**Project Specification- Active Debris Removal- Refuelling Study Phase 1 Overview**

The key aim of the study is to establish the feasibility of a refuelling mission. The end of study will be marked by a formal review of the study outcomes.

The Grant Recipient shall perform a number of key tasks during the study, as outlined below. In the Grant Recipient’s Response to this call for proposals, they should elaborate and critique these tasks, identifying any additional suitable activities (with justification), presenting Work Package Descriptions (WPDs) and a Work Breakdown Structure (WBS) demonstrating a comprehensive and organised management approach.

### **Task 1 High Level Requirements**

The justification for a refuelling mission needs to be based on firm requirements This task is intended to capture these requirements in a High-Level Requirements Document.

* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
    - Task Description
      * Create a hierarchical set of high level requirements that address:
        + User Requirements that will need to be meet by a refuelling service provider in order to justify designing satellites that are capable of being refuelled in orbit. These can be actual user requirements or inferred requirements that the Grant Recipient recognises will need to be met.
        + Mission Requirements that meet the user requirements and any constraints that the Grant Recipient considers relevant. Include safety requirements, e.g. for the handling of fuel throughout the mission lifecycle including rendezvous, docking, transfer and undocking. Include requirements to minimise waste and to avoid producing additional debris.
        + Initial Space Segment Requirements that include high level requirements for the design, manufacture and test of the refuelling spacecraft.
        + Initial Ground Segment Requirements that address how the refuelling spacecraft will be monitored and controlled, and the interactions with the ground segment of the satellite to be refuelled. Address both ground segment hardware and software requirements.
* Output
  + High Level Requirements Document (HLRD)
    - Including traceability of lower level requirements to higher level requirements through use of a requirements numbering system.
    - Addressing options where appropriate e.g. relating to the refuelling interface.

### **Task 2 Concept of Operations**

This task is intended to provide an overview of the way a proposed refuelling mission would be executed to refuel an ADR satellite plus a third party satellite in Low Earth Orbit.

* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
      * Specification of the baseline UK ADR mission
      * High-level requirements from Task 1
* Task Description
  + Operations Scenarios
    - Outline operational scenarios, sequences and timeline for all mission phases
    - Address the approach, docking and transfer of fuel to the target spacecraft,
    - Address orbit plane/height change issues (LEO only)
    - Describe nominal and contingency operations
  + Communications Concept
    - Establish communication architecture for uplink and downlink, to achieve commandability and observability in nominal and degraded operations to include consideration of key technical parameters
    - Define communications scenarios for all mission phases
    - Propose the frequency band to be used in line with International Telecommunication Union (ITU) Radio Regulations
    - Consider use of intersatellite comms with ADR
  + Ground Segment Definition
    - Produce a preliminary design of the Ground Segment in accordance with the operational concept and the requirements flowed-down from Task 1.
* Output
  + Concept of Operations (CONOPS) Report

### **Task 3** **Baseline Satellite Design**

This task is intended to provide a technical overview of the proposed refuelling spacecraft.

* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
      * High-level requirements from Task 1
      * CONOPS from Task 2
* Task Description
  + Produce a preliminary design of the satellite in accordance with the requirements flowed down from Task 1, down to subsystem level. Address any trade-offs that have led to the baseline design, State the TRL levels of subsystems etc.
  + Address the design of the refuelling subsystem hardware and software
  + Address the design of the navigation hardware and software
  + Produce a risk assessment highlighting the top 10 technical risks to the satellite design.
* Outputs
  + Baseline Satellite Design Report (BSDR)

### **Task 4 Future Mission Planning and Delivery**

The UKSA is keen to explore all avenues of mission delivery and how such a refuelling mission may be delivered outside of the traditional Phase B,C, D, E institutional model. Participants are invited to explore non-traditional approaches to mission delivery and how such approaches could be used whilst still giving UKSA confidence in committing public finance and enabling a good understanding of the factors that may affect the schedule and cost of the project.

* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
      * High-level requirements from Task 1
      * CONOPS from Task 2
      * Basic Satellite Design from Task 3
* Task Description
  + Produce a delivery plan which gives confidence to UKSA which includes:
  + an overview of the project team and the project management approach.
  + an analysis of the level of definition of the technologies selected for the baseline satellite design. Identify long lead items, the source of supply (UK/Non-UK, etc.) and any ITAR/EAR and other export control issues.
  + an overview of the Manufacture, Assembly, Integration and Test (MAIT) approach.
  + an overview of the Product Assurance (PA) approach.
  + external interfaces and dependencies, and their potential impact on the cost and schedule.
  + the Risk Management approach; identify the top 10 cost and schedule risks.
  + an overview of any validation to be performed in orbit and supporting on-ground activities
  + Define the mission schedule (one or more Gannt Charts in MS Project or compatible format) including clear identification of the critical path and key delivery milestones for all project phases. Include a summary bar chart in the Development Plan.
  + Provide an itemized ROM cost, in MS Excel format, for the activities from the start of Phase B to the launch and commissioning of the spacecraft. Include a summary of the costs in the Development Plan document.
  + Provide an itemized estimate ROM cost, in MS Excel format, of the annual operations cost once the satellite has been commissioned. Include a summary of the costs in the Development Plan.
* Outputs
  + Development and Delivery Plan
  + Project Gantt Chart(s)
  + ROM Cost Estimates which cover whole life mission costs

### **Task 5 The Business Case**

The business case is crucial to the decision to build a spacecraft to refuel a target spacecraft. The cost to the user must be less than the cost of replacing a spent satellite with an identical replacement.

* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
      * High-level requirements from Task 1
      * CONOPS from Task 2
      * Basic Satellite Design from Task 3
      * Development and Delivery Plan from Task 4
* Task Description
  + Propose options for an economic infrastructure to refuel satellites, including:
* Market analysis
* Consideration of ground-based versus ‘gas station in space’ approaches
* Pricing policy e.g. price per servicing mission, multiple serving deals etc.
* Discussion of how many serving missions are needed per year to make them economic for both the users and the provider
* Assess the number and type of spacecraft that may adopt a refuelling approach and how they might be incentivized to make this commitment
* Produce a risk assessment highlighting the top 10 business risks
* Demonstrate the benefits to the UK economy
* Outputs
  + Business Case for Satellite Refuelling Missions in Low Earth Orbit

### **Task 6 Project Management**

This task relates to the management of the study.

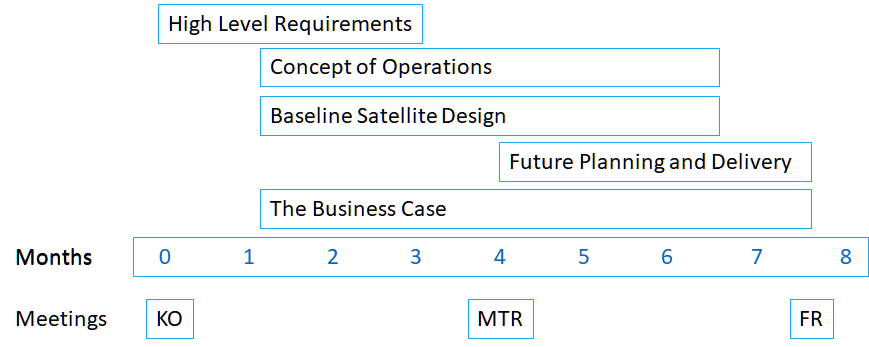
* + - Input
      * All applicable documents (e.g. the Call Guidance Document)
* Task Description
  + - * Produce a Project Management Plan (PMP) to manage the study
      * Provide regular reports on each of the tasks:
* Monthly progress reports, with reports sent on the last Tuesday of every month and prepared following the ‘monthly written report template’ outlined by UKSA.
  + - * Organise a Mid Term Review (MTR) and Final Review (FR); take minutes, record actions etc.
* Outputs
  + Project Management Plan
  + Monthly Reports
  + Meeting Minutes

## Workflow and Timeline

The project will be completed by 30th June 2024. The project will be punctuated by a series of project milestone meetings. Ahead of these meetings, the teams will be required to provide the relevant outputs and deliverables to the UKSA panel for review. The main milestones for the project are to include the following:

* Project Kick-Off: The Grant Recipient shall outline their plans for the study, recapping their proposal, highlighting any concerns/discussion points and stating any assumptions they have made.
* Project Mid-Term Review (MTR): The Mid-Term Review will allow for a review on the progress of the study highlighting progress in the development of the requirements baseline, the concept of operations and the baseline spacecraft design definition.
* Final Review (FR): Planned for the end of the study, this review will provide updates on the requirements baseline, the concept of operations and the baseline spacecraft design definition but will focus on the future mission planning and delivery, and the Business Case for a refuelling mission.

The indicative timeline for the project is as follows:



The Mid-Term Review is expected to occur approximately half-way through the study (approximately 4 months after Project Kick-Off). The Final Review will take place at the end of the study, ideally no later than 8 months after Project Kick-Off.

## Deliverables

[Table 1](bookmark://_bookmark11) defines the deliverables required in the study and allocates them to project milestones. All deliverables shall be delivered 5 working days ahead of the milestone dates to allow for review. The only exceptions to this are the summary presentations for the KO, MTR, and FR – grant recipients should provide them at least 24 hours ahead of the corresponding review meeting.

Applicants are invited to consider and propose additional deliverables and milestones needed to progress their project.

*Table* 1*: Expected deliverables*

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| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
| **Task** | **Deliverable Name** | **KO** | **MTR** | **FR** | **Notes** |
| 6 | KO Presentation | Issue 1 |  |  |  |
| 6 | Project management Plan | Issue 1 |  |  |  |
| 1 | High Level Requirements Document |  | Issue 1 | Issue 2 |  |
| 2 | * Concept of Operations |  | Issue 1 | Issue 2 |  |
| 3 | * Baseline Satellite Design |  | Issue 1 | Issue 2 |  |
| 4 | * Development and Delivery Plan |  |  | Issue 1 |  |
| 4 | * Development and Delivery Gantt chart(s) |  |  | Issue 1 |  |
| 4 | * ROM cost for Development and Delivery |  |  | Issue 1 |  |
| 5 | The Business Case |  |  | Issue 1 |  |
| 6 | Project Management Plan | Issue 1 |  |  |  |
| 6 | KO Presentations and Minutes | Issue 1 |  |  |  |
| 6 | MTR Presentations and Minutes |  | Issue 1 |  |  |
| 6 | FR Presentations and Minutes |  |  | Issue 1 |  |
| 6 | Monthly Progress Reports |  |  |  |  |
|  |  |  |  |  |  |