

Experiment Cube to ICE Cubes Service ICD Template

ICE Cubes




Title : Experiment Cube to ICE Cubes Service ICD Template

Abstract : This ICD Template defines the base for the generation of the Experiment Cube-specific Interface Control Document (ICD).



International Commercial
Experiments Service

Experiment Cube to ICE Cubes Service ICD Template

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DOCUMENT CHANGE RECORD				
Version	Date	Author	Changed Sections / Pages	Reason for Change / RID No
1.0.0	29-Aug-2018	T. Peignier		Initial issue
1.1.0	27-Mar-2019	T. Peignier	§1.5, §2.3, §2.5, §3.2, §3.4, §3.5, §3.6, §3.9, §3.11.6, §3.11.8, §3.11.10, §3.12, §3.13	Update to reflect version 1.4.1 of the IRD [AD1]; Editorial corrections
1.2.0	12-Mar-2020	T. Peignier	§3.9.1	Update to reflect version 1.6.0 of the IRD [AD1]

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1 Introduction

1.1 Purpose and Scope

This ICD Template defines the base for the generation of the Experiment Cube-specific ICD. The purpose of the ICD Template is to give a template for the implementation of a common structure for all ICDs between the Experiment Cubes and the ICE Cubes Service, namely:

- Between the Experiment Cube itself and the ICE Cubes Facility (ICF) on board the International Space Station (ISS), and
- Between the Experiment Cube User Home Base (UHB) and the ICE Cubes Mission Control Centre (ICMCC) on ground.

One unique ICD will be generated for each Experiment Cube. It will be based on this ICD Template.

Inputs from the Experiment Cube Developer (ECD) are required for the different budgets, the utilization of ICE Cubes interfaces and the description of the interface implementation on the Experiment Cube / UHB side.

Inputs from the ICE Cubes Service are mainly related to the definition of the Experiment Cube allocations (power, data).

The Experiment Cube-specific ICD will contain all information on the individual subsystems/devices of the Experiment Cube, and all budgets related to the Experiment Cube, and will describe the mechanical, electrical and communication interfaces of the Experiment Cube with the ICE Cubes Service.

1.2 Notation / Experiment Cube Overview

Instructions for the Experiment Cube developer to complete the ICD Template are written with **grey highlighted text**. This text shall be replaced by the requested information or deleted in the Experiment Cube-specific ICD.

Value shall be provided by the Experiment Cube Developer (ECD).

m, n Value shall be provided by the ECD for each case/item.

optional Shall be filled in by the ECD.

Note: This chapter is to be deleted from the Experiment Cube-specific ICD and should be replaced by an overview of the Experiment Cube.

1.3 Document Structure

This ICD defines the Experiment Cube interfaces to the ICF, the used ICE Cubes services and the related Experiment Cube budgets.

In addition to this document, if applicable, interfaces of the Experiment Cube inside the Columbus module and/or the launch vehicle may be documented in another ICD, and attached as Appendix B.

1.4 Applicable Documents

AD1 Space Applications Services – ICE Cubes Facility to Experiment Cube IRD, ICU-SA-RQ-004, latest version

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1.5 Reference Documents

RD1 The ECD shall add RDs (e.g. reference to reports) as needed <TBD 1.5-1 by ECD>

1.6 Acronyms

AD	Applicable Document
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
CoG	Centre of Gravity
CTB	Cargo Transfer Bag
DC	Direct Current
DDS	Data Distribution Service
ECD	Experiment Cube Developer
EPM	European Physiology Module
ESA	European Space Agency
GRE	Generic Routing Encapsulation
H&S	Health & Status
HTTP	Hypertext Transfer Protocol
HTTPS	HTTP Secure
ICD	Interface Control Document
ICE Cubes	International Commercial Experiment Cubes
ICF	ICE Cubes Facility
ICMCC	ICE Cubes Mission Control Centre
ICMP	Internet Control Message Protocol
IP	Internet Protocol
IRD	Interface Requirements Document
IRN	Interface Revision Notice
ISS	International Space Station
LAN	Local Area Network
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NTP	Network Time Protocol
OS	Operating System
P/N	Part Number
RD	Reference Document
RDP	Remote Desktop Protocol
RFB	Remote Framebuffer
RID	Review Item Discrepancy
RTCP	RTP Control Protocol
RTP	Real-time Transport Protocol
RTPS	Real Time Publish Subscribe
RTSP	Real Time Streaming Protocol
SFTP	SSH File Transfer Protocol
S/N	Serial Number
SPL	Sound Pressure Level
SSD	Solid State Drive
SSH	Secured Shell
SSL	Secure Sockets Layer
TBD	To Be Determined
TC	Telecommand
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TM	Telemetry
U	Unit (= 10 x 10 x 10 cm)

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UDP	User Datagram Protocol
UHB	User Home Base
USB	Universal Serial Bus
VNC	Virtual Network Computing
VPN	Virtual Private Network
WLAN	Wireless Local Area Network

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2 Experiment Cube Configuration

This section describes the Experiment Cube configuration. The detailed information on the interfaces are to be described in the following sections of the ICD.

2.1 Experiment Cube On-Orbit Configuration

<TBD 2.1-1 by ECD>

The ECD shall describe the configuration of the Experiment Cube in the ICF. The accommodation of all items (if the Experiment Cube comprises several items) shall be depicted. Any support equipment and/or harness and/or USB flash drive shall be included.



Figure 1 Experiment Cube on-orbit configuration

<TBD 2.1-3 by ICE Cubes Service>

The ICE Cubes Service shall define, with the ECD's agreement, the position of the Experiment Cube onto the ICF (e.g. ICF J01 to J21).

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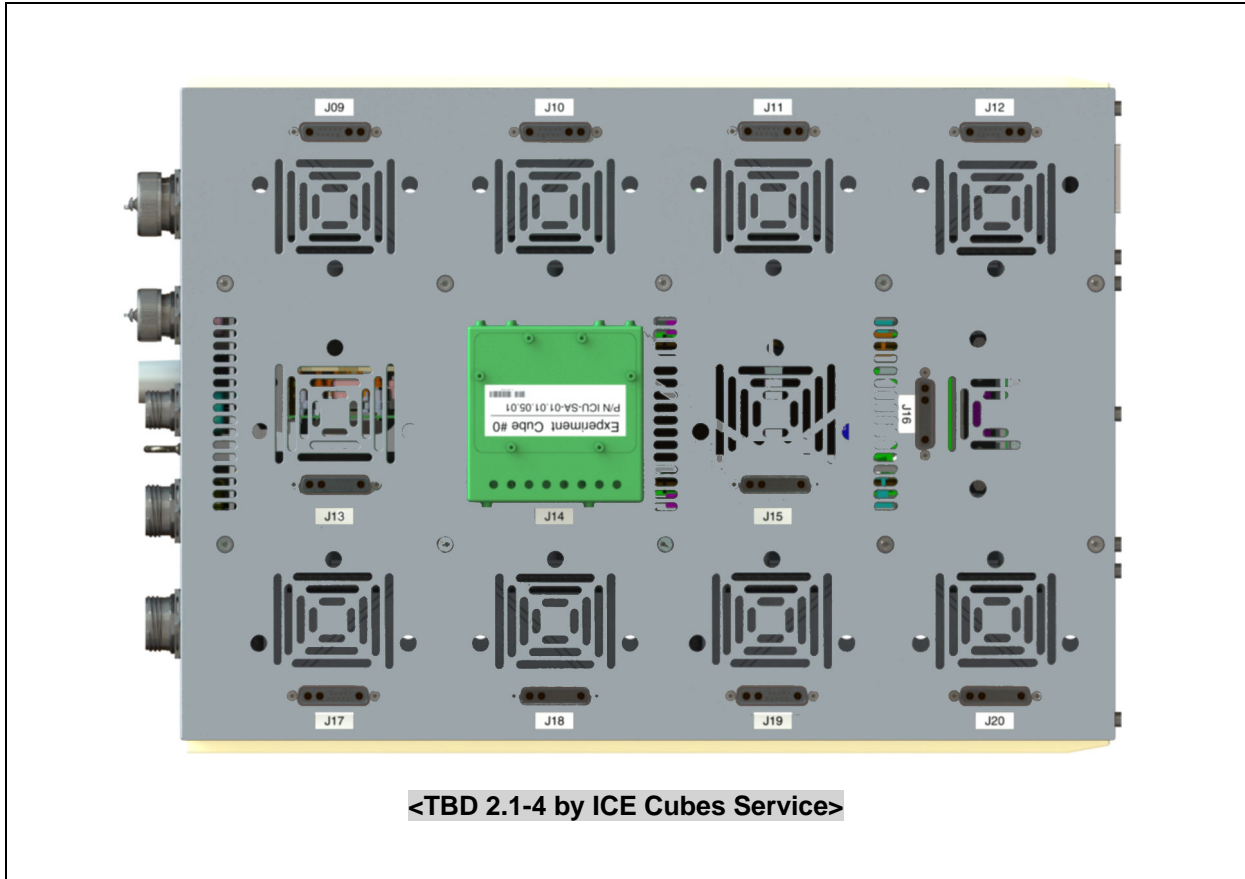


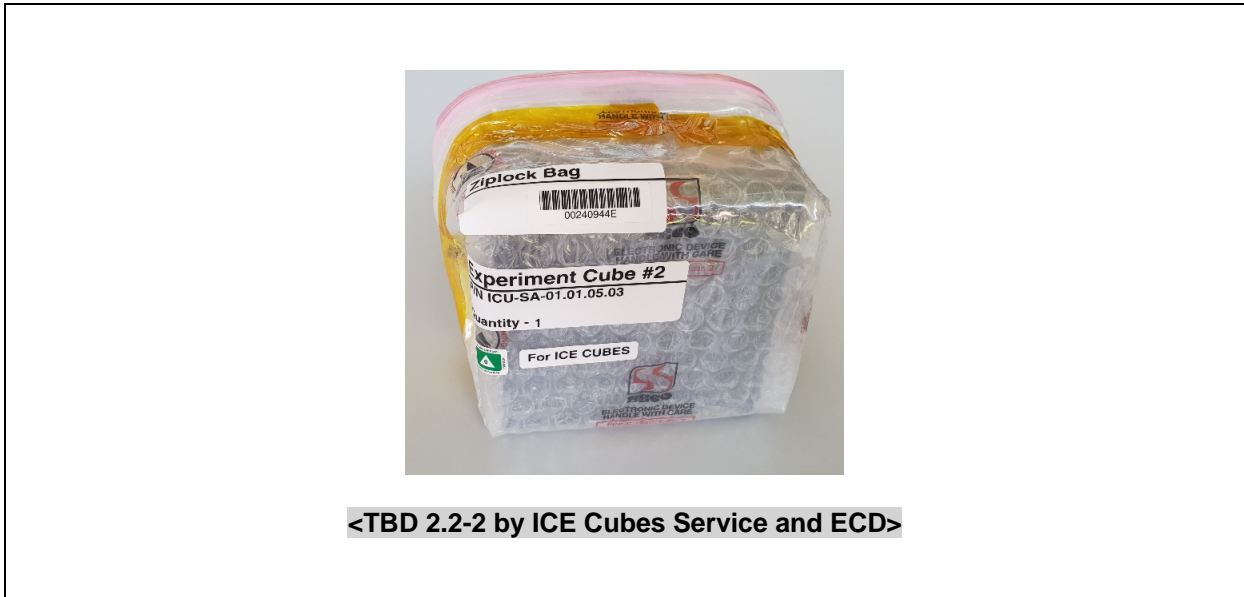
Figure 2 Experiment Cube on the ICF

2.2 Experiment Cube Launch (and Return) Configuration

<TBD 2.2-1 by ECD and ICE Cubes Service>

The launch configuration shall be described. Unless otherwise specified, the default launch (and return, if applicable) configuration is the same as the on-orbit configuration wrapped into a bubblewrap ziplock bag. For launch (and return), the packed hardware can for example be accommodated in a Cargo Transfer Bag (CTB).

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<TBD 2.2-2 by ICE Cubes Service and ECD>

Figure 3 Experiment Cube launch (and return) configuration

2.3 Experiment Cube Items

<TBD 2.3-1 by ECD>

The ECD shall fill in the following tables and provide figures for all items belonging to the Experiment Cube, including umbilical, spares and consumables, if any. In agreement with the ICE Cubes Service, the coordinate system for the Experiment Cube may be different than the one pictured in Figure 4.

Table 1 Items composing the Experiment Cube and unit masses

Item P/N	Description	Quantity	Unit Mass
TBD	Experiment Cube ###	1 (TBC)	#.## kg
		TBD	#.## kg
		TBD	#.## kg

Table 2 Experiment Cube items dimensions and CoG

Item P/N	Width (X)	Length (Y)	Height (Z)	X _{CoG}	Y _{CoG}	Z _{CoG}
TBD	# mm	# mm	# mm	# mm	# mm	# mm
	# mm	# mm	# mm	# mm	# mm	# mm
	# mm	# mm	# mm	# mm	# mm	# mm

Note: The above-listed dimensions do not include the small protrusions from the Cube external walls such as connector(s), feet and screw heads.

Experiment Cube to ICE Cubes Service ICD Template

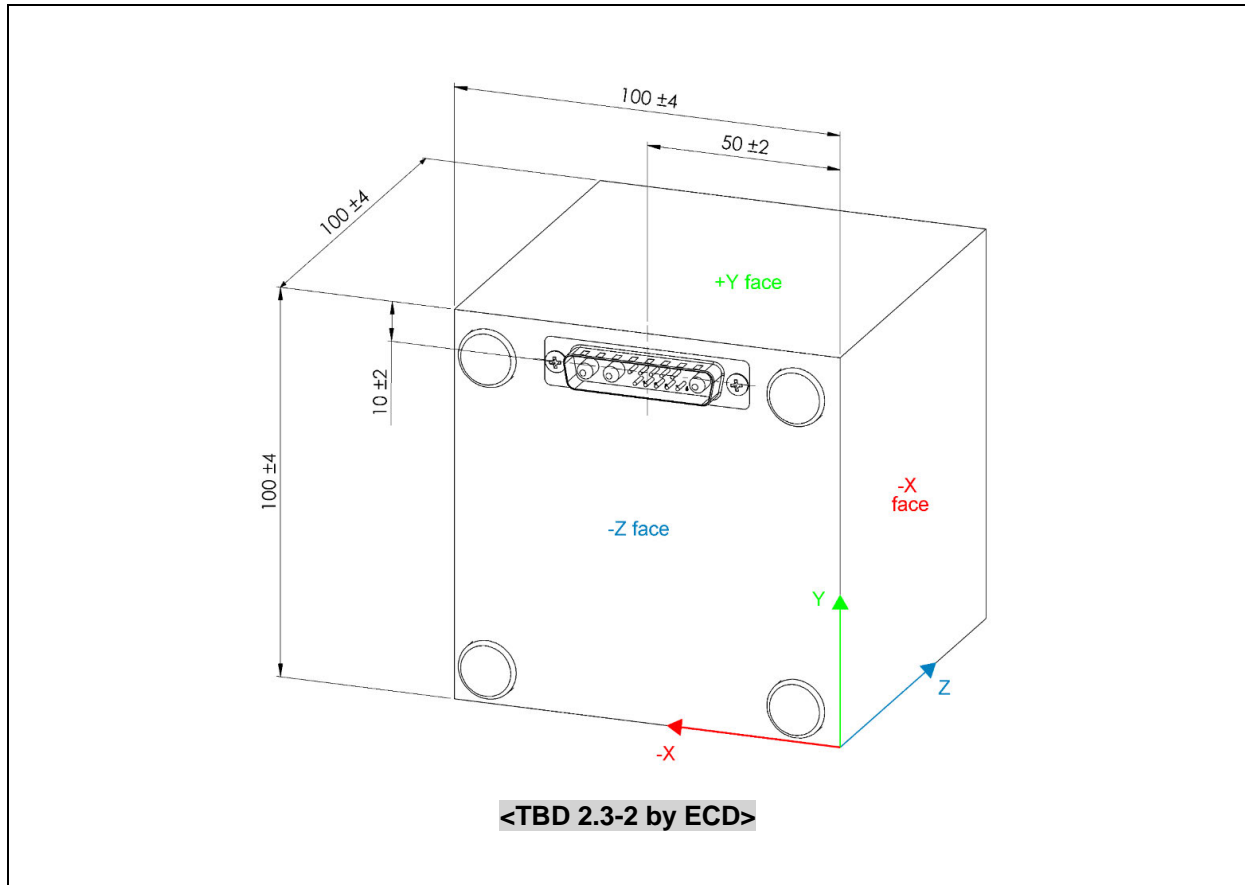


Figure 4 Experiment Cube dimensions and coordinate system

2.4 Special On-Orbit Stowage Requirements

<TBD 2.4-1 by ECD>

In case items need to be stowed (the Experiment Cube itself may for example be stowed between its arrival on board the ISS and its installation on the ICF, or upon its removal from the ICF), specific stowage requirements (e.g. temperature range) shall be given by the ECD for the items listed in §2.3. Otherwise “None” shall be written.

2.5 Special On-Orbit Operational Constraints

<TBD 2.5-1 by ECD>

In case required, specific operational constraints (e.g. maximum time between on-orbit arrival and installation on the ICF, maximum allowed time without power, etc.) shall be given by the ECD. Otherwise, “None” shall be written.

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3 Experiment Cube Interfaces

3.1 Experiment Cube Connectors

<TBD 3.1-1 by ECD>

The ECD shall provide a list of the connectors accessible by the astronauts on the Experiment Cube items, regardless if these connectors are wired or not. In case the Experiment Cube has only one connector, §3.1 and §3.1.1 can be merged.

Table 3 Experiment Cube connectors

ID	Connector Type	Function	Location	Remark
TBD	DB13W3P	Gigabit Ethernet + 5V/12V power	Experiment Cube +Z face	For connection to ICF J##

3.1.1 Connector n

This section shall be repeated for each connector.

<TBD 3.1.n-1 by ECD>

The ECD shall provide figure(s) and pinout diagram(s) of the Experiment Cube connector(s) accessible by the astronauts (i.e. of the DB13W3P connector if that is the only one), regardless if these connectors are wired or not.



Figure 5 Experiment Cube connector n: DB13W3P male plug

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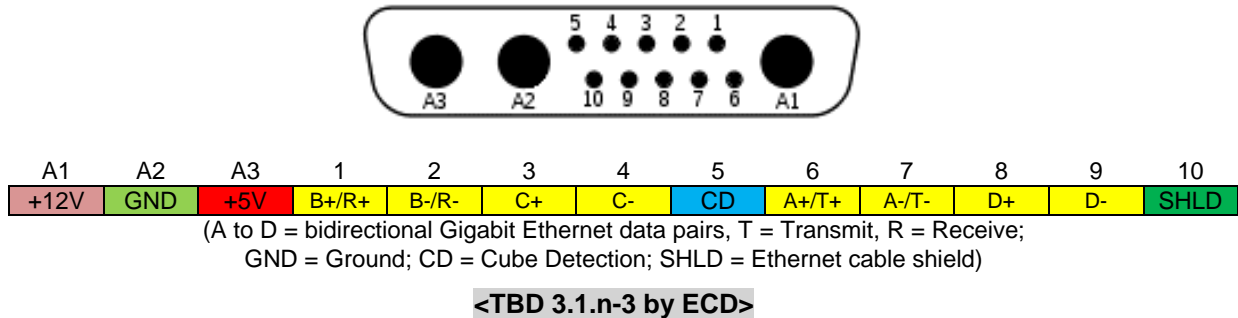


Figure 6 Experiment Cube connector n pinout diagram

The Cube Detection resistance (measured between pin 5 and pin A2 of the DB13W3 connector, cf. Figure 6) is <TBD 3.1.n-4 by ICE Cubes Service> Ω.

3.2 Experiment Cube Protrusions

<TBD 3.2-1 by ECD>

The ECD shall describe the objects or elements (including the DB13W3P connector and feet) protruding from the external walls of the Experiment Cube. Figures shall be provided as well. For an “external” Experiment Cube (e.g. connected on the ICF connector J21), this section is not applicable and may be replaced by a more appropriate one.

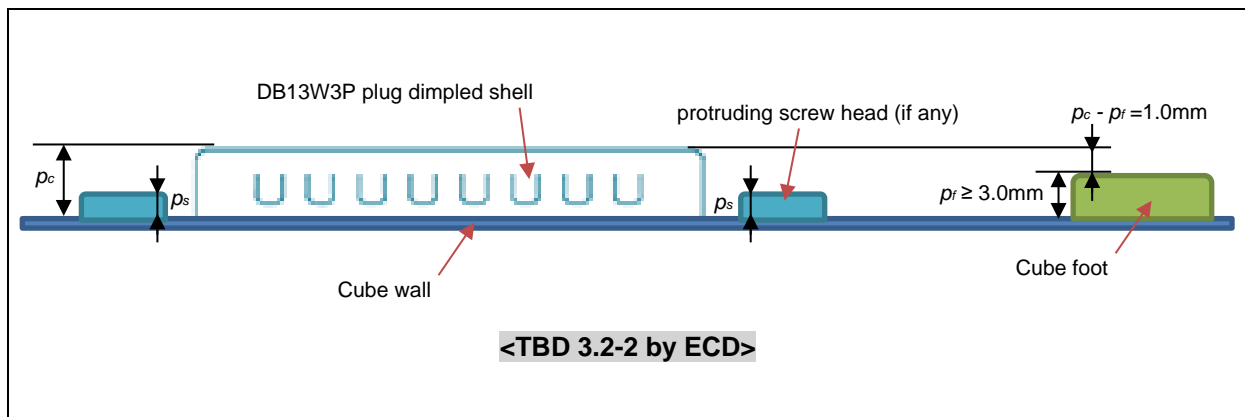


Figure 7 Protrusion of the connector n and feet from the Experiment Cube wall

3.3 Experiment Cube Fins, Vents and Fans

<TBD 3.3-1 by ECD>

The ECD shall describe the objects or elements which have the potential to significantly alter the direction and/or speed of the forced air flow around the Experiment Cube, if any. Otherwise “None” shall be written. For an “external” Experiment Cube (e.g. connected on the ICF connector J21), this section is not applicable and may be replaced by a more appropriate one.

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3.4 Operational Cases

The Experiment Cube audible noise, electrical usage, thermal load and data rate (<TBC 3.4-1 by ECD: delete as appropriate) are dependent on the different operational cases. In this section the Experiment Cube operational cases are defined. The Experiment Cube has <TBD 3.4-2 by ECD> operational cases.

3.4.1 Experiment Cube Operational Case m

This section shall be repeated for each operational case.

<TBD 3.4.m-1 by ECD>

A description of the operational case m shall be given.

3.5 Audible Noise

<TBD 3.5-1 by ECD>

The ECD shall provide the Sound Pressure Level (SPL) generated by the Experiment Cube items for each operational case and in particular for the worst operational case (i.e. the operational case for which the audible noises are the loudest) measured at the required distance from the noisiest Experiment Cube face, or explain why Experiment Cube items did not require to be tested.

Table 4 Noise measured at TBD m from the Experiment Cube

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
SPL	# dB _L	# dB _L	# dB _L	# dB _L	# dB _L	# dB _L	# dB _L	# dB _L

3.6 Experiment Cube Grounding, Bonding & Isolation

<TBD 3.6-1 by ECD>

The ECD shall describe the grounding (i.e. ground return) and bonding (i.e. chassis ground) strategy, e.g. using figure(s), and define the bonding and isolation resistances/couplings according to section 3.5.1 (grounding, bonding & isolation) of the IRD [AD1].

Table 5 Experiment Cube bonding and isolation

Bonding Path	Requirement	Measured Value
Pin A3 ⇔ pins A2, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (if +5V is not used)	> 10MΩ	# MΩ
Pin A1 ⇔ pins A2, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (if +12V is not used)	> 10MΩ	# MΩ
DB13W3P shell ⇔ pins A1, A2, A3, 1, 2, 3, 4, 5, 6, 7, 8, 9	> 10MΩ	# MΩ
DB13W3P shell ⇔ pin A1	< 220nF	# F
DB13W3P shell ⇔ pin A2	< 220nF	# F

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Bonding Path	Requirement	Measured Value
DB13W3P shell ↔ pin A3	< 220nF	# F
Structure ↔ structure (if applicable)	≤ 2.5mΩ	# mΩ
Structure ↔ DB13W3P shell (if applicable)	≤ 2.5mΩ	# mΩ
Pin 10 ↔ DB13W3P shell (if applicable)	≤ 7mΩ	# mΩ

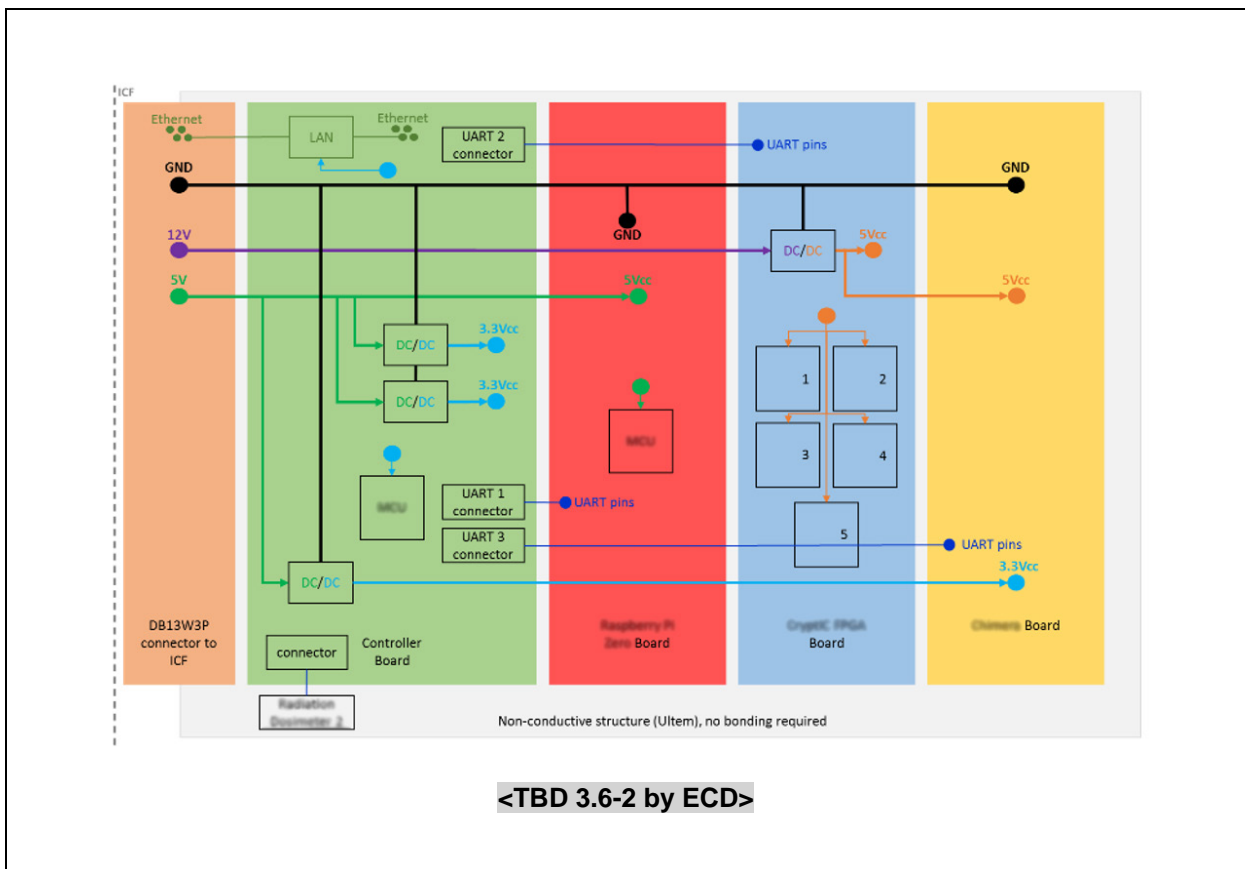


Figure 8 Experiment Cube electrical and grounding block diagram

3.7 Experiment Cube Electromagnetic Interference (EMI)

<TBD 3.7-1 by ECD>

The ECD shall provide evidence of compliance to the relevant requirements in section 3.5.2 (electromagnetic interference) of the IRD [AD1] (e.g. reference to test report, assessment, etc.).

3.8 Experiment Cube DC Magnetic Fields

<TBD 3.8-1 by ECD>

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The ECD shall provide the measured DC magnetic field emission for the Experiment Cube items in the worst operational case (i.e. the operational case for which the emissions are the highest), or explain why Experiment Cube items did not require to be tested.

Table 6 DC magnetic field emission measurements at 7 cm (highest value per face)

Experiment Cube	-X face	+X face	-Y face	+Y face	-Z face	+Z face
Unpowered	# μ T	# μ T	# μ T	# μ T	# μ T	# μ T
Operational case m	# μ T	# μ T	# μ T	# μ T	# μ T	# μ T

3.9 Power Interface (ICF J01 to J21)

The Experiment Cube power budget allocation is defined in the following sections for each operational case as defined in §3.4. The typical/average Experiment Cube power is indicated in the column 'Power Allocation'. The column 'Peak Power Allocation' defines the maximum power allocation for a time period from 1 second to 15 minutes.

<TBD 3.9-1 by ECD>

The ECD shall specify if, after a loss of power (not linked to Cube tripping), the re-powering of the Experiment Cube upon ICF reboot shall be done automatically or not.

3.9.1 Power Budget for Operational Case m

<TBD 3.9.m-1 by ECD>

This section shall be repeated for each operational case (add lines for additional power interfaces as needed).

Table 7 Experiment Cube power allocation for operational case m

ICF Interface	Power Allocation	Peak Power Allocation
+5V, 1A (ICF J01 to J21)	# W	# W
+12V, 3.1A (ICF J01 to J21)	# W	# W

3.10 Thermal Interface

<TBD 3.10-1 by ECD>

For each operational cases (described in §3.4), the ECD shall describe the thermal load. Depending on the Experiment Cube characteristics, it could for example be assumed that all electrical power consumed by the Experiment Cube is transformed into heat, evenly distributed on all Experiment Cube external surfaces.

The ECD shall specify if an Experiment Cube surface or a particular element on a surface will get e.g. hotter or colder, the estimated temperatures, and if the Experiment Cube can generate additional heat than that dissipated from the electrical power. See also sections 3.2.1.3 (thermal environment) and 3.3 (thermal requirements) of the IRD [AD1]. Figures from thermal models may be provided.

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3.11 Data, Communication and Software Interface

3.11.1 Gigabit Ethernet Interface (ICF J01 to J21)

<TBD 3.11.1-1 by ECD>

The ECD shall describe whether the Ethernet interface (pins 1 to 4 and 6 to 9 of the DB13W3 connector, cf. Figure 6) is used, the support of 10/100/1000base-T auto-negotiation, its data transmission rate capability (e.g. Gigabit Ethernet, 100 Mbit/s...), and provide the MAC address of the Experiment Cube.

3.11.2 Auxiliary LAN Interface (ICF J22)

<TBD 3.11.2-1 by ECD>

The ECD shall describe the way in which the auxiliary LAN interface on the ICF is used. Otherwise, "Not used" shall be written.

3.11.3 USB 3.0 Interface (ICF J23 and J24)

<TBD 3.11.3-1 by ECD>

The ECD shall describe whether the USB interface (e.g. for a USB flash drive) on the ICF is used, and the characteristics of the USB device to be connected. Datasheet of the USB device may be annexed.

3.11.4 Wi-Fi Interface

<TBD 3.11.4-1 by ECD>

The ECD shall describe whether any Experiment Cube item makes use of the ICF WLAN interface, and give the characteristics of the interface (transmission rate capability, MAC address, antenna characteristics...).

3.11.5 Data Traffic

<TBD 3.11.5-1 by ECD and ICE Cubes Service>

The allocated Experiment Cube data rates are to be agreed with the ICE Cubes Service, either as flat rates during the whole mission, or with a timeline (e.g. within each 24-hour period, or within the mission duration), or for each operational cases (described in §3.4). These values will not be exceeded during the Experiment Cube mission.

Table 8 Experiment Cube data rates

ICF Interface	Data Rates		Allocated Data Rates	
	Up	Down	Up	Down
Gigabit Ethernet (ICF J01 to J21)	# Mbit/s	# Mbit/s	# Mbit/s	# Mbit/s
Aux. LAN (ICF J22)	# Mbit/s	# Mbit/s	# Mbit/s	# Mbit/s
USB 3.0 (ICF J23 & J24)	# Mbit/s	# Mbit/s	N/A	N/A
Wi-Fi (ICF WLAN)	# Mbit/s	# Mbit/s	# Mbit/s	# Mbit/s

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3.11.6 Data Storage and Data Synchronisation Service

<TBD 3.11.6-1 by ECD and ICE Cubes Service>

The ECD and the ICE Cubes Service shall define and agree on the total amounts of data which will be stored on the different storage devices (ICF Data SSD storage on board; ICMCC server storage on ground).

<TBD 3.11.6-2 by ECD>

The ECD shall specify whether the data synchronisation service is used (cf. §3.6.2, §4.2.3.1 and §4.2.3.2 of the IRD [AD1]), and the expected usage characteristics (e.g. data amounts, frequency, etc.).

3.11.7 Data & Communication Protocols

<TBD 3.11.7-1 by ECD and ICE Cubes Service>

The table below shall be filled by the ECD depending on which software interfaces will be used by the Experiment Cube items. The remark column can be filled optionally.

Table 9 Internet protocols used by the Experiment Cube

Internet Layer	Transport Layer	Application Layer	Used	Remark
ICMP			yes /no	
IPv4	TCP	HTTP	yes /no	
		HTTPS/SSL	yes /no	
		Opus	yes /no	
		RDP	yes /no	
		SSH	yes /no	
		SFTP, SSH	yes /no	
		SSL/TLS	yes /no	
		VNC/Remote Desktop, RFB	yes /no	
		mobiNET (proprietary)	yes /no	
		VP8/HTTP	yes /no	
		Other (specify)	yes /no	
IPv4	UDP	CFDP, CCSDS Stack	yes /no	
		DDS, RTPS	yes /no	
		RTP, RTCP	yes /no	
		RTSP	yes /no	
		Other (specify)	yes /no	
IP	GRE	GRE	yes /no	

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3.11.8 UHB to ICMCC Interface

<TBD 3.11.8-1 by ECD and ICE Cubes Service>

The table below shall be filled by the ECD and the ICE Cubes Service depending on which software interfaces will be used by the UHB. The remark column can be filled optionally.

Table 10 Software interfaces

ICMCC Service	Used	Remark
VPN connection via Internet to ICMCC	yes / no	
ICMCC NTP service (UTS time synchronisation)	yes / no	
Data synchronisation service	yes / no	
TCP connection to Experiment Cube private IP	yes / no	
UDP connection to Experiment Cube private IP	yes / no	
HTTP server for housekeeping (HK) data	yes / no	
HTTP server for planning and support	yes / no	

The table below shall be filled by the ECD. Unless otherwise noted, it is assumed that the persons responsible for the eToken are also the contact persons for any operational aspects during the mission in orbit.

Table 11 VPN e-token(s) used by the UHB

e-token S/N	UHB OS	Responsible person
#####	MacOS/Windows/Linux, 32/64 bits	<TBD 3.11.8-2 by ECD> name(s), function(s) and contact detail(s) of the persons that is/are responsible of the e-token(s) until the end of the Cube mission shall be filled by the ECD
#####	MacOS/Windows/Linux, 32/64 bits	

3.11.9 Additional Telemetry

<TBD 3.11.9-1 by ECD and ICE Cubes Service>

If needed, the ECD shall list the telemetry to be received by the UHB which is not coming from the Experiment Cube itself (e.g. air temperature, microgravity level). The appropriate level of details (e.g. frequency, accuracy) shall also be identified. This list, to be agreed with the ICE Cubes Service, can only comprise telemetry already available (e.g. from the ICF itself, ESA or NASA).

3.11.10 Software Security

<TBD 3.11.10-1 by ECD >

If applicable, the ECD shall provide information about the OS and antimalware software running/active on the Experiment Cube. In particular, the following shall be described: the OS type, version and hardening strategy; the plan to periodically perform antivirus scans and update the virus signature

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definitions list in orbit; the likelihood (if any) to update the OS in orbit. It is advised to also add the latest date at which an antivirus scan of the entire system has been performed (with no threat found).

3.12 Experiment Cube Items Nomenclature, Labels and Decals

<TBD 3.12-1 by ICE Cubes Service or ECD>

Unless otherwise agreed, the ICE Cubes Service will provide the ISS-approved labels for the Experiment Cube items to the commercial ECD.

If a dedicated label plan for the Experiment Cube items exists, this chapter can be substituted by a reference to that document. A complete list of all labels and decals shall be provided, with an example of the label / decal, the measures, the font and font size in the table below, next to a figure of each label.

<TBD 3.12-2 by ECD and ICE Cubes Service>

Table 12 Experiment Cube Items Identification

OpNom	Engineering Name	P/N	S/N	Barcode
Experiment Cube ###				

<TBD 3.12-3 by ICE Cubes Service and/or ECD>

Table 13 Experiment Cube Labels/Decals

Label ID	Label Dimensions / Reference	Content	Quantity*	Position(s)
01	2.00" x 1.00" [50.8 mmx 25.4mm] SDG32108325-033	Experiment Cube ### ----- -- P/N ##### [barcode]	1	Experiment Cube +Z face
02	3.00" x 1.00" [76.2 mm x 25.4 mm] SDG32112286-002	Experiment Cube ### ----- -- P/N #####	1	Launch bag
03	2.50" x 1.00" [63.5mm x 25.4mm] SDG32112207-001	Ziplock Bag	1	Launch bag
04	1.05" x 0.50" [26.7mm x 12.7mm] SDG32105720-061	[barcode]	1	Launch bag

Experiment Cube to ICE Cubes Service ICD Template

Label ID	Label Dimensions / Reference	Content	Quantity*	Position(s)
05	2.00" x 0.30" [50.8mm x 7.6mm] SDG32112252-003	For ICE CUBES	1	Launch bag
06	0.59" x 0.47" [15.0mm x 12.0mm] SKD39123122-2###	Non/Hazardous Material #	2	Experiment Cube +Z face and launch bag
07	2.88" x 1.25" [72.6mm x 31.8mm] SDG32104806-006	Caution, parts and assemblies sensitive to electrostatic discharge	2	Experiment Cube -Z face and launch bag
08				

* not including spare labels

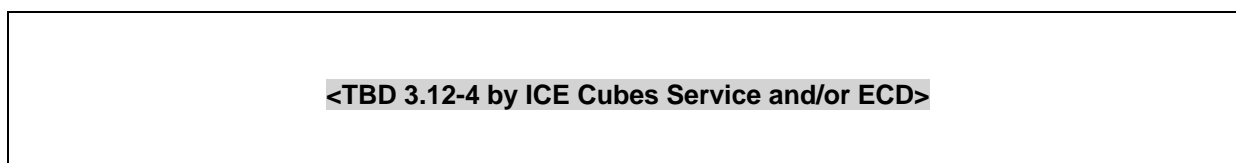


Figure 9 Experiment Cube label n

3.13 Astronaut Interaction

<TBD 3.13-1 by ECD and ICE Cubes Service>

If specific astronaut interaction (besides the Cube installation on and removal from the ICF) has been agreed between the ECD and the ICE Cubes Service, it shall be described here, together with an estimation of the time required for each specific astronaut activity.

3.14 Tools and Handling Devices

<TBD 3.14-1 by ECD>

The ECD shall define the standard Columbus/ISS tools and/or private tools and/or handling devices needed for operating the Experiment Cube items or for maintenance purpose.

Table 14 List of tools used for the Experiment Cube

Tool Name	Operation the tool is required for

Experiment Cube to ICE Cubes Service ICD Template

Appendix A Deviations / Waivers

The list of all deviations and waivers with their current approval status shall be provided. If the list is empty, "None" shall be written.

Experiment Cube to ICE Cubes Service ICD Template

Appendix B Unique Interfaces / Columbus Interfaces

Optional appendix, please delete if not applicable.