→ PREPARATION

Orbex Launch Services

ORB-ESA-PROG040-MN_MicroLauncher_Executive_Summary

Preparation Activities for Launch Services from European Privately Developed Mini/MicroLaunchers

Affiliation(s): Orbital Launch Services Ltd (Orbex)

Activity summary:
ESA is interested in launch services from European operators of European privately developed launch services for its mission needs. This executive summary outlines the assessment of Orbex as a potential launch service provider, as well as four future ESA missions as delivered on the Orbex Prime launch vehicle. It will outline the assessment methodology and resulting mission design. DRACO and LEO-PNT are projected to be fully compliant. A gap analysis is presented to detail how LUMIO could be fulfilled. It is concluded that SATIS is unsuited to the Prime launch vehicle.

Publishing Date: 02/08/24
Contract Number: 4000143508/23/NL/AS

1. Introduction

ESA is interested in launch services from European operators of European privately developed launch services for its mission needs.

Within that context this report provides an executive summary of the activities under ESA contract No. 4000143508/23/NL/AS related to the "Preparation Activities for Launch Services from European Privately Developed Mini/Micro Launchers (RCP/5-50034/23/NL/AS)"

The specific objectives of the contract are to:

- Assess the robustness of Orbex as a launch service provider for micro and mini launch services
- Perform feasibility studies on selected real ESA payloads or payload aggregates below 500kg.
- To detail the technical, programmatic or legal gaps in Orbex' roadmap with respect to the identified missions.

2. Project Background

Orbex aims to establish a sustainable launch service tailored to the deployment of small satellites (under 180 kg) into low Earth orbit from European soil. Our flagship project, Prime, is a two-stage reusable launch vehicle designed specifically for this purpose, offering a nominal payload capacity of 180 kg to LEO. Moreover, Orbex is also developing and operating the Sutherland Spaceport, strategically located on Scotland's north coast, providing access to orbits within inclinations ranging from 83° to 99°, effectively covering the most commonly used orbits for small satellites.

Prime is a two-stage launch vehicle tailored for the small satellite market, capable of launching up to 180 kg to Low Earth Orbit (LEO). It features an innovative carbon fibre coaxial tank configuration for both stages, using Liquid Petroleum Gas (LPG) as fuel and Liquid Oxygen (LOX) as the oxidiser. This design choice drives a 30% decrease in mass versus a traditional stacked-tank architecture thanks to a simpler architecture and a more efficient thermal management between the tanks.

The Stage 1 and Stage 2 engines were developed with extensive use of large scale, state-of-the-art additive manufacturing technology. The S1 engine features a turbopump assembly and a turbine, all arranged on a single shaft and forming a single subsystem, while the S2 engine utilises a simpler pressure-fed engine cycle to reduce component count and enhance operational reliability.

Figure 1 is a picture of Prime in the Orbex test site facility with some of the key technology highlighted.

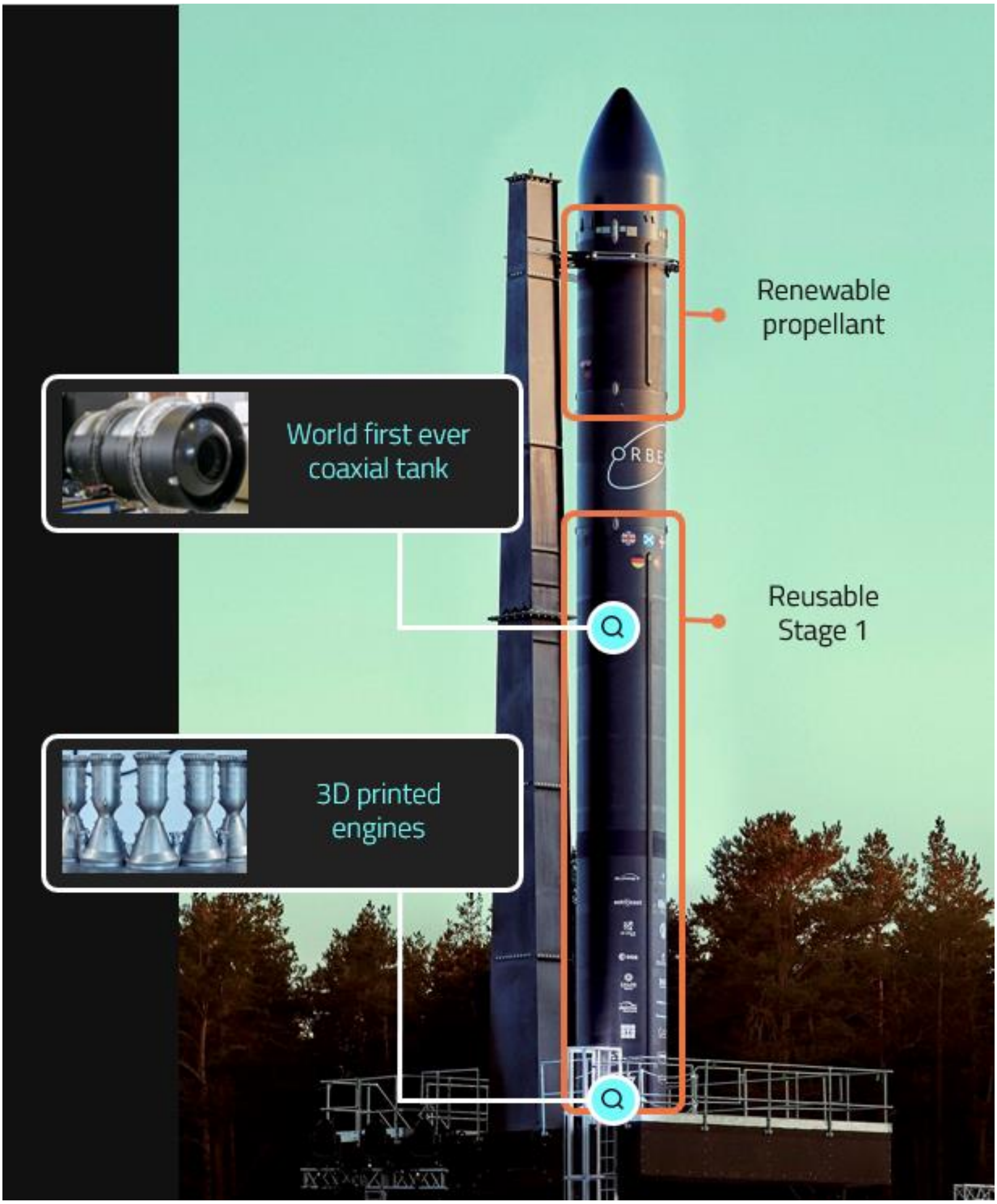


Figure 1: Orbex Prime Launch Vehicle

The purpose of the contracted activities was to evaluate the readiness and applicability of Orbex launch services to meet ESA's needs, identify any gaps, and formulate a roadmap to address them. The contract focuses on three key areas: (i) an assessment of the company's robustness; (ii) a mission feasibility analysis of four ESA missions; and (iii) a gap analysis of the current launch system relative to ESA requirements, followed by a high-level roadmap to close the identified gaps.

The missions under assessment are outlined in Table 1.

Name of mission	DRACO	LUMIO	SATIS	LEO-PNT Pfb
MISSION OBJECTIVES	Destructive Re-entry Assessment Container Object. Full orbital to be representative.	Lunar Meteroid Impact Flash mission. Requires chemical propulsion	Space safety: Apophis rendezvous mission (2 months prior to close encounter with Earth in 2029 (31500km altitude)	Positioning, Navigation and Timing (PNT) In-Orbit Services Demonstration in Low Earth Orbit. Comprehensive system validation
LAUNCH YEAR	2026 (TBC)	2026/27 (FAR 4Q2026)	2027	2026
MASS AT LAUNCH	190 kg	12U XL	12U XL	TBD (40-80 kg)
INJECTION ORBIT	No constraint. Re-entry burn by launcher upper-stage or OTV.	Earth-Moon L2 halo orbit. Delta-V required 80 m/s	SSO 500 km with 350 kg kick-stage to L2	TBD LEO circular orbit 600km, typically SSO
MISSION DURATION	~ 12 hours			3 years

Table 1: ESA missions for technical feasibility assessment

3. Methodology

3.1 Company Robustness Analysis

Company robustness analysis followed a structured three-phase approach:

<u>Phase 1 - Clarify the Orbex' Short term Objectives</u>. This phase details the company's extant position. This includes the Prime launch vehicle and associated design, manufacture and assembly facilities, as well as the Sutherland Spaceport facility.

<u>Phase 2 - Current Company Status Review</u>

This provided a comprehensive understanding of the company's current position through an in-depth review of the status across three key domains: technical, commercial, and financial. Within the technical domain, the existing technology, infrastructure, and capabilities were assessed. Commercially, a market analysis was performed that identified target market segments, potential growth opportunities and summarised the current launch manifest. Financially, the company's current financial resources were assessed and its funding strategy up to this point.

<u>Phase 3 - Review of the Short to Mid-term Plans for Each Domain</u>

The final phase summarised the current mid-term plans and perspectives for each of the three key domains of phase 2. Within the technical domain, a roadmap for the remaining technology development, and infrastructure enhancement was presented. Commercially, the commercial initiatives planned to achieve the short-term launch ramp up were outlined. Financially, the funding strategy going forward was reviewed.

3.2 Mission Assessment

The assessment of the four proposed mission concepts against the Orbex launch system's capabilities was approached in two phases:

<u>Phase 1 – Mission Concept Compliance Screening and Down-Selection</u>

In this initial phase, a screening process was conducted to evaluate mission concepts against the Orbex launch system current and projected capabilities. This analysis was methodically approached, focusing on four critical compatibility areas namely technical compliance, operational compatibility, commercial compatibility and regulatory compatibility. Missions that exhibit the highest degree of alignment with the Orbex launch system were down-selected for further analysis.

<u>Phase 2 – Feasibility Analysis for Each of the Missions</u>

A detailed feasibility analysis was performed on each down-selected mission from phase 1. The feasibility covered the following areas:

Assessment Area	Comment
Technical Compatibility	
Payload Capacity	Analysing the ability of the launch system to accommodate the mission's payload requirements
Orbital Requirements:	Assessing whether the launch system can achieve the desired orbits specified for the missions.
Ground Support & Safety	Ensuring that ground operations, including safety protocols, align with the mission needs.
Mission Functions	Reviewing the compatibility of the launch system with the specific functions and objectives of each mission.
Launch Vehicle Interfaces	Checking the compatibility of the launch vehicle with the satellites' hardware and technology.
Operational Compatibility	
Mission Integration	Examining the compatibility of the integration operations flow at Sutherland Spaceport with each mission.
Launch Schedule	Aligning the mission's timeline with the launch schedule of Orbex.
In-flight Operations	Ensuring the compatibility of in-flight operations and procedures with the mission requirements.
Commercial Compatibility	
Customer Support	Evaluating the ability of Orbex to provide the necessary customer support throughout the mission.
Ancillary Services	Determining the availability and suitability of additional services that might be required for the mission
Regulatory Compatibility	
Licensing	Ensuring that all necessary licenses can be obtained for the mission in compliance with relevant laws and regulations.
Insurance	Assessing the insurance requirements and availability for the mission, in line with industry standards and practices.

Table 2: Feasibility analysis areas

3.3 Gap Analysis

Following Mission feasibility study, the gap analysis followed a three phased approach to ensure the alignment of the Orbex launch services with ESA's launch requirements, namely:

<u>Phase 1 - Framework Definition</u>
As systematic assessment framework was proposed to address both mission and commercial compliance factors as laid out in Table 3.

<u>Phase 2 - Gap Identification</u>

The selected missions were systematically assessed against the framework defined in phase 1. Any discrepancies or gaps between Orbex services and the mission requirements were identified and categorised based on severity (1 being trivial and 3 requiring most effort).

<u>Phase 3 - Roadmap Formulation</u>

Having identified and documented the gaps, a strategy to close the gap was identified. Where missions had been excluded, the insurmountable gaps were identified and documented.

Category	Element	Comment
Mission Level		
Technical	Payload capacity and compatibility	Assess whether Orbex' launch vehicle can accommodate the mission's payload in terms of weight, size, and shape.
	Interface requirements	Examine the compatibility of the mission's interfaces with the launch vehicle. This includes electrical, mechanical, and communication interfaces
	Orbital requirements	Determine whether Orbex can provide the required orbit for the mission, including mission-specific requirements, such as specific orbit injection accuracy, payload deployment methods, or specialized mission profiles.
	Ground Support & Safety	Examine the ground infrastructure and support services provided by Orbex, such as launch facilities, mission control, and tracking and telemetry.
Operational	Mission integration	Evaluate how the mission's payload will be integrated into the launch vehicle and assess toolchain requirements for missionization.
	Launch schedule	Analyse Orbex' launch schedule and availability. Ensure that the proposed launch dates align with the mission's timeline and objectives.
Commercial	Customer support	Assess the level of customer support and communication provided by Orbex throughout the mission lifecycle.
	Ancillary services requirements	Consider ancillary services requirements such as testing, data retrieval, telemetry, and support for on-orbit operations.
Regulatory	Licensing	Assess the support required and/or impact of the UK payload and launch vehicle licensing regime for ESA missions.
	Insurance	Evaluate Orbex' insurance coverage and liability policies to ensure they align with the mission's risk management requirements.
Company level		
Insurance	Third party liability	Eligibility of the company for third liability insurance.
	Payload insurance and liability	Chain of responsibility and liability for the payload up until launch, and the accompanying insurance.
Regulatory	Licences	Regulatory approvals in the spaceport jurisdiction.
	Export control	Assessment of any restrictions imposed by export-controlled components, and limitations to ESA missions.
Environmental	ESA Debris Mitigation Policy and Requirements	Compliance to ESA debris mitigation policy and the Do No Significant Harm European policy.
Commercial	Pricing policy	Assessment of ceiling prices for standard launch service offer.

Table 3: Gap analysis Framework

4. Key Findings

4.1 Company Robustness

With nearly 200 employees, eight facilities encompassing manufacturing, testing, and a proprietary spaceport, and being the second most funded private launch company in Europe, Orbex is a robust company ready to serve ESA's launch needs.

From a technical perspective, Orbex is in late-stage development of one of the most innovative and sustainable launch vehicles, along with its ground segment and spaceport. The launch system is designed to enable small satellites to tailor all mission requirements, something they never have the chance to do in rideshare or piggyback missions.

From a commercial perspective, the Prime value proposition distinguishes itself in the market through four key pillars: (i) ease of use; (ii) responsiveness; (iii) customization; and (iv) sustainability. The customer journey is well-defined, with contractual, regulatory, and insurance matters clearly identified and progressing as expected, ensuring a seamless experience for clients.

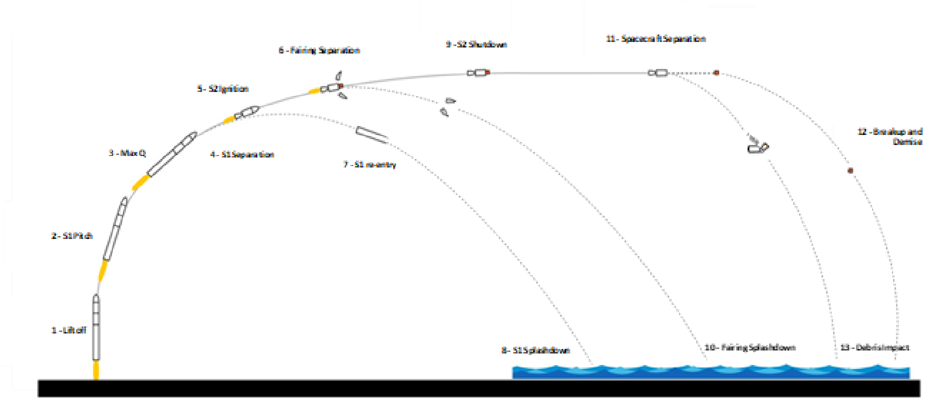
Finally, Orbex has successfully attracted a diverse portfolio of private investors, including prominent financial investors such as Octopus Venture and Heartcore, strategic investors from leading space companies like Deimos and Jacobs, and national investment funds like the Scottish National Investment Bank and the Danish Export Fund. This private capital has been further supplemented by grants from esteemed institutions, including ESA, UKSA, and the European Commission, underscoring the company's technical expertise and credibility.

In conclusion, the analysis clearly shows that Orbex is a robust company well-positioned to meet current ESA launch needs and that its long-term plans are aligned with ESA's future needs for a dynamic, cost-effective, and flexible launch alternative.

4.2 DRACO

DRACO exemplifies the advantages of Prime. Thanks to its performance and the flexibility of Orbex's launch service, Orbex can tailor the launch parameters specifically to the DRACO mission, avoiding the constraints and limitations associated with rideshare or piggyback missions that would result in a compromise orbit/re-entry parameters.

Detailed mission analysis demonstrates a viable solution targeting a 500 km x 0 km re-entry trajectory directly from the launch vehicle's ascent phase. This approach injects the DRACO payload and upper stage into the re-entry trajectory at SECO1 (first Second Engine Cut Off), eliminating the unnecessary risk of an in-orbit engine relight and enabling full customization of the re-entry parameters. Figure 2 illustrates the proposed mission profile and provides a high-level operational timeline for this solution.



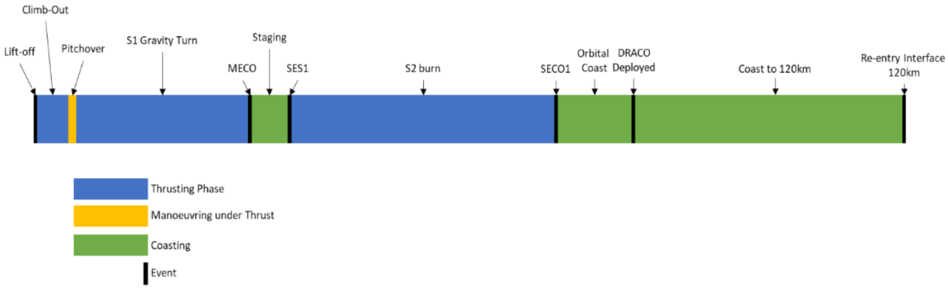


Figure 2: DRACO mission profile and timeline

4.3 LEO-PNT

LEO-PNT is a standard mission architecture for Prime. Similar to DRACO, the flexibility and dedicated nature of the Orbex launch service allows the company to offer ESA a direct deployment of each pair of LEO-PNT satellites to their required inclination.

The proposed mission solution is a standard 2-stage burn to a transfer orbit injection, a coast to apogee and then an insertion into the required orbit via the Prime Upper Stage, with a release of the two payloads once final orbit is achieved. After an attitude alignment manoeuvre, the LEO-PNT payloads are deployed. A coasting phase for separation build up, with an optional Collision and Contaminants Avoidance Manoeuvre (CCAM) performed, allows for sufficient distance between the upper stage and the deployed payloads for Prime to perform an orbit lowering burn to ensure end-of-life state compliant to standard ESA practice. Figure 4 shows the proposed mission profile and high-level concept timeline for operations for the proposed solution.

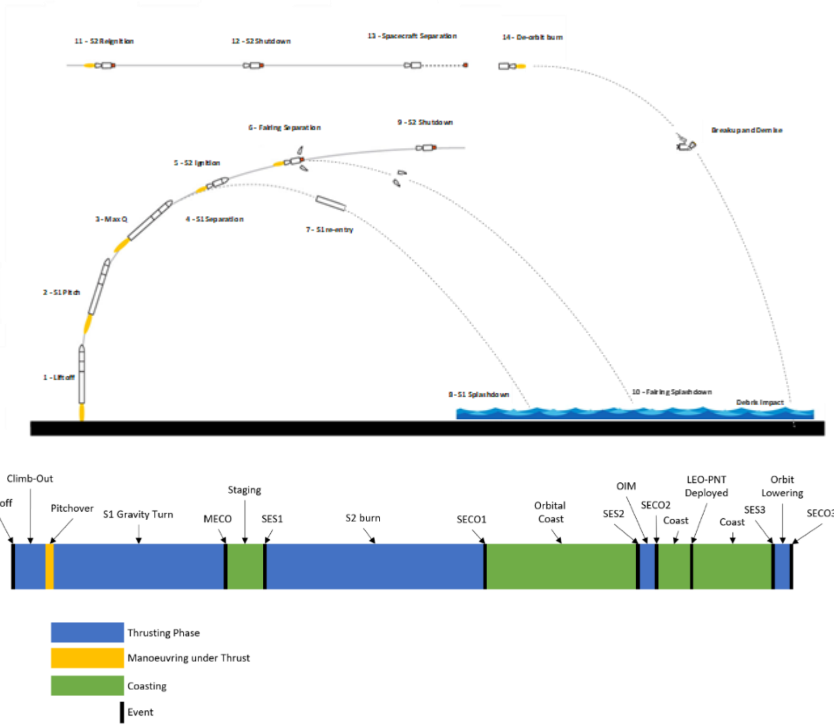
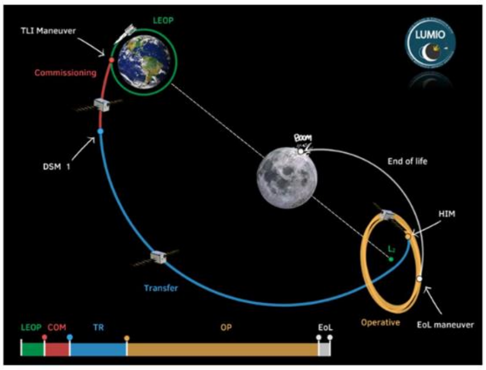


Figure 3: LEO-PNT mission profile and timeline

4.4 LUMIO

LUMIO is at the limit of what Prime can perform and while the vehicle could perform the mission, there is some development and operational development needed. The LUMIO mission architecture is illustrated in figure 5 with highlights where the feasibility of using Orbex Prime as the service function was assessed.



1) Launch and Early Operations Phase
- Piggyback on launch vehicle
- Release in translunar trajectory (Weak Stability Boundary transfer)

2) Commissioning Phase (7 days)

3) Transfer Phase (100 days)
- WSB to Earth-Moon L2 halo orbit
- 3 Deep Space Manoeuvres

4) Operative Phase (1 year)
- Earth-Moon L2 Halo orbit
- 14-day science, 14 day nav/eng cycle

5) End of life Phase
- Crash on the Moon

Serviced by Orbex Prime

Not considered

Figure 4: LUMIO Mission Architecture

Initial analysis revealed that Prime in its baseline configuration launching from Sutherland Spaceport did not have the required performance, however, further analysis identified a method to close the performance gap. The required delta-v could be achieved using the Orbex Prime launch system given the 2 following conditions being true:

- Orbex will have to operate the Prime vehicle from an equatorial spaceport (in this analysis, Centre Spatial Guyunais was used as the baseline).
- A kick stage or Orbital Transfer Vehicle (OTV) will have to be developed or procured, and integrated with the Orbex Prime vehicle as a third stage.

While DRACO and LEO-PNT highlight the capabilities Orbex can offer ESA today, LUMIO exemplifies the flexibility and potential that Prime will provide to ESA in the near future.

4.5 SATIS

The SATIS mission was assessed during the downselection exercise and scoped out of the detailed analysis given the mismatch between Prime's performance and the 350kg upmass of the kick stage and payload stack.

5. Conclusion

In conclusion, this study has provided an in-depth analysis of Orbex's robustness as a company, and its feasibility to deliver four real ESA payloads or payload aggregates.

The analysis clearly shows that Orbex is a robust company from a technical, commercial and financial perspective, with a clear path to service ESA contracts. Orbex is projected to be fully compliant in servicing the DRACO and LEO-PNT missions using its Prime launch vehicle operating from Sutherland Spaceport. Additionally, Orbex could service the LUMIO mission with access to an equatorial spaceport and development to integrate an OTV.

6. Future Work

Future work can be defined in four broad categories, namely LV continued development, Spaceport continued development, Legislative Enablers and Mission design.

LV development: As discussed in the Company Robustness Analysis, the Prime Launch Vehicle is presently in late-stage development, with future work envisioned in the short term to take this product to full commercial exploitation. The launch of the first mission will be instrumental to characterise the operational environment induced within the LV. This will refine and validate the payload specifications and derisk the integration of DRACO or LEO-PNT.

Spaceport Development: Sutherland Spaceport is presently under construction with an expected completion date of Spring 2025.

Legislative Enablers: In order to allow for Prime to launch from Sutherland spaceport, five licences are required, namely a Launcher Operator licence, Spaceport Operator Licence, a Range operator licence, an airspace change and a marine licence. Applications have been submitted and are expected to be in place by Q2 2025.

Launch 3rd party insurance requires legislative clarification from the UK government, however it is anticipated that this will be in place by 2025. Orbex has established good relationships with service providers via insurance for our engine test firing campaigns and will need to extend this to launches.

Mission Design: Prime is ideally positioned to serve DRACO and LEO-PNT, but there is minor additional development work needed to enable the full mission capabilities (ie. telemetry downlink interface to payload). As for LUMIO, future work includes certifying Orbex and Prime to launch from CSG (with all the regulatory and development work that implies) and integrating an Orbit Transfer Vehicle as a third stage to augment Prime’s performance.