The Strategic Research Cluster in Space robotics technology

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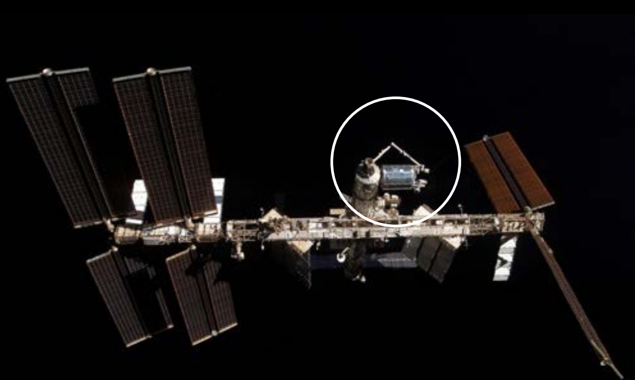
A Strategic Research Cluster is a coordinated effort of individual research and development grants that aim at producing a significant demonstration of a specific technology

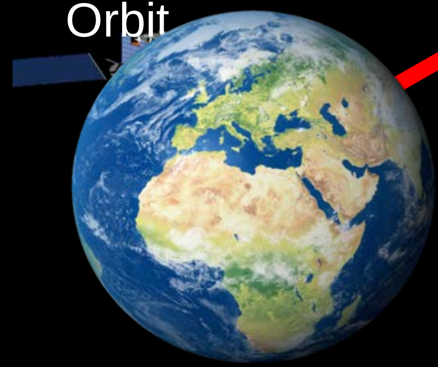
We are talking here of
Space Robotics Technology

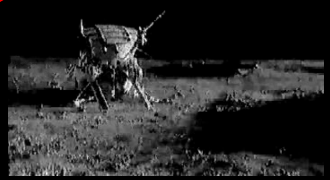
Orbital Applications

Robotics in
Low Earth Orbit
(Space Station)

Robotics in
Geostationary
Orbit







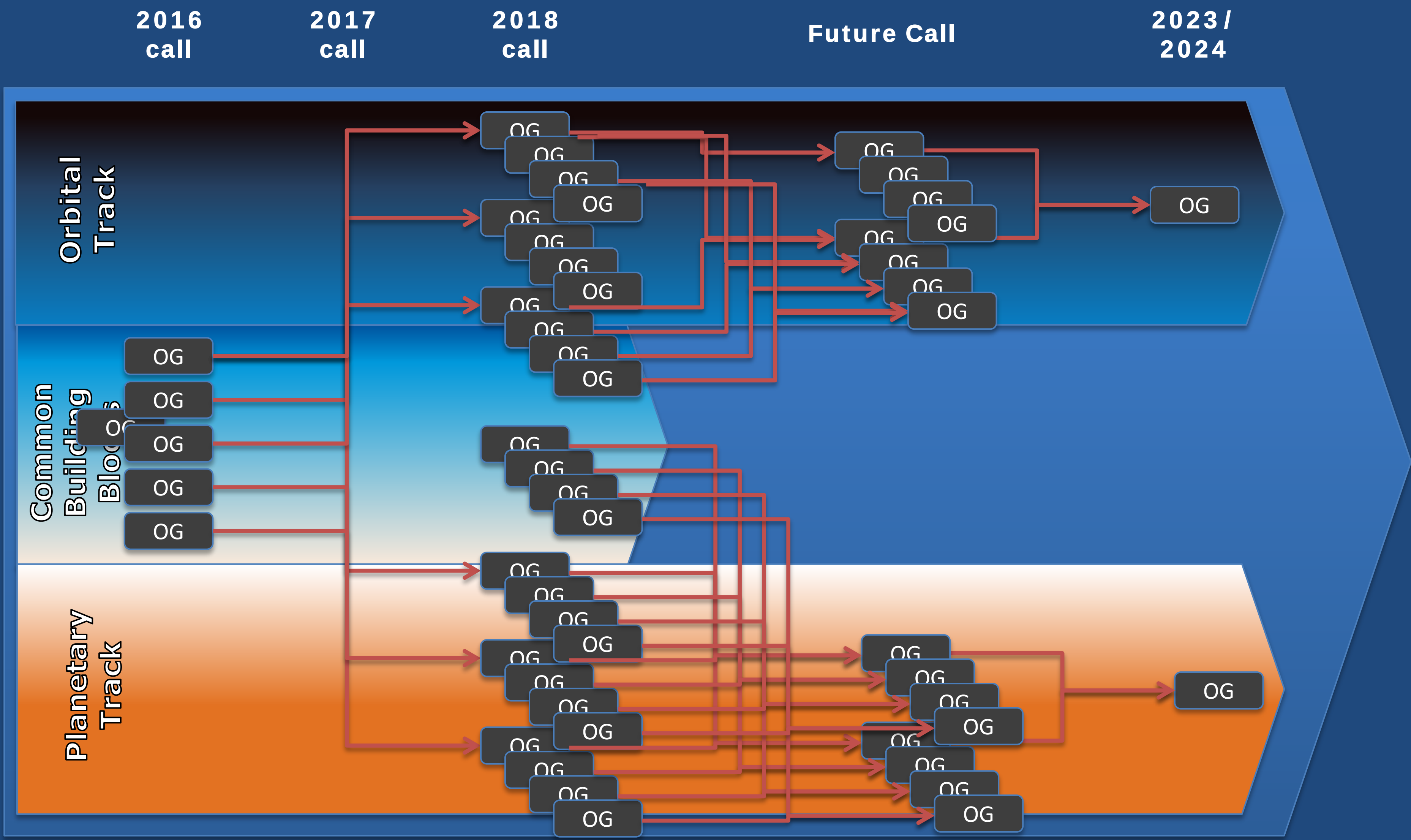
Robotics
on Small
Bodies
(Comets,
Asteroids)

Robotics on
Mo

Planetary Robotics

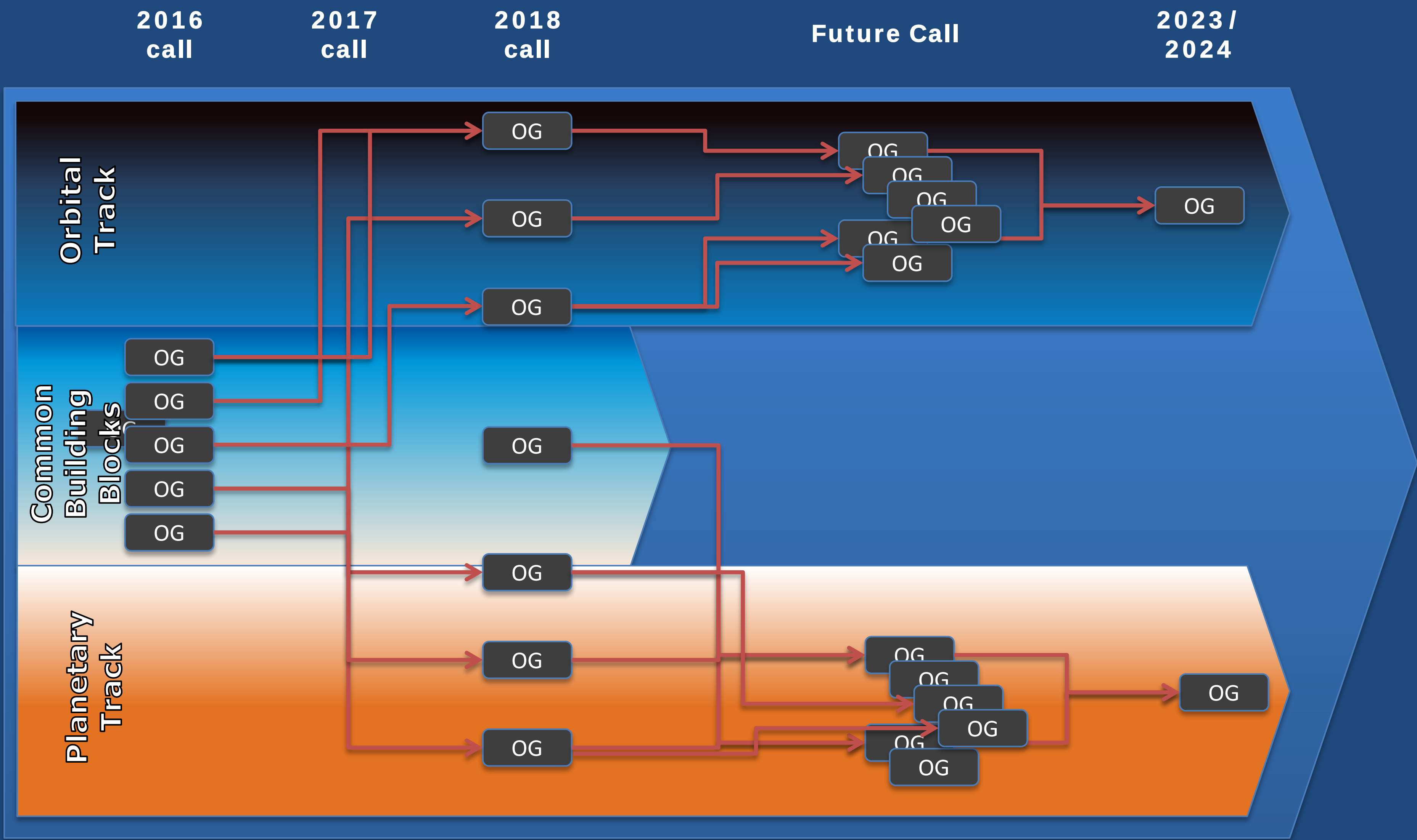
1st stage:

1) detailed definition of OGs for the first call
2) A number of options for the second call
3) Several possible end-goals for both Orbital and Planetary Track



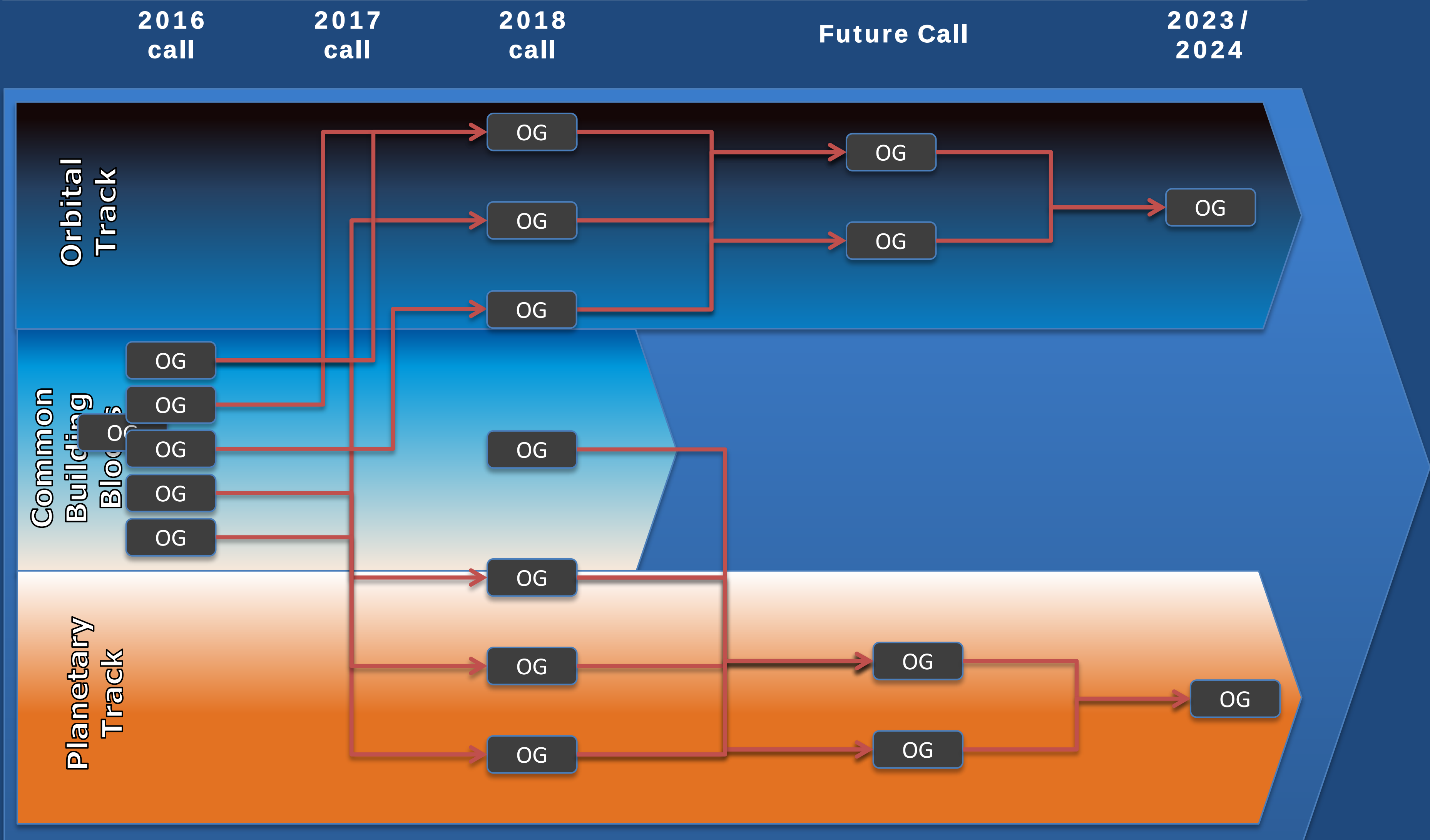
2nd stage:

1) OGs for the first call awarded and running, first results considered
2) detailed definition of OGs for the second call
3) Reduced number of possible end-goals for both Orbital and Planetary Track



3rd stage:

1) OGs for the first call completed, results available to 2nd call OGs
2) OGs for the 2nd call awarded and running, first results considered
3) Detailed definition of end-goals for both Orbital and Planetary Track



The Space Robotics Technology Strategic Research Cluster offers an unique opportunity to carry out a foundation-making programme of research and development of high impact and high consistency.

The roadmap describes a programme to implement a set of long-lasting community-building developments that not only will serve the initial purpose of the SRC, i.e. demonstration of space robotics technology, but could allow future institutional missions in the field of space robotics.

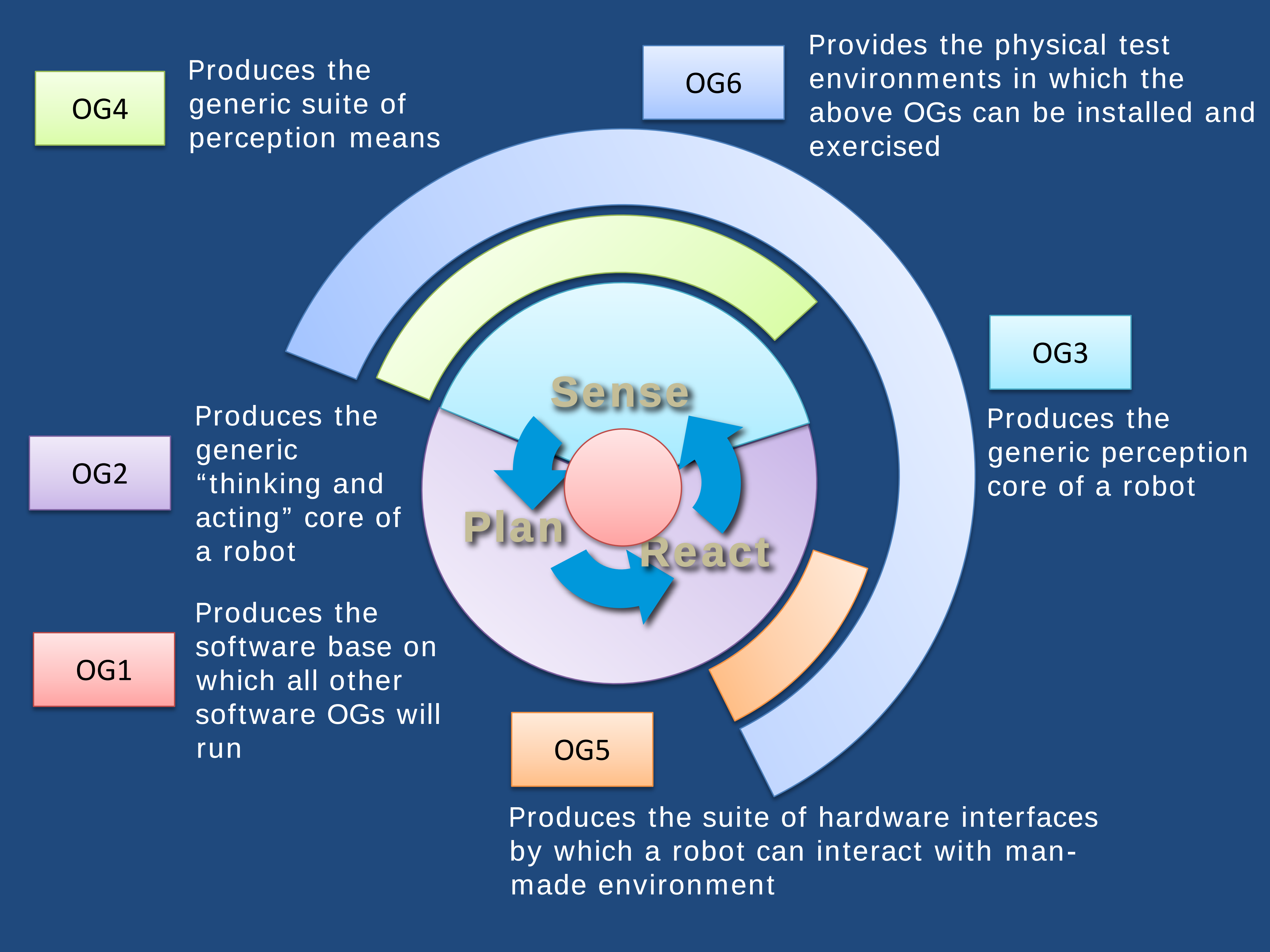
Coherence, complementarity and coordination of the Operational Grants are capital for the success of the SRC

COHERENCE
COMPLEMENTARITY
AND
COORDINATION
IN THE SRC

Coherence and complementarity are realised by the detailed specification of operational grants.

Each OG deals with different aspects of a robot systems

Each OG has a carefully defined scope and set of deliverables


OG4
Produces the generic suite of perception means
OG6
Provides the physical test environments in which the above OGs can be installed and exercised
OG3
Produces the generic perception core of a robot
OG2
Produces the generic “thinking and acting” core of a robot
OG1
Produces the software base on which all other software OGs will run
OG5
Produces the suite of hardware interfaces by which a robot can interact with man-made environment
Sense
Plan
React

OG4

Produces the generic suite of perception means

OG2

Produces the generic "thinking and acting" core of a robot

OG3

Produces the generic perception core of a robot

OG6

Provides the physical test environments in which the other OGs can be installed and exercised

OG5

Produces the a suite hardware interfaces by which a robot can interact with man-made environment

OG1

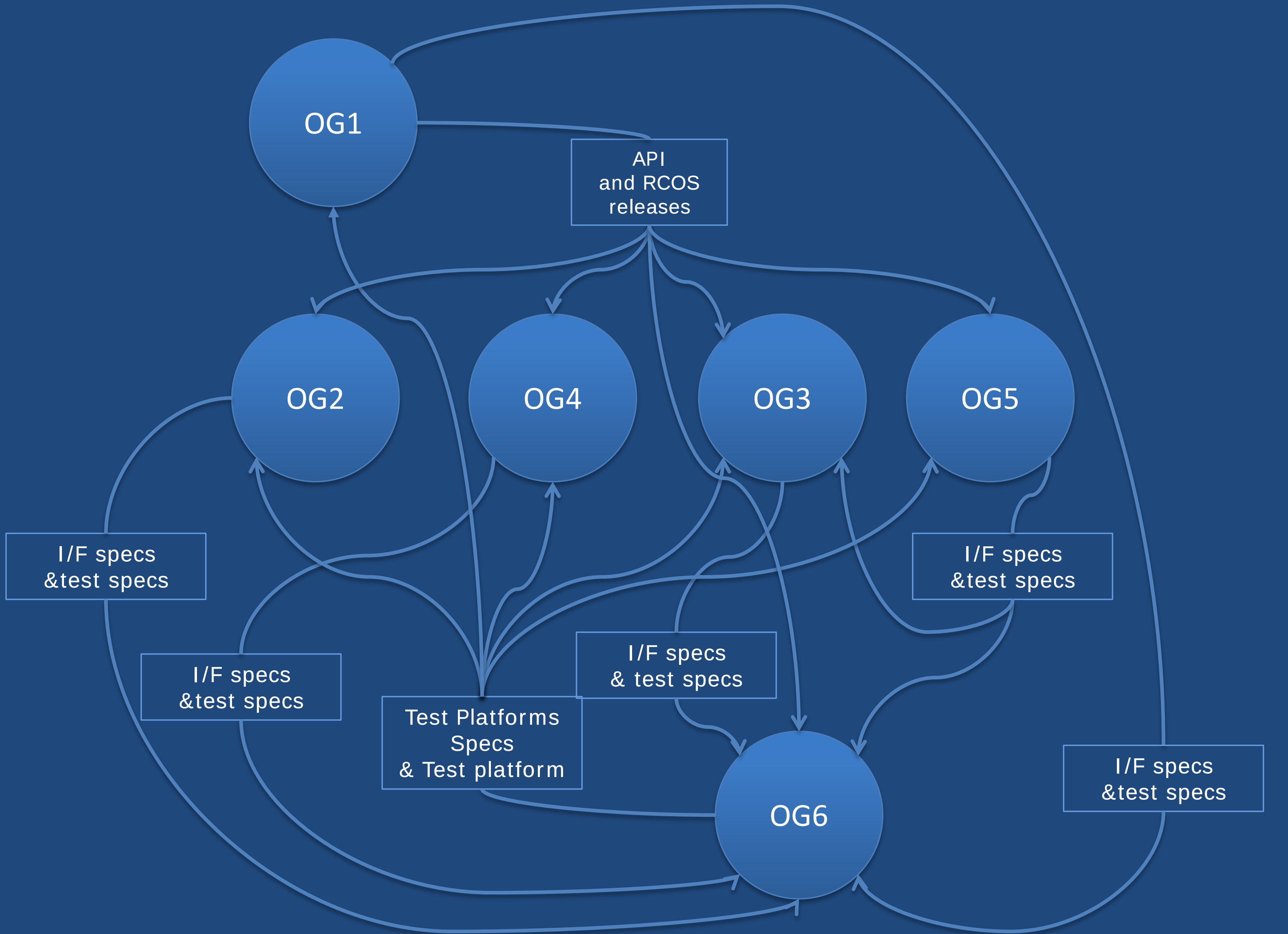
Produces the software base on which all other software OGs will run

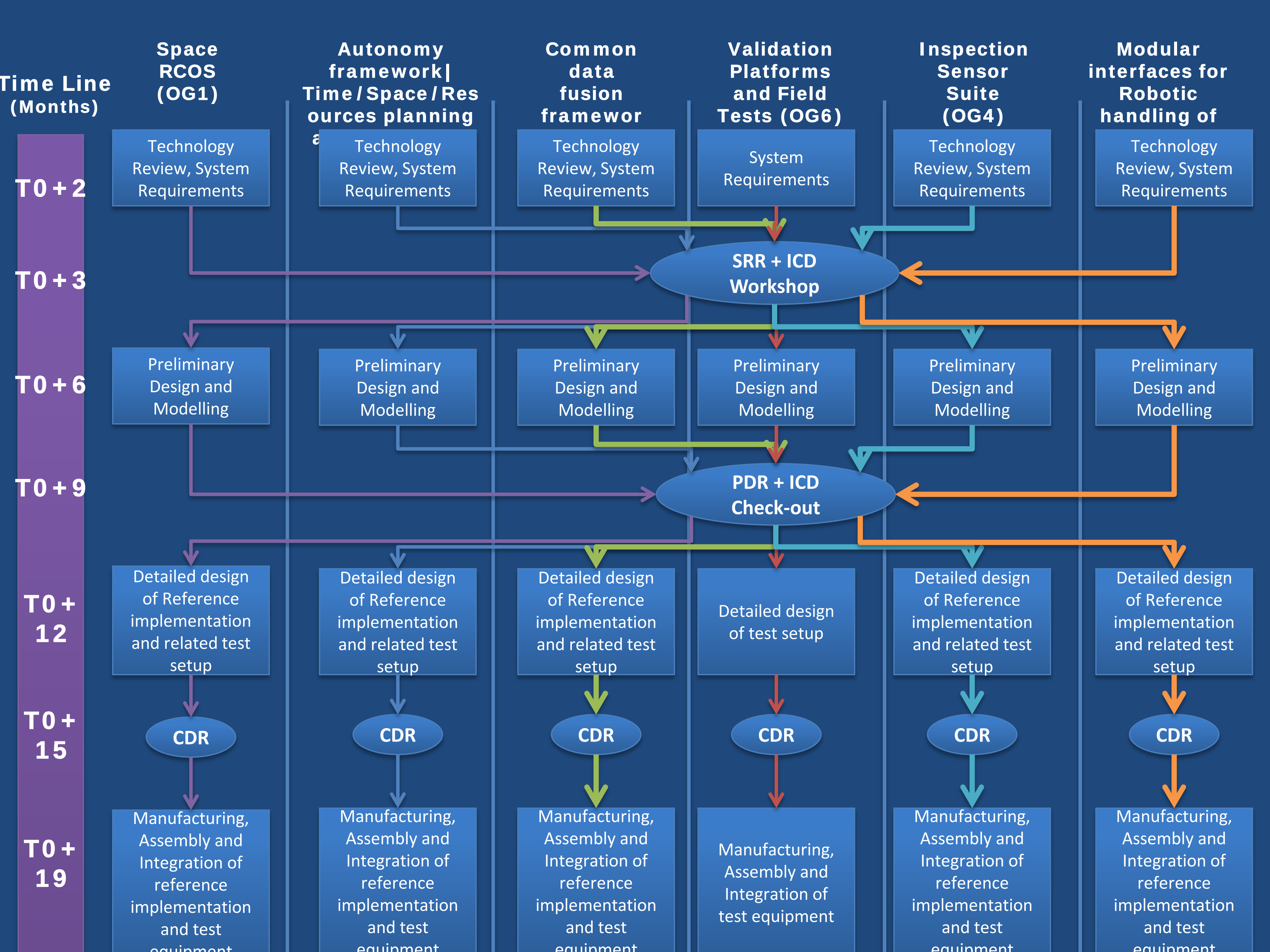
Coordination is implemented by means of:

Commonly defined and agreed requirements and interfaces

cross-delivery among OGs of partial results

Common meetings


OG1
API
and RCOS
releases
OG2
OG4
OG3
OG5
I/F specs
&test specs
I/F specs
&test specs
I/F specs
&test specs
I/F specs
& test specs
Test Platforms
Specs
& Test platform
OG6
I/F specs
&test specs


Time Line (Months)
Space RCOS (OG1)
Autonomy framework| Time/Space/Resources planning a
Common data fusion framewor
Validation Platforms and Field Tests (OG6)
Inspection Sensor Suite (OG4)
Modular interfaces for Robotic handling of
T0+2
T0+3
T0+6
T0+9
T0+12
T0+15
T0+19
Technology Review, System Requirements
Technology Review, System Requirements
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System Requirements
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Technology Review, System Requirements
SRR + ICD Workshop
Preliminary Design and Modelling
Preliminary Design and Modelling
Preliminary Design and Modelling
Preliminary Design and Modelling
Preliminary Design and Modelling
Preliminary Design and Modelling
PDR + ICD Check-out
Detailed design of Reference implementation and related test setup
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Detailed design of test setup
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CDR
CDR
CDR
CDR
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Manufacturing, Assembly and Integration of reference implementation and test equipment
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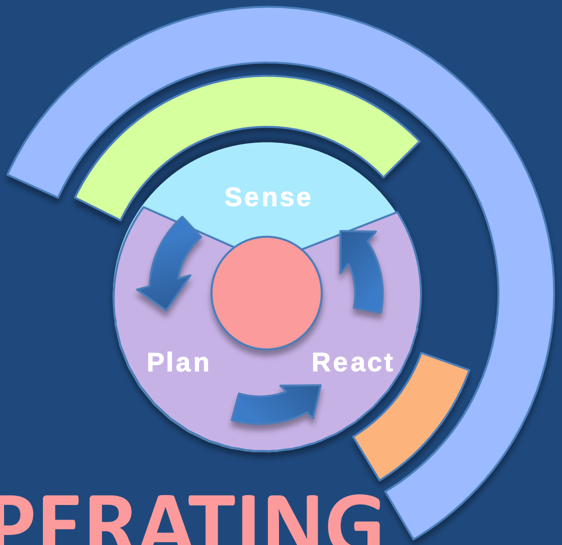
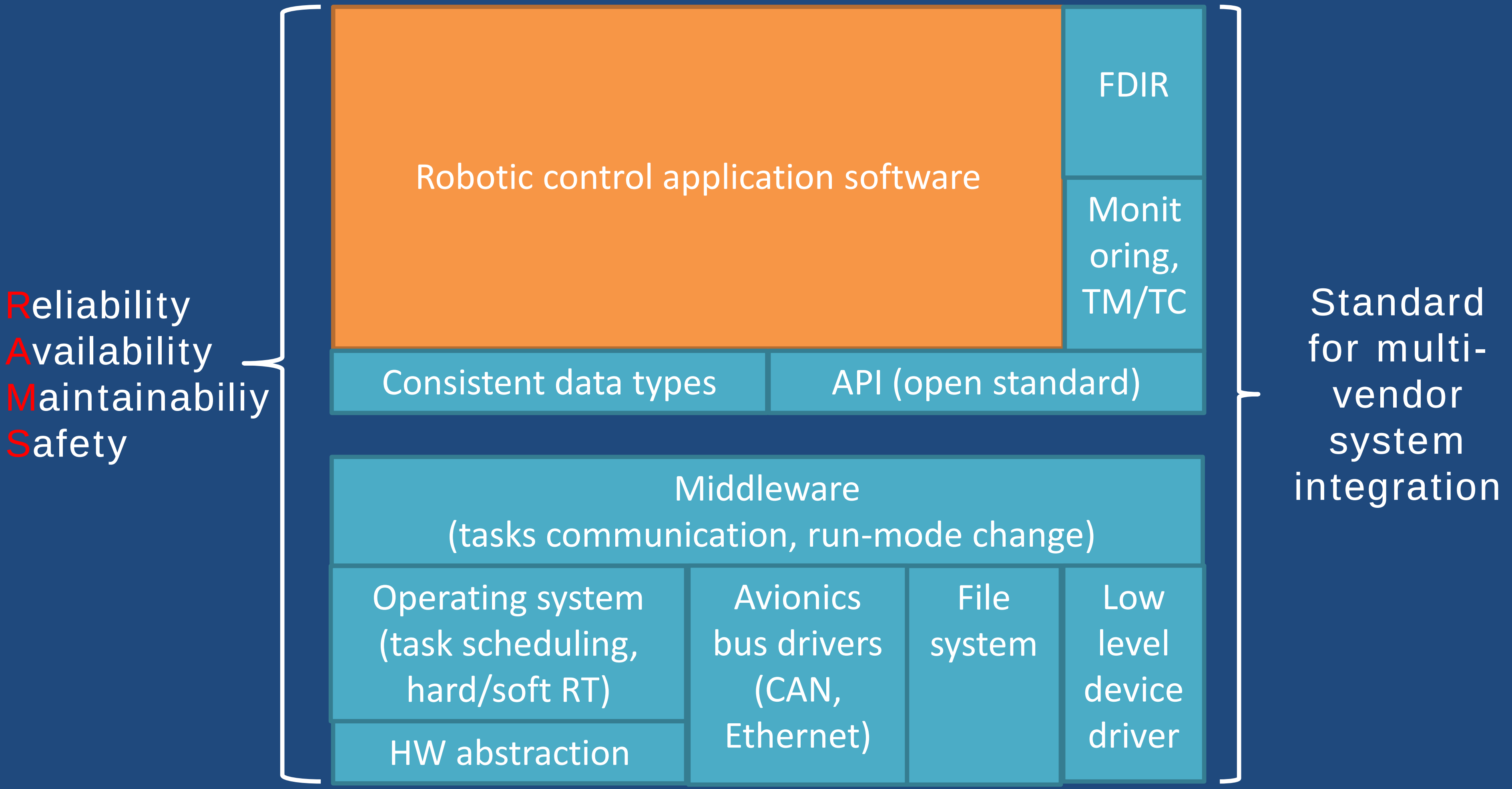
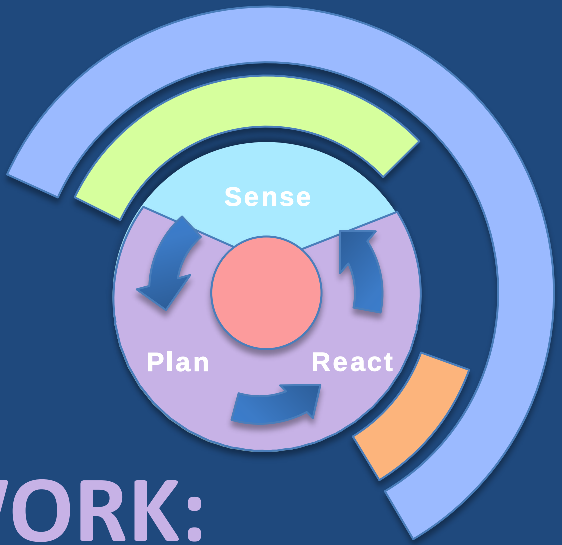
The validation approach

- Stages of validation
  1. Each OG realizes an independent verification and validation
  2. OG5 provides for validation in common test platforms (Orbital & Planetary)
  3. Validation of fully integrated OGs (next stage)
- Objectives
  - A good interaction and coordination between all OGs is vital for the future integration
  - The validation tests shall be coherent with the demonstration scenarios and the Roadmap goals.
  - The result and deliverables of the OGs must be consistent with the SRC_Guidelines_Space_Robotics_Technologies (COMPET-4-2016)



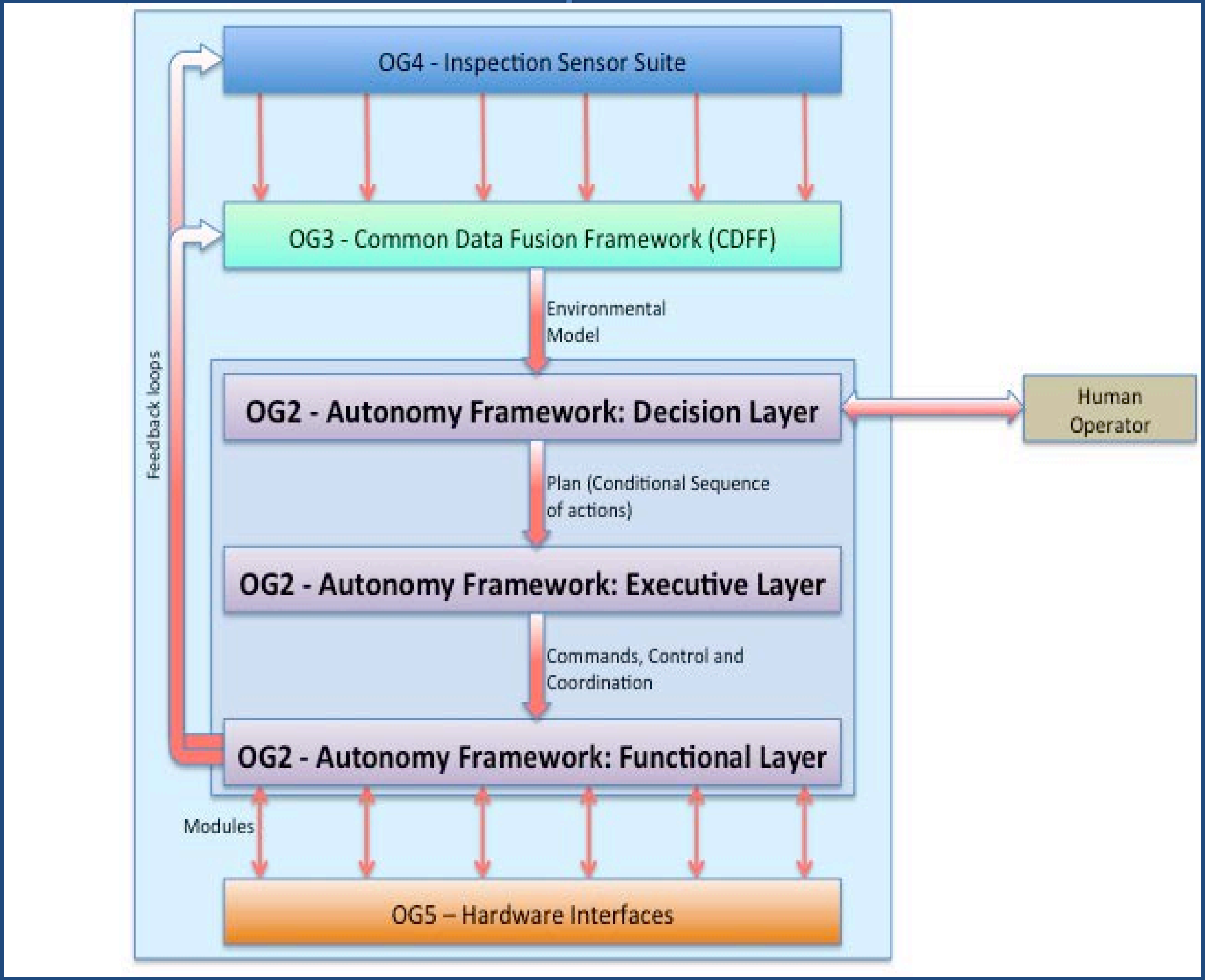
SPACE ROBOT CONTROL OPERATING SYSTEM
(OG1)

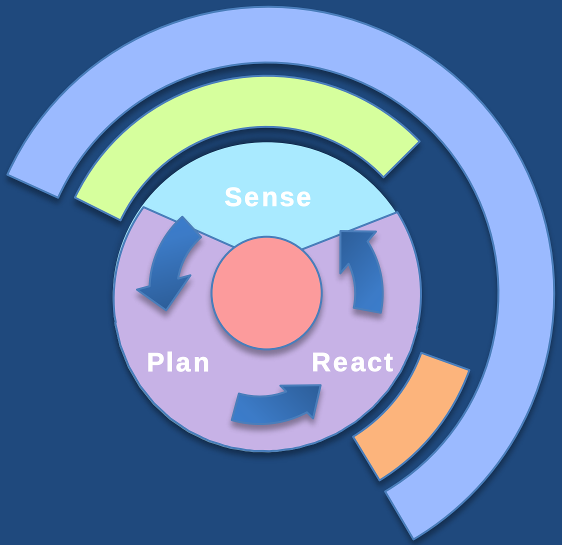

Reliability
Availability
Maintainabiliy
Safety
Robotic control application software
FDIR
Monitoring, TM/TC
Consistent data types
API (open standard)
Middleware
(tasks communication, run-mode change)
Operating system (task scheduling, hard/soft RT)
HW abstraction
Avionics bus drivers (CAN, Ethernet)
File system
Low level device driver
Standard for multi-vendor system integration



AUTONOMY FRAMEWORK: TIME/SPACE/RESOURCES/PLANNING/SCHEDULING (OG2)

3-Tiered Architecture Capable of Decision-Making and Execution





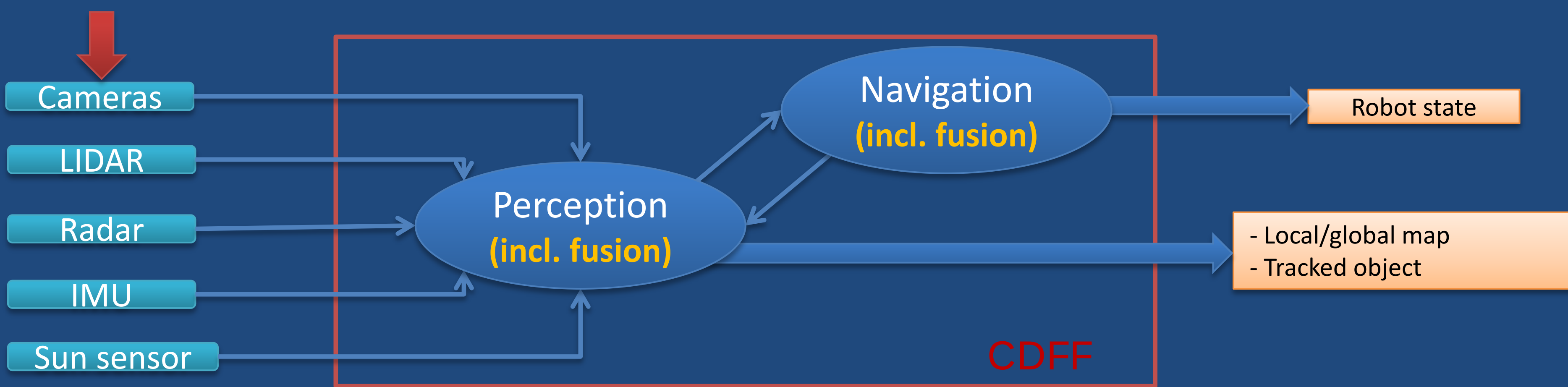
COMMON DATA FUSION FRAMEWORK (OG3)

S/W framework implementing data fusion techniques

Data fusion :

- combination of data from **multiple sensors** with potential **information from relevant data bases**
  - ➢ improve accuracy and robustness
  - ➢ build more global information on the environment

Data acquisition out of the scope (OG4)



Perception

- convert raw data into **refined measurements**,
- process **complementary information** from different types of sensors
- merge **multiple observations** from single / multiple sensor(s)
- extract or **track features** from dense data sets
- detect and identify or track objects
- build a **3D model** of the environment,
- perform environment characterization (**map**)

Orbital applications :

- detection, tracking and relative pose estimation of cooperative / non cooperative /hazardous objects
- reconstructing the objects 3D model by the incremental association of 2D/3D data acquired from multiple points of view (rendezvous, inspection, capture /docking and satellite servicing)
- required for situation assessment, motion planning and motion control
- Detect anomaly situations

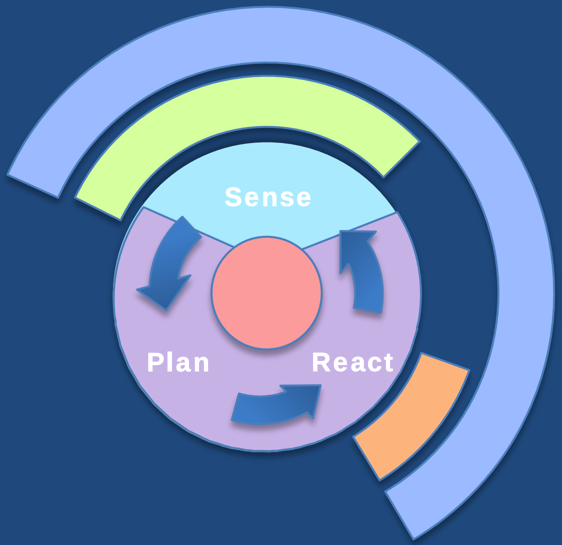
Inputs

Navigation

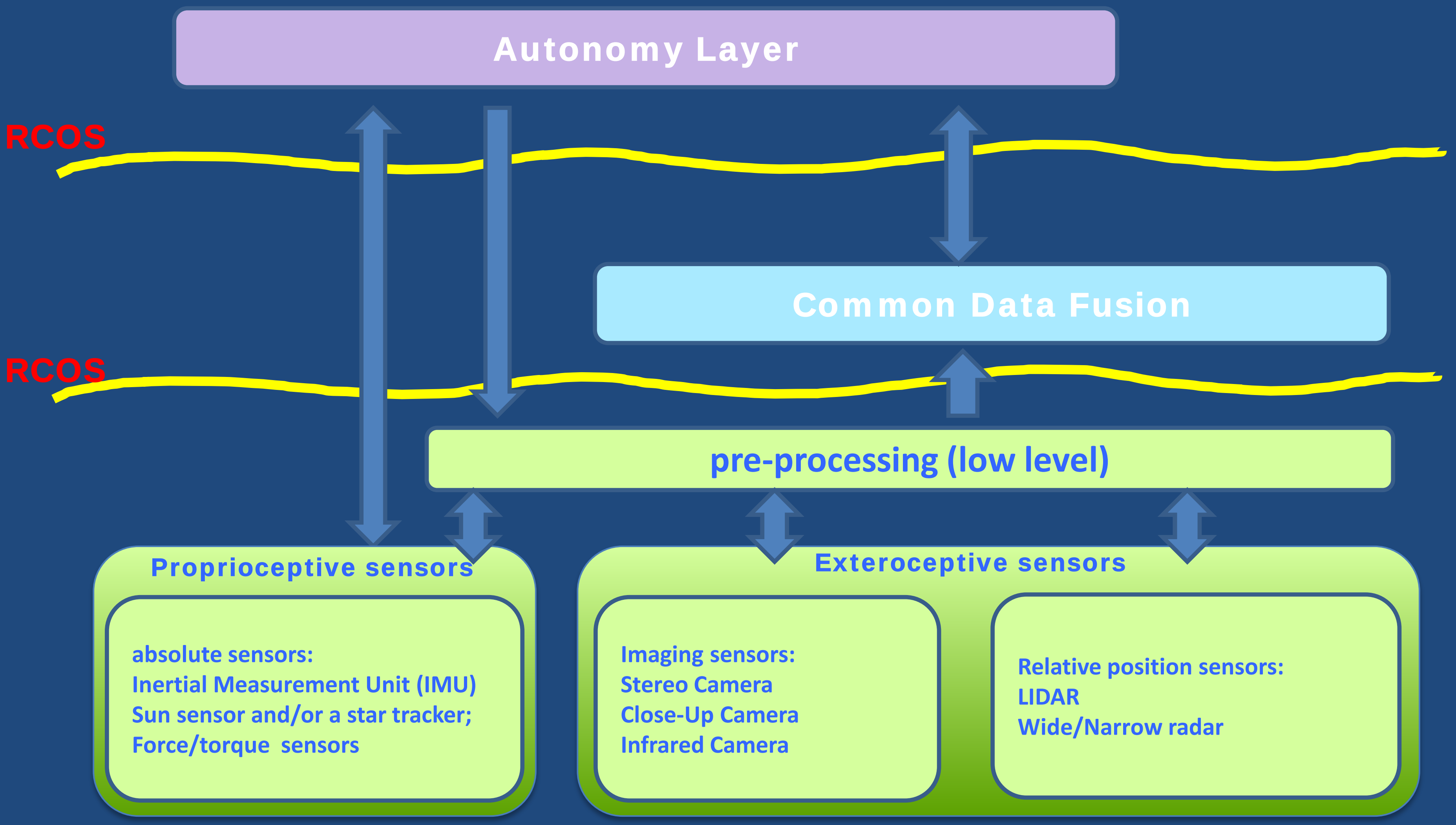
- provide geometrical/dynamic **state of a machine estimation** process : combination of data coming from absolute and/or relative sensors and a priori information
- Applicable to **multi-robots system**

Planetary exploration :

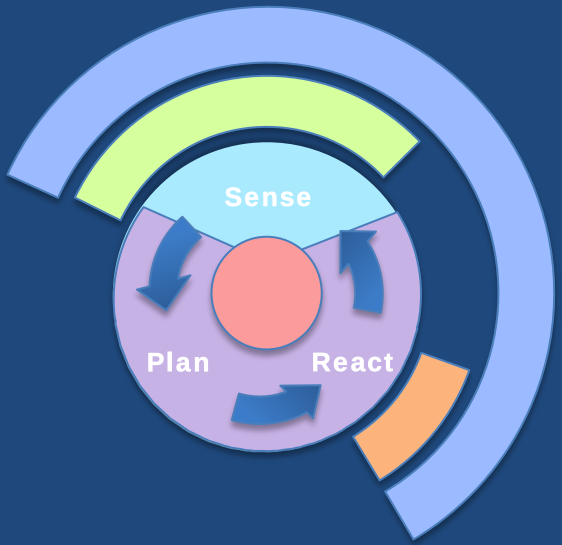
- **Navigation / Localisation of robots** in natural environments
- Geometrical/topological **reconstruction of environment**
- Detection, tracking and estimation of the **relative position**/pose of objects that are either structured (planetary assets) or unstructured (i.e. landmarks)
- Building and update of symbolic and compact **representations of the environment** (maps of obstacle profiles)
- Detect anomaly situations



COMMON INSPECTION SENSOR SUITE (OG4)



FUNCTIONAL SCHEME



MODULAR INTERFACES FOR ROBOTIC HANDLING OF PAYLOADS (OG5)

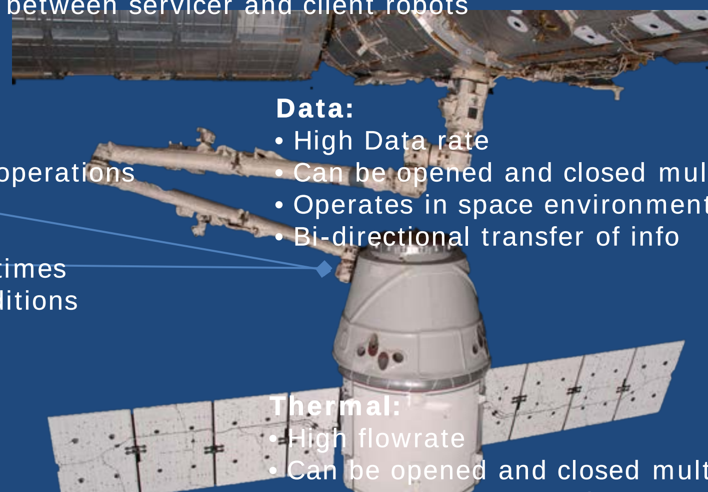
Interface for payload modules and manipulator

Overview

Standard Interface Supporting:

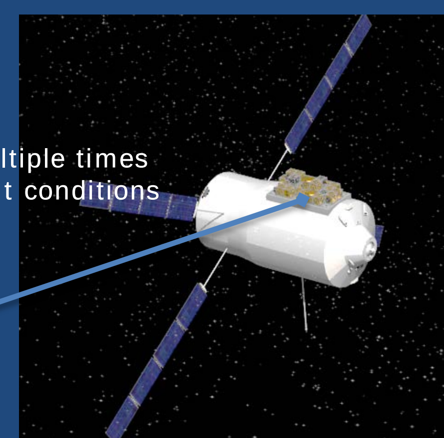
- Mechanical Loads
- Electrical Signals
- Data flow
- Thermal Flow

Manipulator end-effector
supporting standard interface



Interface Criteria:

- Scalability
- Internal redundancy
- Compatibility to robot servicing
- Low complexity, mass and volume
- Rotation of axis and symmetry
- Reusability
- Connection of nearly arbitrary modules without restriction on the relative module orientation



Active Payload Modules (APM)
connected via standard interface
to other modules and satellite bus

Interface Functionalities

General:

- Connect APMs with each other, spacecraft, and bus
- Couple with compatible robotic manipulator
- Exchange data through manipulator between servicer and client robots

Mechanical:

- Androgynous design
- Absorption of loads arising through operations
- Absorption of launch loads
- Requires only energy to undock
- Can be opened and closed multiple times
- Operates in space environment conditions
- High position tolerance for docking

Data:

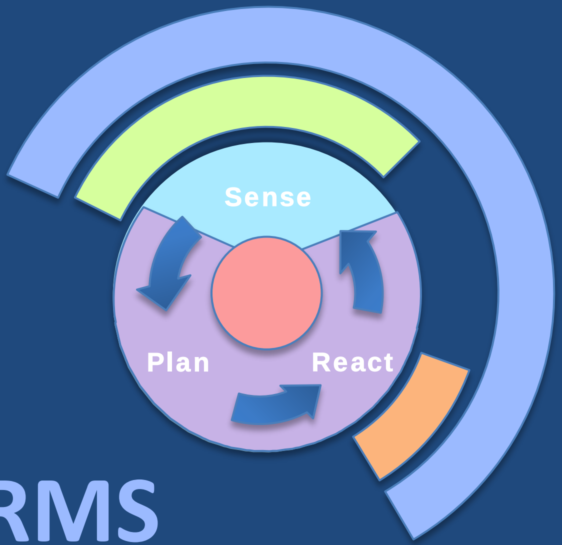
- High Data rate
- Can be opened and closed multiple times
- Operates in space environment conditions
- Bi-directional transfer of info

Electrical:

- Short circuit protection
- Surge protection
- Electro-magnetic compatibility w/coupled modules
- Transfer of power in both directions
- Can be opened and closed multiple times
- Operates in Space Environment conditions
- Withstands launch loads
- High positioning tolerance for docking

Thermal:

- High flowrate
- Can be opened and closed multiple times
- Operates in space environment conditions



VALIDATION PLATFORMS AND FIELD TESTS (OG6)

Goals

- Validation of the common building blocks in the highest fidelity analog environment
- Assist validation & integration for both scenarios Planetary & Orbital
- Provide the necessary facilities (Already existing laboratories, only small adaptations intended)
- Provide the necessary: Platforms, specifications, interfaces, models, datasets & monitoring
- OG6 shall assist and give on-site support to validation, but validation tasks are outside the scope of this activity

Orbital Validation Scenario

Scenario

- Reproduce in-orbit servicing (rendezvous & capture)
- Simulate robotic servicer tracking
- Space-like controllable conditions
- Hardware-in-the-loop

Equipment

- Al least 2 robotic arms (6DoF)
- High precision calibration system
- Controllable illumination system
- Sensor representative proximity operations
- Truth position/attitude measurement
- Scaled Mockup for target satellite

Robot will allow

- OG1: Robot Arm controlled by RCOS
- OG2: Implementation manipulation motion as commanded by AF
- OG3: Provide sensory data to CDFF
- OG4: Necessary interfaces to host ISS
- OG5: provide manipulation for the end-effector & APM

Planetary Validation Scenario

Scenario

- Short-range scenario (Moon/Mars yard) with different regolith & orography
- Long-range scenario (Earth analogue)
- Specialized measurement systems (indoor/outdoor)

Equipment

- Rover Platform
- Space representative avionics
- Standard interfaces (HW/SW)
- Necessary sensors

Rover Platform will allow

- OG1: locomotion controlled by RCOS
- OG2: Implementation of navigation
- OG3: Provide sensory data to CDFF
- OG4: Necessary interfaces to host ISS
- OG5: provide manipulation for the end-effector & APM

Spin-In/Out Potential:
Impacting On Robotic Activity on Earth

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

Robotic Activity on Earth

Greater Innovation
Market Exploitation
New Collaboration

SPARC Roadmap, EC Strategic Research Agenda, National Roadmaps, Market Reports

Iteration 1

- Identification of high-level sectors and operating environments, and case studies

Terrestrial Sectors

- Manufacturing
- Healthcare
- Agriculture
- Civil
- Commercial
- Transport
- Consumer
- Military

Operating Environments

- On the ground
- In the Air
- Underwater
- In space
- In the human body

Case Studies

- Canadarm
- Micro-robots

€157m invested in 2016-17 ICT Call for terrestrial robotics
http://ec.europa/programmes/horizon2020/en/draft-work-programmes-2016-17

Iteration 2

Identification of applications for existing and future SRC technologies

- RCOS
- Autonomy Framework
- Data Fusion Framework
- Inspection Sensor Suite
- Manipulator Interfaces
- Validation & Testing

- Other technologies on the original PSA roadmap

Iteration 3

Identification of applications for greater numbers of existing and future SRC technologies

Crucial Points

- Technologies to be developed in the OGs were selected based on the master plan task priorities
  → time for technology maturation is considered

- Roadmap was built considering the required technology maturation and integration process to reach SRC end goal
  → common building blocks (Call 1) develop technology needed for orbital and planetary track (Call 2/3)
  → OG's are interconnected: this must be considered and understood

➢ SRC end goal and **Call 2 / 3 OGs –orbital / planetary building block-** depend on the realization of all **Call 1 OGs -common building blocks-**