that will

- Build on heritage on an existing body of robot control software
- Provide adequate RAMS attributes for industrial and space use
- Provide support for modularity and re-usability (of modules and/or entire applications)
- Provide an open standard implementation
- Provide a large community of developers and users

See the RCOS Forum on Tuesday

Plans – Orbital Robotics

With ADR remaining a priority for ESA, the further validation of the capturing technology is must

-> The activity **end-to-end validation of the NET system on sounding rocket** will undertake the final step of validation of the NET system: a full scale net (hundreds of m^2) will be deployed from the side of a sounding rocket and measured in its unfolding.

The project “PER ASPERA (ad ASTRA)” (Latin meaning “Through hardships to the stars”) aims at developing an integrated master plan (a.k.a. roadmap) of activities and associated activity descriptions, for a Strategic Research Cluster (SRC) in Space Robotics Technology.

The roadmap will be implemented within the SRC through operational grants, which will be recommended by PERASPERA and issued by the European Commission.

PERASPERA will plan and accompany the SRC to attain its overall objective to deliver, within the 2023/2024 framework, key enabling technologies and demonstrate autonomous robotic systems at a significant scale as key elements for on-orbit satellite servicing and planetary exploration

The PERASPERA roadmap has been presented and endorsed in a dedicated workshop on 11-12/2/2015 in the ESTEC area

http://www.h2020-peraspera.eu

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This presentation reflects only the Consortium's view. The EC/REA are not responsible for any use that may be made of the information it contains.

Conclusions

- ASTRA has 25 years!
- We have closed the circle with the first ESA robotics mission that ASTRA has followed up (it started when ROSETTA was called CNSR).
- The second ESA robotics mission (ERA) still awaits launch…
- ExoMars is taking physical shape and yet still provides for research subjects and experience growth.
- While the planetary exploration goals are being refined, technology development goes on relentlessly.
- The EU PERASPERA provides for a very good opportunity to complement ESA's and National Agencies efforts in in the maturation and demonstration of space robotics technologies.