INNOSPACE

HANBIT-Nano
PAYLOAD USER'S GUIDE

VERSION 1.1 FEBRUARY 2024

CHANGING THE FUTURE OF SPACE MOBILITY
WITH HYBRID SMALL SATELLITE LAUNCH VEHICLE

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1 INTRODUCTION

1.1 USER'S GUIDE PURPOSE

This Payload User's Guide serves as a reference document to help payload developers and customers understand INNOSPACE's standard launch services using HANBIT-Nano launch vehicle.

The user's guide provides initial planning information and guidance to customers of INNOSPACE regarding the capabilities, performance, requirements, interfaces, facilities, and operations for HANBIT-Nano launch system and services. The user's guide is not intended to provide detailed design. Design and technical data is subjected to change and will be provided to INNOSPACE's contracting customers by the mission managers. Revisions to the payload user's guide will be made as INNOSPACE continues to develop and enhance the capabilities and design of HANBIT-Nano launch vehicles.

1.2 COMPANY DESCRIPTION

Established in 2017, INNOSPACE is a South Korean company which offers small satellite launch vehicles for access to space. We are developing a family of hybrid rocket-powered launch vehicles (HANBIT) to provide disruptive launch services focused on low-latency, low-cost, and reliability.

INNOSPACE provides space access to all commercial and government customers across the global with customized and flexible launch services. The company operates oversea subsidiaries to offer dedicated customer service worldwide and a collaborative approach to address specific launch mission needs including mission planning, technical consultations, and pre-and-post-launch support.

INNOSPACE is able to provide a dynamic launch manifest that allows customers to secure launch slots tailored to their specific timeline as the company is committed to securing multiple launch sites worldwide in countries like Norway, Australia, and South Korea, with Brazil being our primary launch site. In particular, the Alcantara Space Center which the company has secured for the commercial use based on the contract with Brazilian Air Force is located at two degrees south latitude and is the closest launch site to the equator. Its launch azimuth up to 107 degrees and proximity to the equator makes it easier for the rocket to approach orbit, while reducing fuel consumption.

INNOSPACE has worked toward a single goal to develop the world's most efficient small satellite launcher. The decades of experience of highly talented personnel in the aerospace industry brought during the early days of our corporation actualized the development of our home-grown hybrid rocket engine. In the coming years, proving our flight heritage and safety, we hope to become the go to name in the satellite launch market.

Headquartered in Sejong, South Korea, INNOSPACE has state-of-the-art manufacturing and integration facilities to produce reliable commercial orbital launch vehicles. It also built engine test facilities with our proprietary technology to develop world class hybrid rocket engine. INNOSPACE's hybrid rocket engine employs a non-explosive paraffin-based high performance solid fuels and liquid oxygen (LOx) for propellants. The patented electric motor-driven oxidizer pump enables thrust throttling, which is need for precise orbital insertion. The low handling costs and its relative structural simplicity allows for low-cost manufacturing and shorter lead times. These allow us to maintain a high cadence while providing competitive pricing to our customers.

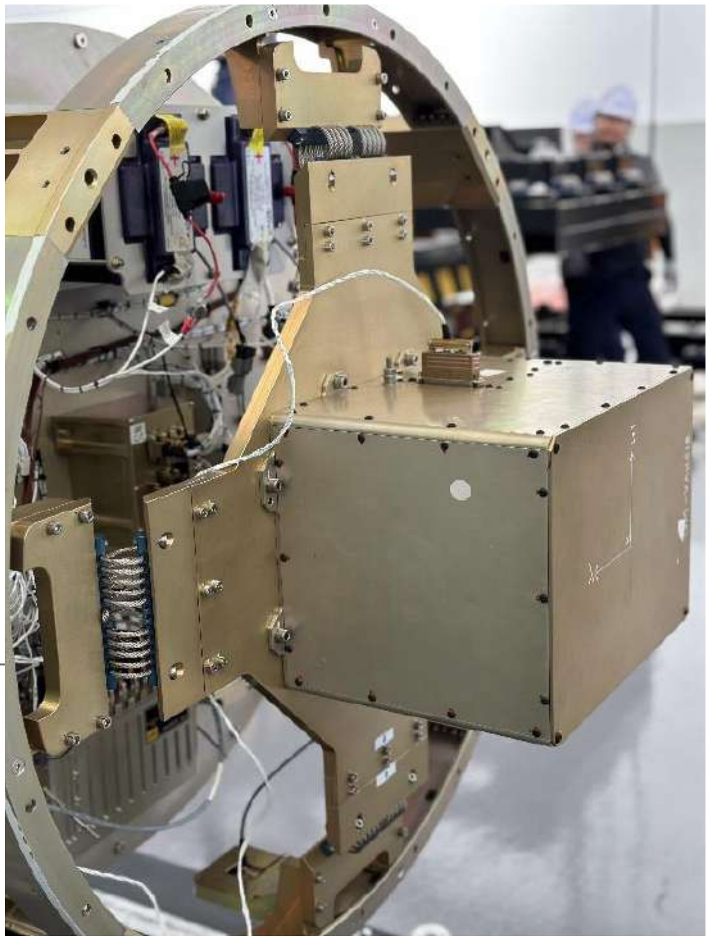
1.3 ACHIEVEMENTS

In March 2023, INNOSPACE successfully launched its test launch vehicle 'HANBIT-TLV' to verify the flight performance of the first stage 150 kN thrust hybrid rocket engine from the Alcantara Space Center in Brazil. Despite being a test flight, HANBIT-TLV carried 'SISNAV' onboard, an inertial navigation system payload weighing 20 kg developed by the Brazilian Airforce (DCTA), which was also tested successfully. This was the world's first suborbital launch vehicle that used a hybrid rocket engine with an elecpump. INNOSPACE is the first commercial international company to launch from Alcantara Space Center in Brazil. With this historical achievement, the company has officially proved capabilities for rocket technology and launch system operations. The purpose of HANBIT-TLV test flight is to validate the first stage engine of HANBIT-Nano, a small satellite launch vehicle. HANBIT-TLV is a 150 kN thrust single stage hybrid rocket with a height of 16.3 m, 1-meter-diameter, and weight of 8.4 ton.


Camera 04


한빛
HANBIT
TLV
INNOSPACE


INNOSPACE



1.4 CONTACT INFORMATION

As INNOSPACE progresses incrementally towards the objective of HANBIT-Nano's launch, exciting to interact with customers. For any technical queries or additional details regarding HANBIT-Nano plans, pricing, and availability, customers are encouraged to get in touch with the Sales team via email at marshal.win@innospc.com.

Headquarters

A-412, Sejong Business Center,
232, Gareum-ro, Sejong-si, 30121,
Republic of Korea

INNOSPACE do Brazil

Av. São João, 2375 Sala 1005,
São João dos Campos/SP CEP 12242-000,
BRAZIL

INNOSPACE SAS France

115 rue Saint-Dominique
75007 Paris,
France

2 VEHICLES

2.1 HANBIT-Nano OVERVIEW

HANBIT-Nano is a 2-stage orbital launcher capable to inserting multiple payloads of more than 90 kg (Alcantara Space Center, Brazil) to 500 km altitude to a wide range of orbital inclinations in Low Earth orbit (LEO).

HyPER, the first stage engine of HANBIT-Nano launcher is a 245 kN ElecPump cycle hybrid rocket engine using LOx and paraffin-based solid fuel. The second stage engine, LiMER, is a 29 kN ElecPump cycle liquid rocket engine using LOx and liquid methane(LCH$_4$). The LiMER engine was developed utilizing the ElecPump technology developed in conjunction with the HyPER engine.

Each engine is independently developed, and HyPER is a hybrid rocket engine applied to the only space launch vehicle to which the ElecPump LOx supply system is applied. Additive manufacturing technology is used to manufacture LiMER engine and ElecPump systems.

OVERVIEW

LENGTH	21.8 m
DIAMETER	1.4 m
LIFT-OFF WEIGHT	18.8 t
STAGE	2

PAYLOAD

NOMINAL PAYLOAD	90 kg to 500 km SSO
FAIRING DIAMETER	1.4 m
FAIRING HEIGHT	2.1 m

SECOND STAGE

ENGINE	LiMER (ElecPump Cycle)
PROPELLANTS	LOx & METHANE
THRUST	29 kN
BURN TIME	300 sec

FIRST STAGE

ENGINE	HyPER (ElecPump Cycle)
PROPELLANTS	LOx & PARAFFIN
THRUST	245 kN
BURN TIME	150 sec

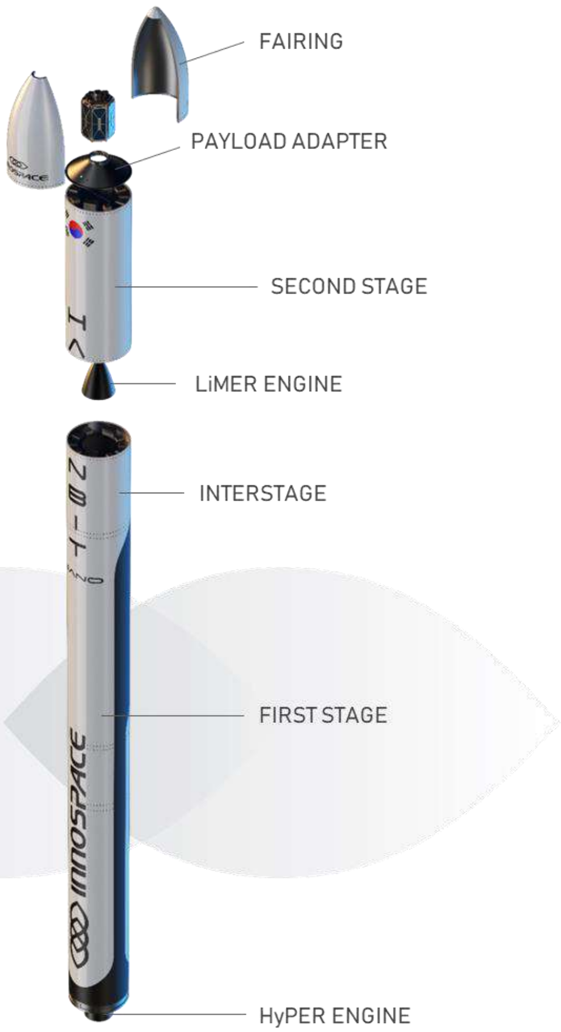


Figure 2-1. INNOSPACE's vehicle – HANBIT-Nano (500km SSO, Alcantara)

2.2 MISSION PROFILE

The major flight events of 2-stage orbital launcher, HANBIT-Nano is given below. Main Engine Cut Off, MECO will occur at approximately 150 seconds after liftoff, sequentially followed by stage separation. Second Engine Cut off, SECO is mission dependent, but will occur at approximately 470 seconds.

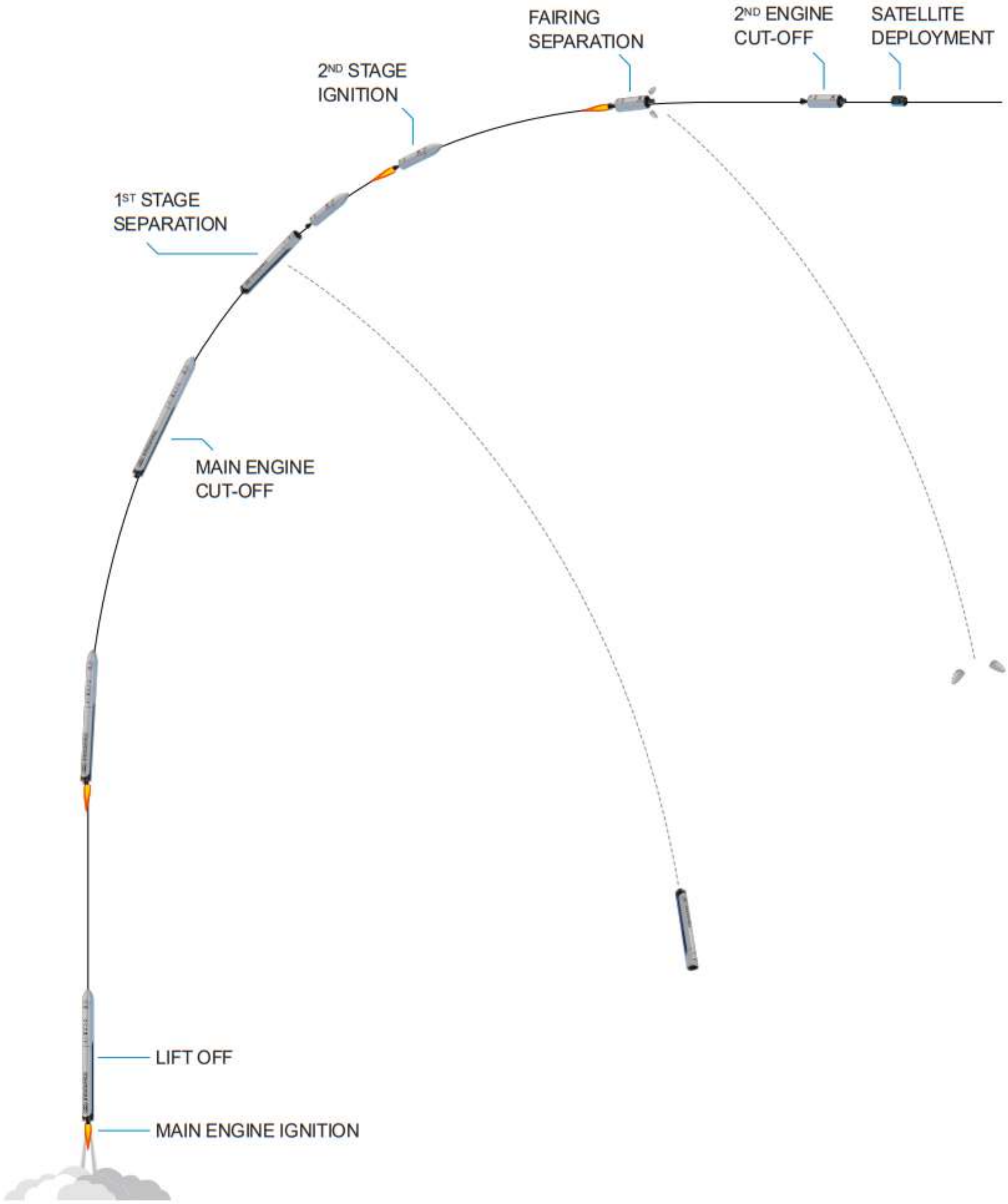


Figure 2-2. HANBIT-Nano's flight profile

3 PAYLOAD ACCOMMODATION

3.1 FAIRING

The fairing of the HANBIT-Nano is made of carbon composite and aluminum alloy. The fairing separation will not impose any loads on the payload during separation.

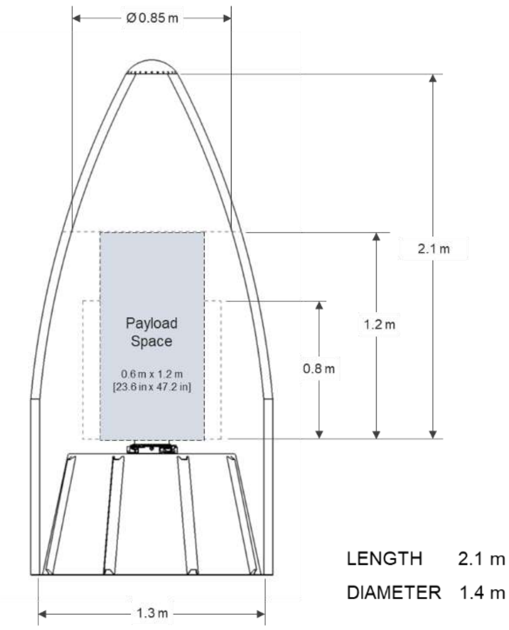


Figure 3-1. Fairing capacity

3.2 ACCOMMODATIONS (CONFIGURATIONS)

INNOSPACE offers diverse payload configurations based on mission needs. The payload is directly mounted on the payload adapter via the separation systems.

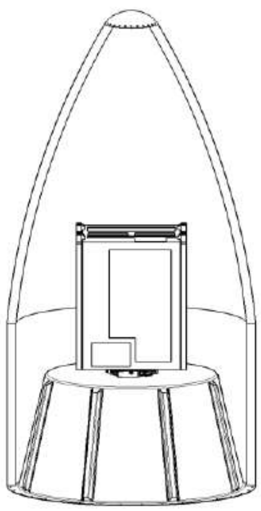


Figure 3-2. Primary payload configuration

3.3 MECHANICAL INTERFACES AND SEPARATION SYSTEMS

HANBIT-Nano payload adapter is compatible with standard COTS (Commercial off the Shelf) separation systems and CubeSat dispensers.

These separation systems will be arranged in various configurations to accommodate customer orbital insertion requirements in the best possible way. It easily meets the needs of any mission. These mechanical interfaces will be directly mounted onto the payload adapter. The payload adapter is attached to the upper stage with vibration-damping mounts. CubeSat dispensers can also be arranged on the adapter in various configurations.

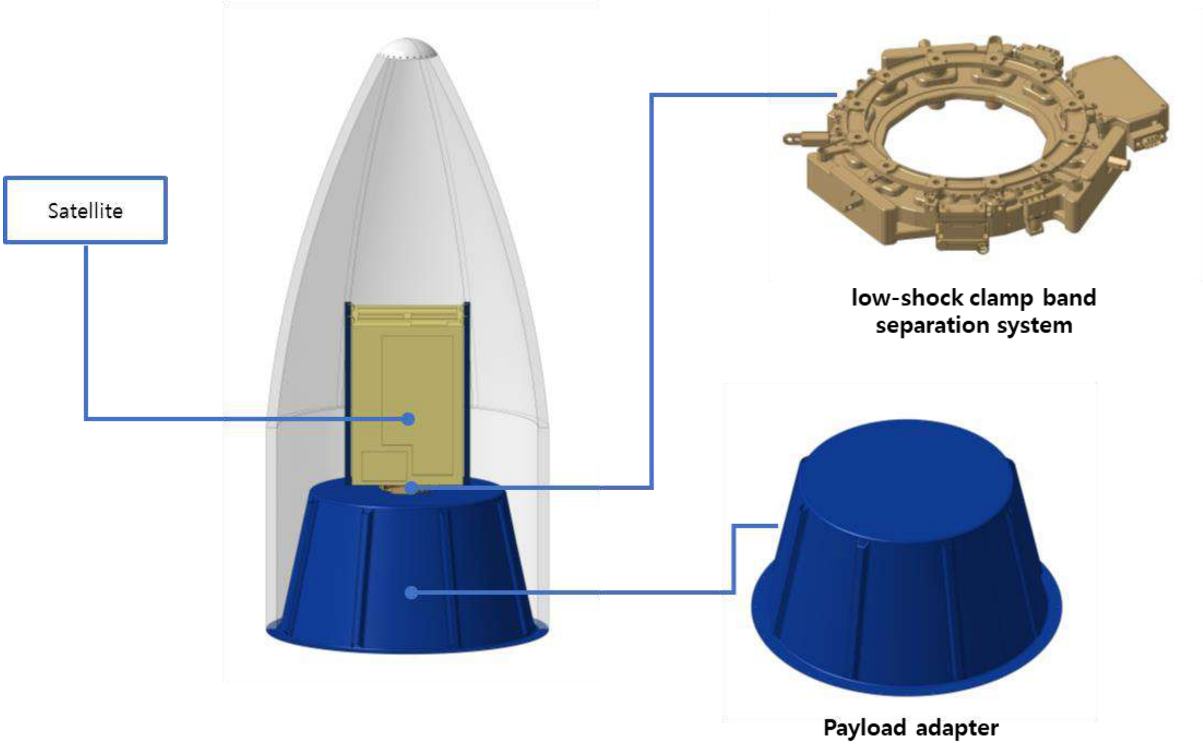


Figure 3-3. Sample configuration inside of fairing

HANBIT-Nano uses low-shock separation devices and spring pushers for payload fairing separation. If necessary, non-pyrotechnic release mechanisms which are commercially available also can be applied to fairing separation devices. After separation, each half of the fairing is designed to rotate on a hinge away from the launch vehicle, resulting in a safe separation.

HANBIT-Nano stage separation system is located at the forward end of the interstage and interfaces with the second stage. And they are accomplished by separation mechanisms around the circumference of the vehicle. The mechanism is comprised of low-shock separation bolts and several spring-based pushers.

3.4 ELECTRICAL INTERFACES

HANBIT-Nano standard electrical interfaces are shown in the images below. Standard interface will provide five communication channels as a standard service. Customers are to provide the harness between payload and the standard interface. The mating connector shall be the male standard COTS connector, one of the typical options being the 15 pin D-SUB connector.

The mission-specific ICD (Interface Control Document) will provide detailed interface specifications. The customer can also make specific requests regarding the electronic interface, which will be evaluated and discussed for its feasibility and whether it could be provided as a standard service.

Before Encapsulation, customers can directly connect to payload using Payload Processing Facility Harness (Gray line). After Encapsulation, the direct communication is no longer supported but through Ground Control Center (Black line).

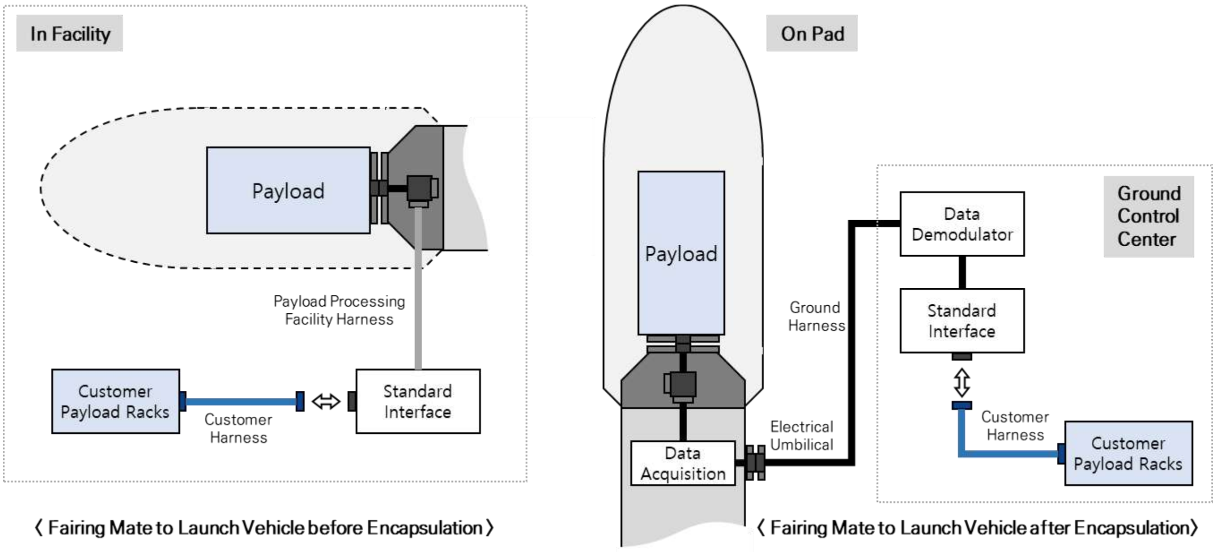


Figure 3-4. Fairing mate to launch vehicle

4 FLIGHT ENVIRONMENTS

4.1 ACCELERATION LOADS

Payload on the HANBIT-Nano must endure axial and lateral acceleration loads. The figure below illustrates the envelope of axial and lateral accelerations during flight for both static and dynamic loads. The positive axis describes compressive stress. Once the arrangement and coupled load analysis have been done, the mission-specific acceleration will be derived and then included in the mission ICD.

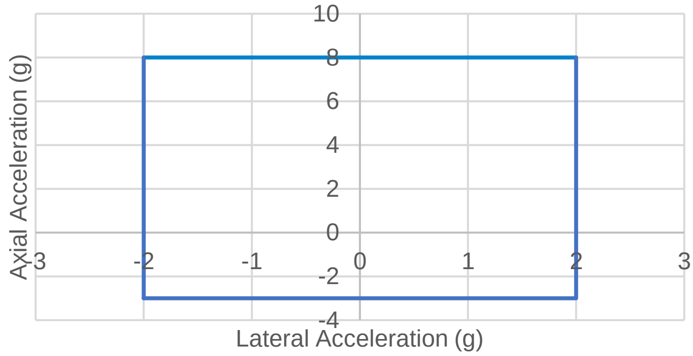


Figure 4-1. HANBIT-Nano acceleration MPE

4.2 SHOCK

The maximum shock load varies with each mission, but the graph below depicts the shock response on the payload adapter of the HANBIT-Nano.

Table 4-1.HANBIT-Nano shock MPE

Natural Frequency (Hz)	SRS Acceleration (g)
100	50
1,000	700
10,000	700

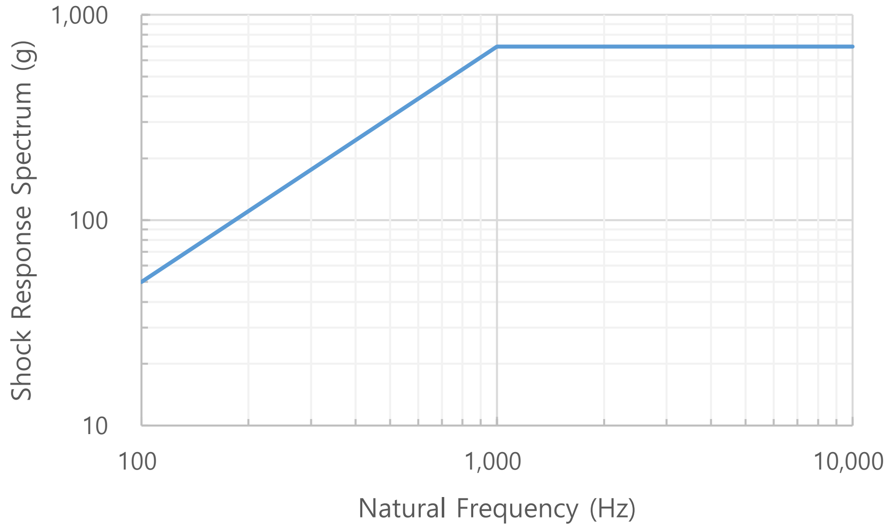


Figure 4-2. HANBIT-Nano shock MPE

4.3 ACOUSTICS

The acoustic load from liftoff to the end of the mission is expected to be in the range shown below.

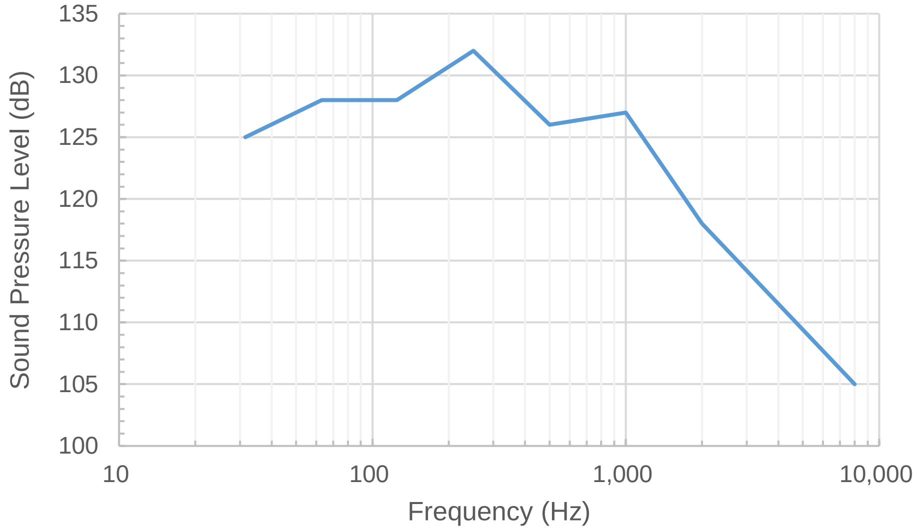


Figure 4-3. HANBIT-Nano acoustic MPE

4.4 RANDOM VIBRATION

The figure below describes the maximum random vibration load based on the standard HANBIT-Nano mission modeling. This will adhere to NASA's General Environmental Verification Standard (GEVS).

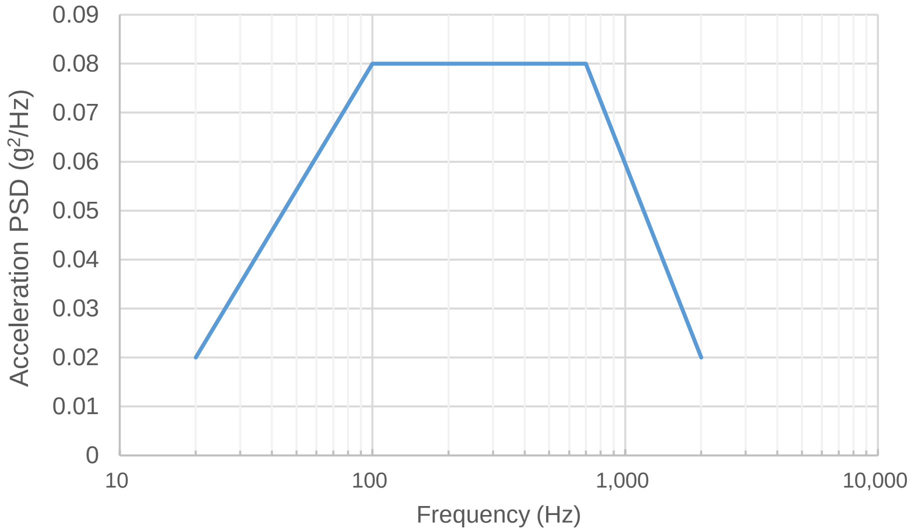


Figure 4-4. HANBIT-Nano random vibration MPE

4.5 VENTING

The HANBIT-Nano's maximum depressurization rate, which occurs during transonic flight, is no larger than 0.025 Bar/s. The specifics of depressurization and absolute pressure depend on the mission.

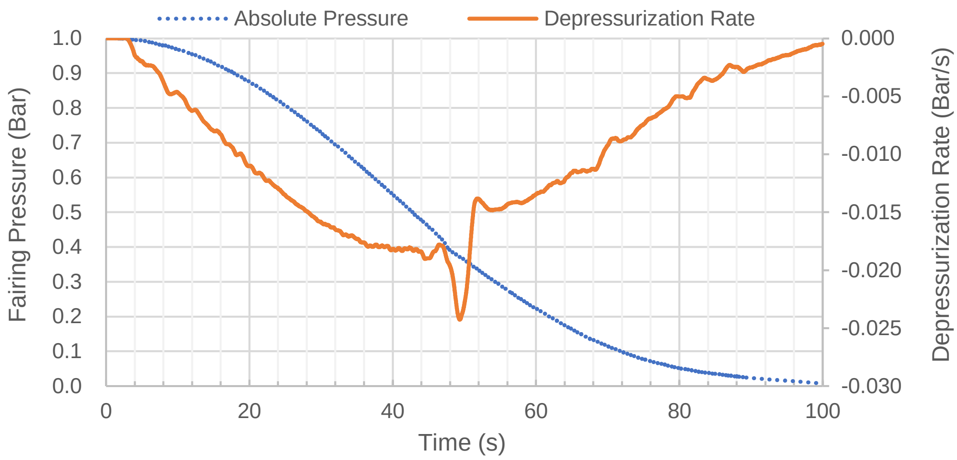


Figure 4-5. HANBIT-Nano fairing venting

4.6 RADIO FREQUENCY

The HANBIT-Nano's operational frequency will be in the range mentioned in the table below.

Table 4-2. HANBIT-Nano transmitting frequency

Source (Transmit)	Frequency (MHz)	Power (W)
S-Band Telemetry	2,200 ~ 2,300	Max 20

Table 4-3. HANBIT-Nano receiving frequency

Sink (Receive)	Frequency (MHz)
GPS L1	1,575.42
GPS L2	1,227.60
GLONASS L1	1,593 – 1,610
Galileo E1	1,575.42
FTS	443 MHz

5 PERFORMANCES

Based on the launch site, HANBIT-Nano is capable of carrying payload from 75 kg to 500 km altitude in various Low Earth Orbit. However, different payload masses and types of orbits will have different maximum altitudes, as shown in the figure for HANBIT-Nano orbital capabilities according to the launch sites below.

5.1 ALCANTARA SPACE CENTER, BRAZIL

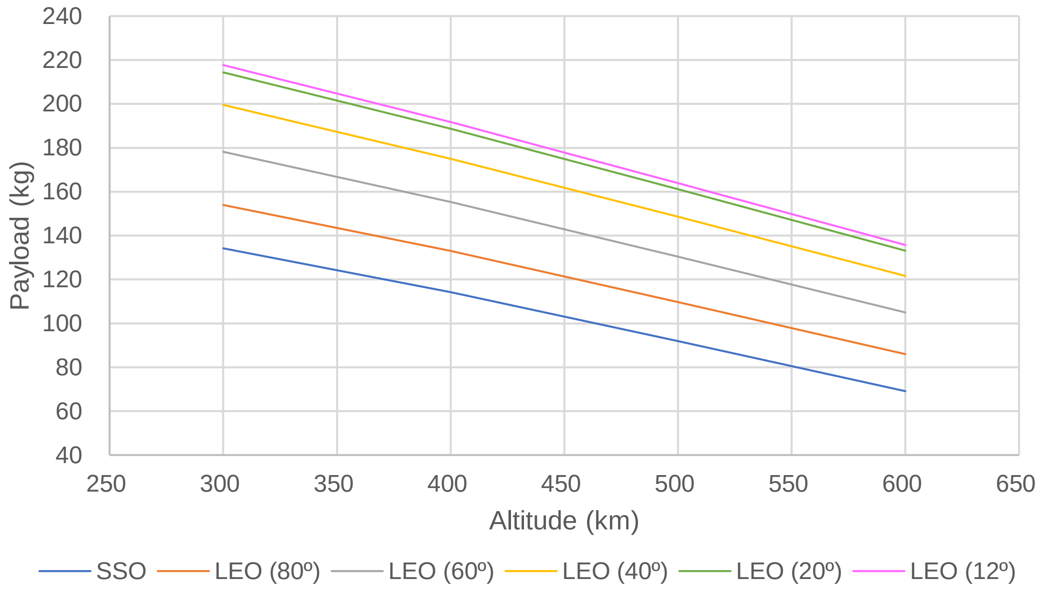


Figure 5-1. HANBIT-Nano orbital capability of the Alcantara Space Center

5.2 ANDOYA SPACE PORT, NORWAY

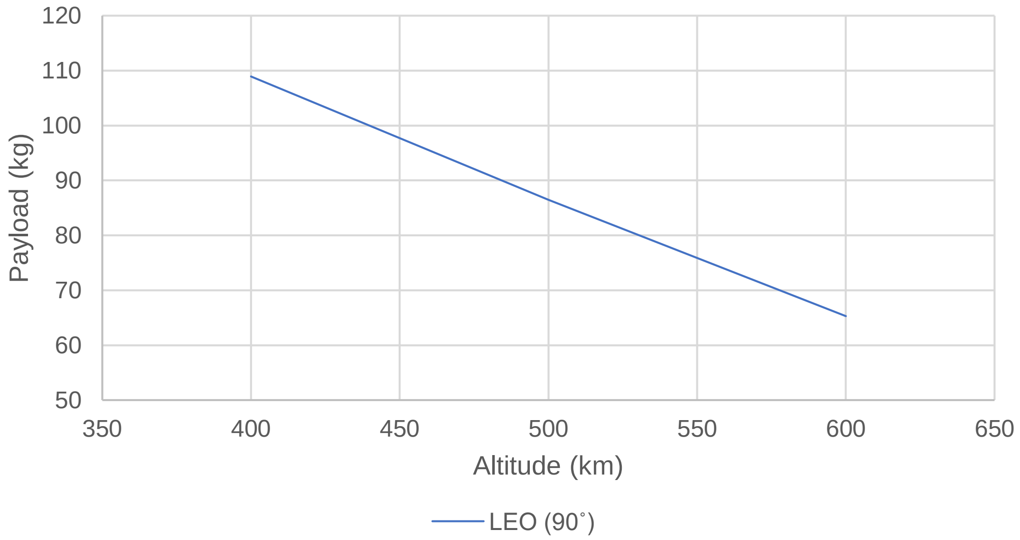


Figure 5-2. HANBIT-Nano orbital capability of the Andoya Space Port

5.3 ARNHEM SPACE CENTRE, AUSTRALIA

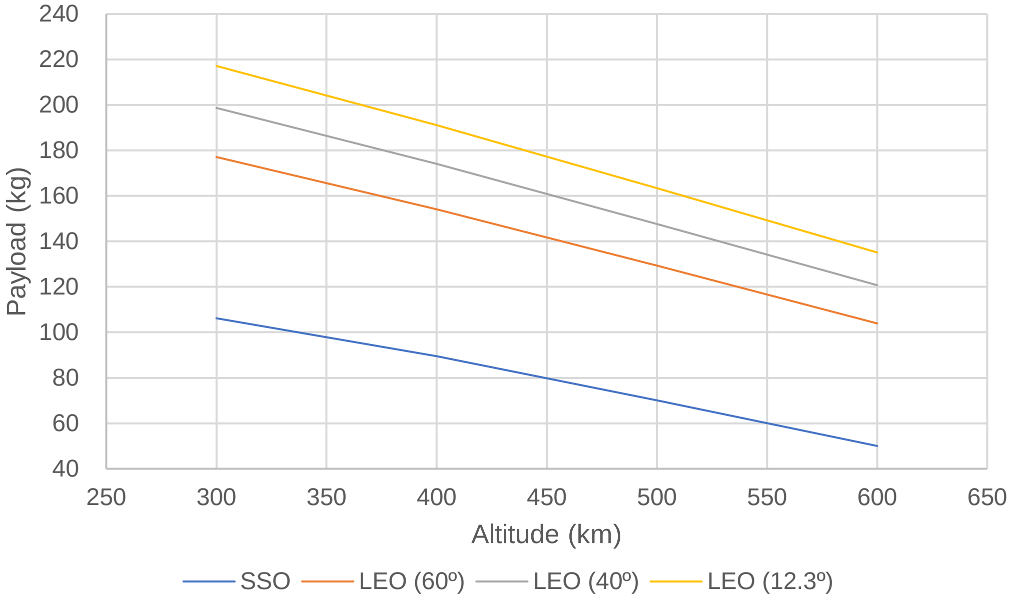


Figure 5-3. HANBIT-Nano orbital capability of the Arnhem Space Centre

5.4 GOHEUNG, SOUTH KOREA

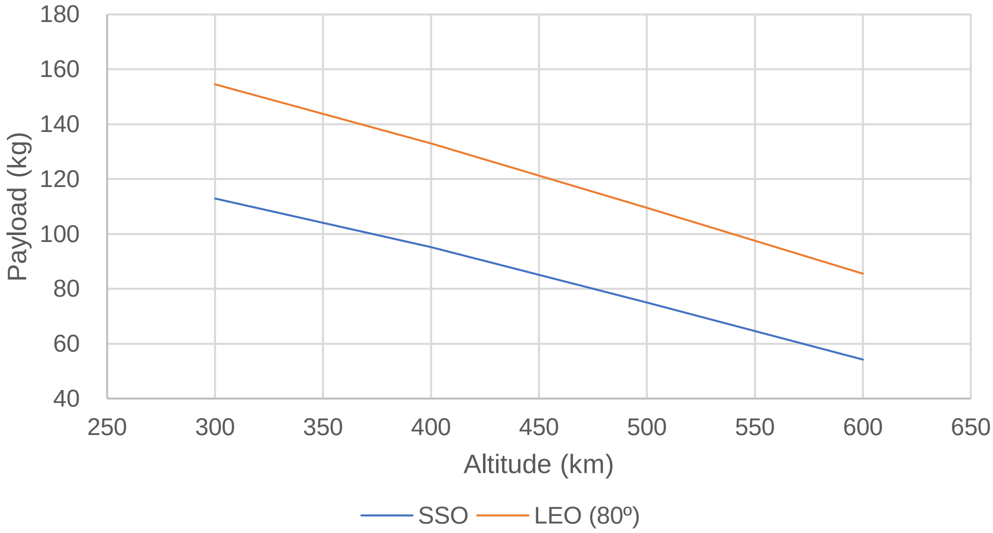


Figure 5-4. HANBIT-Nano orbital capability of Goheung

5.5 ACCURACIES

HANBIT-Nano's injection and deployment accuracies for a standard 500 km SSO mission are listed below.

Table 5-1. Orbit injection accuracy

Apogee	± 15 km
Perigee	± 15 km
Inclination	± 0.15 deg

Injection accuracies for each type of orbit and altitude will be calculated according to the respective mission during mission planning.

Table 5-2. Deployment accuracy

Separation Velocity	2 m/s
Attitude (Roll/Pitch/Yaw)	± 5 deg
Rates (Roll/Pitch/Yaw)	± 3.4 deg/s

Deployment accuracy will also vary depending on the orbit and altitude, which will also be calculated according to the respective mission during mission planning.

6 LAUNCHES

6.1 LAUNCH OPERATIONS SCHEDULE

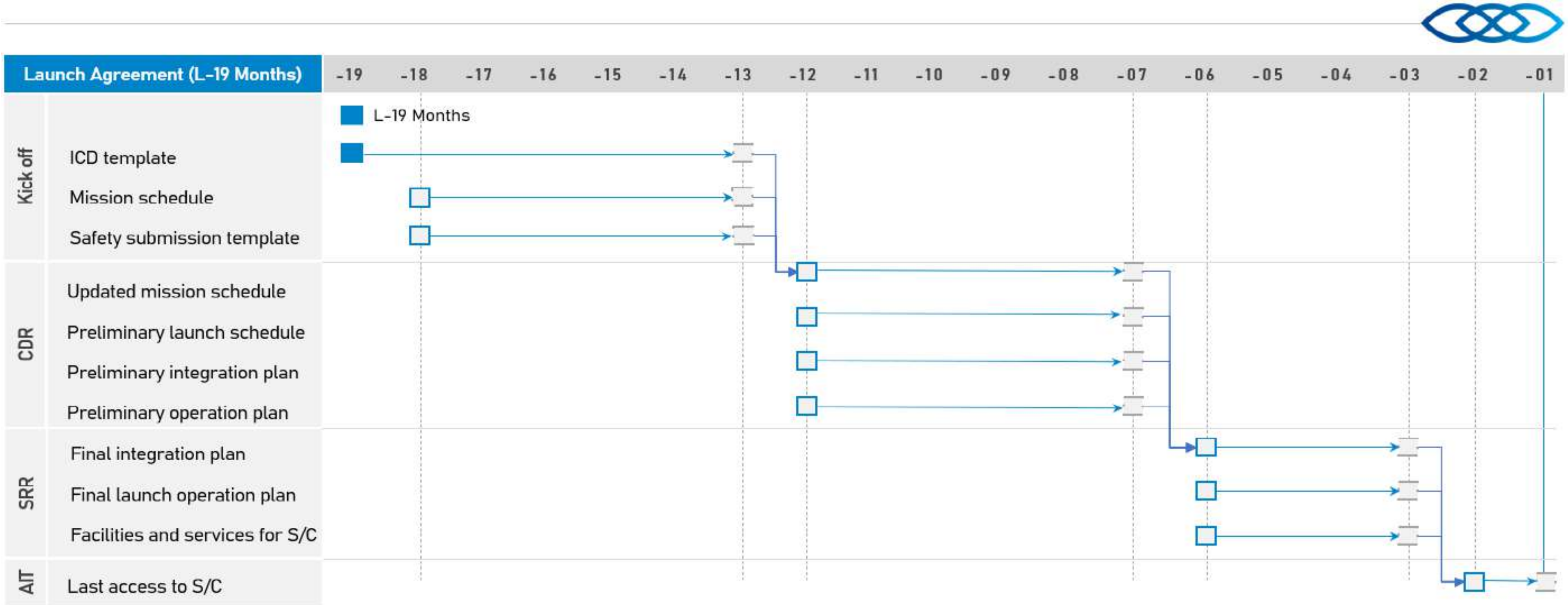


Figure 6-1. Launch operations schedule

The mission management process occurs over a period of time average 12 or more months before scheduled launch date, with more complex missions requiring more time to execute. An example mission management timeline is summarized in Figure 6-1. The specific mission schedules released over the course of the mission include overall program schedule, integration schedule, and launch campaign schedule. INNOSPACE serves the process of both understanding and executing required documentation outputs from payload provider to INNOSPACE. The customer deliverable during the mission is listed in appendix 1.

A Typical launch operation will follow the timeline below. Some changes to the expected dates can be coordinated with INNOSPACE and the customer.

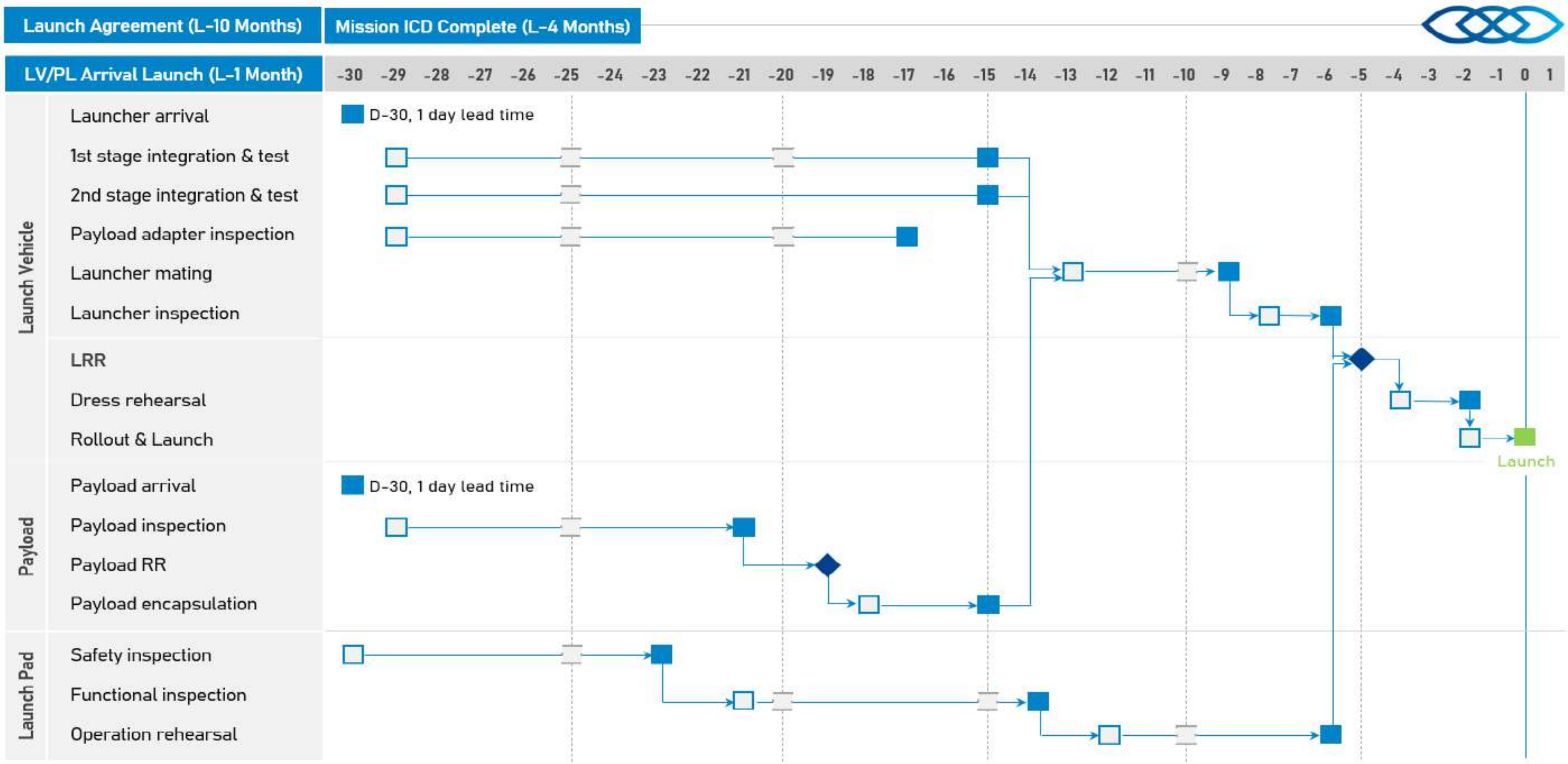


Figure 6-2. Launch operations schedule

6.2 LAUNCH SITES AND PAYLOAD PROCESSING FACILITIES

INNOSPACE's strategy is to launch from multiple launch sites across the globe. Alcantara Space Center - Brazil, Andoya Space Center – Norway, Arnhem Space Center – Australia are some of the global launch sites INNOSPACE will be launching from along with its domestic launch site in Goheung.

This will allow us to maintain a high cadence and reduce bottlenecks. These launch locations allow INNOSPACE to launch flexibly to the equatorial, sun-synchronous, polar, and every other inclination. In the coming years, we plan to continue expanding our global launch site portfolio.

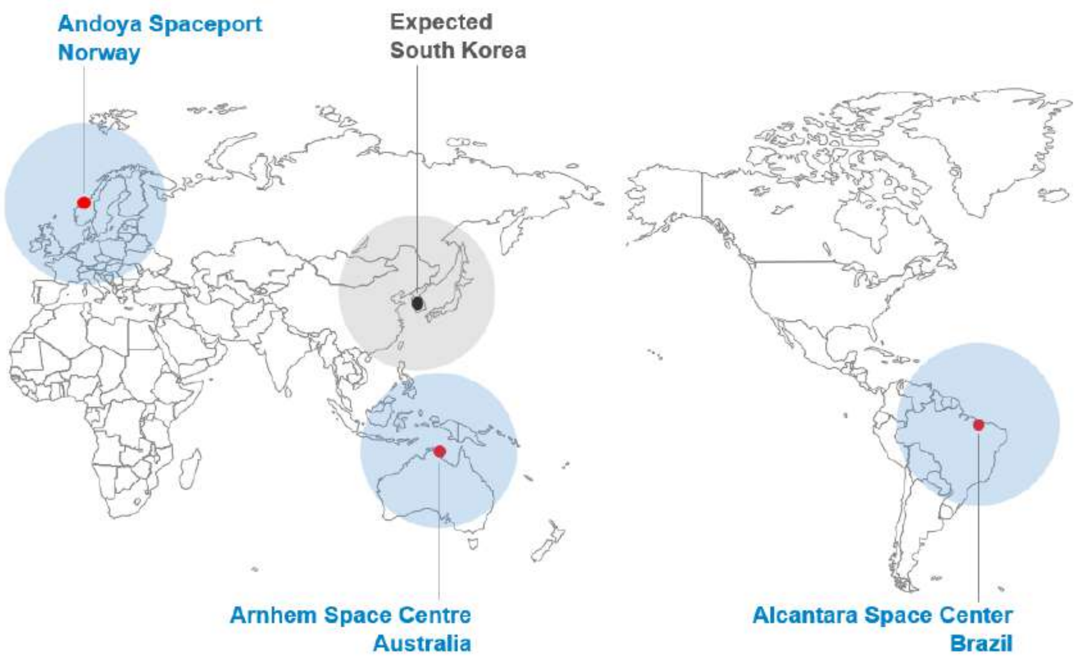


Figure 6-3. INNOSPACE's global launch sites

6.2.1 ALCANTARA SPACE CENTER, BRAZIL

The Alcantara spaceport, located in Brazil, is our primary launch site. This equatorial position allows us to launch with higher efficiency by virtue of its proximity to the Equator, taking advantage of the earth's rotation. With a wide range of azimuth & inclination angles, equatorial orbits, mid-inclination orbits, and polar orbits can be achieved from a single launch site.

6.2.1.1 FEATURES

Greater fuel economy on launches due to its proximity to the Equator.

- Possibilities of launching to equatorial, polar, and inclined orbits; inclinations up to 107 degrees. Possible launch azimuths & orbit inclinations in the image below.
- Favorable safety and security in the area.
- Proximity to the Atlantic Ocean and low population density in the area pose a low risk to life.
- Low air & marine traffic.

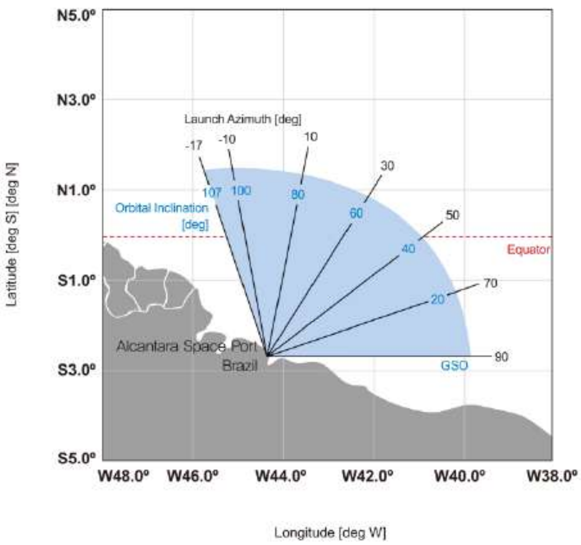


Figure 6-4. Orbital inclination and launch azimuth of ALCANTARA SPACE CENTER

6.2.1.2 FACILITIES

The AIT (Assembly, Integration & Test) Facility at Alcantara has a cleanroom with access to the rocket integration room. Payloads will be integrated into the payload envelope and sealed before mating with the rocket. Customers will also be provided with an office space and will have access to meeting rooms in a different if needed.

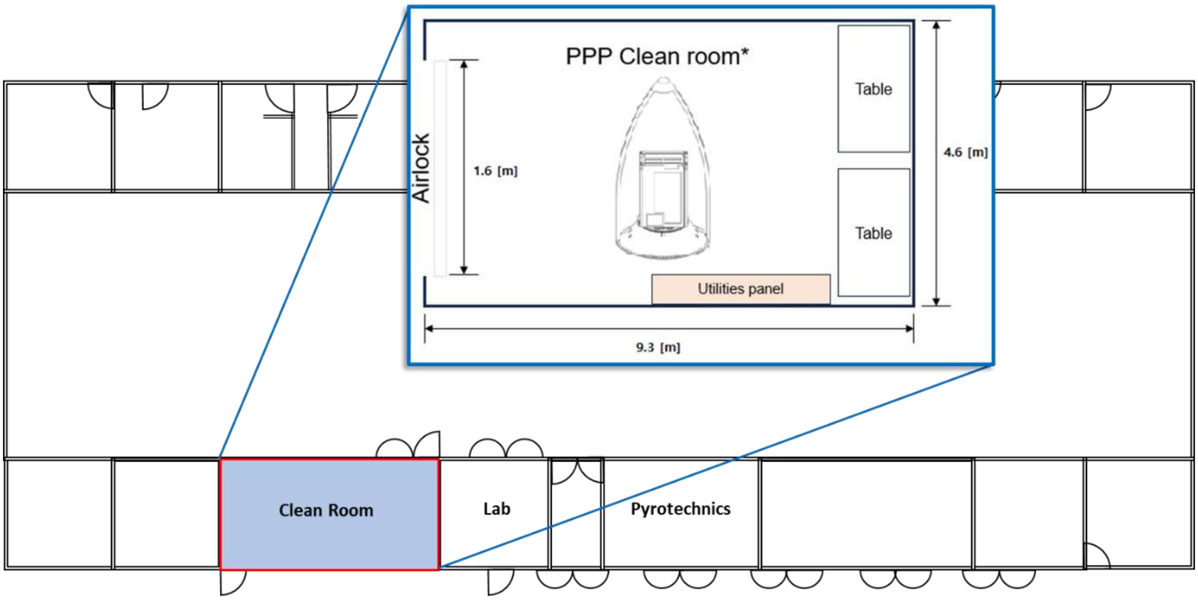
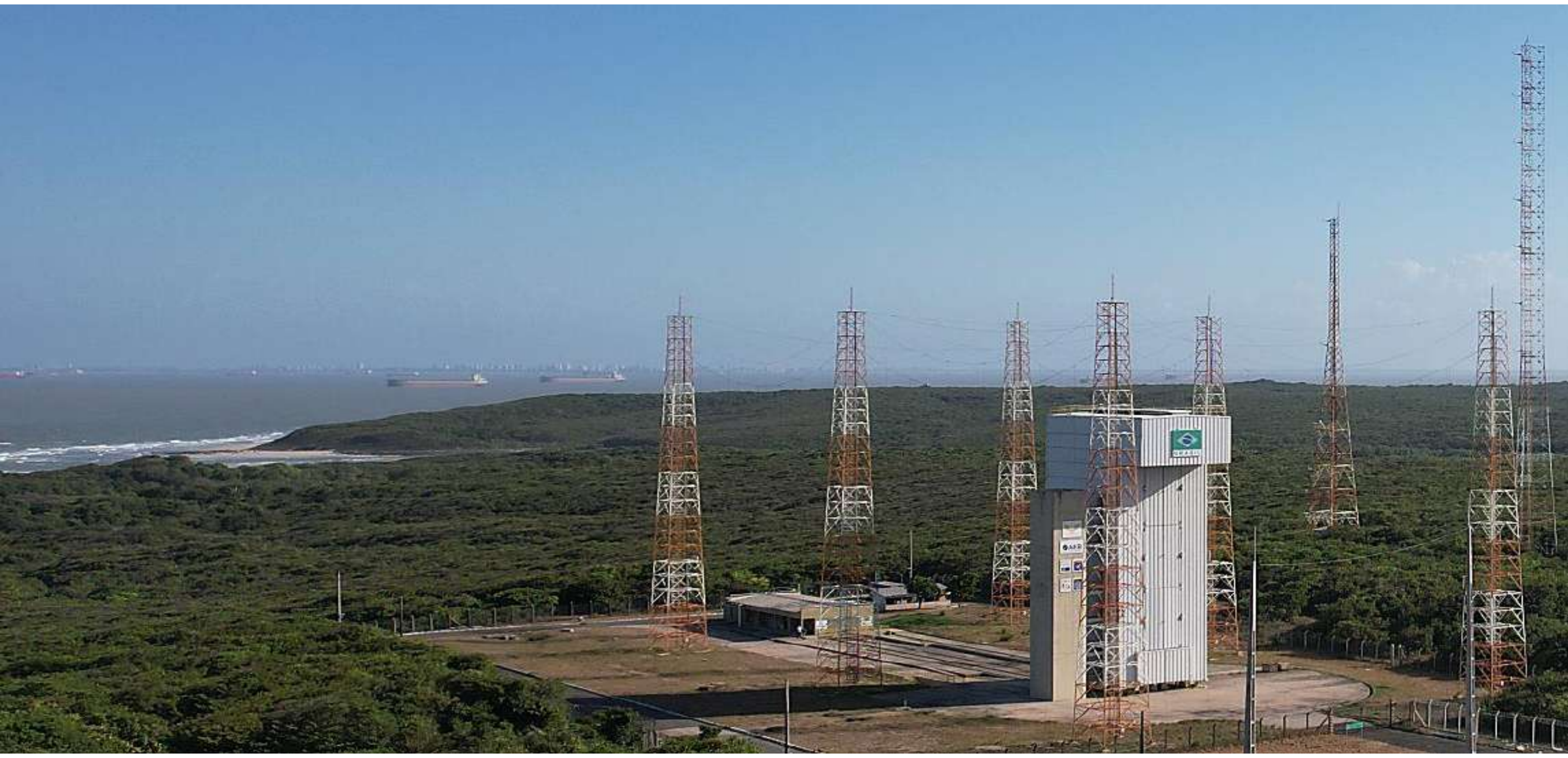


Figure 6-5. Sample layout of the AIT



6.2.2 ARNHEM SPACE CENTRE, AUSTRALIA

The Arnhem Spaceport is located in East Arnhem, Australia. Its proximity to the Equator will also allow us to launch with higher efficiency and will be ideal for mid-inclination launches. The launch site is under construction and is expected to be completed by the end of 2025.

6.2.2.1 FEATURES

Located near the Equator, it's great for mid-inclinations.

- Possible launch azimuths & orbit inclinations are shown in the image below.
- Flightpath over non-populated areas. Best for stage and test payload recovery
- Very close to air and seaports.

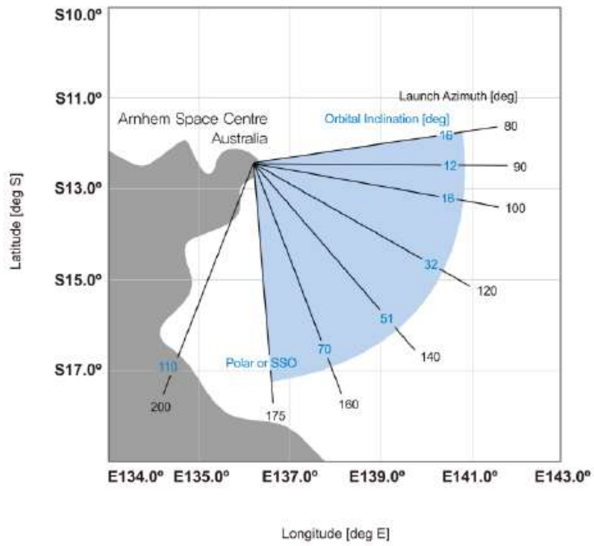


Figure 6-6. Orbital inclination and launch azimuth of ARNHEM SPACE CENTRE

6.2.2.2 FACILITIES

The AIT (Assembly, Integration & Test) Facility at ARNHEM SPACE CENTRE has a cleanroom. Payloads will be integrated into the payload envelope and sealed before mating with the rocket. Customers will also be provided with an office space and will have access to meeting rooms in a different if needed.

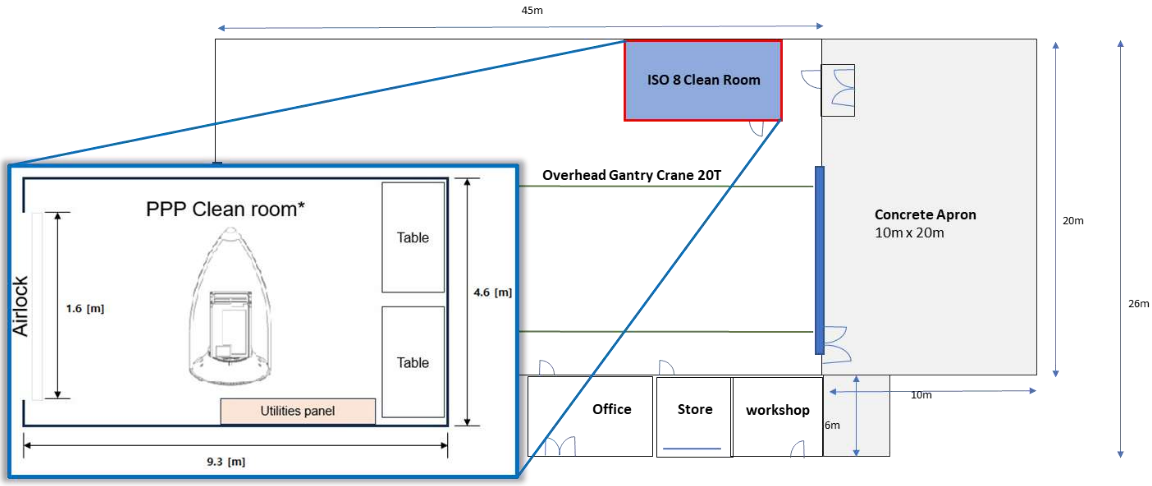


Figure 6-7. Horizontal Integration / Assembly Integration and Test Facility of ARNHEM SPACE CENTRE

6.2.3 *EXPECTED* - ANDOYA SPACEPORT, NORWAY

Andoya spaceport, which is located in Norway, is one of the sites nearest to the North Pole. The Andoya Spaceport is advantageous when launching to polar orbits. The launch site is currently under construction and expected to be completed by the end of 2025.

6.2.3.1 FEATURES

Great for polar and sun-synchronous orbits.

- Orbit inclinations from 87.4 – 108 degrees. Possible launch azimuths & orbit inclinations shown in image below.
- Flightpath over non-populated areas. Proximity to the Artic Ocean and low population density in the area pose low life risk.
- Low air & marine traffic.

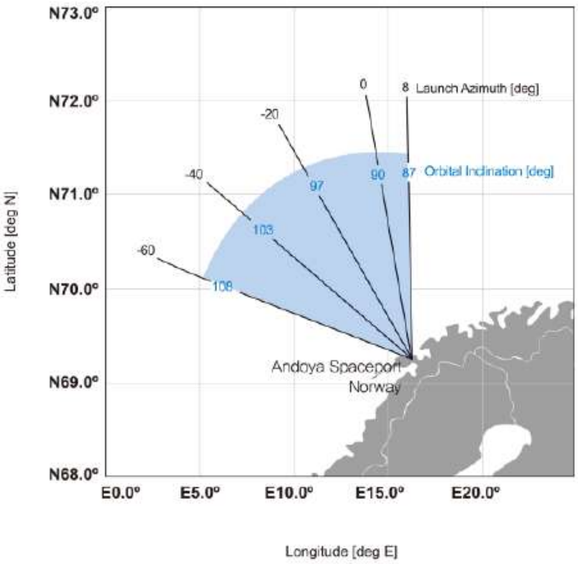


Figure 6-8. Orbital inclination and launch azimuth of ANDOYA SPACEPORT

6.2.4 *EXPECTED* – GOHEUNG, SOUTH KOREA

A commercial launch center is planned to be established in Goheung, Republic of Korea.

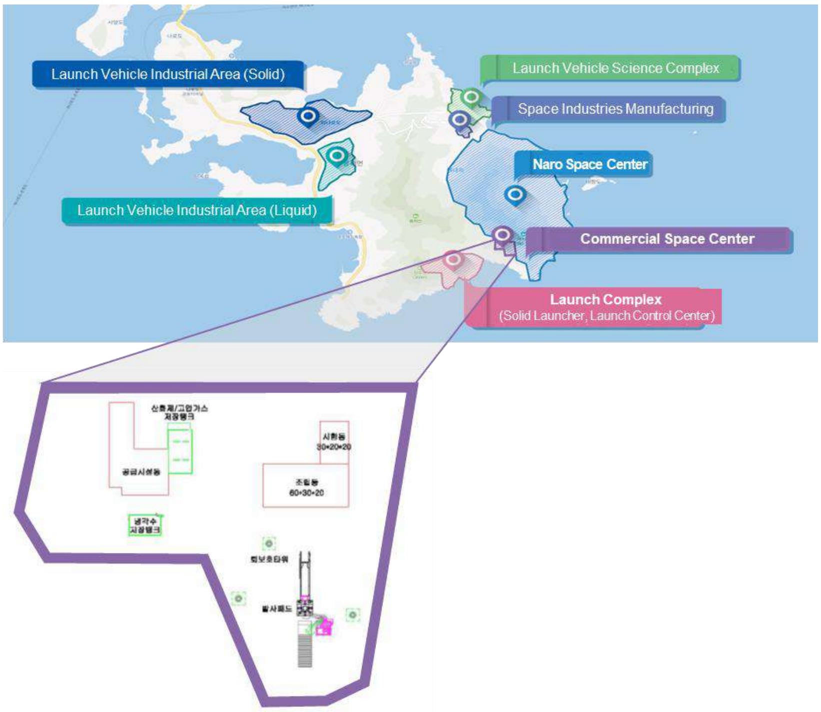


Figure 6-9. A space launch vehicle-specialized district of the Republic of Korea

6.2.4.1 FEATURE

Located on Goheung, South Korea.

- Launch azimuth is fixed at 170 deg shown in the image below.
- Orbit inclinations 80 – 100 deg (SSO).
- Very close to Naro Space Center which is launch site for KARI's launch vehicles.

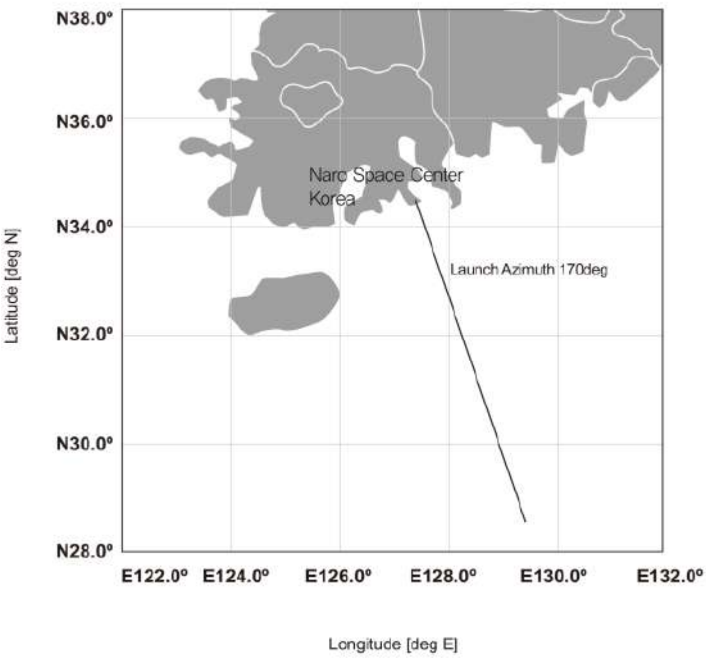


Figure 6-10. Launch azimuth of Goheung

7 STANDARD SERVICES

7.1 MISSION

As standard service, INNOSPACE will provide the following:

7.1.1 MISSION MANAGEMENT

- **General mission assurance and management**
  INNOSPACE shall assign the mission manager to make your mission a success through the mission period. The mission manager will continuously stay in contact from the beginning of the launch contract to launch and post launch period, coordinating at every stage of the launch schedule.

- **Mission feasibility analysis**
  As a part of the launch contract preparation process, INNOSPACE's mission management and engineering teams evaluate compatibility of payload design with given launch opportunity based on the information provided in the payload questionnaire. These assessments typically include mass properties analysis in relation to rideshare adapter and deployment system capabilities.

- **Generate and manage mission-specific Interface Control Document**
  For mission success, it is necessary to create and maintain an Interface Control Document (ICD). The ICD contains all kinds of information of payload including the mechanical interface, electrical interface and all kinds of sub-system (propulsion system, RF system, Optic system, power system). ICD is going to be updated through every phase of launch schedule and the mission manager will deliver the ICD template and will manage it.

- **Launch licensing for the payload from the respective authorities**
  The payload customer must produce and provide all necessary documents including documents that certify that the payload is compatible with the launcher's maximum loads as indicated in the Flight environments (Section 4). These documents are crucial to procure launch licensing for the payload. INNOSPACE will apply and procure such launch license.

- **Launch insurance (OPTIONAL)**
  To manage the risk, it is recommended the customer procure insurance for the payload. INNOSPACE will acquire the Third Party Liability insurance at its own expense which should cover the payload from the time it is unpacked at the launch site up to 30 days after launch.

- **Launch campaign**
  During the launch campaign, after the payload customer arrives at the launch site, INNOSPACE will make provision for cleanroom class ISO 8 or equivalent with Relative Humidity of 35 – 65 (%) and Temperature: 17 - 25 (℃); Office space to work; payload bay environment control and payload deployment command

7.1.2 ANALYSIS

Collision avoidance analysis:
INNOSPACE will perform a complete mission analysis, including risk analysis.

In-flight and post-flight analysis:
INNOSPACE will provide payload telemetry during and after flight, based on flight data received at the ground control center.

Orbit Disposal analysis:
All payloads are expected to comply with the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines for space debris, which states that small satellites in LEO should re-enter the atmosphere within 25 years from the end of the mission. INNOSPACE will provide the Orbit disposal time of the payload based on the provided payload data.

Non-standard services will be provided based on customer request.

8 HANBIT SERIES

To cater to the growing launch demand and diverse payload sizes and orbital requirements, INNOSPACE plans to scale up its payload capacities by clustering our main engine HyPER.

HANBIT-Micro is a 2-stage + kick stage launcher, is designed to carry payloads over 170 kg to a 500 km LEO or SSO orbit. And HANBIT-Mini is a 3-stage launcher, is designed to carry payloads over 1,300 kg to a 500 km LEO or SSO orbit.

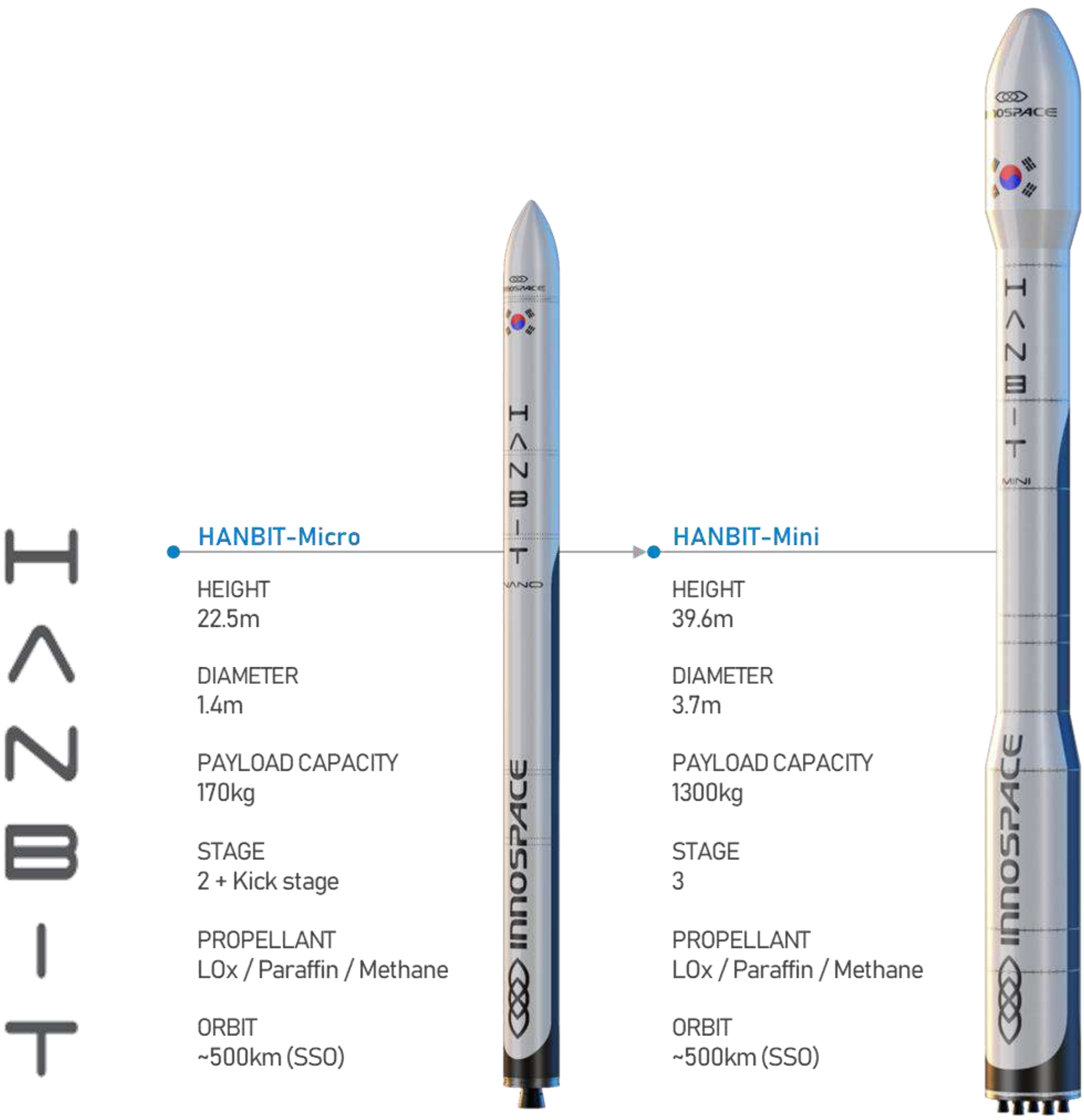


Figure 8-1. INNOSPACE's future vehicles

8.1 HANBIT LAUNCH SERVICE FEATURE

- Hybrid rocket propulsion system
- Safe
- ElecPump (+ 3D printing)
- Multiple launch sites

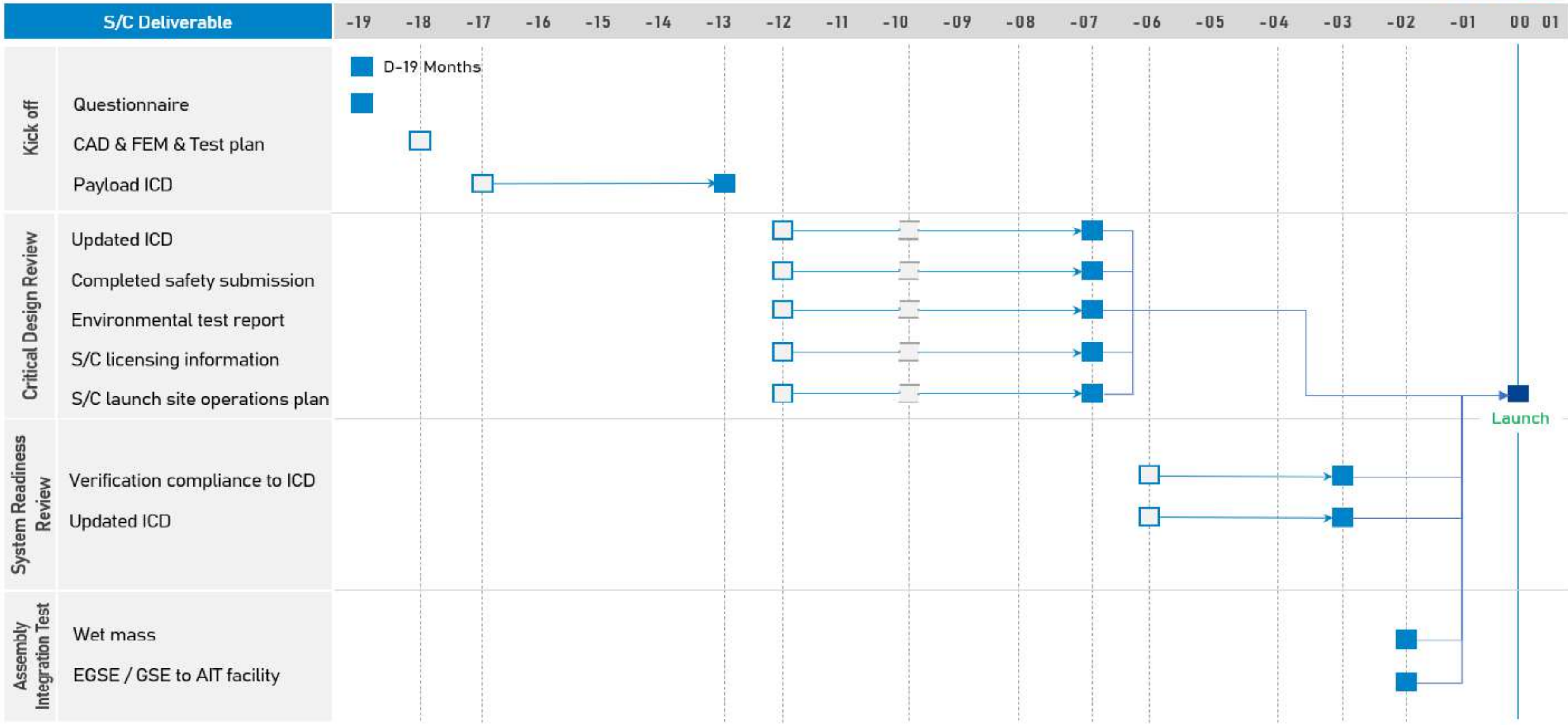
As one of the world leaders in Hybrid rocket technologies, INNOSPACE is the first to develop and successfully launch an ElecPump oxidizer-fed hybrid rocket-powered launcher in the world.

INNOSPACE's proprietary high-performance paraffin blend solid fuel technology is one of the top tier in the world and is capable of manufacturing complex geometries in large scales.

HANBIT-Nano employs our patented high-efficiency electric pump feed system. Manufactured mostly through 3D printed parts, our electric pump is able to efficiently maintain and regulate the mass flow rate while adding minimal mass to the launch vehicle.

Figure 8-2. INNOSPACE's safe, economic, and throttleable hybrid rocket technology

APPENDIX 1.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Kick off
Questionnaire
CAD & FEM & Test plan
Payload ICD
Critical Design Review
Updated ICD
Completed safety submission
Environmental test report
S/C licensing information
S/C launch site operations plan
Launch
System Readiness Review
Verification compliance to ICD
Updated ICD
Assembly Integration Test
Wet mass
EGSE / GSE to AIT facility