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Stratospheric Observatory

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LIST OF ABBREVIATIONS AND DEFINITIONS

Abbreviation	Definition
ACU	Attitude Control Unit
BLoS	Beyond Line of Sight
ESBO	European Stratospheric Balloon Observatory
FDMA	Frequency Division Multiple Access
FEE	Front End Equipment
GPS	Global Positioning System
GSE	Ground Support Equipment
ICD	Interface Control Document
IRS	Institute of Space Systems (Institut für Raumfahrtsysteme)
ISS	Image Stabilization System
LoS	Line of Sight
MIB	Mission Information Base
OBC	On Board Computer
OTA	Optical Tube Assembly
PBS	Product Breakdown Structure
Rx	Receive
SSC	Swedish Space Corporation
STUDIO	Stratospheric Ultraviolet Demonstrator of an Imaging Observatory
TBC	To be confirmed
TBD	To be determined
TC	Telecommand
TIP	Telescope Instruments Platform
TM	Telemetry
Tx	Transmit
UV	Ultraviolet
VPN	Virtual Private Network

REFERENCE DOCUMENTS

[RD1]	ESBO_DS-D10.1_1.0- Telescope Requirements Baseline and Interface Control Document_2018-09-29.docx
[RD2]	SCIPROJ-195965613-4 ESBO ICD, version 0.3, 2018-03-21, Issued by SSC
[RD5]	ECSS-E-ST-10-24C Space Engineering-Interface Management, 1 June 2015

1 INTRODUCTION

This document is to define the interfaces of the ESBO system. It introduces the internal and external interfaces of the balloon observatory infrastructure elements identified up to now and specifies them to the extent possible.

This Interface Control Document (ICD) will be further developed throughout the project.

1.1 SCOPE

The "Infrastructure elements" includes bus and payload, ground systems, data pipelines and interfaces to the users. It covers STUDIO, as the prototype mission, and any element foreseen for future infrastructure.

ESBO includes numerous elements and thus, when it comes to defining the interfaces, it is important to keep the information well-structured. To keep the information coherent in this version, and the information flow clear and logical, the document covers interfaces between different levels of product tree items for STUDIO. These levels are listed in the table below.

It should also be noted that this ICD covers technical interfaces. There are other programmatic and logistical interfaces which are not covered here.

The document only lists the interfaces and their defining parameters. Value of the interface parameters are not provided.

Table 1 PBS elements covered in ICD

Level 1	Level 2	Level 3	Level 4
Mission			
1000	Flight System		
	1100	Gondola/Bus	
		1110	Pointing & Image Stabilization System
		1120	Gondola Structure
		1130	Power Subsystem
		1140	OBC & Communication Subsystem
		1150	Gondola Thermal Control System
	1200	Scientific Payload	
		1201	Telescope Assembly Mass Dummy
		1210	Telescope
		1220	Telescope Instrument Platform
		1230	Visible Instrument
		1240	UV Instrument
		1260	Payload Thermal Control System
		1270	Payload Command & Data Handling
2000	Ground System		
	2100	Balloon/Gondola Ground Segment	
	2200	Payload Ground Segment	
3000	Scientific Users		

2 INTERFACE DEFINITIONS

2.1 INTRODUCTION

As explained previously, the interfaces are defined in four levels of the Product Breakdown Structure (PBS), as listed in Table 1:

- The first level defines the interfaces between the ESBO system and the external environment;
- The second level defines the interfaces between the flight system, the ground system and the users;
- The Third level defines the interfaces between Gondola and payload and between payload ground system and gondola ground system. Here in this level of interfaces, references to level 4 PBS elements also exists.

In the following sections, each level of interfaces is defined. While the interfaces would mostly be relevant to future missions as well, the specifications can be different. Thus, any values presented in this document are applicable to the STUDIO prototype mission, and not ESBO in general.

2.2 LEVEL 1 INTERFACES: INTERFACES BETWEEN ESBO SYSTEM AND EXTERNAL ENVIRONMENT

The highest level of technical interfaces are defined between the ESBO system as a whole and the external environment.

The table below lists the interfaces and the parameters to specify each. Each parameter should be specified by a responsible entity within the consortium. Those that are already known are specified here in this document. For the ones that are not specified yet, the responsible entity is mentioned.

Table 2 PBS Level 1 Interfaces

Interface	**Parameters**	**Responsible Entity for definition**
External Thermal Environment	Minimum external temperature	SSC
	Maximum external temperature	SSC
External Mechanical load	Mechanical loads during transport (random vibration levels)	SSC / IRS
	Mechanical loads during launch (vertical loads, all-direction loads)	SSC
	Mechanical loads at float condition (random vibration levels)	SSC
	Mechanical loads during landing (landing shocks in vertical and all directions)	SSC
Moisture levels	Maximum atmospheric humidity	IRS
Pressure levels	Minimum ambient pressure	SSC
Radiation levels	Maximum radiation exposure	SSC
Launch Interfaces	Launch location	IRS / SSC
	Launch window	IRS / SSC
Background brightness	Sun zenith angle	IRS
Swivel connection to flighttrain	Mechanical specifications	SSC
Ground mission operation system	Data security protection measures	IRS
	MIB[1] structure	IRS

[1] MIB refers to a database that defines mission related data for mission operations systems. It usually includes list of TM data and their identification numbers and upper-lower value boundaries, list of commands, events and so on.

external interfaces (in case service provider entities are used)	Software configurations	IRS
	Software interfaces to observation scheduling and payload data analysis modules	IRS

2.3 LEVEL 2 INTERFACES

The second level of interfaces includes interfaces between flight system, as a whole entity, ground system, as another whole entity, and also scientific users. In this context, users are mostly instrument providers (who will benefit from the images obtained directly, and define the observation requirements and real time processing requirements).

At this level interfaces mostly define the communication between these entities, in terms of data exchange and communication links. The system as used for STUDIO has two main communication systems. ELINK, which provides a LoS (Line of Sight) communication for the payload and gondola, and a BLoS (Beyond Line of Sight) Iridium system. The architecture of these two systems are shown below. It should be noted that in future implementations in the ESBO system, a single payload communication system (depending on the flight trajectory either only a LoS system of only a BLoS system) might be used. The parameters for the respective system will mostly remain the same, however.

Table 3 PBS Level 2 Interfaces

Interface	**Parameters**	**Responsible Entity for definition**
Flight-Ground interfaces	ELINK Antenna	SSC
	ELINK operating frequency band	SSC
	ELINK max. output power	SSC
	ELINK modulation	SSC
	ELINK channel bandwidth	SSC
	ELINK max. range LoS	SSC
	ELINK data bandwidth	SSC
	BLoS Antenna	SSC
	BLoS operating frequency Tx	SSC
	BLoS operating frequency Rx	SSC
	BLoS max. output power	SSC
	BLoS FDMA[2] spacing	SSC
	BLoS data bandwidth	SSC
	Switching criteria from ELINK to BLoS	SSC
	Payload flight-ground communication protocol	SSC, IRS
	Gondola flight-ground communication Protocol	SSC

[2] Frequency Division Multiple Access

	List of payload TM (incl. frequency of data capture)	IRS
	List of gondola TM (incl. frequency of data capture)	SSC
	Image downlink rate	Instrument Provider (Instrument dependent)
	List of payload TC	IRS
	List of gondola TC	SSC
GSE-Flight interfaces	GSE connection to flight system	SSC
	Electrical Power umbilical connector 1 type on the interface panel	SSC
	Electrical Power umbilical connector 1 position	SSC
	Electrical Power umbilical connector 2 type on the interface panel	SSC
	Electrical Power umbilical connector 2 position	SSC
	Umbilical power supply voltage	SSC
	Umbilical power supply current	SSC
	Electrical E-link Ethernet umbilical connector type on the interface panel	SSC
	Electrical E-link Ethernet umbilical connector position	SSC
	Electrical Flight computer umbilical connector type	SSC
	Electrical Flight computer umbilical connector position	SSC
User-Ground interfaces	Observational plan format	Instrument Provider (Instrument dependent)
	Image Archive structure and specifications (including access to the archive, data security, etc.)	Instrument Provider (Instrument dependent)
	Image metadata list	Instrument Provider (Instrument dependent)

2.4 LEVEL 3 INTERFACES

Within the third level, interfaces are defined in the flight system between scientific payload and gondola/bus elements, and in the ground system between the payload ground system and the gondola ground system. At this level the interfaces are very much design-dependent and mission-dependent, and may change in future missions significantly.

While a specific landing mechanism is not specified for STUDIO as of now, and the alternatives are still being assessed, the interfaces are included in this section. Depending on the final design decision for this element, these interfaces might or might not materialize for STUDIO. They are, for this reason, listed in a different subsection.

Interfaces in this level are defined in several categories, including data exchanges and software, electrical, mechanical, and thermal interfaces, each of which is listed in a separate section.

2.4.1 DATA EXCHANGE BETWEEN GONDOLA AND PAYLOAD

Payload onboard software communicates with the gondola Attitude Control Unit (ACU) for successful pointing and stabilization. The data interfaces between gondola and payload are listed in the table below.

Table 4 data interfaces between STUDIO payload and gondola

Interface	**Parameters**	**Responsible Entity for definition**
Data exchange from payload OBC to gondola ACU	Pointing commands Data packet format (to ACU)	SSC
	Frequency/triggers of data provision	SSC
Data exchange from ACU to payload OBC	Telescope actual pointing offset frequency of data exchange	SSC
	Telescope actual pointing offset data packet format	SSC
	Telescope actual drift velocity frequency of data exchange	SSC
	Telescope actual drift velocity data packet format	SSC
	GPS data frequency of data update	SSC
	GPS data packet format	SSC

2.4.2 ELECTRICAL INTERFACES BETWEEN GONDOLA AND PAYLOAD

Payload and gondola have several electrical connections listed below. Interfaces also include power consumptions.

Table 5 Electrical Interfaces between STUDIO payload and gondola

Interface	**Parameters**	**Responsible Entity for definition**
Power consumptions	Payload maximum power consumption	IRS
	Payload average power consumption	IRS
Power distribution specifications	Voltage lines provided to payload (voltage levels and number of lines)	IRS
	Overcurrent protections	IRS
Connector specifications (Identifiers, function, type, number of pins, gender, part numbers if available, any coding, connector pin descriptions)	Payload OBC to LoS connector specifications	IRS-SSC
	Payload OBC to BLoS connector specifications	IRS-SSC
	Payload OBC to gondola ACU connector specifications	IRS-SSC
	Payload power module to gondola power unit connector specifications	IRS-SSC
	Landing mechanism electrical connection specifications	SSC
Wiring between payload units and gondola units (cable types, wire gauges, colour coding, shielding of cables, max./min. length of cables)	Payload OBC to LoS wiring	IRS-SSC
	Payload OBC to BLoS wiring	IRS-SSC
	Payload OBC to ACU wiring	IRS-SSC
	Payload OBC to gondola power unit wiring	IRS-SSC

2.4.3 THERMAL AND OPTICAL INTERFACES BETWEEN GONDOLA AND PAYLOAD

Some of the optical and thermal characteristics of gondola may affect the thermal and optical design of the payload telescope. The interfaces expected are listed in the table below.

Table 6 Optical and thermal interfaces between gondola and payload

Interface	**Parameters**	**Responsible Entity for definition**
Thermal interfaces	Thermal expansion coefficient of the mechanical interface between OTA and gondola	IRS
	Material of the mechanical interface between OTA and gondola (thermal conductivity, thermal contact resistance)	IRS
	Radiator mounting angle on the gondola bay	SSC IRS
Optical interfaces	Optical properties of the gondola internal surfaces (e.g. reflectivity)	SSC
	Geometrical model of gondola suitable for thermal simulations, or alternatively expected temperature distribution over internal surfaces over mission duration.	SSC IRS

2.4.4 MECHANICAL INTERFACES BETWEEN GONDOLA AND PAYLOAD

Mechanical interfaces between gondola and payload include mass specifications, alignments, mounting interfaces for different elements, and telescope geometrical envelope in different modes.

Table 7 Mechanical interfaces between STUDIO payload and gondola

Interface	**Parameters**	**Responsible Entity for definition**
Mass specifications	elevation-controlled payload mass	IRS
	Non elevation-controlled payload mass	IRS
	OTA moment of inertia	IRS
	OTA center of gravity	IRS
OTA geometrical envelope	In non-operational mode	IRS
	In operational mode	IRS
Geometric constraints/ Conversion between gondola and payload reference frames	Conversion matrices	IRS-SSC
Telescope alignment with respect to gondola	Positional tolerances	IRS
	degrees of freedom between the corresponding reference frames	IRS
Telescope mounting	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Applied/allowable torques levels	IRS
Telescope lid mounting	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Applied/Allowable torque levels	IRS
Payload instrument radiator mounting	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Applied/allowable torque levels	IRS

Payload instrument cooling circuit mounting	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Min. bending radius	IRS
	Max. torque onto elevation axis	IRS
Payload electronics equipment mounting in the gondola electronics bay (separately specified for each equipment mounting)	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Applied/allowable torque levels	IRS
Star tracker mounting on the OTA	Mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	IRS
	Applied/allowable torque levels	IRS

2.4.5 INTERFACES BETWEEN GONDOLA GROUND SEGMENTAND PAYLOAD GROUND SEGMENT

The payload ground segment is connected to the ground station of the gondola through a VPN connection provided by the gondola ground segment. The interfaces between the two ground elements depend on which software solution is used for payload: if payload ground operations system uses the same ground network as gondola or a separate network and solution.

Table 8: Interfaces between STUDIO payload ground segment and gondola ground segment

Interface	**Parameters**	**Responsible Entity for definition**
Payload ground segment connection to ground station	Communication protocol	SSC
	Data rate	SSC
Time synchronization interface between payload and gondola mission operations systems (in case systems are on different networks)	Sync rate	SSC
	Time exchange format	SSC
Gondola ground network monitoring module interfaces (in case systems are on one network)	Data exchange format	SSC
	Data frequency	SSC

2.4.6 INTERFACES OF THE LANDING SYSTEM

The landing system interfaces are generally defined here. Future design decisions for this element will define these interfaces in more details.

Table 9 Landing system interfaces

Interface	**Parameters**	**Responsible Entity for definition**
Landing mechanism mechanical interfaces	Attachment and mounting hardware technical drawing (incl. hole/thread patterns, form closures, etc.)	SSC
	Supported mass	SSC
Landing mechanism data interfaces	Mechanism controller data exchange items (e.g. control commands for steerable systems)	SSC
	Data packet formats, data exchange triggers and frequency of data exchange	SSC
Landing mechanism electrical interfaces	Electrical connectors to the ACU specifications	SSC
	Power consumption	SSC
	Power distribution interfaces (voltage, current, protections)	SSC