OPTEL-µ IMPLEMENTATION STUDY ON ISS

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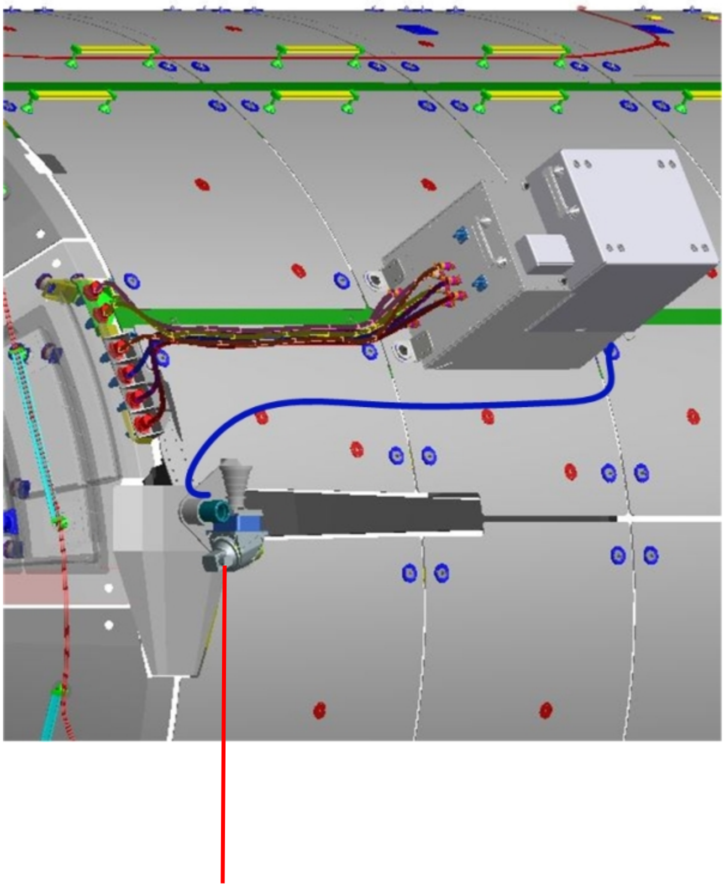


1 INTRODUCTION

1.1 Overview and Study Objectives

The *Optel-μ Implementation Study on ISS* has been set up to assess the feasibility of an IOD (In Orbit Demonstration) of the Optel-μ Space Terminal on the ISS (International Space Station).

The Optel-μ system provides an optical data downlink from a LEO (Low Earth Orbit) S/C to an Optical Ground Station with a data rate up to 2Gbit/s. It is being developed by RUAG Space in the frame of the ARTES program.

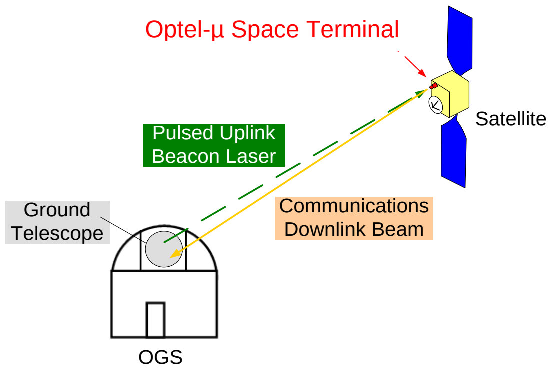


Figure 1-1 Optel-μ System

The Optel-μ Space Terminal is designed for small and medium S/Cs with dedicated interfaces. The objective of this study was to define a concept of a combined installation of the Optel-μ Space Terminal together with the COLKa (Columbus Ka band Terminal) platform – a platform which is being developed by Kayser Italia for a Ka band radar test on the Columbus module of the ISS.

This executive summary presents the work done during the study, which was performed under the contract number 4000113991/15/NL/RA.

1.2 Study Organisation

This study is part of ESA's General Studies Programme (GSP).

Prime contractor is RUAG Space (Switzerland) with Kayser Italia as subcontractor.

There was support from ESA specifically to the interfaces and boundary conditions of Columbus and the ISS.

2 PROPOSED IOD CONCEPT(S)

2.1 Overview

A trade-off between different concepts has been made.

In the preferred concept the electronic units are integrated in the COLKa platform and the Optical Head Unit is mounted on a removable platform which will finally be placed on a point with a better view to the earth. It is described in §2.3

An alternative concept with all equipment for the Optel-µ IOD on a separate platform may be used if e.g. the Optel-µ IOD took place after the COLKa experiment. This is described in §2.4.

2.2 Optel-µ Space Terminal

The Optel-µ Space Terminal is designed to be integrated on small LEO S/Cs to perform an optical data download to a Ground Station.

The Optel-µ Space Terminal consists of the following three subunits:

- Optical Head Unit (OHU): The optical head unit is mounted outside the S/C. It tracks the beacon from the ground station and on the same time transmits its communication laser beam towards the Optical Ground Station (OGS)
- Electronics Unit: The EU is an electronics box inside the S/C. It contains the electronics to control the Optical Head Unit and the Laser Unit.
- Laser Unit: The Laser Unit consists of two boxes, the Pulsed Laser Transmitter (PLT) and the Optical Fibre Amplifier (OFA).

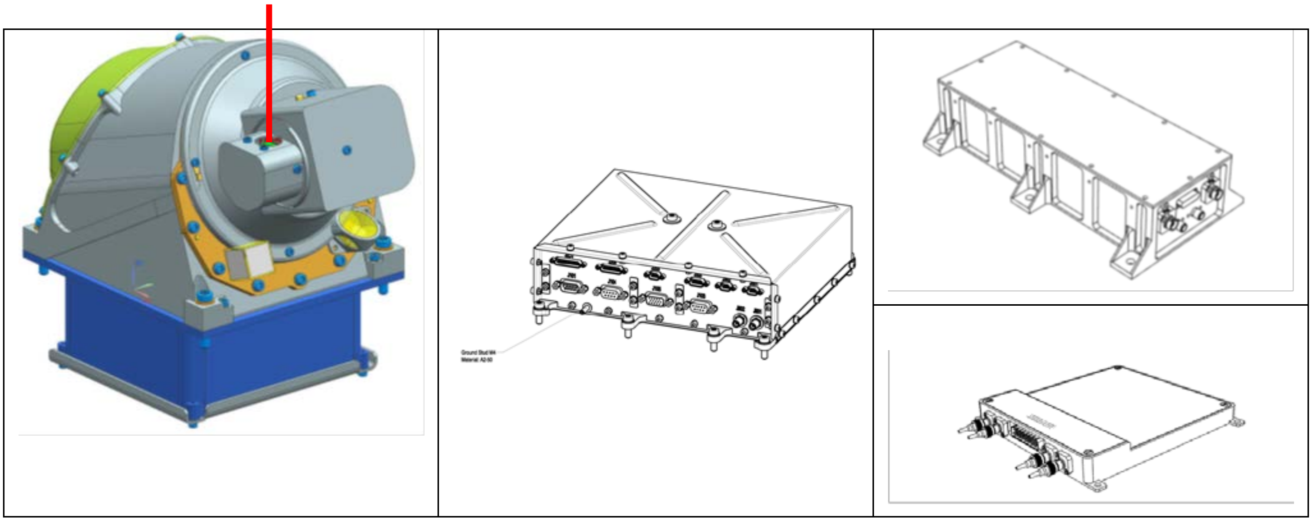


Figure 2-1 Optical Head Unit, Electronics Unit and Laser Unit (PLT and OFA)

2.3 Preferred Concept: Optical Head Unit on a Removable Platform

This concept profits from the COLKa experiment. All IOD equipment is initially integrated in the COLKa box so that a common EVA (Extra-Vehicular Activity) is possible. The Optical Head Unit together with the star tracker camera are on a removable platform which is placed 1-2 m away from the COLKa.

The integration of the electronics units of the IOD Set-up on the bottom of the COLKa platform looks well feasible. The Optical Head Unit is on a removable platform; in contrast a permanent integration on the COLKa platform would hardly be feasible. The FoV of the OHU is better on the location of the Starboard Trunnion compared to the COLKa platform.

The overall dimension, specifically the length of the COLKa box, may get critical when moving it through the Quest Airlock. Here we need confirmation by NASA, after NBL (Neutral Buoyancy Laboratory) tests in November 2015.

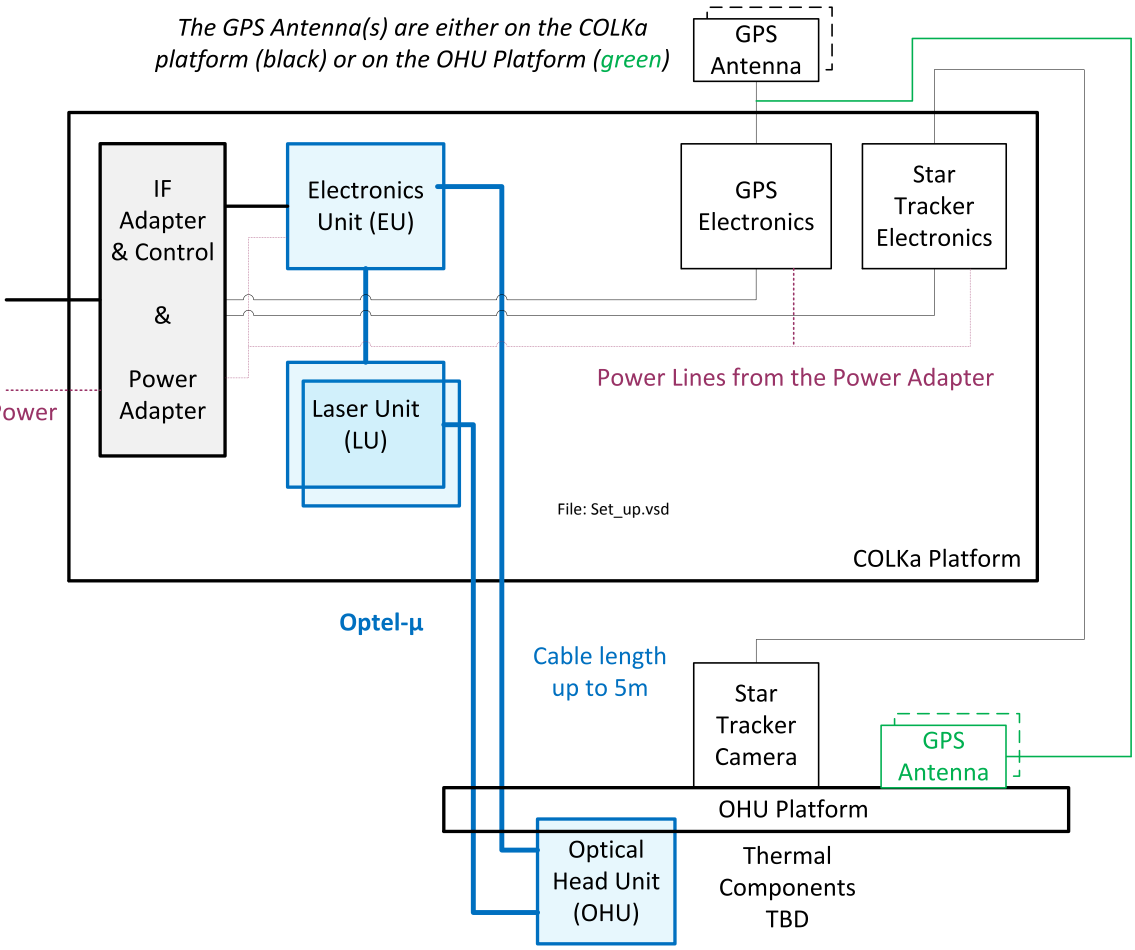


Figure 2-2 Optel-μ IOD Set-Up (2 Boxes)

The COLKa mounted on its nominal location is shown in Figure 2-3.

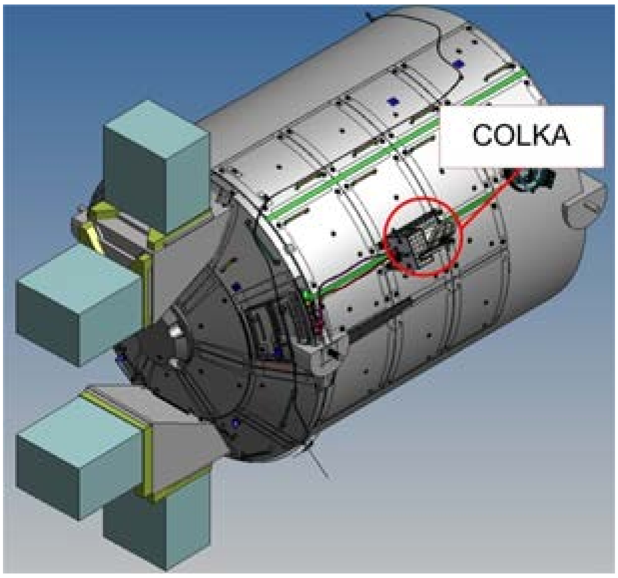


Figure 2-3 Location of the COLKa Flight Unit on the COLUMBUS Forward Zenith Surface

The following items would be accommodated permanently in the bottom part of the COLKa Platform:

- the Electronics Unit (EU)
- the Laser Unit (OFA and PLT)
- the IF Adapter & Control & Power Adapter
- the GPS Electronics
- the Star Tracker Electronics

Figure 2-4 shows the accommodation of the Optel-µ IOD Set-up items on the bottom part of the COLKa Platform.

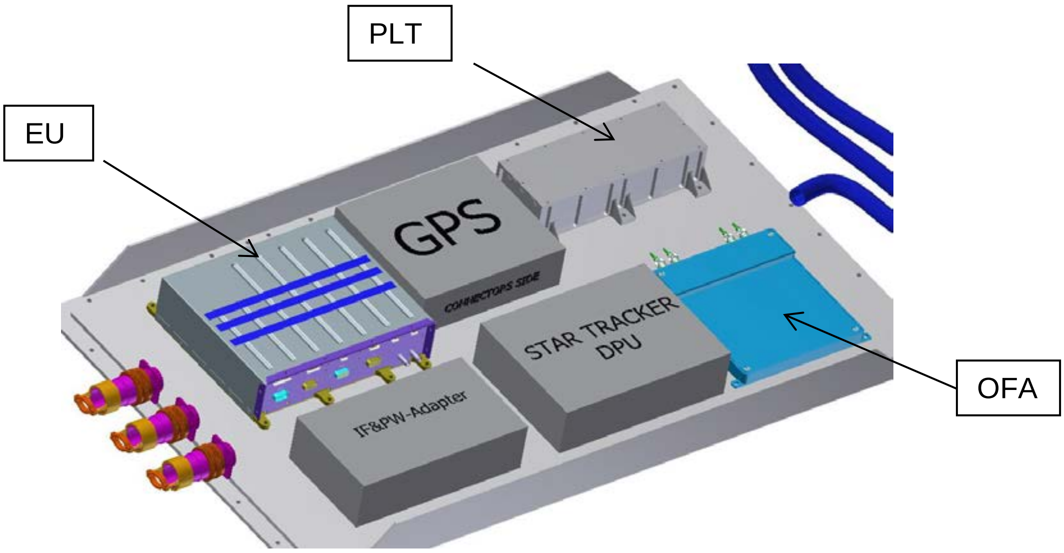


Figure 2-4 Optel-µ IOD Set-up items accommodation inside COLKa

During the EVA transfer from the ISS cabin to the external surface of the COLUMBUS module, the OHU Platform, including the OHU, the Star Tracker Camera and possibly the GPS antennas are attached to the Port side of the COLKa Platform (see Figure 2-5).

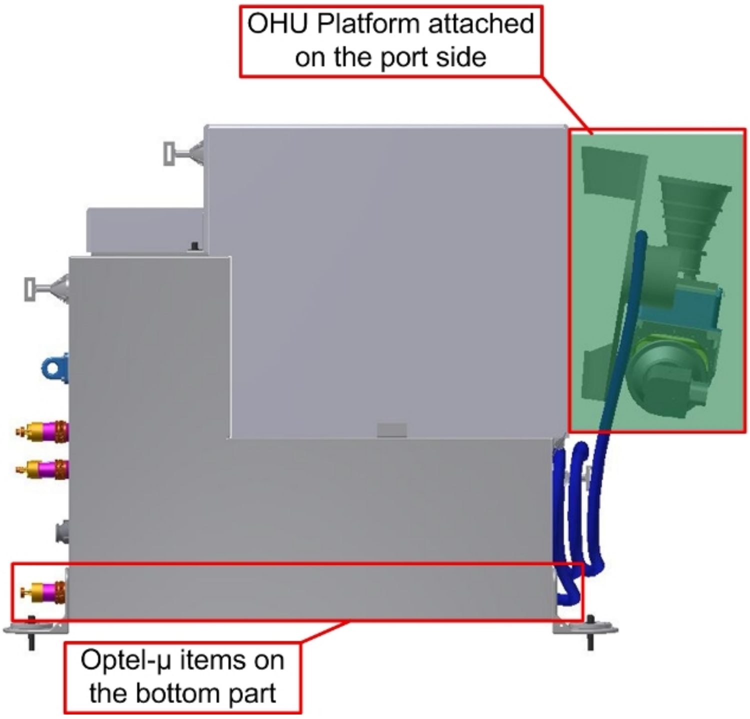


Figure 2-5 Optel-µ IOD Set-Up Main Parts in the Transfer Setup

Figure 2-6 and Figure 2-7 show the COLKa Platform (including the COLKa Terminal and the Optel-µ items) and the OHU Platform in their final positions. The OHU is mounted Nadir pointing while the Star Tracker Camera is mounted Zenith pointing.

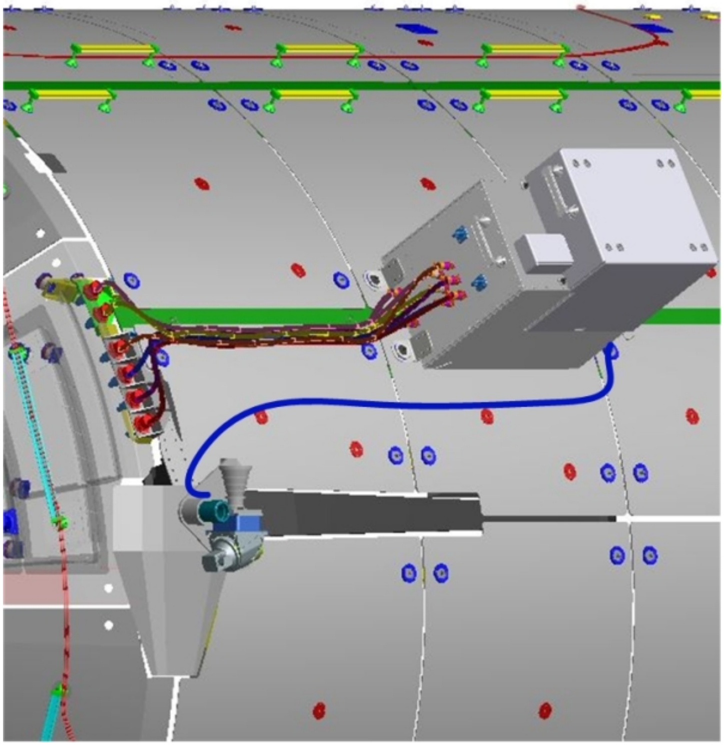
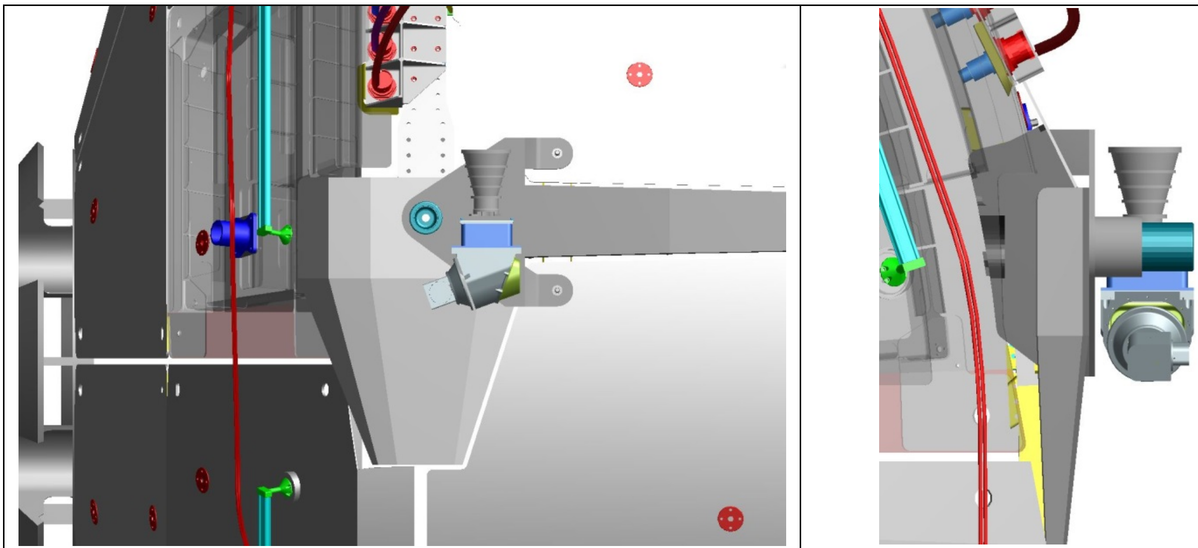


Figure 2-6 Optel-µ and COLKa in their Final Positions



Front View	Side View

Figure 2-7 Optel-µ OHU Platform on the Starboard Trunnion

2.4 Stand-alone platform

The Optel-µ IOD set-up is mounted on a stand-alone platform.

This platform will be mounted on the Columbus module with a separate EVA.

Such a concept is regarded as rather unlikely due to the high EVA costs.

On the other hand, this concept would allow the best view if the platform were mounted on the forward/Nadir Micro-meteoroid and Debris Protection System (MDPS) of the COLUMBUS module.

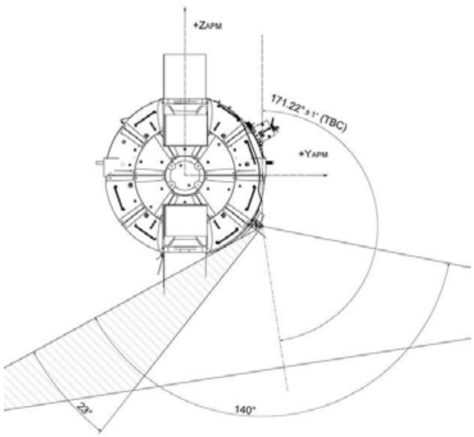


Figure 2-8 Good View from the Forward/Nadir MDPS of the COLUMBUS

The following figure shows the block diagram of a standalone version of the IOD Set-up.

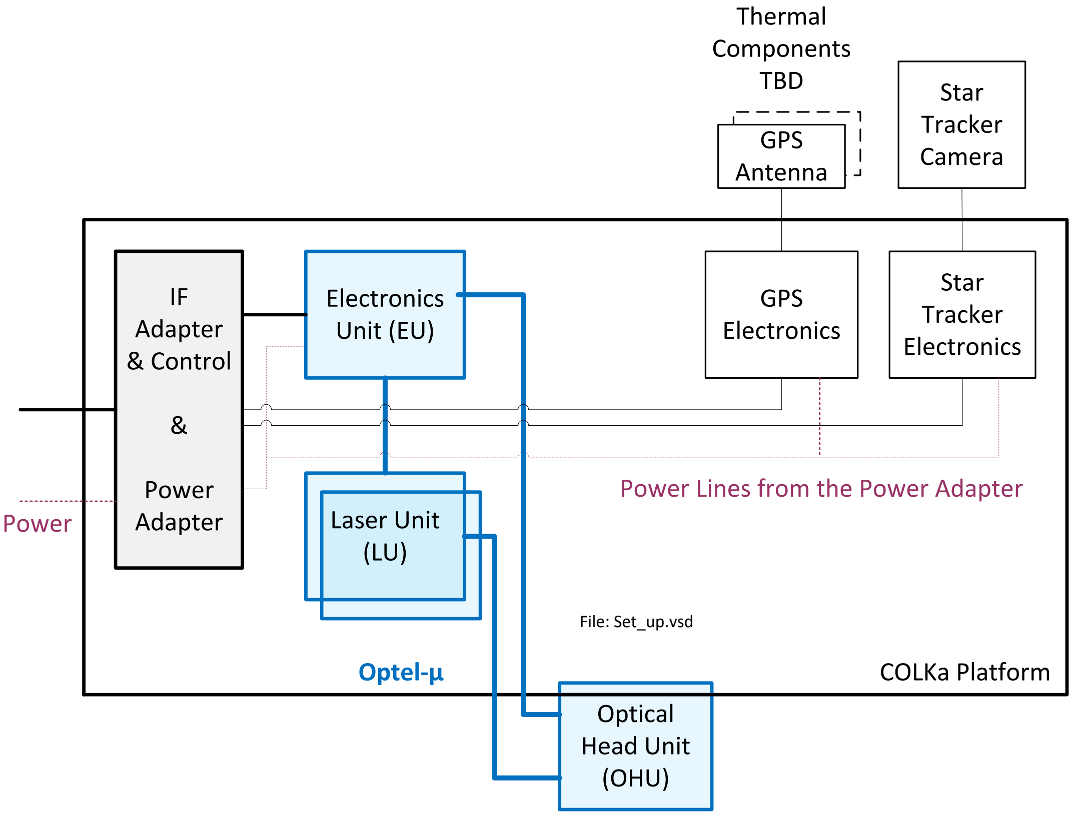


Figure 2-9 Optel-µ IOD Set-Up (1 Box)

3 INSTALLATION ON THE COLUMBUS MODULE

3.1 Intra-Vehicular Activity (IVA) Operations

After their upload, the COLKa and Optel-µ equipment will be transferred to the ISS cabin where they will be stowed in a temporary location until the final installation.

Before the final installation, some activities will be performed in the ISS cabin (IVA), e.g. connection of the cables which were unplugged during launch.

3.2 EVA Operations

EVA Operations are foreseen to be performed by 2 astronauts.

Figure 3-1 shows the COLKa position outside the COLUMBUS module and the location of the QUEST airlock. The EVA Primary Translation Paths are shown in Figure 3-2: the EVA crewmembers will follow this path to reach the COLUMBUS external surface from the Quest airlock. The red arrow shows the direct path, i.e. the start and the end of the EVA path.

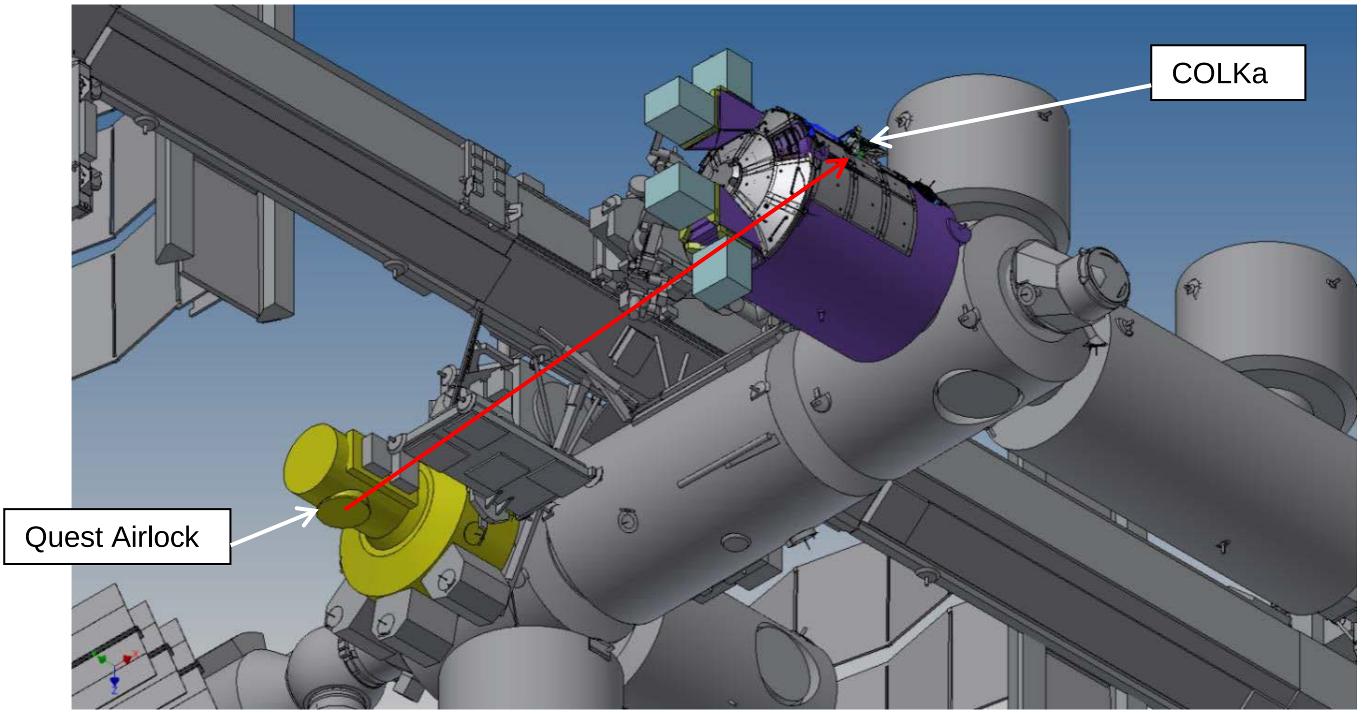


Figure 3-1 Airlock and COLKa Relative Position (Bottom View)

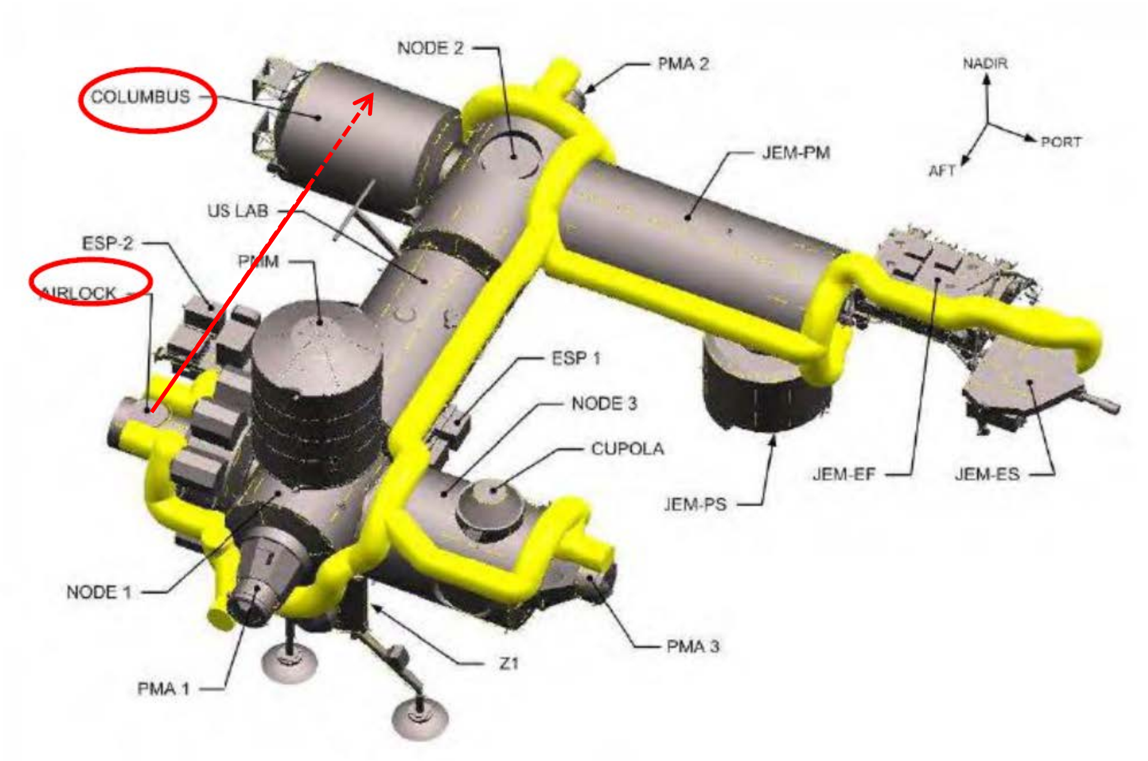


Figure 3-2 Primary Translation Path - Bottom View

4 CONCEPT OF OPERATION

4.1 Operation

The general concept of operation foresees 3 phases, Preparation, Data Download and Finalisation.

This is visualised in Figure 4-1. Transmitted data is shown in rectangles. Radio transmissions are indicated with flash symbols, internet transmissions with normal arrows.

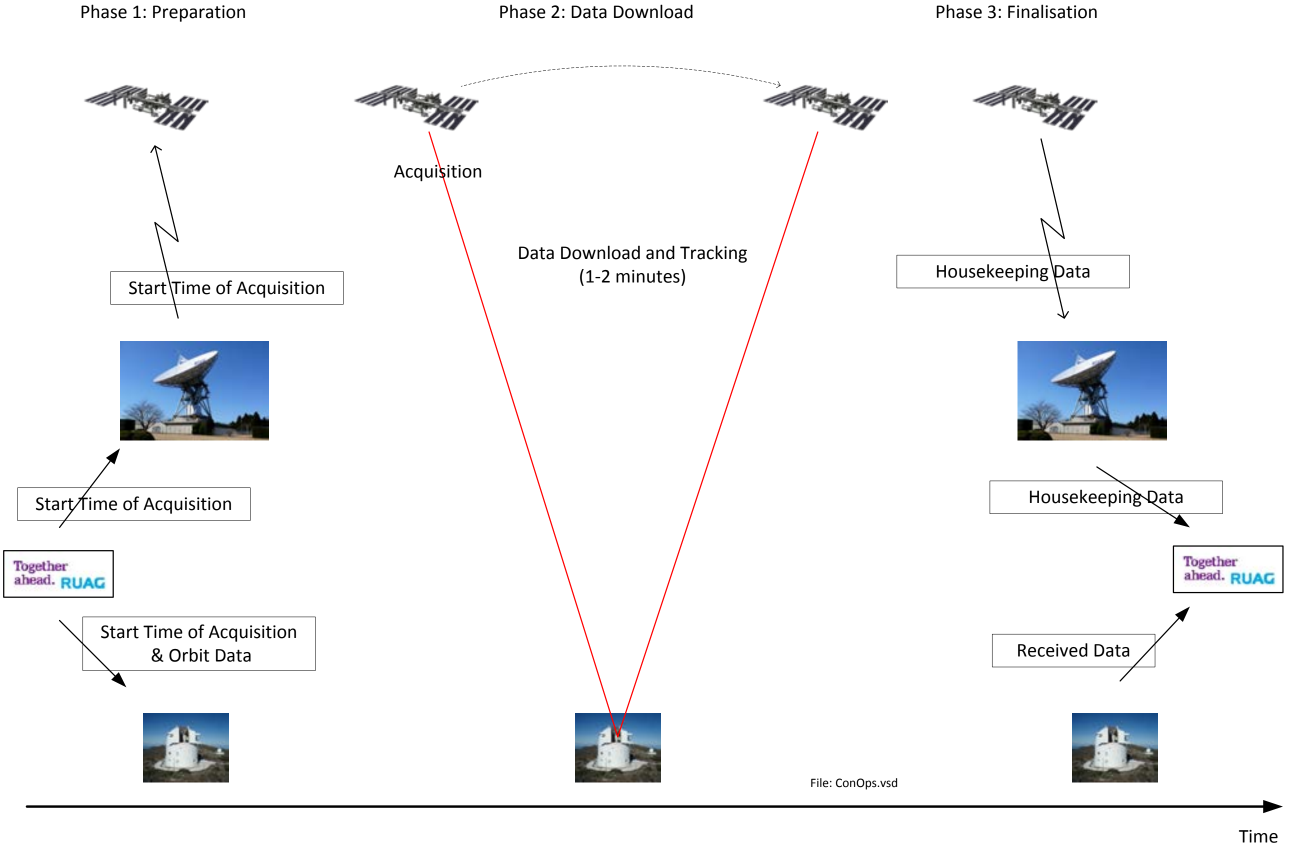


Figure 4-1 Concept of Operation

4.2 Data Volume

The data volume per flyover (in clear weather) is estimated as follows

- for a one minute path: 2·200Mb/s·1min = 24 Gb = 3 GB
- for a two minutes path: 2·600Mb/s·2min = 144 Gb = 18 GB

Since the data rate varies during the path, i.e. from 2·125Mpbs in the beginning to 2·1Gbps towards zenith the above estimation uses an average value of 2·600Mbps in case of the long path; in case of the short path the ground elevation is always below 30°, therefore 2·200Mbps are taken.

4.3 Data to be Downloaded

4.3.1 Test of the Downlink and of the Optel-µ

The data to be downloaded is preferably pseudo random noise – at least from the technical point of view. So no user data interface has to be designed. The service channel could additionally be used to send internally recorded data so that a maximum evaluation of the performance of the involved subsystems is possible (Micro-Pointing Assembly, GPS, Star Tracker, Communication System).

4.3.2 Additional Tests to get Research Data

4.3.2.1 Micro-Vibrations

If the IOD Set-up were extended with accelerometers and an angular rate sensor we could get on the one hand data to better judge the link quality, and on the other hand basic measured translational (linear) and angular (rotatory) acceleration data.

This kind of data is very rarely available in the space community. Measured data, which additionally combine translational and angular motions, would help to bring some light in the rather dark theme of micro-vibrations.

4.3.2.2 Atmospheric Data

The received intensity of the uplink could be recorded in the Space Terminal; this data could be downloaded to the ground via the service channel. This information could be used to improve the atmospheric model.

In parallel the energy and shape of the received laser beam on ground shall be recorded to get further data to characterise the atmosphere.

Atmospheric data recording can be done with the existing basic hardware.

4.3.3 Test for Public Relations

For public relations reasons a video stream should be demonstrated. For this a camera including the interface should be provided. This extra effort is recommended for commercial reasons:

“First Live Video Stream Optically Downloaded From Space To Ground”