Space AI and Robotics at ESA

@ASTRA 2023

Gianfranco Visentin
Head, Automation & Robotics Section
(TEC-MMA)

Overview

This presentation is an introduction to the field of space robotics and AI 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

While many (but not all) of the subjects introduced will be detailed by dedicated presentations in the conference, this presentation intends to:

- provide an organic view of the different subjects
- provide references to individual presentations
- conclude on what is ESA's view of the current status

ESA and the EU H2020 Research Programme

Space Robotics R&D in Europe is also supported by the European Union.

ESA and the EU coordinate investments through a Harmonised Roadmap of developments.

One aspect of this coordination is the H2020 Space Robotics Technologies Clusters, which aims at demonstrating Robotics in space at a significant scale by 2024

To arrive at such demonstration an integrated roadmap has been set up by the PERASPERA consortium, composed by the Italian Space Agency (ASI), the Spanish Center for Technology Development (CDTI), the French Space Agency (CNES), the German Space Agency (DLR) and the UK Space Agency (UKSA) and coordinated by ESA

The H2020 SRC has been concluded in 2023 and now there is no more an integrated roadmap

Planetary Missions: 2023 was a failure of International Cooperation

The war in Ukraine has caused the termination of the Exploration missions done in cooperation with Russia. Both exploration of the Moon and Mars have been affected:

- A new ExoMars mission (including lander) targeting launch in 2023 is in procurement. However it still relies on international cooperation (NASA) for its launch. Everything over ExoMars in **Plenary talk Thursday morning**
- The ESA contribution (PROSPECT) to the Luna-Resurs and Luna-Grunt missions awaits new users

Also Mars Sample Fetching Rover (SFR) was ‘grounded’ as JPL could not accommodate it on its lander**.** SFR breadboard continue to be used in R&D (see **Sessions 2A, 2B and 5B**)

On the good side, the Sample Transfer Arm (STA) continues its development, see **next pres** and pres in **session 3A**

Planetary Mission plans: The Moon

ARGONAUT will

- employ a “Manipulator for Argonaut Payload Needs and Unloading Support (MANUS)” in procurement
- employ a “Lifting and Offloading Add-on Device for EL3 Resources (LOADER)” also in procurement
- make use of the European Moon Rover System (EMRS) being studied at the moment. **See presentations in session 3A and 9A**.

Work on de-risking technologies for lunar teleoperation is continuing **see 5A**

Planetary Mission plans: Mars

ESA has performed a number of CDF studies aiming at small missions for Mars in the frame of the the TERRAE NOVAE 2030+ programme.

Some missions such as the FAHRENHEIT (network landers) and ARMADILLO (Ice access) require important robotics elements.

See plenary presentation on Friday morning.

Orbital Robotics Missions

Currently there are a number of ESA sponsored Orbital Robotics missions in different stages of development:

- ESA Clearspace ADRIOS, a ‘pilot’ mission to de-orbit an ESA own debris. **See presentation in this session**
- EU Orbital Demonstration Mission, running Phase B2-C with the EROSS-IOD consortium this mission is the final product of the PERASPERA roadmap.
- ESA has negotiated 1 study for demonstrating commercial in-orbit services (IOS) . The study is executed by industrial teams grouping a service provider and a service client. The output of this study is meant to inform the ESA executive on a possible proposal to the ESA ministerial conference. The proposal will address a demonstrator of commercial IOS.

Other Orbital robotics missions being undertaken in Europe and presented at ASTRA:

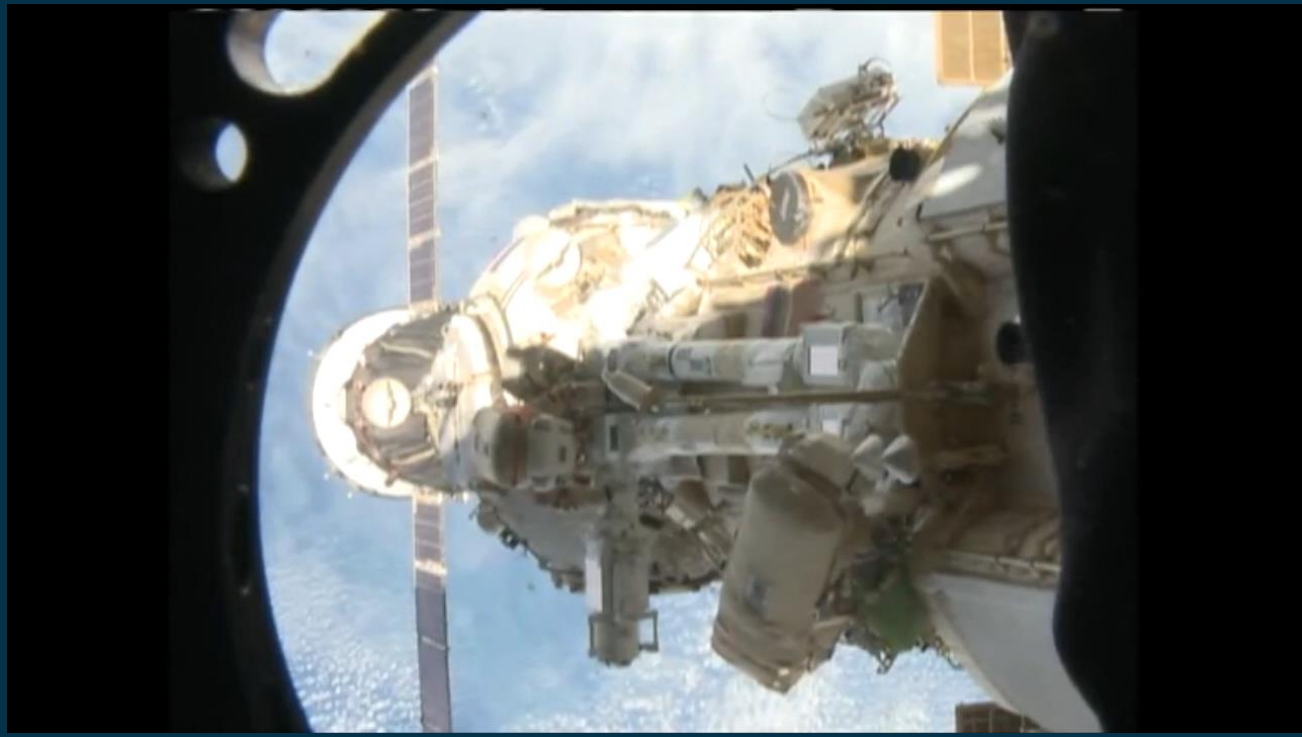
- The ASI sponsored IOS demonstrator, **see session 2C** for connected development

Orbital Robotics Missions: ERA works

After 27 year of mission development (of which 15 waiting in storage) the European Robot Arm finally moved on the Russian side of the ISS.

This success is due to the incredible perseverance of people in the project.

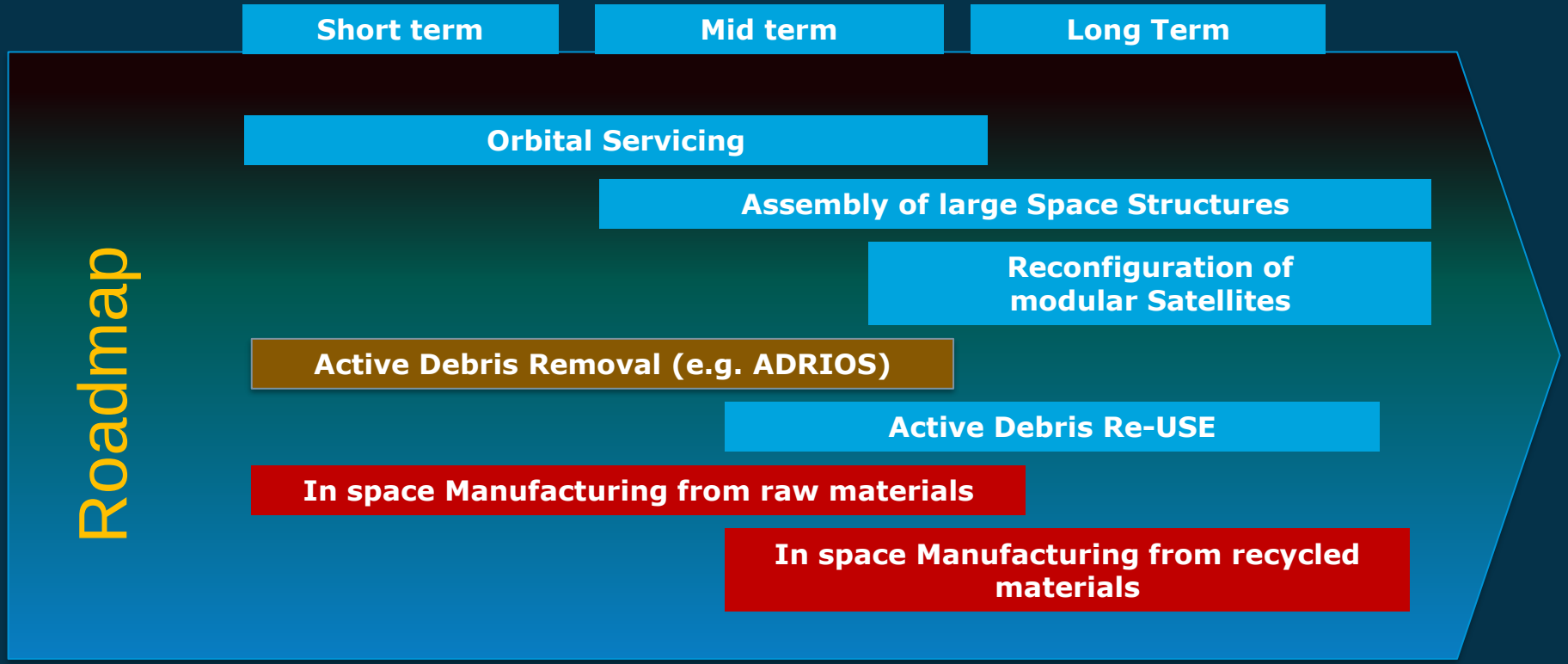
See nest pres.



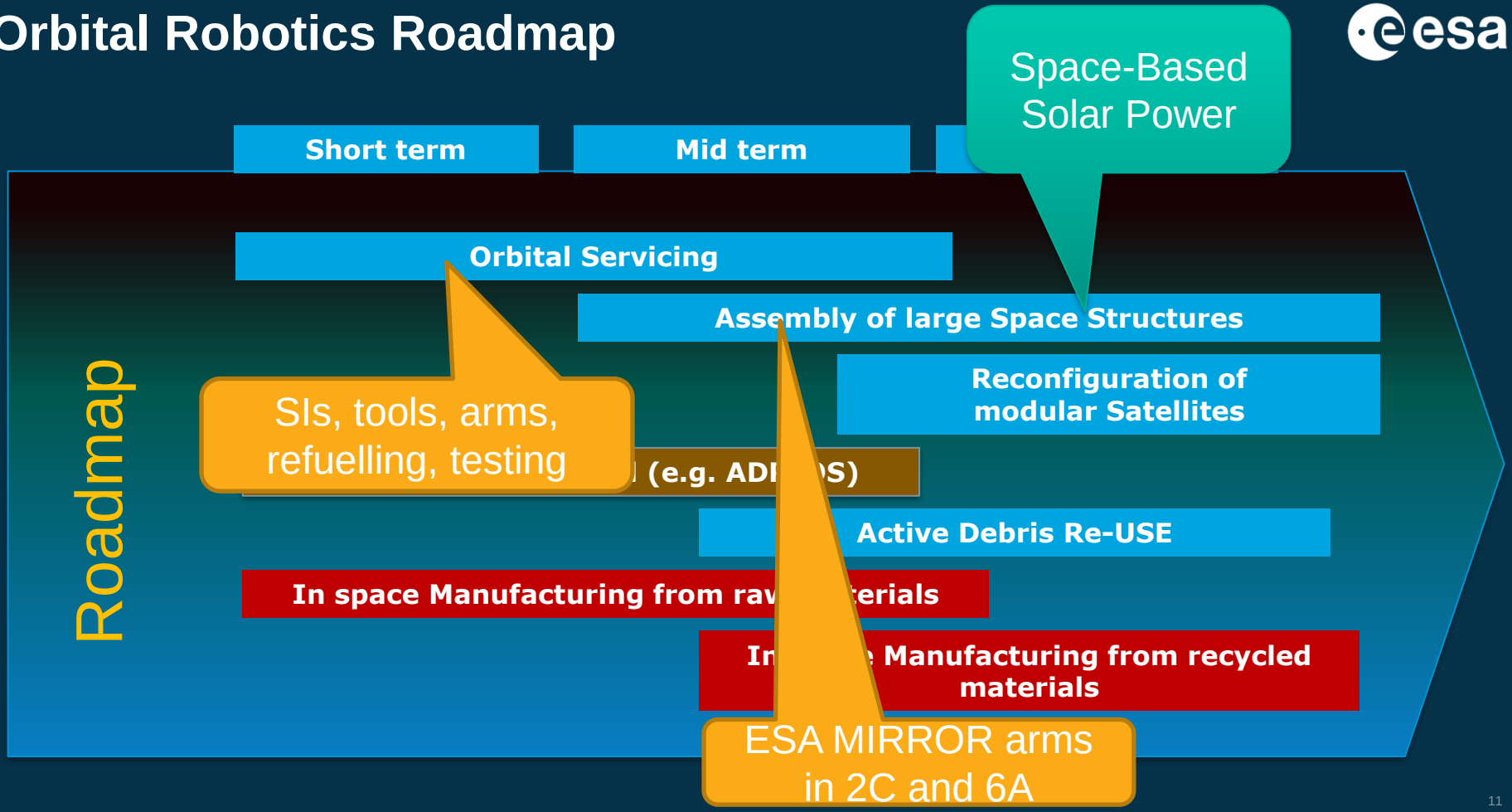
Objectives of Space Robotics R&D

1. Implementation of new space robotics applications:
    1. Taking advantage of terrestrial robotics and AI R&D
    2. Considering resource limitations and environment constraints and opportunities (e.g. gravity)
    3. Validating the application at the earliest occasion
2. Implementation of robotics systems, subsystems, components and underlying technologies suitable for the peculiar space constraints:
    3. Hardening against the environmental constraints
    4. Coping with the very limited resource constraints
    5. Implement extreme Reliability Availability Maintainability and Safety (RAMS)

Orbital Robotics Roadmap



Orbital Robotics Roadmap



Space-Based Solar Power

DESCRIPTION

technologies to build and maintain extremely large space structures

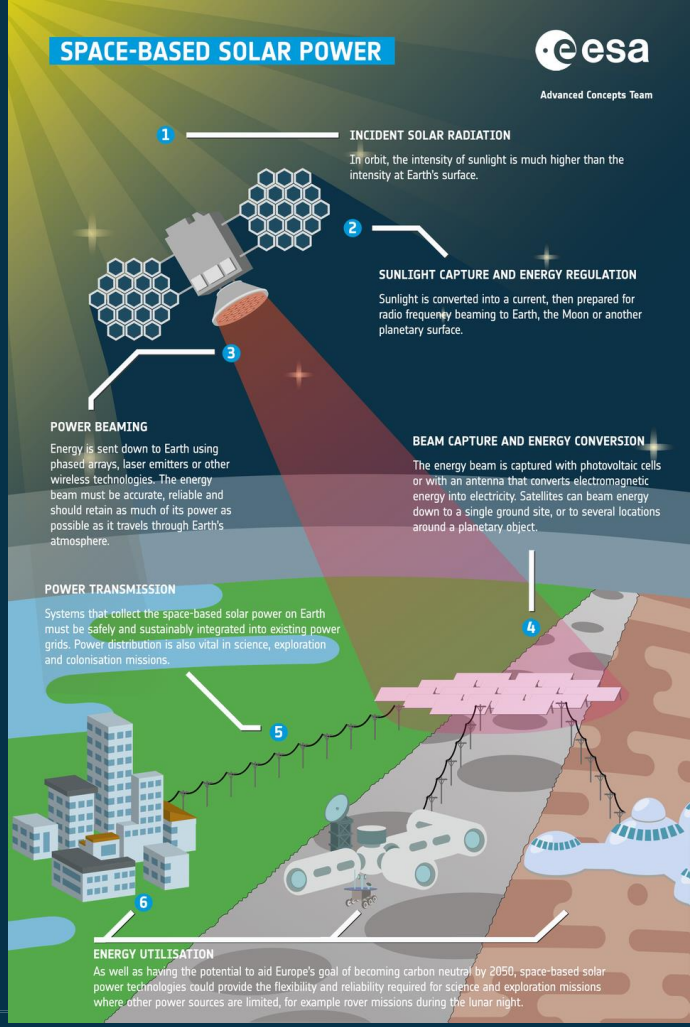
JUSTIFICATION

Space Based Solar Power (SBSP) promises to offer continuous, independent and GREEN energy for a cost per GW competitive to other technologies but with much less land/sea use and long term liabilities.

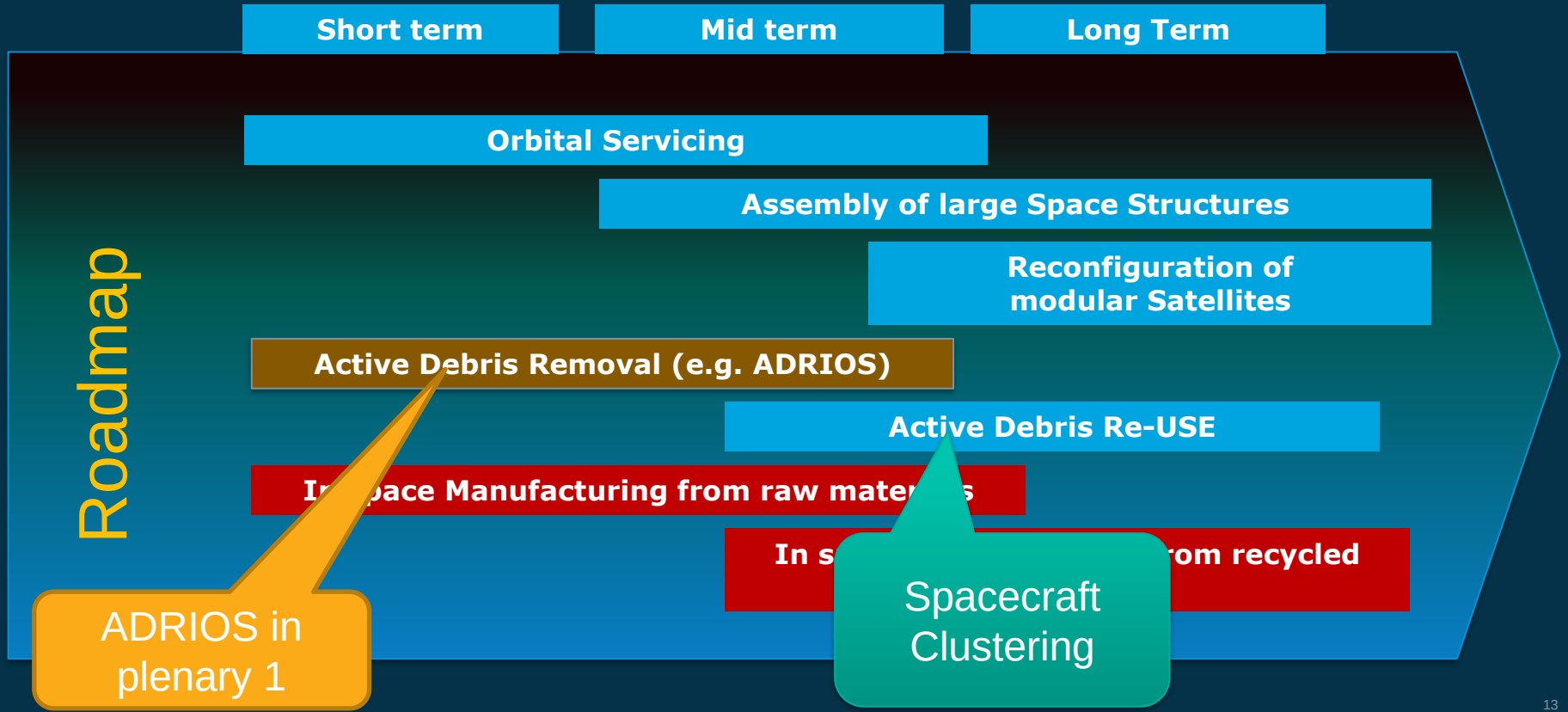
SBSP power stations will be enormous for today's standard, they will need to be assembled and maintained by autonomous robots.

ACTIVITIES

- TDE (Q2/2024) **Networked Orbital Mobility for robotic Assembly/Deployment (NOMAD)**
- GSTP (Q4/2023) **Robotics Interfaces and tooling for SBSP Engineering (RISE)**
- GSTP **End to End Humanoid for Automation Non Compliances and Exceptions in SBSP (ENHANCES)**
- GSTP **Class of Robotics Expert Workers for SBSP (CREWS)**



Orbital Robotics Roadmap



Spacecraft Clustering Technologies

DESCRIPTION

technologies to collect defunct spacecraft (debris) in a common orbit (e.g. SSO) and assemble them on a structure that has orbital manoeuvring ability.

JUSTIFICATION

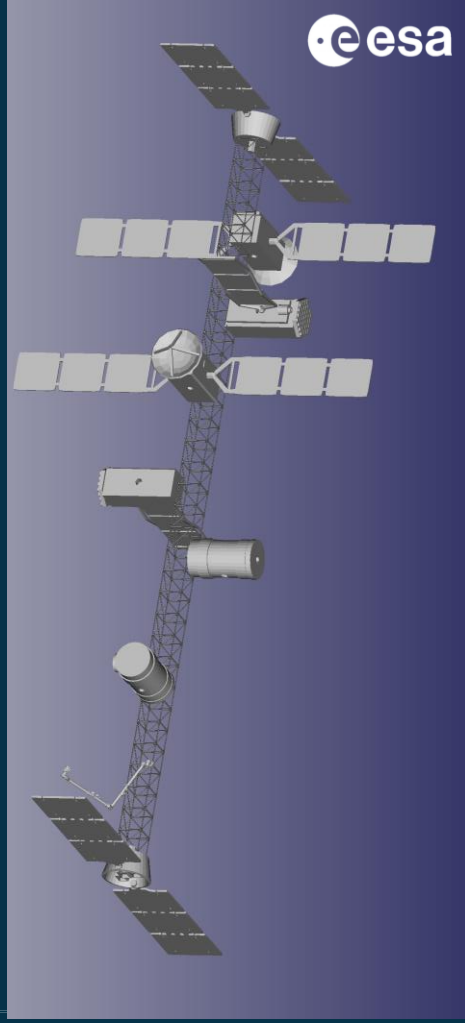
Active Debris Removal controls the risk of defunct satellites fragmentation by deorbiting them. The risk can also be controlled by attaching the satellites to a structure that can actively perform collision avoidance maneuvers.

Clustering technologies address the operations of collecting defunct spacecraft, tugging them to the structure, attaching them to it.

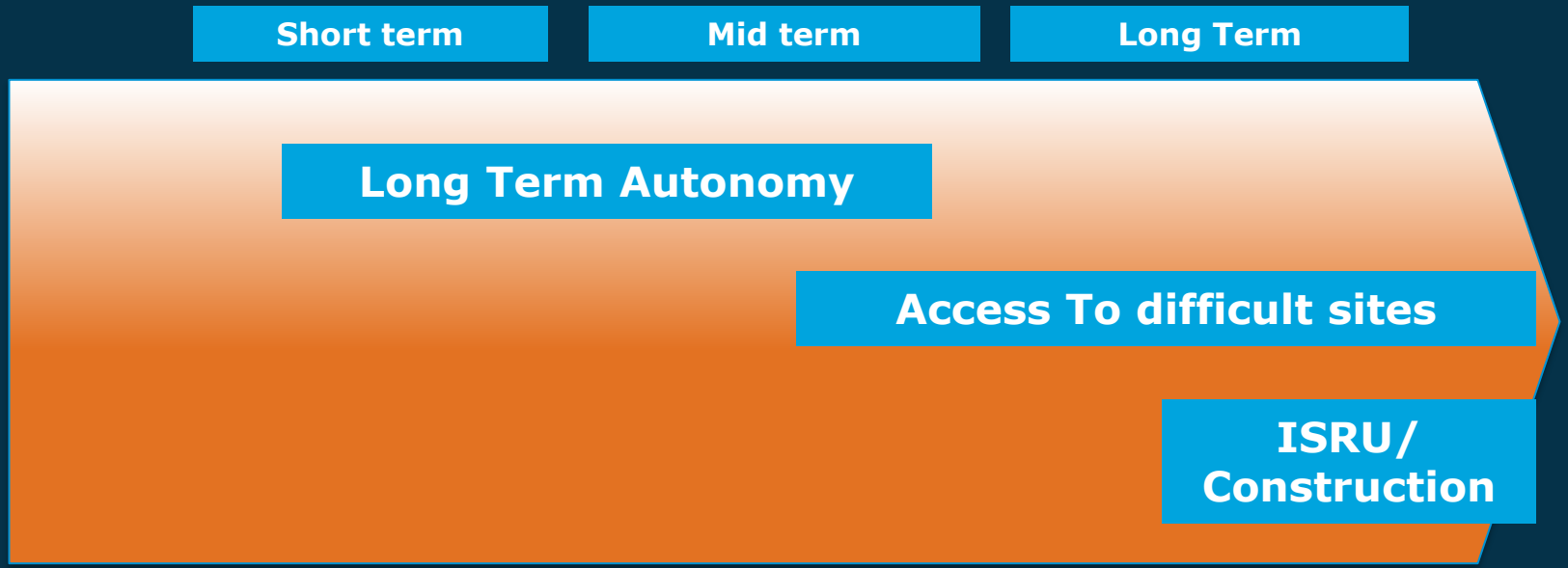
Clustering dead spacecraft is a the way to transition between Active Debris Removal to Active Debris re-Use/re-Cycle. Debris are at the moment a liability, but they can become in the future an asset as their components and materials can be reused for manufacturing other spacecraft in orbit.

ACTIVITIES

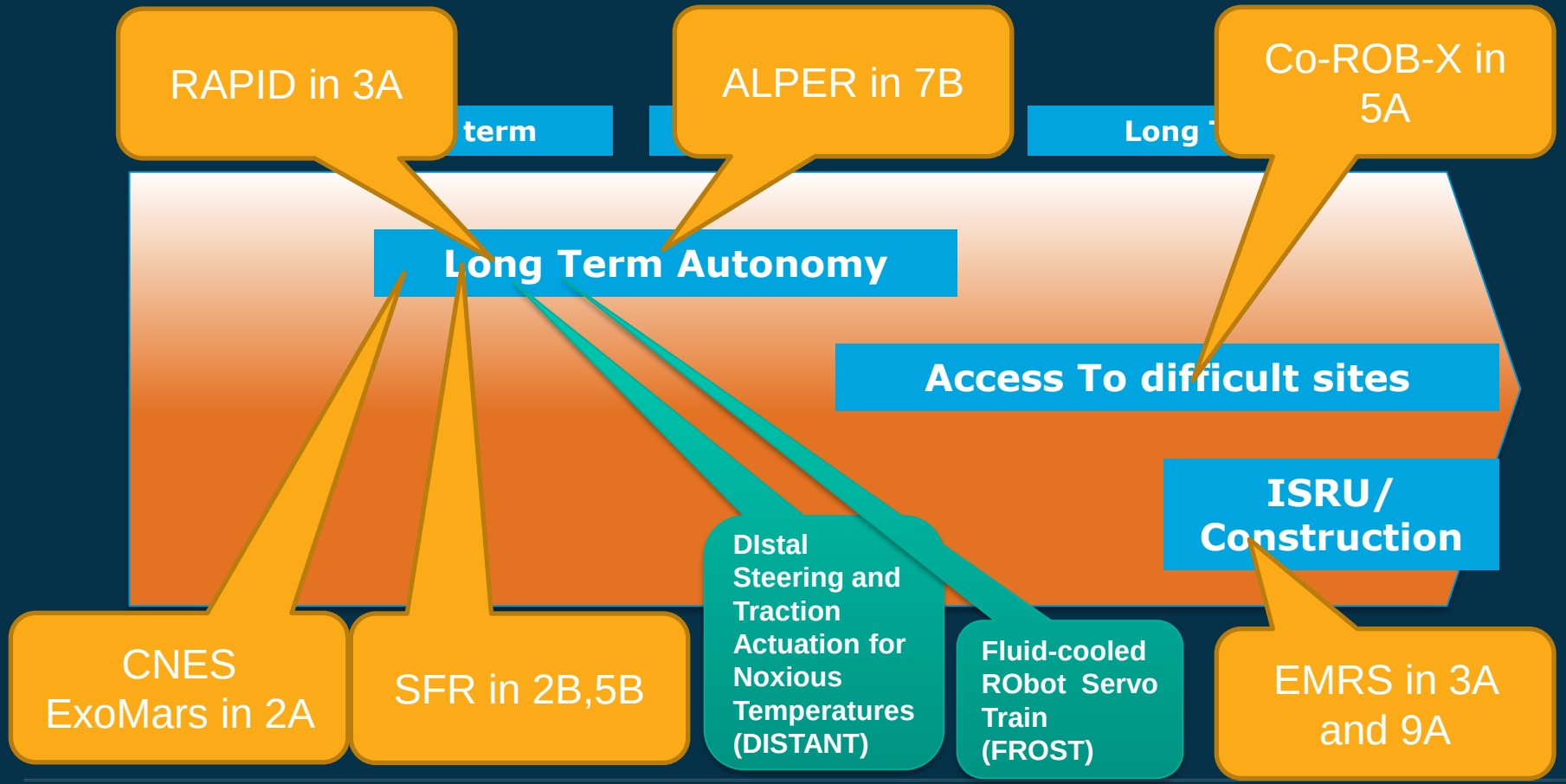
- TDE (running) **In-Space Assembly And Construction technologies (ISAAC) – robotic assembly of trusses**
- TDE (Q2/2024) **Carryable LAR Adapter (CLARA)** technologies to collect defunct spacecraft, connect them to a central structure



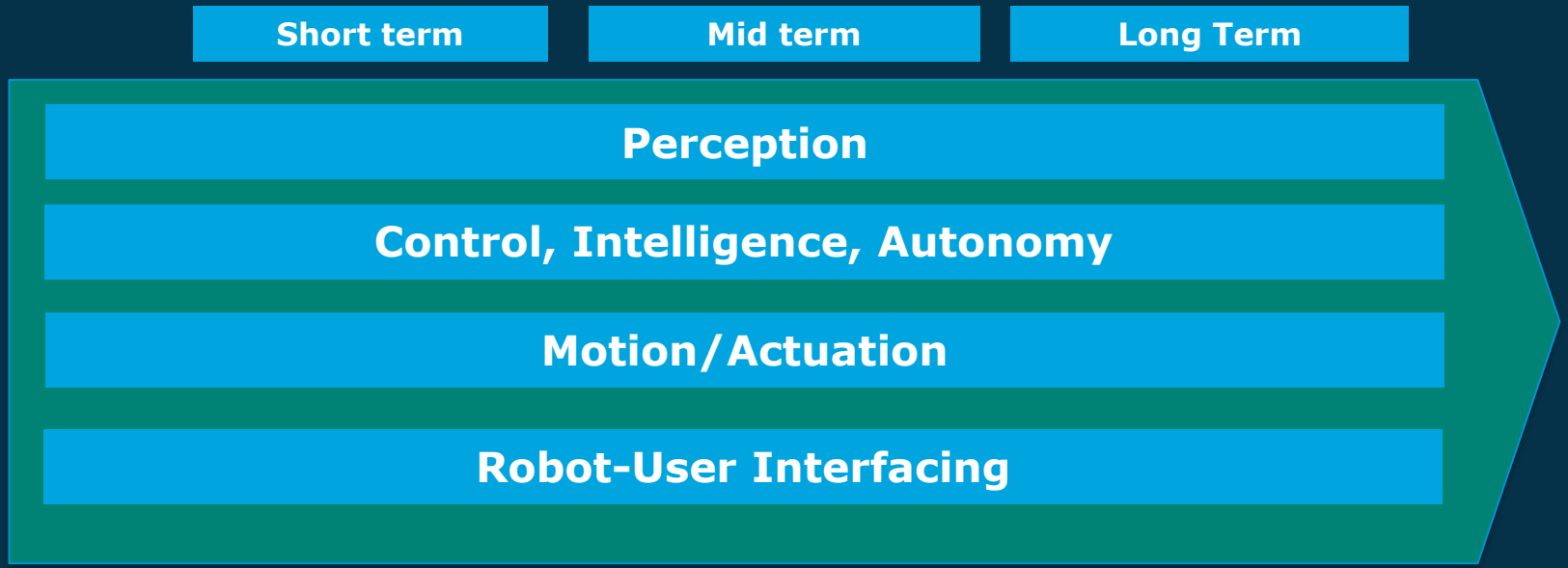
Planetary Robotics Roadmap



Planetary Robotics Roadmap



Common Building Blocks Roadmap

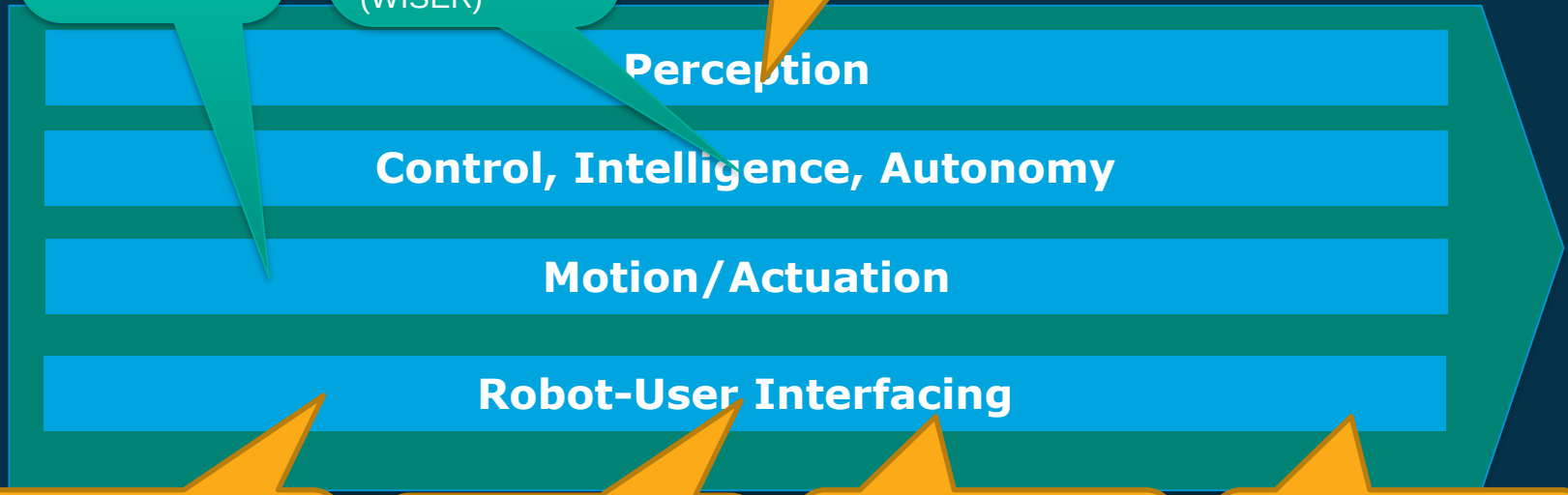


Com di Roadmap

ENdlessly Controllable Organically Redundant invErter (ENCORE)

Workflow for Industrialisation of Software produced in Experimental Robotics (WISER)

3D imaging in 7C



Teleop. haptics 3C

Astronaut exercising 3C

Multi-rover in expl. 5C

CISRU in 3C

Conclusions

Some of the setbacks of ExoMars, SFR and PROSPECT have been resolved.

ExoMars will be recovered (ERA is a good example that shows this happens at ESA).

EL3 requires quite a lot of robotics.

Particularly positive appear the applications in Orbital Robotics, with missions in the making and future applications that will have enormous demands in Robotics and AI.

SBSP could be the largest ever space endeavor, with single assets worth 20 B€ all needing tens of robots for logistics, assembly and maintenance.

SBSP could be make space robotics an important solution provider for the hardest of all human challenges: 0 emissions by 2050