

Status of the European Robotic Arm Project and Other Activities of the Robotics Office of ESA's ISS Programme

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- In March 2010, the Heads of Space Agencies, assembled in Tokyo, in the context of discussing the extension of the ISS lifetime till 2020, identified the use of the Station as a test-bed in preparation for Exploration as a key objective for the Partnership.
- In the frame of the on-going ESA Directorate re-organization, the activities on the ISS and on human exploration will be concentrated in the Department of the ISS Programme and Exploration of the new ESA Directorate of Human Spaceflight and Operations (HSO).
- The ERA and Robotics Project Office is part of that department and covers robotics for ISS and exploration.

Robotics Activities (general)



ESA has robotics activities in several areas:

- robot technology development:
 - 3 types of missions drive technology requirements from Human Spaceflight and Operations directorate: i) robotics on orbiters (zero-g), ii) robotics on the surface (autonomous or operated from the surface), iii) robots on the surface teleoperated from an orbiter
 - Technology development for these missions is mainly done by ESA's technical directorate
- robots for human exploration => Human Spaceflight and Operations
- robots for scientific exploration => Science directorate
- large European Robotic Arm (ERA) for the Russian Segment of the ISS => Human Spaceflight and Operations

Robotic Activities (specific)



- European Robotic Arm for ISS (ERA)
- Exploration Robotics Requirements and Concepts study (XROB)
- Eurobot EVA assistant
- Eurobot surface robot+rover
- Eurobot analogue field test (Rio Tinto Spain 18-22 April 2011)
- METERON: operate Earth based robots from an advanced MMI on ISS

Ground Segment

- mid life update of ERA Mission Preparation and Training Equipment (obsolete HW replaced, SW ported) installed in Estec, GCTC and in RSC Energia
- Mission Control Centre functions being defined: Moscow (main) and Estec (support)

Flight Equipment Integration

- First ERA hardware being integrated on MLM (ERA basepoints)
- SW integration at RSC Energia
- HW Integration programme at RSC Energia, Khrunichev and Baikonur Cosmodrome

Training and Operations Preparation

- ERA training courses given to new GCTC people (Gagarin Cosmonauts Training Centre)
- Preparation started of In Orbit Validation mission and first 2 operational missions (installation of MLM of airlock and radiator)

Safety and Mission preparation

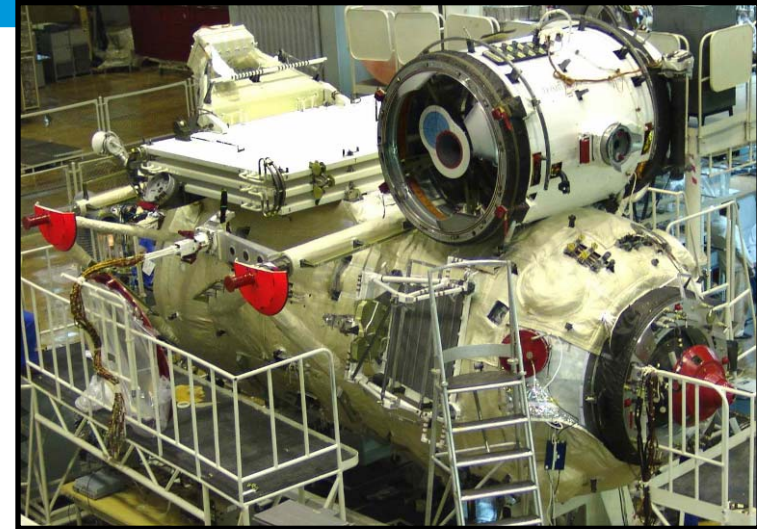
- MLM/ERA Safety Review several sessions held; ERA standalone Safety Review passed in the ERA design phase (2001) but changes since then are being discussed

Launch date December 2012

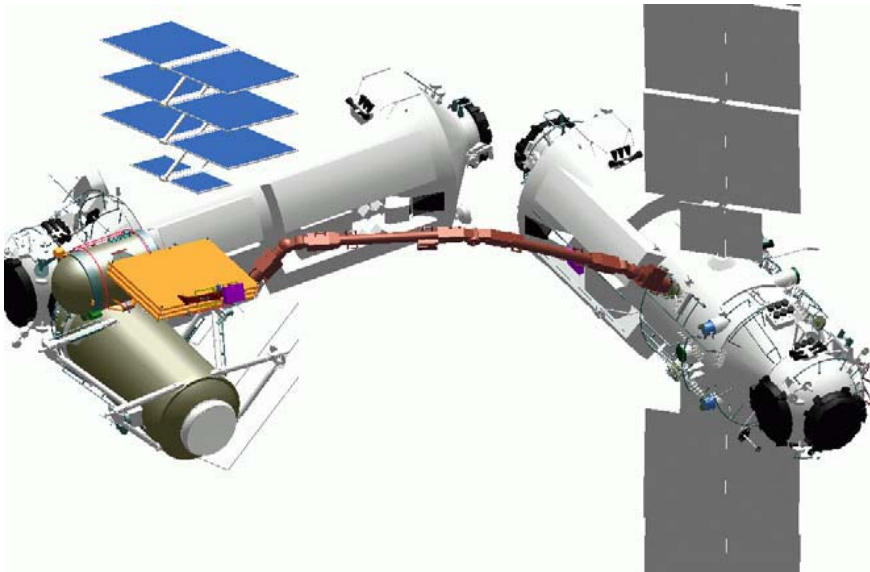
ERA (2)



**MLM
Airlock
Operated
by ERA**



**ERA ops preparation
With RSC-Energia**



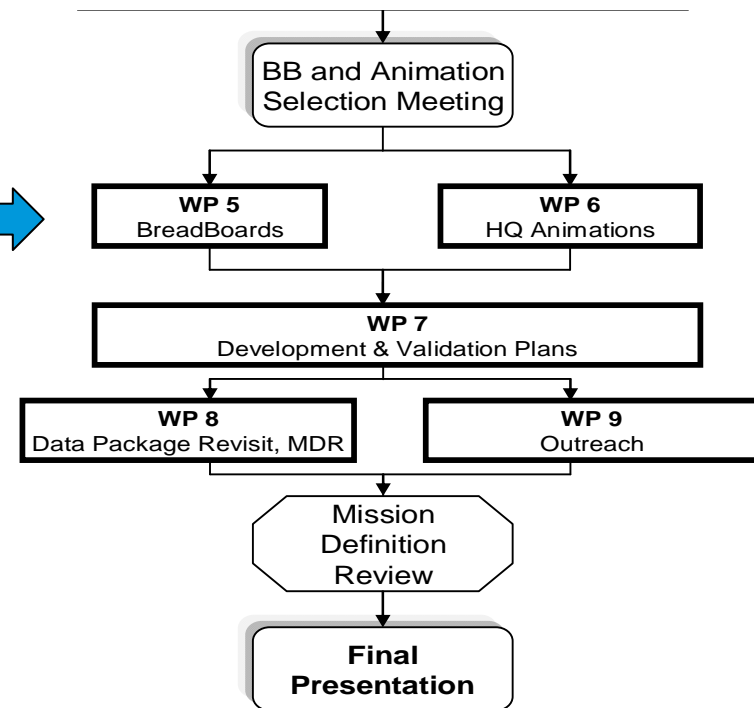
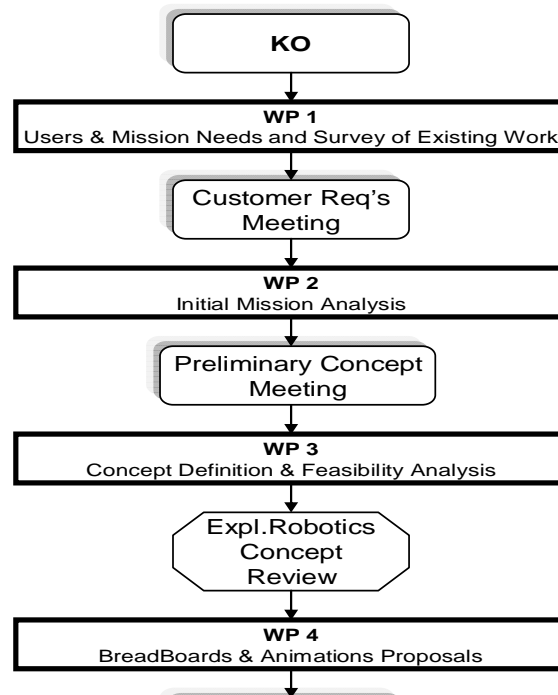
**STS-132 with MRM1,
ERA spare and ERA's
first payloads (14 May)**



Objectives

Analyze robotic functions required in exploration, develop cost efficient robotic concepts for these needs

- For 4 different phase of exploration and for 3 different environments
- For robotic explorers, builders and crew assistants (robotic agents)

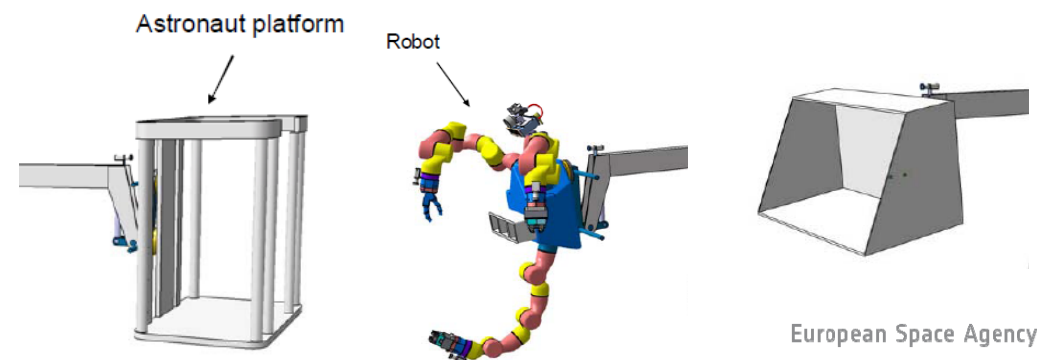
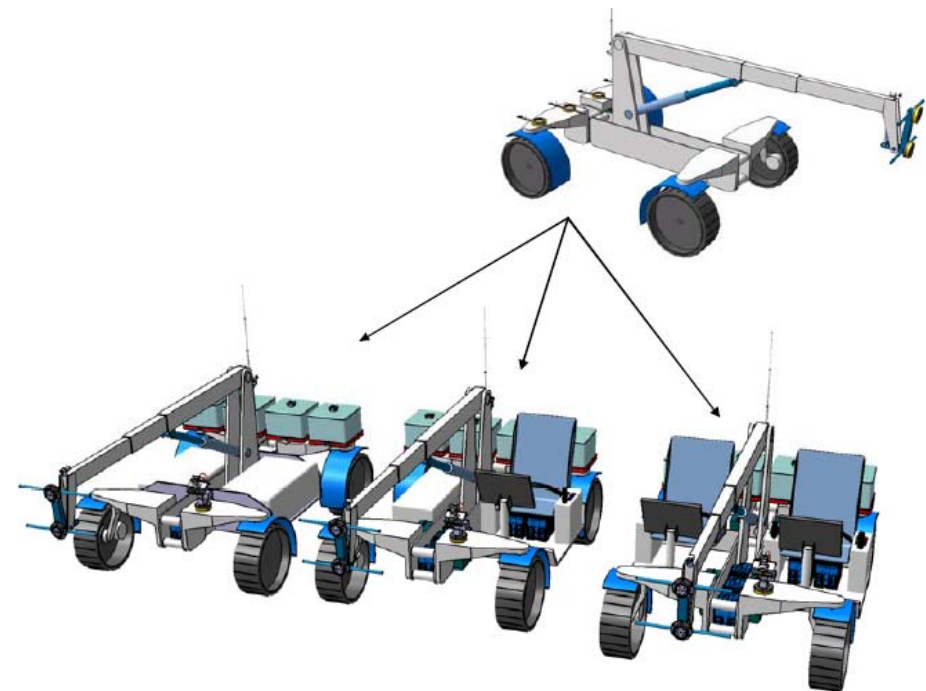
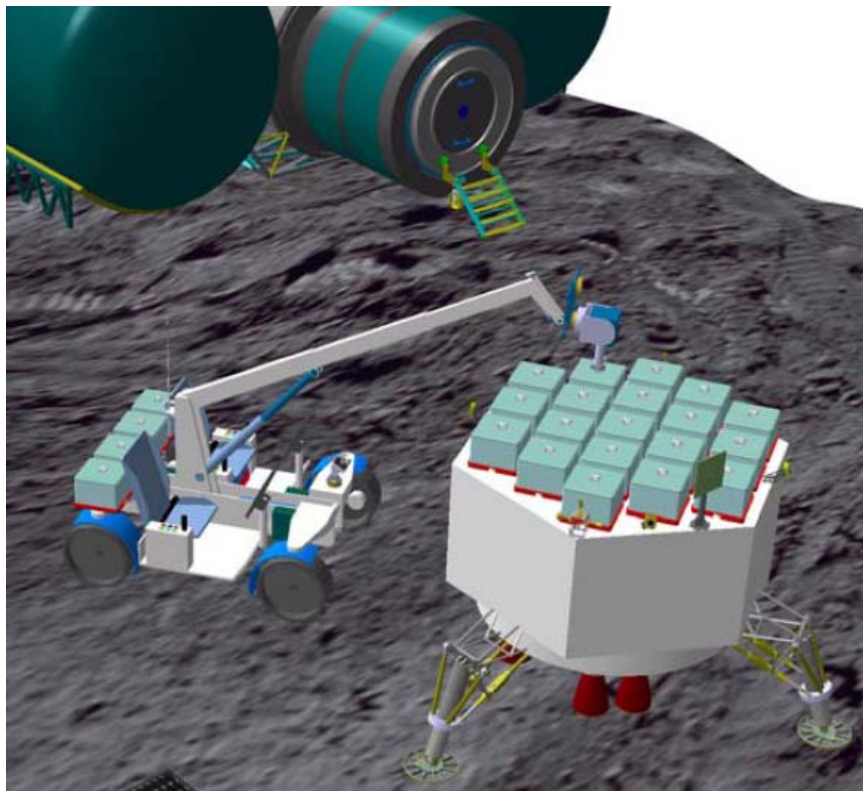


XROB (2)

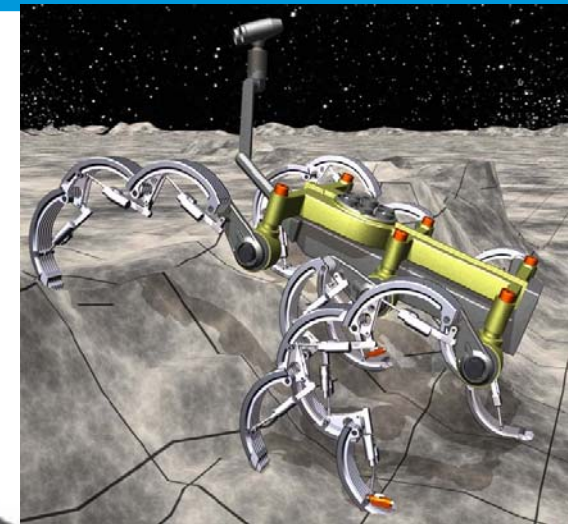
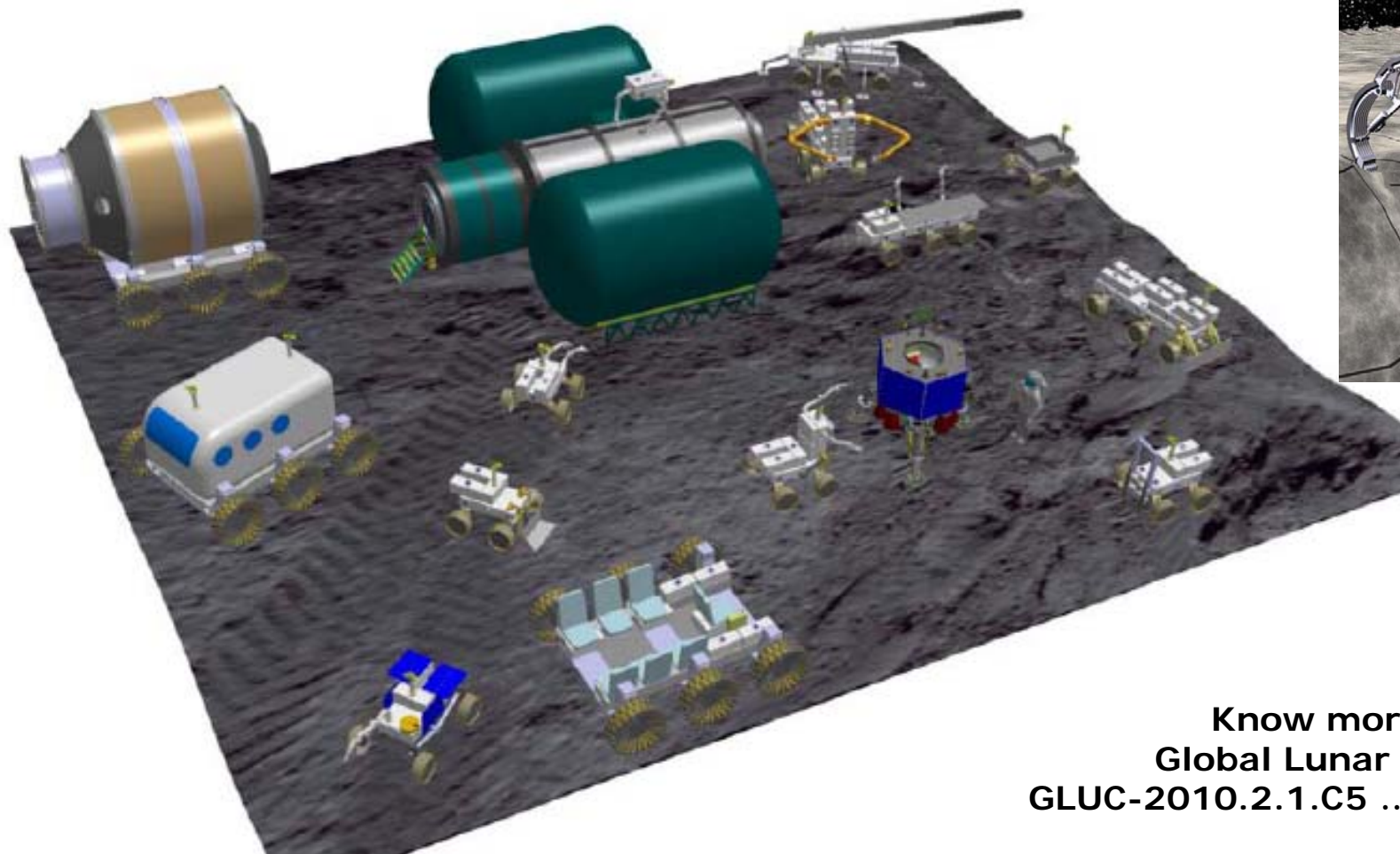


Modularity and reuseability examples

- Different versions of the builder rover depending on which device is on the boom



XROB (3)



Breadboard Wheel/leg/arm

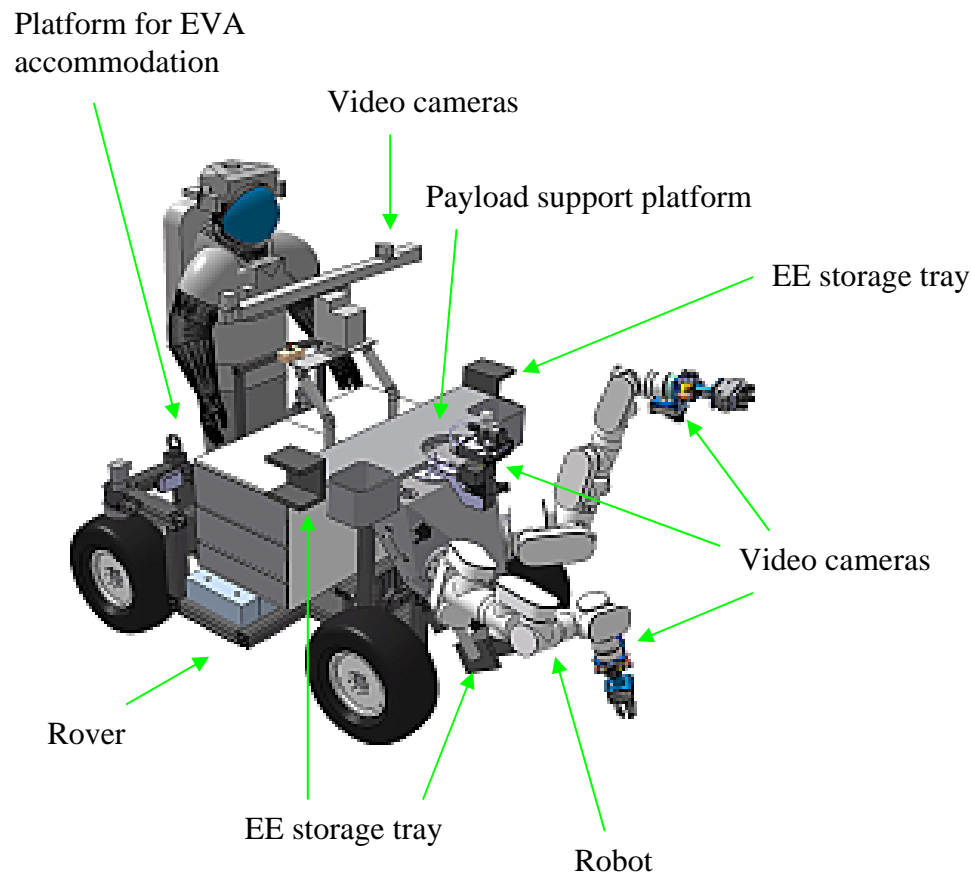
**Know more? Read paper from
Global Lunar Conference Beijing:
GLUC-2010.2.1.C5 ...THE XROB STUDY.....**

Eurobot EVA assistant



Eurobot is a humanoid robot designed for EVA assistance on the ISS: worksite setup, cooperation, cleanup. Final test with ESA astronaut Clervoy in ESA hydrolab in 2007.

Eurobot surface robot + rover (1)



- In 2008 ESA started a new Eurobot phase - the Eurobot Ground Prototype (**EGP**) – for use in exploration missions on the planetary surface (Moon and later Mars)
- The EGP project addresses the use of robotics in preparation for human arrival and robotic assistance during human presence
- The project conducted a deep test campaign to demonstrate the use of robotic technologies for exploration and to gain experience on (cooperative) robotic tasks

Eurobot surface robot + rover (2)



Final demo at Estec 11 June 2010



test under difficult light conditions
(shadows and reflections)



Collision avoidance model in bad light
(L) and good light (R)



Shadow hand mounted
on Eurobot arm



Control with master-slave arm

Joystick with force feedback



CONTROL METHODS



Control with master-slave hand



Automatic mode



TECHNO- LOGY

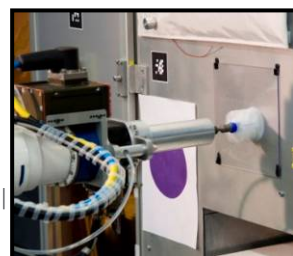
DLR hand with Eurobot



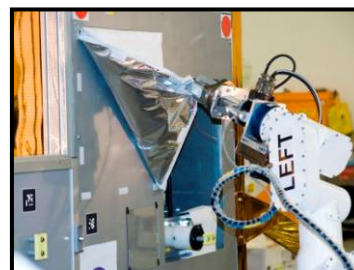
Deployment of solar array



Cleaning dust off window



Removal of thermal insulation



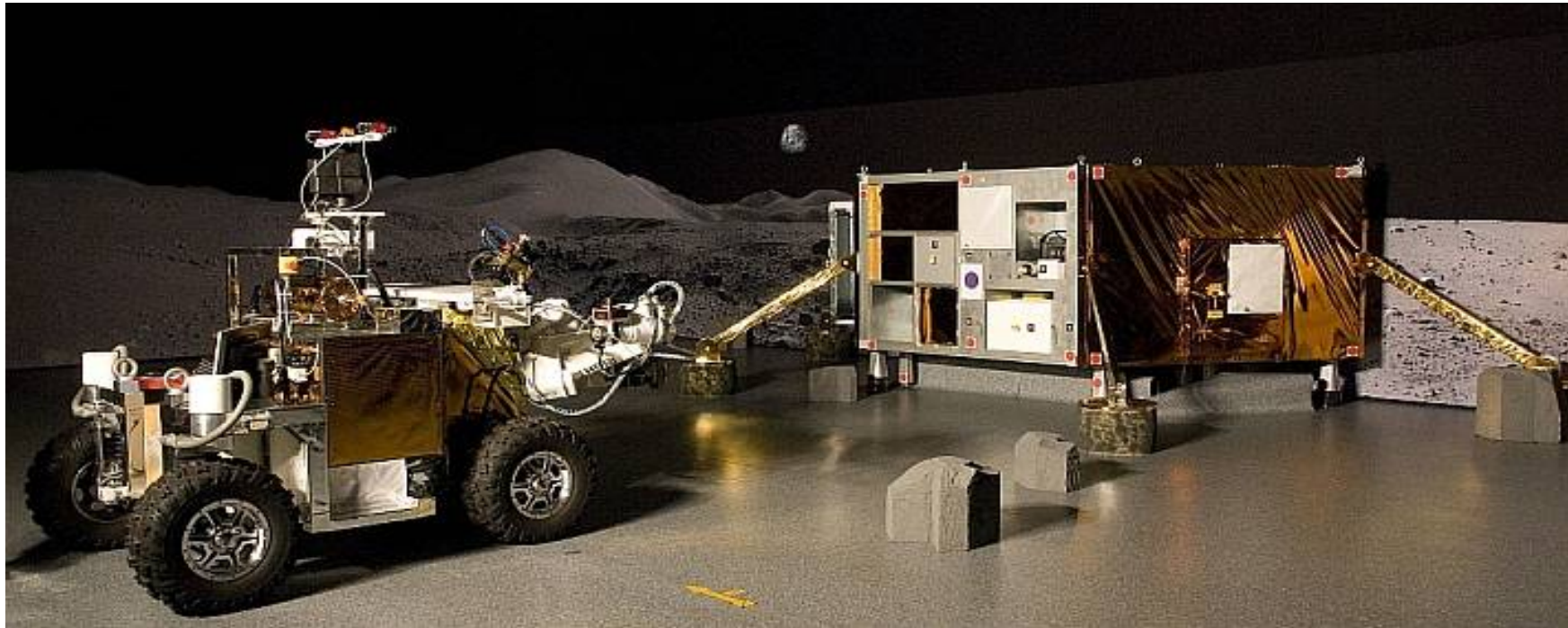
Off-loading of a lander



APPLI- CATIONS

European Space Agency

Eurobot surface robot + rover (3)

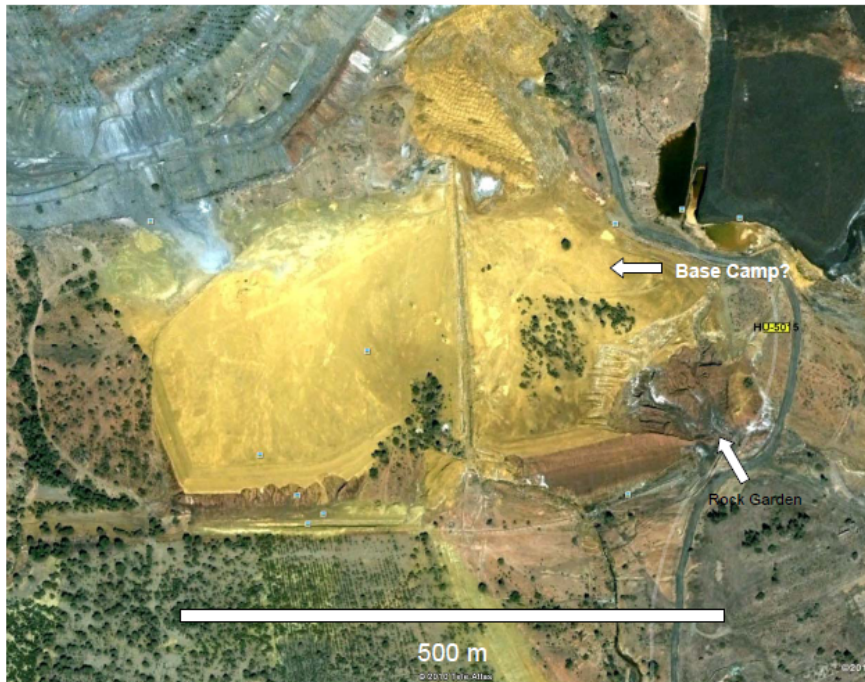


- As a next step, make the system more flight representative (arms, wrists)
- Improve system autonomy (more intelligence and better batteries)
- Test vision system in various unfavorable light conditions and improve Digital Elevation Map, synthesize information from all sensors
- Improve and add sensors (ranging, grasping, odometry, force/torque)
- Improve anthropomorphic end effectors (robot hands)
- Improve Man Machine Interface (joysticks, stereovision, exoskeleton, voice)
- Improve rover and robot speed and robustness

Eurobot analogue field test (1)



GPSPat: 37 40' 39,60" [DMS], GPSLong: 6 33' 57,60" [DMS]



- test in Mars-like landscape, Rio Tinto Spain, 18-22 Apr
- Organised by Austrian Space Forum, providing "Aouda-X" Space Suit
- ESA provides Eurobot and LTMS (vest for long term medical survey)
- 60 people (30 Spain, 30 MCC Innsbruck)

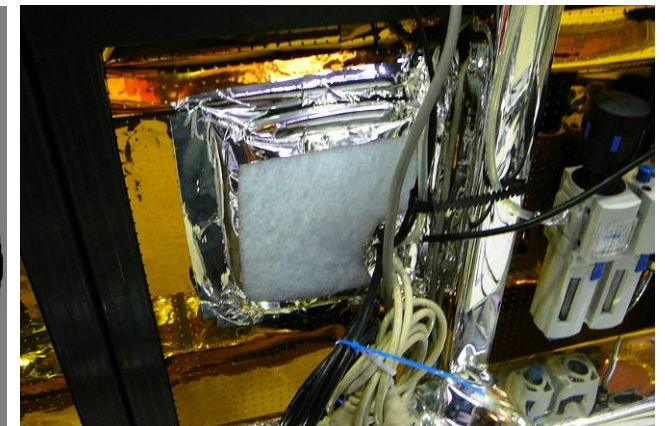
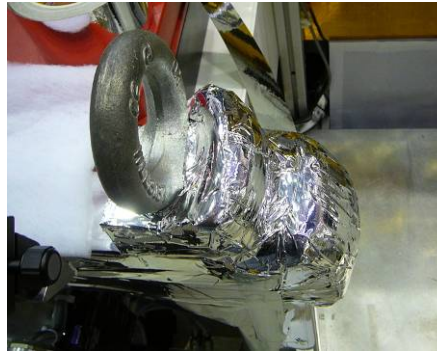


Eurobot analogue field test (2)



Preparations:

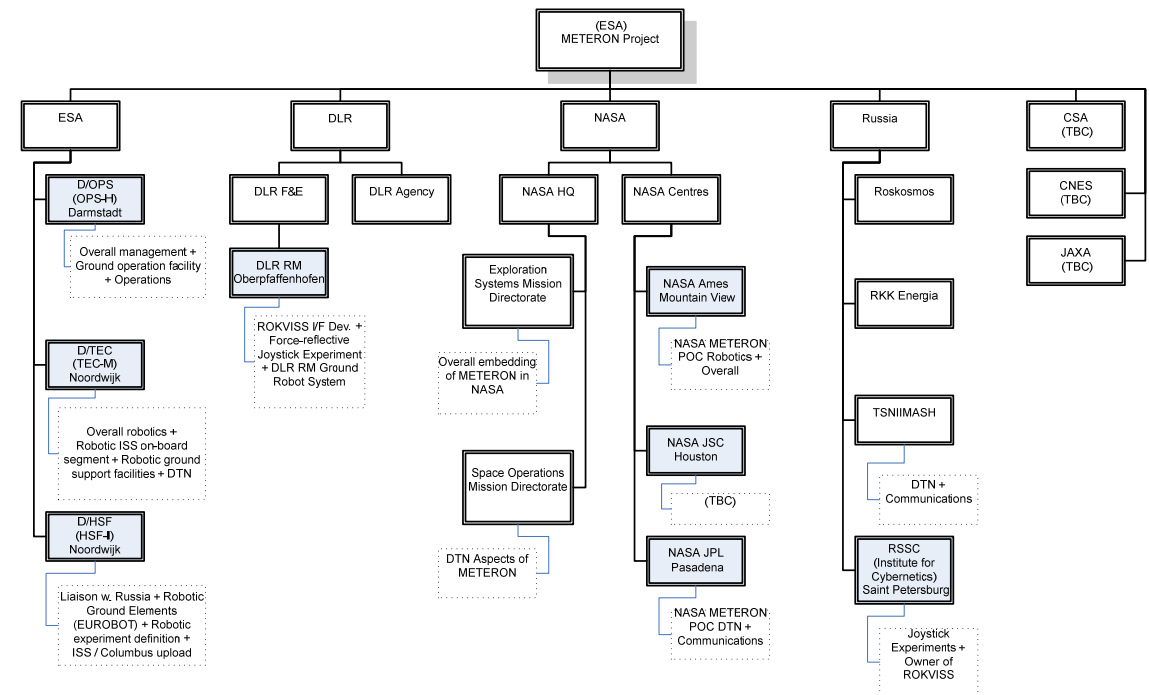
- Headset distance test
- Wireless comms tests
- Dustproofing
- Shockproofing
- Sharp edges/corners
- Vision parameters adjustment
- Dry run of procedures
- Transportation preparation



METERON



- Submitted to Human Spaceflight directorate Call for Ideas on the use of ISS for exploration, by HSF/ISR (now HSO), OPS/HSA (now HSO) & TEC/MMA
- Cooperation discussions are on-going with NASA, Roscosmos and DLR
- See presentation by Andre Schiele TEC-MMA**



Thank you for your attention



Ending with a quote....

- “Not robots vs. humans
- but robots and humans”
- (ESA Director General JJ. Dordain, GLUC keynote address 31 May 2010)

