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The PERASPERA roadmap

presentation at the 1st PERASPERA workshop

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PERASPERA Partner



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Outline

- The PERASPERA Roadmap
 - How the roadmap has been developed
 - How the roadmap will change
 - General process
 - Individual steps: Spin-in/over
 - Example of strawman missions
 - The technologies with priority 4

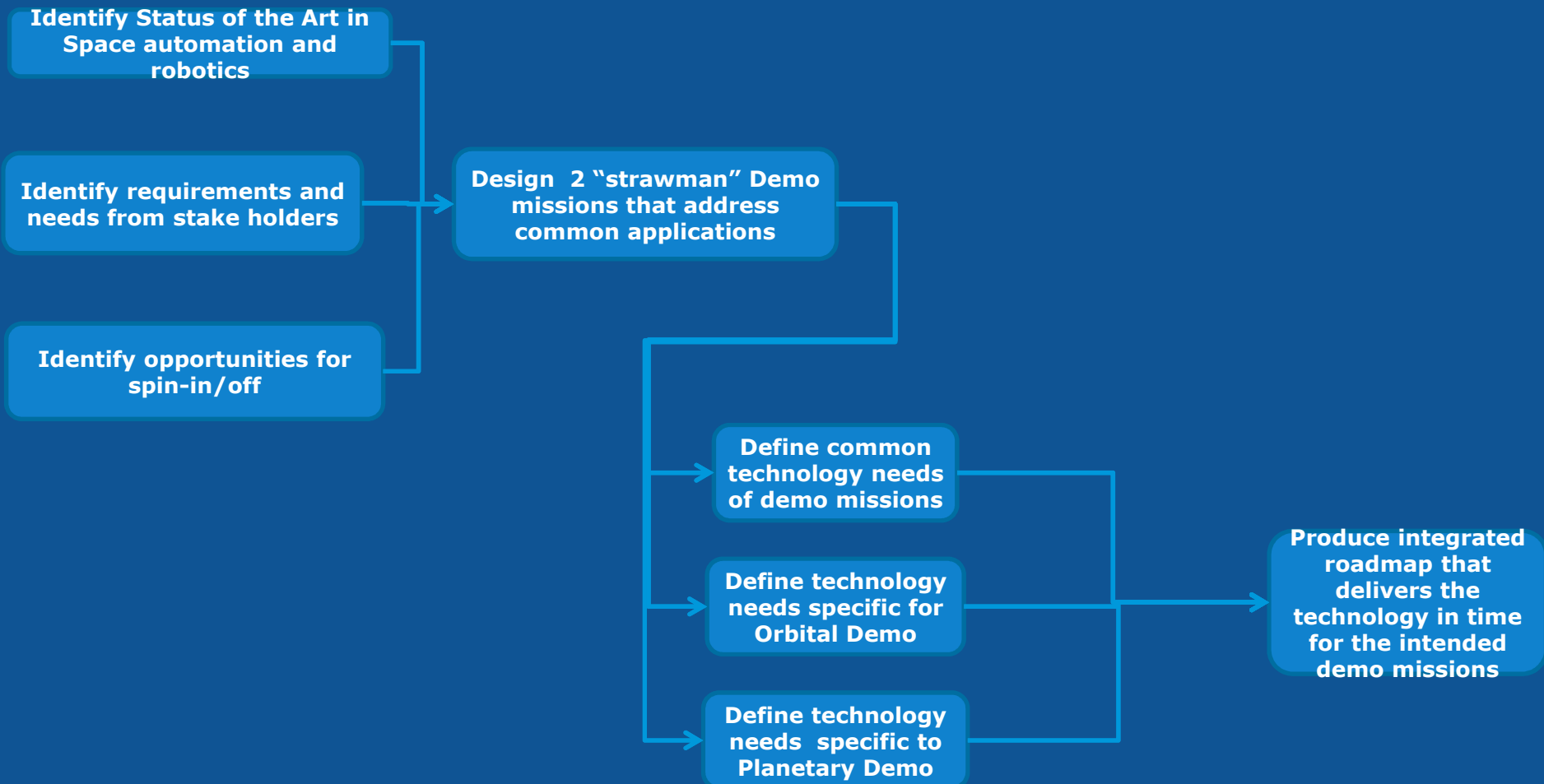


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How the roadmap is built

PERASPERA will execute for three times the following process of definition and refinement of the SRC roadmap





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Roadmap development

The Roadmap will have the following stages:

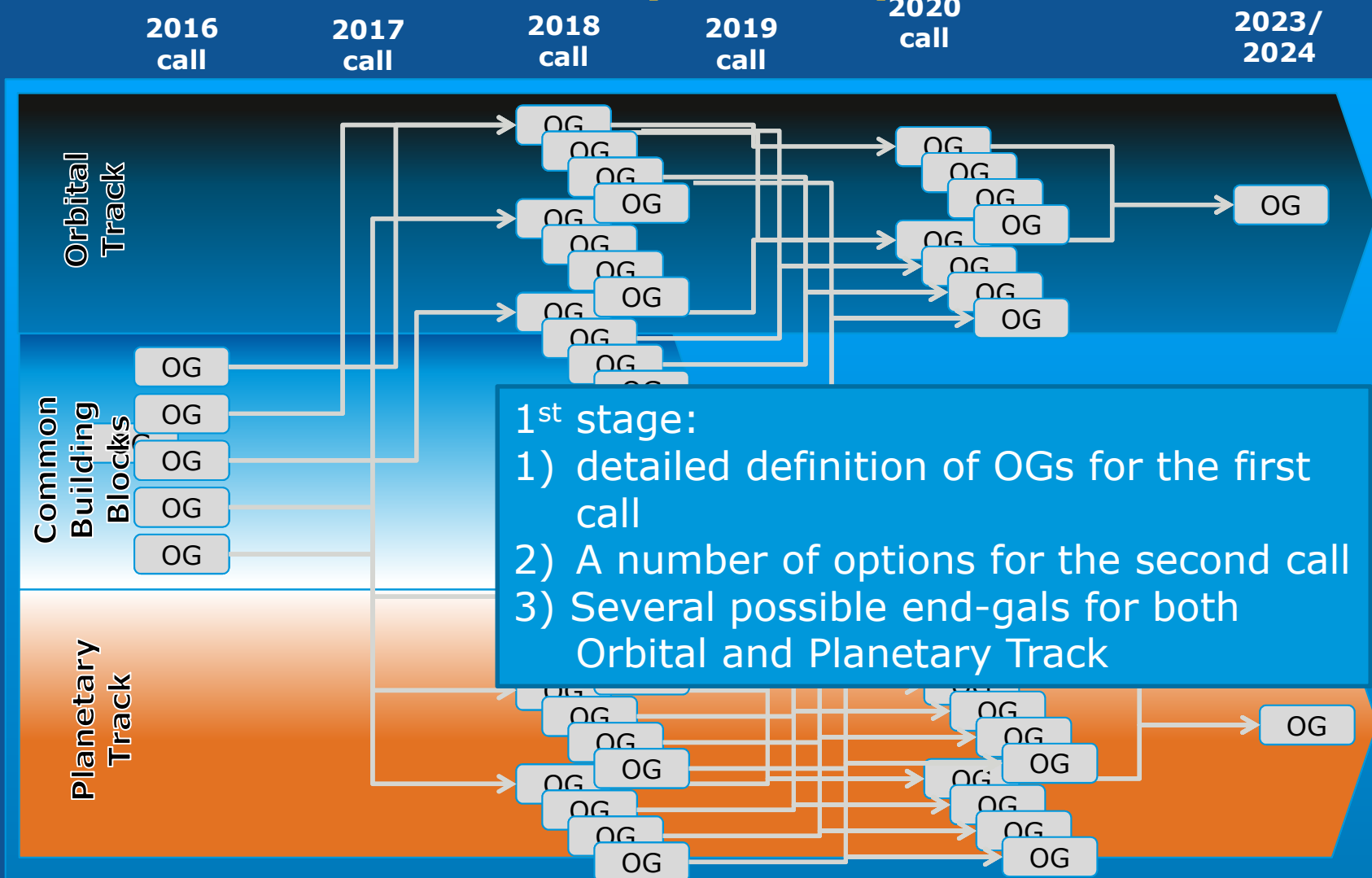
1. Initial Stage: the roadmap defines a set of final goals for the on-orbit servicing and planetary scenarios and identifies in detail *technology maturation* activities for common building blocks
2. Intermediate Stage: the roadmap reduces the set of final goals for the on-orbit servicing and planetary scenarios and identifies in detail *technology maturation* activities and *concept studies* for the on-orbit servicing and planetary scenarios
3. Final Stage: the roadmap defines two final demonstration goals (one for the on-orbit servicing and one for the planetary scenarios) and defines the *system definition activities* for the demonstrations.



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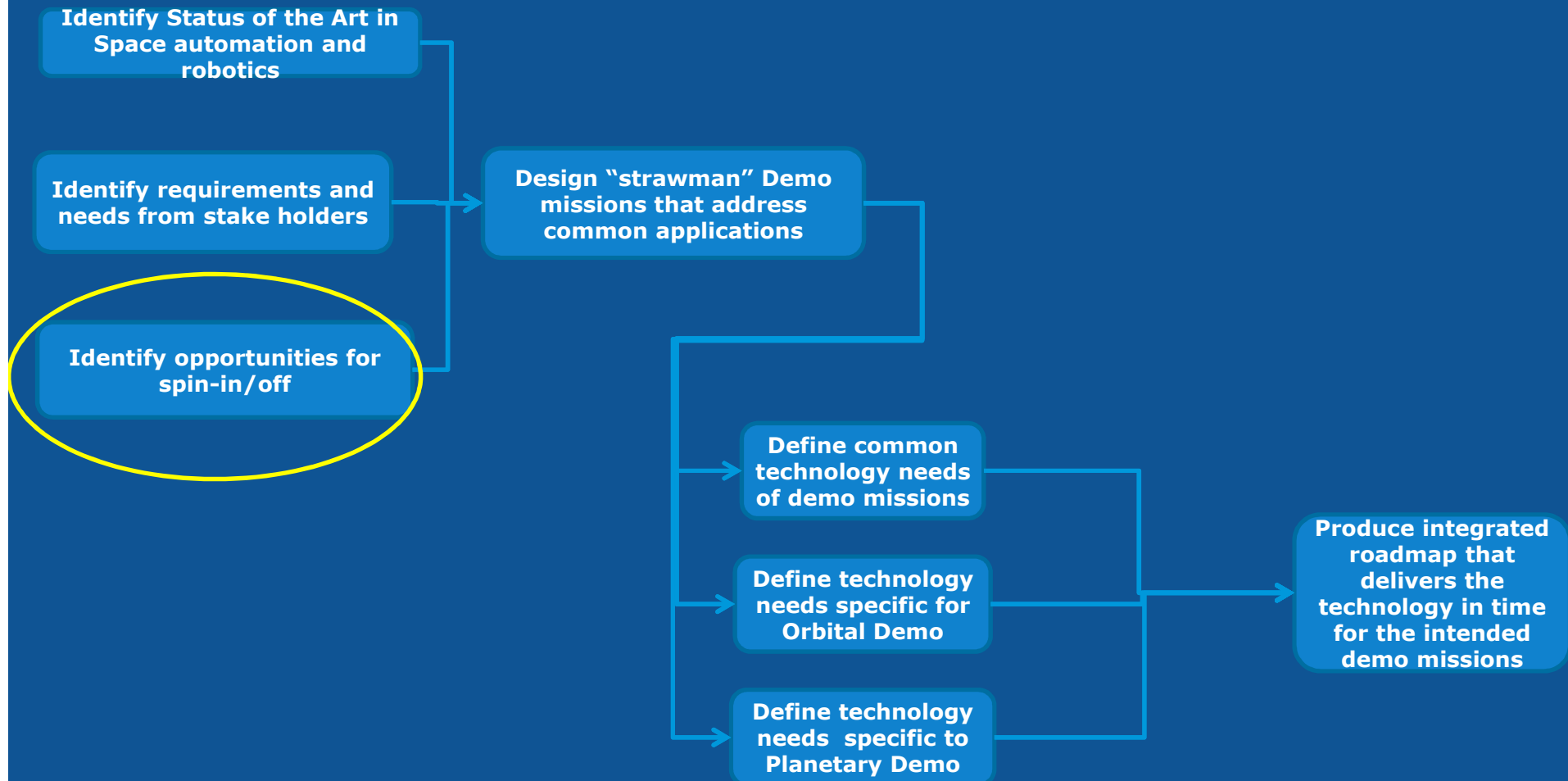
Roadmap development



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Spin In / Out Assessment





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Spin In / Out Assessment

Why Spin-In / Out?

- RAS Technologies have huge potential for transfer across many sectors
- Peraspera-related space RAS technologies are highly (re)applicable in other areas.

Expected Impacts

- Increased efficiencies
- Reduction of duplication of effort
- Cross-pollination of expertise and knowledge
- Cost reduction
- Increased opportunity for exploitation of IP
- Driven by UK Space Agency but looking across Europe



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Spin In / Out Assessment

Overview

Peraspera has ranked a range of space robotic technology areas for planetary and orbital tracks, as well as common build blocks, in terms of priority:

- 4 – Highest Priority, in budget and scope**
- 3 – High Priority, maybe in budget / scope**
- 2 – Of Some Interest, maybe out of budget / scope**
- 1 – Low Priority, maybe out of budget / scope**
- 0 – Out of budget and scope**

- Spin-In / Out Opportunities detailed for all Priority 4 technology areas
- Priority levels **not defined** by Spin-In / Out Opportunity, but Spin-In / Out represents significant added value to industry
- Spin-In defined as sectors and specific projects with state-of-the-art capability that could be exploited by the SRC (specific project names and owners withheld)
- Spin-Out defined as space capabilities developed by the SRC with potential application in other sectors



Spin In / Out Assessment

Peraspera Technology Topics

Ground Support Equipment

Spin-In

Spin-Out

Priority Areas of Interest

- **Civil**
 - **Event & scenario simulation**
 - **Structured SSE**
 - **Virtual Demonstrations**
 - **Tele-robotics > Tele-autonomy**
- **Analog Field Trials**
- **Physical / Virtual Testbeds**
 - Large, unstructured testbeds
 - Development of existing testbeds
 - Simulation of specific challenges
 - Planetary mock-ups
- **Commercial**
 - **Navigation**
 - **Testing specific challenges**
 - **Robotic arm testing**
 - **V&V of RC robots in hazardous environments**
- **Civil**
 - **V&V of RC robots in hazardous environments**




Spin In / Out Assessment

Peraspera Technology Topics

Basic Software

Priority Areas of Interest

- 
- **Space**
 - Teleoperation
 - Pose / state estimation
 - FDIR
 - **Manufacturing**
 - ROS ops

- OS Robot Operating System
- Software Design, Development, V&V Methodology
- Dynamic Software Architecture for modular spacecraft
 - Comms Infrastructure
 - Geometry Library
 - Pose / State estimation, localisation, map-building & navigation
 - Teleoperation and teleautonomy
 - Space-grade reliability, availability, maintainability and safety

- 
- **Manufacturing**
 - Manipulation
 - Teleoperation
 - **Commercial**
 - Fast 3D Mapping
 - Navigation
 - **Consumer**
 - Localisation
 - **Transport & Logistics**
 - Localisation
 - Comms
 - Navigation



Spin In / Out Assessment

Peraspera Technology Topics

Perception & Navigation

Spin-In

- **Manufacturing**
 - Health Management
 - Condition Monitoring
- **Civil**
 - Advanced cognitive awareness
 - Data Fusion
 - Landscape Modelling
- **Manufacturing**
 - ROS ops

Priority Areas of Interest

- Perception & Navigation Core
 - Sensor Data Fusion
 - Self-localisation
 - Landmark tracking
 - Path planning
 - Fast and large map building
 - Generic target detection and localisation

Spin-Out

- **Civil**
 - Enhanced manoeuvrability
 - Localisation
 - Scientific Investigation
- **Agriculture**
 - Location, asset tracking
- **Consumer**
 - Localisation, asset / people tracking
- **Transport & Logistics**
 - Localisation



Spin In / Out Assessment

Peraspera Technology Topics

Sensors

Spin-In

- **Manufacturing**
 - Health Management
 - Condition Monitoring
- **Civil**
 - Advanced cognitive awareness
 - Data Fusion
 - Landscape Modelling
- **Manufacturing**
 - ROS ops

Priority Areas of Interest

- Sensor Data Fusion
- Sensor Suite for Inspection
 - Reduction of number of sensors
 - Algorithmic solutions for data fusion
 - Increased efficiency
 - Hardware frames and interfaces
 - Software framework to support different sensor types
 - Management of data traffic

Spin-Out

- **Civil**
 - Scientific Investigation
 - Image analysis
- **Commercial**
 - Navigation
 - Operation in harsh environments
- **Transport & Logistics**
 - Efficiency
 - Communications linkages



Spin In / Out Assessment

Peraspera Technology Topics

Manipulators & End-Effectors

Spin-In

Spin-Out

Priority Areas of Interest

- **Manufacturing**
 - Intuitive robot tasking
 - Autonomous manipulation
- **Civil**
 - Arm-kinetics
- **Healthcare**
 - Advanced and miniaturised actuators and mechatronics

- Control Algorithms
- Servicing Tools
- Interface Standardisation
 - Generic software solutions
 - Supporting high-accuracy tasks
 - Novel client-capturing system
 - System allowing transfer of data and energy to client
 - Multi-functional intelligent interfaces for connecting building blocks, and satellites with servers

- **Manufacturing**
 - Intelligent assembly and component manipulation
 - Machine learning
- **Commercial**
 - Operation in harsh environments
 - Human Assistance / replacement
- **Healthcare**
 - High accuracy tasks ie surgery



Spin In / Out Assessment

Peraspera Technology Topics

Teleoperation & Telepresence

Spin-In

- **Civil**
 - Digital support for human operators
 - Virtual representation of training environments
 - SSE scenarios

Priority Areas of Interest

- Adjustable levels of autonomy
- Tele-operation protocols for space robotics
 - Robot AI capabilities
 - Formal verification of autonomy
 - Auto-adaption of MMI to operator
 - Visual navigation aids to assist control of robots
 - Increased situational awareness
 - Enhancing on-ground testing facilities
 - Design & manufacture of standard mech, elec, S/W interfaces

Spin-Out

- **Civil**
 - Machine Learning
 - Quick, safe deployment into hazardous scenarios
- **Military**
 - Bomb disposal
 - Field surgery
 - High-stress ops
- **Healthcare**
 - Rehabilitative medicine, physio care
 - Emergency medical relief
 - Remote surgery



Spin In / Out Assessment

Peraspera Technology Topics

Autonomy

Spin-In

- **Manufacturing**
 - Autonomous manipulation
 - Control and planning
 - Resource management and FDIR
- **Agriculture**
 - Learning via sensing and perception
 - Object recognition
- **Transport & Logistics**
 - Decision-making based upon sensor fusion and perception

Priority Areas of Interest

- Temporal/spatial (re)planning, scheduling and deliberative / reactive reasoning
 - Autonomous navigation management
 - Adaptive execution
 - Validation of uploaded planning and alignment with onboard resources
 - Management of comms links
 - Reduction in teleoperations
 - Reduction in power consumption

Spin-Out

- **Transport & Logistics**
 - Safer systems
 - Navigation, Air Traffic Control
 - Fault diagnosis
 - Operation in hard-to-reach areas
 - Flight plotting
- **Commercial**
 - Mission planning
 - Operation in hard-to-reach areas



Spin In / Out Assessment

Peraspera Technology Topics

Mobility

Spin-In

- **Manufacturing**
 - Improved spatial awareness and mobility
 - Robotic cooperation
 - Intelligent mobility
- **Agriculture**
 - Novel locomotion for different surface types
 - Autonomous, observation-based navigation
- **Civil**
 - Decision-making based upon sensor fusion and perception

Priority Areas of Interest

- Mobility systems for long-rangetraverses and difficult areas
 - Locomotion strategies for different surface characteristics
 - Prototypical implementation of locomotion hardware and software and testing in HiL (Hardware-in-the-Loop) scenarios

Spin-Out

- **Commercial**
 - Investigation and activity in hard-to-reach environments
 - Deployment
- **Civil**
 - Deployment into hazardous scenarios
 - Disaster relief
 - Operation in hard-to-reach areas
- **Military**
 - Forensic investigation and detection of toxins



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Spin In / Out Assessment

Conclusions and Next Steps

Conclusions:

- Strong cases for spin-in / out
- Some sectors identified as being of strategic importance
- *Don't let the tail wag the dog!*

Next Steps:

- Extensive industrial consultation
 - Provide granularity
 - Disseminate findings
 - Ensure industrial buy-in
 - Ensure buy-in from non-space sectors



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Spin In / Out Assessment

Space Robotics In The Community

To discuss how your capability or technology might have applicability in space robotics, or if the space robotics technologies may be of interest to your industry, get in touch!

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Examples of strawman missions

(OT-2) Future Low-cost EXchangeable/EXpandable/EXTendable SATellite (FLEXSAT), which targets the demonstration of robotics servicing technology aimed at achieving composable, re-configurable and refuel-able spacecraft. The demonstration mission, that is the final goal of the scenario, will feature a small satellite system that, through robotics technology, can deploy/reconfigure/extend itself, thus allowing the spacecraft mission to evolve. The scenario will use common building blocks, mature the dedicated manipulation and assembly technologies and finally develop the demonstration mission in its last operational grant. This grant will need to have adequate funding for procuring the spacecraft hardware and the launch opportunity.



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Examples of strawman missions

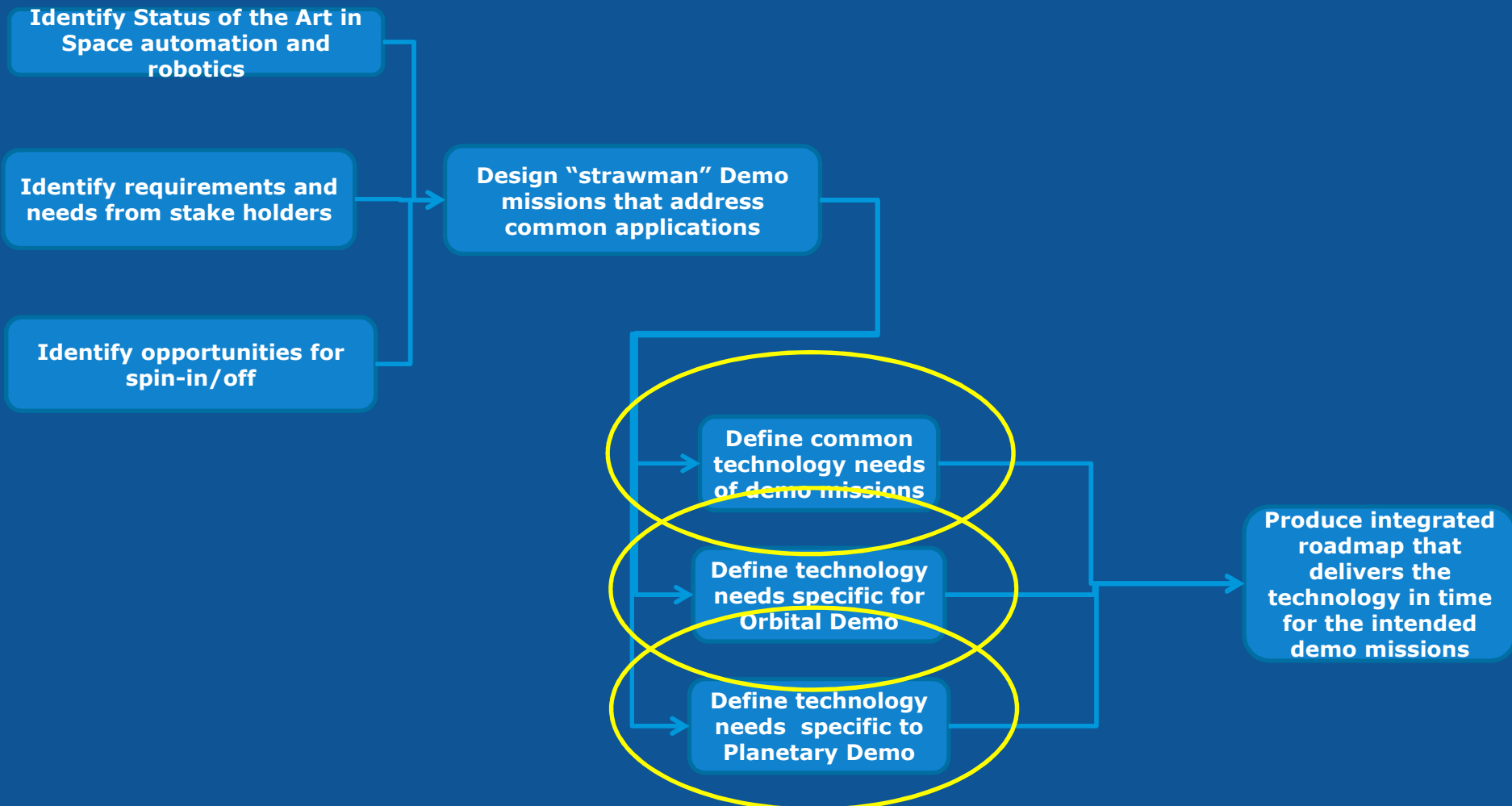
(PT-1) Martian Long-range Autonomous Scientist, which targets the demonstration of highly autonomous technologies that will allow future Martian rovers to roam across the vast extents of the Martian surface and return autonomously detected science, compatible with the limited energy and telecommunication budgets associated to Martian missions. The scenario will use common building blocks, mature the dedicated autonomous navigation and science detection technologies and finally develop a demonstration field trial in its last operational grant.



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The technology needs and priorities





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Priority

Priority Level 4: This activity is an important generic building block enhancing capabilities in both orbital and planetary tracks, the PERASPERA consortium believes that this a subject to pursue

Priority Level 3: This technology is very important, however it appears not affordable within the SRC scheme at this time

Priority Level 2: although it is recognised that it is a technology of importance, there are other activities that need to be pursued with higher urgency

Priority Level 1: This technology may become very important for Space Robotics, however the development of it is likely to come from the terrestrial sector, so the SRC will wait for this development to happen

Priority Level 0: This technology may have great potential benefits, however the maturation of it is beyond the possibilities of the Space Robotics SRC