MOSAR

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Abstract : This document presents the system requirements for MOSAR that were derived from the application and technology review, and the analysis of the operational and demonstration scenarios.

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Project Officer EC : Christos Ampatzis (REA)

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DOCUMENT APPROVAL SHEET			
	Name	**Organization**	**Date**
Prepared and cross-review by:		Space Applications Services Thales Alenia Space France Thales Alenia Space UK SITAEL GMV University of Strathclyde German Aerospace Centre (DLR) MAG SOAR	28/06/2019

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Contents

List of Figures

List of Tables

1 Introduction

1.1 Purpose and Scope

The purpose of this document is to provide the system requirements for MOSAR that are derived from the from the SRC Compendium document, the analysis of the modular spacecraft applications and relevant technology review (including previous OGs building blocks), the MOSAR operational concept and the demonstration scenarios.

The document is mainly divided in two parts. The first part addresses the extraction of requirements associated with future space mission scenarios of modular spacecraft applications. They are mainly derived from the analysis of the most promising use cases of On-orbit reconfiguration and the associated technological needs (RD2-D1.2). These requirements are considered as guidelines for the development of the MOSAR demonstrator, to target a good representativeness of future missions.

The second part addresses more specifically the technical requirements of the MOSAR demonstrator that will be designed, developed and tested during this activity. The requirements are described at system level, for each of the main sub-systems and for the validation phase.

1.2 Document Structure

This document is structured as follows:

Section 1 Introduction

Section 2 Modular Spacecraft Requirements

Section 3 MOSAR Demonstrator Requirements

1.3 Applicable Documents

AD1 SRC – Guidance Document for H2020 Work Programe 2018-2020 (SPACE-12-TEC-2018)

AD2 MOSAR Consortium Agreement, version 1.0 (7th November 2018)

AD3 MOSAR Grant Agreement (821996) (18th January 2019)

AD4 MOSAR Proposal; H2020-SPACE-2018-2020 (SEP-210504862)

1.4 Reference Documents

RD1 MOSAR-WP1-D1.1-GMV OG1-5 Building Block Update Documentation Package

RD2 MOSAR-WP1-D1.2-TASF Report on MOSAR Applicable Technologies Review

RD3 MOSAR-WP1-D1.3-DLR Operational Concept

1.5 Acronyms

APM	Active Payload Module
ASM	Active System Module
CAN	Controller Area Network
CLT	Client (spacecraft)
DDS	Data Distribution Service
ERGO	European Robotic Goal-Oriented Autonomous Controller
ESA	European Space Agency
ESROCOS	European Space Robotics Control and Operating System
FES	Functional Engineering Simulator
FM	Functional Module
GEO	Geostationary Earth Orbit
GTO	Geostationary Transfer Orbit
I3DS	Integrated 3D Sensors
InFuse	Infusing Data Fusion in Space Robotics
LEO	Low Earth Orbit
MCC	Monitoring and Control Center
MOSAR	Modular Spacecraft Assembly and Reconfiguration
OBC	On-Board Computer
OG	Operational Grant
PERASPERA	Plan the European Roadmap and its Activities for Space Exploitation of Robotics and Autonomy
PUS	Packet Utilization Standard
R-ICU	Reduced Instrument Control Unit
SI	Standard Interface
SIROM	Standard Interface for Robotic Manipulation of Payloads in Future Space Missions
SM	Spacecraft Modules
SpW	SpaceWire
SRC	Strategic Research Cluster
SVC	Servicer (spacecraft)
TASTE	The ASSERT Set of Tools for Engineering
TBC	To be Confirmed
TBD	To be Defined
TC	Telecommand
TM	Telemetry
WM	Walking Manipulator

2 Modular Spacecraft Requirements

2.1 Mission Overview

The selection of the MOSAR space mission application has to be done in perspective with the other space mission applications selected for PULSAR and for EROSS:

- PULSAR space mission will consist in assembling a large telescope at Earth-Sun L2 point using a robotic manipulator, with all the telescope and platform elements packaged in a single launch.

- EROSS space mission will consist in the in-space servicing of a LEO satellite, with refueling and units replacement, using state-of-the-art robotic arm and equipment.

Following the analysis of RD2, a mission concept is proposed that exploits at best the benefits of the modular approach, that is realistically feasible in the short/mid-term and that is commercially oriented towards the reduction of costs and the maximization of profit.

The proposed MOSAR space mission application consists in upgrading, reconfiguring and repairing an operational GEO telecommunication satellite.

The satellite, in its original configuration, will have an initial telecommunication payload capacity and will be assembled and tested on-ground, but it will feature key design concepts to meet the mission objective:

- **Modular design:**
  The satellite original configuration will be based on the conventional all-integrated platform, but will feature some specific modules, removable from the outside of the satellite, dedicated to power generation (solar array + power conditioning) and payloads.

- **Scalable design:**
  The satellite original configuration will allow in-space connection of additional modules through standard interfaces at the outside of the satellite.

The mission is divided into 3 different phases:

- Phase 1: launch of satellite with initial capacity

The satellite is assembled and tested on-ground and is launched fully integrated into a GTO. The satellite then uses its own propulsion system to raise its orbit to reach its GEO position slot.

After in-orbit tests and commissioning, the satellite is capable to deliver an initial capacity (e.g. high throughput internet connection).

- Phase 2: capacity increase + upgrade of payload + addition of hosted payload

After several years in-orbit (approximately 5 years), there is a need coming from the market to upgrade the payload (removal of obsolete technologies) and to add telecommunication capacity to the existing satellite, while also adding an hosted payload for meteorology on the Earth pointing panel to increase financial revenues and profitability.

Dedicated modules (power generation module, payload modules, hosted payload module) will be manufactured, tested on-ground and launched into GTO (can be a co-passenger with another GEO satellite). A servicer equipped with a robotic arm and positioned near the GTO injection point, will then capture the modules, bring them to the satellite operational orbit (i.e. perform an orbit raising and insertion into GEO slot of its client) where it will assemble them with the following sequence:

- Addition of power generation module and in-orbit tests for verification of performances
- Removal and storage of obsolete payload modules
- Replacement of obsolete payload modules and in-orbit tests for verification of performances
- Addition of telecommunication payload modules and in-orbit tests for verification of performances
- Addition of hosted payload module and in-orbit tests for verification of performances

- Phase 3: replacement of failed battery + addition of deorbiting propulsion kit

After additional years of operations, failure of parts subjected to ageing (e.g. battery, thrusters) occurred preventing the satellite from operating nominally and performing specific station keeping maneuvers (e.g. E/W or N/S).

Dedicated modules (battery module, propulsion kit) are manufactured, tested on-ground and launched as co-passenger to another GTO mission. As for Phase 2, a servicer will capture and bring them to the satellite operational orbit and perform the modules exchange.

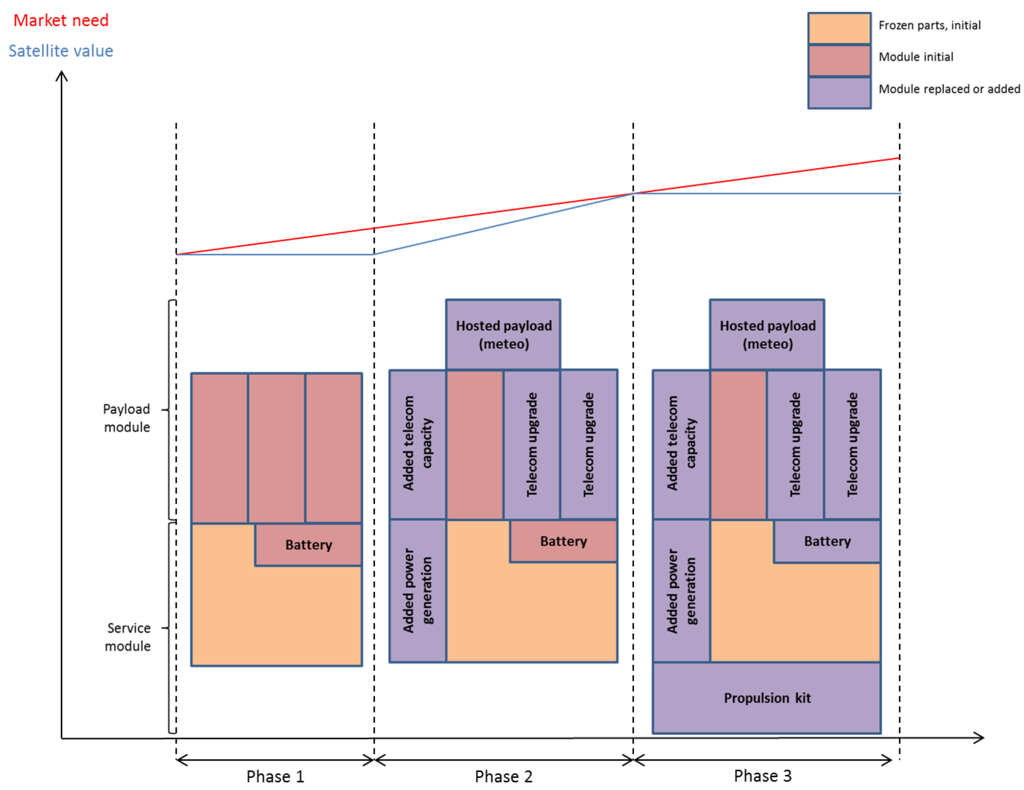


Figure 2-1 - Schematic view of a MOSAR-like mission.

This mission concept is proposed as an example, to guide the development of the demonstrator. However it should not limit in any way the applicability of MOSAR to any other kind of mission.

MOSAR is a project aiming at demonstrating a set of key technologies that are considered essential for the development of future applications of On-Orbit Servicing and On-Orbit Assembly. The objectives of MOSAR include (AD3):

- Review, extension and integration of common robotic building blocks: ESROCOS, ERGO and InFuse software building blocks; I3DS perception suite and SIROM standard interface.
- Development of a repositionable walking manipulator, enabling a cost-effective solution for actuation on a wide workspace without escalation of size and performance of the robot.
- Elaboration of a concept for modular spacecraft: identifying key design choices and highlighting recommendations for development of standards for design and operation of future modular space vehicles.

The first two objectives should be generic and independent from any specific mission, as the final purpose is to develop a standard that is unique and re-usable across different missions. As for the third objective, the applicability of the modular approach to different missions is discussed in RD2, highlighting the main advantages that modularity would bring to specific applications and the main design and operation requirement that would need to be fulfilled.

2.2 Space Scenarios Requirements

MOSAR does not target a specific mission in particular, but rather aims at demonstrating key functionalities that are intended to be generic and applicable to very different scenarios. Therefore, it has been preferred not to restrain MOSAR applicability to a given mission, but to present general requirements that can be common to multiple missions. These requirements are not expected to be fully verified in the context of the current project. They should be considered as guidelines for the developments in the current activity to favor compatibility with future mission goals and requirements.

2.2.1 Formalism

The following section details the space scenarios requirements following the structure exemplified in this table:

Table 1: Example of requirement

YY_uniqueID	**Title**	LEVEL
STATEMENT	Requirement Statement	
COVERS	Origin	
COMMENT	Additional comment and explanations	

The top row of the table includes:

- Unique ID: identificator with the structure YY_uniqueID
    - YY: type of the requirement - Functional requirements (FuncR), Performance requirements (PerfR), Interface requirements (IntR), …
    - uniqueID: unique reference with 4 characters:
        - The first character is a “S”, for Space Scenarios Requirements
        - The next number identifies the type of requirement inside the subsystem

- The next two numbers identify a number assigned to each requirement in that category
- Title: highlighting the topic of the requirement
- LEVEL: indicates the level of importance of the requirement (mandatory / desirable / optional)

The rest of the table includes the following fields:

- STATEMENT: clear and concise description of the requirement
- COVERS: gives indication about the origin/scope of the requirements (specific user requirement or user case, partner expertise, project constraint, etc.)
- COMMENT: provides rationale or additional comments about the requirement

2.2.2 S100: Functional requirements [FuncR]

FuncR_S101	**Satellite repair and update**	Mandatory
STATEMENT	The MOSAR technology shall allow repair and update of modular spacecraft by manipulation and repositioning of functional modules with a robotic manipulator	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R02	
COMMENT		

FuncR_S102	**Mission tasks update**	Mandatory
STATEMENT	The modular spacecraft shall be reconfigurable and should be able to use new functionalities brought by additional functional modules, in order to perform new mission tasks	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R05	
COMMENT		

FuncR_S103	**Functional modules replacement**	Mandatory
STATEMENT	The robotic manipulator shall be able to add and replace whole functional modules (ASM/APM) by using the interconnectors of these modules.	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R01	
COMMENT		

FuncR_S104	**Robot relocation**	Mandatory

STATEMENT	The robotic manipulator shall be able to reposition itself by using the interconnectors/structure of the functional modules or the spacecraft
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R03
COMMENT	

FuncR_S105	**Design software**	Mandatory
STATEMENT	A design software shall be able to create a robotic compatible servicing / reconfiguration plan for the modular spacecraft	
COVERS	Operational Concept RD3 Guidelines AD1-OG9-R12	
COMMENT		

FuncR_S106	**Simulation software**	Mandatory
STATEMENT	A simulation software shall be able to simulate the system with all related robotics elements following the execution plan	
COVERS	Operational Concept RD3 Guidelines AD1-OG9-R12	
COMMENT		

FuncR_S107	Robot high-level control	Mandatory
STATEMENT	The modular spacecraft shall perform the high-level control of the robot, by the execution and monitoring of the reconfiguration plan (task level)	
COVERS	Operational Concept RD3 Guidelines AD1-OG9-R04	
COMMENT	The high-level control of the robot can also be managed by the servicer satellite (depending on the servicing or local reconfiguration scenario)	

FuncR_S108	Robot low-level control	Mandatory
STATEMENT	The robotic manipulator shall ensure its low-level control for the execution of the high-level tasks	
COVERS	Operational Concept RD3 Guidelines AD1-OG9-R04	
COMMENT		

FuncR_S109	Functional module monitoring	Mandatory
STATEMENT	The modular spacecraft shall be able to monitor the status of essential parameters of each connected functional module	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R12	
COMMENT		

FuncR_S110	Resources reallocation	Mandatory
STATEMENT	The system shall be able to reallocate resources (e.g. power, data, computational power, etc.) and assign different path automatically in case of a defect (e.g. interconnector of an APM)	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R07	
COMMENT		

FuncR_S111	**Failure handling**	Mandatory
STATEMENT	The system shall be able to handle the tasks even during a connection failure or a power interruption of defect modules/interconnectors.	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R08	
COMMENT		

FuncR_S112	**Electrical power supply**	Mandatory
STATEMENT	One or several modules options shall be available to implement for electrical power supply enabling operation of the functional modules and the robot manipulator	
COVERS	Mission analysis RD2	
COMMENT	The power system could be integrated by one or more functional modules	

FuncR_S113	**Electrical power supply, power management**	Mandatory
STATEMENT	The modular spacecraft shall be able to shut down or command a stand-by mode of any non-critical module to reduce power consumption if needed. Critical functions should not be affected by shutting down of non-critical modules.	
COVERS	Mission analysis RD2	
COMMENT		

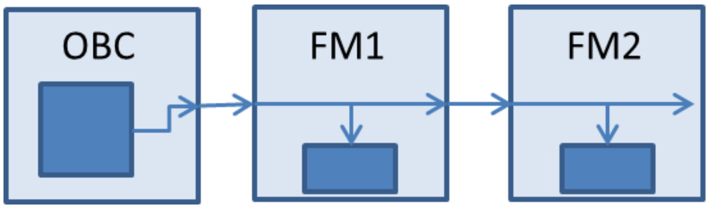
FuncR_S114	**Data handling system**	Mandatory
STATEMENT	One or several modules options shall be available to implement a data handling system (that can be composed of one or more modules) that enables operation of the different modules and the manipulator.	
COVERS	Mission analysis RD2	
COMMENT	The data handling system could be integrated by one or more functional modules	

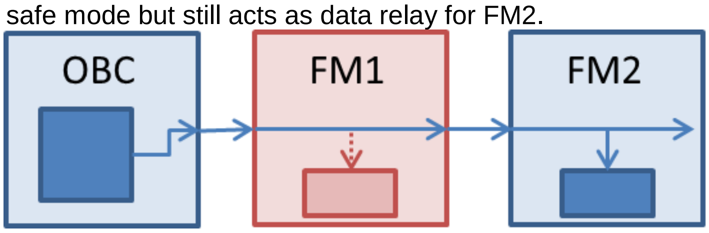
FuncR_S115	Heat management and thermal considerations	Mandatory
STATEMENT	One or several modules options shall be available to implement heat management functions that allow thermal regulation of the different modules within its specific range of temperatures. The heat management system could be composed of one or more modules.	
COVERS	Mission analysis RD2	
COMMENT		

FuncR_S116	Propulsion subsystem	Mandatory
STATEMENT	One or several modules options shall be available to implement a propulsion subsystem with capacity to perform at least: ▪ Station keeping manoeuvers. ▪ Orbit relocation. ▪ De-orbiting.	
COVERS	Mission analysis RD2	
COMMENT	The propulsion subsystem could be integrated by one or more functional modules.	

FuncR_S117	Attitude control subsystem	Mandatory
STATEMENT	One or several modules options shall be available to implement an attitude control subsystem, with capacity to perform at least: ▪ Spacecraft reorientation. ▪ Attitude control compatible with mission objectives. ▪ Autonomous search of the Sun and the Earth	
COVERS	Mission analysis RD2	
COMMENT	The attitude control subsystem is essential to ensure correct functioning of other subsystems.	

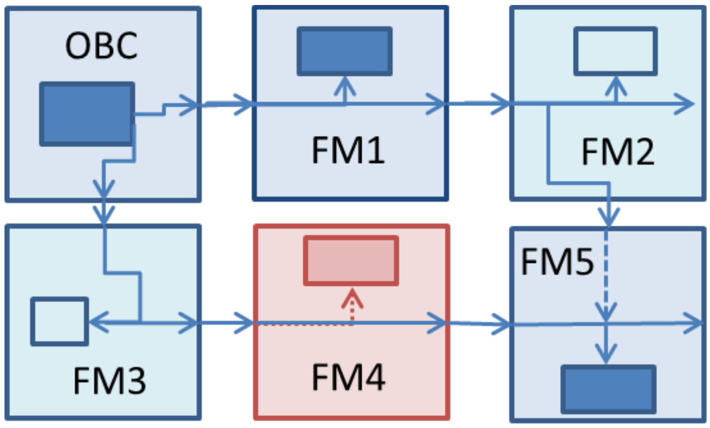
FuncR_S118	Module mechanical connections	Mandatory
STATEMENT	Modules shall be able to connect mechanically to other modules or to the spacecraft through interconnectors.	
COVERS	Mission analysis RD2	
COMMENT	~~Not every module is directly linked to the OBC of the modular platform. Data relay function is needed to dispatch telecommands and telemetries through a network of modules.~~	

<table>
<tr><th>FuncR_S119</th><th>Module data relay</th><th>Mandatory</th></tr>
<tr><td>STATEMENT</td><td colspan="2">Any module should be able to act as a data relay for other modules or the robotic manipulator through their interconnector, also if the module is in safe mode</td></tr>
<tr><td>COVERS</td><td colspan="2">Mission analysis RD2</td></tr>
<tr><td>COMMENT</td><td colspan="2">Not every module is directly linked to the OBC of the modular platform. Data relay function is needed to dispatch telecommands and telemetries through a network of modules.


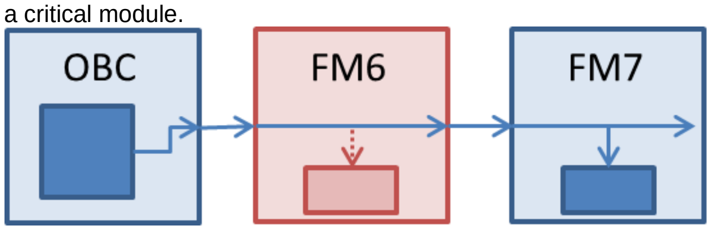
FM1 is in safe mode but still acts as data relay for FM2.


</td></tr>
</table>

FuncR_S120	Data routing	Mandatory
STATEMENT	The OBC shall be able to redirect telecommands to specific modules, for the spacecraft configuration or for instance upon detection of failure on any point of the network. If an alternative path is not available, the OBC shall be able to isolate the faulty node and all the others nodes connected downstream.	
COVERS	Mission analysis RD2	
COMMENT	FM5 has a nominal link to the OBC through FM3 and FM4. In case of failure of any of these components, the OBC should redirect telecommands to FM5 through the alternative path using FM1 and FM2.	



FM7 only has connection to the OBC through FM6. In case of failure of FM1 the OBC should isolate both modules and stop sending TCs to them until FM6 is recovered. FM7 cannot be a critical module.



FuncR_S121	**Module power relay**	Mandatory
STATEMENT	Module should be able to act as a power relay for other modules or the robotic manipulator through their interconnectors, also if the module is in safe mode	
COVERS	Mission analysis RD2 FuncR_S112	
COMMENT	To allow power distribution between the power supply (spacecraft or functional module) and the other active modules	

FuncR_S122	**Power routing**	Mandatory
STATEMENT	The OBC shall be able to redirect power to specific modules, for the spacecraft configuration or for instance upon detection of power failure on any point of the network. If an alternative path is not available, the OBC shall be able to isolate the faulty node and all the others nodes connected downstream.	
COVERS	Mission analysis RD2	
COMMENT	To allow power distribution between the power supply (spacecraft or functional module) and the other active modules	

FuncR_S123	**Module thermal relay**	Mandatory
STATEMENT	Module should be able to act as a thermal relay for other modules through their interconnectors	
COVERS	Mission analysis RD2 FuncR_S115	
COMMENT	To allow thermal distribution and management between the modules	

2.2.3 S200: Performance requirements [PerfR]

Performance requirements are specific to each application. Detailed mission analysis is needed to adapt the generic requirements presented hereafter to the specific need of the mission.

PerfR_S201	**Mechanical interfaces**	Mandatory
STATEMENT	The modular spacecraft shall be able to withstand the loads expected on orbit with significant (TBD) safety margins. In any case, the mechanical integrity of the ensemble should not be compromised.	
COVERS	Mission analysis RD2	
COMMENT		

PerfR_S202	**Manipulator mechanical loads**	Mandatory
STATEMENT	The robot manipulator and its connections to the modules or spacecraft shall be able to withstand the loads expected during modules operations with significant (TBC) safety margins. In any case, the mechanical integrity of the robotic arm and its connection with the spacecraft or modules should not be compromised.	
COVERS	Mission analysis RD2	
COMMENT		

PerfR_S203	**Mechanical interfaces (alignment and stiffness)**	Mandatory
STATEMENT	The mechanical interfaces of the modular spacecraft shall provide the required alignment accuracy and stiffness required by the different modules to meet their respective performance requirements and to not constitute a harm to the rest of the spacecraft.	
COVERS	Mission analysis RD2	
COMMENT	The performance requirements of the different modules could be treated at system level, showing adequacy to the mission objectives. The minimum need in terms of alignment and stiffness of the mechanical interface should at least guarantee that every module is safely integrated into the modular platform.	

2.2.4 S300: Interface requirements [IntRD]

IntR_S301	**Ground segment communication**	Mandatory
STATEMENT	The modular spacecraft shall have a redundant communication link with the ground segment for telemetry and telecommands.	
COVERS	Mission analysis RD2	
COMMENT		

IntR_S302	**Telemetry of different modules**	Mandatory
STATEMENT	Every module shall have a communication link enabling to send telemetry to the spacecraft monitoring unit (OBC) and ultimately to the ground station. The link with the ground station could be done through a specific communication module implemented on the modular spacecraft.	
COVERS	Mission analysis RD2	
COMMENT		

IntR_S303	**Ground segment surveillance**	Mandatory
STATEMENT	The ground segment shall know at any moment the status of the different modules of the modular spacecraft. This information is passed through two types of telemetries: • Periodic telemetry with standardized packets. • Asynchronous telemetry with error message.	
COVERS	Mission analysis RD2	
COMMENT	The ground segment is able to detect problems in case an anomaly message is received (asynchronous telemetry). Even if the error message is never received (for instance, sudden power loss), the ground segment is able to detect a problem if the periodic telemetry is not received and investigate the problem by analyzing this data.	

IntR_S304	**Grounding (electrical power)**	Mandatory
STATEMENT	Any module of the modular spacecraft provided with an electrical power interface should have a connection to ground.	
COVERS	Mission analysis RD2	
COMMENT	Reduces the risk of introducing stray currents or ground loop currents.	

2.2.5 S400: Design requirements [DesR]

DesR_S401	**Modular satellite reliability**	Desirable
STATEMENT	The modular spacecraft shall be quantifiably more reliable by design than a monolithic system over the mission lifetime of the satellite, including (and as a specific advantage) under extensions of mission lifetime.	
COVERS	Mission analysis RD2	
COMMENT		

DesR_S402	**Modular satellite flexibility**	Desirable
STATEMENT	The modular spacecraft shall be quantifiably more flexible in operation and responsive to mission changes than a traditional satellite with a similar mission.	
COVERS	Mission analysis RD2	
COMMENT		

DesR_S403	**Modular satellite economy**	Desirable
STATEMENT	The modular spacecraft shall have quantifiable advantages in cost-effectiveness and economy of operation from a mission perspective over the projected lifetime of the satellite. Otherwise, it should be demonstrated that the benefits (in terms of enhanced functionalities) compensate the additional costs.	
COVERS	Mission analysis RD2	
COMMENT		

DesR_S404	**Available connection interfaces**	Mandatory
STATEMENT	The modular spacecraft and modules assembly shall implement a minimum number of connection interfaces such as at least two of these interfaces are available at any moment and within the reach of the robotic manipulator.	
COVERS	Mission analysis RD2	
COMMENT	one spot for anchorage on the client spacecraft and a second one for placing a new module.	

DesR_S405	Compatibility between modules	Mandatory
STATEMENT	The assembly of modules on a modular spacecraft respond to a planning and design that has previously being verified on ground.	
COVERS	Mission analysis RD2	
COMMENT		

2.2.6 S500: Physical and resource requirements [PhyR]

PhyR_S501	Components weight	Mandatory
STATEMENT	The weight of all components associated with the concept of modular spacecraft shall be minimized (interconnectors, functional module structure, robotic manipulator)	
COVERS	Mission analysis RD2	
COMMENT	The concept of modular spacecraft brings additional components that creates a penalty on the system weight.	

PhyR_S502	Interconnectors size and volume	Mandatory
STATEMENT	The size and volume of the interconnectors shall be minimized to offer more place inside the functional modules	
COVERS	Mission analysis RD2	
COMMENT		

2.2.7 S600: Environmental and Operational requirements [OpR]

OpR_S601	Servicer satellite	Mandatory
STATEMENT	The functional modules shall be delivered to the modular spacecraft by a servicer satellite equipped with a robotic manipulator	
COVERS	Mission analysis RD2 Operational Concept RD3	
COMMENT		

OpR_S602	On-Orbit Rendez-vous, interfaces	Mandatory
STATEMENT	The modular spacecraft shall implement a physical interface for docking and/or berthing of a servicer satellite.	
COVERS	Mission analysis RD2	
COMMENT		

OpR_S603	On-Orbit Rendez-vous, coupled spacecraft	Mandatory
STATEMENT	The modular spacecraft shall be able to remain coupled to the servicer spacecraft without time limitation.	
COVERS	Mission analysis RD2	
COMMENT	There should be no limitation coming from any of the subsystems of the modular spacecraft (ADCS, power, thermal etc.).	

OpR_S604	On-Orbit Rendez-vous, communication to servicer	Mandatory
STATEMENT	The modular spacecraft should be able to communicate with the servicer and exchange data during and after rendez-vous operation.	
COVERS	Mission analysis RD2	
COMMENT	Not essential during rendez-vous but highly desirable for enhanced autonomy during operations without (or with minimum) ground support.	

OpR_S605	On-Orbit Rendez-vous, ground communications	Mandatory
STATEMENT	The modular spacecraft shall be able to monitor operations during and after rendez-vous and send reports to the ground segment.	
COVERS	Mission analysis RD2	
COMMENT	Continuous link to ground stations is not essential for rendez-vous, however, different phases are usually defined with specific milestones that are controlled by ground operators. After rendez-vous, the communication supports transfer of the execution plan and the monitoring and feedback of the operations to the ground.	

OpR_S606	**Space environment**	Mandatory
STATEMENT	The components of the modular spacecraft: subsystems, interfaces and structures shall be able to withstand the space environment for the whole duration of the mission.	
COVERS	Mission analysis RD2	
COMMENT	Generic requirement to be verified depending on the specific application.	

OpR_S607	**Launch loads**	Desirable
STATEMENT	The interconnectors design shall optimize launch load capabilities, to offer the wider range of possibilities regarding pre-assembled functional modules (on the initial spacecraft or the servicer) before launch	
COVERS	Mission analysis RD2	
COMMENT	Conditions are function of the launch conditions, configuration of the modules (inertia, COG,…) and type of connection with the launcher	

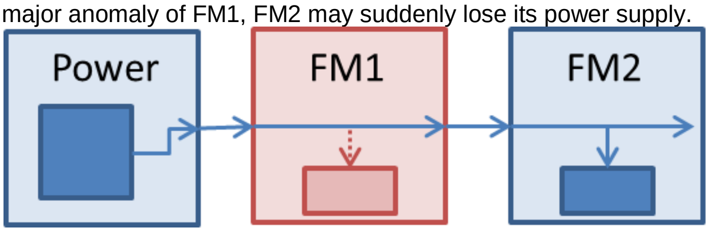
2.2.8 S700: Safety requirements [SafR]

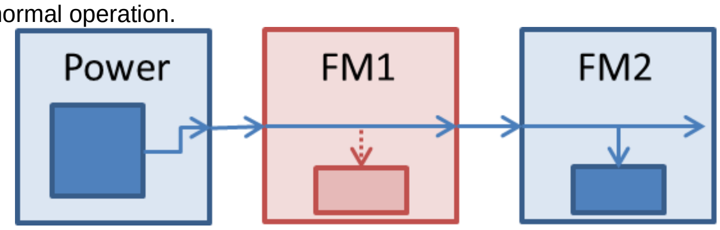
SafR_S701	**Critical functionalities**	Mandatory
STATEMENT	The failure of any functional module shall not yield to the loss of the spacecraft.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S702	**Redundancy of critical functionalities**	Mandatory
STATEMENT	Any functional module providing a critical functionality (one that is needed for the safe mode of the functional platform) shall be redundant.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S703	**Propagation of failures**	Mandatory
STATEMENT	Any module of the modular spacecraft shall be designed as to avoid failure propagation. In particular, the module shall prevent itself or any of its components from degrading performances of other modules or damaging the modular spacecraft.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S704	**Substitution of critical modules**	Mandatory
STATEMENT	Any module that is considered critical (without this module the spacecraft loss one of its basic functionalities) can only be exchanged if: 1. Another module covering its functionality has already been added to the client spacecraft. 2. This second module is already operational. 3. The module to be substituted has already been isolated and switched off. 4. No anomaly has been detected between steps 2 and 3.	
COVERS	Mission analysis RD2	
COMMENT	The design principle of "do not harm" should be applied for the modules of a modular spacecraft.	

SafR_S705	**Robustness to power loss**	Mandatory
STATEMENT	Any module shall be able to withstand a sudden power loss without any damage to itself or to other modules. The module shall autonomously shut down or enter a standby mode of minimum power consumption.	
COVERS	Mission analysis RD2	
COMMENT	The design principle of "do not harm" should be applied for the modules of a modular spacecraft. In case of major anomaly of FM1, FM2 may suddenly lose its power supply. 	

SafR_S706	Restart after power loss	Mandatory
STATEMENT	After a sudden power loss, any module of the modular spacecraft shall be able to restart and resume normal operation when power supply is restored.	
COVERS	Mission analysis RD2	
COMMENT	The design principle of “do not harm” should be applied for the modules of a modular spacecraft. When functionality of FM1 is restored, the modules downstream (FM2) can restart and resume normal operation.  	

SafR_S707	Data handling system (redundancy)	Mandatory
STATEMENT	The modular spacecraft shall implement a redundant on-board computer. The two (or more) OBCs could be integrated in different modules or in the same module. If the OBCs are integrated in the same module, two different interfaces should be provided, ensuring that in any case a single failure does not yield to the loss of the spacecraft.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S708	Modular Satellite Failure Detection, Isolation and Recovery	Mandatory
STATEMENT	The modular satellite shall be able to detect failure of any module, isolate the faulty equipment and perform recovery operations when possible.	
COVERS	Mission analysis RD2	
COMMENT		

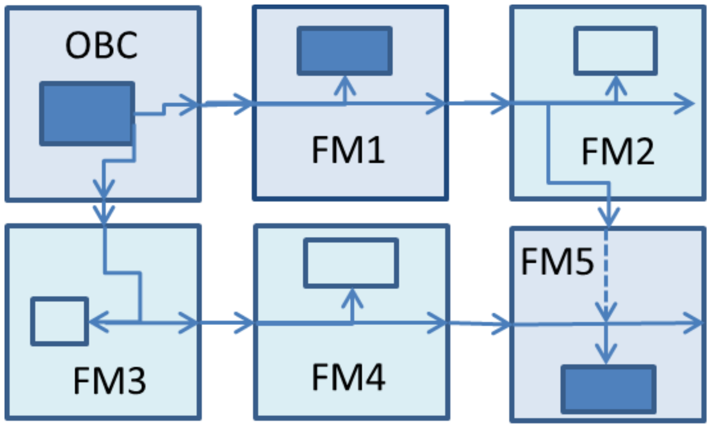
SafR_S709	Safe mode	Mandatory
STATEMENT	The modular spacecraft shall implement a safe mode that guarantees a stable condition of the spacecraft without time limitation. This mode should be fully autonomous (without any ground intervention).	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S710	Safe mode (modules)	Mandatory
STATEMENT	Any module of the modular spacecraft shall implement a safe mode. This mode minimizes hardware and software functions as to make minimal use of the modular spacecraft resources (power).	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S711	Safe mode (command)	Mandatory
STATEMENT	The modular spacecraft should enter safe mode either by autonomous transition triggered by the on-board computer or through ground command.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S712	Safe mode (modules, command)	Mandatory
STATEMENT	Any module of the modular spacecraft should enter in safe mode when commanded by the on-board computer of the modular spacecraft, by ground command or by autonomous triggering of the module itself.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S713	Data relay for critical modules	Mandatory
STATEMENT	Any module considered as critical (needed for the safe mode of the modular platform, ensuring no loss of the spacecraft) shall have either: a) A direct connection to the OBC. b) Two independent paths to reach the OBC through other modules.	
COVERS	Mission analysis RD2 Guidelines AD1-OG9-R07	
COMMENT	FM1 and FM5 are critical modules. FM1 is directly connected to the OBC. FM5 is not directly connected to the OBC, but has two alternative ways of communicating with the OBC. The design is robust to a single failure of any of the non-critical modules.	

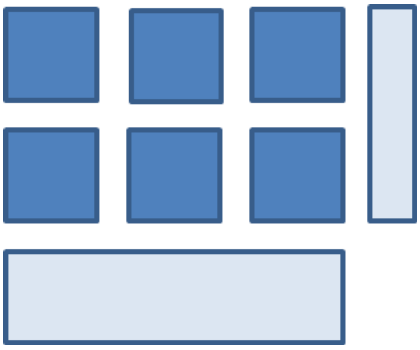
	

SafR_S714	**Power relay for critical modules**	Mandatory
STATEMENT	Any module considered as critical (needed for the safe mode of the modular platform, ensuring no loss of the spacecraft) shall have either: a) A direct connection to the power supply. b) Two independent paths to reach the power supply through other modules.	
COVERS	Mission analysis RD2	
COMMENT		

SafR_S715	**Single points of failure**	Mandatory
STATEMENT	The design of the modular spacecraft shall minimize the number of single point of failures (failure that yields to loss of the spacecraft or its mission). Every single point of failure should be fully described, analyzed, and justified why any other implementation is not better than the selected one.	
COVERS	Mission analysis RD2	
COMMENT		

2.2.9 S800: Configuration and implementation requirements [ConfR]

ConfR_S801	**Configuration of the modular spacecraft**	Mandatory
STATEMENT	A modular spacecraft implements identical modules in terms of structure shape and materials. Singularly, different shapes could be accepted provided that compatibility with the basic modules is ensured.	
COVERS	Mission analysis RD2	
COMMENT	The basic module is the rectangle. Singularly, other modules that are compatible could	

	be added to the modular spacecraft. 

ConfR_S802	Functional module orientation	Mandatory
STATEMENT	The functional module orientation shall be adjustable as function of its function and position on the modular spacecraft	
COVERS	Mission analysis RD2	
COMMENT	The function of the module could require a specific orientation (e.g. camera orientation, radiator)	

3 MOSAR Demonstrator Requirements

3.1 Demonstrator Overview

The purpose of the MOSAR demonstrator is to illustrate scenarios of modular spacecraft assembly and re-configuration operations. The baseline scenario is the one of a Servicer Spacecraft (SVC) transporting a cargo of Spacecraft Modules (SM) and a dedicated Walking Manipulator (WM), performing a number of operations with the transfer of SM from and to the Client Spacecraft (CLT) by the manipulator.

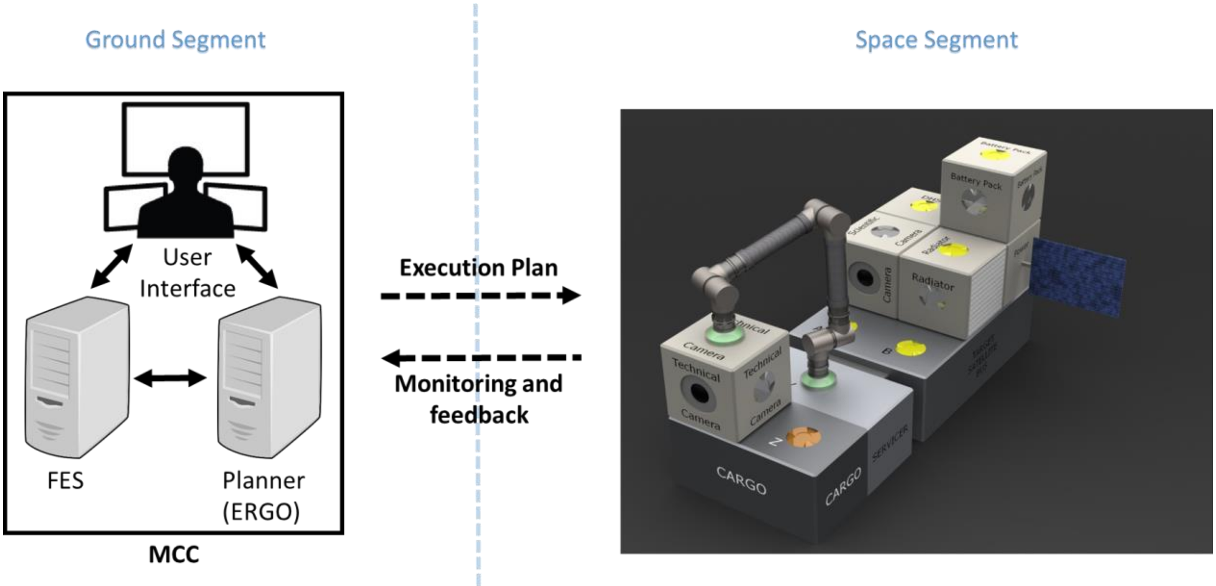


Figure 3-1: MOSAR Demonstrator Concept

Spacecraft Modules are individual structures associated with a specific function of the spacecraft, that once assembled, will ensure the spacecraft operations. They can cover system (ASM, Active System Modules) or payload (APM, Active Payload Modules) functions. The SM are equipped with Standard Interfaces (SI) enabling Modules to Modules and Modules to spacecraft connections. Each SI provides mechanical, data, power and thermal transfer capabilities, allowing a full configuration of the CLT functions. That includes mechanical structural integrity, data transmission, power routing and thermal management along the elements.

The main purpose of the manipulator is to transfer the SM between the servicer and the client satellite. In order to answer the problem of reachability, the MOSAR concept is based on the implementation of a walking manipulator that ensures a high mobility along the structure. Equipped with Standard Interfaces at its both end-effectors, it can attach and manipulate the SM, but also move along the structure by connection to either the SM or the spacecraft SI. The connection is also used to power the arm and transfer the control commands coming from the spacecraft computer.

The autonomous transfer and configuration of the SM follow an execution plan prepared and validated off-line, in the Monitoring and Control Centre (MCC), on the ground segment. The MCC includes a satellite design, modelling and validation tool, specifically targeting modular satellites applications. It also allows the automatic planning of the assembly or reconfiguration sequence that can be verified with a multi-physics simulator. All these elements are working iteratively together to prepare a valid execution plan that is finally uploaded to the spacecraft for execution. Based on the monitoring and feedback information received from the spacecraft during the operations (e.g. detected failed module), the MCC can update the execution plan. The MCC finally includes visualisation front-end to support the design, verification and monitoring activities during sequence execution.

3.2 Formalism

The following section details the system requirements following the structure exemplified in this table:

Table 2: Example of requirement

<table>
<tr><td>YY_uniqueID</td><td colspan="3">Title</td><td>LEVEL</td></tr>
<tr><td>STATEMENT</td><td colspan="4">Requirement Statement</td></tr>
<tr><td>VERIFICATION</td><td>Review of Design (ROD) / Analysis / Inspection / Testing</td><td>COVERS</td><td colspan="2">PSA_FuncR_A000</td></tr>
<tr><td>RESPONSIBLE</td><td colspan="4">SPACEAPPS, DLR, GMV, TAS-F, TAS-UK, SITAEL, MAGSOAR, USTRAT, ELLIDISS</td></tr>
<tr><td>COMMENT</td><td colspan="4">Additional comment and explanations</td></tr>
</table>

The top row of the table includes:

- Unique ID: identificator with the structure YY_uniqueID
  - YY: type of the requirement - Functional requirements (FuncR), Performance requirements (PerfR), Interface requirements (IntR), …
  - uniqueID: unique reference with 4 characters:
    - The first character is a letter identifying the subsystem the requirement belongs to
    - The next number identifies the type of requirement inside the subsystem
    - The next two numbers identify a number assigned to each requirement in that category
- Title: highlighting the topic of the requirement
- LEVEL: indicates the level of importance of the requirement (mandatory / desirable / optional)

The rest of the table includes the following fields:

- STATEMENT: clear and concise description of the requirement
- VERIFICATION METHOD: indicates how the requirement is going to be verified (simulation, internal testing, lunar analog testing) with a short description of the validation process (1 to 3 lines)

- COVERS: gives indication about the origin/scope of the requirements (specific user requirement or user case, partner expertise, project constraint, etc.)
- RESPONSIBLE: indicates which partner is responsible for the verification and follow up of the requirement
- COMMENT: provides rationale or additional comments about the requirement

3.3 System Requirements [Axxx]

This section and following ones list the requirements for the physical demonstrator system and sub-systems developed in MOSAR.

3.3.1 A100: Functional requirements [FuncR]

FuncR_A101	**Demonstrator purpose**			Mandatory
STATEMENT	The MOSAR demonstrator shall illustrate the repair and update of modular spacecraft by manipulation and repositioning of SM with the WM.			
VERIFICATION	Testing	**COVERS**	FuncR_S101, FuncR_S102	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_A102	**Demonstrator components**			Mandatory
STATEMENT	The MOSAR demonstrator shall include: • A set of spacecraft modules (ASM/APM) to illustrate the scenarios and functionalities of modular spacecraft • A robotic walking manipulator for the manipulation of the SM • A servicer satellite and client modular spacecraft mockup to support the demonstration scenarios • A monitoring and control center that includes a design and simulation tool to create and simulate the execution plan and a monitoring interface			
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 Operational Concept RD3	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_A103	**Plan execution**			Mandatory
STATEMENT	The SVC OBC shall execute autonomously the assembly/ reconfiguration plan prepared by the design and simulation tool			
VERIFICATION	Testing	**COVERS**	FuncR_S107 MOSAR Operational Concept	
RESPONSIBLE	GMV			
COMMENT	None			

FuncR_A104	**SVC high level control**		Mandatory
STATEMENT	The SVC OBC shall perform the high-level control of the WM, SM and SI for the execution of the assembly/ reconfiguration plan		
VERIFICATION	Review of Design / Testing	**COVERS**	FuncR_S107 MOSAR Operational Concept
RESPONSIBLE	GMV / DLR		
COMMENT	None		

FuncR_A105	**Components low level control**		Mandatory
STATEMENT	Low level control of the WM, SM and SI shall be performed locally by each component		
VERIFICATION	Review of Design / Testing	**COVERS**	FuncR_S108 MOSAR Operational Concept
RESPONSIBLE	SPACEAPSS, DLR, SITAEL, TAS-UK		
COMMENT	This allow to relax constraints on the data bus requirements (e.g. high rate robotic control), the SVC OBC having to send only high level commands to the components		

FuncR_A106	**WM modules operations**		Mandatory
STATEMENT	The WM shall be able to add and replace SM (ASM/APM) by using SI.		
VERIFICATION	Testing	**COVERS**	FuncR_S103 Operational Concept RD3
RESPONSIBLE	SPACEAPPS / DLR		
COMMENT	None		

FuncR_A107	**WM relocation**		Mandatory
STATEMENT	The WM shall be able to reposition itself by using the SI of the functional modules or the platform		
VERIFICATION	Testing	**COVERS**	FuncR_S104 Operational Concept RD3
RESPONSIBLE	SPACEAPPS / DLR		
COMMENT	None		

FuncR_A108	**Monitoring**		Mandatory
STATEMENT	The SVC OBC shall be able to monitor the parameters of the SM, WM and SI		
VERIFICATION	Testing	**COVERS**	FuncR_S109
RESPONSIBLE	GMV, SITAEL		
COMMENT	None		

FuncR_A109	**Spacecraft reconfiguration**		Mandatory
STATEMENT	The system shall be able to re-configure the CLT (e.g. SM exchange) in case of a defect (e.g. malfunction of a SM)		
VERIFICATION	Testing	**COVERS**	FuncR_S101
RESPONSIBLE	GMV, DLR, SPACEAPPS		
COMMENT			

FuncR_A110	**System redundancy**		Mandatory
STATEMENT	The system shall be able to re-route and reallocate resources (e.g. power, data, computational power, etc.) in case of a defect (e.g. interconnector of an APM)		
VERIFICATION	Testing	**COVERS**	FuncR_S110, FuncR_S120, FuncR_S122, SafR_S813, SafR_S814
RESPONSIBLE	GMV, DLR, SPACEAPPS		
COMMENT	This should support connection failure or a power interruption of defect modules / interconnectors. Computational power can only be done in the simulator.		

FuncR_A111	**Modules Plug & Play detection**		Mandatory
STATEMENT	The SVC OBC shall be able to detect and use additional functional modules (plug & play principle)		
VERIFICATION	Testing	**COVERS**	FuncR_S102
RESPONSIBLE	GMV, ELLI, UBREST, TAS-UK		
COMMENT			

FuncR_A112	**Fault detection**			Mandatory
STATEMENT	The SVC OBC shall be able to react to a faulty behavior detected by the SM, WM or SI			
VERIFICATION	Testing	**COVERS**	SafR_S808	
RESPONSIBLE	GMV			
COMMENT	The reaction could include local management on the spacecraft (e.g. SM isolation) or feedback to the MCC			

FuncR_A113	**3D reconstruction through WM**			Optional
STATEMENT	A 3D reconstruction of the satellite could be produced from the observation by a camera mounted on the WM, with a maximum surface average error of 1cm			
VERIFICATION	Testing	**COVERS**	Re-use of OG3	
RESPONSIBLE	USTRATH			
COMMENT	Supported after re-configuration process. The WM is used to obtain different view points The 3D reconstruction should allow a human operator to assess the correctness of the re-configuration, and 1cm maximum surface error should be enough to meet the target			

FuncR_A114	**3D reconstruction through SM**			Optional
STATEMENT	A 3D reconstruction of the satellite could be produced from the observation by a camera mounted in a SM, with a maximum surface average error of 1cm			
VERIFICATION	Testing	**COVERS**	Re-use of OG3	
RESPONSIBLE	USTRATH			
COMMENT	Supported during re-configuration process, in real time (30 frames/sec) The 3D reconstruction should allow a human operator to assess the correctness of the re-configuration, and 1cm maximum surface error should be enough to meet the target.			

FuncR_A115	**Camera Localization**			Optional
STATEMENT	The 3D pose estimation of the camera mounted on the WM could be computed based on the image stream, with a mean error not larger than 1 cm translation and 5° rotation, with a minimum of 30 frame/sec			
VERIFICATION	Testing	**COVERS**	Re-use of OG3	
RESPONSIBLE	USTRATH			
COMMENT	The accuracy of the estimated pose should allow correct positioning and connection of the hardware interfaces. It should also allow 3D reconstruction with errors defined in			

	FuncR_A113 and FuncR_A114. 1cm translation and 5° rotation errors is a reasonable previously achieved target that are compatible with the initiation of the connection process of the interconnectors through the use of the form-fit guidance. Furthermore, localization has to happen in real time, and 30 milliseconds / frame is an acceptable value achieved by recent 3d localization and mapping algorithms as described in RD2.

FuncR_A116	**SM Localization**		Optional
STATEMENT	The 3D pose estimation of the SM could be computed based on the image stream obtained by the camera mounted on the WM, with a mean error not larger than 1 cm translation and 5° rotation, with a minimum of 30 frame/sec (first estimation of a new module 10 sec after appearance)		
VERIFICATION	Testing	**COVERS**	Re-use of OG3
RESPONSIBLE	USTRATH		
COMMENT	The accuracy of the estimated pose should allow correct positioning and connection of the hardware interfaces. It should also allow 3D reconstruction with errors defined in FuncR_A113 and FuncR_A114. 1cm translation and 5° rotation errors is a reasonable previously achieved target that are compatible with the initiation of the connection process of the interconnectors through the use of the form-fit guidance. Furthermore, localization has to happen in real time, and 30 milliseconds / frame is an acceptable value achieved by recent 3d localization and mapping algorithms as described in RD2. Initial detection of a module does not require real-time capabilities, but needs to be achieved in useful operating time, 10 seconds is an acceptable operation delay.		

3.3.2 A200: Performance requirements [PerfR]

PerfR_A201	**Sub-systems TM/TC data rate**		Mandatory
STATEMENT	TM/TC control of the WM and SM, including their SI, by the SVC OBC shall require a network supporting a data rate of 1Mbps or greater		
VERIFICATION	Review of Design	**COVERS**	Operational Concept
RESPONSIBLE	TAS-UK, SPACEAPPS, DLR		
COMMENT	The TM/TC control of the platform should not rely on high data rate links with low latency.		

PerfR_A202	**Sub-systems services data rate**		Mandatory
STATEMENT	SVC OBC shall require a network supporting a data rate of 50Mbps or greater for SM service data.		
VERIFICATION	Review of Design	**COVERS**	Operational Concept
RESPONSIBLE	TAS-UK, SPACEAPPS, SITAEL		

COMMENT	For a camera APM, at 50 Mbps, a 4Mpixel image will take several seconds to transfer across the data network.

3.3.3 A300: Interface requirements [IntR]

IntR_A301	**SVC to CLT mechanical interface**		Mandatory
STATEMENT	The SVC shall provide a mechanical docking connection to the CLT		
VERIFICATION	Review of Design	**COVERS**	OpR_S603 Operational Concept
RESPONSIBLE	SITAEL, TAS-UK		
COMMENT	The docking procedure is not part of the In MOSAR demonstration scenarios. Both spacecraft will be rigidly connected all along the demonstrations with a representative gap.		

IntR_A302	**SVC to CLT data interface**		Mandatory
STATEMENT	The SVC shall provide a data interface to the CLT to connect both internal networks		
VERIFICATION	Review of Design	**COVERS**	OpR_S604 Operational Concept
RESPONSIBLE	SITAEL, TAS-UK		
COMMENT	The data interface allows the SVC to take the control of all the components for the execution of the re-configuration plan		

IntR_A303	**SVC to CLT power interface**		Optional
STATEMENT	The SVC shall provide a power interface to the CLT to be able to power CLT components		
VERIFICATION	Review of Design	**COVERS**	Operational Concept
RESPONSIBLE	SITAEL, TAS-UK		
COMMENT	Not required as, in the demonstration, the CLT could have his own power sub-system		

IntR_A304	**MCC to SVC data link**		Mandatory
STATEMENT	The MCC shall provide a data link for upload of the execution plan and TM/TC services with the SVC		
VERIFICATION	Review of Design	**COVERS**	OpR_S605 Operational Concept
RESPONSIBLE	GMV, DLR		
COMMENT	Represent the satellite link communication, could implement space standard		

	communication protocols, e.g. the packet utilization standard (PUS) to give some level of representativeness to the demonstrator.

IntR_A305	**MCC to SVC debugging link**		Mandatory
STATEMENT	The MCC shall provide a data link for monitoring and debugging purpose during the integration and testing of the demonstrator		
VERIFICATION	Review of Design	**COVERS**	Partner expertise
RESPONSIBLE	GMV		
COMMENT			

IntR_A306	**SVC and CTL SI**		Mandatory
STATEMENT	The SVC and CTL shall provide SI to enable connection with the SM and the WM		
VERIFICATION	Review of Design	**COVERS**	FuncR_S110, FuncR_S118
RESPONSIBLE	SITAEL, SPACEAPPS		
COMMENT			

3.3.4 A400: Design requirements [DesR]

DesR_A401	**OG1 Reuse**		Mandatory
STATEMENT	The platform shall implement ESROCOS from OG1 for the control of the system		
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R10
RESPONSIBLE	GMV		
COMMENT	A number of adaptations and extensions are anticipate (see RD1)		

DesR_A402	**OG2 Reuse**		Mandatory
STATEMENT	The platform shall implement autonomy functions using OG2 (ERGO)		
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R10
RESPONSIBLE	GMV		
COMMENT	A number of adaptations and extensions are anticipate (see RD1)		

DesR_A403	**OG3 Reuse**			Optional
STATEMENT	The platform shall implement sensor data fusion techniques from OG3 (Infuse)			
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R10	
RESPONSIBLE	USTRATH			
COMMENT	The WM operations would rely only on known geometry information, without the need of data fusion techniques. To be discussed and decided at SRR if data fusion techniques are illustrated in the scenario (e.g. SVC visual validation)			

DesR_A404	**OG4 Reuse**			Mandatory
STATEMENT	The satellite shall be equipped with its own integrated R-ICU derived from the OG4 I3DS architecture and illustrate operations of functional modules equipped with selected sensors suite from I3DS			
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R10	
RESPONSIBLE	TAS-UK, TAS-F			
COMMENT	A number of adaptations and extensions are anticipate (see RD1)			

DesR_A405	**OG5 Reuse**			Mandatory
STATEMENT	The required H/W units in OG9 (platform, ASMs/APMs, robot) shall be equipped with standard interfaces from OG5.			
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R10	
RESPONSIBLE	SPACEAPPS			
COMMENT	A number of adaptations and extensions are anticipate (see RD1)			

DesR_A406	**SVC and CLT OBC**			Mandatory
STATEMENT	The SVC and CLT spacecraft shall have on OBC for the management of the different components associated with the spacecraft and the communications			
VERIFICATION	Review of Design	**COVERS**	FuncR_S114	
RESPONSIBLE	SITAEL			
COMMENT	In the MOSAR demonstration, the SVC OBC should take the lead on all the components of the system.			

DesR_A407	**Data Network**			Mandatory
STATEMENT	The system shall implement a data technology network that supports data bus re-configuration and routing			
VERIFICATION	Review of Design / Testing	**COVERS**	FuncR_S110, FuncR_S119	
RESPONSIBLE	TAS-UK			
COMMENT	In the MOSAR demonstration, the SVC OBC should take the lead on all the components of the system. The current selected technology is SpaceWire based on the developments and outputs of OG4			

DesR_A408	**Relevance to flight hardware**			Desirable
STATEMENT	The demonstrator design should not be de-rated for demonstration use and be representative of an actual space system in terms of capabilities (e.g. mass movement capacity, speed of reconfiguration, processing capacity of on-board computing), while still retaining feasibility of operation in Earth's gravity (so as to be functional)			
VERIFICATION	Review of Design	**COVERS**	PERASPERA final objectives	
RESPONSIBLE	ALL			
COMMENT				

3.3.5 A500: Physical and resource requirements [PhyR]

N./A.

3.3.6 A600: Environmental and Operational requirements [OpR]

OpR_A601	**Laboratory Environment**			Mandatory
STATEMENT	The demonstrator shall be able to work under laboratory conditions in a temperature range between 10 and 30 deg			
VERIFICATION	Review of Design	**COVERS**	Demonstration Constraint	
RESPONSIBLE	ALL			
COMMENT				

OpR_A602	**Gravity conditions**			Mandatory
STATEMENT	The demonstrator shall be able to work under 1g			
VERIFICATION	Review of Design	**COVERS**	Demonstration Constraint	
RESPONSIBLE	ALL			
COMMENT				

OpR_A603	**Demonstrator Power supply**			Mandatory
STATEMENT	The demonstrator shall be able to be powered from standard power plugs			
VERIFICATION	Review of Design	**COVERS**	Demonstration Constraint	
RESPONSIBLE	ALL			
COMMENT				

3.3.7 A700: Safety requirements [SafR]

SafR_A701	**Demonstrator Safety**			Mandatory
STATEMENT	Demonstrator shall be inherently safe during operation, considering the implementation in a laboratory environment with trained operators			
VERIFICATION	Review of Design	**COVERS**	Safety rules	
RESPONSIBLE	ALL			
COMMENT	Safety should consider mechanical and electrical potential issue. Safety can be addressed by system design (limited speeds, compliance) and/or through implementation of safety features (Emergency stops, interlocks or sensors barriers)			

3.3.8 A800: Configuration and implementation requirements [ConfR]

ConfR_A801	**SVC and TGT test bench**			Mandatory
STATEMENT	A test bench shall be designed and integrated to represent the SVC satellite to the CLT spacecraft, considering the gap existing between both the platform during docking condition			
VERIFICATION	Review of Design, Inspection	**COVERS**	OpR_S603 Operational Concept RD3	
RESPONSIBLE	SITAEL			
COMMENT				

ConfR_A801	**Test bench mechanical structure**			Mandatory
STATEMENT	The structure of the test bench shall be stable and able to carry the own mass and the loads introduced by the SMs and WM			
VERIFICATION	Review of Design, Analysis	**COVERS**	Preliminary MOSAR demonstrator	
RESPONSIBLE	SITAEL			
COMMENT				

ConfR_A802	**Test bench SI interfaces**			Mandatory
STATEMENT	The SVC and CTL test benches shall provide the required number of SI to cover the MOSAR scenario demonstrations			
VERIFICATION	Review of Design	**COVERS**	IntR_A306	
RESPONSIBLE	SITAEL, SPACEAPPS			
COMMENT				
ConfR_A803	**Test bench harnessing**			Mandatory
STATEMENT	The test bench shall include the internal and external harnessing of the SVC and CTL spacecraft and the connected SI			
VERIFICATION	Review of Design, Inspection	**COVERS**	Operational Concept RD3 Preliminary MOSAR demonstrator	
RESPONSIBLE	SITAEL, SPACEAPPS, TAS-UK			
COMMENT				

3.4 Walking Manipulator Requirements [Bxxx]

3.4.1 B100: Functional requirements [FuncR]

FuncR_B101	**SM connection**		Mandatory
STATEMENT	The WM shall be able to connect to the SI of the SM or the spacecraft mockup, independently through one of its own SI		
VERIFICATION	Testing	**COVERS**	FuncR_A106, FuncR_A107
RESPONSIBLE	SPACEAPPS, DLR		
COMMENT			

FuncR_B102	**SM manipulation**		Mandatory
STATEMENT	The WM shall be able to move and assemble the functional modules in a 3-dimensional way		
VERIFICATION	Testing	**COVERS**	FuncR_A106
RESPONSIBLE	SPACEAPPS, DLR		
COMMENT			

FuncR_B103	**Joint position control**		Mandatory
STATEMENT	The WM shall provide local joint position control at minimum 500 Hz		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept Partner Expertise
RESPONSIBLE	DLR, SPACEAPPS		
COMMENT			

FuncR_B104	**Cartesian position control**		Mandatory
STATEMENT	The WM shall provide local Cartesian position control of the free end-effector at minimum 500 Hz		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept Partner Expertise
RESPONSIBLE	DLR, SPACEAPPS		
COMMENT	To support manipulation of the SM along pre-defined trajectories and initial SI alignment		

FuncR_B104	Impedance control			Mandatory
STATEMENT	The WM shall provide impedance control at minimum 500 Hz			
VERIFICATION	Testing	COVERS	MOSAR Operational Concept Partner Expertise	
RESPONSIBLE	DLR, SPACEAPPS			
COMMENT	To support SI alignment or connection process			

FuncR_B105	Fault detection			Mandatory
STATEMENT	The WM shall be able to detect malfunction of its operations			
VERIFICATION	Testing	COVERS	FuncR_A112	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_B106	Power-on/off			Desirable
STATEMENT	The WM shall be able to be powered on/off, keeping its current position			
VERIFICATION	Testing	COVERS	MOSAR Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT	To reduce consumption when the WM is not in use. The power switch could be managed at the SI level			

FuncR_B107	WM start and initialization			Mandatory
STATEMENT	The WM shall be able to start and initialize automatically after power-on, reaching a state ready for communication and operations			
VERIFICATION	Testing	COVERS	MOSAR Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_B106	WM perception		Optional
STATEMENT	The WM could have the ability to perceive the location of SMs in three dimensions to an error of 1cm using attached stereo vision sensors.		
VERIFICATION	Testing	COVERS	Operational Concept
RESPONSIBLE	DLR, USTRATH		
COMMENT	Not required with the current approach of WM SM approach and manipulation (based on known geometry and SM localization). Would require additional sensors		

3.4.2 B200: Performance requirements [PerfR]

PerfR_B201	WM payload capability		Mandatory
STATEMENT	The WM shall be able to manipulate a payload of 7kg all around his workspace		
VERIFICATION	Testing	COVERS	Demonstration Scenario OpR_A602
RESPONSIBLE	SPACEAPPS		
COMMENT	The target is to not implement external gravity compensation on the SM, TBC depending on the updated weight estimations during PDR		

PerfR_B202	WM reachability		Mandatory
STATEMENT	The WM kinematic structure shall be compatible in size and joint configuration to support all MOSAR scenarios demonstrations		
VERIFICATION	Testing	COVERS	Demonstration Scenario DesR_S404
RESPONSIBLE	SPACEAPPS		
COMMENT	Kinematic configuration and reachability analyzed during PDR phase		

PerfR_B203	WM data interface rate for TM/TC		Mandatory
STATEMENT	The data interface of the WM shall support a data rate of 1Mbps or greater for TM/TC control.		
VERIFICATION	Testing	COVERS	MOSAR Operational Concept PerfR_A201
RESPONSIBLE	SPACEAPPS, DLR, TAS-UK		
COMMENT	The TM/TC control of the platform should not rely on high data rate links with low latency.		

PerfR_B204	**WM data interface rate for service data**			Mandatory
STATEMENT	The data interface of the WM shall support a data rate of 50 Mbps or greater for service data.			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept PerfR_A202	
RESPONSIBLE	SPACEAPPS, DLR, TAS-UK			
COMMENT	E.g. to support data transfer from a connected SM The services provided by the Spacecraft Module share the same data interface as TM/TC and will have a higher bandwidth requirement. At 50 Mbps, a 4Mpixel image will take several seconds to transfer across the data network.			

PerfR_B205	**WM power interface rate**			Mandatory
STATEMENT	The power interface of the WM shall support 0.5kW [TBC] of power transfer			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept PerfR_A202	
RESPONSIBLE	SPACEAPPS			
COMMENT	For the operation of the WM and one connected SM (APM). Value TBC for PDR			

3.4.3 B300: Interface requirements [IntR]

IntR_B301	**WM TM/TC**			Mandatory
STATEMENT	The WM shall transmit telemetry and receive high-level tele-command with the SVC OBC, independently through the data interface of one of the connected SI			
VERIFICATION	Testing	**COVERS**	Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT				

IntR_B302	**WM data transfer**		Mandatory
STATEMENT	The WM shall be able to transmit TM/TC and data from the SVC OBC with the SM connected at its SI		
VERIFICATION	Testing	**COVERS**	Operational Concept Guidelines AD1
RESPONSIBLE	SPACEAPPS		
COMMENT			

IntR_B303	**WM power**		Mandatory
STATEMENT	The WM shall get power from the spacecraft/modules through the power interface of the connected SI		
VERIFICATION	Testing	**COVERS**	Operational Concept
RESPONSIBLE	SPACEAPPS		
COMMENT			

IntR_B304	**WM power transfer**		Mandatory
STATEMENT	The WM shall be able to transmit power to the SM connected at its SI		
VERIFICATION	Testing	**COVERS**	Operational Concept
RESPONSIBLE	SPACEAPPS		
COMMENT			

IntR_B304	**WM interface switch**		Mandatory
STATEMENT	The WM shall be able to switch power and data interface between the two SI extremities		
VERIFICATION	Testing	**COVERS**	Operational Concept
RESPONSIBLE	SPACEAPPS		
COMMENT			

IntR_B305	**WM local CAN network**			Mandatory
STATEMENT	The WM shall provide a local CAN network to interface and control the end-effectors SI			
VERIFICATION	Testing	**COVERS**	Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT	CAN network technology is currently selected based on OG5 outputs			

IntR_B306	**WM local control network**			Mandatory
STATEMENT	The WM shall be able to parse information from/to its data interface through the two SI extremities and translate it in its own local bus for Real-Timer monitor and control of its joins.			
VERIFICATION	Testing	**COVERS**	Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT				

IntR_B307	**WM mechanical interface to SI**			Mandatory
STATEMENT	The WM shall provide a mechanical interface connection at each extremity to attach a SI			
VERIFICATION	Testing	**COVERS**	Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT				

3.4.4 B400: Design requirements [DesR]

DesR_B401	**SI as WM end-effectors**			Mandatory
STATEMENT	The WM shall be equipped with a SI at each of its extremities			
VERIFICATION	Review of Design	**COVERS**	Operational Concept RD3	
RESPONSIBLE	SPACEAPPS			
COMMENT				

DesR_B402	**Embedded controller**			Mandatory
STATEMENT	The WM shall have an embedded local controller to convert high-level control commands from the SVC OBC to low-level control of the joints			
VERIFICATION	Review of Design	**COVERS**	FuncR_S108 MOSAR Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT				

DesR_B403	**Torque/force sensors**			Mandatory
STATEMENT	The WM shall be equipped with Force/Torque sensors to support the implementation of the impedance control			
VERIFICATION	Review of Design	**COVERS**	Operational Concept RD3	
RESPONSIBLE	SPACEAPPS			
COMMENT	End-tip of joint torque TBC			

DesR_B404	**Compatibility to environmental tests conditions**			Mandatory
STATEMENT	The design of the WM shall be such that it is able to withstand the test environmental conditions			
VERIFICATION	Review of Design	**COVERS**	Demonstration constraints	
RESPONSIBLE	SPACEAPPS			
COMMENT				

DesR_B405	**Compatibility to space design**			Mandatory
STATEMENT	The design of the WM shall be such that the later product is able to withstand the harsh conditions in space			
VERIFICATION	Review of Design	**COVERS**	Guidelines RD3 OG9-R09 OpR_S606	
RESPONSIBLE	SPACEAPPS			
COMMENT				

3.4.5 B500: Physical and resource requirements [PhyR]

PhyR_B501	**WM weight**			Mandatory
STATEMENT	The weight of the WM shall minimized with a targeted weight of 14kg [TBC], including the SI.			
VERIFICATION	Testing	**COVERS**	PhyR_S501	
RESPONSIBLE	SPACEAPPS			
COMMENT	Based on the assumption of a 1 to half payload capability of 7kg			

3.4.6 B600: Environmental and Operational requirements [OpR]

N./A.

3.4.7 B700: Safety requirements [SafR]

N./A.

3.4.8 B800: Configuration and implementation requirements [ConfR]

N./A.

3.5 Spacecraft Modules Requirements [Cxxx]

3.5.1 C100: Functional requirements [FuncR]

FuncR_C101	**SM functions**		Mandatory
STATEMENT	The SMs shall provide all required support functions to any embarked unit and guarantee the required operative profile during the lifetime		
VERIFICATION	Review of Design, Testing	**COVERS**	Operational Concept RD3
RESPONSIBLE	SITAEL		
COMMENT			

FuncR_C102	**SM components**		Mandatory
STATEMENT	Each SM shall be able to host all the components needed to fulfill its functions		
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R11
RESPONSIBLE	SITAEL		
COMMENT			

FuncR_C103	**SM data routing configuration**		Mandatory
STATEMENT	The baseline functionality of a Spacecraft Module shall include the ability to externally configure the SM's data routing function between the Standard Interfaces and services provided by SM		
VERIFICATION	Review of Design / Testing	**COVERS**	FuncR_S120 MOSAR Operational Concept
RESPONSIBLE	TAS-UK		
COMMENT			

FuncR_C104	**SM data transmission**			Mandatory
STATEMENT	The baseline functionality of a Spacecraft Module shall include the ability to provide external TM/TC control and service data of the Spacecraft Module via the SM data interface once the routing function has been configured			
VERIFICATION	Review of Design / Testing	**COVERS**	FuncR_S119, FuncR_A108 MOSAR Operational Concept	
RESPONSIBLE	TAS-UK			
COMMENT				

FuncR_C103	**SM rower routing configuration**			Mandatory
STATEMENT	The baseline functionality of a Spacecraft Module shall include the ability to externally configure the SM's power routing function between the Standard Interfaces			
VERIFICATION	Review of Design / Testing	**COVERS**	MOSAR Operational Concept	
RESPONSIBLE	TAS-UK			
COMMENT	This can be envisaged by an internal power distribution unit in the SM or at the SI level			

FuncR_C105	**SM redundancy**			Mandatory
STATEMENT	The assembled modules shall be able to switch to redundant data and power paths			
VERIFICATION	Testing	**COVERS**	FuncR_A110	
RESPONSIBLE	TAS-UK, SPACEAPPS			
COMMENT				

FuncR_C106	**SM power-on/off**			Desirable
STATEMENT	The SM shall be able to be powered on/off or put in stand-by mode, keeping its capability to transmit data and power to other SM			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept	
RESPONSIBLE	SITAEL			
COMMENT	To reduce consumption when the SM is not in use.			

FuncR_C107	**SM start and initialization**		Mandatory
STATEMENT	The SM shall be able to start and initialize automatically after power-on, reaching a state ready for communication and operations		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept
RESPONSIBLE	SITAEL, TAS-UK		
COMMENT			

FuncR_C108	**Identification information**		Mandatory
STATEMENT	The SM shall be able to provide identification information including unique identifier number and list of capabilities		
VERIFICATION	Testing	**COVERS**	FuncR_A111
RESPONSIBLE	SITAEL, TAS-UK		
COMMENT	To support automatic detection and plug and play operations		

FuncR_C109	**Fault detection**		Mandatory
STATEMENT	The SM shall be able to detect malfunction of its operations		
VERIFICATION	Testing	**COVERS**	FuncR_A112
RESPONSIBLE	SITAEL		
COMMENT			

3.5.2 C200: Performance requirements [PerfR]

PerfR_C201	**SM data interface rate for TM/TC**		Mandatory
STATEMENT	The data interface of the Spacecraft Module shall support a data rate of 1Mbps or greater for TM/TC control.		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept PerfA_A202
RESPONSIBLE	SPACEAPPS, DLR, TAS-UK		
COMMENT	The TM/TC control of the platform should not rely on high data rate links with low latency.		

PerfR_C202	**SM data interface rate for service data**		Mandatory
STATEMENT	The data interface of the Spacecraft Module shall support a data rate of 50 Mbps or greater for service data.		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept PerfA_A203
RESPONSIBLE	SPACEAPPS, DLR, TAS-UK		
COMMENT	The services provided by the Spacecraft Module share the same data interface as TM/TC and will have a higher bandwidth requirement. At 50 Mbps, a 4Mpixel image will take several seconds to transfer across the data network.		

PerfR_C203	**SM power interface rate**		Mandatory
STATEMENT	The power interface of the SM shall support [1-2kW] [TBC] of power transfer		
VERIFICATION	Testing	**COVERS**	Operational Concept RD3PerfR_A202
RESPONSIBLE	SITAEL, SPACEAPPS		
COMMENT	The power APM should be able to deliver the required power for the operations of the other SM, WM and SI. Value TBC for PDR		

3.5.3 C300: Interface requirements [IntR]

IntR_C301	**SM power**		Mandatory
STATEMENT	The SM shall get power from the power interface of one of the connected SI		
VERIFICATION	Testing	**COVERS**	Operational Concept
RESPONSIBLE	SPACEAPPS		
COMMENT			

IntR_C302	**SM R-ICU power Up**		Mandatory
STATEMENT	The Spacecraft Module’s R-ICU shall be powered up whenever external power is supplied to any of its Standard Interfaces.		
VERIFICATION	Testing	**COVERS**	Operational Concept RD3
RESPONSIBLE	SITAEL, SPACEAPPS		
COMMENT	Enables plug and play of Spacecraft Modules.		

IntR_C303	**SM R-ICU to SI TM/TC**		Mandatory
STATEMENT	The R-ICU shall provide TM/TC control of the Standard Interfaces using CANbus		
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept
RESPONSIBLE	SPACEAPPS, TAS-UK		
COMMENT	The R-ICU is the CAN bus master and the Standard Interfaces are all slaves to the R-ICU. CAN network technology is currently selected based on OG5 outputs		

IntR_C304	**SM mechanical interface to SI**		Mandatory
STATEMENT	The SM shall provide a mechanical interface connection to attach a SI		
VERIFICATION	Testing	**COVERS**	Operational Concept
RESPONSIBLE	SITAEL		
COMMENT			

3.5.4 C400: Design requirements [DesR]

DesR_C401	**SM structure**		Mandatory
STATEMENT	The SM structure shall be composed by the following units: • 6 lateral panels • 12 beams • 4 corners • Connection items (to connect all the units of the SMs with the structural units of the SMs)		
VERIFICATION	Review of Design	**COVERS**	Partner expertise
RESPONSIBLE	SITAEL		
COMMENT	For improved cross-compatibility of launchers and internal systems, SMs should target to the form factor for a cubic 27U CubeSat (RD1).		

DesR_C402	**Number of SI**			Mandatory
STATEMENT	All SM shall have a sufficient number of SI in order to manipulate them with the WM and to couple them with each other and to the SVC or CLT			
VERIFICATION	Review of Design	**COVERS**	Operational Concept RD3 Guidelines AD1	
RESPONSIBLE	SITAEL, DLR			
COMMENT	A maximum number of 3 SI are currently considered as optimization between demonstration application and demonstration constraints (weight, costs)			

DesR_C403	**SM mechanical loading**			Mandatory
STATEMENT	The structure of the modules shall be able to carry its own mass under the gravity force and the loads introduced by the "walking" robot-system during the manipulation of the SMs.			
VERIFICATION	Analysis, Testing	**COVERS**	Operational Concept RD3 Guidelines AD1	
RESPONSIBLE	SITAEL			
COMMENT				

DesR_C404	**SM mechanical loading data**			Mandatory
STATEMENT	The forces applied by the WM and the motion dynamics shall be provided for the design of the SMs in the worst case.			
VERIFICATION	Analysis	**COVERS**	Partner Expertise	
RESPONSIBLE	SITAEL			
COMMENT				

DesR_C405	**SM physical layout**			Mandatory
STATEMENT	The SMs physical layout shall allow the accommodation of all the equipment, by guaranteeing the proper mechanically assembly, the thermo-mechanical behavior, the SM mechanical/electrical integration and testing, as required by the test requirements			
VERIFICATION	Review of Design	**COVERS**	Partner expertise	
RESPONSIBLE	SITAEL			
COMMENT				

DesR_C406	**SM accommodation**		Mandatory
STATEMENT	The accommodation of the units shall take into account the following criteria: • Need of assembly and disassembly • Easy access to the electrical connectors, fixation points, grounding studs • Alignment requirements • Mass distribution • Envelope • Harness routing • FOV constraints (in the case of the integration of optical sensors)		
VERIFICATION	Review of Design, Inspection, Testing	**COVERS**	Partner expertise
RESPONSIBLE	SITAEL		
COMMENT			

DesR_C407	**SM accommodation flexibility**		Mandatory
STATEMENT	The SMs structure shall be flexible in order to allow the accommodation of different kind of internal equipment		
VERIFICATION	Inspection	**COVERS**	Mission analysis RD2 Guidelines AD1
RESPONSIBLE	SITAEL		
COMMENT			

DesR_C408	**SM face assignation**		Mandatory
STATEMENT	Only the assigned faces of the SM shall host the standard interfaces. While, only one customized face for each SM shall host all the other units needed to fulfill the SM functions.		
VERIFICATION	Review of Design	**COVERS**	Partner Expertise
RESPONSIBLE	SITAEL		
COMMENT			

DesR_C409	**Thermal conditions**		Mandatory
STATEMENT	The SMs shall be design in order to guarantee the required thermal conditions to all the units mounted inside the SMs		
VERIFICATION	Review of Design, Testing	**COVERS**	Partner Expertise
RESPONSIBLE	SITAEL		
COMMENT			

DesR_C405	**Compatibility to environmental tests conditions**		Mandatory
STATEMENT	The design of the SM shall be such that it is able to withstand the test environmental conditions		
VERIFICATION	Review of Design	**COVERS**	Demonstration constraints
RESPONSIBLE	SITAEL		
COMMENT			

DesR_C406	**Compatibility to space design**		Mandatory
STATEMENT	The design of the SM shall be such that the later product is able to withstand the harsh conditions in space		
VERIFICATION	Review of Design	**COVERS**	Guidelines RD3 OG9-R09 OpR_S606
RESPONSIBLE	SITAEL		
COMMENT			

3.5.5 C500: Physical and resource requirements [PhyR]

PhyR_C501	**SM Weight**		Mandatory
STATEMENT	The weight of the SM shall be minimized with a target mass of 7kg [TBC]		
VERIFICATION	Testing	**COVERS**	PhyR_S501
RESPONSIBLE	SITAEL		
COMMENT	For improved cross-compatibility of launchers and internal systems, SMs should target to the form factor for a cubic 27U CubeSat (RD1).		

DesR_C502	**SM size**		Mandatory
STATEMENT	The SM shall be cubical in shape in size 300 to 400 mm (TBD) per side		
VERIFICATION	Review of Design	**COVERS**	Mission analysis RD2
RESPONSIBLE	SITAEL		
COMMENT	For improved cross-compatibility of launchers and internal systems, SMs should target to the form factor for a cubic 27U CubeSat (RD1).		

3.5.6 C600: Environmental and Operational requirements [OpR]

3.5.7 C700: Safety requirements [SafR]

SafR_C701	**SM hand manipulation**		Mandatory
STATEMENT	The SM shall be able to be safely manipulated by hand		
VERIFICATION	Inspection	**COVERS**	Safety rules
RESPONSIBLE	SITAEL		
COMMENT			

3.5.8 C800: Configuration and implementation requirements [ConfR]

ConfR_C801	**Demonstrator SM Configurations**		Mandatory
STATEMENT	A set of 7 SMs shall be developed, with the following functions: • 4 ASMs: ○ Data Management Subsystem module (DMS): this ASM hosts the main Onboard Computer of the target spacecraft. ○ Power Subsystem (PWS): is managing the electrical power on the TGT spacecraft. ○ Battery ORU module (BAT): is an SM that comprises a set of Lithium-ion batteries and the electronic to manage them. ○ Thermal Subsystem module (THS): is responsible for the thermal management of the TGT SMs • 2 APMs Optical Sensor Payload module (OSP): is an SM that exposes an optical lens on one of its faces. • 1 back-up SM		
VERIFICATION	Review of Design	**COVERS**	FuncR_S112, FuncR_S114, FuncR_S115 Scenarios Description
RESPONSIBLE	SITAEL		
COMMENT	Selection of ASM and APM are illustrative to the possible missions scenario, final selection and specifications of each developed module at PDR		

3.6 Standard Interfaces Requirements [Dxxx]

3.6.1 D100: Functional requirements [FuncR]

FuncR_D101	**Mechanical, Data and Electrical Interface**			Mandatory
STATEMENT	The standard interface shall provide • a mechanical interface to mechanically couple two system components • an electrical interface to transfer electrical energy (power) between two system components • a data interface to allow exchange of data between two system components			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT	MOSAR system components include Spacecraft Modules, Spacecraft Bus and Walking Manipulator			

FuncR_D102	**Thermal Interface**			Mandatory
STATEMENT	The standard interface shall provide a thermal interface to allow active transfer of thermal flow between two Spacecraft Modules			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT	In MOSAR, active thermal transfer is only considered between SM (not with the Spacecraft Bus or Walking Manipulator)			

FuncR_D103	**Passive Coupling**			Mandatory
STATEMENT	The standard interface shall allow the mechanical, power, data and thermal coupling with another interface that cannot provide actuation			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT	Passive configurations of the SI is currently envisaged in the scenarios for costs reductions (could also have an interest for future exploitation)			

FuncR_D104	Passive Decoupling			Mandatory
STATEMENT	The standard interface shall allow the mechanical, power, data and thermal de-coupling with another interface that cannot provide actuation			
VERIFICATION	Review of Design	COVERS	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_D105	Electrical Interface Protection			Mandatory
STATEMENT	The electrical interface shall have an overcurrent and overvoltage protection			
VERIFICATION	Review of Design / Testing	COVERS	OG5 Requirement Internal Expertise	
RESPONSIBLE	SPACEAPPS			
COMMENT				

FuncR_D106	Electrical Interface Switch			Mandatory
STATEMENT	The electrical interface shall incorporate a bidirectional power switch to control current flow at the interface.			
VERIFICATION	Review of Design / Testing	COVERS	FuncR_S122	
RESPONSIBLE	SPACEAPPS			
COMMENT	Required to support (re)-routing of electrical power. Could also be managed by a central power distribution unit in the SM			

FuncR_D107	Electrical Interface Telemetry			Mandatory
STATEMENT	The electrical interface shall provide voltage and current telemetry at the power bus system level, in both power transfer direction			
VERIFICATION	Testing	COVERS	FuncR_S122	
RESPONSIBLE	SPACEAPPS			
COMMENT	Required to monitor (re)-routing of electrical power.			

FuncR_D108	**Data Interface Support**		Mandatory
STATEMENT	The data interface shall support at least one technology with capabilities of dynamic data bus re-configuration and routing		
VERIFICATION	Review of Design	**COVERS**	DesR_A407
RESPONSIBLE	SPACEAPPS / TAS-UK		
COMMENT	Current selected technology in MOSAR is SpaceWire, based on OG4 outputs		

FuncR_D109	**SI Telemetry**		Mandatory
STATEMENT	The SI shall measure and store the following local SI parameters: • Temperature (Power electronics if local, structure) • Alignment / proximity status • Locking status • SI orientation (in relation with design symmetry) • Data/Power interface status • Thermal interface status • Motor position (incremental or absolute) / Mechanism position (absolute) • Motor current • Controller supply voltage		
VERIFICATION	Review of Design / Testing	**COVERS**	OG1-5 Review RD1 Operational Concept RD3
RESPONSIBLE	SPACEAPPS		
COMMENT	Needed to monitor the function of the SI and support autonomous operation in MOSAR		

3.6.2 D200: Performance requirements [PerfR]

PerfR_D201	**Mechanical Loads**		Mandatory
STATEMENT	The mechanical interface shall withstand, in connected mode, all mechanical loads induced by the demonstration operations: • Axial Force: 250 / 160 N • Radial Force: 250 / 160 N • Bending Moment: 204 / 84 Nm • Torsion: TBD Nm As function of the gravity compensation of the SM (TBC).		
VERIFICATION	Analysis / Testing	**COVERS**	OG1-5 Review RD1 OpR_A602
RESPONSIBLE	SPACEAPPS		
COMMENT	Best current estimations Required load transfer will depend on the configuration of the demonstrator setup and the possible application of gravity mitigation technics. Due to the complexity of the operations and motions, we currently target to not implement gravity compensation (left number). We could however still envisage compensation of the SM (right number)		

PerfR_D202	**Positioning Tolerance**			Mandatory
STATEMENT	The mechanical interface shall maximize positioning tolerance for guidance and mating			
VERIFICATION	Analysis / Testing	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT				

PerfR_D203	**Power Transfer Rating**			Mandatory
STATEMENT	The electrical interface shall be capable of supporting [1-2kW] (TBC) of power transfer, as required by the MOSAR demonstration The power interface of the SM shall support [1-2kW] [TBC] of power transfer			
VERIFICATION	Analysis / Testing	**COVERS**	PerfR_C203	
RESPONSIBLE	SPACEAPPS			
COMMENT	Value TBC for PDR			

PerfR_D204	**Data Interface Rating**			Mandatory
STATEMENT	The data interface shall allow a data rate of minimum 50Mbit/s			
VERIFICATION	Analysis / Testing	**COVERS**	PerfR_A202	
RESPONSIBLE	SPACEAPPS			
COMMENT	To support the recording and processing of large amounts of data between modules and with the spacecraft, value TBC during PDR phase			

PerfR_D205	**Thermal Interface Rating**			Mandatory
STATEMENT	The thermal interface shall allow a thermal flow rating of: TBD W			
VERIFICATION	Analysis / Testing	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	MAGSOAR / SPACEAPPS			
COMMENT				

3.6.3 D300: Interface requirements [IntR]

IntR_D301	**Mechanical Interface to Components**		Mandatory
STATEMENT	The standard interface shall provide a mechanical connection to the modules, spacecraft bus or robotic base/end-effector manipulator, compatible with the mechanical loads transferred through the interface.		
VERIFICATION	Review of Design / Analysis	**COVERS**	OG1-5 Review RD1 IntR_B307, IntR_C304
RESPONSIBLE	SPACEAPPS, SITAEL		
COMMENT			

IntR_D302	**Harnessing to Components**		Mandatory
STATEMENT	The standard interface shall provide internal harnessing to connect power, data and control buses from the module, spacecraft or robotic base/end-effector manipulator		
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1
RESPONSIBLE	SPACEAPPS, SITAEL		
COMMENT			

IntR_D303	**Interface to Module Thermal System**		Mandatory
STATEMENT	The thermal interface shall enable thermal connection to the thermal module sub-system		
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1
RESPONSIBLE	SPACEAPPS, SITAEL, MAGSOAR		
COMMENT			

IntR_D304	**Power Distribution Unit**		Mandatory
STATEMENT	The SI shall be interfaced with a Power Distribution Unit (PDU) to provide low-level voltage power rails to supply the internal components of the SI (controller, sensors and motor drives)		
VERIFICATION	Review of Design	**COVERS**	Partner Expertise
RESPONSIBLE	SPACEAPPS		
COMMENT	The PDU could be local to the SI or shared at module level		

IntR_D305	**Standard Interface TM/TC**			Mandatory
STATEMENT	The SI shall be able to send/receive local TM/TC to/from the module or spacecraft OBC TM: See FuncR_D109 list TC: • Coupling / de-coupling (TBC for intermediate states) • Electrical power transfer on/off • Low-level control (TBC)			
VERIFICATION	Testing	**COVERS**	FuncR_A104	
RESPONSIBLE	SPACEAPPS			
COMMENT	Based on OG5 developments, CAN is the current selected technology for SI TM/TC			

IntR_D306	**Redundant Data/Power/Control Interface**			Mandatory
STATEMENT	The SI shall feature redundant data, power and control interface			
VERIFICATION	Review of Design	**COVERS**	SafR_S702	
RESPONSIBLE	SPACEAPPS			
COMMENT	In case of failure, the SI shall be able to switch to a redundant bus			

3.6.4 D400: Design requirements [DesR]

DesR_D401	**Androgynous Design**			Mandatory
STATEMENT	The standard interface shall have an androgynous design, including mechanical, data, power and thermal interface			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	SPACEAPPS			
COMMENT				

DesR_D402	**Design Symmetry**			Mandatory
STATEMENT	The standard interface shall present a 90deg. rotational symmetry, including mechanical, data, power and thermal interface			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1 ConfR_S902	
RESPONSIBLE	SPACEAPPS			
COMMENT	The standard interface shall allow module connections without restriction on relative module orientation			

DesR_D403	**Diagonal Engagement**			Mandatory
STATEMENT	The standard interface shall allow diagonal engagement up to 55 deg			
VERIFICATION	Review of Design / Testing	**COVERS**	OG1-5 Review RD1 Operational Concept RD3	
RESPONSIBLE	SPACEAPPS			
COMMENT	To enable multiple simultaneous approach and connection (e.g. corner example)			

DesR_D404	**Form-Fit Guidance**			Mandatory
STATEMENT	The standard interface shall provide guidance form-fit features			
VERIFICATION	Review of Design / Testing	**COVERS**	OG1-5 Review RD1 Operational Concept RD3	
RESPONSIBLE	SPACEAPPS			
COMMENT	To support the alignment process between two interfaces, specifically when multiple connections are considered, without requiring external guidance system			

DesR_D405	**SI Costs**			Mandatory
STATEMENT	The design of the SI shall take into account optimization of the manufacturing and integration costs			
VERIFICATION	Analysis	**COVERS**	DesR_S403	
RESPONSIBLE	SPACEAPPS			
COMMENT	Cost should be a design driver considering the large quantity of interfaces in the proposed operational concept.			

3.6.5 D500: Physical requirements [PhyR]

PhyR_D501	**Standard Interface Mass**			Mandatory
STATEMENT	The standard interface shall be optimized regarding the mass			
VERIFICATION	Testing	**COVERS**	PhyR_S501, PhyR_B501, PhyR_C501	
RESPONSIBLE	SPACEAPPS			
COMMENT				

PhyR_D502	**Standard Interface Volume**			Mandatory
STATEMENT	The standard interface shall be optimized regarding size and volume			
VERIFICATION	Testing	**COVERS**	PhyR_S502	
RESPONSIBLE	SPACEAPPS			
COMMENT	To reduce constraints on the module design and integration			

3.6.6 D600: Environmental and Operational requirements [OpR]

PhyR_D601	**Standard Interface ShutDown**			Desirable
STATEMENT	The standard interface (or a part of it) shall be able to be switched off/on (behave as a passive plug), while ensuring data and power transfer.			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT	In regards to the total mission time, the operation time of the standard interface is very small. For energy optimization, it could be interesting to be able to switch off the component (and be able to revive it later).			

PhyR_D602	**Standard Interface Power Consumption**			Mandatory
STATEMENT	The power consumption of the standard interface shall be minimized			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept OG5 Expertise	
RESPONSIBLE	SPACEAPPS			
COMMENT	Values TBC during PDR phase			

PhyR_D603	**Coupling Time**			Mandatory
STATEMENT	The coupling time between two standard interfaces shall be minimized			
VERIFICATION	Testing	**COVERS**	MOSAR Operational Concept	
RESPONSIBLE	SPACEAPPS			
COMMENT	MOSAR demonstration will require a lot of successive mating/demating operations			

3.6.7 D700: Safety requirements [SafR]

SafR_D801	**SI Safe Manipulation**			Mandatory
STATEMENT	The SI shall be safe to be manipulated during integration within SM, WM or Spacecraft Buses. If there exist potential risks, they shall be well documented			
VERIFICATION	Inspection	**COVERS**	Safety Rules	
RESPONSIBLE	SPACEAPPS			
COMMENT				

3.6.8 D800: Configuration and implementation requirements [ConfR]

PhyR_D901	**SI Design Configurations**			Mandatory
STATEMENT	The standard interface shall be declined in different configurations that are: • Active • Passive (not active behavior but can be couple and transmit data and power) • Mechanical (not active and can only be coupled) • Thermal (including thermal interface connectors, either active or passive)			
VERIFICATION	Review of Design / Testing	**COVERS**	OGs costs and physical characteristics constraints	
RESPONSIBLE	SPACEAPPS			
COMMENT	This is mainly to support costs and volume/weight reduction in the ground demonstrators. This could also be applicable in future mission depending on specific mission characteristics.			

3.7 Planner and Simulator Requirements [Exxx]

3.7.1 E100: Functional requirements [FuncR]

FuncR_E101	**Design and Simulation Tool Purpose**			Mandatory
STATEMENT	The design and simulation software shall be able to simulate the system with all related robotic elements and tasks (e.g. reconfiguration) as well as create a robotic compatible servicing plan for the satellite platform			
VERIFICATION	Testing	**COVERS**	FuncR_S105, FuncR_S106	
RESPONSIBLE	DLR/GMV			
COMMENT				

FuncR_E102	**Design Software**			Mandatory
STATEMENT	The software shall support engineers developing new components and satellites and shall give system integrators the chance to test the entire satellite including all relevant aspects of on-orbit assembly and servicing operation.			
VERIFICATION	Review of Design	**COVERS**	FuncR_S105	
RESPONSIBLE	DLR			
COMMENT				

FuncR_E103	**System Simulation**			Mandatory
STATEMENT	The software shall allow users to simulation and test high-modular building block space system architectures with regard to the requirements and constraints of robotics, structure and the entire system			
VERIFICATION	Review of Design	**COVERS**	FuncR_S106	
RESPONSIBLE	DLR			
COMMENT				

FuncR_E104	Task Planning and Simulation			Mandatory
STATEMENT	The software shall be used to plan and to test the servicing task of the robot system			
VERIFICATION	Testing	COVERS	Guidelines AD1	
RESPONSIBLE	GMV (Planner) and DLR (Test)			
COMMENT				

FuncR_E105	Simulation Topics			Mandatory
STATEMENT	The software shall allow to test and simulate the demonstration scenario regarding mechanical and thermal loads as well as distribution of resources.			
VERIFICATION	Review of Design	COVERS	Guidelines AD1	
RESPONSIBLE	DLR			
COMMENT				

FuncR_E106	Simulation of Reconfiguration			Mandatory
STATEMENT	The software shall allow the addition of functional modules to the spacecraft, perform reconfiguration process, and simulate the servicing task considering dedicated robotic specifications.			
VERIFICATION	Review of Design	COVERS	Guidelines AD1	
RESPONSIBLE	DLR			
COMMENT				

FuncR_E108	Environmental Conditions Simulation			Optional
STATEMENT	The simulation software shall be able to simulate the environmental conditions in LEO			
VERIFICATION	Inspection	COVERS	Mission Analysis RD2	
RESPONSIBLE	DLR			
COMMENT	The effects of orbital disturbances and their respective relevance shall be verified based on dedicated simulation output signals.			

FuncR_E109	**Manipulator Dynamics Simulation**		Mandatory
STATEMENT	The simulation software shall be able to represent manipulator dynamics like motor dynamics and joint flexibilities, if relevant in the demonstrator scenario.		
VERIFICATION	Inspection	**COVERS**	Operational Concept RD3
RESPONSIBLE	DLR		
COMMENT			

3.7.2 D200: Performance requirements [PerfR]

PerfR_E201	**Simulation Real-Time Performance**		Desirable
STATEMENT	The simulation software shall be able to compute the reconfiguration scenarios in real time as far as possible.		
VERIFICATION	Testing	**COVERS**	Operational Concept RD3
RESPONSIBLE	DLR		
COMMENT	The real-time performance is verified during reference simulation runs (TBD).		

PerfR_E202	**Number of SM in Simulation**		Mandatory
STATEMENT	The simulation software shall be able to process as many replaceable modules models as required according to the demonstration scenarios.		
VERIFICATION	Testing	**COVERS**	Operational Concept RD3
RESPONSIBLE	DLR		
COMMENT	The ability to handle a sufficient number of modules is verified during reference simulation runs (TBD).		

3.7.3 D300: Interface requirements [IntR]

IntR_E301	**Simulator Input Interfaces**		Mandatory
STATEMENT	The simulation software of the FES shall be able to receive joint control inputs from external joint controllers and planners..		
VERIFICATION	Testing	**COVERS**	Operational Concept RD3
RESPONSIBLE	DLR		
COMMENT			

IntR_E302	**Simulator Output Interfaces**			Mandatory
STATEMENT	The simulation software of the FES shall be able to feed back sensor information from sensor models and simulation states to external controllers or a control console			
VERIFICATION	Testing	**COVERS**	Operational Concept RD3	
RESPONSIBLE	DLR			
COMMENT				

IntR_E303	**Simulator Communication Interface**			Optional
STATEMENT	The simulation software shall be able to communicate with external entities via TCP/IP or UDP			
VERIFICATION	Testing	**COVERS**	Operational Concept RD3	
RESPONSIBLE	DLR			
COMMENT				

IntR_E304	**Generation of plan for onboard execution**			Mandatory
STATEMENT	The ground instance of the ERGO Agent used to generate and validate the reconfiguration plan shall generate a static plan that can be transferred to and executed by the onboard ERGO Agent.			
VERIFICATION	Testing	**COVERS**	Operational Concept RD3	
RESPONSIBLE	GMV			
COMMENT				

3.7.4 D400: Design requirements [DesR]

N./A.

3.7.5 D500: Physical and resource requirements [PhyR]

PhyR_E501	**Simulator Computing Platform**		Mandatory
STATEMENT	The FES shall run on an individual single-purpose PC		
VERIFICATION	Inspection / Testing	**COVERS**	
RESPONSIBLE	DLR		
COMMENT			

3.7.6 D600: Environmental and Operational requirements [OpR]

N./A.

3.7.7 D700: Safety requirements [SafR]

N./A.

3.7.8 D800: Configuration and implementation requirements [ConfR]

ConfR_E901	**Scenario Simulation Models**		Desirable
STATEMENT	For each scenario to be demonstrated, an individual simulation model shall be provided		
VERIFICATION	Inspection	**COVERS**	Partner Expertise
RESPONSIBLE	DLR		
COMMENT	In order to minimize re-configuration activities		

3.8 Software Requirements [Fxxx]

This section lists the requirements for on-board software that is run on the MOSAR demonstrator SVC platform, SMs and WM for control and management of the system.

3.8.1 F100: Functional requirements [FuncR]

FuncR_F101	**Extension of TASTE for reconfigurable systems**			Mandatory
STATEMENT	The TASTE framework shall be extended to support modelling and code generation for software systems that can switch between different configurations known at design time.			
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	ELLI, UBREST, GMV			
COMMENT				

FuncR_F102	**TASTE-DDS bridge**			Desirable
STATEMENT	A middleware bridge generator that enables the communication between TASTE and DDS in runtime should be developed in order to assess the capabilities of the software and modelling environment needed to support the reconfiguration of an onboard system with configurations not known at design time.			
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	ELLI, UBREST, GMV			
COMMENT				

FuncR_F103	**DDS over SpaceWire**			Desirable
STATEMENT	An existing open DDS implementation should be adapted to run over SpaceWire links so that it can be deployed in the MOSAR demonstrator.			
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	GMV			
COMMENT	Feasibility needs to be assessed			

FuncR_F104	**Large data transfer over SpaceWire**		Optional
STATEMENT	The software should provide a common mechanism to transfer large data messages (1KiB to 1MiB) over SpaceWire links, in order to transfer images from the camera sensor to the OBC and the ground system.		
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1
RESPONSIBLE	GMV, TAS-F, USTRAT, SPACEAPPS		
COMMENT	Feasibility needs to be assessed		

FuncR_F105	**ERGO robotic arm driver for WM**		Mandatory
STATEMENT	A robotic arm driver component shall be developed to execute the robot plan actions on the WM and return the observations needed by the Agent to manage the execution of the plan.		
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1
RESPONSIBLE	GMV, DLR		
COMMENT			

FuncR_F106	**ERGO Agent for plan execution**		Mandatory
STATEMENT	An instance of the ERGO Agent shall be deployed on the OBC to command and monitor the execution of the robotic reconfiguration plan generated on ground.		
VERIFICATION	Testing	**COVERS**	OG1-5 Review RD1
RESPONSIBLE	GMV		
COMMENT			

3.8.2 F200: Performance requirements [PerfR]

N./A.

3.8.3 F300: Interface requirements [IntR]

IntR_F301	PUS services			Mandatory
STATEMENT	The monitoring and control from the ground system of the onboard system status and the execution of the robotic reconfiguration plan shall be done using the ESROCOS PUS services library, extended with mission-specific services.			
VERIFICATION	Testing	COVERS	OG1-5 Review RD1	
RESPONSIBLE	GMV			
COMMENT				

3.8.4 F400: Design requirements [DesR]

DesR_F401	Robotics data types			Mandatory
STATEMENT	The data types used for the interface between the ERGO Agent and the Functional Layer shall be modelled in ASN.1. If a suitable data type is available from ESROCOS, it should be reused rather than defining a new data type.			
VERIFICATION	Review of Design	COVERS	OG1-5 Review RD1	
RESPONSIBLE	GMV			
COMMENT				

3.8.5 F500: Physical and resource requirements [PhyR]

N./A.

3.8.6 F600: Environmental and Operational requirements [OpR]

OpR_F601	Plan execution monitoring			Mandatory
STATEMENT	A graphical tool shall allow the operator to command and monitor the execution of the robotic reconfiguration plan, both simulated and onboard.			
VERIFICATION	Review of Design	COVERS	Operational Concept RD3 Demonstrator preliminary Concept	
RESPONSIBLE	GMV			
COMMENT				

3.8.7 F700: Safety requirements [SafR]

N./A.

3.8.8 F800: Configuration and implementation requirements [ConfR]

ConfR_F801	**TASTE modelling**			Mandatory
STATEMENT	The TASTE framework shall be used to model the software components running on the OBC. These components include: - Functions related to robot autonomy (ERGO Agent and functional layer) - Sample OBSW for the management of the reconfigurable system (monitoring and control of the SM)			
VERIFICATION	Review of Design	**COVERS**	OG1-5 Review RD1	
RESPONSIBLE	GMV			
COMMENT				

ConfR_F802	**Development platform**			Mandatory
STATEMENT	The development platform for the OBSW shall be Ubuntu Linux 18.04 LTS (64 bit) on x86. The ESROCOS framework, and in particular TASTE, shall be adapted to run on this platform.			
VERIFICATION	Review of Design	**COVERS**		
RESPONSIBLE	GMV			
COMMENT				

3.9 Validation Requirements [Gxxx]

VerR_G101	**Validation purpose**			Mandatory
STATEMENT	The MOSAR demonstrator shall allow to verify and validate the following functionalities relevant for future modular spacecraft missions: • Creation of a re-configuration execution plan (FuncR_S105) • Simulation of the execution plan (FuncR_S106) • Manipulation and repositioning of SM (FuncR_S101) • Control and re-location of the WM (FuncR_S104, FuncR_S107) • Update/upgrade of satellite functionalities (FuncR_S102) • Data and power transfer between SM • Heat management between SM (FuncR_S115) • Failure detection and handling (FuncR_S111) • Resources re-allocation, data and power routing (FuncR_S110)			
VERIFICATION	Testing	**COVERS**	Mission Analysis RD2	
RESPONSIBLE	SPACEAPPS			
COMMENT				

VerR_G102	**Validation sequence**			Mandatory
STATEMENT	The validation shall include the following sequence: 1. Calibrate/verify the simulation tool 2. Simulate the reconfiguration process and generate a valid robot execution plan 3. Execute the plan on the demonstrator setup			
VERIFICATION	Review of Design	**COVERS**	Guidelines AD1 OG9-R14	
RESPONSIBLE	SPACEAPPS, DLR			
COMMENT				

VerR_G103	**SM modules selection**			Mandatory
STATEMENT	The SM implemented in the MOSAR demonstrator should be representative of relevant modules for future modular spacecraft missions.			
VERIFICATION	Review of Design	**COVERS**	Mission Analysis RD2	
RESPONSIBLE	SITAEL, TAS-Fs			
COMMENT				

VerR_G104	**Orbital Test Facility**		Mandatory
STATEMENT	The demonstrator shall be integrated in an orbital simulation facility to validate the MOSAR scenarios		
VERIFICATION	Inspection	**COVERS**	Guidelines AD1 OG9-R13 Guidelines AD1 OG9-R14
RESPONSIBLE	SPACEAPPS		
COMMENT	The orbital dynamics is not relevant in OG9 – e.g. docking is not part of the scenarios. The provided facility (in SPACEAPPS' lab) could however produce illumination conditions that are relevant w.r.t. orbital applications (if relevant)		

VerR_G105	**Test facility dimensions**		Mandatory
STATEMENT	The test facility shall ensure a volume of 5 m (L)x 3.5 m (W)x 3 m (H) in order to allow the integration of the test bench and all required components for the regular performance of the demonstration		
VERIFICATION	Inspection	**COVERS**	MOSAR Demonstrator
RESPONSIBLE	SPACEAPPS		
COMMENT	Values TBC by PDR		

VerR_G106	**Test facility displays**		Mandatory
STATEMENT	The test facility shall provide displays to support the design and monitoring of the execution plan		
VERIFICATION	Inspection	**COVERS**	MOSAR Demonstrator
RESPONSIBLE	SPACEAPPS		
COMMENT			

VerR_G107	**Test facility power**		Mandatory
STATEMENT	The test facility shall provide the required power for the performance of the demonstration		
VERIFICATION	Inspection	**COVERS**	MOSAR Demonstrator
RESPONSIBLE	SPACEAPPS		
COMMENT	It can include barrier protections, flashing light during operations,		

VerR_G108	**Test facility safety features**			Mandatory
STATEMENT	The test facility shall provide safety features to guarantee the safe operation of the demonstrator			
VERIFICATION	Inspection	**COVERS**	MOSAR Demonstrator	
RESPONSIBLE	SPACEAPPS			
COMMENT	It can include barrier protections, flashing light during operations,			

4 Conclusions

The overall system requirements and associated verification methods are described in this document, detailing the specific requirements for each of the high level subsystems. They reflect the consortium analysis and vision of MOSAR system requirements to develop the demonstrator reflecting the proposed concept of space modular spacecraft and operations. This document will serve as a baseline for the preliminary design analysis, including the detailed system architecture, interfaces definitions between subsystems, the detailed technical requirements of the equipment and their respective preliminary design that shall be consolidated by the end of M9 (PDR milestone).

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