D6.3 – DSSCK: Design and Development Specification for the satellite Construction Kit

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Abstract

This document constitutes the Design and Development Specification for the satellite Construction Kit (DSSCK) applicable to the ORUs (Orbital Replacement Unit) in the frame of ORU BOAS project.

Keywords

ORU-BOAS, DSSCK

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1. INTRODUCTION

1.1 Scope and Purpose

This document outlines the Design and Development requirements for any generic ORU (Orbit Replaceable Unit) to be carried in space thanks to a Transporter.

The primary goal of such a document is to specify technical requirements towards any 'ORU Provider' from an 'ORU Transporter' standpoint.

A secondary goal of the document is to derive programmatic essentials (e.g. schedule backbones, preliminary deliverable lists) linked to these technical requirements from the ORU Transporter viewpoint.

It shall be noted that the 'ORU Customer' within this document is only the ORU Transporter (and not the End User of the actual payload, service or function provided by the ORU in space - once installed onto a space systems).

By 'ORU Transporter', it is meant Space Carrier from launcher (rocket) carrier injection to ORU delivery onto a space systems.

Note: As an example, a typical 'ORU Transporter' could be a servicer or a logistic vehicle.

1.2 List of acronyms

CAM	Collision avoidance manoeuvre: a manoeuvre performed by the servicer aiming to place the servicer in an orbit passively free of collision with the servicer, not to be confused with collision avoidance manoeuvre with debris or active satellite -other than dummy client-, or COLA (Collision Avoidance).
MLI	Multi-Layer Insulation
ORU	Orbital Replacement Unit

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1.3 Definitions

Orbital Replaceable Unit (ORU): -the object of this specification-, a standalone unit (payload, service or function) designed to be transported by the ORU Transporter towards an orbital space systems which will receive & operate it during the ORU lifetime.

ORU Transporter: Space Carrier from launcher (rocket) carrier injection to ORU delivery onto a space systems. The Transporter does not operate the ORU.

ORU Provider: Supplier of the ORU to the ORU Transporter.

Standard interface: an electromechanical device allowing to mechanically and electrically connect with a matching interface.

TT&C: Telemetry Tracking & Command

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1.4 Applicable & Reference Documents

1.4.1 Applicable Documents

[AD1] Space USB Standard Interface Specification, 0005-0018252681, Issue 01

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2 SERVICE AND TRANSPORT MISSION

2.1 Transporter Performance

The Transporter Spacecraft or Vehicle shall provide the ORU Transportation service to the ORU Provider under the best possible conditions.

The possible ORU orbit deliveries are described in the table here below:

ORU Orbit Delivery by the Transporter	**Feasible**	**Unfeasible**
LEO	X	
MEO	X	
GEO	X	
Interplanetary orbits		X

Table 1 : ORU Orbit Delivery by the Transporter

Note: Interplanetary missions are deemed unfeasible at this stage as they would require a very specific Transporter spacecraft due to mission constraints (e.g. propulsion subsystems, transfer lifetime). From a business forecast point of view, interplanetary ORU deliveries are not a primary need.

2.2 Lifetime

The Transporter Vehicle will be designed for an ORU Transportation mission of 1 year – maximum.

As a consequence, the ORU Provider shall take this data into account for its ORU design at Kick-Off stage.

During the mission preparation phase, the Transporter shall detail the exact Transportation mission duration and the associated space operation segments (starting from launch and ending with ORU delivery).

Note: This lifetime is consistent with reachable destination orbits specified in Section 2.1.

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2.3 Ground Segment & Data Transmission

For any mission, a detailed Ground Segment & TT&C Plan (documentation) will be supplied by the ORU Transporter to the ORU Provider.

The ORU Transporter will be responsible for planning ground segments operations (e.g. ground stations service providers) accordingly, taking into account the ORU technical constraints regarding TT&C.

The ORU Transporter shall detail to the ORU Customer the available ORU Provider TT&C (if available).

The data volumes and protocols will be discussed following Kick-Off.

This topic is mission-specific and shall be co-engineered during the mission preparation phase.

2.4 Launcher Compatibility

The ORU Transporter shall sign the launch contract with a rocket operator of its choice.

These contractual and technical discussions with the launch (rocket) operator shall not be dealt with by the ORU Provider.

This launch contract remains mission-specific in order to offer to the ORU Provider the best choice amongst currently existing (and potentially upcoming) launch providers, both in terms of mission analysis & programmatic (cost & schedule) aspects.

Hence, the launch operator choice is not restricted to specific countries or continents.

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3 ENVIRONMENTAL CONDITIONS

3.1 Mechanical environment

The mechanical environment due to ORU Transporter is induced by mechanical loads withstood during launch & transportation.

This environment is mission specific and should be discussed from Kick-Off Stage.

The ORU Provider shall ensure & justify that the ORU will not be degraded under such a mechanical environment.

Here below a typical example of a mechanical environment that could be sustained by the ORU:

Note : This environment given here below should not be considered as generic.

	Sine vibration: Qualification levels				**Quasi Static Load (QSL)**	**First Frequency**
	⊥ to mounting plane		// to mounting plane			
	Frequency (Hz)	Level(*)	Frequency (Hz)	Level(*)		
ORU	5-20 20-30 30-125	±5g ±25g ±5 g	5-20 20-30 30-125	±5g ±20g ±5 g	24g (//) 28g(⊥)	>120 Hz

Table 2 : Mechanical typical environment - Sine, QSL, First Frequency

	Random vibration: Qualification levels				
	⊥ to mounting plane		// to mounting plane		
	Frequency (Hz)	Level (g2/Hz)	Frequency (Hz)	Level (g2/Hz)	
ORU	20 300-800 2000	0.01 0.3 - 0.3 0.0001	20 300-800 2000	0.01 0.3 - 0.3 0.0001	Notching strategy shall be discuss with the ORU Transporter
	Global : 14.9 g RMS		Global : 14.9 g RMS		

Tableau 3 : Mechanical typical environment - Random

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Shock Qualification levels	
Frequency (Hz)	SRS (Q=10)
100	30 g
1000	1500 g
10000	1500 g

Table 4 : Mechanical typical environment - Shock

Note:

All loads are qualification loads.

QSL loads are applied at center of gravity.

Sine, random and shock loads are applied at interface.

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3.2 Thermal Environment

The thermal environment & conditions shall be considered by the ORU Provider when designing an ORU compatible with the transportation mission.

This environment is mission specific and should be discussed from Kick-Off Stage.

Here below a typical example of thermal environment & conditions to be considered by the ORU Provider:

Note: This environment given here below should not be considered as generic.

- Thermal environment:

	Operating range (°C)	Non-operating range (°C)	Start-up (°C)
Qualification	-30 to +60	-40 to +70	-40
Acceptance	-25 to +55	-35 to +65	-35

Table 5 : Thermal typical environment

- Thermal interface conditions:

Conductive interface:

- Transporter +Zsc Panel (panel of ORU interface) temperature range: -20°C to +50°C in operating mode / -30°C to +60°C in non-operating mode

Radiative interface:

- Space node temperature: -270°C
- Transporter Platform MLI temperature range (orbital variation): -150°C to +100°C
- Transporter Platform MLI emissivity: 0.8

External fluxes

- Hot case:
  - Albedo flux constant: 355 W/m² (Albedo coefficient = 0.25)
  - IR Earth flux constant: 267 W/m² (Earth temperature = 262K)
  - Solar flux constant : 1418 W/m²
- Cold cases: no fluxes

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3.3 Radiation

The ORU shall be designed by the ORU Provider to withstand radiations during the phase led by the Transporter.

This environment is mission specific and should be discussed from Kick-Off Stage.

A specific radiation analysis shall be performed by the ORU Provider taking into account:

- The Transportation Phase (inputs to be given by the ORU Provider)
- The mission lifetime (inputs to be given by the ORU End User – excluded from this document scope)

Given the nature of radiation spectrums and depending on the ORU Orbit Delivery (LEO, MEO, GEO) the Transportation Phase radiation dose may be an (or several) order(s) of magnitude below the mission lifetime radiation dose.

The Transportation Phase radiation spectrum is also highly dependent on the ORU Orbit delivery.

That is why in this document no typical radiation spectrum is specified.

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4 ORU INTERFACES

4.1 Mechanical

4.1.1 Dimensions

The ORU from the ORU Provider shall fit within one of the following dimensional categories:

ORU Slot	**Small** **S**	**Medium** **M**	**Large** **L**	**Extra-Large** **XL**
ORU maximum dimensions	100x200x300mm	200x200x300mm	300x300x300mm	1000x1000x1000mm
Typical form factor	6U	12U	27U	Medium size bulky elements
Rationale	Robotic tools for specific maintenance activities, compact equipments or subsystems (cameras, electronic boxes, platform standalone subsystems), nanosatellite spares			Medium size subsystems (e.g. propellant tanks) or payloads

Table 6 : ORU Mechanical dimension classes

4.1.2 Mass

The ORU from the ORU Provider shall comply with one of the following mass categories:

ORU Slot	**Small** **S**	**Medium** **M**	**Large** **L**	**Extra-Large** **XL**
ORU maximum mass	5kg	10kg	50kg	200kg

Table 7 : ORU Mass classes

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4.1.3 Handling & Fixation

4.1.3.1 Standard Interface

To be able to be mounted onto the Transporter spacecraft and handled post Transportation, the ORU shall be provided along with two passive standard interfaces on two of its external (ORU) sides.

The passive standard interfaces shall comply with [AD1] Space USB EU Standard.

The definition of the mounting location of the ORU onto the Transporter shall be reviewed & agreed by the Transporter.

4.1.3.2 HRM

To withstand mechanical launches, the ORU shall be provide along with a Hold on & Release Mechanism (HRM).

The definition of the supporting HRM shall be reviewed & agreed by the Transporter.

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4.2 Thermal

The ORU shall be designed to be thermally decoupled from the Transporter spacecraft.

The ORU shall be designed to receive Sun flux from any direction *(including the face of the fixation interface which can be illuminated during robotic transfer).*

Active thermal control, if any, shall be autonomous and shall **not** rely on Transporter spacecraft data acquisition/commanding.

The ORU thermal control shall not draw more than the allocated power budget specified in Section 4.3.1.

Any deviation to these Thermal requirements shall be reviewed & agreed by the Transporter before launch.

4.3 Electrical

4.3.1 Power

Power is distributed to the ORU using harness during the Transporter mission.

For each one of the ORU slot categories, the following power subcases have been defined and can be requested by the ORU Provider:

ORU Slot	**Extra-Small** **XS**	**Small** **S**	**Medium** **M**	**Large** **L**	**Extra-Large** **XL**
ORU maximum power	10W	20W	50W	100W	500W

Table 8 : ORU Power Consumption classes

4.3.2 Pin Allocation

The ORU pin allocation shall be compatible of a Standard Interface compliant with [AD1] Space USB EU Standard.

The exact definition of the pin allocation shall be co-engineered before launch, reviewed & agreed by the Transporter.

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4.3.3 Grounding

The ORU shall be electrically grounded, i.e. any conductive element shall offer a conductive path to an associated grounding line.

The strategy for ORU grounding shall be proposed by the ORU Provider, providing a grounding sketch at ORU level.

It shall be reviewed & agreed by the ORU Transporter.

4.3.4 Transfer Phase

During the ORU Transfer Phase from the Transporter to the Client, The ORU shall be designed to remain completely unpowered during transfer by the robotic arm for a duration not exceeding 90 minutes.

4.4 Command and Control

The ORU shall be commandable and controllable via a protocol as specified in [AD1] Space USB EU Standard.

4.5 Pointing

Since the ORU Transporter primary goal is not to operate the ORU in space (but to deliver it to a final ORU Client), pointing requirements will not be defined in this document.

If need be, technical discussions can be held between ORU Provider and ORU Transporter on pointing budgets & strategy – before launch.

Any technical need on pointing shall be reviewed & agreed by the Transporter before launch.

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4.6 EMC & ESD

4.6.1 EMC

The ORU shall comply with the requirements from ECSS-E-ST-20-07C.

This compliance could be dealt with at Transporter system level – in which case inputs would have to be provided by the ORU Provider to allow a coupled system EMC analysis & validation.

4.6.2 ESD

The ORU shall comply with the requirements from ECSS-E-ST-20-06C.

This compliance could be dealt with at Transporter system level - in which case inputs would have to be provided by the ORU Provider to allow a coupled system charging analysis & validation.

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5 MISSION INTEGRATION AND TRANSPORTATION SERVICE MANAGEMENT

5.1 Introduction

To provide the ORU Provider with smooth Transportation preparation, a customer-oriented mission integration and management process is implemented.

The mission integration and management process is consolidated through the mission documentation and revised during formal meetings and reviews.

5.2 Transportation service management

5.2.1 Contract organization

The contractual commitments between the Transporter (or Transport service provider) and the ORU Provider are defined in the following documentation:

- Statement of Work (SoW)
- ORU Technical Specification

The Statement of Work identifies the tasks and deliveries of the parties, and the Technical Specification identifies the technical interfaces and requirements.

At contract signature, a project manager from the Transporter is appointed to be the single point of contact with the ORU Provider. She/He is in charge of all aspects of the mission including technical and financial matters.

Besides the meetings and reviews described hereafter, the Transporter will meet the ORU Provider when required to discuss technical, contractual or management items. The following main principles will apply for these meetings:

- Dates, location and agenda will be defined in advance by mutual agreement.
- The designed host will be responsible for meeting organization.
- The participation will be open for both sides subcontractors and third companies by mutual preliminary agreement.

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5.2.2 Mission Integration Schedule

The mission integration schedule will be established in compliance with the milestones and launch date specified in the statement of work.

A typical mission integration schedule is shown here below in Table 3.

Note: Acronyms for reviews are being defined in Section 5.2.3.

	Month before launch													
	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1
Reviews	KO		ORU-CDR				ORU-IRR		ORU-IRB		FRR		L	IOCR
Procurement Phases														
Mission Analysis														
ORU Integration on Transporter vehicle														
Launch Campaign Preparation														
In-Orbit Commissioning														

Table 2 : Mission Integration Schedule – Typical

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5.2.3 Mission Documentation

Associated to these reviews and this typical schedule, critical documentation must be reviewed and agreed on both ends (the ORU provider and the Transporter). This ensures a smooth integration of the ORU onto the Transporter vehicle and leads towards a successful launch campaign and in orbit ORU delivery.

Review	Time line	ORU Provider required deliverables	Transporter required deliverables
Kick-Off (KO)	L-12	ORU Mechanical ICD (draft) ORU Electrical ICD (draft)	Mission plan (draft) Transporter Interface ICD (Mech & Elec) Statement of Work (SoW) ORU Technical Specification
ORU Critical Design Review (ORU-CDR)	L-10	ORU Mechanical ICD ORU Electrical ICD Mechanical coupled analysis Inputs Electromagnetic and RF compatibility analysis inputs ORU Integration & Test Spec ORU Mechanical & Electrical GSE for Integration on Transporter (Draft)	Mission Analysis (Draft) Launch Contract
ORU Integration Readiness Review (ORU-IRR)	L-6	ORU Mechanical & Electrical GSE for Integration on Transporter	Mechanical coupled analysis Results Electromagnetic and RF compatibility analysis Results ORU Integration Test Plan ORU Integration Plan
ORU Integration Review Board (ORU-IRB)	L-4		ORU Integration Test Report
FRR (Flight Readiness Review)	L-2		Mission Analysis Ground Segment & TT&C Plan
Launch (L)	L		Mission Status
In-Orbit Commissioning Review	L+1		Commissioning (ORU Delivery) Report

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5.2.4 Integration Phase

Following a successful ORU-IRR milestone, the Integration Phase will start at the ORU Transporter premises.

It is defined as mechanical & electrical integration of the ORU onto the Transporter spacecraft or vehicle.

This phase will be under the responsibility of the ORU Transporter with technical inputs provided by the ORU Provider as defined in Section 5.2.3 for reviews ORU.

In response, the ORU Transporter will provide Technical Inputs as defined in Section 5.2.3 for reviews ORU-IRR.

This documentation exchange shall be reviewed & agreed by the ORU Transporter which will make final decisions in case of conflict.

Regarding Ground Support Equipments (GSE) necessary to the Integration Phase, they shall be reviewed & agreed by the ORU Transporter.

At this stage, they are mission-specific and no GSE portfolio is available ahead of the project design phases.

5.2.5 Applicable Standards

Any space standard could potentially apply to the ORU mission. This shall be clearly stated at the Kick-Off milestone and indicated contractually in the Statement of Work and Technical Specification.

This document in itself is not a substitute to any broader space standard (e.g. ECSS Standards) that could be called in by the contractual mission-specific documentation.

END OF DOCUMENT

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