
# ESRANGE USER'S HANDBOOK

## Volume IX
## Spaceport

## CHANGE LOG

| Version | Issued | Changes |
|---|---|---|
| 1.2 | 24 August 2022 | Doc Id added |
| 1.1 | 21 May 2021 | Risk calc numbers referenced to ESM; author and title added in file info |
| 1 | 7 May 2021 | Full re-write of Volume, new issue |
| | | |

## APPROVAL

This version was approved by Mr Lennart Poromaa, Head of Esrange Space Center, on the date of issue.

Lennart Poromaa

Digitally signed by Alf Lennart Poromaa
Date: 2022-08-24 12:44:08+02:00

## PREFACE

Swedish Space Corporation (SSC) owns and operates Esrange Space Center (ESC) located in the north of Sweden, where a multitude of activities are performed in support of space and Earth science research, satellite communications, aerospace technology development and orbital launches. SSC also maintains capabilities to conduct mobile launch activities for stratospheric balloons at Esrange.

Users of Esrange include space agencies, scientific and research organizations, universities, and commercial customers from all over the world.

This Esrange User's Handbook summarizes policies and procedures for facility use and provides a description of the range capabilities to users.

The handbook is divided into 11 volumes, with the three first addressing general information related to the range, safety and range instrumentation, while the next seven address specific facilities, processes and operations related to individual types of activities (e.g., sounding rockets or orbital launch).

Abbreviations and acronyms used throughout the handbook, as well as identified references, are included in Volume A.

Each new version of an individual volume of the Esrange User's Handbook replaces all previous versions of that particular document (but not any of the other volumes).

The most current version of the complete/consolidated Esrange User's Handbook, and other documents referenced within it, can be found at http://www.sscspace.com.

**Volumes in Esrange User's Handbook**

| | |
|---|---|
| Vol. I - General Information | Vol. II - Safety |
| Vol. III - Launch Range Instrumentation | Vol. A - Abbreviations and References |
| Vol. IV - Scientific Ground Instruments | |
| Vol. V - UAS | Vol. VI - Stratospheric Balloons |
| Vol. VII - Sounding Rockets | Vol. VIII - Propulsive Development Testing |
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# 1 INTRODUCTION

The possibility to use Esrange Space Center for orbital launches has been contemplated to various degrees since the base was first inaugurated in 1966, under the auspices of the European Sounding Rocket Organization (ESRO). The development of the SmallSat and CubeSat market and the multitude of Launch Vehicles to support them has created an increased demand for orbital launch services. With the political support of Sweden as a launching state SSC is currently expanding Esrange Space Center to meet this need and help placing satellites in sun-synchronous and polar orbits.

## 1.1 New Esrange Program

In 2012 the Esrange Space Center was designated a strategic national asset by the Swedish government. As a result of this new designation, a plan for increasing the capabilities of Esrange was developed and initiated; an overview of which is provided in Fig. 1.

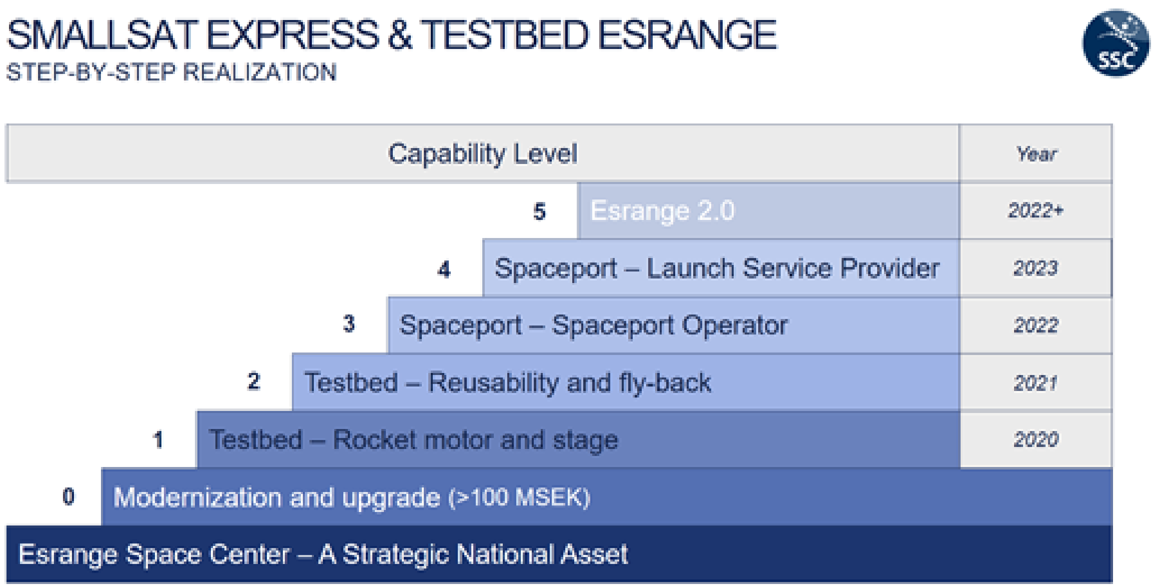


*Fig. 1 - Development strategy for the New Esrange program*

In order to achieve the increased capabilities outlined in the development plan, SSC began executing a project called "New Esrange" with the objective to build up new capabilities in a pragmatic and step-wise approach through a combination of new infrastructure investments and the leveraging/expansion of existing services. A new launch complex (Launch Complex 3) is currently being constructed to enable these new capabilities.

The key phases of the New Esrange project are aligned with the overall development plan and consist of the following capability improvements:

<u>Level 0</u> – Modernization of Esrange base infrastructure

- 56 different projects involving major investments in infrastructure upgrades at Esrange Space Center have been completed.

<u>Level 1</u> – Testbed Esrange

- Investment in horizontal and vertical test stands for rocket engine development testing.
- Investments in pre-requisite infrastructure (e.g., roads, optical fiber, groundworks at Launch Complex 3, etc.) needed to support Level 2.

<u>Level 2</u> – Reusability

- SSC investments, in combination with ESA projects for reusability development testing, to create launch infrastructure for the integration and launch of reusable rockets.

- Investment in pre-requisite infrastructure needed to support Level 3.

Level 3 – Spaceport

- Investments in technical infrastructure at Launch Complex 3 needed to support launch of orbital rockets from Esrange, with SSC acting primarily as a spaceport operator.

Level 4 – Launch Service Provider

- Investments in technical support systems to ensure that SSC, in partnership with launch vehicle manufacturer(s), can market and execute orbital launches from Esrange; with the possibility to supply a wide range of additional services required by satellite customers, from mission inception to end-of-life.

Level 5 – Esrange 2.0

- Additional upgrades to Esrange Space Center facilities and infrastructure, to meet the vision set out in the Swedish space strategy.

One of the sub-projects to New Esrange is called "SmallSat Express", which is the technical development project that will define all aspects required for adding the capability to launch satellites from Esrange. The SmallSat Express project was initiated in 2014 and is phased according to aerospace standards. The project is currently in Phase D with respect to achieving capability level 3 (Spaceport Operator) and Phase C2 with respect to the definition of capability level 4 (Launch Service Provider).

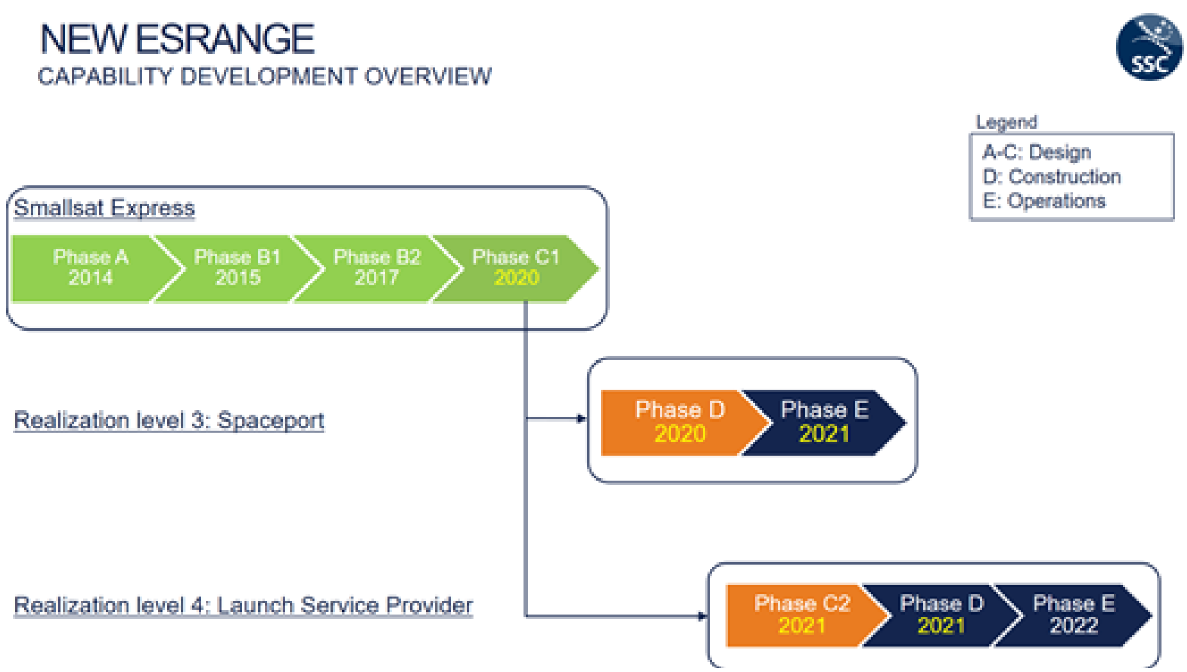


*Fig. 2 - SmallSat Express timeline and connection to the New Esrange realization strategy*

### 1.1.1 Spaceport Buildout

Development of the initial spaceport capability is being funded through a combined investment by the Swedish government and SSC. On 14 October 2020, the Swedish government's representative for space-related activities formally announced the decision to provide funding for infrastructure needed to begin launching small satellites into orbit from Esrange and its support for Sweden as a launching state.

Construction of the "Phase 1" spaceport capability started in 2020 and is planned to become operational during 2021 and 2022. As illustrated in Fig. 3, the Phase 1 construction activities will include the first two launch pads (LC-3A and LC-3B) and the necessary hardware integration areas inside the Launch Vehicle Integration Building (LVIB). SSC can, even in this initial phase, also provide tailored support to orbital launch campaigns with experienced personnel or development of critical infrastructure/

systems, upon request.

"Phase 2" is planned to start in 2022 and become operational in 2023. This phase will include the construction of a third launch pad (LC-3C) for larger Lauch Vehicles and additional capability improvements to various infrastructure/facilities that were started in Phase 1.

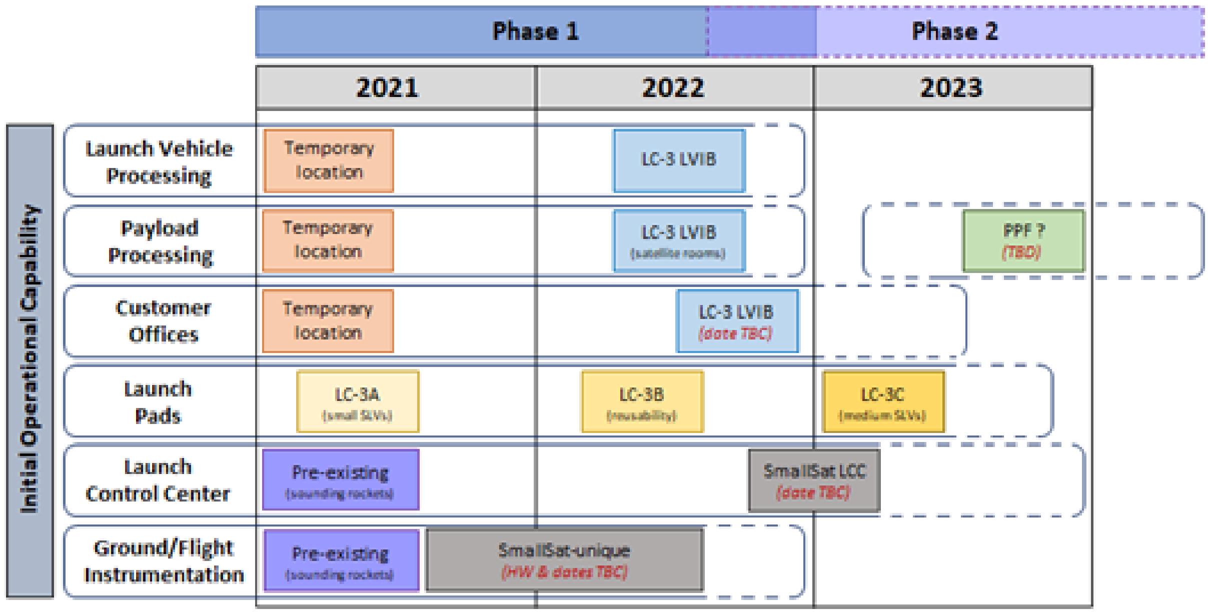


*Fig. 3 - Timeline for the development of SmallSat Express (spaceport) capabilities at Esrange*

## 1.2 Spaceport Philosophy

SSC is a multi-mission service provider, meaning that infrastructure at the Esrange Space Center is shared by multiple customers to enable effective utilization of the available resources.

When complete, the Esrange spaceport will contain 'generic' infrastructure to support multiple Launch Service Providers launching to orbit from Launch Complex 3 (LC-3). Specific systems (such as those related to individual launch vehicles) will need to be provided by the launch vehicle manufacturers.

### 1.2.1 Hosting of Different Launch Vehicles

In light of SSC's role as a multi-mission provider, the LC-3 launch site has been designed to allow multiple Launch Service Providers (LSPs) to utilize the same facilities. The design of the LVIB will also enable two independent launch campaigns to run in parallel, providing each customer with designated parts of the building (described in more detail in section 2.1.2). Activities on each of the different launch pads will however need to be limited to one launch vehicle/campaign at a time.

In the event that the multi-mission nature of LC-3 operations are unable to meet a LSP's longer-term future launch requirements, and the LSP is willing to invest in the development of dedicated infrastructure, SSC will of course be happy to discuss the possibility of establishing additional orbital launch site(s) with associated buildings at Esrange.

### 1.2.2 Exclusive Access of Facilities

In relation to each orbital launch campaign a LSP will be granted exclusive access (for a defined period) to those parts of the LVIB which are required for the necessary work and contracted accordingly. This will typically include one complete 'half' of the LVIB, to include one LV integration bay, one satellite processing room and office space for LSP and/or payload personnel. However, if a LSP's launch schedule were to necessitate it, exclusive access to both 'halves' of the LVIB could be provided simultaneously.

In connection with the LV roll-out and subsequent launch operations, exclusive access will also be granted to the relevant launch pad(s).

SSC can also facilitate the deployment of LSP-provided infrastructure at the Esrange Space Center. Any such customer-furnished equipment would be exclusively available to the LSP which owns it.

## 1.3 Launch Considerations

Some general constraints that will affect orbital launch trajectories and/or flight operations are described below. Additional information can be found in Volume II (Safety) of Esrange User's Handbook.

### 1.3.1 Trajectory considerations

#### 1.3.1.1 Azimuth Constraints

The primary constraint for the initial flight azimuth is the Esrange downrange impact area. This would mean an initial azimuth of between 320° and 020°. However, a reliable launch vehicle without any planned impacts on land can apply for other azimuths. Each proposed trajectory will be assessed according to the defined risk constraints.

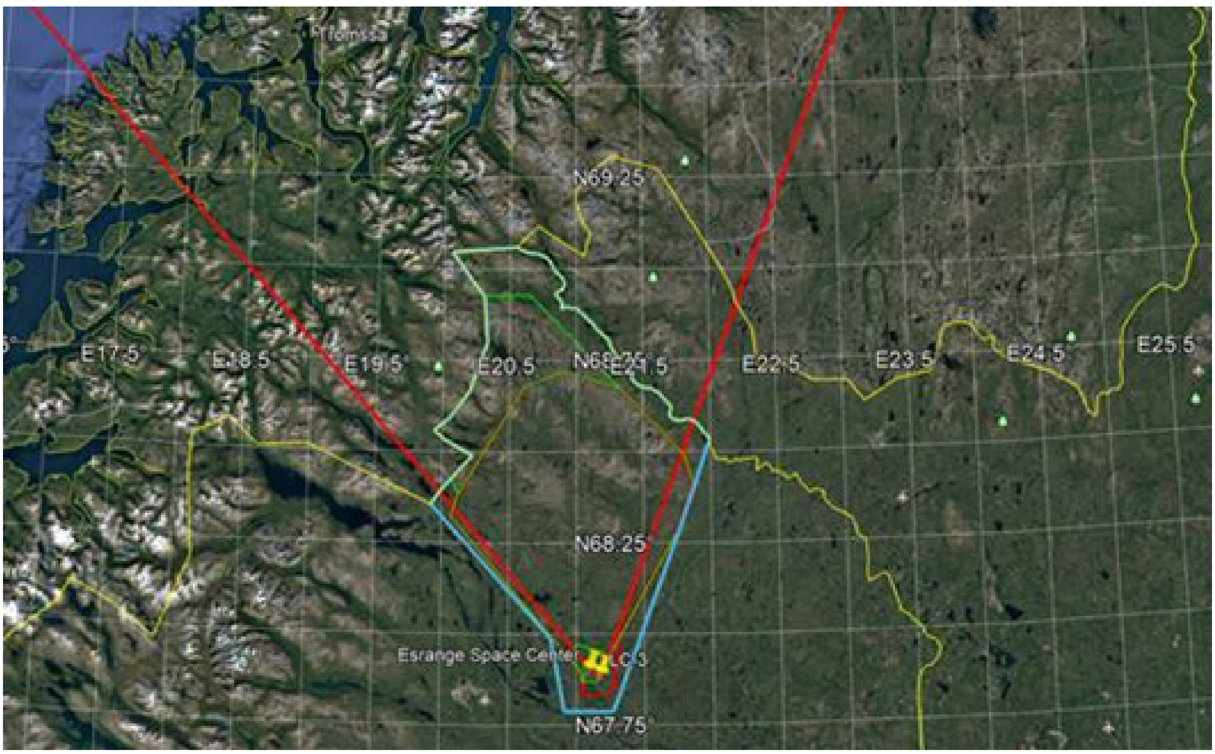


*Fig. 4 - Visualization of possible limits in initial azimuth*

#### 1.3.1.2 Altitude Constraints

A launch vehicle cannot operate in a shared airspace with aircraft and other flying vehicles. The airspace north of Esrange Space Center will be closed (all the way to the borders with Norway and Finland) for every launch attempt. Before exiting Esrange-controlled airspace, launch vehicles must attain an altitude sufficiently above air traffic flight levels.

#### 1.3.1.3 Jettison Constraints

The planned jettison of physical components adds some additional constraints on the trajectory of the launch vehicle. There cannot be any planned impacts on foreign nations without agreements in place. Impacts near populated areas (including oil rigs) shall also be avoided.

Fig. 5 shows the allowable impact locations as a function of downrange distance and azimuth. Green areas indicate where a planned impact can be allowed, whereas red areas indicate where planned impacts are anticipated to be forbidden. Additional details regarding the red areas are provided for clarity.

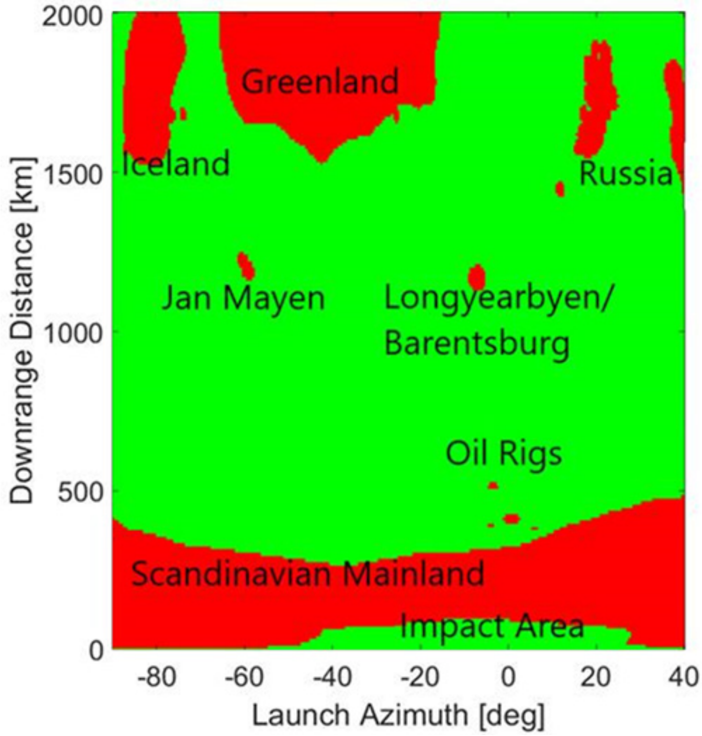


*Fig. 5 - Figure showing the allowed locations for a planned impact (in green)*

#### 1.3.1.4 Risk Constraints

Orbital launches from Esrange must follow the risk criteria specified in the Esrange Safety Manual (ESM). Please refer to it, which can be found at https://sscspace.com/esrange-safety-manual/.

***NOTE: At the time of the printing of this volume, ESM is being updated to reflect orbital launch regulations, which will be found in version 10.***

What this means for a specific launch vehicle must be evaluated in a Flight Safety Analysis. Possible additional constraints may also need to be applied to the trajectory to satisfy the risk criteria. Since the risk numbers are based on probability of failure, the restrictions imposed on an individual type of launch vehicle may become less stringent after two successful missions.

Large parts of most trajectories will be over sparsely populated areas, including inhabited areas within the Esrange downrange impact zone. The largest settlement that lies within the range of possible trajectory azimuths is the Norwegian town of Tromsø, situated at a distance of 220 kilometer and 337° direction from LC-3. Depending on the launch vehicle, doglegs to avoid Tromsø might be necessary in order to meet the required risk criteria.

### 1.3.2 Collision Avoidance (COLA)

SSC will provide, via an existing commercial bilateral agreement with the U.S. Department of Defense Strategic Command (STRATCOM) for sharing Space Situational Awareness (SSA) services, collision avoidance analysis reports as part of the launch approval process.

Additional information related to the COLA analysis process is provided in Volume II (Safety).

### 1.3.3 Launch Scheduling

No specific dates or times of day are prohibited from a legal perspective.

However, the downrange impact area north of Esrange Space Center is, apart from space-related activities, also used for reindeer herding and mobile recreational activities. There is a local agreement with the other parties involved in which SSC tries to refrain from launching during September due to public safety reasons. So, although there is nothing formally preventing launches from taking place in September, doing so has historically been avoided.

## 2 FACILITIES

The following facilities will be available for spaceport customers at Esrange Space Center.

### 2.1 Launch Complex 3

SSC is developing a new launch site outside the Esrange main base area. This new launch site is designated Launch Complex 3, or LC-3 in short. The primary purpose of LC-3 is to provide the launch infrastructure necessary for orbital launches and testing of reusable launch vehicles and planetary landers (e.g., hovering and landing tests).

The LC-3 site is located approximately 4 km southeast from the Esrange Main Building. The access road from the Esrange Space Center main base area to LC-3 is a 5-meter-wide gravel road, suitable for commercial transportation carriers. The LC-3 site will have its own perimeter fence and be security controlled.

The site coordinates are:

| Latitude | Longitude | Elevation |
|---|---|---|
| 67.876° N | 21.175° E | 315 m |

*Fig. 6 - Map of the Esrange base area, with LC-3 circled in red*

Construction activities at the LC-3 site are ongoing and, as described in paragraph 1.1.1, an initial orbital launch capability is planned to become operational during 2022.

*Fig. 7 - Status of LC-3 site development (as of Sep 2020)*

When complete, the LC-3 site will consist primarily of a large hardware integration building for the preparation of the launch vehicles and payloads, and three separate launch pads for different types of launch vehicles. The planned layout of the LC-3 site is presented in Fig. 8 and Fig. 9.

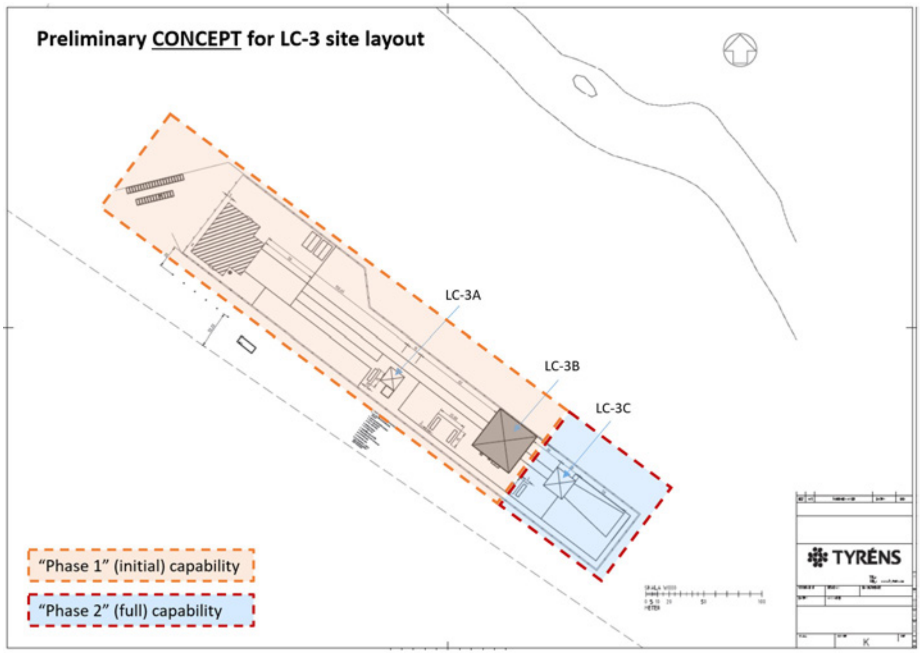


*Fig. 8 - Planned layout of the LC-3 launch site*

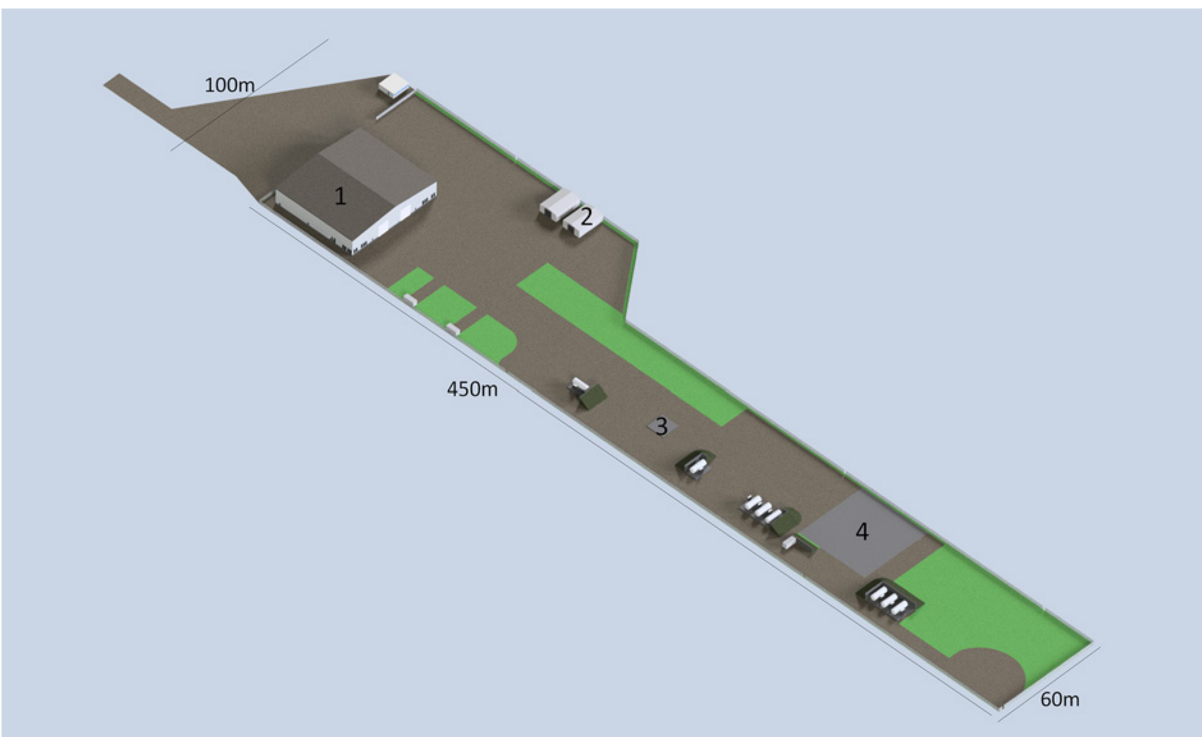


*Fig. 9 - Launch Complex 3 as envisioned it will be in late 2022: Launch Vehicle Integration Building (1), Dry storage (2), LC-3A launch pad area (3), and LC-3B launch pad area (4).*
*LC-3C launch pad area will be in the green area in lower right.*

### Geological Assessment

A preliminary geological study was performed in 2017, based on which the location of the LC-3 site was selected. A comprehensive geotechnical analysis of the LC-3 site was then performed in April 2020. The approximate location of the assessed area is identified by the red rectangle in Fig. 10. The investigations were performed in accordance with Geotechnical Category 2 (GC2) of Eurocode 7.

*Fig. 10 - Area of LC-3 geotechnical analysis*

The analysis consisted of 24 ground composition soundings, 17 drilling locations, 32 soil samples, and measurement of groundwater levels in 4 locations. An overview of the locations where various types of measurements and/or samples were taken is provided in Fig. 11.

The general composition of the assessed area (starting at ground level and going down) was found to consist of:

- Soil and filling consisting of sand and silty sand (a small layer, approximately 1.5 – 3m depth)
- Sand (ranging from about 1.5 – 6m depth)
- Silt with elements of fine sand layers (approximately 3 – 9.5m depth)
- Moraine (approximately 7.5 – 17m depth)
- Presumed solid rock

The results of the geotechnical analysis did not identify any significant concerns regarding the planned construction activities. The only observation which warranted a specific comment was that due to there being a lot of silt and higher groundwater levels at the eastern end of the site, heavy structures to be located there may need to either have their foundations placed directly on the bedrock (15m below the current ground level) or be supported on piles. However, neither of the suggested approaches was deemed to be problematic considering both being common techniques for construction activities throughout Sweden.

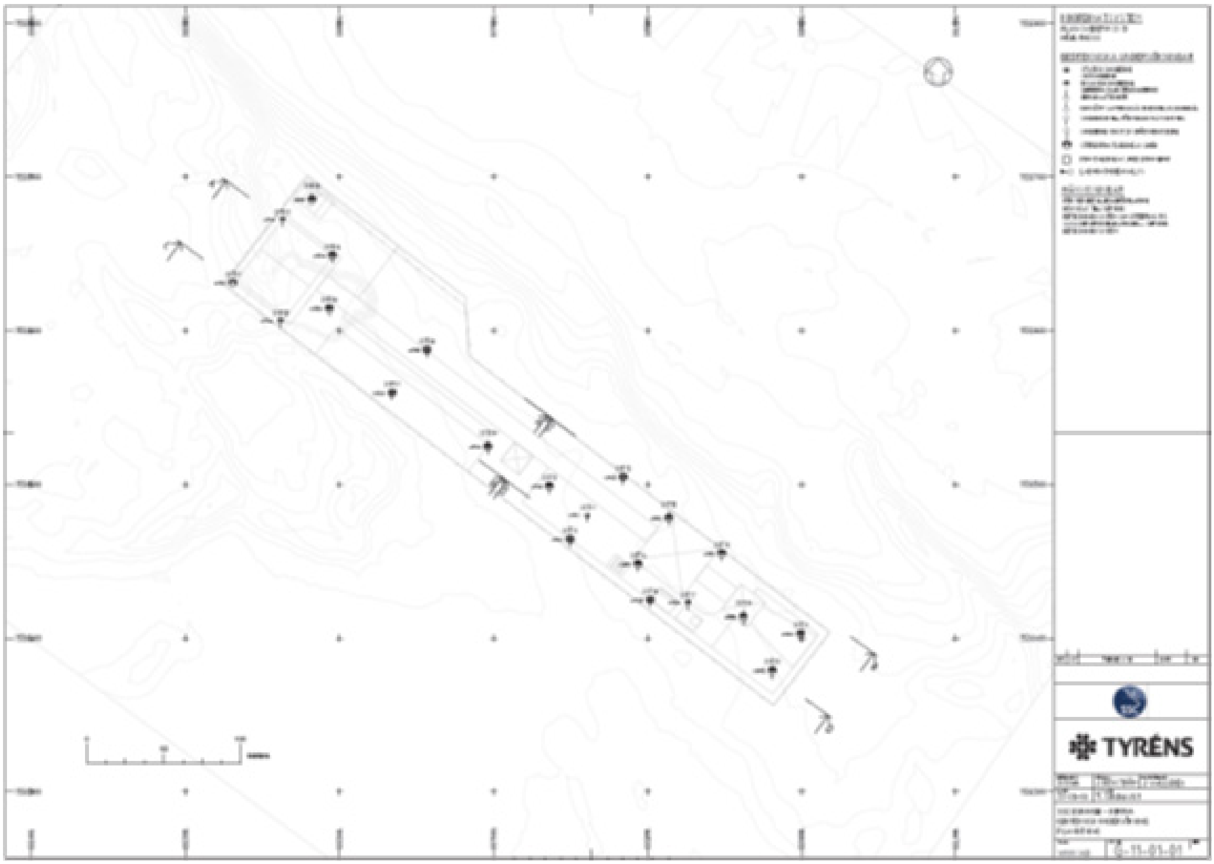

*Fig. 11 - Geological sample locations within the LC-3 site area*

### Environmental Regulations and Permits

During all work performed to date, SSC has remained in full compliance with the relevant environmental requirements.

Kiruna Municipality is the local governmental authority that supervises the activities carried out at Esrange from an environmental perspective. All permits that have been obtained so far as well as the underlying investigations are in Swedish. As required from the authorities prior to issuing permits, the following investigations and other means of measurements have been made:

- Stakeholder dialogues with Kiruna Municipality, the County of Norrbotten, reindeer herding, and other stakeholders have been conducted. This according to the Swedish Environmental Code. The notification was handled by the County of Norrbotten.
- Geotechnical investigations
- Natural interest investigation
- Ancient remains investigation. A few ancient remains were found, and SSC was granted permission from the County of Norrbotten to move these.
- Wetlands and dead wood investigation

SSC has obtained permits for:

- Establishing a road to the launch complex and land works at the site issued by Kiruna Municipality
- Logging at the site approved by the Swedish Forest Agency
- Species protection exemption issued by the County of Norrbotten

Since the LC-3 launch site is still under construction, applications for further permits will be submitted as necessary. For example, SSC has, among other things, applied for a permit to install geothermal heating at the LVIB. SSC is in regular contact with the environmental office at Kiruna Municipality as the work related to the construction of LC-3 progresses.

### 2.1.1 Site Power

Electric power is supplied by the existing 22 kV commercial grid and is transformed locally at LC-3. The power provided follows EU standards with 230/400 V, 50 Hz outlets. LC-3 will have a possible total power usage of 300 kW simultaneously.

Additional information regarding the power system at Esrange is available in Volume I (General).

#### 2.1.1.1 Backup Power

SSC will provide backup power from on-site generators in the unlikely event of a power outage son the commercial grid. This backup power will take a few seconds to get started.

#### 2.1.1.2 Uninterruptable Power Supply

SSC will provide UPS for safety-related launch site infrastructure and critical operational equipment.

Provision of any UPS which may be required by the launch vehicle or payloads will be the responsibility of the LSP.

### 2.1.2 Launch Vehicle Integration Building

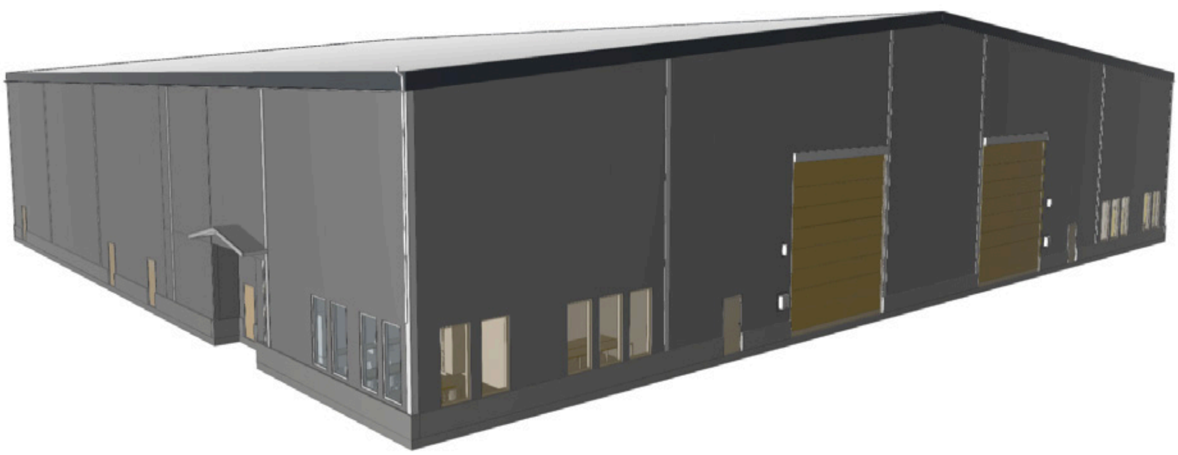

*Fig. 12 - LVIB*

SSC plans to build a Launch Vehicle Integration Building (LVIB) within the LC-3 perimeter, to be in operation Q2 2022. It should be noted that the drawings and exact layout might be subject to change until the final design has been decided upon and construction has started.

The 45 m (L) x 50 m (W) LVIB will be situated at the west end of the site and is designed to support assembly of launch vehicles in a horizontal configuration. This building is divided down the middle into two mirrored areas, to enable two different launch campaigns to be hosted inside the building and run in parallel.

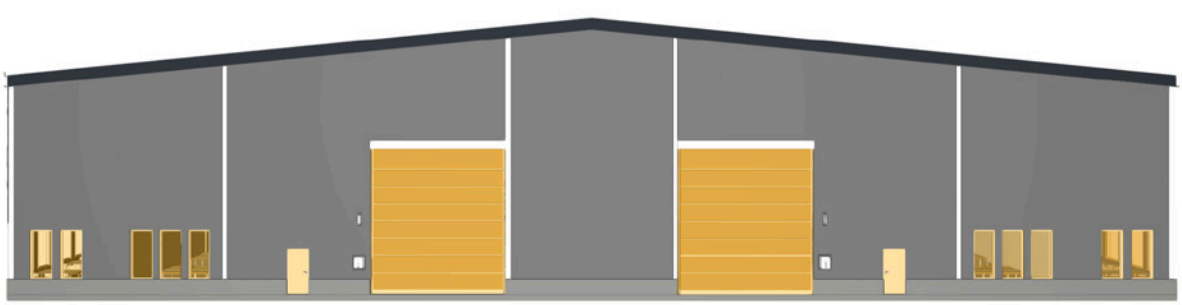

*Fig. 13 - West entrance side of the LVIB*

The west and east sides of the building will have two 8 m (W) x 8 m (H) roll-up doors (i.e., one at each end of both LV integration bays) to enable large logistical vehicles to drive through the building, if necessary. However, to minimize the introduction of dirt and debris into the LV integration bays, the large open area immediately east of the building should be used for logistics offloading operations whenever possible.

On both the east and north sides of the building there will be large obstacle-free areas, which can be used for unloading containers or equipment from trucks. Two smaller auxiliary buildings are also planned in the northeast corner of the obstacle-free area, which can be used for dry storage and/or activities requiring a workshop-type environment.

#### 2.1.2.1 Launch Vehicle Integration bays

The LVIB will contain two identical 45 m (L) x 15 m (W) x 9 m (H) LV integration bays separated by a wall. This enables two parallel launch campaigns at the same time. In case of having just one campaign a 4x4m roll-up door can be opened between the two bays to provide access to the other side.

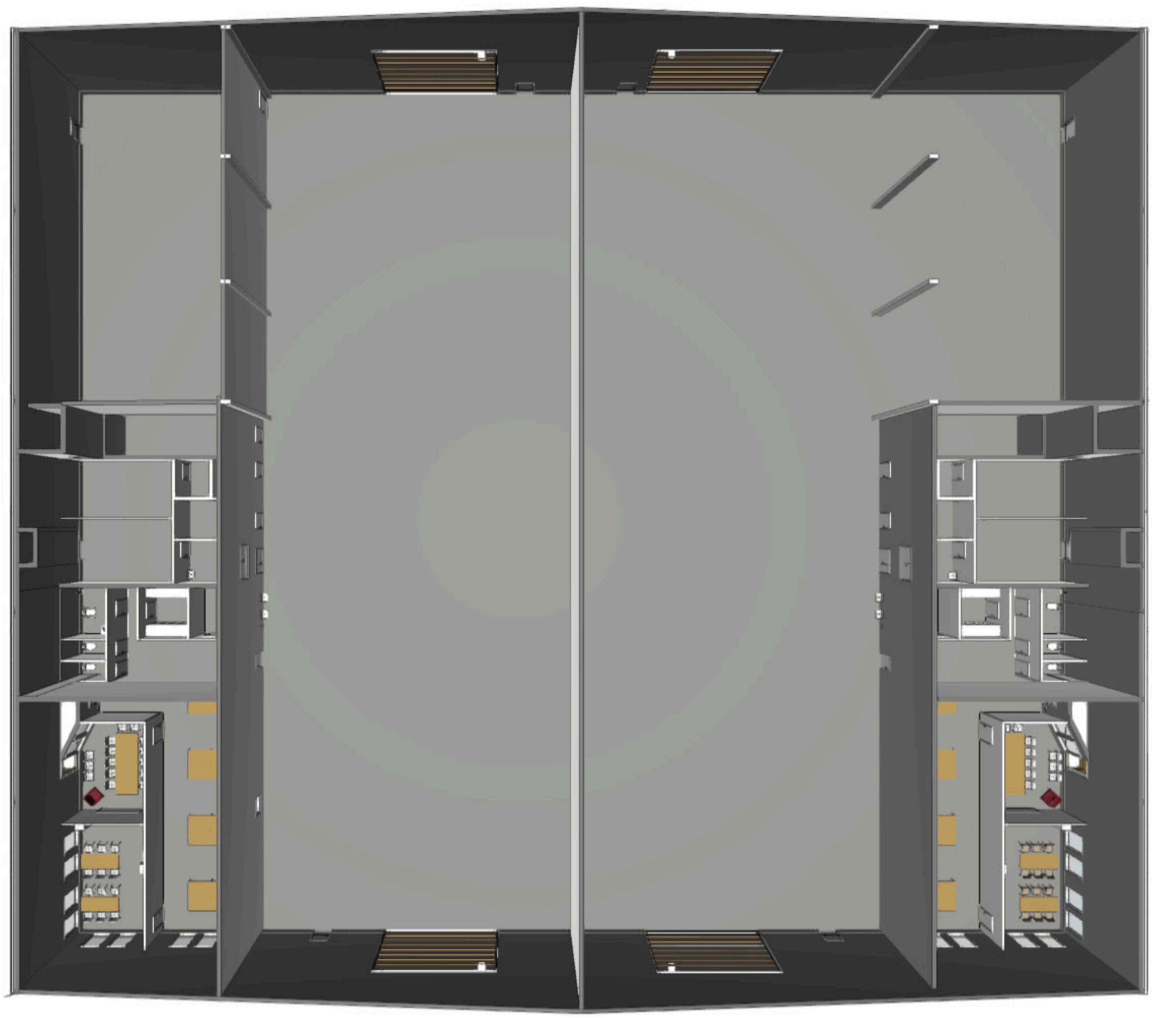

Fig. 14 - Preliminary layout of the Launch Vehicle Integration Building

The minimum ceiling height of the LV integration bays will be 9.5m. Each bay will include two 12.5 metric ton bridge cranes with a free hook height of 7m. The joint lift capacity of these cranes is up to 25 metric ton.

The LV integration bays will be temperature controlled (shirt sleeve environment) as long as the roll-up doors are closed. The bays will be maintained as 'clean' workspaces but will not follow any ISO standard for cleanliness. The floor will be flat concrete with an ESD protective finish. In the middle of the room there will be a small trench for spill catchment.

Each bay will be illuminated from above and at 45deg from the walls, to provide a work lighting environment of 750 Lx.

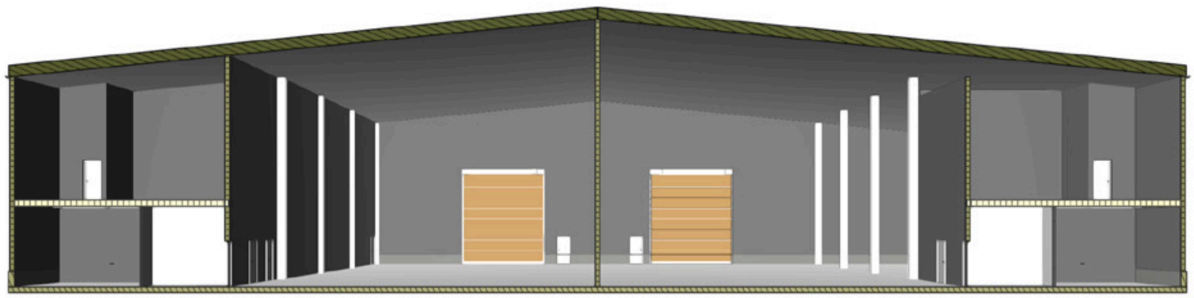

Fig. 15 - Cross-sectional view of the Launch Vehicle Integration Building

### Power, Communications and Data

Power, communication, and data network connections will be provided inside the LVIB and these will follow EU standards. Each LV integration bay will contain the following power outlets distributed around the interior walls:

| Quantity (minimum) | Voltage | Current |
|---|---|---|
| 2 | 400 V | 63 A |
| 2 | 400 V | 32 A |
| 6 | 400 V | 16 A |
| TBD | 230 V | TBD |

### HVAC

Control of heating, ventilation, and air-conditioning in the LVIB will be performed locally (i.e., from inside the building).

The LVIB will be climate controlled (temperature and humidity). The planned climate control ranges inside the LV integration bays, when the large roll-up doors are closed, are 18°C ≤ T ≤ 25°C and 30% ≤ RH ≤ 70%.

Unless agreed otherwise in the launch campaign support contract, the user will be responsible for fulfilling any HVAC requirements related to the launch vehicle and/or payloads.

### Water

Provision of potable water to the LVIB will be from a well drilled on site. If there is any need for water purification it will be performed locally. Water heaters will be installed for hot water supply. There will be access to tap water in both bays in form of a sink.

### Compressed air

Compressed air will be provided in the LV integration bays via portable compressors.

### Industrial Gases

Bottle racks of industrial gases at standard pressures will be supplied to the LVIB and launch pad in quantities needed for each mission.

### Lightning and Fire Protection

The LVIB will have a building class 3 lightning protection, evacuation, and fire alarms, but no automatic fire suppression system. Manual fire extinguishers will be provided throughout the building, in accordance with applicable safety regulations.

### 2.1.2.2 Satellite Processing Rooms

There will be a separate 8 m (L) x 9 m (W) x 7 m (H) (TBC) room adjacent to each of the LV integration bays that can be used for satellite processing or as dry storage. These room will be accessible from the bays via a large roll-up door, and a small personnel door located next to the roll-up door. There will be an emergency exit on the opposite side of the room, providing an exit path directly out of the building. The floor will be flat concrete at the same level as the LV integration bays and will have an ESD protective finish.

These rooms will be maintained as 'clean' workspaces but will not follow any ISO standard for cleanliness. If the environmental requirements for certain payloads exceed the capabilities of the LVIB's HVAC system, a portable ISO cleanroom tent could be placed inside either the satellite processing room or LV integration bay.

There will be sufficient interior lighting for normal mechanical work (750Lx). A 16A / 400V outlet will be placed near the door, as well as some 230V outlets distributed around the walls.

### 2.1.2.3 Customer Offices

Offices and associated common facilities will be provided on each side of the LVIB for the LSP's and payload providers' operational staff. Each office area is planned to include an open working area for 20-25 people, and a conference room able to accommodate 10-12 people. Each office area will also include common facilities such as a kitchen, a changing room, and toilets.

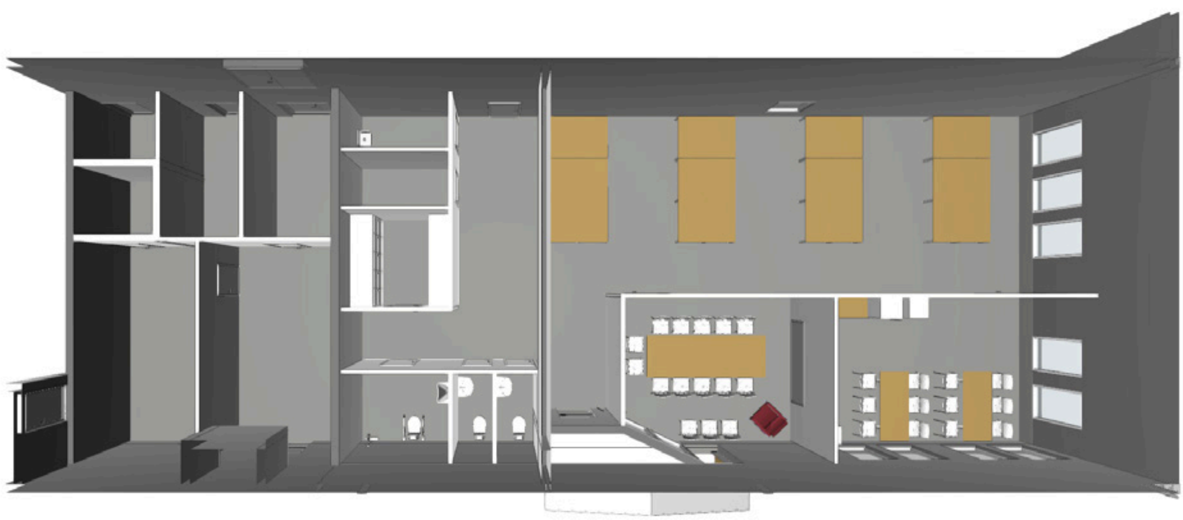

Fig. 16 - Offices and associated common facilities inside the LVIB

### 2.1.3 Launch Pads

The three planned launch pads are:

- LC-3A – Intended for smaller orbital and suborbital launch vehicles
- LC-3B – Intended for testing of reusable launch vehicles and planetary landers
- LC-3C – Intended for medium orbital launch vehicles

A general summary of the different launch pads is provided in the table below:

| | LC-3A | LC-3B | LC-3C |
|---|---|---|---|
| **IOC** | Q1 2021 | Q2 2022 | 2023 |
| **Size (m)** | 7 x 7 (TBC) | 40 x 40 | 20 x 20 (TBC) |
| **Material** | Gravel/concrete (TBC) | Concrete | Concrete |
| **Flame duct** | No | No | Yes |
| **Water deluge** | No | No | Yes |
| **Lightning towers** | No | No | Yes |
| **Gantry tower** | No | No | TBD |

### 2.1.3.1 LC-3A

The LC-3A launch pad is intended to support small launch vehicles with potential blast profiles up to 1.5 metric tons TNT equivalent. The pad area will be lit by floodlights to enable outdoor work during all seasons.

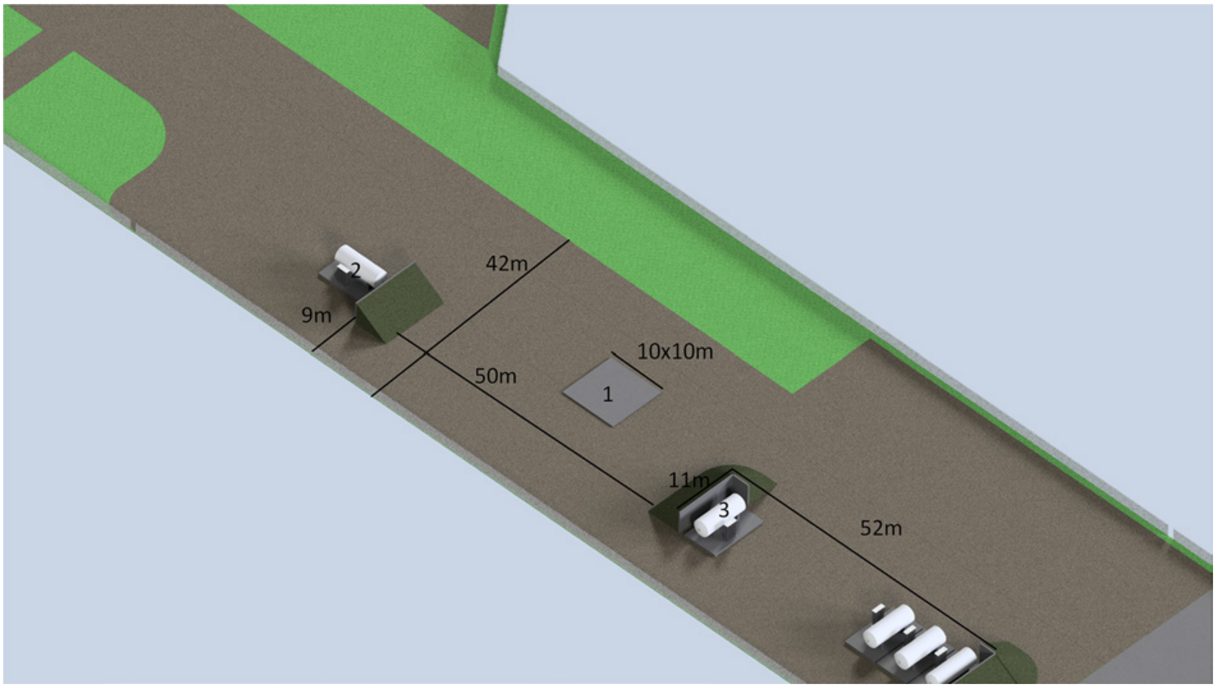


*Fig. 17 - Launch Pad LC-3A area: Launch Pad (1), Oxidizer storage (2), Fuel storage (3)*

#### Launch Pad

The LC-3A pad area is currently planned to be packed gravel (TBC). The flat open area is planned to be approximately 50 m x 44 m in total, with a center area of approximately 7 m x 7 m for the launch vehicle and associated launch stool. The pad will have a direct roll-out path from the LVIB's south integration bay.

#### Cryogenic Liquid Propellant Storage

The cryogenic liquid propellant storage area will consist of storage tank(s) and will be located on the east side of the LC-3A pad. This will be a shared cryogenic liquid propellant storage area, for use by both the LC-3A and LC-3B pads. The area will be protected against an on-pad explosion by 3.5 m high berms. The area can accommodate several tanks, depending on the size and orientation of the chosen tanks. The total area inside the berm will be 15 m x 25 m.

Vacuum insulated piping will run from the propellant storage location to an interface point located close to the pad. The exact location is TBD.

The de-fueling system is to be implemented together with the launch vehicle providers.

#### Fuel Storage

The LC-3A pad will have its own dedicated fuel storage area, consisting of storage tank(s) located on the west side of the pad. The area can accommodate several 40-foot shipping containers. The area will be protected against an on-pad explosion by a 3.5 m high berm.

Fixed piping will run from the propellant storage location to an interface point located close to the pad. The exact location is TBD.

The de-fueling system is to be implemented together with the launch vehicle providers.

### Gas Supply

Industrial gases can be provided (in Swedish standard bottle sizes and pressures) with mobile solutions near the launch pad area, as needed.

### Water Supply System

No process water supply system is planned in the vicinity of the LC-3A pad area.

### Power, Communications and Data

In proximity to the south fence line there will be a breakout box for power, communication and data, with EU standards for power connections (400V/63A [TBC] and 230V/16A [TBC]) and single mode fiber terminated with SC contacts.

### Lightning Protection

No fixed lightning protection systems will be provided in the vicinity of the LC-3A pad area.

### 2.1.3.2 LC-3B

The LC-3B launch pad is intended to support small-to-medium launch vehicles with potential blast profiles up to 3 metric tons TNT equivalent, and is primarily intended for launch and landing of reusable launch vehicle demonstrators, testing of planetary landers, etc. The pad area will be lit by floodlights to enable outdoor work during all seasons.

This pad will first be used to host the Themis project; thus priority will be to provide the infrastructure required for the Themis missions during their planned launch campaigns in 2022.

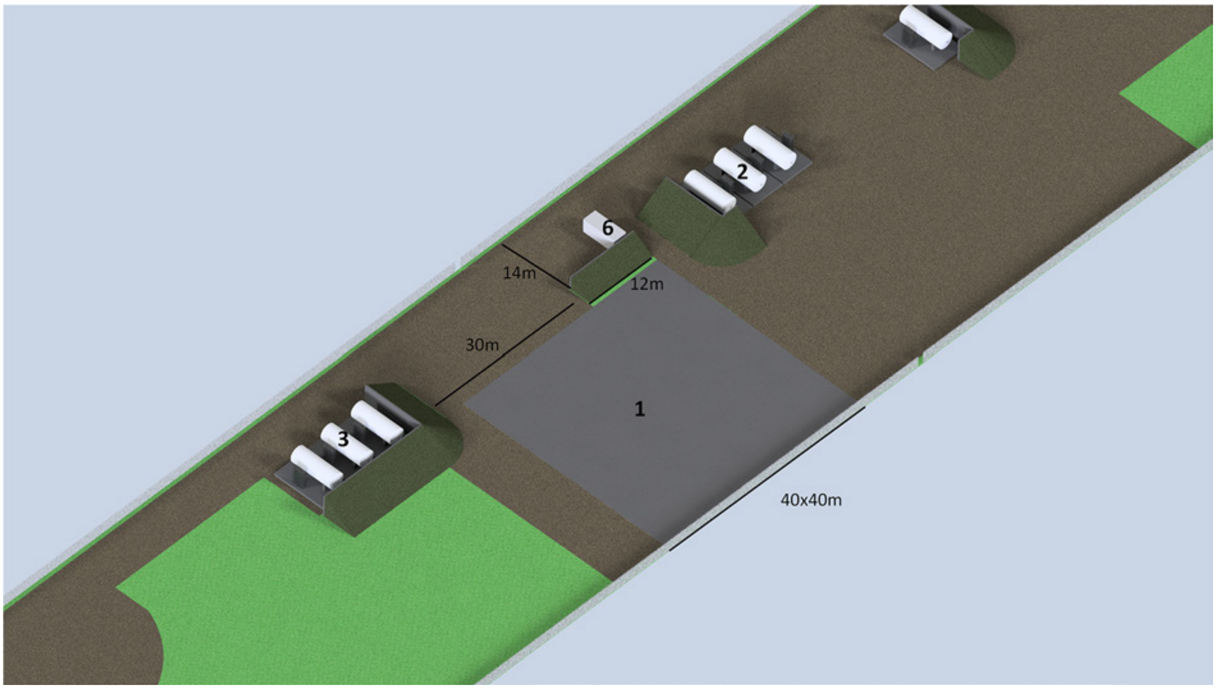


*Fig. 18 - Launch Pad LC-3B area: Launch pad (1), Fuel storage (2), Oxidizer storage (3), storage area for control and power containers (6)*

#### Launch Pad

The LC-3B pad area will consist of a 40 m x 40 m concrete slab. The pad will have a direct roll-out path from the LVIB's north integration bay.

The pad will have an angle of 1% (TBC) from the middle to the north and south edges of the pad, to allow for rainwater drainage.

#### Cryogenic Liquid Propellant Storage

Cryogenic liquid propellant storage for the LC-3B pad will be located in the same area as for the LC-3A pad, as described above.

Cryogenic propellants will be stored in vacuum isolated tanks close to the launch pad. The propellant storage tanks will be protected by soil berms. Vacuum insulated piping will run from the propellant storage location to an interface point by the southwest corner of the pad. From the interface point a LV-specific line (provided by the LV manufacturer) will carry the propellant onward to the launch vehicle.

A system for de-fueling can be implemented in collaboration with the launch vehicle providers.

### Fuel Storage

The fuel storage area will be located on the east side of the LC-3B pad. This will be a shared fuel storage area, for use by both the LC-3B and LC-3C pads. The area will be protected against an on-pad explosion by a 3.5 m high berm. The area can accommodate several tanks, depending of the size and orientation of the chosen tanks.

Fixed piping will be provided from the storage tank(s) to the southeast corner of the LC-3B pad.

The de-fueling system is to be implemented together with the launch vehicle providers.

### Gas Supply

Industrial gases can be provided (in Swedish standard bottle sizes and pressures) with mobile solutions near the launch pad area, as needed.

### Water Supply System

No process water supply system is planned in the vicinity of the LC-3B pad area.

### Power, Communications and Data

In each corner of the LC-3B there will be a breakout box for power, communication and data, with EU standards for power connections (400V/63A [TBC] and 230V/16A [TBC]) and single mode fiber terminated with SC contacts.

Behind a protective wall located south of the LC-3B launch pad area there will be a power access point, from where it will possible to extract up to 300 kW power with a dedicated cable. From this access point there is also possibilities to connect to the LVIB or LCC via either a single mode fiber with SC connections, or CAT-6 cables utilizing SSC's switches. The fixed power and communications outlets at all launch pads are also fed from this access point.

### Lightning Protection

Grounding points for lightning protection will be installed in each corner of the concrete slab. Lightning protection systems that may be installed above ground are TBD.

#### 2.1.3.3 LC-3C

The design of the LC-3C pad area is still in a preliminary stage; the planned system-level solutions might change as specific LV interface requirements become better defined.

The LC-3C launch pad is intended to support medium launch vehicles with potential blast profiles up to 15 metric tons TNT equivalent, which would require a flame deflector and/or water suppression system. This pad may also be able to be used for first stage acceptance testing (TBD). The pad area will be lit by floodlights to enable outdoor work during all seasons.

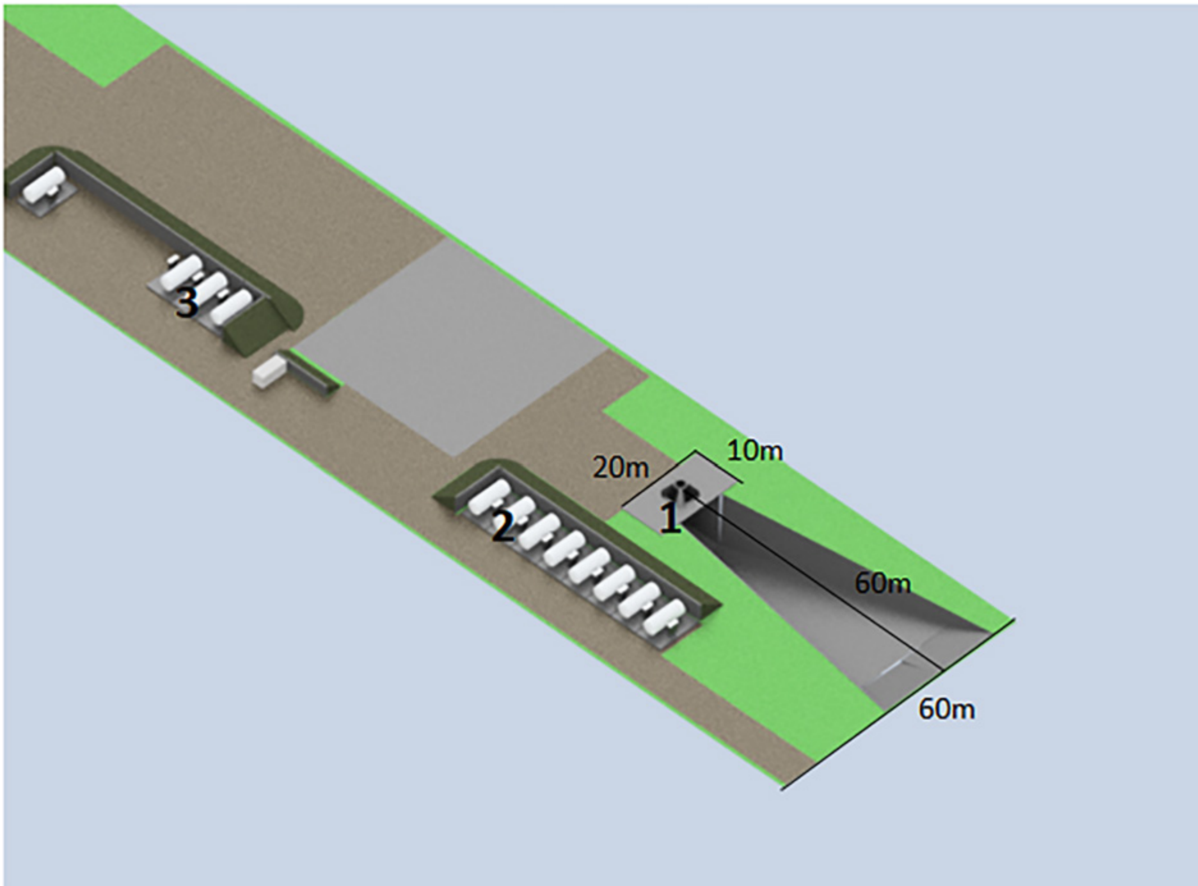


*Fig. 19 - Launch Pad LC-3C area: Launch Pad (1), Oxidizer storage (2), Fuel storage (3)*

**Launch Pad**

The preliminary design of the LC-3C pad area includes a 20 m x 10 m concrete slab on top of an underground flame trench. The pad will have a direct roll-out path from the LVIB's north integration bay.

**Flame Trench and Water Deluge**

The preliminary design of the LC-3C launch pad area includes a flame trench and water deluge infrastructure for noise suppression and cooling, with catchment and recycling of the process water.

Compatibility of the planned systems with a specific launch vehicle will have to be analyzed in the future, as data for the thermal or acoustic environments induced by the launcher will have to be provided to SSC.

**Environmental regulations**

If required by environmental regulations, a water catchment system will be built at the LC-3C launch pad for collecting 'process water' used during launch. To the extent possible, process water will be cleaned on site and reused. Process water that is too contaminated to be reused will be disposed of in cooperation with a local treatment plant.

### Cryogenic Liquid Propellant Storage

The LC-3C pad is planned to have its own dedicated cryogenic liquid propellant storage area (TBD).

Cryogenic propellants will be stored in vacuum isolated tanks close to the launch pad. The propellant storage tanks will be protected by soil berms. Vacuum isolated piping will run from the propellant storage locations to an interface point near the launch pad. From the interface point a LV-specific line (provided by the LV manufacturer) will carry the propellant onward to the launch vehicle.

A system for de-fueling can be implemented in collaboration with the launch vehicle providers.

### Fuel Storage

The fuel storage will be located in the same area as for pad LC-3B (TBC).

### Gas Supply

TBD (pending requirements)

### Water Supply System

TBD (pending requirements)

### Power, Communications and Data

At LC-3C there will be a breakout box for power, communication and data, with EU standards for power connections (400V/63A [TBC] and 230V/16A [TBC]) and single mode fiber terminated with SC contacts.

### Lightning Protection

A fixed lightning protection system will be provided around the LC-3C launch pad. The design of the system is still TBD. Currently, two 45 m high masts (TBD) are considered, but this is highly dependent on the launch vehicles and their characteristics.

### Mobile Gantry (TBD)

A mobile gantry building is considered a possible solution for weather protection, either on wheels or rails. A gantry building would be insulated and heated during winter, and potentially include an overhead crane (TBD) to help erect LVs, if required by the launch vehicle providers' CONOPS.

### 2.1.4 Fire Detection and Extinguishing

Critical infrastructure in vicinity of the launch pad areas will be equipped with fire detection and/or extinguishing capabilities. The type(s) of extinguishing equipment (e.g., manual vs. automatic) which may be employed at individual locations will be based on the results of a fire hazard risk assessment.

Rooms containing critical electronics will also be equipped with fire detection and/or extinguishing capabilities. Again, the type(s) of extinguishing equipment (e.g., manual vs. automatic) which may be employed at individual locations will be based on the results of a fire hazard risk assessment.

### 2.1.5 Temporary Storage

#### Dry Storage

The two separate LV integration bays inside the assembly hall are generously sized, at 45 m (L) x 15 m (W) each, to provide ample space for both LV assembly activities and the temporary storage of associated equipment.

Space has also been reserved near the LVIB, on the north side of LC-3, for up to two additional buildings (tent halls) able to be used for dry storage (image to the right).

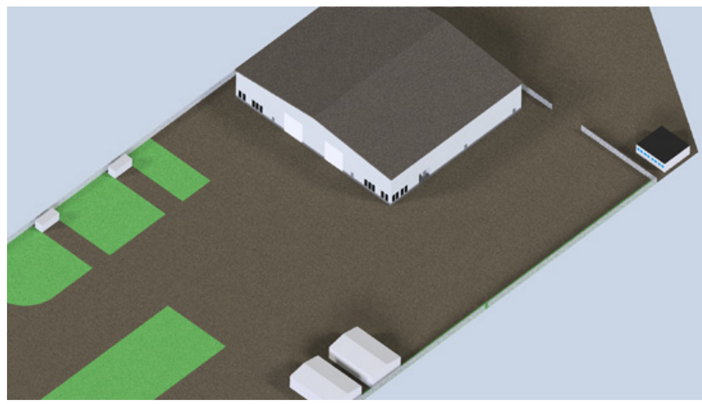

*Fig. 20 - LVIB with dry storage buildings in the bottom of image.*

#### Exposed Storage

There are open areas inside the LC-3 site that can be used for outdoor/exposed storage, if needed.

#### Hazardous Materials Storage

A hazardous materials storage container can be provided on the LC-3 site.

## 2.2 Payload Processing

In the first phase of Esrange spaceport operations, each LV integration bay inside the LVIB will include a separate room, capable of housing an ISO cleanroom tent, for basic payload preparation (including the handling of non-toxic satellite fuels) and LV fairing encapsulation. Additional details regarding the planned design of the satellite processing rooms is provided in paragraph 2.1.2.2.

SSC has already started preliminary planning for a dedicated Payload Processing Facility (PPF) with several separate controlled environments; that could potentially also include hazardous fuel handling.

Additional information related to satellite fueling operations is provided in paragraph 3.2.2.2.

## 2.3 Launch Control Center

There are currently 3 pre-existing Operations Centers (e.g., mission control rooms) at Esrange. A requirements compliance assessment will be performed to determine which of these location(s) can best meet the needs of orbital launches.

If deemed necessary, a new/dedicated Launch Control Center (LCC) for orbital launches will be constructed. Preliminary designs for such a facility have already been developed.

# 3 OPERATIONS

## 3.1 General

SSC's Spaceport Service will include access to the infrastructure needed as well as a range of activities to successfully carry out an orbital launch from Esrange Space Center.

Esrange segregates operational activities from other activities of the launch base. For the current activities related to sounding rocket launch and balloon release campaigns, ESC has different departments (with separate staff) to enable dedicated support of launch campaigns versus infrastructure/maintenance activities.

Work related to spaceport operations will be managed in a similar way.

### 3.1.1 Access to Infrastructure

The infrastructure given access to is:

- Launch Vehicle Integration Building
- Launch Control Center
- Payload Processing Facility (TBD)
- Launch pad
- Mechanical workshop
- Storage facilities
- Office space and IT services

SSC will provide the security required at Launch Complex 3 during and in-between launch campaigns and see to that the facilities are maintained. Prior to a campaign SSC will also prepare the facilities and ensure that they are accessible (clearing of snow, etc.).

### 3.1.2 Launch Campaign Preparations

SSC is responsible for planning and scheduling of resources at Esrange Space Center to be available for a campaign. During launch campaign preparations, resources needed will be allocated to prepare the relevant facilities for a campaign. The logistics function will be of service to support Launch Vehicle Manufacturers / Launch Service Providers with any administrative tasks related to logistics and import/export to facilitate the shipping of launch vehicles and other related equipment.

A Mission Analysis will be conducted covering, among other things, the campaign requirements and its impact on flight and ground safety. SSC will also ensure that the required launch licenses issued by the Swedish government are in place as well as the required licenses for tracking, TM/TC and FTS.

### 3.1.3 Launch Campaign

For each orbital launch campaign SSC will assign an Operations Manager with an overall responsible for the execution of the campaign in accordance with the operations plan. SSC will also offer Launch Team support, meteorological support and make Range Operations personnel available to support the Launch Service Provider (LSP) during each campaign.

SSC is responsible for range clearance prior to a launch. This involves restricting public air, land and sea traffic. This includes Esrange Space Center, the downrange impact areas, NOTAMs (Notice to Airmen), NOTMARs (Notice to Mariners), public radio announcements etc. SSC also has an overall responsibility for the safety of personnel at Esrange Space Center during the campaign.

During the launch campaign SSC is responsible for having an Emergency Response Team available and ready at Esrange Space Center. In case of any incident these would be the first responders and be responsible for alerting the relevant authorities.

SSC will perform launch vehicle tracking and receive flight telemetry data via antennas based at Esrange Space Center and downrange stations (e.g, Svalbard). This also includes initiation of the Flight Termination System in the event of anomalies outside of the required flight safety requirements.

After the campaign SSC will be responsible for hazardous waste disposal.

### 3.1.4 Recurring Activities

There will be several recurring activities at the base.

- For each launch campaign there will be maintenance and upkeep of:
    - » Buildings, roads, power, water and other basic facilities at the base that are applicable to the launch
    - » LC-3 (SSC-owned infrastructure, GSE and systems)
    - » Infrastructure and systems for cryogenic storage, gaseous storage, and water supplies
    - » Cleanroom facilities
    - » LVIB and storage solutions for LC-3 together with its systems
    - » Telemetry, tracking and FTS equipment and systems on the base and downrange

  Optional::
    - » Additional downrange or mobile equipment for each launch
    - » Modifications to GSE for each launch
    - » Changes to the LVIB and/or cleanrooms for each launch
    - » Changes to the Launch Control Center for each launch
- For each launch campaign there will be recurring work of SSC personnel directly involved in preparing for and supporting the campaign. This is very much dependent on the length of the launch campaign, the required preparation together with number of launch attempts.
    - » Campaign project management
    - » Mission analysis
    - » Launch campaign & operations support personnel
    - » Security personnel
    - » Metrological support
    - » Downrange clearance
    - » Telemetry and tracking support
    - » Range Safety (Ground & Flight)
    - » FTS support
    - » Emergency response
    - » Fueling support
    - » Licensing

  Optional:
    - » LEOP support, using SSC's Global Ground Station Network.
- For each launch campaign there will be consumables used, such as:
    - » Propellants: Propane, LOX & satellite propellants
    - » Gases: GHE, GN2 & GOX
    - » Liquids: LN2, Water
    - » Weather balloons
- For each launch campaign there will be additional recurring on-site services, such as:
    - » Hazardous waste disposal
    - » Data recording and distribution
    - » Photo video support
    - » Additional ground-based equipment
    - » Personnel accommodation and/or meals

### 3.1.5 Non-recurring Activities

As part of SSC's SmallSat Express program, significant investments are being made into infrastructure to support orbital launches from Esrange. The investments have funded the initial development of LC-3, including a large integration hall, multiple launch pads for reusability testing and orbital launches, together with the required support systems.

Depending on the eventual requirements of a specific LV, additional work may need to be done to modify or customize certain aspects of the infrastructure at LC-3. The amounts cannot be estimated until the LSP's requirements have been provided.

SSC's strategic goal is to provide the most cost-efficient services possible for space launches, and as such required modifications to the general infrastructure shall be highlighted and part of the technical exchange leading up to a Spaceport Service Agreement.

### 3.1.6 Launch Cadence

There is nothing that formally limits the number of orbital launches that can be performed at Esrange Space Center every year. However, as is the case at all launch sites, the availability of specific launch windows is dependent upon Range scheduling (which in turn necessitates that contractual commitments are made far enough in advance to guarantee the timing of each individual launch campaign).

The preliminary design of the LVIB (as described in paragraph 2.1.2) is intended to provide increased flexibility with respect to schedule de-confliction between successive launches, by allowing more than one launch campaign to occur simultaneously at LC-3.

## 3.2 Ground Operations

Top-level descriptions of spaceport ground operations are provided below. Additional information can be found in Volume II (Safety).

### 3.2.1 LV Operations

#### 3.2.1.1 Transport of Launcher Elements

Delivery of all hardware (including the launch vehicle and associated ground support equipment) to the launch site will be the responsibility of the LSP.

#### 3.2.1.2 LV Assembly

The LVIB layout contains two separate LV integration bays, each 45 m (L) x 15 m (W), that are designed to enable horizontal integration of launch vehicles, and all associated procedures.

Each LV integration bay has been sized to enable two medium launch vehicles to be integrated next to each other (in a single bay), thus enabling parallel assembly activities. Furthermore, if an individual bay does not provide adequate space, the separating wall between the two LV integration bays includes a large roll-up door to allow for the possibility of both bays being used concurrently by the same LSP.

#### 3.2.1.3 Fairing Encapsulation

As described in paragraph 2.1.2.2, the current design of the LVIB includes two separate rooms that can be used for payload processing. Depending on the size of the LV payload fairing and/or the amount of space needed for the payload encapsulation process, integration of the fairing onto the payload adapter could occur either in a satellite processing room or in the larger LV integration bay.

#### 3.2.1.4 LV roll-out / Emplacement

The LVIB includes large (8 m x 8 m) roll-up doors at each end of both LV integration bays, allowing for the possibility of entry through one end and exit through the other end. The roll-up doors on the east side of the LV integration bays are directly aligned with the various launch pads; a large open area will also exist immediately east of the LVIB in order to enable the horizontal transfer of fully integrated launch vehicles from either LV integration bay to any launch pad.

The LSP will be responsible for the physical roll-out of the fully integrated launch vehicle from the LVIB to the launch pad, using a LSP-provided transporter/erector vehicle. However, connection of the transporter/erector to the launch pad and erection of the launch vehicle on the launch stool will need to be a joint effort involving both SSC and LSP personnel.

Determining exactly what the final roll-out & emplacement procedure will look like, and which party will have lead responsibility for different phases, will depend on the eventual interfaces between the transporter/pad and LV/pad.

### 3.2.2 Payload Operations

#### 3.2.2.1 Payload Processing

The LVIB in its baseline configuration is well suited to accommodate and facilitate the activities below:

i. Unpacking, hoisting
ii. Internal displacements
iii. Mechanical and fluid tests
iv. Electrical and RF tests
v. Pyrotechnical test (health checks/ ignition circuit integrity tests)
vi. Satellite fueling
vii. Integration and checks of the payloads with the LV payload adapter
viii. Encapsulation and checks of the payloads under the fairing

Regarding the tests and checks mentioned in points (iii) to (v) and (vii) to (viii), the LSP will be responsible for providing the relevant equipment.

Regarding point (vi), satellite fueling, see below.

#### 3.2.2.2 Satellite Fueling

All payload fueling operations performed at Esrange will need to be compliant with the EU's REACH regulation, wherein the handling of UDMH, MMH and NTO is currently being debated. As of today, propulsion systems for use on satellites are exempt from REACH.

In the first phase of Esrange spaceport operations there will be one payload preparation room per LV integration bay inside the LVIB, with capability to handle non-toxic1 satellite fuels. In later phases, SSC could consider adding a specific hazardous fuel handling facility in a separate/dedicated location, given that there is a sufficiently strong customer need and proven business case.

All fueling processes and procedures must be reviewed and approved by the Esrange Safety Board.

#### 3.2.2.3 Late Access to Payloads

The LSP will be responsible for the payload-to-LV integration and encapsulation within the LV payload fairing, and subsequent mating of the complete fairing to the LV.

Access to payloads encapsulated inside the fairing while the LV is still in a horizontal orientation inside the LVIB should generally not be an issue, but could be limited by the fairing design and/or the presence of any hazardous materials in specific payloads. Although the LV integration bays will be maintained as 'clean' workspaces, they will not provide any ISO-level cleanliness. So, depending on the needs of individual payloads, it may not always be possible to meet all environmental requirements. In such cases it may become necessary to de-mate the LV fairing and move the payload(s) back into the satellite processing room.

Late access (for example, after LV roll-out and before emplacement/erection at the launch pad) to payloads should also be possible, so long as doing so does not pose any personnel safety risks. In the event of late access being necessary when the LV is located outside the LVIB, and unless agreed otherwise in the launch campaign support contract, the LSP will be responsible for ensuring that any required payload environmental conditions are able to be maintained.

### 3.3 Launch Operations

Top-level descriptions of spaceport launch operations are provided below. Additional information can be found in Volume II (Safety).

#### Operational Command and Control

SSC will provide suitable accommodation and power for the range user personnel to operate the relevant equipment, and communication (typically TCP/IP) between the LCC and launch infrastructure located at LC-3.

The LSP will be responsible for providing the relevant equipment (typically computer-based systems hosting dedicated software) needed to communicate with and control the launch vehicle, and associated launch GSE.

### Support Functions

SSC will provide personnel and means to monitor and control the various functions identified below:

- Power systems
- Telecommunication systems
- Supply of consumables (e.g., propellants and gases, water, etc.)
- Ground Safety
- Flight Safety
- Security

Telecommunication infrastructure will primarily consist of TCP/IP communication between ESC facilities.

Items related to safety and security will be monitored and managed in accordance with Swedish regulations.

### 3.3.1 Countdown activities

#### 3.3.1.1 Rehearsals

##### Dry Dress Rehearsal

The LSP can perform a dry dress rehearsal at ESC before each launch. End-to-end verification testing will be accomplished for RF and FTS systems as a part of the pre-launch subsystem and system-level testing.

##### Wet Dress Rehearsal

Wet dress rehearsals are viewed as a beneficial risk reduction activity by the ESC Range Safety office. Upon request, SSC personnel will be available to support LSP's performance of a wet dress rehearsal as part of any individual launch campaign.

#### 3.3.1.2 Launch Attempts

Additional information to be added in the next revision.

### 3.3.2 Launch Pad Access

LSP personnel will be able to access to the launch pad area immediately prior to the start of countdown activities (and/or during the countdown, if authorized by Ground Safety) to perform final preparation of the launch vehicle, including:

- Fluid and electrical interface connections
- Arming of pyro-cords/elements, etc.
- Final inspections of the LV, the verticalized transporter and associated interfaces

### 3.3.3 LV Fueling

The final design of the LC-3 site and associated launch pad/fueling infrastructure will depend on the user requirements. However, the site is being designed to allow all LV propellant loading and unloading operations to be performed remotely – and, due to safety reasons, the site will be evacuated before the start of any fueling activities.

The final fueling procedures will be dependent upon the CONOPS for each individual LV.

### 3.3.4 Propulsive Landing

Esrange Space Center will have the capability to host test flights of reusable launch vehicles from LC-3 beginning in 2022. Pad LC-3B is specifically intended for the launch and landing of vehicles that will perform propulsive landings.

The large impact area (5,200 km$^2$) downrange from LC-3 could also be used as a landing area.

## 3.4 Post-launch Operations

Top-level descriptions of spaceport post-launch operations are provided below. Additional information can be found in Volume II (Safety).

### 3.4.1 Post-launch Access to Launch Site Infrastructure

Additional information to be added in the next revision.

### 3.4.2 Launch Site Refurbishment

The preliminary designs of all the various LC-3 facilities are intended to meet both the anticipated launch campaign functional requirements and also enable necessary post-launch refurbishment activities to be performed in as non-intrusive a manner as possible, from the customers' perspective.

Since the entire business case of a spaceport service provider is directly related to the total number of launches able to be performed each year, completing all necessary post-launch refurbishment and revalidation activities as quickly as possible is clearly in SSC's interest. However, that said, the amount of time that may be needed to perform certain repair/refurbishment activities will depend on the specific physical damages caused by each individual launch – and can therefore not be known with certainty in advance.

### 3.4.3 LV Transporter/Erector Refurbishment

The LSP will continue to have exclusive access to the LV assembly bay for a pre-defined amount of time after each launch and should therefore be able to perform at least some refurbishment of equipment there. However, it will not be possible for the LSP to perform certain types of particularly contaminating maintenance activities (such as extensive engine work or hydraulic system re-builds) inside the LVIB; nor are activities requiring significant amounts of time (to include long-term storage of a transporter/erector) anticipated to be possible there.

In cases where the LVIB is not a viable option, SSC will attempt to identify an alternate location at Esrange based on the requirements identified by the LSP. Use of facilities outside the perimeter of LC-3 and/or for periods of time exceeding an individual launch campaign will result in additional costs to be borne by the LSP.

# 4 LICENSING

## 4.1 Introduction

Sweden has a space law, the "1982:963 Space Activity Act" and an associated decree "1982:1069 Space Activities Decree". Both of these are based on UN's Outer Space Treaty which has been formally adopted by Sweden. The law applies to activities in outer space, including space launches. All space activities to be performed in Sweden by non-governmental entities (including commercial companies) require a permit from the Swedish government. Approved permits will identify the scope of the authorized activity, and any associated limitations. The Swedish government retains the right to withdraw previously approved permits if a licensee deviates from any stipulated obligations.

The Swedish National Space Agency (SNSA) is the responsible government entity for reviewing applications to conduct space activities, for coordinating with other agencies and authorities affected by the applications, as well as presenting the applications to the Swedish government. SNSA also acts as the control agency for organizations granted permits and is obliged to notify the government on any violation of the law.

The Swedish government and the SNSA are aware that there is a need to update the law since space-related activities are no longer conducted only by governmental organizations. A process for updating the law has been initiated, recently the government commissioned a special investigator to review the Space Act and, if necessary, the associated Space Decree. The Swedish space industry, SSC, as well as other entities involved in space activities will be consulted on the issue and provided the opportunity to present their views.

## 4.2 Launch Licensing

### 4.2.1 Swedish Launch License

SSC does not see any obstacles with respect to submitting launch license applications under the current space law and associated decree. Commercial Launch Service Providers will simply need to provide SSC with the information required for the SNSA launch license application. As a baseline, the following information will be required:

- Technical description of the launch vehicle
- Flight safety analysis
- Description of payload (i.e., satellite/s, owner/s, country/countries of origin, mission descriptions, related launch licenses, etc.) if known at the time of admission of the launch license application, otherwise to be provided when known
- Reliability (i.e., that the applicant has the necessary technical expertise and financial conditions to carry out the identified space activity)
- Concept of operations and accountability between the parties involved (i.e., who is responsible for what)
- Description of the liability insurance or other similar means of financial responsibility that are planned (in accordance with the requirements of the UNOOSA Liability Convention), to protect from claims by third parties for death, bodily injury, or property damage or loss
- Compliance with ITU regulations regarding frequency allocations and orbital positions
- Description of environmental assessment and risk mitigation during flight
- Description and mitigation of any resulting space debris

### 4.2.2 Customer home country launch licenses

#### 4.2.2.1 Launch Vehicles

Additional information to be added in the next revision.

#### 4.2.2.2 Satellites

Additional information to be added in the next revision.

## 4.3 Export Control

Additional information to be added in the next revision.

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Photo: Marcus Lindh