ESA Automation and Robotics R&D Overview

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Outline:

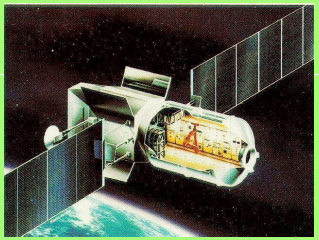
1. The past
   1. Mission needs
   2. The ESA R&D Philosophy
   3. R&D activities and results
   4. Lessons learned
2. The present
   1. Mission needs
   2. What is being developed
3. The future
   1. Which missions? The trend.
   2. The technology Tree
   3. The vision
   4. How to make it happen
4. Conclusions

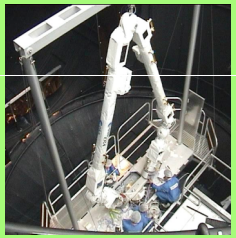
1.1 The Past: Missions Needs

ESA missions which (might have) required A&R:

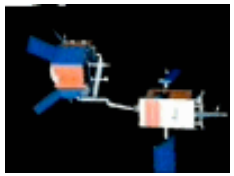
- A&R for external or internal applications on Space Stations


MFC Facilities


MTFF Automation

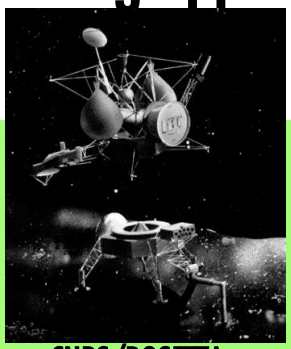

ERA


EUTEF

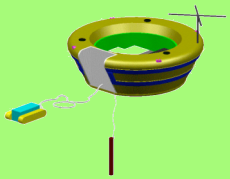

Geostationary Satellite Servicer

- S/C servicing applications

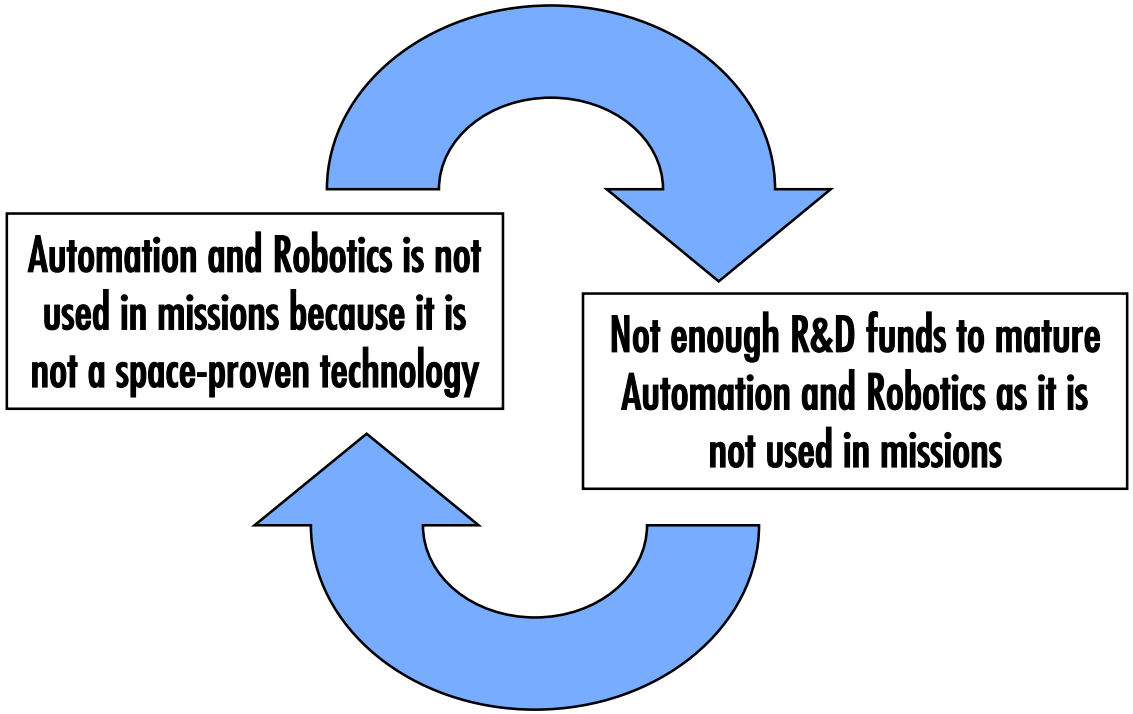
- Planetary exploration


CNRS/ROSETTA


Marsnet/Intermarsnet


Bepicolombo MSE

1.2 The Past: ESA R&D philosophy



Goal:

- Break the deadly loop

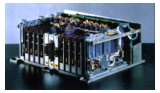
Recipe:

- Use the little funding available to prepare multi-use "building-blocks"
- Harmonise R&D across European partners (i.e. try to avoid duplication: ESA avoided development of robot arm, dexterous gripper, autonomous rover navigation, robot teleoperation)

1.3 The Past: R&D activities and results (1)

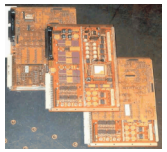
Space Station Applications

Calibration Platform (RODYM)



Servo and Power S/S Flight HW (SPEAR)

1st generation Robot Control SW (SPARCO)



1st generation Robot Control SW and Flight HW (CESAR)

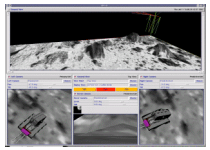
Flexible Ground Control Station (FAMOUS)

Ground Station validated in flight (VIABLE)

Validated and flight ready end-to-end robot control but NO ROBOT

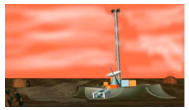
- ☹ MTFF was cancelled
- 😐 ERA made use of RODYM
- ☹ Robotic EuTEF faded away (no arm)
- 😐 MFC do not use common controller

Planetary Applications



Microrover Ground Control Station

Microrover Hardware



Microrover end-to-end control system

Imaging System for Rover Control

Complete demonstrator of microrover application

- ☹ Marsnet/ Intermarsnet did not materialise
- ☹ BepiColombo MSR descoped due to budget

1.3 The Past: R&D activities and results (2)

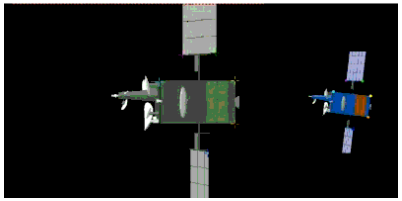
ROSETTA Application →

Large Corer with care capture mechanism

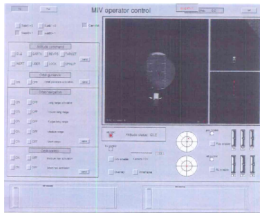
} **Experimental knowledge in low-temperature drilling** {

- 😐 Rosetta re-sized (small lander Philae)
- ☺ Experience passed in Philae DS²

GSV Application →



Computer Vision system for GSV



Simulator tool for Manouvering a Servicing Inspection Vehicle

} **Full understanding of GSV RVD** {

- ☹ GSV did not materialise
- 😐 RVD experience and MIV used in ConeXpress OLEV

1.4 Lesson Learned

Observations:

1. Availability of proven (even flight-ready) technology is no guarantee for use in mission. Project planners will use "exotic" technology only if nothing else works
2. Even already developed technology needed by missions, might be re-developed due to geographical /industrial constraints
3. Harmonisation not always works
   - 😐 Harmonised items come with too many strings
   - ☺ ExoMars will use CNES navigation
   - ☹ No-robot, no-robotised EuTEF

Conclusions for planning R&D:

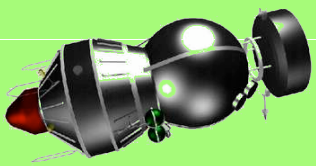
- Do not follow too much project needs as it does not pay. Follow the general application.
- Do not go for the full qualification, unless it is for a multi-application product
- Foster technology across boundaries to decrease the geographical risk
- Secure non-ESA harmonised items with firm agreement

2.1 The present: Missions needs

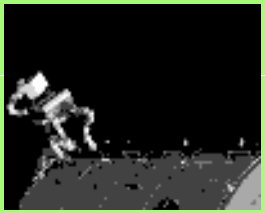
Current ESA missions which use A&R are:

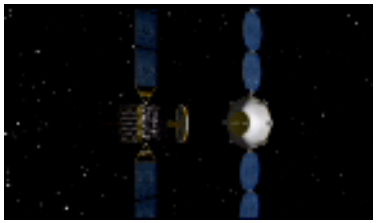
- A&R for external or internal applications


MFC Facilities


Foton M2 & M3


ERA


EUROBOT


ConeXpress OLEV (Phase B)

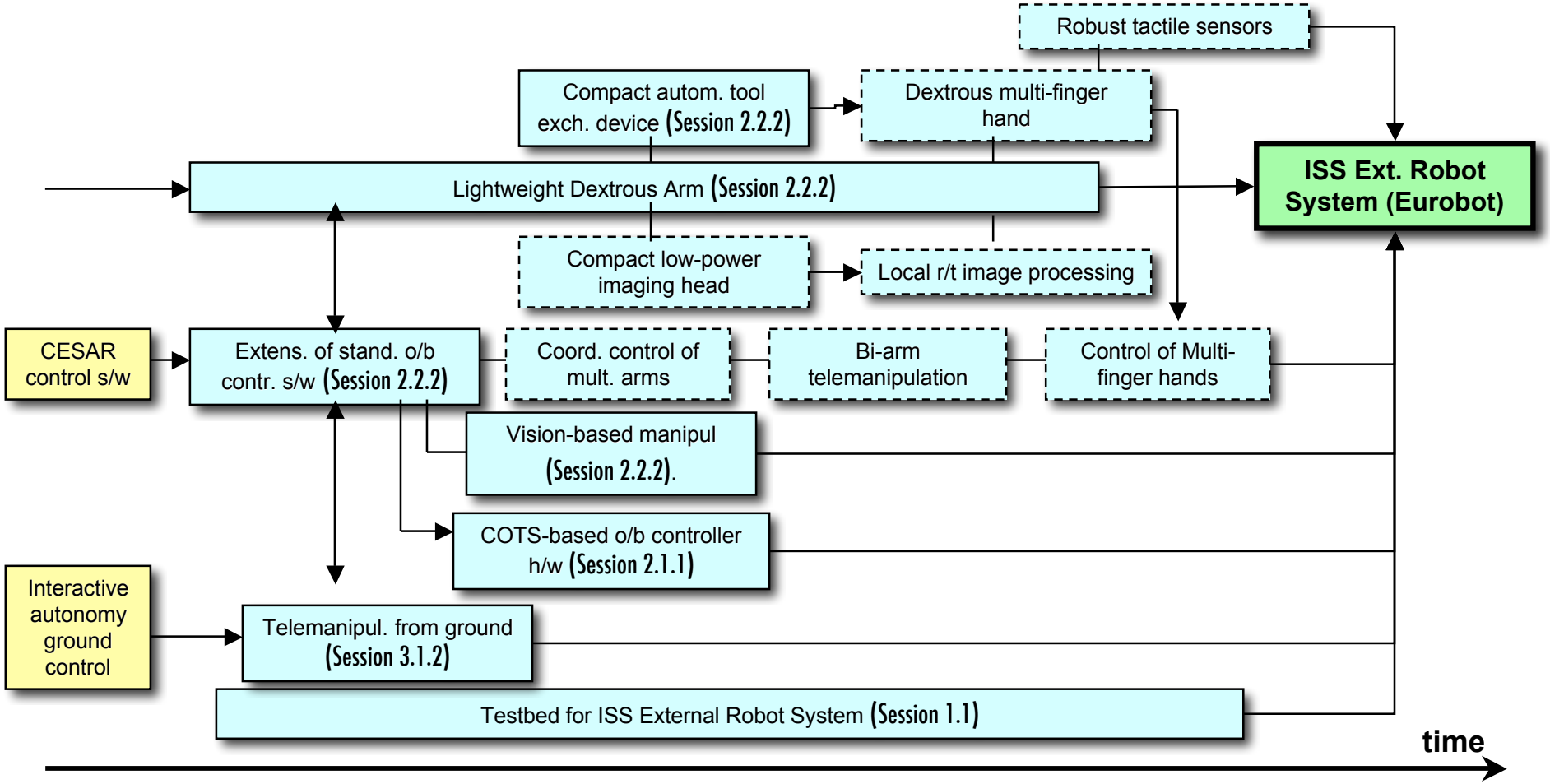
- S/C servicing applications

- Planetary exploration

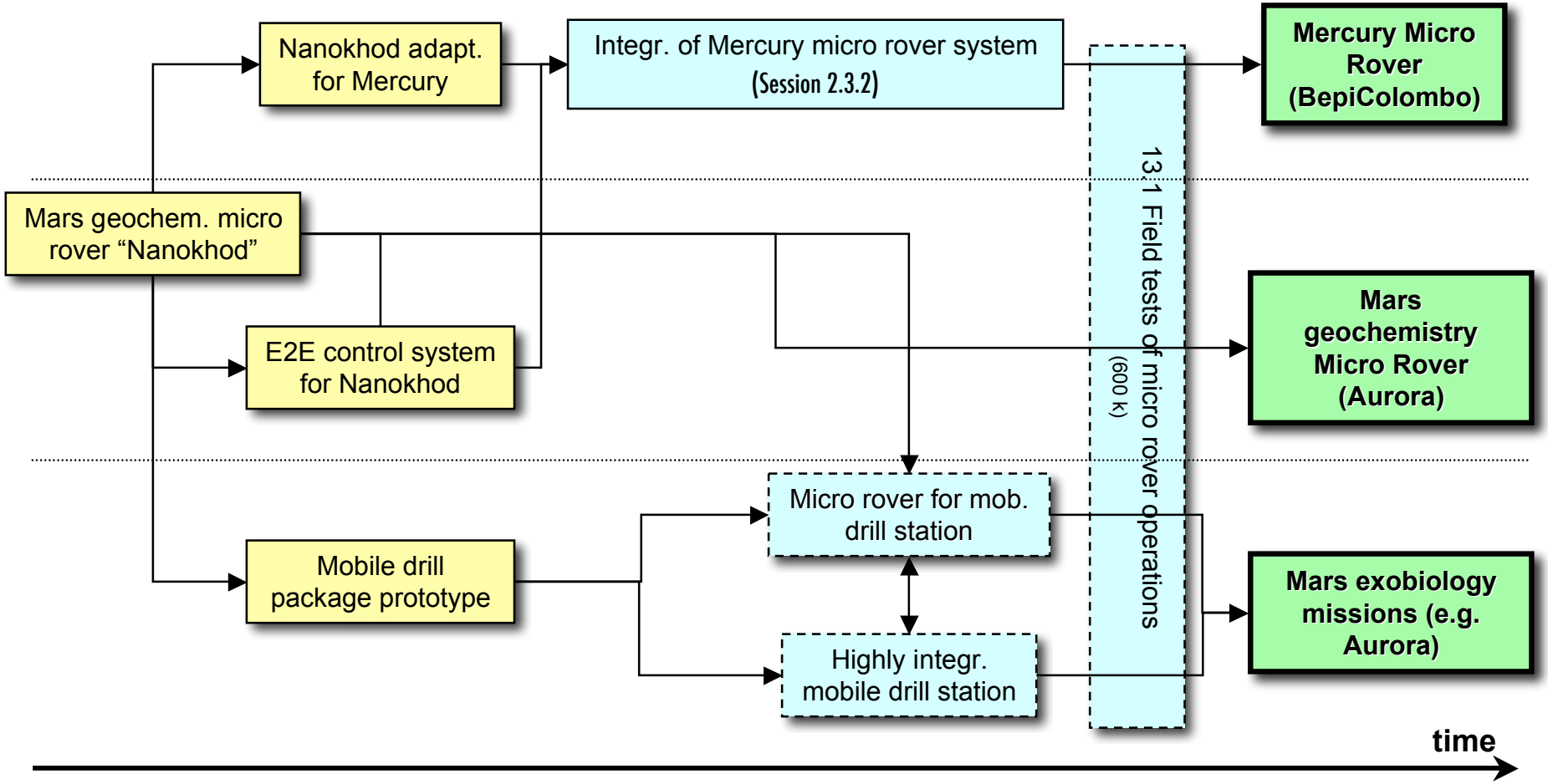

EXOMARS (Phase A/B)


ROSETTA

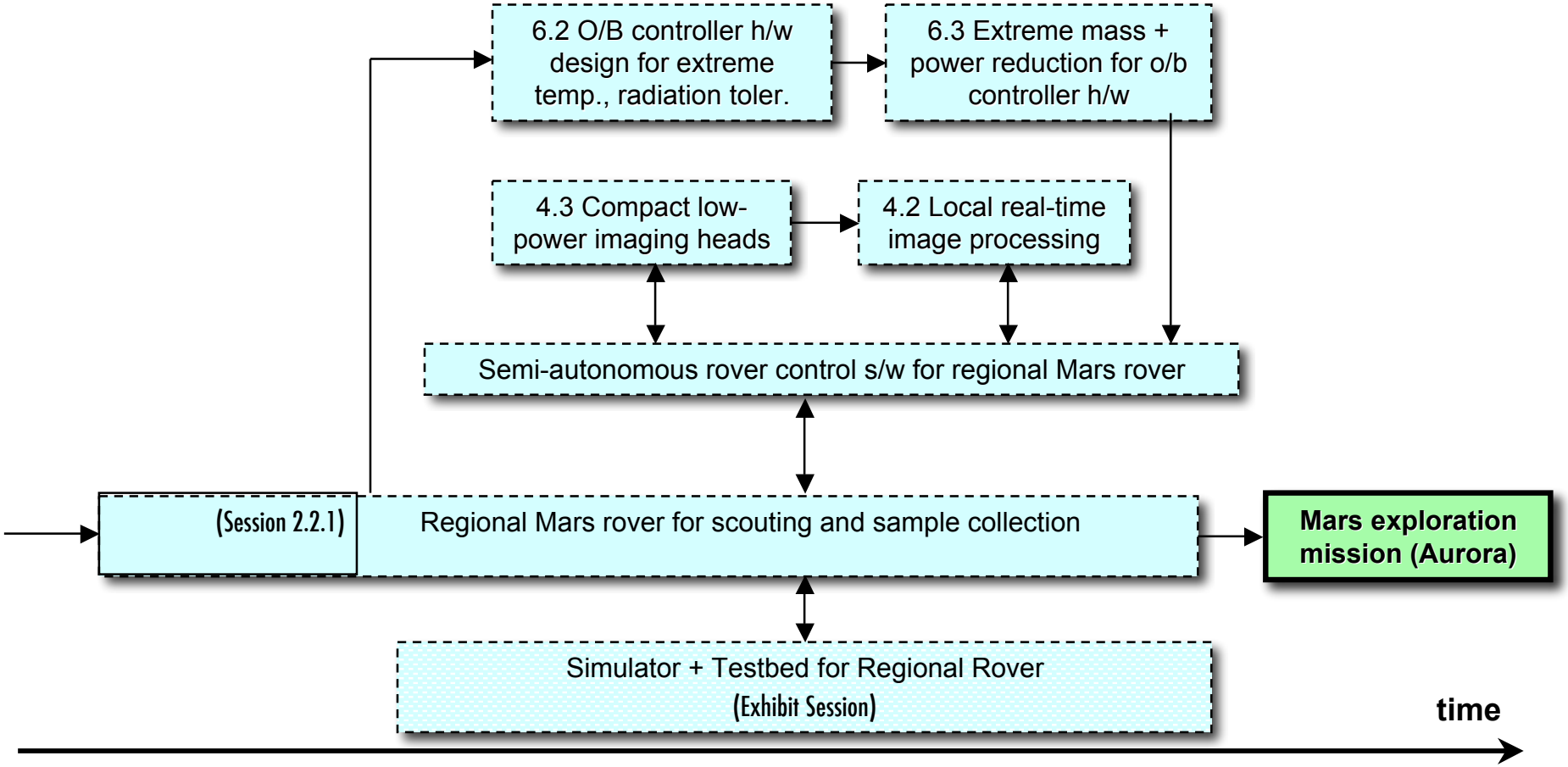
2.2 The present:What is being developed (1)



2.2 The present:What is being developed (2)



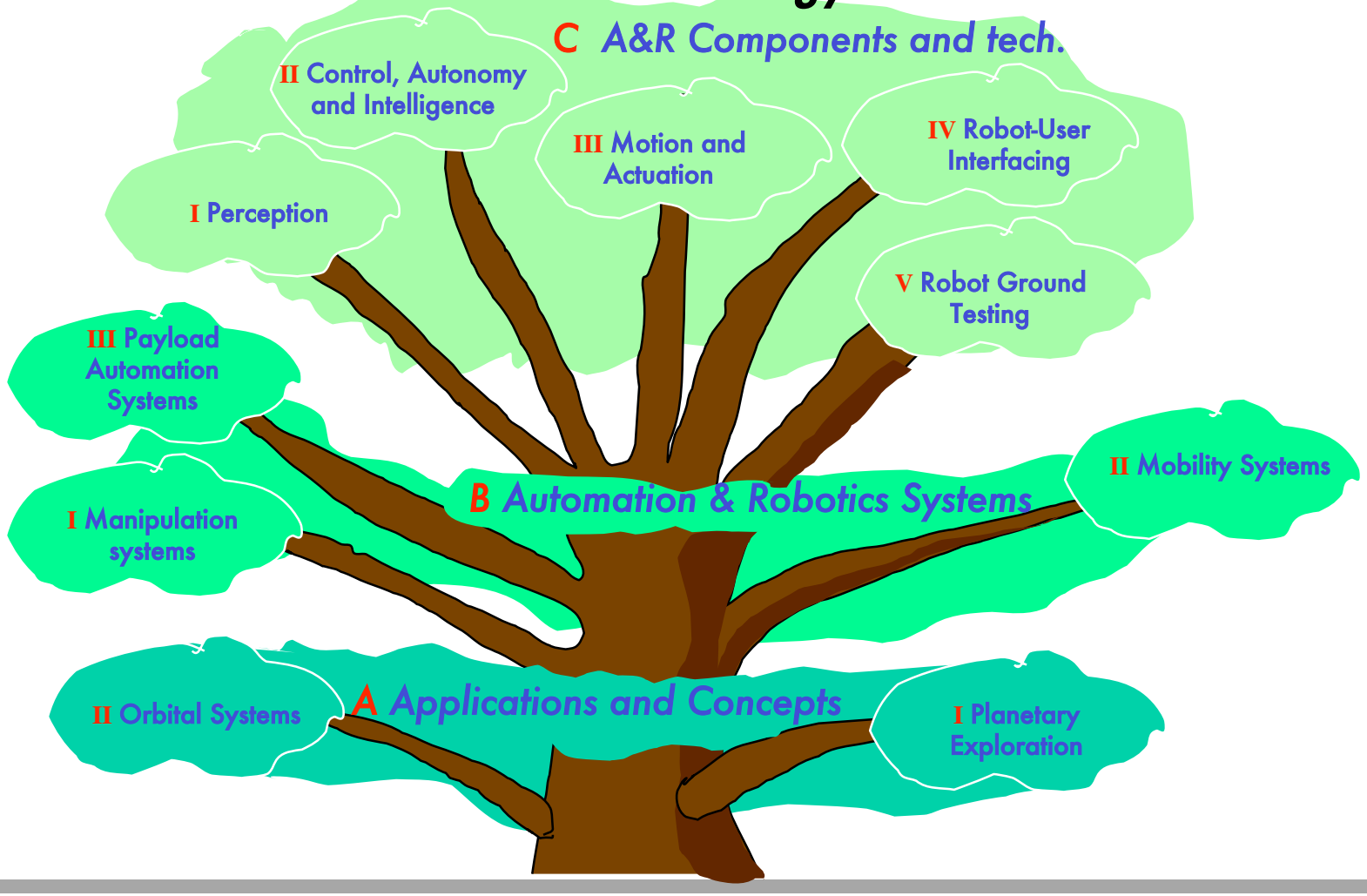
2.2 The present:What is being developed (3)



3.1 The Future: Which Missions?

- Difficult to say. In general we can say that future space missions will use:
  - Robot Assistants: helping Astronauts to perform their task quicker, safer, with higher quality and more economically.
  - Robot Agents: working into hostile and dangerous areas and acting in place of humans to perform assembly, maintenance and production tasks in tele-operated or semi-autonomous way
  - Robot Explorers: venturing in the hostile and remote environments for exploration and science. Coping with and taking advantage of the peculiar environmental conditions to achieve long duration and extensive range missions.

3.2 The Future: The Technology Tree



3.3 The Future: ESA Vision (1)

Robot Assistants:

A-I Planetary Applications: Moon crew support

- B-I 2 arm manipulator with crane torso
- B-II 6 wheels heavy-duty articulated chassis (ExoMars derived) or 6 legs chassis

C-I Need for detection and tracking of humans
C-II Semi-autonomous control with teach-in capacity
C-III Need for high-efficiency powerful locomotion drives
C-IV Language based interfacing
C-V Need large size testing facility

A-II Orbital Applications: crew support Eurobot-like on Space Station

- B-I 3 arm manipulator

C-I Need for detection and tracking of humans
C-II Semi-autonomous control with teach-in capacity
C-III No extra development w.r.t Eurobot
C-IV Language based interfacing
C-V No extra development w.r.t Eurobot

3.3 The Future: ESA Vision (2)

Robot Agents:

A-I Planetary Applications: Exploration of Moon pole craters

B-I sampling arm

B-II climbing/rappelling capable chassis / robot crew (ARAMIES based?)

C-I Need for low energy perception in the dark

C-II Need for supervisory teleoperation with LOS autonomy

C-III Need for high-efficiency/low-temp. drives

C-IV Need for predictive dynamic simulator

C-V Need large size testing facility

A-II Orbital Applications: Eurobot-like servicer on GEO satellites

B-I 2 arm manipulator mounted on large arm or 3 arm manipulator with scaffold

C-I No special needs

C-II Need for coordinated AOCS-satellite control

C-III Need for highly dexterous end-effectors

C-IV Need for haptic (exoskeleton) manipulation with predictive dynamics

C-V No special development w.r.t Eurobot

3.3 The Future: ESA Vision (3)

Robot Explorers:

A-I Planetary Applications: Sample Return from Mars

- B-I sampling arm
- B-II 6 wheels long range articulated chassis (ExoMars derived)

C-I Need for low energy perception in the dark

C-II Need for more autonomous control than ExoMars

C-III No new technology w.r.t ExoMars

C-IV No new technology w.r.t ExoMars

C-V Need of large size testing facility

A-II Orbital Applications: Autonomous Opportunistic Science Probes

- B-III Automation system for on-board processing of science data (similar to ESA Aerobot project)

C-I Possibly need for specialised event triggering detectors

C-II Need for autonomous science processing

C-III Not applicable

C-IV Not applicable

C-V Not applicable

3.3 The Future: ESA Vision (4)

Robot Explorers:

A-I Planetary Applications: Aerobot Mission Study

B-II Balloon/ Motorglider/ Microprobes/ Rotary Decelerators

C-I Not applicable

C-II Need for autonomous navigation and resource management

C-III Not Applicable

C-IV Not Applicable

C-V Not Applicable

A-I Planetary Applications: Deep Underground Explorers

B-II Mole/Subsurface Explorer

C-I Not Applicable

C-II Not Applicable

C-III Full implementation of chip removal system and tether

C-IV Not applicable

C-V Not applicable

3.4 How to make it happen (1)

FUNDING SOURCES for A&R R&D:

- ESA
  - GSP, TRP, GSTP, CTP, ASTE, ARTES
  - Project specific developments
- National Agencies (ASI,CNES,DLR,PPARC,BSNC)
- The EU
  - indirectly through FP until FP6
  - Directly with FP7 through the priorities identified by the technology platforms:
    - ESTP
    - EUROP

PROBLEMS in ESA R&D:

- "Space only" A&R
- Breadth: not all R&D fields needed by space can be pursued (lack of funds)
- Depth: subjects that require upfront research have to be discarded (rigid funding scheme)
- Time span: no long term research and no product development from lab proven technology

3.4 How to make it happen (2)

The SOLUTION

ESA sees the different Space related platforms as ideal complement of ESA's activities to:

- Enlarge the breadth of R&D in Space A&R (EUROP)
- Provide upfront R&D (EUROP)
- Allow R&D to turn into products (ESTP) for strategic independence

The ESA Harmonisation process is again proposed as a means to achieve:

- Co-ordination with National Agencies (institutional)
- Co-ordination with EUROP for possible co-funded EU-ESA activities
- Steer ESTP towards funding of robotics components

4. Conclusions

Lots of technology being prepared at the moment, however this could still improve as not much is done

A Harmonisation Exercise will take place on February 14-15, 2007.

ESA will propose the development of technology supporting our vision:

- In agreement with National Agencies and Industry
- promoting co-funding with EUROP
- Using the possibilities offered by ESTP


THANK YOU
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