EUROBOT
EVA-assistant robot for ISS

Ph. Schoonejans, F. Didot, R. Stott, A. Jain (ESA)

D. Buffa, R. Boaretto, (Alenia Spazio)

C. Heemskerk (Dutch Space)
Presentation Overview

- EUROBOT Mission Objectives & Task Requirements
- Modes of Operation
- System Breakdown
- Mobile Segment Configurations Under Trade-Off
- Tools Panoply
- ORU & I/F Panoply
- Home Base
- Life after ISS ... applications for Exploration...
- Project Schedule
- Conclusion
Objectives

- **EUROBOT Motivations:**
  - *Reduce the amount of crew time required for ISS external maintenance*
  - Reduce EVA sortie duration & numbers
  - Surgical model: human = surgeon, Eurobot = nurse

- **EUROBOT Tasks Requirements:**
  - EVA worksite preparation & closing tasks (2 EVAs in 1)
  - EVA co-operative task (2 EVAs in 1)
  - EVA sortie substitute:
    - Orbital Replacement Unit (ORU) installation / exchange
    - Payload servicing/ maintenance
Tasks Requirements

- Deployment from Home-Base
- Locomotion & Transportation
  - self-RELOCATE to specified location (using handrails & / or other standard external ISS I/Fs)
  - TRANSPORT ORU/ payload (hold in 1 hand) while relocating
- Prepare EVA worksite
- Support EVA sortie (lighting worksite, monitoring, temporary stowage for ORUs, tools... )
- Close-up inspection and monitoring
- Safing / Keep-Alive / Maintenance
  - RECHARGE at Home-Base docking station
  - enter SAFE / STAND-BY / DORMANT state (stand-by & dormant at docking station)
Modes of Operation

- **Modes of Operation:**
  - *Autonomous* for all well structured/ repeatable/ tasks such as:
    - Deployment, locomotion & transportation to worksite
    - Worksite preparation prior to EVA sortie: foot-restraint installation, camera / lighting set-up, carrying tools-set
    - EVR compatible ORUs exchange
  - *Manual* for less structured/ predictable tasks:
    - EVA/ EUROBOT choreography while at worksite
    - Local inspection for troubleshooting
System Configuration

- Trade-off ongoing for different configurations
- Key issues
  - Large number of handling I/Fs to deal with
  - Large number of actuation I/Fs to deal with
  - Difficult to choose between many configuration options
  - Home base location
  - Charging station (TBC) location(s)
  - Wireless communications
  - Thermal
- Constraints
  - Ingress/egress through airlock
Initial ESA Baseline Configuration

One central cylindrical body with two rotating caps

Three identical limbs (arms / legs) with 7 joints

Front cap (Head) is equipped with camera and lighting unit

Back cap (Tool Backpack) holds end effectors / tools
Configuration-1 Under Trade

- 3 identical arms of 1 meter each
- Each arm with 7 d.o.f
- Symmetrically mounted at 120 degrees around the body
- Initial PRR configuration
Configuration-2 Under Trade

- 3 identical arms of 1 meter each
- Each arm with 7 d.o.f, with camera & lighting
- Symmetrically at 120 degrees around the body
- Set of cameras mounted (2 mono or 1 stereo) on pan & tilt unit on central body (not visible in picture)
Configuration-2 Under Trade

- EUROBOT size/reach compared to EVA
Configuration-3 Under Trade

- 2 identical arms of 1 meter each
- 1 stronger leg arm
- Each arm with 7 d.o.f
- 2 arms symmetrically mounted
- 2 cameras mounted on central body, on pan & tilt unit
Configuration-4 Under Trade

- Identical arms of 1 meter each
- 1 stronger leg arm
- Each arm with 7 d.o.f
- 2 symmetrically mounted arms
- Same concept as –3- but different head and arms
Configuration-5 Under Trade

- Identical arms of 1 meter each
- Each arm with 7 d.o.f
- 2 symmetrically mounted arms
- Camera on top
- End effector storage on “belly”
- Removable battery
Configuration-5 Under Trade
Configuration-5 at work on Columbus-EPF
Stepping over Columbus-Node3
Tools Panoply

- Hand-Rail End-Effector
- Robotic I/F End-Effector
- General Gripper End-Effector
- Multi-Tool End-Effector
- Specific Operation End-Effector
Example: US segment alone has large quantity of EVR ORUs (~300 already)
ORU Panoply: from Small (~1 kg) to Large (max 362 kg)
I/F Panoply

H-Fixture

Micro Square

Micro Conical

US-Segment “Dog Bone”

RS “Square”
Home Base Concept

- ExPA positions on ISS truss
- UCP position on US airlock
- EUROBOT platform position on US trunnion
- ExPA Adapter on Columbus EPF
- EUROBOT platform position on Columbus trunnion
Home Base Concept

- Dedicated Eurobot homebase platform mounted to a Columbus trunnion (TBC)
- Eurobot homebase mounted to EPF (TBC)

Placement of the home base on ISS
Life After ISS ...

- Humans will move beyond Earth orbit ... back to the Moon & on to Mars
- Mobile **manipulator technologies** developed for EUROBOT project may be applied & developed further for Exploration programme
- Technologies used both in early robotic missions & later human missions
- Human missions may benefit from dedicated Mobile Manipulator System (MMS) in the role of EVA crew assistant
## Manipulators in Space

### Exploration Phase

<table>
<thead>
<tr>
<th>Space Environment</th>
<th>Robotic Exploration</th>
<th>Human Arrival Imminent</th>
<th>Human Arrival</th>
<th>Long-Term Presence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth orbit</td>
<td>Test robotic/MMS technology &amp; operations in LEO or on ISS</td>
<td>Test robotic/MMS technology &amp; operations in LEO or on ISS</td>
<td>Use during potential on-orbit assembly of human mission modules</td>
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</tr>
<tr>
<td>Interplanetary Space</td>
<td></td>
<td></td>
<td>Transfer vehicle maintenance; crew assistant</td>
<td>Transfer vehicle maintenance; crew assistant</td>
</tr>
<tr>
<td>Moon/Mars orbit</td>
<td>On MSR mission, use for sample handover from ascent vehicle to Earth-return vehicle</td>
<td>Maintenance of human mission modules sent in advance of human arrival</td>
<td>Orbit vehicle maintenance; crew assistant</td>
<td>Orbit vehicle maintenance; crew assistant</td>
</tr>
</tbody>
</table>
# Manipulators on Moon/Mars Surface

<table>
<thead>
<tr>
<th>Planetary Science</th>
<th>Site Scouting &amp; Characterisation</th>
<th>Site Preparation &amp; Infrastructure Deployment</th>
<th>Infrastructure Operation &amp; Maintenance</th>
<th>EVA Support</th>
<th>IVA Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface characterisation experiments</td>
<td>Imaging/mapping</td>
<td>Clearing landing site?</td>
<td>Operation &amp; inspection of ISRU systems</td>
<td>Carry tools and hand them to astronauts</td>
<td>Routine greenhouse operations</td>
</tr>
<tr>
<td>Sample handling*</td>
<td>Travel to/through hostile terrain</td>
<td>Deployment of solar arrays</td>
<td>Inspection &amp; monitoring of propellant &amp; consumables storage tanks</td>
<td>“Eyes” for IVA astronaut</td>
<td>Process plants into ingredients</td>
</tr>
<tr>
<td>Imaging</td>
<td>Mobile &quot;weather&quot; station</td>
<td>Deployment &amp; check-out of nuclear power systems</td>
<td>Inspection of nuclear facility</td>
<td>Emergency / back-up comms station</td>
<td>Telemedicine?</td>
</tr>
<tr>
<td>Astrobiology experiments (search for life)</td>
<td>Search for micro-climates, eg thru changes in volatiles</td>
<td>Deployment &amp; check-out of ISRU units</td>
<td>Inspection of site damage after storm</td>
<td>Additional / mobile comms relay station</td>
<td></td>
</tr>
<tr>
<td>Telescope/observatory operation</td>
<td>Determine present state, 3D distribution and cycling of water</td>
<td>Help make Lunar/Martian concrete/cement</td>
<td>NDI (Non-destructive Inspection) type testing of structures</td>
<td>Sample handling*</td>
<td></td>
</tr>
<tr>
<td>Characterise surface-atmosphere interactions</td>
<td>Sample handling</td>
<td>Maintenance of solar arrays (eg wrt dust etc)</td>
<td></td>
<td>Robotic cameraman / journalist</td>
<td></td>
</tr>
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### Required Capabilities:

- Instrument deployment & positioning
- Soil manipulation
- Science sample handling (acquiring, transferring, delivering & analysing)
- Object & parts handling
- Mechanism actuation
- Tools handling and manipulation
- Imaging
- “Interface with surface systems, payloads & crew”

**Notes:**
- Determine electrical effects of atmosphere (Mars)
- Determine processes controlling distributions of dust, water, CO2 by determining long & short term events

2 Nov 2004
HME-MRE
KO: April 04

PRR/dPRR: Mid Nov 04

SRR: Feb 2005

PDR: Jun 2005
PR: Jun 2005 input for C/Min

2 Nov 2004
HME-MRE
Conclusion

Eurobot presents a robotic solution to problems of EVA crew availability and hostile environments

ESA robotics studies harmonised to focus in same direction (arm/leg, hand, teleops, MMI)

Study aimed at getting a flight demonstrator on ISS before end of this decade