IOD Programme Requirements for CEOI 10th Call for Proposals

1. Purpose and scope of the document

The purpose of this document is to define the In-Orbit Demonstration (IOD) programme requirements in the context of payloads being developed through the CEOI 10th Call for Proposals.

In the standard IOD programme, payloads with a TRL of 5-6 are expected while the CEOI call targets payloads that are less mature. With this in mind, an IOD opportunity is reserved for a CEOI funded payload upon the condition that the payload and associated business case for the service to be demonstrated reaches a level of maturity that satisfies the standard selection criteria for the IOD Programme during the course of the CEOI activity.

Section 2 outlines the final criteria which are used to assess a mission for selection, Section 3 describes how the standard IOD selection process is adapted to a payload developed through the CEOI and the support the Catapult will provide throughout this process and Section 4 provides references for the format of a pitch to the IOD board for final selection.

If you have any queries regarding the IOD programme, this document or the general suitability of a payload to the programme, the Catapult IOD team can be contacted by emailing iod@sa.catapult.org.uk.

2. Selection criteria for an IOD mission

It will be required that the payload developed through the CEOI Project will comply with following criteria at Launch -12 months. The assessment will be carried out by members of the IOD board.

- **Business case**: the mission will demonstrate a commercial service supported by a business case projecting a clear return on investment, ensuring the involvement of the different players across the value chain required to deliver the service. The criteria used to assess the strength of the business case are captured in the document *IOD Business Proposal*, which includes an appraisal of skillset, size of the market, and proposed commercialisation strategy.
- **Technical suitability**:
    - The mission will fly a payload that will provide a meaningful capability that can be exploited through the service described in the business case.
    - The payload complies to the requirements of the Clyde Space platform, can be launched by Nanoracks and is compatible with the overall mission concept of operations.
    - The payload development schedule is compatible with that of the mission schedule and any risks to this are adequately accounted for.

Innovate UK

CATAPULT Satellite Applications

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.

The information required to demonstrate a viable technical case for each candidate is captured in the document *IOD Technical Proposal.*

- **Commitment**: the lead entity shall lead the demonstration of the service; contribute to the cost of the mission; and provide evidence of the intent to exploit the service through the UK. The lead entity or consortium also complies with the terms of the *Collaborative Research agreement* with the Catapult.

The details to assess these high-level objectives are in the respective documents indicated.

3. Adapted IOD Selection Process for CEOI Payloads

A candidate payload will go through the standard selection process defined by the IOD programme partners adapted for the timing of the CEOI project with due account taken for the lower initial maturity of technologies under development. This process acts as a support process to mature the CEOI payload for selection as an IOD mission. The steps are:

- **CEOI EO 10th Call selection**: Catapult involvement in selecting the proposals most likely to meet the IOD mission technical and programmatic criteria; this will be based on the information provided in the CEOI EO10 CALL Section 4.3 *The Technical proposal - Cubesat Payload Flagship* and Section 4.4 *Business Plan - Cubesat payload proposals*
- **During the CEOI project**: Technical support for the payload developer through interactions with the Catapult and the spacecraft provider during the course of the CEOI project to ensure compatibility with IOD technical constraints; support in formulating a consortium that spans the value chain and evolving the business case.
- **~ Launch -15months**: Towards the end of the payload development or just after the project completion the payload provider will undertake a technical and commercial maturation phase of 2 months in collaboration with the Catapult to prepare the formal proposal to the IOD Programme. This is done through the maturation of the *IOD Business Proposal* and *IOD Technical Proposal* documents.
- **Launch -12 months**: After the 2-month maturation phase a presentation to the IOD Board validating fulfilment of the above detailed criteria through the presentation of the *IOD Business Proposal* and the *IOD Technical Proposal*.

If the final selection process is not successfully concluded due to failure to meet technical or operational constraints, the Catapult will work with the payload provider and CEOI to identify other potential flight opportunities.

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.

4. Reference documents

The below documents are those used to present a mission to the IOD Board for selection. These documents are not required for the CEOI call, they are referenced here to indicate what would be expected from the payload developer towards the end of the CEOI project.

IOD Business Proposal

This document captures the business proposal for an IOD mission, the template is available by contacting the IOD team and may be made available on the Catapult IOD webpage. Note that the *Business Plan* of the CEOI call is aligned to facilitate a later filling of the template.

IOD Technical Proposal

This document captures the technical proposal for an IOD mission, the template is available by contacting the IOD team and may be made available on the Catapult IOD webpage. Note that the *Technical proposal* of the CEOI call is aligned to facilitate a later filling of the template.

Collaborative research agreement

This document captures the information needed by the Catapult to enter in a Collaborative research agreement with an entity or consortium, the template is available by contacting the IOD team.

Innovate UK

CATAPULT Satellite Applications

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.

IOD Summary Interface Control Document

1. Introduction

This document provides a summary interface definition for integrating a payload into the platform provided for the In-Orbit Demonstration (IOD) programme.

This summary is to be treated as indicative and the exact configuration and capabilities of the platform will vary from mission to mission based on payload requirements. The full Interface Control Document (ICD) from the platform manufacturer, Clyde Space Ltd (CSL), of which this is a summary will be made available upon request from the CEOI.

2. Platform Overview

The satellite platform is based on CSL's Outernet 3U platform, with the deployed configuration shown in Figure 2.1 & 2.2. Nominally the Z- face is Earth-pointing.

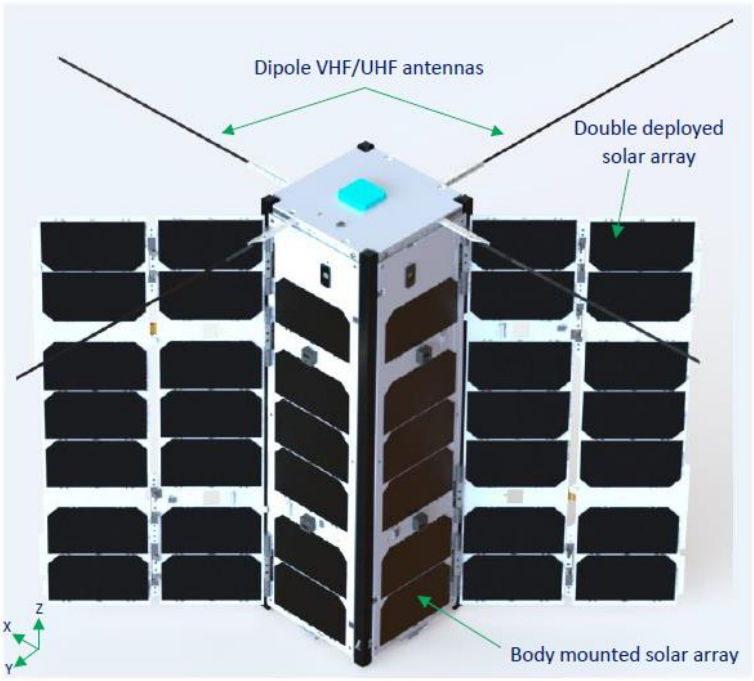


Figure 2.1 - Deployed CSL 3U Platform ©Clyde Space Ltd

Innovate UK

CATAPULT Satellite Applications

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.

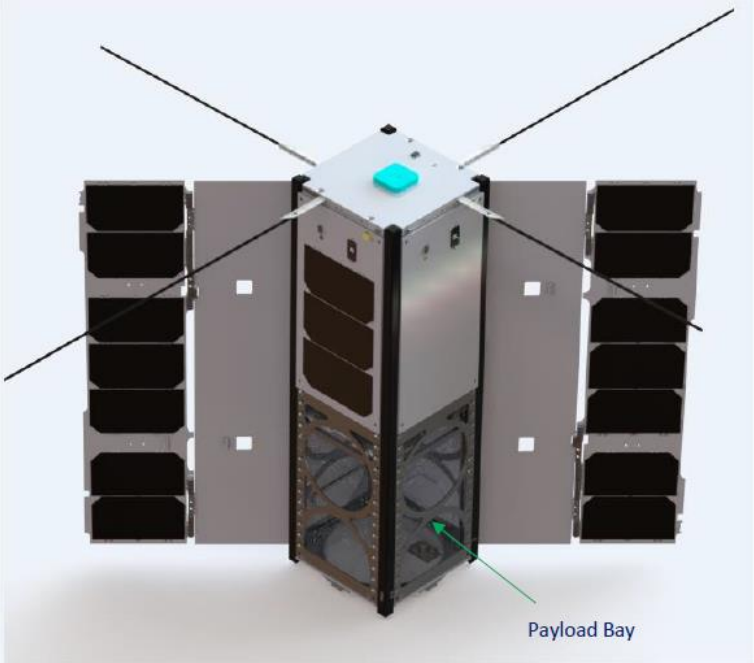


Figure 2.2 CSL 3U platform (rear view) ©Clyde Space Ltd.

2.1. Mechanical & Payload Accommodation

The platform avionics and payload are housed within the CSL 3U CubeSat structure which conforms to the CubeSat Design Specifications and provides mounting points for the payload as well as apertures and cut-outs if required.

The allocated payload volume is nominally approximately 1U with a mass allocation of ~1kg. This payload allocation may have some flexibility and alterations to this can be discussed on a case by case basis.

2.2. Electrical & Power

The power and data buses are implemented through the CubeSat Kit Bus form factor and there will be Payload Interface Module with which the payload interfaces via a dedicated connector.

Power is provided by solar arrays and distributed and regulated by CSL's third generation Electrical Power System. 3.3V, 5V, 12V and VBAT (unregulated battery voltage) power buses are available to the payload.The power budget available to the payload depends on the exact mission concept of operations but will be between 0.5W on-orbit average (continuously nadir pointing) to 2W on-orbit average (alternating nadir & sun pointing orbits). Payloads with higher power requirements could be possible through duty cycling. The maximum peak platform power is ~18-20W (VBAT).

On board data processing is carried out by CSL's on board computer that provides the I2C, SPI, CAN, RS232 (TTL) or RS422 data buses for interfacing with the payload. The level of on-

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.

board data processing and storage required by the payload is to be discussed on a case by case basis.

2.3. Communications

The platform has a VHF/UHF communications systems for telemetry and telecommand (TMTC) and an S-band system for payload data downlink of around 0.5Gb/day. The exact amount of available payload data downlink capacity will depend on the mission concept of operations and available power.

2.4. Attitude Determination and Control

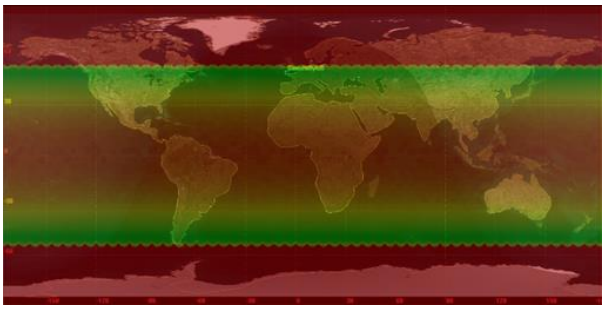
Pointing of the platform is achieved using a combination of coarse and fine sun sensors, gyroscopes, magnetometers, magnetorquers and a 3-axis reaction wheel set. Nominally the pointing accuracy of the platform is +/-2° in sunlight and +/-15° in eclipse, although a potential improvement to +/- 1° for the entire orbit through the use of a star tracker could be discussed.

3. Launch, Orbit and Concept of Operations

The satellite will be launched to the ISS via the NanoRacks Space Act agreement with NASA. Following deployment from the ISS using the NanoRacks Cubesat Deployer there will be a period early of operations and commissioning after which the satellite will have a nominal operational lifetime of 6 months. The specific mission concept of operations and the space environment at the time can adjust this in both directions.

The exact orbit will depend on the orbit of the ISS at the time of deployment and will evolve over the mission lifetime of the satellite but can be approximated to:

Attitude	400km
Inclination	51.64°
Eccentricity	0.00018



The concept of operations will be developed once the payload's requirements are known and should be discussed on a case by case basis. The image above gives a map of the estimated revisit frequency (green: 6 times/day, red: not visible).

4. Assembly Integration and Test (AIT)

The AIT philosophy assumes that a Qualification Model (QM) of the payload will be produced that is identical to the Flight Model (FM). This QM will undergo qualification testing to the level as defined in the full ICD or superseded by the launch providers testing levels where applicable.

The Flight Model will undergo acceptance testing as part of the integrated spacecraft to the levels defined in the full ICD.

The Satellite Applications Catapult is one of a network of elite technology and innovation centres established by InnovateUK, as a long-term investment in the UK's economic capability. Applying business-led research, Catapults help businesses transform great ideas into valuable products and services to compete in the global markets of tomorrow. The Satellite Applications Catapult Limited is a company limited by guarantee, registered in England and Wales with company number 7964746.

Registered office: Electron Building, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire OX11 0QR.