Accessing Space with the ISS Bartolomeo Platform

UNOOSA Call for Interest

Summary

The United Nations Office for Outer Space Affairs (UNOOSA) is partnering with Airbus Defence and Space GmbH to offer United Nations Member States the opportunity to accommodate a payload on the Airbus *Bartolomeo* external platform on the International Space Station. The mission will be open to all Member States of the United Nations, and developing countries are particularly encouraged to participate. The platform will accommodate and operate payloads provided by institutions in the participating countries.

The purpose of this Call for Interest (CFI) is to provide a summary of the proposed mission opportunity and to solicit information from Member States' entities interested in providing payloads that could be flown on this mission. The CFI also has the objective of gathering information on the interested countries so that UNOOSA may better understand the demand for this type of mission.

This mission is devoted to addressing the Sustainable Development Goals (SDGs).

Introduction

The mission of UNOOSA is to promote international cooperation in the use of outer space to achieve development goals for the benefit of humankind. There is no better example of UNOOSA's vision 'to bring the benefits of space to humankind' by showing space's importance in the realization and implementation of the 17 Sustainable Development Goals shown in Figure 1.

Figure 1: Sustainable Development Goals

UNOOSA intends to capitalize on the technological and innovative skills of the private sector to benefit developing countries and to deliver the Access to Space initiative to address all 17 Sustainable Development Goals. For the proposed Mission to access space, UNOOSA has been working with Airbus under an agreement signed in 2018 to define a dedicated mission opportunity for payloads developed by institutions in United Nations Member States, with particular attention to developing and emerging countries. In addition to addressing the 17 Sustainable Development Goals, a key aspect of the mission is to provide training and facilitate development of know-how at the national level in the practical applications of space technology, in particular for developing countries.

What type of experiments can be carried out?

Bartolomeo offers 12 new external payload sites, all of them at the forward-facing side of *Columbus*. As a standard *Bartolomeo* offers to host payloads in a mass range of 50 to 450 kg. Smaller payloads down to 3U size can be accommodated in the *ArgUS* multi-payload frame installed on one standard slot. Designed to user requirements from the commercial and institutional sector *Bartolomeo* complements the International Space Station with its unique capabilities and resupply logistics with unique features: access to best viewing angles in nadir, zenith and limb directions with minimal obstructions from other ISS elements, choice between unpressurized and pressurized launch of payloads to ISS, compatibility with all ISS payload airlocks, return option, real-time data link and enhanced, but non-real-time data downlink capability through optical communication, and easy access to space with standardized payload interfaces. The platform will start operations at the beginning of 2020.

Within the frame of this call payloads up to a 3 cubesat units (U) size can be proposed. The selected payload will be accommodated on the *ArgUS* multi-payload frame and operated for one year. The platform will start operations in early 2020. Payload mission within the frame of this call may start as early as end 2021.

With its unique capabilities Bartolomeo enables a wide variety of space missions. Some of the mission opportunities are presented in Table 1. Of course, Bartolomeo is not limited to these use cases.

Table 1: Mission opportunities on *Bartolomeo*

Use Case	Description
Remote Sensing	• The unobscured view of Earth from *Bartolomeo* in approximately 400 km orbit altitude enables high quality imaging with cost-efficient instrumentation • Line-of-sight pointing and stabilization systems may be made available as optional service, if necessary
Astrophysics / Heliophysics	• *Bartolomeo* offers among the best view towards the Zenith direction • Line-of-sight pointing and stabilization systems may be made available as optional service, if necessary
Atmospheric Research	• All forward-facing payloads have unobstructed view to the space / atmosphere boundary • Usually, Limb-oriented instruments do not require specific pointing or stabilization and can be hosted on *Bartolomeo* very easily • Broadband data downlink capabilities of *Bartolomeo* allows for a high data production rate
Space Weather	• The unobstructed Zenith-oriented view allows cost-efficient space observation, e. g. for solar activity monitoring
On-orbit Assembly for Exploration	• *Bartolomeo* payloads have only some restrictions regarding their volume in space • *Bartolomeo* can provide an opportunity to assemble space system components on-orbit and deploy them with appropriate systems • Short-term realization of a long-term vision to provide larger space systems unrestricted by the launcher payload fairing for exploration
Robotics Testing	• *Bartolomeo* payloads have only some restrictions regarding their volume in space • *Bartolomeo* can provide an opportunity to perform robotic operations in a protected testing environment
In-orbit Testing	• With power, data and viewing available *Bartolomeo* can serve as general in-orbit demonstration test bed • If compliant with safety regulations any technology can be tested on ISS as long as it is of civilian purpose
Propulsion Testing	• With power available up 800 W per payload *Bartolomeo* can serve as testbed for new electric space propulsion systems
Material Science	• With unobstructed Zenith-oriented view *Bartolomeo* gives the opportunity to expose material samples to space and solar radiation • With unobstructed Ram-facing view the effects of atomic oxygen can be studied on samples
Spacecraft Deployment	• One of the *Bartolomeo* payload sites can be converted to a small satellite deployment system • If deployed directly from *Bartolomeo* satellites can have more mass than deployable by existing systems
In-space Manufacturing	• Via *Bartolomeo* and its large / extendable payload envelopes on orbit in-space manufacturing can be performed to produce large space structure with 3D printing or other appropriate methods

More detailed information about the *Bartolomeo* platform and service can be found in the Annex.

Who should answer this call?

This CFI targets institutions from all Member States of the United Nations. Institutions from developing and emerging countries are strongly encouraged to participate. Teams incorporating multiple entities or countries are very welcome. In light of Sustainable Development Goal 17, "Partnership for the Goals", and to increase the benefits of the call, UNOOSA also encourages entities in developed countries to partner with interested institutions in developing and emerging countries as a way to broaden participation in the mission through triangular co-operation. Additionally, any institution or partner in a developed country could also potentially offer facilities/platforms developed for conducting experiments in outer space conditions for use by developing and emerging countries, either bilaterally or via UNOOSA.

CFI Submission/Important Dates

UNOOSA ISS Space Mission Schedule	Date	2018	2019								
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Call For Interest (CFI) Issued	6-Dec-2018	☆									
CFI Responses Due	31-Jan-2019		★								
Payload Providers Briefing (UN Vienna)	27-Feb-2019			☆							
Release of Announcement of Opportunity (AO)	26-Mar-2019				☆						
Closure of the Announcement of Opportunity (AO)	26.Sep-2019										☆

UNOOSA asks that Member States of the United Nations and their institutions interested in participating in this initiative submit a completed CFI response form by 31 January 2019.

Interested Member States and their institutions are also asked to include any additional pertinent information or requests related to this proposed mission that are not addressed in the CFI response form. Responses to this CFI are critical in shaping the mission to maximize the benefits of this unique opportunity to Member States, in particular for developing countries, and will be used to help shape the Announcement of Opportunity.

This is a joint UNOOSA/Airbus Defense and Space Call for Interest, where Airbus Defence and Space is positioned to offer a free slot on Bartolomeo including the "full-in-orbit-servicing" of the mission.

ANNEX: Technical Information

Bartolomeo is a new external payload hosting platform at the *Columbus* module on the International Space Station (ISS) developed, launched and operated by Airbus in Partnership with the European Space Agency and the Center for the Advancement of Science in Space. *Bartolomeo* offers 12 new external payload sites, all of them at the forward-facing side of *Columbus*. Payloads are accommodated using the General-purpose Oceaneering Latching Device 2 which enables full robotic servicing of the facility. As a standard *Bartolomeo* offers to host payloads in a mass range of 50 to 450 kg. Smaller payloads down to 3U size can be accommodated in the *ArgUS* multi-payload frame installed on one standard slot. All payloads can be operated by the user from ground through a web-based console using the functionality of the *Columbus* Multi-Purpose Computer & Communication system. Payloads accommodated on *Bartolomeo* benefit from its unique features:

- View towards ISS nadir, zenith and forward with minimal obstructions in the payload field of regard
- Enhanced data downlink budget
- Launch of payloads foam-packed in pressurized environment for low vibration loads
- Standardized payload interfaces and requirements
- Payload or sample return option

Bringing a payload to the Bartolomeo platform is a highly cost-efficient and flexible way of operating a space mission in low Earth orbit. With the *Bartolomeo* All-in-One Mission Service, the Customer benefits from Airbus' over 20-year experience in developing, integrating and operating payloads on the ISS. The service provides all mission-related elements including payload launch, transfer to outside ISS through a payload airlock, installation with the ISS robotic system and operation (Figure A-1), and can even assist in building the actual payload as optional service. This Customer-oriented service lets the Customer concentrate on the mission objective without the need to worry about the platform environment, developing a complex space system to carry their payload, or having a deep understanding of the ISS.

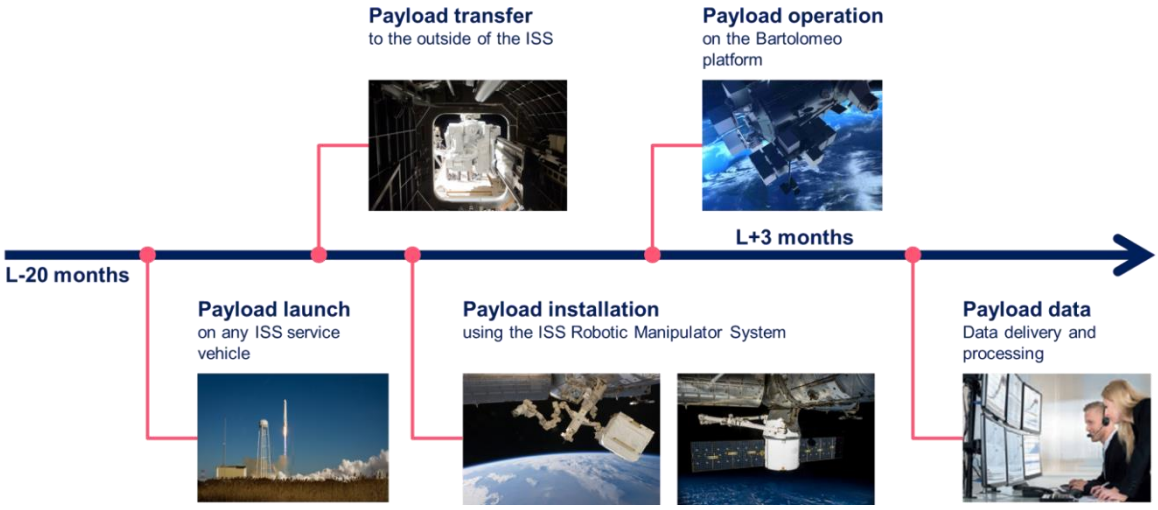


Figure A-1: *Bartolomeo* All-in-one Space Mission Service

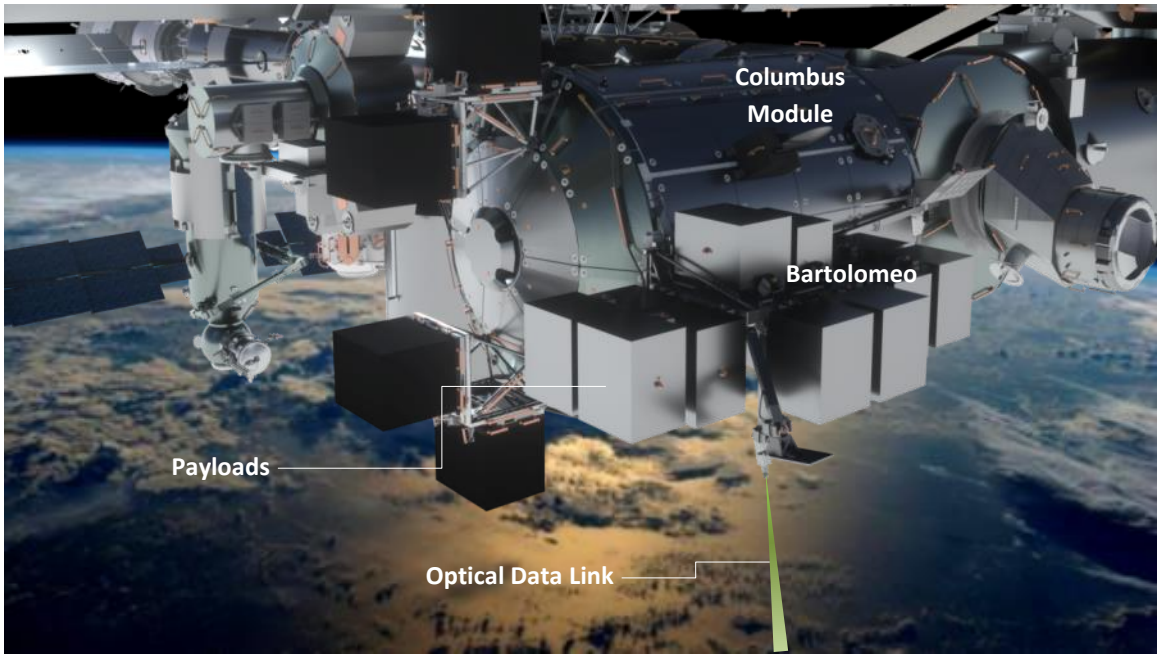


Figure A-2: *Bartolomeo* external payload hosting platform

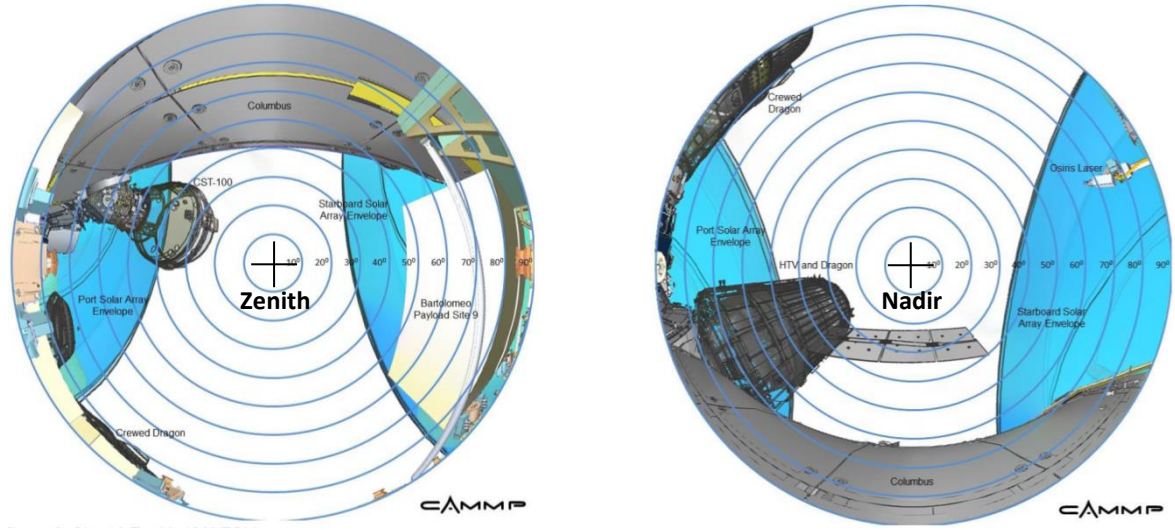
The *Bartolomeo* platform is installed on the International Space Station (ISS). Table A-1 summarizes the ISS orbit parameters. The orbit altitude of the ISS is under influence of the residual Earth atmosphere and is maintained by re-boost maneuvers in regular intervals. With its 51.65° inclined orbit plane the solar beta angle, i.e. the angle between the orbital plane and a line drawn from the Sun to the Earth, undergoes a sinusoidal variation. As the beta angle increases, the ISS and its external payloads are exposed to more sunlight per orbit, and eventually it is in constant sunlight. In other words, there is no passing into the Earth's shadow for extended periods of time, and the payloads are only shaded by other ISS elements.

Table A-1: ISS orbit parameters [1]

Parameter	Value
Orbital inclination	51.64 deg
Orbit altitude	403 - 408 km
Orbital period	92.89 minutes
Solar beta angle variation	-75 to +75 deg
Position error	6 m
Semi-major axis error	20 m

Viewing Conditions

The position of the *Bartolomeo* platform on *Columbus* facing forward provides very good viewing conditions in the zenith, nadir and forward direction, reduced viewing sideward and some limited viewing in the wake direction. The results of a field of view analysis for representative payloads on the pallet are presented in Figure A-3 for the zenith-, nadir-oriented half spheres. In this stereographic projection the blue areas indicate the temporary obscuration of the payload view caused by the ISS solar arrays.



(a) (b)

Figure A-3: Payload fields of view from *Bartolomeo* in stereographic projection with regions of temporary obscuration by ISS solar arrays indicated in blue, (a) Zenith, (b) Nadir direction [2]

The *Bartolomeo* platform structure has very low modal frequency between 1 and 4 Hz depending on the payload configuration and mass distribution. Therefore, *Bartolomeo* payloads experience only minor random vibrations exerted from the *Columbus* module via the structural interfaces as summarized in Figure A-4 for the different payload slots. Slots 3 and 4 offer the best viewing conditions which is supported by the low random vibrations expected there.

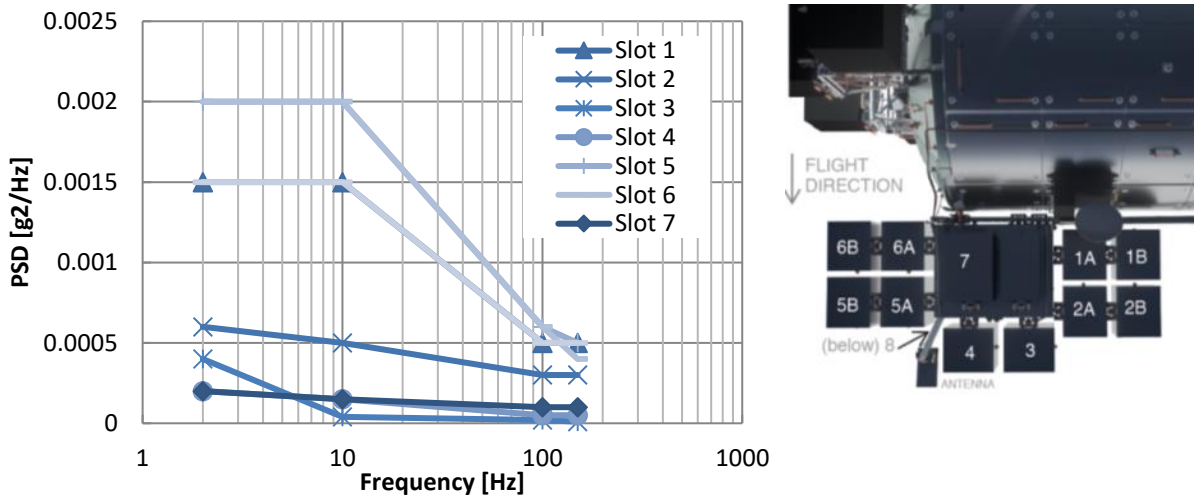


Figure A-4: On-orbit random vibration environment expected at *Bartolomeo* payloads [3].

Communications Architecture

Figure A-5 gives an overview of the communication architecture. For telemetry and tele-commanding purposes the *Bartolomeo* Data Handling System (BTL-DHS) connects all payloads to the *Columbus* Multi-Purpose Computer Communication (MPCC) system allowing the customers to operate and control their payloads directly via Ethernet protocols and under the protection of a Virtual Private Network (VPN) between the MPCC and the *Bartolomeo* Control Center (BTL-CC) at Airbus. The telemetry monitoring and commanding of payloads can be done directly by each customer through an individual web console operating in the Airbus Cloud. The *Columbus* Control-Center (COL-CC) controls the *Bartolomeo* payload power switches via the *Columbus* External Command & Measurement Unit (XCMU). The BTL-DHS provides three independent control layers, two commanded by the COL-XCMU and one by the COL-MPCC. This design enables safety-critical operations by protecting against payload inadvertent switch-on in a two fault tolerant way during specific ISS flight phases. Some payload data can be transferred via the MPCC Ethernet connection which is established within the existing ISS Ku-band based communication link. The Ku link has a very good availability with 70% to 90% availability over the orbit which gives almost real-time data connectivity for considerable amounts of time. For broadband data Bartolomeo offers an additional laser-based communication system [4] transferring data down to a dedicated ground segment. The link capacities are summarized in Table A-2.

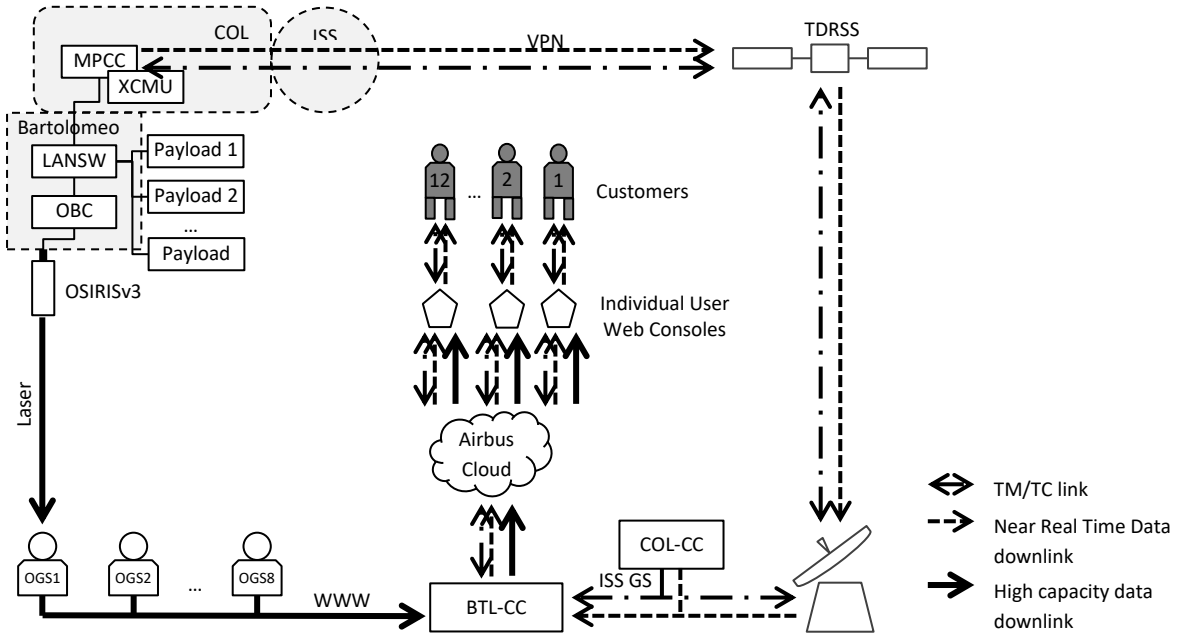


Figure A-5: *Bartolomeo* communications architecture [3].

Table A-2: *Bartolomeo* payload link capabilities

Parameter	Real time Link	High Capacity Link
Downlink	up to 10 Mbps	up to 2.5 TB/day
Uplink	up to 1 Mbps	None
Latency	< 1 s	N/A

ArgUS Multi-Payload Adapter

Small payloads can be accommodated sharing a payload slot using the *ArgUS* multi-payload frame with an own sub-avionics capable of monitoring and controlling the sub-payloads, their power consumption and data flows. This multi-payload frame is compatible with all *Bartolome*o payload slots except for the Zenith- and Nadir-facing slots. *ArgUS* provides for internal ISS payload removal and replacement, transfer of the integrated payload through one of the ISS payload airlocks. *ArgUS* will then operate payloads in the open space environment while attached to the Bartolomeo platform. The *ArgUS* platform allows for various configurations with different standard sizes of payloads. An example is shown in Figure A-6. Payloads are typically oriented in the Nadir-Zenith line. The *ArgUS* plate can accommodate sideward placement for limited payload slots. Payloads with non-standard sizes may either use the available attachment interfaces and volume on the experiment base plate or, in case of large payloads they may use the entire available volume. *ArgUS* has its own avionics and power supply to enable the operations of up to 10 active payloads in parallel. ArgUS also features the robotic umbilical interface required to provide heater power through the ISS robotic system during installation.

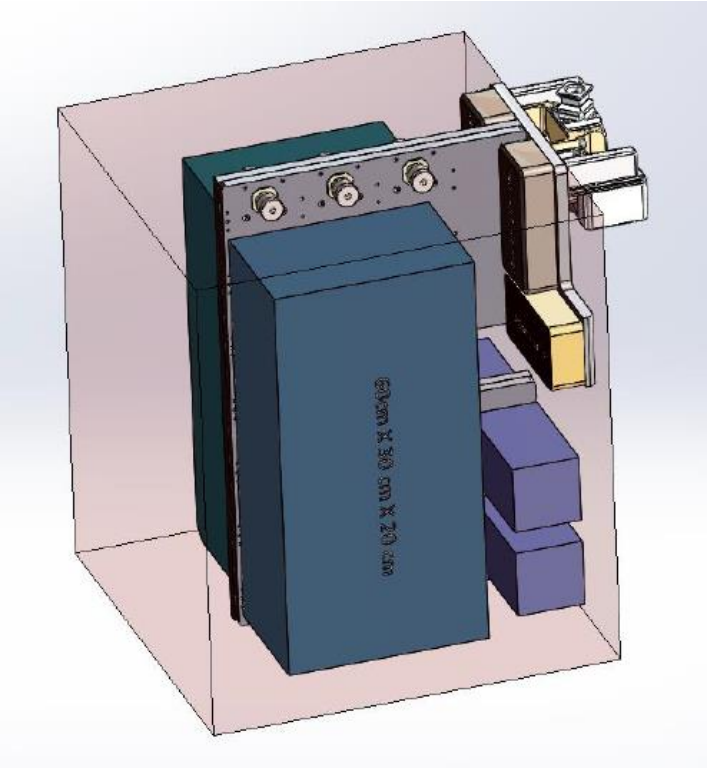


Figure A-6: Argus multi-payload adapter with example payloads and maximum overall useable envelope indicated.

Accommodation and Resources Available for the Payloads in this Call

The *Bartolomeo*-provided payload resources and budgets provided within the frame of this call are summarized in Table A-3. Additional resources like the use of the enhanced data downlink or payload return are an optional service.

Table A-3: Payload budgets and resources provided within this call

Parameter	Specification
Field of view	• Nadir view • Zenith view • Ram view
Geometric envelope	Up to 3000 cm^3 (3U)
Mass	Up to 10 kg
Power	28 VDC
Commanding and Monitoring	• Temperature sensor signal • Current sensor signal • Switch on / off command
Commanding and Monitoring	• Downlink 0.1 Mbit / s • Uplink 0.01 Mbit /s
Data	Switch on / off command 0.1 Mbit / s

References

[1] National Aeronautics and Space Administration, "External Payloads Proposer's Guide to the International Space Station," GSFC 420-01-09 Rev. -, NASA Goddard Space Flight Center, April 2015.

[2] Kennedy, W., "Bartolomeo Payload and Osiris Laser FOV Analysis," CAMMP EC-2927, NASA Johnson Space Center, 1st December 2017.

[3] Steimle, P. C., Walz, C., Fuchs, C., Abdoly, K., Retat, I., Pedersen, D., "New External Payload Platform Bartolomeo on the International Space Station," Paper No. IAC-18.B3.4-B6.4.7, 69th International Astronautical Congress (IAC), Bremen, Germany, 1-5 October 2018.

[4] Schmidt, C., Fuchs, C., "OSIRIS on BiROS: First Experiments, International Conference on Space Optical Systems," 13th to 15th of November 2017, Naha, Okinawa, Japan