

PAYLOAD USER'S GUIDE

SKYRORA

XL



OCTOBER 2019

VERSION 1



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VERSION 1

DEDICATED VERSATILE RESPONSIVE



Dear future customer, this guide has been created by our team to kick-start the process of launching your payload. That process is one that we are doing all we can to keep short and concise, allowing us to get you into space in a timely, effective and cost-effective manner.

We have a firm belief that each and every Skyrora customer should receive a level of customer relationship management, worthy of the incredible, cutting-edge industry that we operate in. After all, together, we are accessing space in order to make our world a safer, better place. A dedicated Account Manager will be with you every step of your journey and our Mission Management team will ensure that journey is carried out as smoothly as possible. Thank you for considering Skyrora for your launch needs, we look forward to surpassing your expectations!

Best regards,

Volodymyr Levykin
CEO Skyrora Ltd

A handwritten signature in black ink, appearing to read 'V. Levykin'.



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1

INTRODUCTION

The Skyrora XL user's guide provides an initial overview of the launch system designed by Skyrora, and offers preliminary information for customer advanced mission planning. Skyrora aims to support the UK's plans for space sector growth through the development of an orbital launch vehicle and a number of carefully selected supply chain innovations, that we believe will benefit the industry as a whole for years to come. The information supplied here is not mission specific data and is subject to change. All the necessary information for the specific mission planning shall be provided in the Interface Control Document (ICD) after the Launch Service Agreement is signed.

REVISION HISTORY

Date	October, 2019
Version	1.0
Changes	First Release

CONTACT SKYRORA LTD

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2 SKYRORA XL OVERVIEW





Skyrora XL is a three-stage, light class launch vehicle, intended for placing payloads into Sun-Synchronous Orbit (SSO) over a range of 500 km to 1000 km altitude, as well as polar orbit over a range of 200 km up to 1000 km. Moreover, the payload mass inserted into Low-Earth Orbit may be specified at the Customer's request for a specific inclination and altitude.

For all stages, a liquid propellant propulsion system is used, with high-test peroxide as the oxidiser and kerosene as the fuel. These propellant components provide easy handling of the launch vehicle services during pre-launch operations. Our propellant components are non-cryogenic, non-hypergolic, non-toxic, storable at the launch site and environmentally friendly.

One of the key design criteria of Skyrora XL is the unification of the launch vehicle's main systems, assemblies and units. This can provide a reduction in time and costs for design and testing processes, and increased reliability of the launch vehicle. Unification within the Skyrora XL architecture is implemented in the following ways; the main engine, named SKYFORCE, is used for both the first and second stages, and has unified turbopump machinery, main units and assemblies, however, the engine nozzle extension on the second stage is adapted for operation in the vacuum of space. A unified pneumo-hydraulic system is used for the first and second stages as well. The pressurisation system for the propellant tanks is designed using unified pressurisation vessels and automatic equipment.

Coaxial propellant tanks are used to increase the dry mass efficiency of the Skyrora XL structure. These tanks satisfy all operational requirements during pre-launch and launch phases, in fact, they are expected to have less mass than conventional tanks. An integrated propellant tank is used for the first and second stages. The structure of the propellant tanks of the 1st and 2nd stages is unified, and presents a joint composite structure.

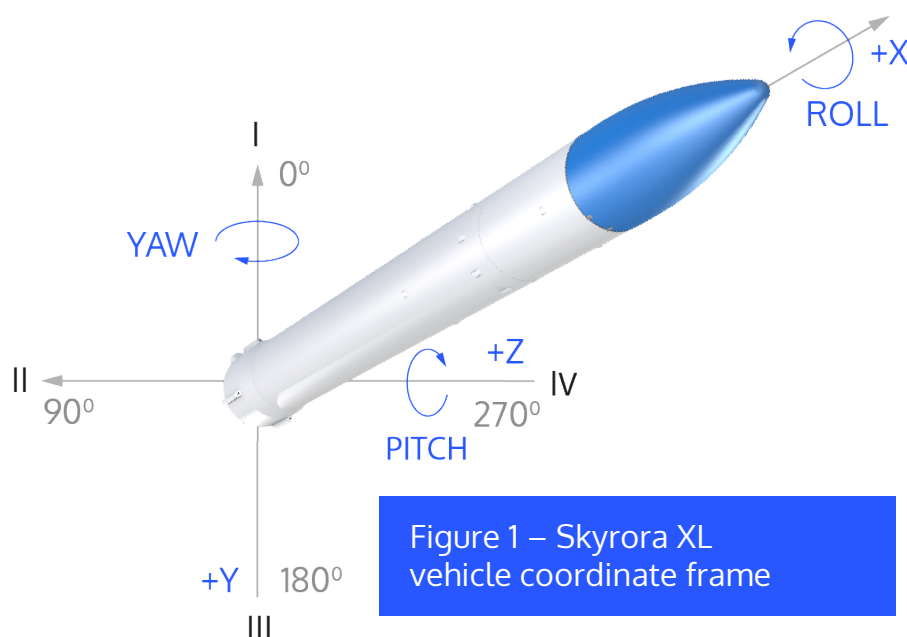
The technology applied for the manufacturing of dry bays is also unified, and the structure of the first and second stage dry bays have a sandwich-type shell.

A “cold” separation system is used for all stages, and is performed by mechanical release with the help of electromechanical locks and repulsing of the separating component.

The third stage reaches a perigee velocity which enables it to enter an elliptical transition orbit, and then a boost to circularise the target orbit. The main propulsion system of the third stage includes the LEO engine, which is capable of multiple ignitions. The third stage uses a pressure fed system for the propellant supply, using cold gas. Helium is used as the pressurant.

To meet the Customer’s payload requirements during installation, maintenance and operation, Skyrora use an “encapsulated” Payload Module, which is assembled as a standalone system from the launch vehicle.

Axes of Skyrora XL are defined and shown in Figure 1. Roll, Yaw and Pitch define rotation around fixed body frame X, Y and Z axes. The axes definitions in Figure 1 are used throughout this User’s Guide to specify payload environments and loads.





To learn more about SKYRORA XL, please see Figure 2.

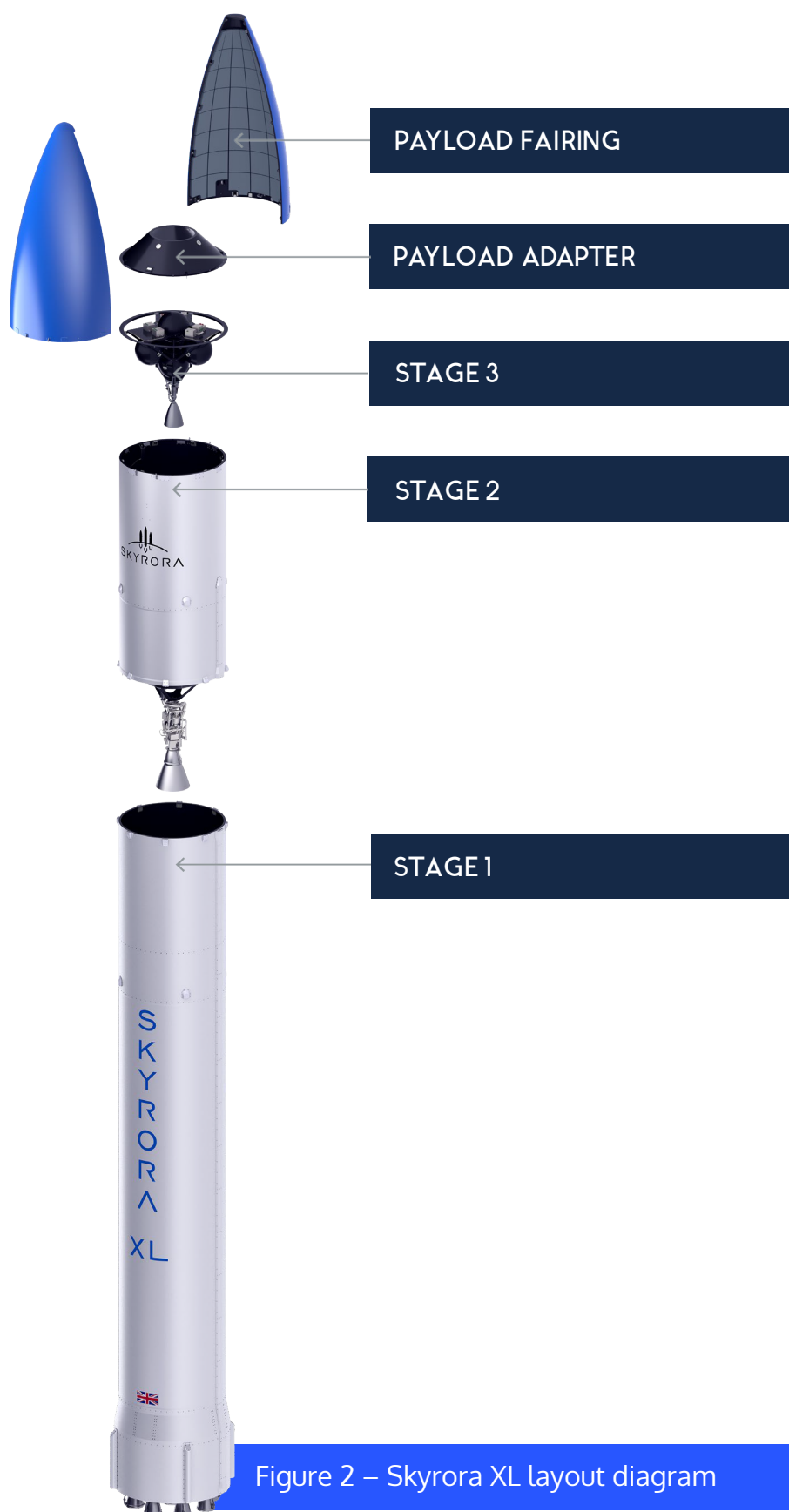


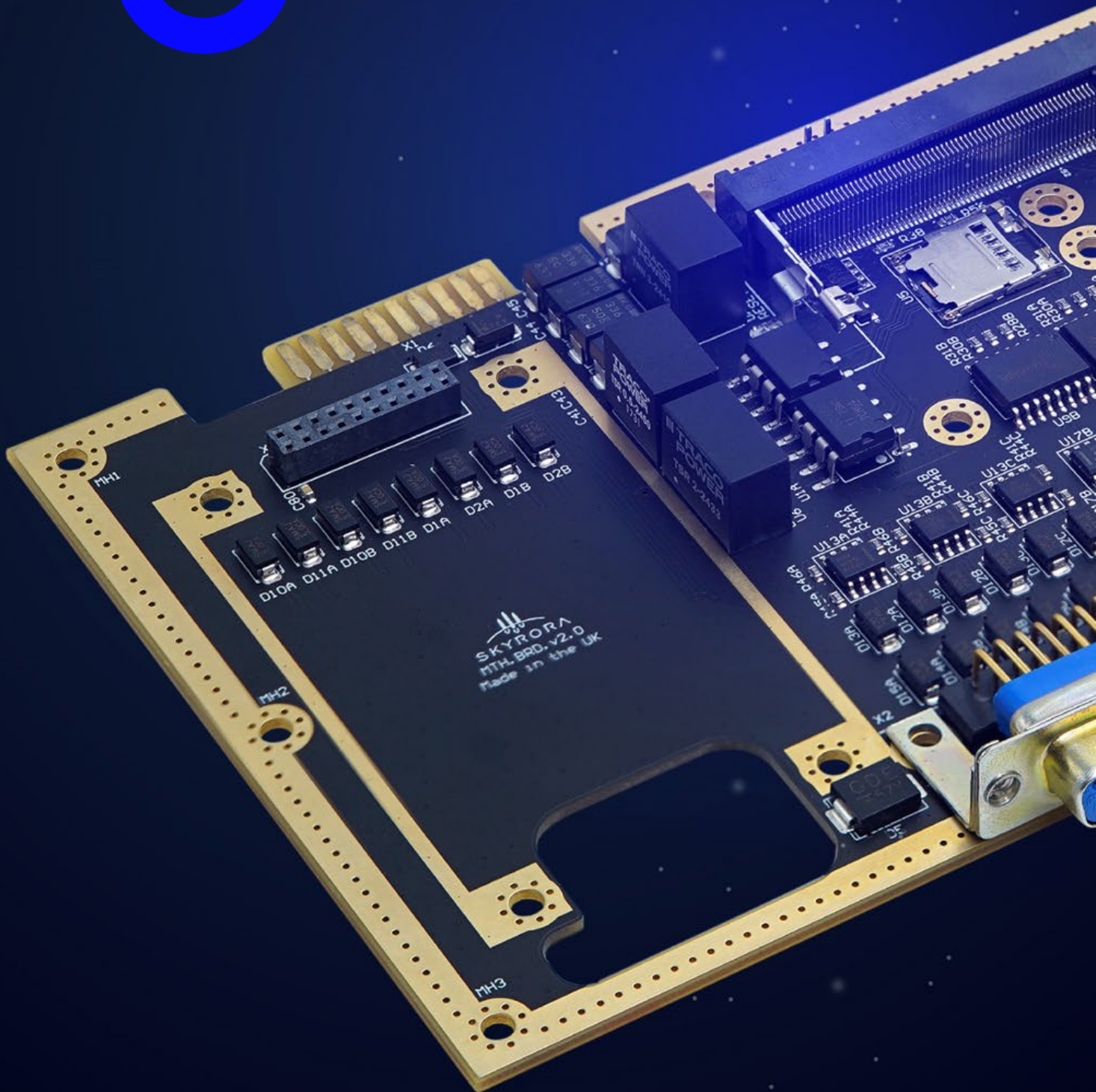
Figure 2 – Skyrora XL layout diagram



PARAMETER	VALUE
Length	24.1 m
Diameter	2.2 m
Stages	3
Lift-off mass	55.8 t
Material/Structure	Composite/Monocoque
Propellant	HTP/Kerosene
STAGE 3	
Propulsion	1 x LEO engine
Thrust	3.5 kN
ISP	305 s
Propellant feed system	Pressure fed
Multiple ignition	yes
STAGE 2	
Propulsion	1 x Skyforce
Thrust in vac	85 kN
ISP in vac	306 s
Propellant feed system	Turbopump
STAGE 1	
Propulsion	9 x Skyforce
Thrust at sea level	630 kN
ISP at sea level	250.4 s
ISP in vac	286.7 s
Propellant feed system	Turbopump

Table 1 – Skyrora XL main characteristics

3 AVIONICS



The Skyrora avionics system features a fault-tolerant architecture that has been designed according to ECSS standards. The avionics system includes a GNSS receiver, inertial navigation system, and flight computers and controllers for vehicle control (propulsion, valves, pressurisation, separation and payload interfaces, etc.) designed and manufactured in-house by Skyrora, as well as S-band transmitters and a C-band transponder for range safety tracking. The Skyrora XL flight computers and controllers are based on automotive electronic components. The S-band transmitters are used to transmit telemetry and video to the ground, from the first, second and third stages, even after stage separation.

The Skyrora XL launch vehicle is equipped with a flight termination system to limit the potential damage caused by launch vehicle malfunction. The system terminates the flight of the vehicle when commanded by the range mission flight control officer, as well as if the LV escapes the safe flight zone.



Figure 3 – Skyrora avionics



4 ENGINES



4.1. THE SKYFORCE ENGINE



The SKYFORCE is a unique staged combustion engine which runs on Hydrogen Peroxide and Kerosene. A closed cycle allows the engine to be throttled over a wide range and increase the specific impulse, without over-engineering of the design.

The same engine is used for the first and second stages of the Skyrora XL launch vehicle. Nine engines will power the first stage of the Skyrora XL launch vehicle, and one engine with an extended, vacuum optimised nozzle, will power the second stage. The use of a common engine on the two stages, allows the number of static test firings required for engine validation, to be reduced.

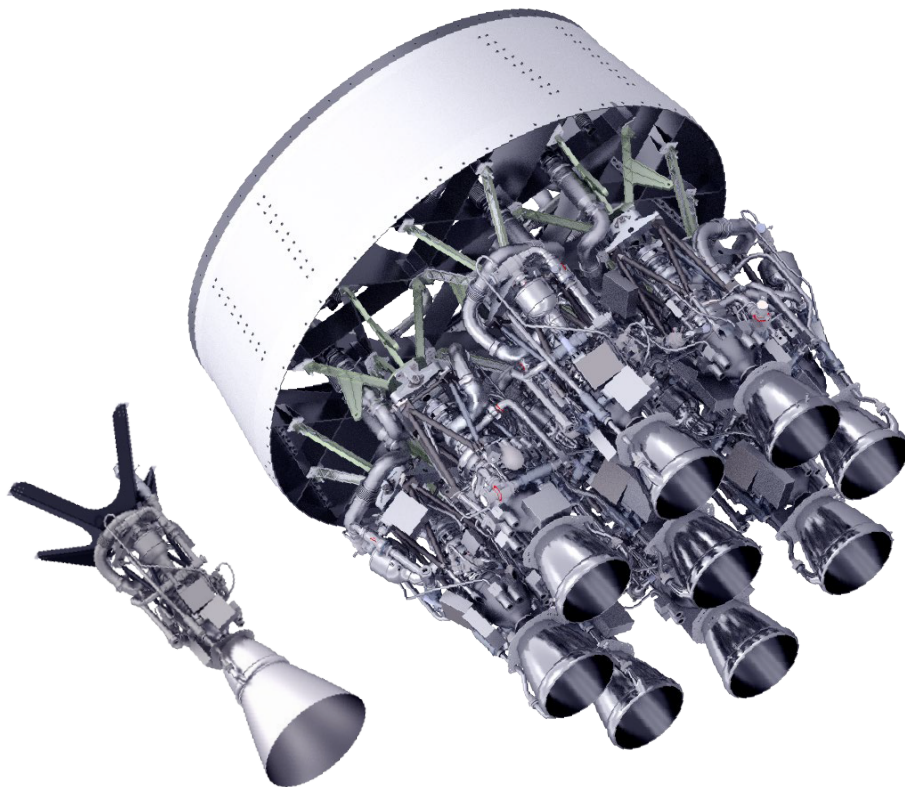


Figure 4 – The SKYFORCE engine, used in the first and second stages



4.2. LEO ENGINE

The LEO engine is a pressure fed rocket engine, designed to power the third stage of the Skyrora XL launch vehicle. As with the first and second stages, to maintain commonality, it uses Hydrogen Peroxide and Kerosene as its propellant components. Design of the thrust chamber is adapted for 3D printing. This approach makes the manufacturing process adjustable for any design changes, and simplifies the manufacturing process for the regeneratively cooled combustion chamber and injector head. Adding to its flexibility, this design also allows the use of HTP as monopropellant.

At the current time, a prototype of this engine has successfully been fired 9 times with a total burn time of more than 600 seconds. The engine has also been tested at Newquay Airport facility, Cornwall. This was the first successful test of a commercially fully 3D printed bi-liquid rocket engine for the last time in UK.

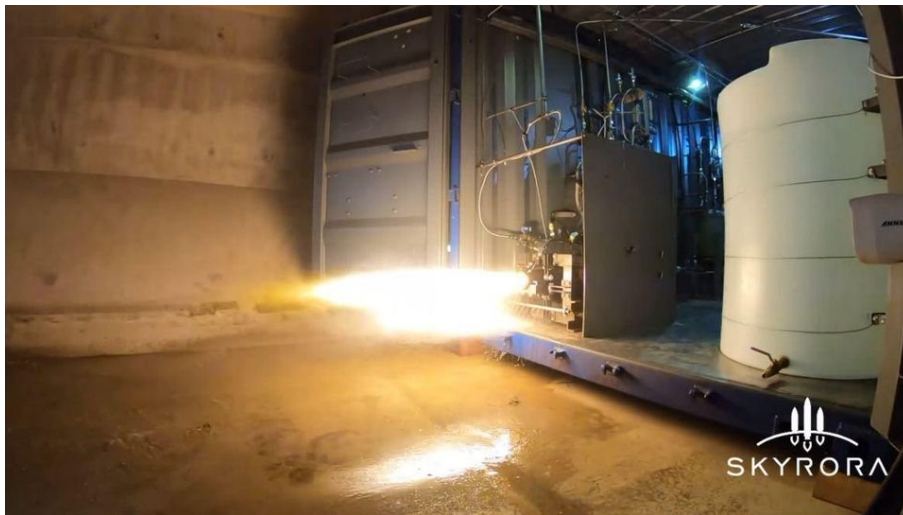
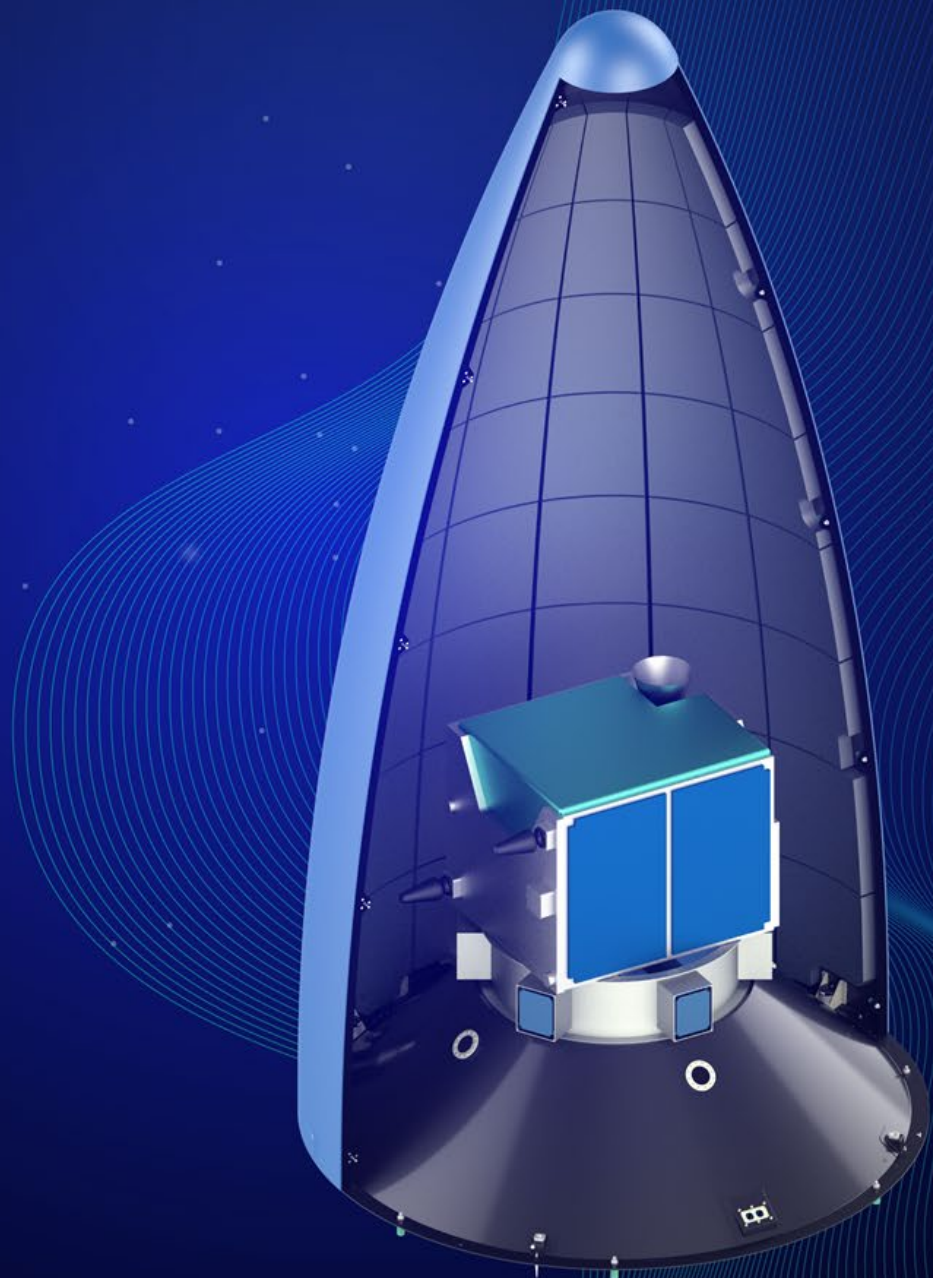


Figure 5 – LEO engine

5 PAYLOAD ACCOMMODATION





5.1. PAYLOAD MODULE

The payload module hosts the payload. To meet the requirements of the Customer's payload during installation, maintenance and operation, Skylark use an "encapsulated" Payload Module, which is assembled as a standalone to the LV. The Payload Module consists of the payload fairing and adapter, dispenser (if required), and other systems for safe operations during pre-launch operations and flight. The payload fairing casing consists of two halves, composed of a 3-layer composite shell with a honeycomb filler. Bearing layers are made of a carbon-fiber composite. When the rocket reaches the required altitude, the halves of the payload fairing are released with the help of push-rod springs installed on the payload fairing casing.

SPECIFICATION	VALUE
Length	4.4 m
Diameter (maximum)	2.2 m
Mass	215 kg
Acoustic protection	Polyethylene foam
Separation System	Electromechanical unlocking, Springs

Table 2 – Skylark XL payload fairing specification

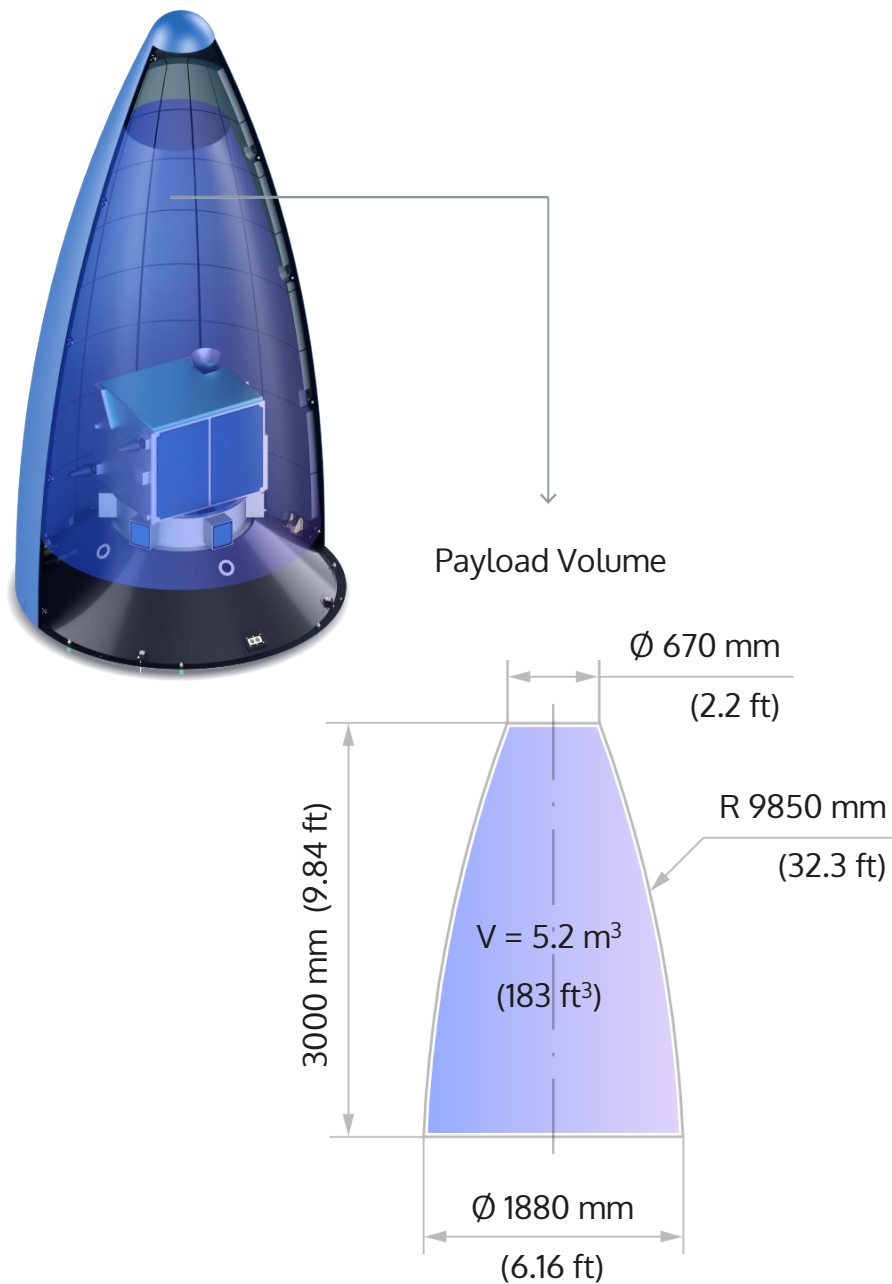
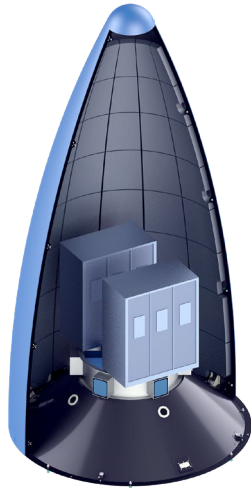


Figure 6 – Payload volume

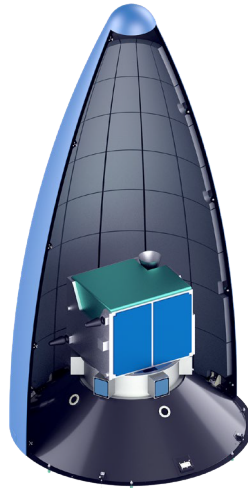
The Payload Module enables the hosting of payloads developed on the most popular light class satellite platforms. Figure 7 shows the positioning of payloads via a custom design platform, SSTL-1150 and SSTL-300 and LM400 (compatible with minor mission-specific modification available for the extra cost of structural modification).





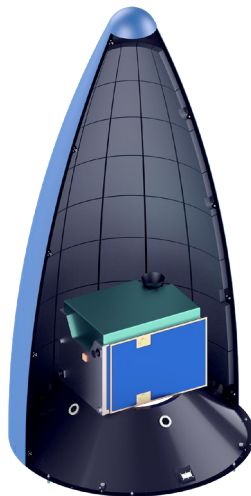
Primary payload:
Custom design

Secondary payload:
P-POD 3U/6U

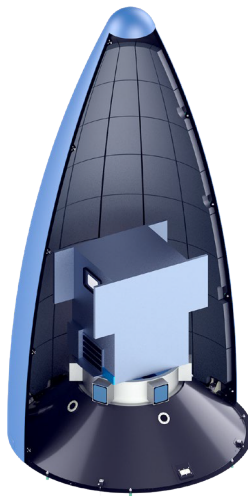


Primary payload:
SSTL-150

Secondary payload:
P-POD 3U/6U



Primary payload:
SSTL-300



Primary payload:
LM400*

Compatible with minor mission-specific
modification available at the extra cost of
structural modification

Figure 7 – Integration diagram of the possible payload platforms

5.2. PAYLOAD ADAPTER & INTERFACE

The payload adapter is a cone-shaped, smooth composite shell. The body is made of a carbon fibre composite. There are interfaces at the upper end of the adapter for connection with the payload. The general layout of the payload adapter and mechanical connection interfaces are shown in Figure 8.

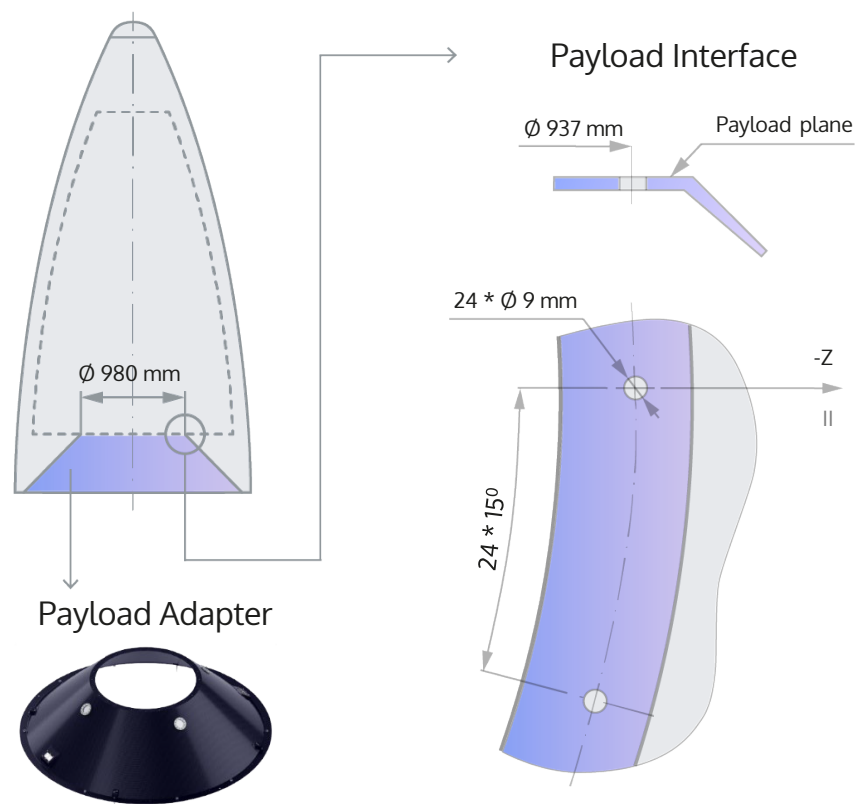


Figure 8 – Skyrora payload adapter interface

Skyrora provides the ability to connect the electrical interfaces of the payload by means of detachable connectors onboard the launch vehicle, which can charge and monitor the payload. Details of this interface are provided in the mission specific ICD. Skyrora provides electrical interfaces for the payload in SC and PLM and test areas that are defined by the mission ICD.



6 PAYLOAD ENVIRONMENTS



6.1. TRANSPORTATION & HANDING LOADS



The payload takes axial, vertical and lateral G-loads during transportation, handling and pre-launch operations at the launch site. The maximum possible G-loads are shown in Table 3. The range of G-loads is coordinated for each launch mission with the Customer.

Axial load (x), g	± 1.5
vertical load (y), g	1 ± 1.0
lateral load (z), g	± 1.25

Table 3 – G-loads



6.2. FLIGHT LOADS – QUASI-STATIC

During the flight, the payload is not expected to endure a G-load exceeding that indicated in Figure 9, corresponding to operation of the first stage.

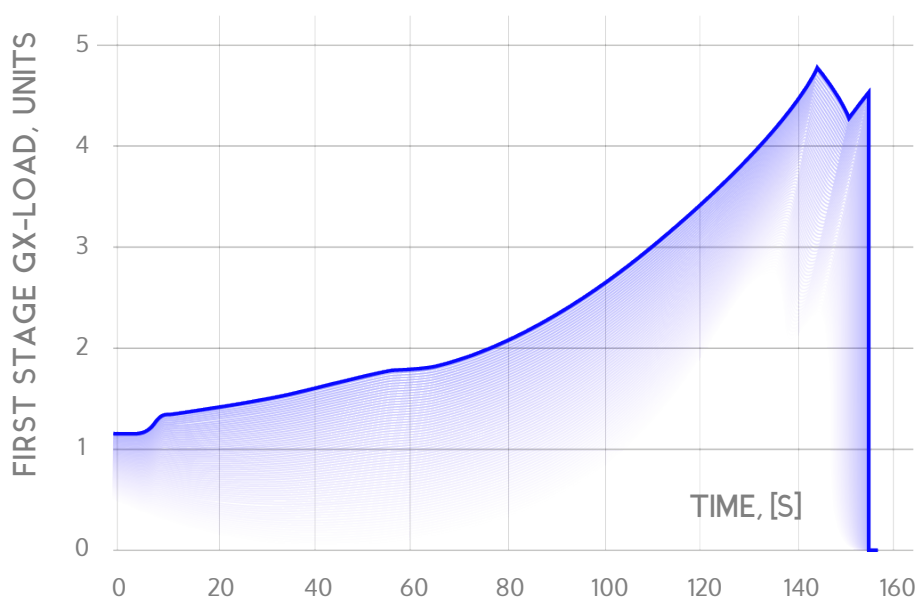


Figure 9 – Gx-load change during first stage operation

6.3. FLIGHT LOADS – ACOUSTIC

Acoustic loads inside the payload fairing during lift-off and transonic flight are constantly analysed. Payload fairing acoustic protection will be used to ensure the Overall Sound Pressure Level (OSPL) is kept below 130 dB.

6.4. PAYLOAD CONDITIONS



The thermal environment provided during payload preparation and launch is shown in Table 4.

SPECIFICATION	VALUE
Ambient temperature around the payload during pre-launch	10-28°
Relative humidity of thermal regulated air during pre-launch operations	less than 65 %
Thermal regulated air velocity during launch processing	less than 3 m/s
Heat flux from the structure of the payload fairing to the payload	less than 400 W/m²
Free molecular heat flux	less than 1135 W/m²
Max rate of pressure change under the fairing volume during the boost phase of the second stage	less than 1600 Pa/s

Table 4 – Payload conditions



6.5. FAIRING PRESSURE

The payload fairing depressurisation rate is expected to be less than 1600 Pa/s from lift-off up to fairing separation. Internal pressure at the moment of fairing jettison is expected to be less than 190 Pa.

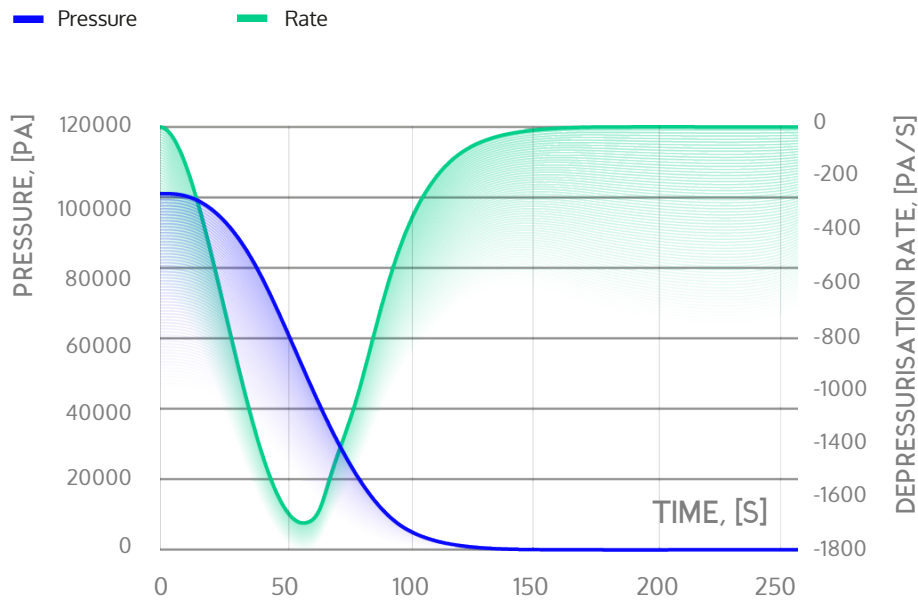


Figure 10 – Preliminary fairing internal pressure profile

6.6. RADIO FREQUENCY



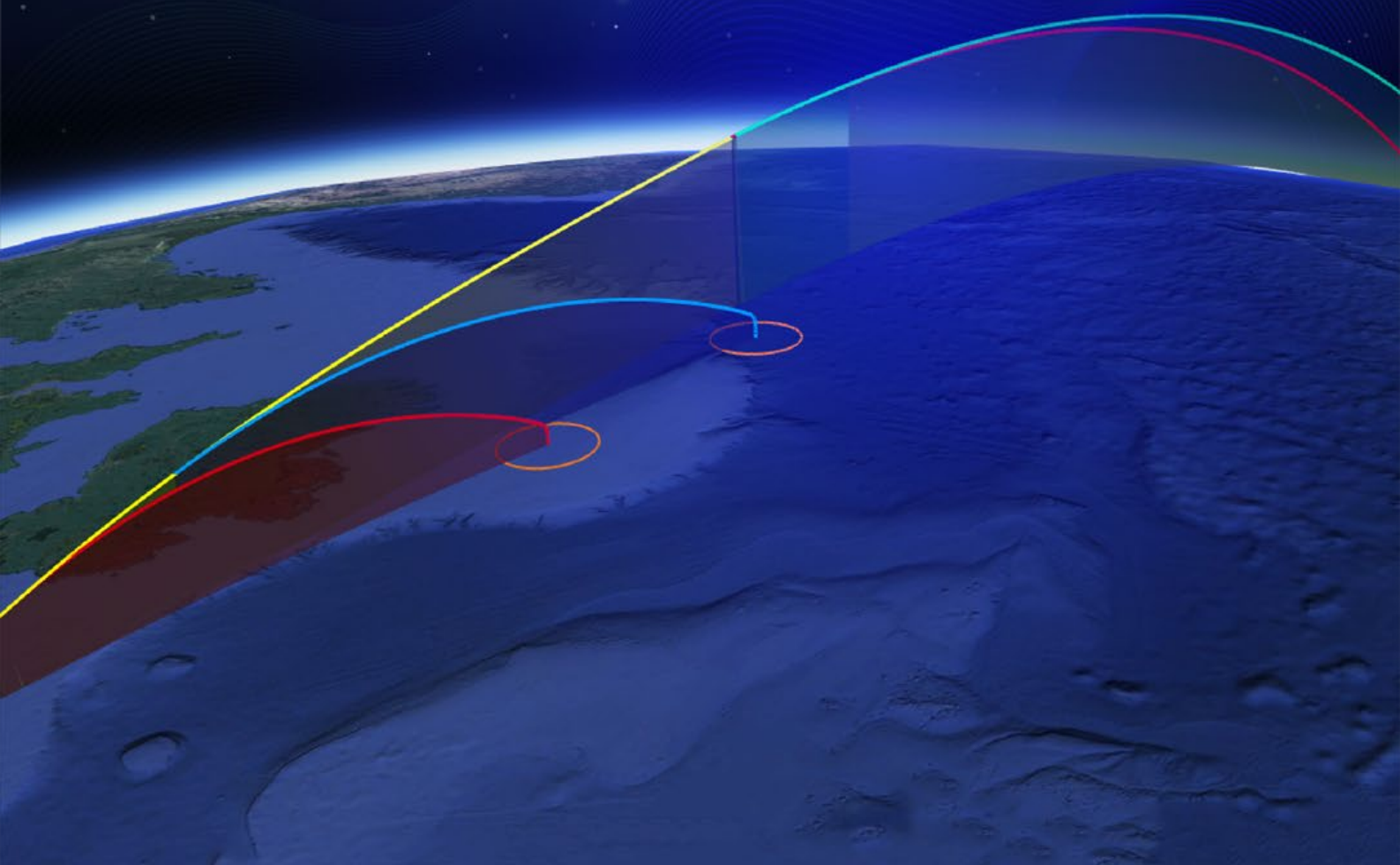
Six radio frequency systems are used for the Skyrora XL launch vehicle, and are shown in Table 5.

RF BAND	PART DESCRIPTION	RX/TX	FREQUENCY (MHZ)	OUTPUT POWER (W)/ RECEIVER SENSITIVITY (DBM)	MODULATION
S-band	Telemetry Transmitter	TX	2200-2400	10 W	PCM/ FM
S-band	Telemetry Transmitter	TX	2200-2400	10 W	PCM/ FM
S-band	Telemetry Transmitter	TX	2200-2400	10 W	PCM/ FM
L-band	GNSS Receiver	RX	1575.42 (L1); 1227.6 (L2)	-140 dBm	BPSK
UHF	FTR Receiver	RX	390-450	-107 dBm	FM
C-band	Radar transponder	RX/ TX	5400-5900	50 W	Pulse

Table 5 – Radio frequency system characteristics

Specific electromagnetic compatibility requirements during the pre-launch and launch phase will be defined in the ICD, and provided in accordance with contractual requirements.

7 PERFORMANCE OVERVIEW



7.1. PERFORMANCE CAPABILITY



Sun-synchronous orbit (SSO) is one of the most requested orbits by customers. Skyrora XL is able to provide payload insertion into SSO with an orbital inclination angle from 97.4 to 99.5 degrees depending on the altitude of the target orbit. The variation of payload mass vs SSO range is shown in Figure 11. Also, Skyrora XL can provide payload insertion into polar orbit with a 90 degree inclination, and with an altitude over a range of 200 km up to 1000 km (Figure 12). Additionally, a payload mass injected into Low-Earth Orbit, with a specific inclination and altitude, can be specified at the Customer's request.

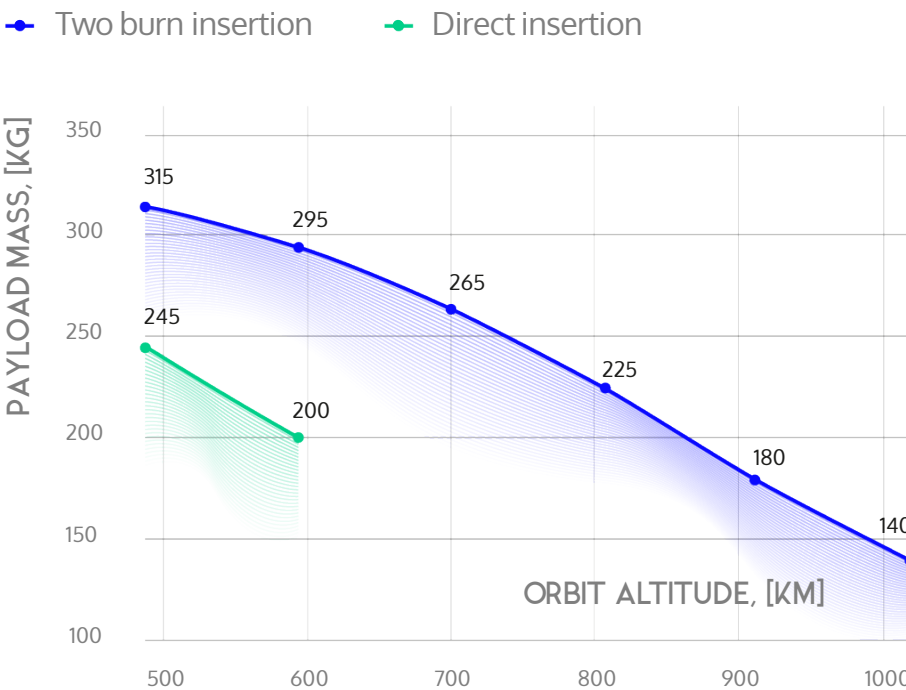


Figure 11 – Performance to circular SSO

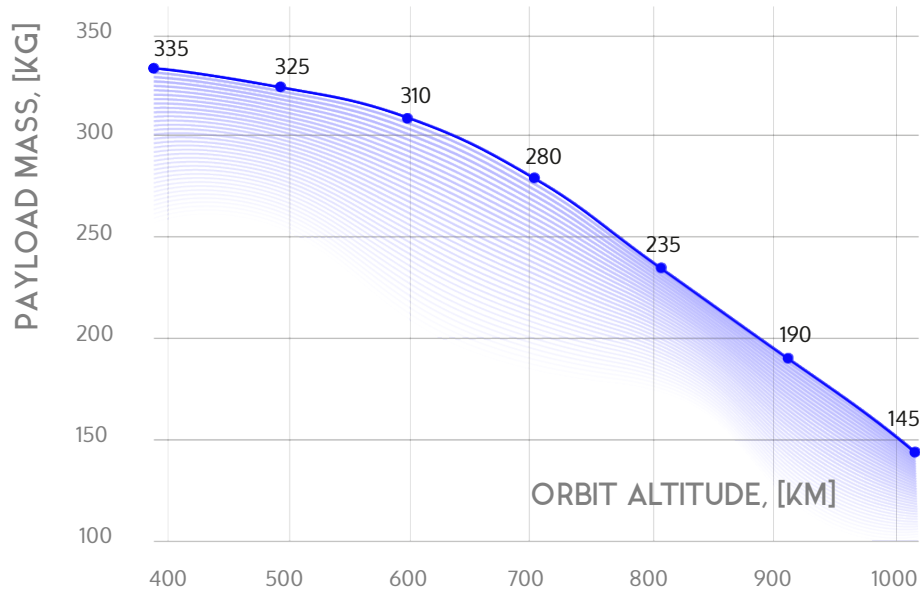


Figure 12 – Performance to circular Polar orbit

7.2. ORBIT INSERTION ACCURACY

The control system ensures a specified accuracy for the insertion of payloads into defined orbits, according to the demand of our customers. The control system is designed to provide the following accuracy for payload orbital placement at the time of payload jettison:

- roll ± 2 deg;
- pitch ± 0.5 deg;
- yaw ± 0.5 deg;
- angular spin rate across all axes ± 0.1 deg/s;
- orbit inclination ± 0.1 deg;
- perigee altitude ± 5 km;
- apogee altitude ± 15 km.

7.3. SAMPLE FLIGHT PROFILE



Skylora XL lifts off after two-seconds of thrust stabilisation, following the ignition of all nine engines of the first stage. During launch, at T+2.5 minutes, the command to separate the first and the second stages is issued, followed by ignition of the second stage engine. The halves of the aerodynamic fairing are jettisoned during the second stage burn, where the minor heat gain will be less than 1135 W/m². The shutdown of the second stage engine occurs at T+7 minutes, and the third stage is separated. During the flight of the third stage, the engine is ignited twice; this allows improved energy performance of the launch vehicle due to an optimised trajectory. The preliminary flight profile is shown in Figure 13. The flight profile and impact area analysis will be refined and finalised in accordance with the launch location, specific flight mission and additional factors, such as weather.

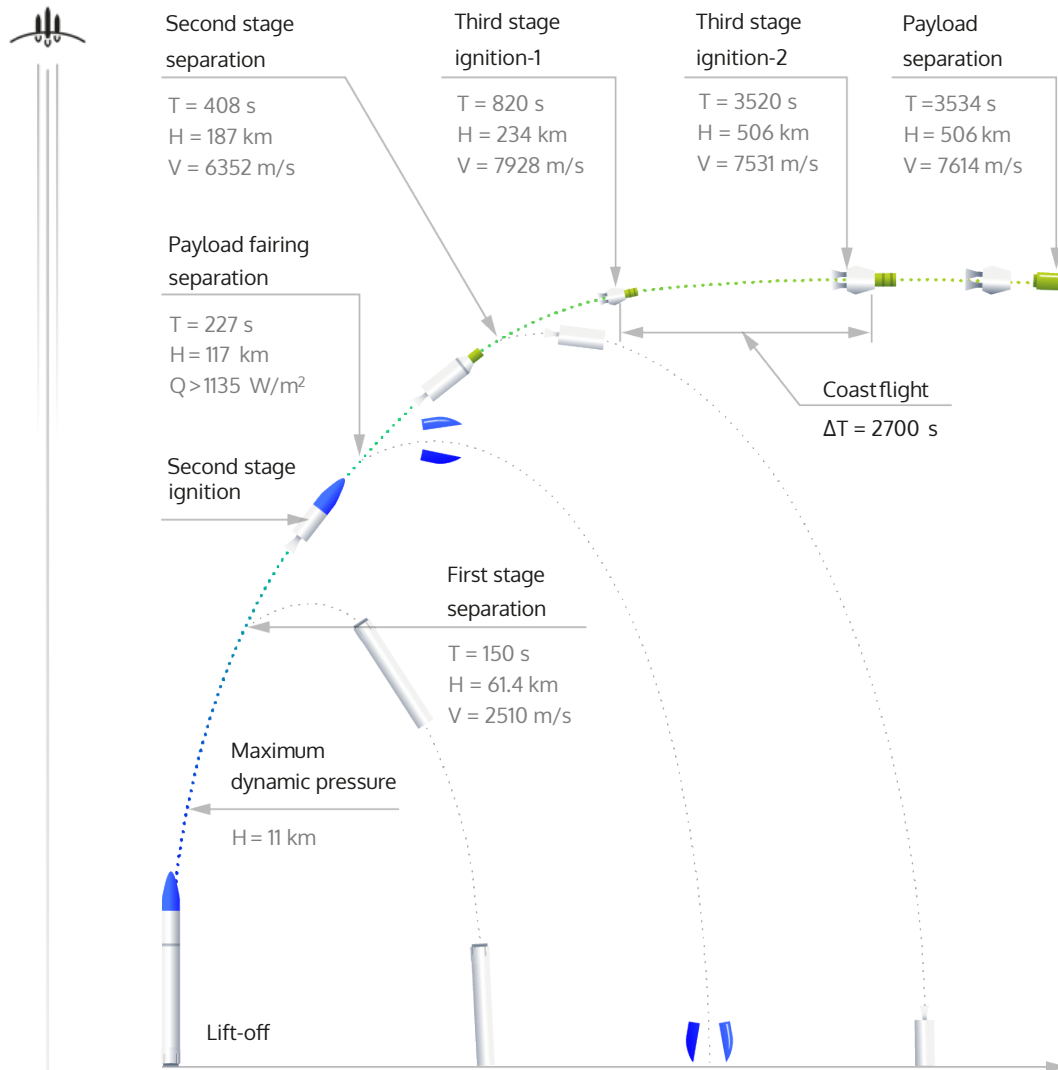


Figure 13 – Skyrora XL preliminary flight profile to a 500 km altitude SSO



PAYLOAD & LAUNCH OPERATIONS



8.1. STANDARD SERVICES

As a part of Skyrora's standard services, the following are provided:

- launch of the payload into the target orbit to the required accuracy;
- personnel, services, hardware, equipment, documentation, reviews, analyses and facilities required to support mission planning, launcher production, mission, payload on the launch range integration and launch;
- cleanliness level according to ISO 4 EN 14644-1:2009 in integration and test rooms for the payload, before the scheduled launch date and personnel;
- processing, integration and encapsulation of the payload within the fairing, testing of electrical and signal interfaces with the payload at the launch site;
- thermal regulation climate control in the payload fairing;
- mission verification, operational readiness, vehicle equipment and ground systems;
- provision of all range and safety interfaces, including requirements document templates for the payload provider;
- facilitation of the range safety integration process;
- collision avoidance analysis and maneuver (as required);
- post-flight analysis to verify successful payload deployment from the launch vehicle, and identification of the payload orbit;
- provision of post-flight launch services, including delivery

of the Post Flight Report, which shall include payload separation confirmation, ephemeris, payload environment, significant events and anomalies;

- generation of all mission required licencing, with input from the payload Customer.

8.2. NON-STANDARD SERVICES

In addition to standard services, Skyrora can also offer our customers the following optional services:

- payload fueling services and hardware;
- custom payload adapters;
- payload heating and/or dedicated thermal control during boost phase up to payload separation;
- additional analyses;
- early integration studies;
- provision of electrical harnesses and connectors;
- arrangement of payload transportation to launch site.





8.3. MISSION INTEGRATION SCHEDULE

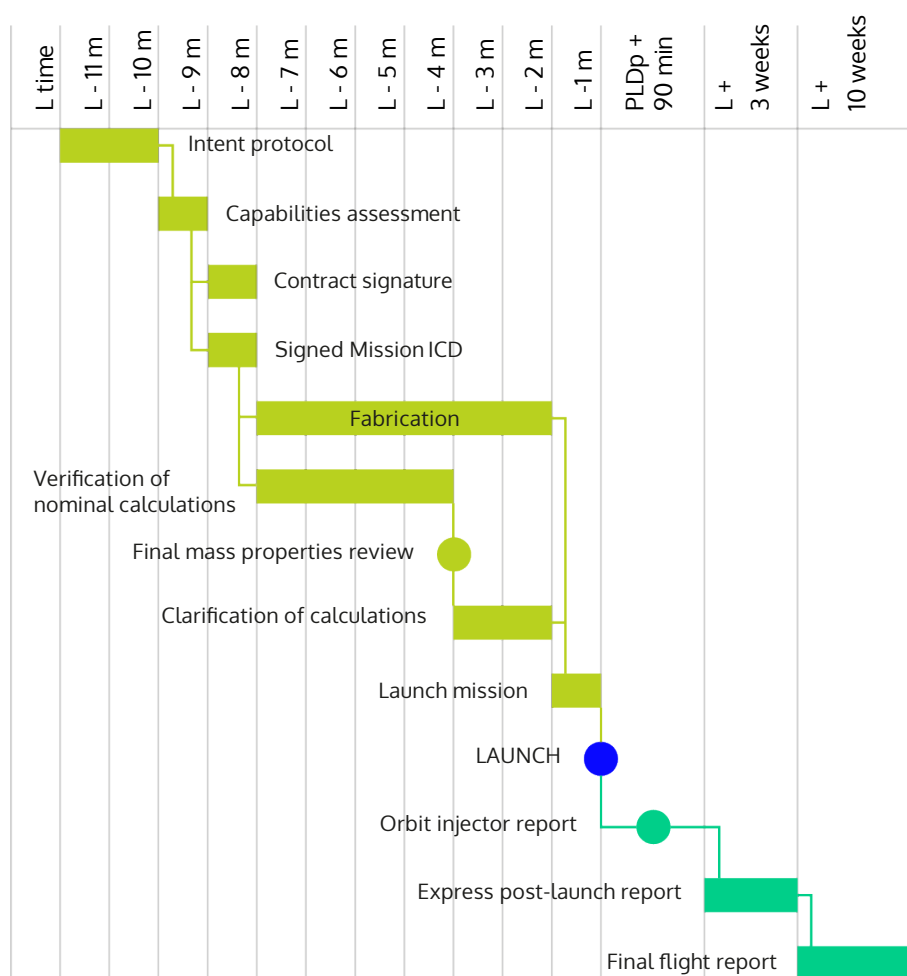


Figure 14 – Mission integration schedule

Description and acronyms:

L – Launch.

PLDp – payload deployment.

Fabrication – manufacturing of additional fittings, parts, units for payload integration with the launch vehicle.

Verification of nominal calculation – verification of nominal trajectory, separation, payload deployment analysis, thermal analysis.

Clarification of calculations – dispersed trajectory, recontact analysis.

Launch mission – 1) payload transportation, assembly work, tests, payload integration to the launch vehicle, pre-launch preparation; 2) rollout readiness assessment – rollout readiness assessment after payload integration to the launch vehicle (2 days prior to the launch); 3) launch readiness review – verification report to the countdown and launch, half a day prior to launch.

Orbit injection report – provide the payload state vector and its attitude to the Customer.



8.4. LAUNCH OPERATIONS SCHEDULE

The launch operations schedule is provided in figure 15. The launch schedule will be updated for each mission. The scope of work for the mission takes 24 days excluding post-launch operations.

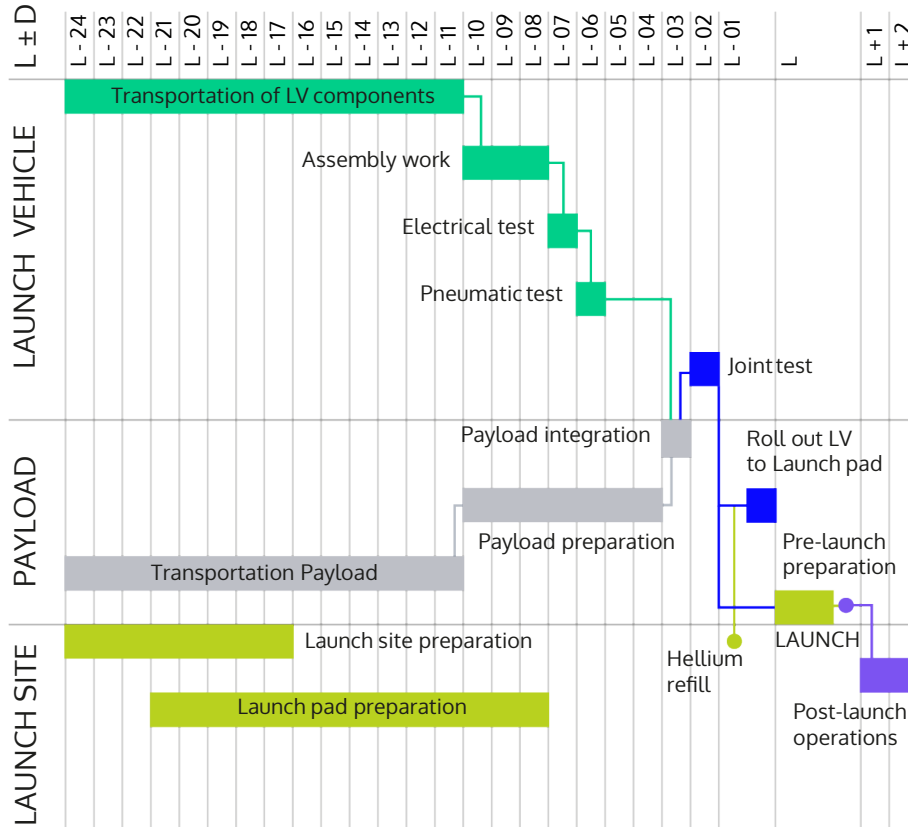


Figure 15 – Launch operations schedule

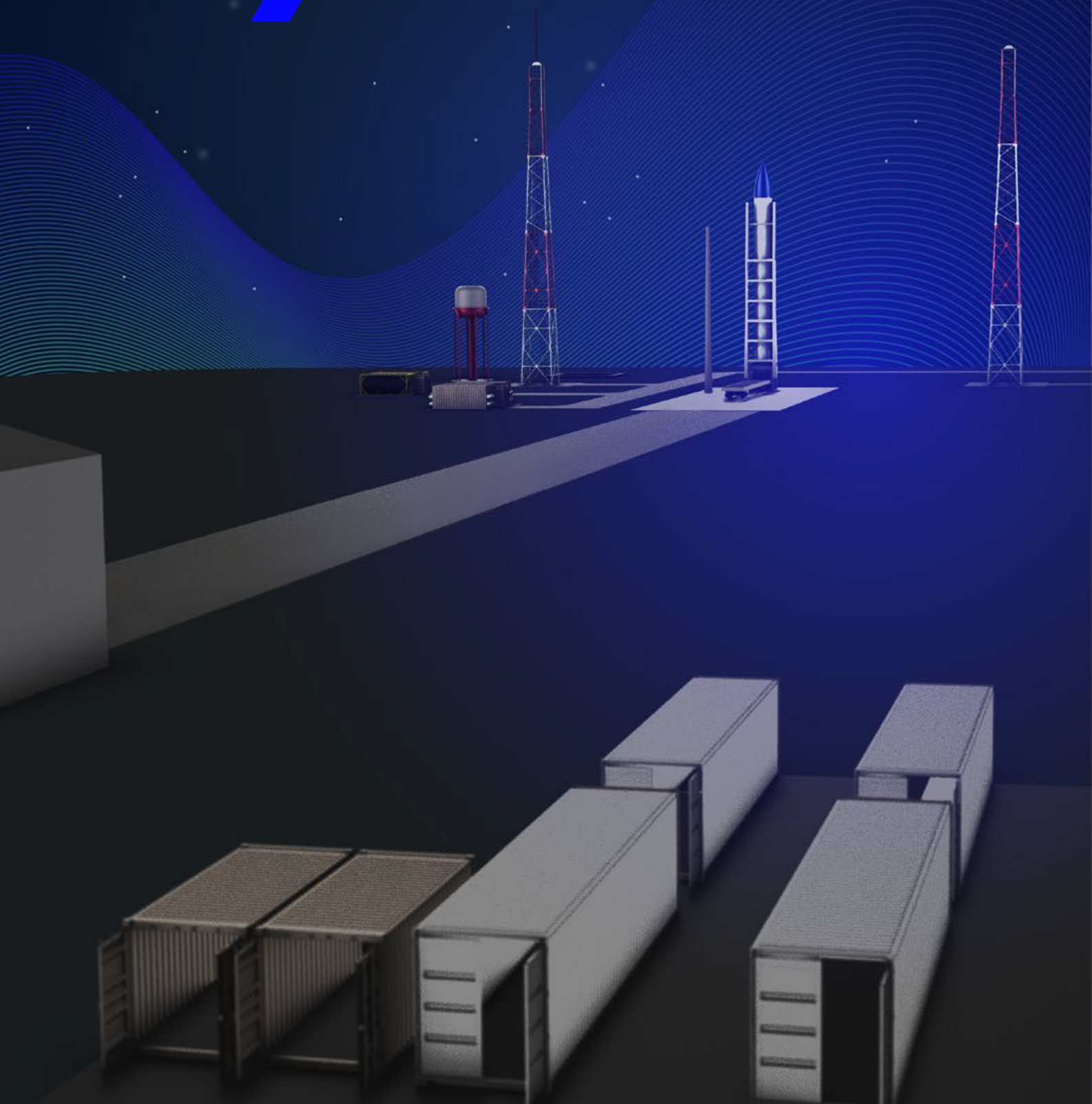
8.5. POST-LAUNCH REPORTING

According to the results of payload deployment and arrival in its orbit, Skyrora will inform our customers regarding the results of the launch mission within 90 minutes.

Upon completion of the mission, within 3 weeks, Skyrora will provide an abbreviated post-launch report, including a description of the key details and milestones which occurred during the mission.

A final mission report, covering an in-depth description of the key details and milestones which occurred during the mission, will be provided within 10 weeks.

9 INFRASTRUCTURE





9.1. SKYRORA XL LAUNCH SITE

The Skyrora XL launch site is under development. The Skyrora team have specified all the requirements and necessary infrastructure for integrated launch vehicle preparation for launch. Skyrora intends to conduct launch operations from a UK based spaceport, however, the Skyrora launch site infrastructure can be adjusted and adapted to fit already existing launch locations.

All the engineering systems of the launch site are of a modular design. Any module size will not exceed a standard 40 ft ISO container.

The launch vehicle and spacecraft test and assembly building is of quickly erectable construction.

The launch pad is a sectional portable unit.

This version of the launch site allows:

- the launch site location to be changed;
- launch services to be provided without impacting the spaceport infrastructure;
- launch services to be provided that involve the spaceport infrastructure;
- rapid preservation/depreservation of a site to be ensured.

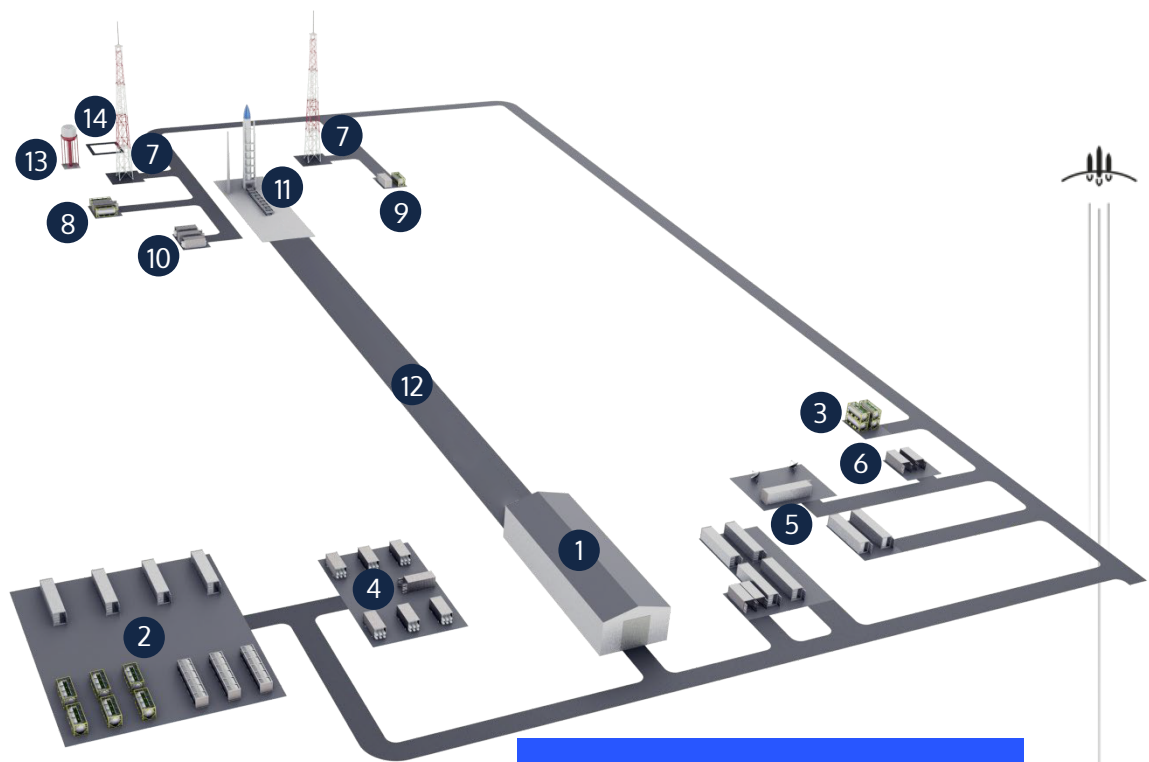


Figure 16 – Skyrora launch site

- 1 – Launch vehicle and spacecraft assembly, integration and test building (+ Area of major assembling + laboratory for autonomous electronics testing);
- 2 – Rocket Propellant Plant (Area for HTP distillation, storage and servicing);
- 3 – Area for fuel storage and servicing;
- 4 – Area for Compressed Gas Manufacturing and Supply System or Compressed Gas Supply System;
- 5 – Mission Control Centre (+ Antennas for Data Measurement, Acquisition, Processing + Video Observation System);
- 6 – Power Supply System of Launch Site;
- 7 – Diverters;
- 8 – Oxidiser Filling System;
- 9 – Fuel Filling System;
- 10 – Compressed Gas Supply System and Static Thermal Regulation System;
- 11 – Launch Pad;
- 12 – Sealed Road;
- 13 – Elevated Tank for emergency fire extinguishing of Launch Vehicle on Launch Pad (or similar system);
- 14 – Tank for emergency drop-off of HTP.



9.2. MISSION CONTROL CENTRE

The Mission Control Centre is designed for central control of launch vehicle preparation, information support for an Operations Manager and launch mission personnel at all stages of launch vehicle preparation, both during normal operations, and in case of emergency situations.

The Mission Control Centre centralises:

- the placement of controllers and launch team operators;
- the placement of workstations;
- the placement of video surveillance systems;
- data reception and transmission to/from the launch vehicle during launch preparation and launch.

The Mission Control Centre ensures central placement and operation of equipment and system hardware for launch services.

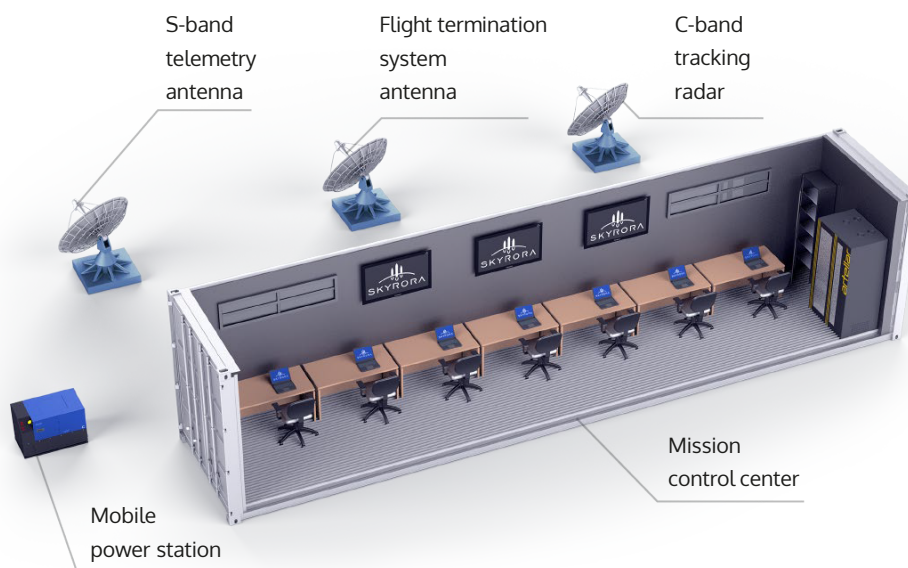


Figure 17 – Skyrora XL Mission Control Centre

9.3. PAYLOAD PROCESSING FACILITY & CUSTOMER AREA



The launch vehicle and spacecraft assembly, integration and test building is designed for preparation of the launch vehicle, its integration with the payload launch module, as well as configuring the launch vehicle ready to be delivered to the launch site. The full area of the building is about 1500 m² with a height of 6.2 m.

The launch vehicle hangar will host the following operations:

- acceptance of launch vehicle components;
- reloading of launch vehicle components to assembly-mating dolly;
- disassembly of removable support equipment;
- assembly and interfacing operations;
- installation of components;
- electrical checkout of the launch vehicle;
- leakage control of launch vehicle systems;
- independent electrical checkout of instruments, cables, spacecraft sensors and measuring equipment of the launch vehicle;
- charging the batteries of the launch vehicle power supply system;
- filling of pressurisation tanks with helium;
- reloading of the launch vehicle on a transporter erector;
- maintenance of the launch vehicle.

The spacecraft and payload launch module area is designed for preparing the spacecraft, its integration with the payload launch module and connection of the payload launch module to the spacecraft ready to be delivered to the launch vehicle

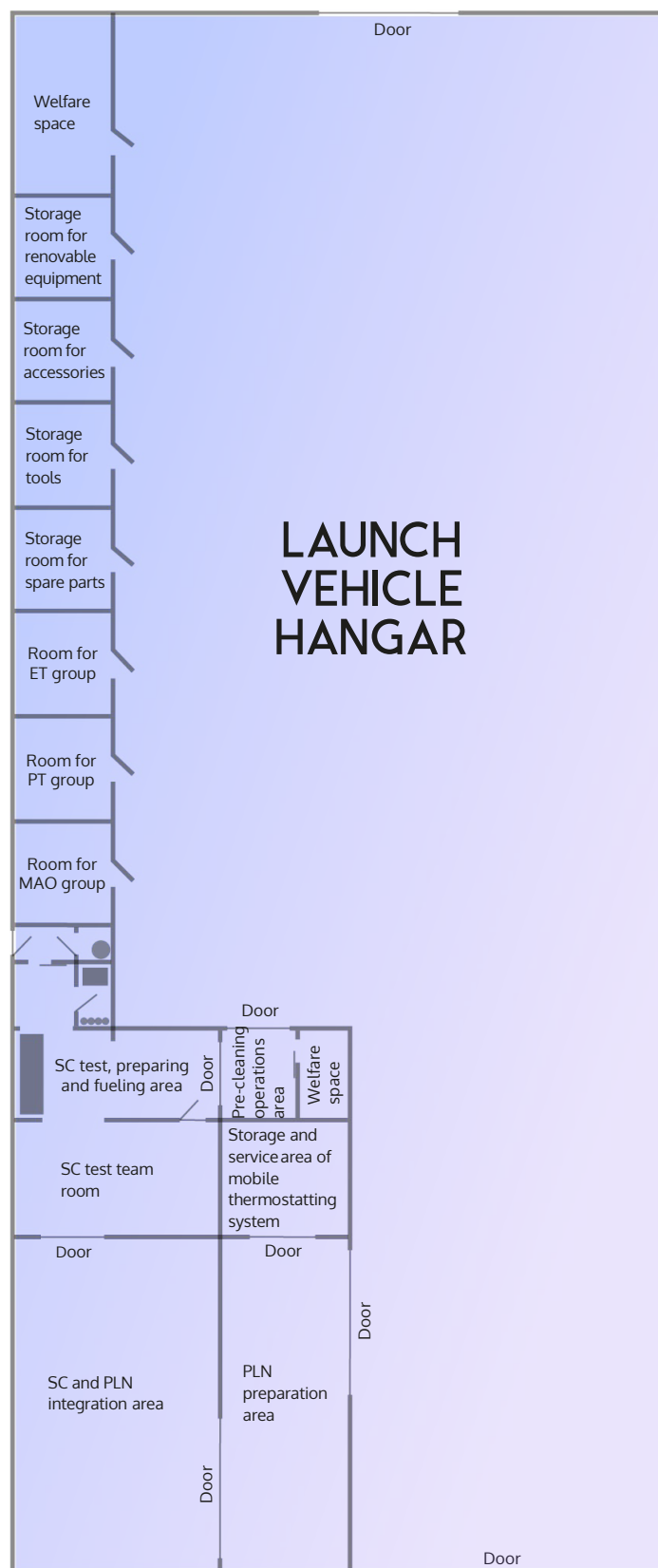


hangar for assembling and testing. The spacecraft and payload launch module area provides the following operations:

- acceptance of the payload launch module;
- preparation of the payload launch module;
- acceptance of the spacecraft;
- preparation of the spacecraft;
- spacecraft filling with monopropellant and compressed gases;
- integration of the spacecraft and the payload launch module;
- climate control of the spacecraft and payload launch module assembly.

The cleanliness level for spacecraft and payload launch module integration and testing areas corresponds to ISO 4 EN 14644-1:2009.

The cleanliness level for all the other spacecraft and payload launch module areas corresponds to ISO 5 EN 14644-1:2009.

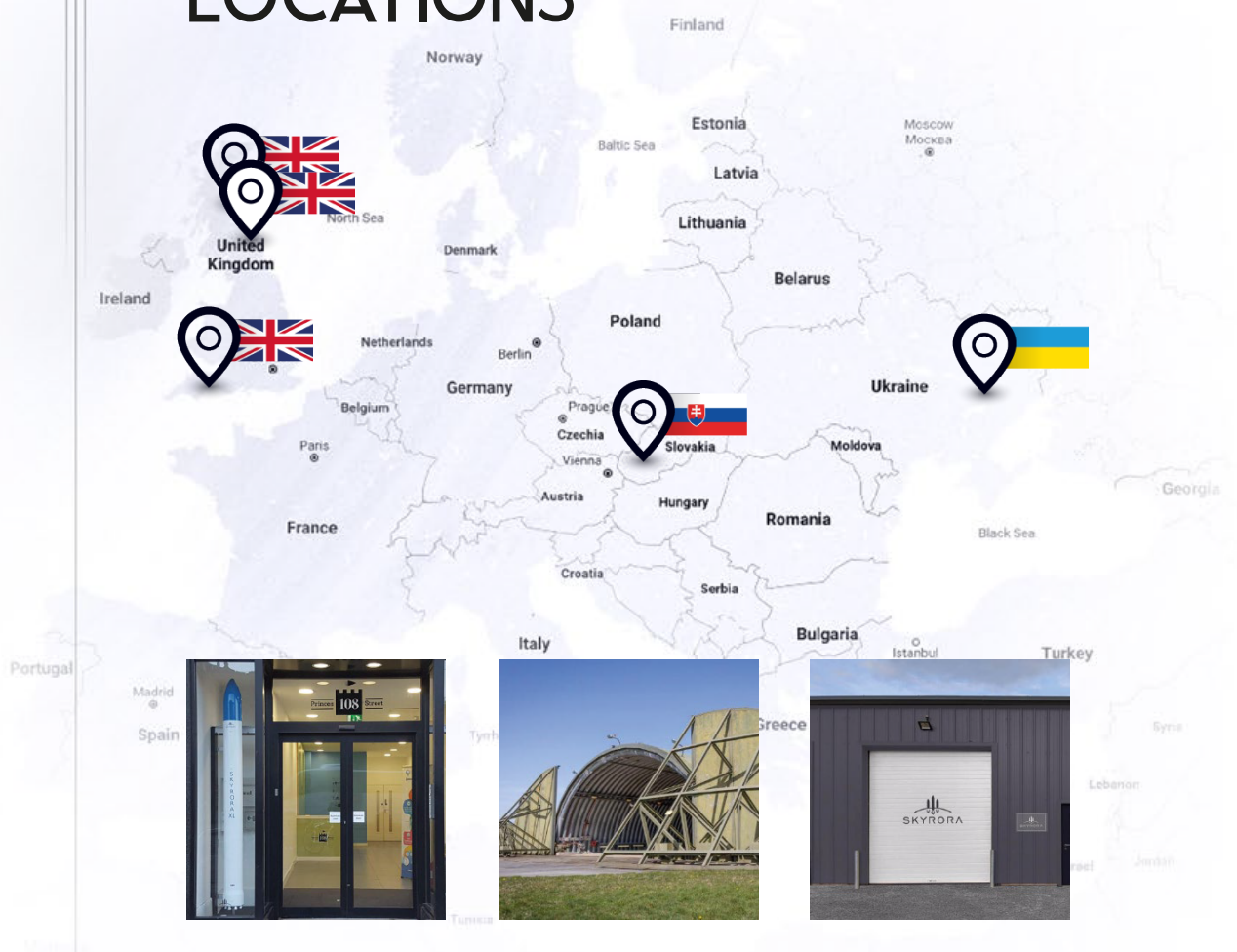


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Figure 18 – LV and spacecraft assembly, integration and test building



9.4. SKYRORA'S LOCATIONS



EDINBURGH

CORNWALL

LOANHEAD

LEO engine test bench

Production facility for
vehicle assembly



BRATISLAVA

Workshop for composite
structure testing and HTP
production



DNIPRO

Innovative co-working
center



Our company is headquartered in Edinburgh, Scotland. The UK government is focused on enabling launch from the UK and Scotland is an ideal location for launch service development due to its geographical suitability for high inclination orbits, strong manufacturing history, impressive academic base and broad value chain representation across the space sector (Glasgow is widely regarded as the European capital of small satellite manufacture).

9.5. TEST FACILITIES

The engine test bench designed by Skyrora enables full-scale, static test firing of the 70 kN thrust engine at sea level, in all operational engine modes, with all necessary sensor data recorded. The layout diagram of the engine test bench is shown in Figure 20. The engine test bench assembly is shown in Figure 19.

The hardware and software systems allow:

- remote control of testing, with thrust levels of up to 70 kN;





- storage and analysis of test data by a comprehensive data logging and analysis system;
- supply of water for hot jet cooling automatically by the water supply system;
- recording of high-speed video of the test automatically, with the subsequent ability to monitor and analyse.



Figure 19 – Assembly of the engine test bench



Figure 20 – Layout diagram of the engine test bench



9.6. COMPOSITE STRUCTURE



Figure 21 – Composite structure

Skyrora develops and manufactures structural elements of its launch vehicles using composite technologies to increase mass efficiency. The use of composite materials can reduce weight from 20 % to 40 %, improving vehicle flight performance. All carbon fibre and glass fibre parts such as tanks, payload fairings and payload adapters are manufactured in-house. Skyrora applies advanced technologies for the composite manufacturing, such as filament winding, vacuum infusion, RTM (having all the necessary equipment on site: winding machine, moulds and other special tools). Composite shells are used in the Skyrora propellant tanks and high-pressure vessels to reinforce metal or plastic liners, and ensure high pressure vessel efficiency. Liners serve as the primary shape and seal the tank.

9.7. HIGH-TEST PEROXIDE FACILITIES



Skyrora has its own facilities for HTP manufacturing (85 - 90 % hydrogen peroxide) to provide the launch vehicle with oxidiser. The HTP plant is based on the distillation process, using weak hydrogen peroxide and evaporation of the water in order to reach the 90 % concentration of hydrogen peroxide. The plant consists of distillation and purification units to obtain the highly pure HTP without impurities.



Figure 22 – The Skyrora Peroxide manufacturing plant



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10.3. LIST OF ACRONYMS

BPSK	– Binary Phase Shift Keying
ECSS	– European Cooperation for Space Standardization
FM	– Frequency modulation
GNSS	– Global Navigation Satellite System
HTP	– High-test peroxide
ICD	– Interface control document
ILV	– Integrated launch vehicle
LV	– Launch vehicle
PCM	– Pulse-code modulation
PHS	– Pneumatic-hydraulic system
PLM	– Payload module
RF	– Radio frequency
RTM	– Resin transfer molding
RX	– Receive
SC	– Spacecraft
SSO	– Sun-synchronous orbit
TX	– Transmit
UHF	– Ultra-high frequency

