



SSC

## Estrange Safety Manual

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## 1 DEFINITIONS

AFS – (Arbetsmiljöverkets författningssamling) Complementary Provisions to Swedish law, mainly to the Swedish *Work Environment Act*, including regulations and general recommendations, which are issued by the *Swedish Work Environment Authority* (Arbetsmiljöverket).

AGC – Automatic Gain Control. Adjustment of ground transmitter to onboard receiver.

ATC – Air Traffic Control

Attitude Controlled Vehicle – A type of guided vehicle whose attitude is controlled.

Balloon Launch Area – The defined area for launching of balloons.

Campaign – The period from arrival to departure of the range user's personnel involved in a launch of rockets, balloons, UAS and other airspace vehicles or test activities.

Campaign Requirements Plan (CRP) – Formal documentation provided by the range user describing e.g. ground and flight systems, operating procedures and other requirements and circumstances necessary for safe and smooth performance of the campaign at Esrange Space Center.

Catastrophic Hazard – A hazard, condition, or event that could result in a mishap causing fatal injury to personnel and/or loss of vehicle, payload, or ground facility.

Category "A" Systems – Those systems which meet all the following: (1) initiation of the system could lead to a chain of events which result in injury or death to personnel or damage to property; (2) sufficient potential energy exists to initiate the device; and (3) the energy output of the system is not controlled by approved mechanical restraints or other safety devices.

Category "A/B" Systems – Those systems which change from Category "B" to Category "A" during the various stages of processing. The change in hazard category is accomplished by utilizing approved out of line SAFE/ARM devices, or mechanical restraining devices, by employing the Man-Rated design requirements, or by other approved means which reduce the effects of an inadvertent actuation to a non-hazardous condition or reduce the probability of occurrence to acceptable levels.

Category "B" Systems – Those systems which (1) are highly improbable of being initiated, or (2) will not cause injury to personnel or damage to property by either the expenditure of their own energy or the chain of events they initiate.

Critical Hazard – A hazard, condition or event that may cause severe injury or occupational illness, or major property damage.

Critical Operations Personnel – Critical Operations Personnel include persons not essential to the specific operation currently being conducted, but who are required to perform safety, security or other critical tasks at the launch landing or test and launch facility. Critical Operations Personnel are notified of the potentially hazardous operation and either trained in mitigation techniques or accompanied by a properly trained escort. Critical Operations Personnel do not include individuals in training for any job or individuals performing routine activities such as administrative, maintenance, or janitorial. Critical Operations





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Personnel may occupy safety clearance zones and hazardous areas and need not to be evacuated with the public. Critical Operations Personnel are included in the same risk category as Mission Essential Personnel.

Cryogenic Safety Board (CSB) – The members of CSB are selected SSC personnel. The CSB shall oversee implementation and maintenance of ESC’s Cryogenic Safety Program.

Danger Area – An area defined by ground and/or flight safety analysis (including impact areas, abort areas, storage areas, or hazard areas) where normal operations or a system malfunction will create impact objects, debris, blast, toxic release, or other hazards and where access must be restricted or otherwise controlled in order to satisfy established risk criteria. See also Section 5.3.2 and the enclosed maps for predefined Danger Areas (APPENDIX 1).

DFO – Distant Focusing Overpressure

Electro Explosive Device (EED) – An electric initiator or other component in which electrical energy is used to cause initiation of explosives contained therein.

Equivalent Level of Safety (ELS) – A determination that a non-compliance with a component performance requirement does not result in a significant increase in risk to people and property and is accepted for use by the affected range.

Estrange Safety and Security Compliance Confirmation (ESSCC) – A document provided by SSC and signed by the range user’s Project Manager to confirm compliance to ESC safety and security regulations of all range user systems and personnel at SSC.

Estrange Safety Board (ESB) – The members of Estrange Safety Board are selected SSC personnel. The board will review the safety and security of all actions planned during a campaign. All requests for waivers will be handled by the Estrange Safety Board.

ESC – Estrange Space Center

ESD – Electrostatic Discharge

Expectation of Casualty (Ec) – The probable number of casualties due to conduct of a mission.

FCO – Flight Control Officer

FCT – Flight Compatibility Test. A test to verify that the flying equipment does not interfere with or limit the operation of other systems.

Flight Hardware – Any hardware that is flown on or is a part of an aircraft, experimental flight vehicle, rocket, lighter-than-air-vehicle or unmanned aerial vehicle. Includes all propellant tanks, pressure vessels, lines and components that constitute airborne equipment on a launch vehicle or payload.

Flight Safety — A philosophy and methodology whereby rocket, balloon, UAS and other airspace vehicle operations can be performed in a reasonable and prudent manner without undue risk to people or property.

Flight Safety System (FSS) – A system used to prevent a launch or aeronautical vehicle and its hazards from reaching any populated areas or other protected area in the event of a vehicle failure.



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Flight Train – The chain of equipment suspended between the gondola and the base of the balloon.

FRR – Flight Readiness Review

FTS – Flight Termination System

Ground Safety – Those safety considerations, procedures, and resultant restrictions associated with hazardous systems during storage, handling, prelaunch, launch abort, launch, and recovery operations, whereby operations can be performed in a reasonable and prudent manner without undue risk to people or property or the environment.

GSE – Ground Support Equipment

Hangfire – A launch attempt where current to the vehicle initiator was delivered by the firing system and the vehicle failed to ignite as planned.

Hazard Area – The operational area within which the risk due to operations exceed the established risk criteria.

HTS – Horizontal Test Stand

ICAO – International Civil Aviation Organization

Impact Area – The area within which one or more objects impacts.

Impact Zones – See enclosed key maps in APPENDIX 2 for Estrange impact zones A, extended A, B and C.

Inertial Navigation System (INS) – System onboard an airspace vehicle capable of influencing the flight course.

Inherently Safe – The predicted trajectory of the vehicle is based solely on the launch and dispersion parameters and on known system errors.

Instantaneous Impact Point (IIP) – The point at which an object would impact if thrust were stopped at a given time.

Launch Abort – Premature and abrupt termination of a launch attempt because of existing or imminent degradation of mission success probability or safety requirements.

Launch Vehicle – Any rocket, rocket system, UAS or balloon that is used to launch a payload, probe, or other experiment.

Marginal Hazard – A hazard, condition or event that may cause minor injury or minor occupational illness to personnel.

Maximum Expected Operating Pressure (MEOP) – The maximum pressure a system should be subjected to during static and dynamic conditions.

Megger Test – A measurement performed on EED's using a megohmmeter to determine the pin-to-case insulation resistance. The test is performed at a known voltage (normally 500 Volts) to verify that the insulation will not break down and permit EED ignition in this mode.



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Microzone – A small area outside ESC fenced area where the operational hazards can extend. When activated by the warning system, the public is not allowed to be inside this area, see APPENDIX 4.

Misfire – A launch attempt in which current was not delivered to the vehicle initiator.

Mission Essential Personnel – Those individuals whose activities contribute directly to the performance of a potentially hazardous operation which is under way, and whose presence is mandatory for completion of the operation.

NOTAM – (Notice to Airmen) An advisory issued to airmen listing restricted or hazardous airspace during certain times.

NOTMAR – (Notice to Mariners) An advisory issued to mariners to inform of important matters affecting navigational safety.

OLRT – Orbital Launch and Rocket Test department

Power Switching – Power transfers where the net energy change exceeds 1.5 Volts or 10 milliamperes.

Probability of Casualty (Pc) – The probability that a single individual becomes a casualty due to the conduct of a mission.

PPE – Personal Protective Equipment

Public – For the purposes of range safety risk management, all people who are not Mission Essential Personnel or Critical Operations Personnel are considered public. Public also include visitors and personnel inside and outside of the launch and test facility.

Radio Silence – Radio transmission forbidden in the specified Danger Area.

Range Commanders Council (RCC) – The RCC is a government organization dedicated to serving the technical and operational needs of U.S. test, training, and operational ranges. The RCC publishes standards and technical reports.

Range Safety – Application of safety policies, principles, and techniques to protect the public, workforce and property from hazards associated with range operations.

Range Safety Office – Independent safety office

Rocket Launch Area – The areas comprising rocket launching pads, blockhouses, and auxiliary support facilities.

R&B – Rockets and Balloons department

SERA – (*Standardized European Rules of the Air*) SERA 923/2012 appendix 2 *unmanned free balloons*. – Regulations issued by the European Aviation Safety Agency (EASA).

Safety Data Sheet (SDS) – Information regarding hazardous material containing e.g., properties, handling and first aid techniques. An SDS is normally provided by the manufacturer/supplier of the material.

SSC – Swedish Space Corporation

SSC official – Ground Safety Officer, Launch Officer, Flight Director, Mission Range Safety Officer, and Security Officer.



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System Initiator – Any device that initiates the action of a system. This includes but is not limited to electro explosive devices, non-explosive initiators, and exploding bridgewire initiators.

TNT Equivalency – The explosive energy per unit mass of the energetic material in question divided by the energy per unit mass of TNT; this number is usually expressed as a percentage.

UAS – Unmanned Aerial System

VTS – Vertical Test Stand



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## **2 INTRODUCTION**

### **2.1 Foreword**

Safety is the responsibility of all SSC personnel, all contractors, experimenters, and range users while conducting operations at Esrange Space Center or other off-range locations where Esrange Space Center has the operational responsibility.

It is the responsibility of all personnel to acquaint themselves with the requirements set forth in this document.

This requires a concerted effort by all personnel to operate in a manner that will minimize the risks inherent in performing rocket, balloon, test, UAS and other operations.

Safety considerations early in the planning stages of a program or project will reduce the possibility of costly engineering changes and/or scheduling delays. Therefore, coordination with Esrange Safety personnel should be established through the SSC Project Manager as early in the planning stages of the project as possible.

Esrange Safety personnel should be notified of and be represented at technical interchange meetings, preliminary design and system design reviews and flight readiness reviews where Ground and Flight Safety issues are addressed.

### **2.2 SSC Safety Policy**

SSC policy is to conduct all operations in accordance with EU regulation and Swedish law, ordinances and provisions and within the risk levels specified in this document.

This manual defines the specific requirements which shall be met to implement this policy.

More stringent safety requirements will be considered by SSC if requested by the range users or experimenters.

### **2.3 Applicable Legislation**

EU regulation, Swedish law, and Swedish safety and security regulations apply to all activities at Esrange Space Center (ESC).

The Work Environment Act is the basic general act of law which defines the framework for provisions concerning occupational safety and health in Sweden. The Work Environment Authority is the administrative authority for questions relating to the working environment. It has issued a Work Environment Ordinance which contains certain supplementary rules to the Act.

Provisions based on the Work Environment Act and other applicable laws addressing occupational safety and health contain more detailed stipulations and obligations in different fields, for example explosives, inflammable materials, toxic materials, electrical facilities, crane and lifting operations etc.

All implemented regulations and procedures and all operations at ESC must comply with Swedish legislation.



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## 2.4 Purpose and Scope

The Estrange Safety Manual (ESM) is applicable for campaign related activities at ESC or in support of SSC programs where ESC has operational responsibility.

The purpose of ESM is to identify requirements and implement safety policies and criteria for Ground Safety and Flight Safety during test activities and when launching or testing unmanned air vehicles (UAS), stratospheric balloons and rockets.

It also defines specific design requirements, restrictions, operational procedures, and support requirements.

It identifies data requirements necessary for SSC to perform appropriate safety analysis and grant approval to conduct operations.

## 2.5 Tailoring

The requirements specified in this document have been written to cover all types of range operations. SSC recognizes that not all requirements are applicable to every operation, and therefore the requirements in this document can be tailored to match the actual requirements of the particular project or campaign. Tailoring of requirements shall be undertaken in agreement with SSC and the range user. The overall intent is to ensure proper interpretation and implementation of the requirements in this document.

## 2.6 Acknowledgement

The first edition of this Estrange Safety Manual in 1995 was prepared with the Range Safety Manual for Goddard Space Flight Center (GSFC)/Wallops Flight Facility (WFF) as model and with considerable support from WFF personnel.



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### 3 RANGE SAFETY ORGANIZATION AND RESPONSIBILITIES

#### 3.1 General

The **President and CEO of SSC** is overall responsible for safety in the company. He/she is responsible for approving overall safety and security policies in the company.

The **Head of Esrange Space Center** is responsible for the range safety policies and criteria. He/she is responsible for approving the ESM.

The **Rockets and Balloons Department Manager** is responsible for conducting operations in accordance with the ESM and other complementary safety policies and regulations.

The **Orbital Launch and Rocket Test Department Manager** is responsible for conducting operations in accordance with the ESM and other complementary safety policies and regulations.

The **Safety and Operations Team Manager** has overall responsibility for delivering safety analysis and safety plans or data packages for tests and launches conducted by the OLRT department.

The **Safety and Launch Team Manager** has overall responsibility for delivering safety analysis and safety plans or data packages for all balloon, rocket and test missions conducted by Rockets and Balloons Department. He/she is also responsible for preparing Ground Safety Plans (GSP), Flight Safety Plan (FSP), Recovery Plans and Rocket Introduction Documents to Swedish authorities. The Safety and Launch Team Manager is responsible for the Ground Safety in the test areas and for the launching areas for rockets and balloons.

The **Security Manager** is responsible for the overall planning of security matters at Esrange Space Center, including supervision of the fulfilment of security regulations in the ESM and in other complementary safety and security policies and regulations.

The **Range Safety Officer (RSO)** is the overall supervisor of safety matters for launch and test operations at ESC or other off-range locations. The RSO supervises the fulfilment of safety regulations in the ESM and in other complementary safety policies and regulations. The RSO provides safety guidance and direction to the Safety organization and program/projects. The RSO approves Risk Analyses and Safety Plans.

The **Flight Safety Engineer (FSE)** conducts pre-mission flight safety analysis and prepares flight safety plan according to the overall pre-mission flight safety process. The RSO reviews and approves the flight safety plan. The flight safety engineer supports the Project/Mission Manager in any flight safety questions. The Flight Safety Engineer presents the flight safety plan to the ESB.





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The **Ground Safety Engineer (GSE)** conducts pre-mission ground safety analysis and prepares a ground safety plan according to the overall pre-mission ground safety process. The RSO reviews and approves the ground safety plan. The Ground Safety Engineer supports the Project/Mission Manager in any ground safety questions. The Ground Safety Engineer presents the ground safety plan to the ESB.

The **Flight Termination System (FTS) Engineer** oversees the design, development, testing and implementation of the onboard flight safety system components for a mission requiring the use of a commanded FTS or AFTS, and reports to the RSO/MRSO. The FTS engineer participates in RCC 319 requirements tailoring and recommends approval to the RSO. The FTS engineer evaluates any FTS related Equivalent Level of Safety and waiver requests, prepares Esrange Safety Office dispositions, and recommends approval to the ESB. The FTS engineer also participates in FTS component and system level testing as a behalf of the Esrange Safety Office, supports the range users for preparing the FTS report, and recommends approval to the ESB.

The **Superintendent for Explosives** is responsible for all handling of explosives at ESC or other off-range locations where SSC has range safety responsibility.

The **Superintendent for Flammables** is responsible for handling the permits to store flammable liquids at ESC.

The **Superintendent of Laser** is responsible for handling the permits to use laser equipment at ESC.

The **SSC Project Manager** is responsible for all contacts with range users and contractors when planning, building up and conducting rocket, balloon and test missions at ESC or other off-range locations.

The **SSC Mission Manager** coordinates with the range user, launch service providers, satellite providers and the Esrange Safety Office to provide mission specific data for the range safety process. SSC Mission Manager is responsible for submission of any request of waivers from range safety requirements and may represent the range user during waiver discussions.

The **Operations Coordinator** is responsible for all contacts with range users and contractors when planning, organizing, building up and conducting rocket engine tests at ESC. The Operations Coordinator is also responsible for the safety communication and coordinating the static test activities with other SSC departments.

The **Site Owner** is responsible for making sure that the static test site fulfils the safety requirements stated in the ESM and for facilitating and maintaining approved safety devices and safety risk controls at the site.

The **Site Safety Manager** is responsible for the operational safety assurance and safety promotion at the static test site, including supervision of the fulfilment of safety regulations in the ESM and in other complementary safety policies and regulations. The Site Safety Manager is also responsible for managing and implementing the safety management system, communicating with the authorities, organizing and conducting of safety training, and conducting static test site incident investigations.





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The **Local Security Officer (LSO)** is responsible for the overall planning of security matters at the static test site, including supervision of the fulfilment of security regulations in the ESM and in other complementary safety and security policies and regulations.

The **Cryogenic Safety Board (CSB)** is responsible to the ESB and its purpose is to oversee implementation and maintenance of ESC's Cryogenic Safety Program, see more details in 5.3.11.

The **Range Safety Office** is responsible for providing range safety expertise to the programs/projects and oversee the implementation of ESC range safety process.

### **3.2 Estrange Safety Board**

The Estrange Safety Board is the approval body for performing campaign or campaign related work.

For all campaign related potentially hazardous operations, a safety data package shall be made and presented to the Estrange Safety Board.

It is recommended that the Project Manager activate the Estrange Safety Board well in advance, since external experts may have to be consulted.

The “senior” roles are selected by the line managers.

The Estrange Safety Board consists at least of the following permanent members:

1. Head of Estrange Space Center (chairperson)
2. Rockets and Balloons Department Manager (alternative chairperson)
3. Orbital Launch and Rocket Test Department Manager (alternative chairperson)
4. Safety and Launch Team Manager for R&B
5. Safety and Operations Team Manager for OLRT
6. Security Manager
7. Range Safety Officers
8. Ground Safety Engineer (senior)
9. Flight Safety Engineer (senior)

To form a quorum, at least four of the permanent members must be present.

Waivers may be granted by Estrange Safety Board provided that, by SSC, acceptable risk levels can be maintained.



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### 3.3 Operational Safety Organization

#### 3.3.1 Operational Safety Roles

The following roles that will come into force during operations are:

The **Flight Director** (FD) is responsible for executing the launch countdown and giving the final GO for a launch. The Flight Director coordinates clearance for hazardous operations (RF Silence) and provides approval to radiate UHF command frequencies.

The **Test Director** (TD) is responsible for executing the test countdown and giving the final GO for a test.

The **Mission Range Safety Officer** (MRSO) leads the operational implementation of the range safety process for a specific mission. The MRSO is the lead of the operational safety personnel during mission specific training, rehearsals, and mission execution. The MRSO is also responsible of verifying of the readiness of the operational safety elements of FSS. The MRSO approves real-time operational deviations from ground and flight safety plans and provides final Range Safety “GO” to the Flight Director. The MRSO appoints the campaign rescue team for the launch. The MRSO coordinates the issuance of NOTAMs and NOTMARs, the activation of Estrange impact areas, and requests collision avoidance assessments.

The **Flight Control Officer** (FCO) verifies the readiness of the FTS during the operation and makes real-time flight termination decisions based on established criteria outlined in Flight Safety Plan. The FCO coordinates with the System Safety Officer to develop specific prelaunch checkout procedures needed to validate the critical elements of the FSS and informs the MRSO of any violations or other concerns. The FCO monitors and interprets flight safety displays to detect errant vehicles and, if deemed necessary, initiates flight termination based on flight safety plan termination criteria.

The **System Safety Officer** (SSO) supports FCO and MRSO in monitoring and interpreting range safety displays to determine the health of on-board and ground-based elements of the FTS. The System Safety Officer coordinates with the FCO to develop specific prelaunch checkout procedures needed to validate elements of the FTS and informs the MRSO of any violations or other concerns. The System Safety Officer assists the FCO to direct range command assets to ensure command control over the vehicle throughout flight.

The **FTS Command Officer** is responsible for the ground-based systems and system functions for possible flight termination during a launch.

The **Wind Weighter** performs a wind weighting analysis as part of the launch countdown process. It is used to predict the wind effect on impact point displacement during the thrusting and ballistic phases of flight.

The **Launch Officer** (LO) is responsible for Ground Safety in the launch or test areas during operations. The LO is leading the work around aa suborbital rocket or a balloon during a countdown.

The **Ground Safety Officer** (GSO) is responsible for the operational safety risk management, including the risk identification, assessment, control, and mitigation



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activities. The GSO oversees that all operational activities fulfil the safety requirements stated in the ESM. The GSO is also responsible for approval and supervision hazardous operations and conducting safety trainings.

The **Launch Pad Manager (LPM)** provides oversight and coordination of all operations occurring on a launch pad, enforces hazard areas, and communicates status to and from the launch pad during all operations. The launch pad manager ensures that the appropriate people and equipment are present at the launch pad.

The **Electronic Supervisor (ES)** is responsible to test and verify the functionality of the balloon service system and the overall co-ordination of electronic system activities prior to balloon launch.

The **Pilot** is responsible to control the balloon during flight as required in a safe and controlled way.

The **Recovery Officer (RO)** is responsible for the overall co-ordination of the recovery activities and issuing the Recovery Plan.

The **Surveillance Officer (SO)** operates the range surveillance system and monitors the regions of land, sea, and air potentially exposed to hazardous debris. The surveillance officer reports any safety risks to the MRSO.

The **Esrange Rescue Team** is responsible for organizing and conducting rescue and first aid activities at ESC.

### 3.3.2 Suborbital Rocket Missions

The operational safety organization for suborbital rocket missions is presented in Figure 1.

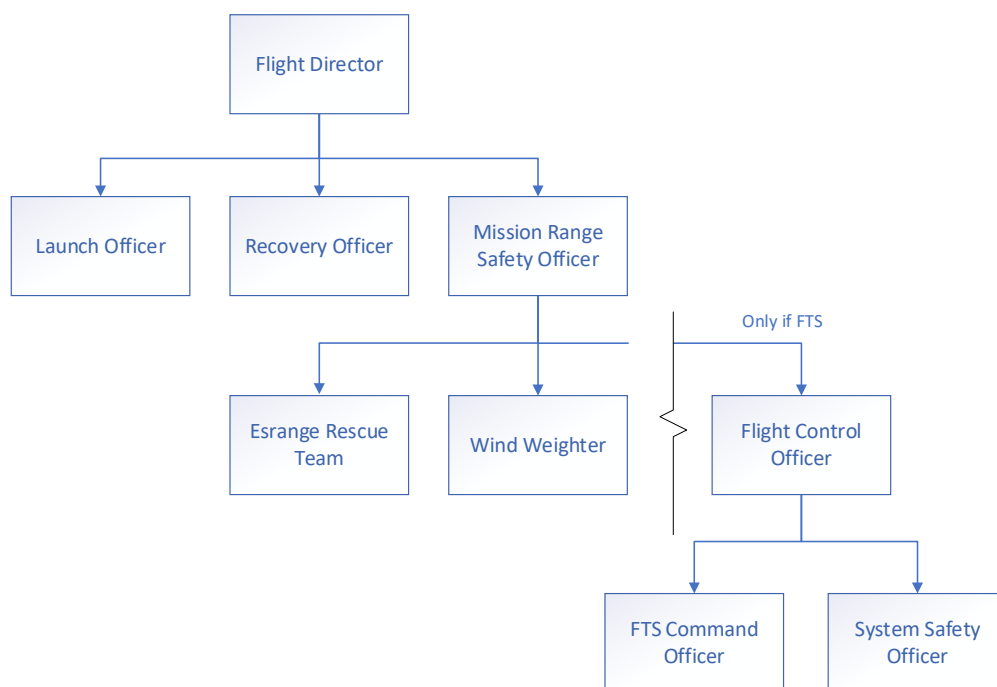


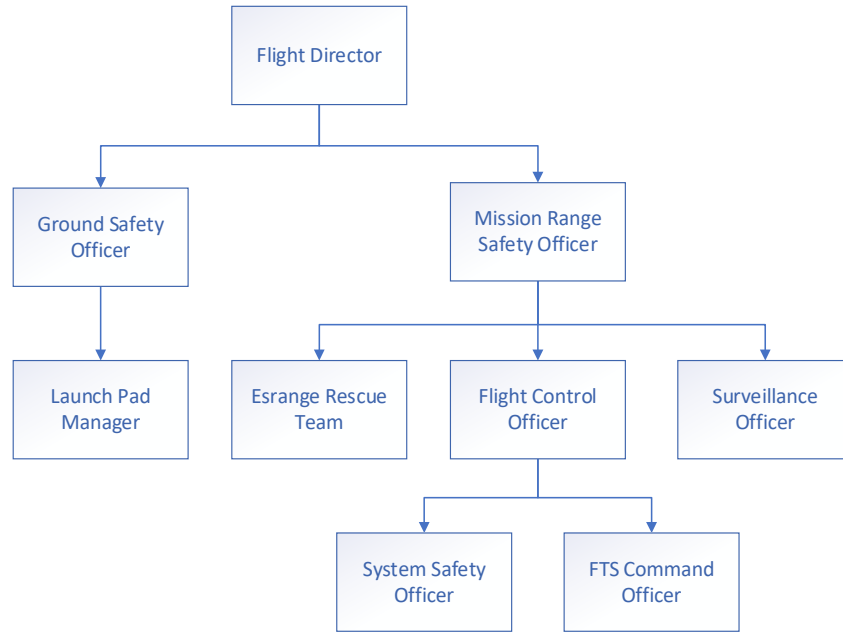
Figure 1. Operational safety organization for suborbital rocket missions.



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**3.3.3 Orbital Rocket Missions**

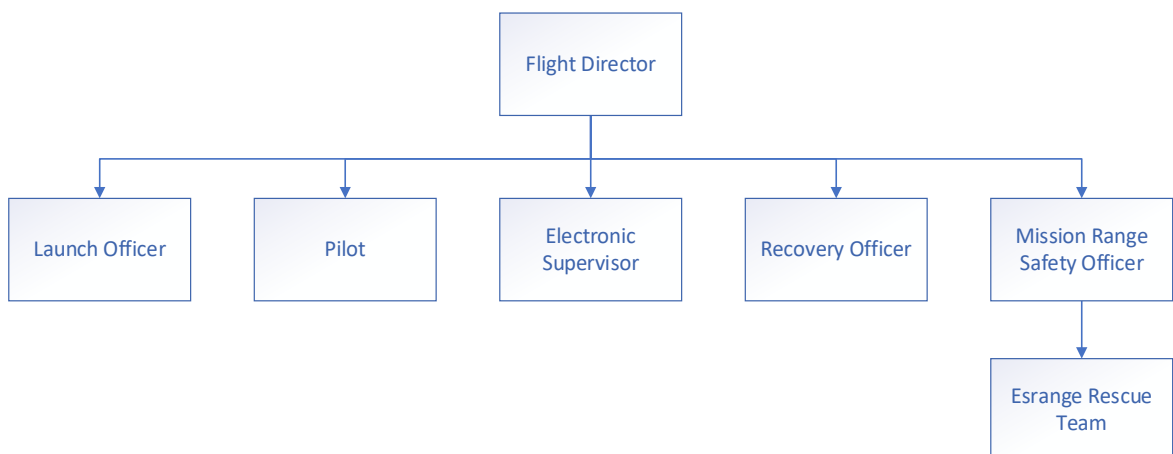
The operational safety organization for orbital rocket missions is presented in Figure 2.



*Figure 2. Operational safety organization for orbital rocket missions.*

**3.3.4 Balloon Missions**

The operational safety organization for balloon missions is presented in Figure 3.



*Figure 3. Operational safety organization for balloon missions.*



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**3.3.5 Static Tests (VTS-1 & VTS-2)**

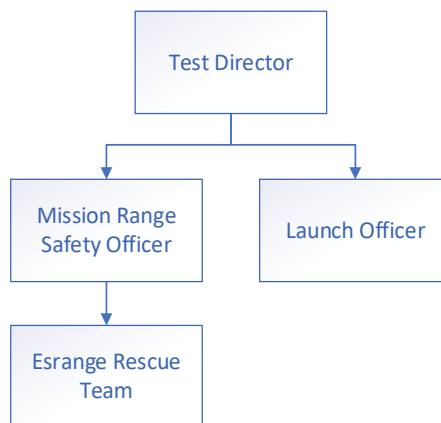
The operational safety organization for VTS-1 and VTS-2 rocket engine static tests is presented in Figure 4.



*Figure 4. Operational safety organization for vertical static tests.*

**3.3.6 Static Tests (HTS-1 at Launch Complex 1)**

The operational safety organization for HTS-1 rocket engine static tests is presented in Figure 5.



*Figure 5. Operational safety organization for horizontal static tests.*



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**3.3.7 Local Incident Management Team**

For operations a Local Incident Management Team (LIMT) will be created. The team constitutes of representatives from SSC and the range user.

Information about the current LIMT will be communicated in connection to the operational phase.

**3.3.8 Fire Fighting and Rescue Work**

In case of an emergency call 112.

The philosophy of the rescue work is based on a first effort from the SSC personnel while awaiting professional rescue service to arrive.

The main task is to save lives by giving first aid to injured people.

The secondary task is to extinguish or keep small fires within bounds.

ESC is equipped with a fire alarm system consisting of smoke and heat detectors. Alarm can also be released manually or by calling the ESC guard. ESC has first aid and initial firefighting equipment on various marked locations.

ESC has a 24/7 guard on duty. The guard can be reached on the internal number 2333 or external +46 980 72333.



## **4 ESRANGE SPACE CENTER PRE-ARRIVAL REQUIREMENTS ON RANGE USERS**

### **4.1 General**

Range users must design their systems to conform to the requirements established by this document.

### **4.2 Reviews**

Range users must notify and invite SSC personnel to project/campaign meetings where safety issues are addressed.

### **4.3 Documentation**

Before a campaign, range users must prepare and provide to SSC formal documentation for safety review. This documentation must include information describing ground and flight systems, operating procedures and unique requirements of the project. Details of the data required and schedule for deliverables are specified in Section 8.

### **4.4 Waivers**

Prior to arrival at ESC, or other off-range locations where SSC has the operational responsibility, range users must submit written requests for waivers to the SSC Project Manager for any requirement of the tailored set of requirements agreed by ESC and the range user that cannot be satisfied. Estrange Safety Board will review the request for the waiver and decide if it will be granted or declined.



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## **5 GROUND SAFETY**

Ground operations at ESC shall comply with the requirements stated in this chapter. Operations that affect the safety for public e.g., outside ESC fenced area and aviation need to also be handled in accordance to chapter 6 FLIGHT SAFETY.

### **5.1 Policies**

The Ground Safety policy at Esrangle Space Center is to conduct operations with a minimum of risk to all personnel involved.

It is required that all systems are designed in such a way that a minimum of two independent failures must occur in order to expose personnel to a hazard.

### **5.2 Hazard Control**

#### **5.2.1 Hazard Control Methods**

The methods employed by SSC to protect personnel and property, and to minimize the risk in conducting potentially hazardous operations are:

1. Identify all the known hazards associated with the project.
2. Minimize exposure of personnel to hazardous systems.
3. Risk assessment.
4. Risk evaluation and criteria comparison.
5. Plan for contingencies.
6. Establish safe operating procedures.
7. Approval of operating procedures.
8. Scheduling of hazardous operations.

#### **5.2.2 Exposure Limits**

The main principle to be observed in any location or operation involving explosives, severe fire hazards, high pressure systems, or other hazardous materials, is to limit the exposure to a minimum number of personnel, to a minimum time, and to a minimum number of potential hazards, consistent with safe operations. Operations must be arranged so that, should an incident occur, it will cause the least possible injury to personnel and damage to facilities or surrounding property. Operations must be conducted in a manner such that the distance a person is from a hazardous system increases, as the possibility of actuating the system increases.

#### **5.2.3 Personnel Limits**

During potentially hazardous operations only Mission Essential personnel are permitted on launch pads, in explosives handling areas or other hazardous areas, supervised and/or authorized by GSO.





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The GSO or other SSC official in charge of the operation, must assure that the number of personnel performing potentially hazardous tasks is kept to a minimum. He/she must also determine the number of personnel necessary to perform each task.

For off-range operations, SSC employees (SSC and/or SSC contractors) shall abide by the requirements of the launch range conducting the operation(s) if that range has requirements or limits more stringent than SSC.

### **5.2.3.1 Rules and requirements for visitors**

Rules and requirements regarding official visitors or guests, tours, etc. are as follows:

1. All visits to danger areas during operations must be approved by the GSO.
2. Early notification of an impending visit or tour must be given to the SSC official in charge of the operation prior to the individual or group arrival. Potentially hazardous operations or tasks must be brought to a safe stopping place and all work on hazardous systems will cease while the tour is in progress.
3. If the hazardous system cannot be placed to a safe stopping place (e.g., pad arming has already occurred), and it has been determined by the Department Manager that the visit is necessary, the Flight Director or SSC Project Manager is to determine the most convenient time and duration for the visit.
4. Tour groups will be accompanied by the GSO or a person approved by GSO. If the group size is too large to be reasonably managed by the person of authority, the tour group shall be split up into two (2) or more groups. The person of authority shall provide a safety briefing to the tour group prior to entering the hazardous area.
5. Members of the tour group shall not be permitted to touch or handle any ordnance or other hazardous hardware. No RF emitting devices (e.g., cell phones, laptops, handheld two-way radios, etc.) shall be allowed without GSO approval.
6. All area-specific safety requirements must be enforced (e.g., safety glasses, hard hats, grounding, clothing, etc.). The GSO or a person approved by GSO is to determine the necessity of wearing static dissipative garments when in the vicinity of explosives or other static sensitive materials.

## **5.2.4 Multiple Operations**

### **5.2.4.1 Single Danger Area**

Multiple unrelated operations must not be conducted simultaneously within a single Danger Area unless the operations are reviewed and specifically approved by the Estrange Safety Board through a waiver process. If such approval is granted, the operations must not exceed personnel limits as established in Section 5.2.3.

### **5.2.4.2 Multiple Danger Areas**

SSC requires that if unrelated tasks need to be conducted simultaneously with Multiple Danger Areas on hazardous systems a Coordination Plan must be developed and granted by ESB.



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## **5.3 Specific Policies and Criteria**

### **5.3.1 Hazard Categorization**

Hazard categories are established to differentiate between hazardous and non-hazardous systems. All systems, including electrical, chemical, pressure etc., are analysed and categorized as either Category "A", Category "B", or Category "A/B".

All hazardous systems are to be considered Category "A" until Category "B" conditions have been determined and approved.

The GSO is responsible for the categorization.

#### **5.3.1.1 Category "A" systems**

Category "A" systems are those systems which meet all the following criteria:

1. Initiation of the system could lead to a chain of events which result in injury or death to personnel or damage to property.
2. Sufficient potential energy exists to initiate the device.
3. The energy output of the system is not controlled by approved mechanical restraints or other safety devices.

#### **5.3.1.2 Category "B" systems**

Category "B" systems are those systems which are highly improbable of being initiated or will not cause injury to personnel or damage to property by either the expenditure of their own energy or the chain of events they initiate.

#### **5.3.1.3 Category "A/B" systems**

Category "A/B" systems are those systems which change from Category "B" to Category "A" during the various stages of processing. The change in state shall be done by following procedures approved by the Superintendent of Explosives or GSO.

Category "A" systems can be categorized Category "A/B" when any of the following conditions exist:

1. Approved restraining devices are employed to reduce the effects of an inadvertent actuation to a non-hazardous condition.
2. The hazardous system is installed, but not connected to its controlling electrical circuit. Hazardous ordnance systems must also have their EEDs shorted, grounded, and shielded.
3. Ordnance systems employ an approved mechanical or electro-mechanical SAFE/ARM device which provides mechanical isolation in the SAFE position.
4. For hazardous chemical systems, the system is closed, contains two independent verifiable inhibits in the flow path, and leak integrity is verified.
5. For pressure systems, the pressure is steady-state and less than or equal to 0.25 times the Design Burst Pressure.



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### **5.3.2 Danger Areas**

For all hazardous systems, a Danger Area must be defined which will adequately contain the hazard and protect personnel, should an inadvertent actuation occur. Restrictions must be established to prohibit access into the Danger Area when the possibility of initiating the hazardous system exists.

The Range Safety Office is responsible for proclaiming Danger Areas and issue maps indicating current Danger Areas. All entrance doors and barricades to Danger Areas will be marked with signs.

Access to Danger Areas must always be authorized by the responsible SSC official.

#### **5.3.2.1 ESC pre-defined Danger Areas**

ESC has 13 pre-defined Danger Areas. The sizes and location of the different danger areas are given in enclosed maps in APPENDIX 1.

Danger Area 1: Rocket Launch Area

Danger Area 2: Centaure Assembly Hall

Danger Area 3: Skylark Assembly Hall

Danger Area 4: Launch Complex 1

Danger Area 5: Storage Area

Danger Area 6: Balloon Launch Area

Danger Area 7: VTS-1

Danger Area 8: VTS-2

Danger Area 9: Launch Complex 3

Danger Area 10: Asgard Clean Room

Danger Area 11: Asgard Integration Hall

Danger Area 12: Midgard Integration Hall

Danger Area 13: Midgard Clean Room

#### **5.3.2.2 Mission specific Danger Areas**

Mission specific Danger Areas for explosives, chemical, biological, pressure, radiation or other hazardous subsystems can be defined on a case-by-case basis.

Parts of pre-defined Danger Areas can be proclaimed as Danger Areas if required.

#### **5.3.2.3 RF restrictions**

The use of mobile telephones and RF-equipment inside Danger Areas 2 through 5 is prohibited whenever those areas are activated. The GSO may grant exemptions from this rule.



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### 5.3.3 Operations/Design Considerations

This document allows range users to utilize various acceptable design techniques defined in Section 5.3.4. Pre-launch operational requirements should be a factor in selecting a specific design. Operations which require personnel to be located inside Danger Areas during switching, power ON/OFF, and RF transmissions can only be performed if the operation is approved by the GSO and the system is verified by the GSO to be in a Category "B" condition.

#### 5.3.3.1 Category "A" systems

Category "A" systems may be converted to a Category "B" state by implementing any of the requirements cited in Section 5.3.1.3 (e.g. out of line safe/arm device).

1. All Danger Areas containing Category "A" systems must be cleared of personnel for operations that require switching, Payload power ON/OFF, or RF transmissions, except as identified, steady state current, in item 4 below.
2. No personnel are allowed within the Danger Area containing Category "A" system if the system has been reduced to only one inhibit.
3. Personnel may be allowed in the Danger Area of Category "A" system whenever there is no switching, power ON/OFF, or RF transmissions occurring, and two independent inhibits are verified on the spot.
4. Personnel may be allowed in Danger Areas to perform work external to the vehicle when power is supplied to a Category "A" system and no switching occurs. This operation must be specifically approved by the GSO.

#### 5.3.3.2 Category "B" systems

Prior to making an electrical change on a non-hazardous (Category "B") system all personnel in the vicinity must be notified of the impending event.

#### 5.3.3.3 Ground Support Equipment

Prior to switching Ground Support Equipment, e.g. vacuum systems, heaters etc., ON for the first time, the applicable Danger Area will be cleared of all personnel regardless of the system status.

### 5.3.4 Hazardous Circuit Design Requirements

All circuits which initiate ordnance devices or initiate other hazardous systems shall be approved by the RSO.

#### 5.3.4.1 Category "A" Systems

All circuits initiating Category "A" devices or systems must satisfy these circuit design criteria:

All Electro-explosive Devices (EEDs) must meet a 1 A/1 W/5-minute NO FIRE requirement

1. Be 100% qualified with a 500 VDC megohmmeter test for 5 seconds from bridgewire to case, and bridgewire to bridgewire if dual bridgewires are used.



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2. Electrical wiring and power source must be completely independent and isolated from all other systems; they must not share common cables, terminals, power sources, tie points, or connectors with any other system.
3. The system initiator shall be electrically isolated by switches in both the power and return legs.
4. All circuit wiring must be twisted and shielded and independent of all other systems. When it is not physically possible to maintain the shield throughout the entire electrical circuit, as a minimum the wiring must be twisted and shielded from the system initiator to the point of the first short circuit condition. This requirement is applicable both before and after installation of SAFE/ARM type connectors. The use of single wire firing lines, with the shield as the return, is prohibited.
5. Shielding must provide a minimum of 20 dB safety margin below the minimum rated function current of the system initiator (max NO-FIRE current for EEDs). Currents exceeding 10% of max NO-FIRE current for EEDs or 10 mA are not allowed.
6. Shielding must provide a minimum of 85% optical coverage. (A solid shield rather than a mesh would provide 100% optical coverage).
7. Shielding must be continuous and terminated to the shell of connectors and/or components. The shield must be electrically joined to the shell of the connector/component around the full 360 degrees of the shield. The shield must only be grounded in one end of the wiring. The shell of connectors/components must provide attenuation at least equal to that of the shield.
8. The electrical circuit to which the system EED is connected must be isolated from vehicle ground by no less than 10 k ohms.
9. All circuits must be designed with a minimum of two independent safety devices. Any time personnel are exposed to a hazardous system, a minimum of two independent safety devices are required to be in place.
10. The system EED must be provided with an electrical short till its programmed actuation. This requirement does not negate the use of solid-state switches.
11. Any electrical relay or switch, which is electrically adjacent to the system initiator either in the power or return leg of the electrical circuit, must not have voltage applied to the switching coil, or the enable/disable circuit for solid state relays/switches, until the programmed initiation event.

Charged ("Hot") batteries may be installed into Category "A" circuits only if at least one of the following design approaches is utilized. Otherwise, the battery must be charged when no personnel are present in the defined Danger Area.

1. The system is designed with a mechanical or electromechanical SAFE/ARM device which must adequately contain the output of the system or its initiator when in the SAFE position.
2. The system is designed to meet Capacitive Discharge Ignition (CDI) circuit criteria as defined in Section 5.3.4.4.



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Category "A" circuits must be designed in such a way that the following operations can be accomplished:

1. Mechanical installation and electrical connection of the system initiators can be performed at the latest possible time in the assembly process, consistent with other assembly operations.
2. Prior to connecting an EED to its electrical circuit, it must be shorted, shielded, and grounded. Connect EEDs to chassis ground and the chassis to a single-point earth ground.
3. Prior to connecting system initiators to their electrical circuit, voltage checks must be made between each leg of the circuit and from each leg to ground to ensure that no voltage is present (zero-volt measurement).
4. After each zero-volt measurement, instrument and leads have to be able to be verified.

### **5.3.4.2 Category "B" Systems**

Category "B" systems must contain a minimum of two independent safety devices which prevent an inadvertent actuation.

### **5.3.4.3 Category "A/B" Systems**

Category "A/B" System Requirements are:

1. The electrical circuit must contain a minimum of two independent open contacts between the power source and the system initiator.
2. The system must be designed in such a way that the conversion from Category "B" to Category "A" will minimize personnel exposure to the hazard. The final conversion to Category "A" will occur during arming operations.
3. Mechanical restraint designs must be approved by the GSO.

### **5.3.4.4 Capacitive Discharge Ignition Systems**

CDI circuit must meet the requirements for standard Category "A" devices, see Section 5.3.4.1, and the following additional requirements.

1. The charging battery must be current limited in such a way that it does not exceed 10% of the minimum rated function current of the system initiator (max NO-FIRE current for EEDs).
2. The firing capacitor must be provided with an electrical short (when the circuit is in the SAFE condition) and a means of remotely monitoring capacitor voltage. Whenever personnel are exposed to the system, the firing capacitor must be shorted.
3. There must be a minimum of two independent open switches between the power source and the system initiator.

## **5.3.5 Ground Support Equipment**

The design of GSE used to make measurements on or provide control of hazardous devices, systems, or circuits must be approved by the GSO.





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### **5.3.5.1 GSE Requirements**

1. All electrical meters or test equipment used to make measurements of hazardous systems must be current limited to 10 mA.
2. All GSE used in, or to obtain measurements of, hazardous systems (electrical meters, pressure gages, slings, scales, etc.) must be calibrated/certified and may not be used beyond the certification period. Certifications must be performed by an authorized company or institute.
3. All meters which are used to measure resistance of ordnance devices (e.g., safety Ohm meters) are required to be tested for proper operation immediately prior to starting the procedure. Measurement on Category "A" devices must be performed remotely from outside the Danger Area.
4. All lifting devices, fixtures, and equipment must conform to the Swedish standards and regulations.

Electrically operated GSE (vacuum systems, heaters, pumps, etc.) used on Category "A" systems must also meet the following design criteria and restrictions.

5. All GSE must be designed in such a way that the system can be remotely switched ON/OFF from outside the Danger Area.
6. GSE must be switched OFF prior to system arming operations. After arming operations are complete, the GSE may be switched ON provided item 5 above is satisfied.
7. The design of GSE should consider the impact of the above restrictions on operations. Fly-away connectors should be used to permit system operation late in the countdown process. For vacuum systems, a remotely operated valve is recommended to maintain vacuum integrity when power is switched OFF.

### **5.3.6 Electrostatic Discharge Hazards**

Precautions must be taken to eliminate or reduce the risk of electrostatic discharge during potentially hazardous operations. The method used to eliminate or reduce static electricity is to provide an electrically continuous path to ground.

- All conductive objects (including personnel) must be electrically connected to a common ground.
- Grounding straps must be used to bridge locations where electrical continuity may be broken by grease, paint, or rust. Equipment in contact with conductive floors or tabletops is not considered adequately grounded.
- Wire used as a static ground conductor must be large enough to withstand mechanical damage and must not be less than described in the Swedish regulations for design and maintenance of electrical installations.
- Connection of static ground conductor shall be made to certified grounding points.
- Grounding point certification must be performed annually.

When performing potentially hazardous operations on electrostatic sensitive systems, personnel must comply with the following:



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1. Verified wrist straps must be worn and connected to a certified ground when handling EEDs or when working on exposed rocket motor grain.
2. Outer garments (e.g., laboratory coats or overalls) that dissipate static charges must be worn. Under special circumstances, the use of static dissipative outer garments may be waived by the GSO, or his/her designee.

### **5.3.7 Electrical Storm Criteria**

1. When an electrical storm is detected within 30 km or the potential for an electrical storm is forecast within 30 km of potentially hazardous work areas, a warning must be issued to bring operations to an appropriate stopping point.
2. When the electrical storm is detected within 20 km or the potential for an electrical storm is forecast within 10 km of potentially hazardous work areas, the area must be evacuated regardless of the status of the operations.
3. If a warning system is not available to determine the approach of an electrical storm, the potentially hazardous work area must be cleared upon hearing thunder or observing weather conditions, which have the potential of producing electrical storms.

### **5.3.8 Radiation Systems**

Radiation must be adequately controlled during all operational phases to assure the protection of personnel, facilities and equipment and compliance with applicable Swedish laws and regulations and ESC local regulations.

Such sources include radio-frequency/microwave emitters, radioactive materials, X-ray devices, lasers and optical emitters.

#### **5.3.8.1 Non-ionizing Radio Frequency Radiation Controls**

1. RF-radiation sources used at ESC must be approved by the Esrangle Safety Board. Frequencies must be coordinated with other Range activities.
2. All operations involving the use of RF transmitters must be coordinated through the SSC Project Manager or Flight Director and conform to the standards and regulations specified at ESC.
3. Mission-specific descriptions of RF transmitters and restrictions are provided in the Campaign Requirements Plan (CRP).
4. RF radiation into areas where ordnance operations are conducted must be controlled to ensure that energy does not exist to cause premature initiation of ordnance.
5. Radio silence in Danger Areas must be established in operational plans for all transmitters capable of producing a potential hazard to any ordnance operation.
6. Personnel and ordnance hazard distances for all transmitters must be jointly defined in accordance with Swedish regulations regarding non-ionizing radiation control.





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**5.3.8.2 Ionizing Radiation Controls**

1. All operations involving the use of radioactive sources must conform to Swedish law regarding protection against radiation and regulations and standards issued by the Swedish Radiation Safety Authority.
2. The range user is responsible for obtaining all licenses for radioactive materials including permission from Esrangle Safety Board.
3. Procedures for the use, handling, and storage of radioactive sources must be designed to minimize the exposure of personnel.
4. Swedish rules according to the regulation Working Safely with Radioactivity issued by the Swedish Radiation Safety Authority must be followed.
5. Range users must identify all radioactive sources and provide Safety Data Sheets (SDS) for each radioactive source to be used. This includes calibration sources as well as test sources.
6. Range users must provide SSC with detailed operating procedures for use, handling, and storage of all radioactive sources.
7. Ionizing radiation sources must be removed from the range by the range user at the end of the program.

**5.3.8.3 Laser Hazards Control**

1. Range users must provide SSC with characteristics and detailed operating procedures for controlling and use of lasers.
2. All use of lasers must be approved by the Esrangle Safety Board.
3. All operations involving the use of lasers must comply with the Swedish standards and regulations.
4. Restrictions are in place for the use of laser of Class 3R, 3B and 4. Special permits are issued by Swedish Radiation Safety Authority.
5. Access and laser illumination levels must be controlled to ensure that no personnel are present within the ocular hazard area of the laser unless suitable protection is provided.
6. Those who operate lasers shall possess good knowledge of the way in which the laser is handled, know the hazards that might be involved and know the current applicable regulations. When operating lasers attention shall be paid to avoid hazardous human exposure.

**5.3.9 Chemical Systems**

Any chemical (solid, liquid or gas) that presents a physical hazard or a health hazard is considered a hazardous chemical. The term physical hazard refers to chemicals for which scientific evidence exists demonstrating the chemical or substance is a combustible liquid, compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive), or water-reactive materials. The term health hazard refers to chemicals for which there is statistically significant evidence based on at least one study conducted in



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accordance with established scientific principles that acute or chronic health effects may occur after exposure. The term health hazard includes chemicals that are carcinogens, toxic, or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes.

This section identifies the design requirements for hazardous chemical systems and associated hardware as well as requirements associated with the handling, storage, transportation, and spill/clean up response. Operations involving hazardous chemicals are considered hazardous operations and should follow the requirements specified in Section 5.4.4. These requirements apply to the range user, range, or any other entity performing operations dealing with hazardous chemicals on ESC property or in support of programs managed under the cognizance of ESC.

As Sweden is part of the EU, ESC is compliant with the EU Regulation No 1907/2006 concerning Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH). In addition, Sweden has rules set by the Swedish Chemical Agency that are applicable only to Sweden. For more information, the range user shall contact Range Safety Office.

For cryogenic systems the requirements of this section and Section 5.3.11 Cryogenic Systems apply.

#### **5.3.9.1 Procedures**

The range user or program shall develop procedures addressing use, transportation, storage, cleanup, and spill response of hazardous chemicals. These procedures shall be reviewed and approved by the GSO.

#### **5.3.9.2 Material Disposal**

The range user or program shall notify the GSO of hazardous chemicals requiring disposal and properly remove hazardous materials from the facility or host site at the end of their operation.

#### **5.3.9.3 Material Safety Data Sheets**

The range user or program shall comply with all of the following:

1. Maintain a hazardous chemicals/materials inventory.
2. Provide a copy of the Safety Data Sheet to the GSO.
3. Ensure a copy of the SDS is available during all operations involving hazardous materials.

#### **5.3.9.4 Material Handling**

Hazardous chemicals/materials handlers, the GSO and the Estrange Rescue Team shall be trained in hazardous chemical material capabilities, physical and health hazards, and first aid techniques relevant to the hazardous chemical materials in use.



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### **5.3.9.5 Information**

To ensure personnel are informed of chemical hazards they may be exposed to at the workplace, the range user or program shall comply with requirements specified in Arbetsplatsens Utformning (AFS2020:1) (only available in Swedish), and Kemiska Arbetsmiljörisker (AFS 2011:19), for proper labeling on all primary and secondary containers housing hazardous chemicals.

### **5.3.9.6 Chemical Spill**

If the possibility of a hazardous chemical spill exists, the range user or program shall ensure a means to minimize the surface area of the spill is readily available.

Examples of this include diking or contamination pallets.

### **5.3.9.7 GSE Requirement**

All GSE electrical hardware (provided by the range or the range user/program) used in areas where flammable/combustible chemicals may be present in local vapor concentrations greater than 25% of the Lower Explosive Limit shall be rated explosion proof in accordance with the ATEX Directive 2014/34/EU.

The SEK Handbok 426 – Klassning av explosionsfarliga områden contains guidance on determining the proper classification of the location. The document is written in Swedish and English.

### **5.3.9.8 Leak Control**

Work areas and storage areas containing highly toxic or reactive chemicals (e.g., hydrazine and nitrogen tetroxide) or highly flammable chemicals (e.g., liquid hydrogen) shall be continuously monitored (including alarm system) to the maximum extent possible by approved equipment to detect toxic and/or flammable concentrations as determined by the GSO. This requirement does not apply to routine industrial work areas that meet Swedish Law requirements. In addition, both of the following apply:

1. In cases where continuous monitoring is not possible or feasible in a daily work area, the work area shall be “sniff checked” using approved equipment at the beginning of the work period prior to personnel performing work and periodically (minimum every two hours) while personnel are present.
2. In cases where continuous monitoring is not possible or feasible in a storage area where personnel are not performing daily operations, the area shall be “sniff checked” prior to entry and periodically (minimum every two hours) while personnel are present.

After the initial sniff check is performed, dosimeter badges may be used instead of performing periodic sniff checks while personnel are present. See Section 5.3.13, Personal Protective Equipment (PPE), for PPE requirements when performing sniff checks in lieu of continuous monitoring.



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**5.3.9.9 Hardware Design**

Hazardous chemical system hardware shall be designed to prevent hazardous chemicals from spilling or leaking.

**5.3.9.10 Hardware Independent Inhibit Design**

The range user or program shall design hazardous chemical systems that release caustic, toxic, or reactive chemicals resulting in a critical or marginal hazard such that the flow path contains two independent inhibits to prevent inadvertent release. If a release results in a catastrophic hazard, three independent inhibits are required.

An inhibit that utilizes a pyrotechnic valve may meet the intent of the two independent inhibits as long as the chemical system is not hypergolic, a spill/leak does not present a catastrophic hazard, and it is reviewed and approved by the Esrange Safety Board. When designing pyrotechnic valves, NASA-SPEC-5022 is recommended.

**5.3.9.11 Chemical System Connection**

Components of hazardous chemical systems shall feature welded fittings or redundant mechanical seals at all fittings to prevent inadvertent flow or release of caustic, toxic, or reactive chemicals.

**5.3.9.12 Material Compatibility**

Materials selected for use in hazardous chemical systems shall be compatible with the hazardous chemical used. This includes compatibility under operating pressure, shock, vibration, reactivity, and temperature conditions.

**5.3.9.13 Bi-Propellant System**

Bi-propellant systems that incorporate both a fuel and an oxidizer shall be designed such that a malfunction of either the oxidizer or the fuel subsystems cannot result in mixing.

**5.3.9.14 Monopropellant System**

Monopropellant systems that feature a fuel and a catalytic bed shall incorporate at least two independent inhibits in the flow path to prevent inadvertent contact of the propellant with the catalytic bed.

**5.3.9.15 Remote Status Monitoring**

If remote status monitoring is required, the range and/or range user shall provide monitoring of hazardous chemical systems, their components, and/or operating personnel. The GSO will determine the required level of monitoring, if any.

**5.3.9.16 GSE Hardware**

Hazardous chemical system GSE hardware (tanks, transfer lines, etc.) shall comply with industry standard and fulfill European regulations.



### **5.3.10 Pressure Vessels and Pressurized Systems**

Any vessel used for the storage or handling of a fluid or gas under positive or negative pressure is considered a pressure vessel. A pressure system is an assembly of components under pressure (e.g., vessels, piping, valves, relief devices, pumps, expansion joints, and gages). The requirements in this section contain design criteria for both flight and ground based pressure vessels and systems. Flight pressure vessel systems are typically not designed with a high factor of safety as compared to ground-based systems (e.g. 4:1) and therefore additional restrictions such as pressurizing remotely must be put in place to mitigate the risk of hazard exposure. Since all pressure vessels and pressure systems are considered hazardous systems, the hazard categorization requirements apply, see Section 5.3.1. Cryogenic systems also present pressure related hazards, and in which case the requirements of this Section in addition to Section 5.3.11 Cryogenic Systems apply.

#### **5.3.10.1 Ground-Based Pressure Systems**

All ground-based pressure systems shall comply with the Pressure Equipment Directive 2014/68/EU and Use and Control of Pressure Equipment AFS 2017:3.

According to AFS 2017:3, the range user shall provide an assessment of the risks associated with the use of the pressure equipment. The risk assessment shall take into account:

1. Experience with the use of device,
2. Information on the remaining lifetime of the device,
3. Repairs and modifications carried out,
4. Accidents and incidents,
5. Any deviation reports and results for the inspection of the pressurized devices.

AFS 2017:3 Class A or B pressure systems shall undergo an initial inspection before being pressurized for the first time or if they have been stationary and are to be pressurized after a change of location. During this inspection, the external inspection body (not SSC) shall check that the device is fit for purpose and not damaged.

AFS 2017:3 Class A and B pressure systems shall be continuously monitored when pressurized.

The AFS 2017:3 classification is done according to the Table 1 and 2.

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Table 1. Pressure times volume in barliters [AFS 2017:3].

Contents		Volume in liters, V	Pressure in bars, p	Classes		
Gas	1a	$V > 1$	$p > 0,5$	B	A	
		$0,1 < V \leq 1$	$p > 200$	A		
	2a	$V > 1$	$p > 0,5$		B	A
		$0,1 < V \leq 1$	$p > 1000$	A		
Liquid	1a	$V > 1$	$p > 10$		B	A
			$0,5 < p \leq 10$		B	
		$0,1 < V \leq 1$	$p > 500$	B		
	2a	$V > 10$	$p > 500$			B

50    200    1000    2000    10000

Pressure times volume in barliters

Table 2. Pressure times nominal diameter [AFS 2017:3].

Contents		Nominal diameter in mm, DN	Pressure in bars, p	Classes		
Gas	1a	$25 < DN \leq 100$	$p > 0,5$	B	A	
		$DN > 100$		A		
	2a	$100 < DN \leq 250$			B	
		$DN > 250$			B	A
Liquid	1a	$DN > 25$	$0,5 < p \leq 10$		B	
			$p > 10$		A	
	2a	$DN > 200$	$p > 10$			B

12,5    1000    2000    3500    5000

Pressure times nominal diameter



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**5.3.10.2 Flight Pressure Systems**

All flight pressure systems and their components to be operated at ESC shall be proof tested 1.25 times the MEOP without burst or leak for at least 5 minutes.

ESM Category A flight pressure systems shall be qualified with pressures above 1.5 times MEOP without burst or leak. Qualification units shall not be flown.

All flight pressure vessels shall be pressure cycle tested 1.25 times the MEOP for 4 times the expected service life. The service life spectrum shall contain a minimum of 13 full cycles to MEOP or above. Pressure cycle tested vessels shall not be flown.

The range user shall provide the test reports to SSC.

**5.3.10.3 Remote Pressurization**

Flight pressure vessels and pressurized systems shall be pressurized and depressurized remotely:

- During initial pressurization following system assembly or refurbishment.
- During pressurization above 0.25 times Design Burst Pressure.
- After the system has been exposed to excessive vibration and/or shock.
- After transportation in an unknown environment.

This does not apply if the system meets one of the three caveats:

- The component is CE certified.
- The component has a safety factor of 4.
- The system's stored energy is less than 19,306 joules (14,240 ft. lbf), its operating pressure is less than 7 bar, and it does not contain hazardous or toxic materials.

**5.3.10.4 Flight Pressure System Recovery**

Flight pressure vessels and pressurized systems shall be designed such that, prior to recovery, the system is remotely depressurized below 7 bar and its stored energy is less than 19,306 J.

**5.3.10.5 Re-Flight of Pressure Systems**

Once flown and recovered, flight pressure vessels and pressure systems shall be re-evaluated by inspection, testing, and/or analysis prior to being re-flown. The method of evaluation shall be documented and approved by the GSO for each vessel/system.

**5.3.10.6 Flex Hoses Handling**

Pressure systems utilizing flex hoses shall be visually inspected at least annually for damaged threads, broken braid, kinks, flattened areas, or other evidence of degradation.





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### **5.3.11 Cryogenic Systems**

A cryogenic system is defined as a hazardous system that contains at least one component that operates at a cryogenic temperature, specifically at or below  $-150^{\circ}\text{C}$ . Cryogenic systems have the potential to cause chemical and temperature related hazards such as frostbite as well as over-pressurization hazards. Cryogenic systems that remain unpressurized or maintain pressure readings at low levels (less than 7 bar) may still present a pressurization hazard due to the possibility of expansion from inadvertent heating. Cryogenic systems can also present an oxygen deficiency hazard given there is enough potential to displace the percent of oxygen in a given space. In general, the requirements for chemical systems and pressure systems apply to all cryogenic systems.

Requirements for personal protective equipment (PPE) when conducting operations with cryogenic systems are provided in [R2] *Cryogenic Safety at Esrange Space Center*.

#### **5.3.11.1 Requirements**

Hazardous cryogenic systems shall meet the requirements specified in [R2] *Cryogenic Safety at Esrange Space Center*.

#### **5.3.11.2 Training Requirements**

All personnel performing work on cryogenic systems and/or working with cryogenic fluids shall be trained in accordance with [R2] *Cryogenic Safety at Esrange Space Center*, or equivalent.

#### **5.3.11.3 Chemical Related Requirements**

All hazardous cryogenic systems shall meet the requirements of Section 5.3.9 Chemical Systems.

#### **5.3.11.4 Pressure Related Requirements**

All hazardous cryogenic systems shall meet the requirements of Section 5.3.10 Pressure Vessels and Pressurized Systems.

### **5.3.12 Liquid Propulsion Systems**

Liquid propulsion systems involve both chemical and pressure related hazards. Depending on the propellant used, these hazards could be catastrophic (leading to permanent injury or death), or critical (leading to a severe injury). Typically, a leak/spill will lead to personnel exposure quickly before a leak/spill response can be performed. Propulsion systems utilizing hypergolic propellants or hydrogen are examples of these types of systems. Accidental mixing in propulsion systems utilizing energetic liquids may cause explosions. The explosive equivalent is used to assess the explosive threat associated with a specific propulsion system. It is computed using the total net weight of the propellants multiplied by a yield factor given by the combination of propellant involved and the specific use case. This section outlines the necessary precautions that must be implemented on both system design and the activities associated with ground processing.





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**5.3.12.1 Three Independent Inhibits**

A liquid propulsion system's primary flow path (i.e. from the propellant tank through the thrusters) shall contain a minimum of three independent, mechanical inhibits in series to prevent inadvertent flow or leakage. If the mechanical inhibits are electrically controlled, the electrical controls shall be independent of each other.

A pyrotechnically actuated isolation valve (with a "parent metal" seal and three electrical inhibits) that is located immediately downstream from the liquid propellant tank may be considered equivalent to two mechanical flow control inhibits upon Esrange Safety Board approval of the valve design and associated quality control and testing processes. Refer to NASA-SPEC-5022 for guidance.

A parent metal seal is created by machining the valve input and output orifices from a single metal block and leaving some of the "parent metal" between the input and output. The tolerances have to be tightly controlled so the seal doesn't inadvertently crack and leak yet will reliably break open when hit by the pyro-activated ram. Such pyro-valves are typically built one at a time in a process that involves significant hand work and where quality control and testing is critical to each valve's reliability and safety.

**5.3.12.2 Two-Fault Tolerant Seals**

Seals associated with potential leak paths (i.e. through or around wetted fittings to the ambient environment) shall be two-fault tolerant to prevent a catastrophic leak/spill past a wetted fitting. *Note: A certified weld is not considered a credible leak path.*

To be considered two-fault tolerant, the system or component must have three independent, verifiable inhibits to ensure the system can sustain two failures and still retain capability.

**5.3.12.3 Hypergolic Flight Hardware**

All connections in a hypergolic flight hardware system shall be made with certified welds in accordance with applicable design codes and standards. Non-welded connectors and fittings, such as National Pipe Thread (NPT) and flared tubing (i.e. type AN), are not permitted in hypergolic flight hardware.

**5.3.12.4 Spill/Leak Response**

Prior to a launch, any operation of flow control devices within a loaded liquid propulsion system shall be conducted with spill/leak response capabilities in place.

**5.3.12.5 Contingency Design**

The range user shall incorporate design features to address contingency liquid propellant off-loading operations into the design of the launch vehicle and/or payload in all phases of ground processing.

A fairing access door, when incorporated, makes for easy access to the spacecraft propulsion system fill and drain valve after the integrated launch vehicle and payload have been staged on the launch pad.



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#### **5.3.12.6 Electrical Flow Control**

Electrical circuits that operate liquid propellant flow control devices **shall satisfy all the following:**

1. The system initiator shall be isolated from the power source by a minimum of three independent inhibits. This requirement is applicable both before and after installation of Safe/Arm plug type connectors.
2. At least two of the three electrical inhibits shall be monitored remotely when conditions preclude spill/leak response.
3. The system initiator shall be electrically isolated by switches in both the power and return legs.
4. The wiring shall be in a separate cable, which is twisted, shielded, double insulated, and independent of all other systems.
5. Protection by use of physical barriers or by physical location of components shall be employed such that short circuits to other power systems are impossible, even assuming loose or broken wires.
6. A Failure Mode and Effects Analysis (FMEA) or equivalent shall be performed to ensure a minimum of three independent failures are required for inadvertent initiation to occur. The level of detail in the analysis shall be established by the Ground Safety Officer and shall be based on factors such as the type of system, system design, and the level of hazard.

#### **5.3.12.7 Electrical Independent Inhibits**

Electrical circuits that operate components whose failure may cause the liquid propellant to catastrophically overheat (thus causing either propellant decomposition or propellant tank over pressurization) shall have three independent inhibits (two-fault tolerant).

#### **5.3.12.8 Pressure Beyond MEOP**

A liquid propulsion system shall be single-fault tolerant (either electrically, mechanically, or a combination of both) against pressurizing beyond the system's Maximum Expected Operating Pressure (MEOP).

#### **5.3.12.9 Pressurizing Beyond Design Burst Pressure**

For pressurizing beyond the system's design burst pressure, the liquid propulsion system shall be both mechanically and electrically single-fault tolerant (i.e. two mechanical and two electrical inhibits).

For cryogenic systems, if single fault tolerance is not achievable, the pressurizing side can be equipped with a pressure relief device set at 10% above MEOP and set pressure tolerances in accordance with applicable relief device standards.
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#### **5.3.12.10 Quality Control**

The range user shall implement a quality control program to verify that all system fittings and seals are properly installed and have leak integrity. This program **shall ensure all following:**



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1. Welds are made by qualified welders.
2. Lot and batch short term capability testing is performed for elastomeric seals to ensure material compatibility.
3. The system implements positive means such as periodic leak checking, manufacturer's gauging techniques, and/or other measures to ensure that metal-to-metal seals do not lose leak integrity by improper installation or loosening ("backing-off") during transport or handling.

The optimum design for redundant mechanical seals is to seat one at the fitting face and one at the other radially to seal the fitting.
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#### **5.3.12.11 Monitoring Requirement**

During ground processing or any operation that involves personnel working on or around a loaded liquid propulsion system, the system shall be continuously monitored for airborne concentrations of the hazardous chemical (see Section 5.3.9.8). During other activities (e.g., captive flight of an air launched vehicle), the system pressure shall be monitored at a minimum.

#### **5.3.13 Personal Protective Equipment**

Safety glasses, safety shoes, wrist straps, hard hats, antistatic clothing, shop coats, etc. have to be used by SSC employees, contractors, experimenters and range users when exposed to certain hazardous conditions.

1. All personnel must wear antistatic clothing in processing areas for ordnance or other hazardous systems which are susceptible to electrostatic discharge.
2. During operations involving EED or exposed grain, all personnel are required to wear verified grounded wrist-straps. Verified leg-stats may be used, in place of wrist-straps, for specific operations approved by the Superintendent for Explosives or his designee.
3. Safety glasses or face shields are required for operations if an ocular hazard may exist.
4. Hard hats are required for operations where personnel work on multiple levels or where overhead objects may impact personnel, e.g. crane and lifting operations.
5. Operations involving chemicals that constitute a health risk require personnel to wear protective equipment, identified on a case-by-case basis in the specific operational procedure. Swedish law and regulations must be enforced.
6. Personnel working with cryogenic liquids must wear proper protective equipment including hand and foot protection, face protection, and appropriate outer garments.



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**5.3.14 Waivers for Small Rockets**

Small rockets, such as student-built rockets and alike, that have great difficulties to fulfil ESM on pressurized, chemical and cryogenic systems as well as liquid propulsion systems, can apply for a set of waivers. The Small Rockets waivers are applicable for rockets that satisfy the following requirements:

1. fueling, pressurizing, and all subsequent procedures are done remotely, and with all personnel outside the hazard area
2. the total propellant mass is less or equal to 200 kg
3. a failure mode and effect analysis (FMEA) must always be performed for the vehicle and its ground support systems

If these requirements are satisfied, it is then possible to obtain waivers of the following paragraphs of the ESM:

5.3.9.10 - Hardware Independent Inhibit Design

5.3.9.11 - Chemical System Connection

5.3.9.14 - Monopropellant System

5.3.12.1 - Three Independent Inhibits

5.3.12.2 - Two-Fault Tolerant Seals

5.3.12.6 - Electrical Flow Control

5.3.12.9 - Pressurizing Beyond Design Burst Pressure

5.3.12.10 - Quality Control

This shall be submitted to Esrange Safety Board at an early stage for assessment. ESB has the authority to deny any waiver if the operations are deemed unsafe.

**5.4 Operational Safety and Security, Controls and Procedures**

SSC has established operational safety controls with which all persons at ESC must comply.

**5.4.1 Security**

All visitors, contractors, campaign guests and SSC personnel use a badge system to enter the ESC base area and to have access to different zones inside the area. This general access badge system is handled by SSC authorities together with the guard.

There are some restricted areas, Danger Areas, see Section 5.3.2, at ESC that have elevated access control when activated.

**5.4.1.1 Operational badge system**

The general access badge system is complemented with a special badge system which is handled by the MRSO. This system is used to keep control of all personnel working in Danger Area 1 (Rocket Launch Area) during countdown or during other operations with the need of special access restrictions.



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This system is generally not used for balloon operations.

## **5.4.2 RF Radiation Controls**

All campaign related RF radiation at ESC is controlled through the SSC Project Manager or Flight Director to ensure that RF limits according to Section 5.3.8.1 are not exceeded and to prevent possible interference with other transmitters. Range users must obtain permission through the SSC Project Manager or Flight Director before any RF transmitters can be switched ON.

### **5.4.2.1 Operational restrictions**

All campaign related RF emitters used at ESC must be periodically analysed to determine whether they pose a potential hazard to personnel or ordnances. When a potential hazard exists, operational restrictions and/or controls must be established to protect personnel and/or ordnance systems.

### **5.4.2.2 Barricades and Signs**

In areas where RF hazards to personnel exist, signs and/or barricades must be erected to prevent personnel from entering the potential hazard area.

### **5.4.2.3 Warning lights**

On high power RF emitters such as Radar Systems, a flashing light must be illuminated to warn personnel whenever the emitter is radiating.

## **5.4.3 Hazardous Operations Controls**

For all campaign related potentially hazardous operations, a risk analysis shall be made.

Under no circumstances must a potentially hazardous operation begin without prior approval through the SSC Project Manager outside countdown and from the Flight Director during countdown.

All personnel performing potentially hazardous operations (explosives handling, chemical transfer, etc.) must be trained and experienced. These personnel must be certified or directly supervised by certified personnel when performing these operations. SSC will approve all personnel certifications or may approve certifications established by user programs. On request, range users must provide documentation that certifies training, experience, or certification of their personnel.

### **5.4.3.1 Emergency response team**

Prior to conducting a potentially hazardous operation, SSC must ensure that emergency procedures are established and an emergency response team is appointed if needed. Range users are obliged to participate in any emergency operation.

### **5.4.3.2 Potentially hazardous operations requirements**

All SSC personnel, contractors, experimenters, range users, and tenants are responsible for:

1. Adhering to the requirements established in this document.



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2. Adhering to the directions issued by the SSC Project Manager, the Safety and Launch Team Manager, the Safety and Operations Team Manager, or another SSC official.
3. Reviewing vehicle and payload potentially hazardous operations with the SSC GSO/ Launch Officer and/or Flight/Test Director.
4. Obtaining permission from the Flight/Test Director during countdown before conducting any potentially hazardous operation in assembly, test, or launch areas.
5. Obtaining permission through the SSC GSO/ Launch Officer for all campaign related potentially hazardous operations not handled by the Flight/Test Director.
6. Identifying Mission Essential personnel for each operation to ensure that only those that are needed for the operation are present.

### **5.4.3.3 Danger area clearance**

For all potentially hazardous operations a plan should define Danger Area clearance requirements and personnel access restrictions.

## **5.4.4 Operational Procedures**

All personnel involved in campaign related work at ESC have to attend the general campaign safety briefing before participating in any operations.

RSO is responsible for the content of the safety briefing while the SSC Project Manager is responsible for the implementation of the safety briefing.

### **5.4.4.1 Hazardous systems**

Range users are responsible for submitting to SSC comprehensive handling, assembly, and/or checkout procedures for all hazardous systems for review and approval. Operations must not be conducted until these assembly and test procedures have been approved by the GSO.

### **5.4.4.2 Instrument requirements**

Instruments used to measure the resistance of EEDs have the following requirements:

1. Contain a certification sticker.
2. Be checked, immediately prior to use, to ensure that the short circuit current is less than 10 mA.
3. Range user's instruments may be used after approval from the GSO.

Prior to connecting system initiators to their electrical circuit, voltage checks must be made between each leg of the circuit and from each leg to ground to ensure that no voltage is present (zero volt measurement).

After each zero volt measurement, instrument and leads have to be verified.

### **5.4.4.3 Switching**

Range users must obtain permission from the Flight Director prior to making a switch on any vehicle/payload or ground support system during countdown.



## 5.5 Requirements for Static Tests with Liquid Propellants

An application shall be submitted to ESC according to the schedule found in Section 8.8. The application must contain a detailed description of the test campaign, test article documentation and test plan.

For static test stands, the amount of energetic liquids held in run tanks can be excluded from the equivalent explosive yield if the test stand infrastructure meets the following criteria:

1. All tanks comply with requirement 5.3.10.1 for ground-based pressure systems.
2. For cryogenic propellants, all tanks are constructed with double wall jacketing.
3. The configuration of the test stand is such that there is a protective structure in between the engine and the run tank to prevent fragments from puncturing the tanks in case of engine malfunction.
4. Each feed line contains two remotely operated valves to shut off energetic liquids flow in the event of a malfunction.

All hazardous activities are required to satisfy the ESM in all its parts. Any deviation from it shall be covered by a request for waiver.

## 5.6 Operational Procedures for Static Tests

### 5.6.1 Countdown Procedures

For each specific mission, a countdown procedure will be established in close co-operation with the range user. The countdown procedures in combination with all applicable operational procedures are described in the Safety plan.

### 5.6.2 Area Clearance During Static Test

For the area clearance the following rules apply:

1. During a static rocket engine test, all personnel shall stay out of the predefined Danger Area according to the Safety Plan.
2. SSC must co-ordinate its operations with the County Administration of Norrbotten. Coordination with Air Traffic Control must be established when airspace restriction is necessary, and Zone R01A shall be closed.
3. The ESC microzone may be used during the whole year. Information about the microzone area is on the warning signs around the zones.
4. When starting a countdown, barriers and warning lights or access restrictions for the concerned Danger Areas must be activated. Signals shall remain activated until operations are over or cancelled.
5. During a countdown the warning sirens at the ESC test site must be initiated to activate a microzone outside the ESC area T-30, T-15, and T-02 minutes before operations start. The siren shall be played in regular intervals as long as the microzone is active. When operations are over or cancelled, the micro-zone is deactivated by playing a danger over siren.





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### 5.6.3 Weather Restrictions

The MRSO must have clear and convincing evidence that the following constraints are not violated:

1. The electrical storm criteria stated in Section 5.3.7.

Weather restrictions established in the Safety Plan.

## 6 FLIGHT SAFETY

### 6.1 Policies

- The main objectives of Flight Safety are to minimize injuries to personnel, damage to property and the probability of impact outside permitted areas. Each vehicle flight must be planned to optimize the probability of success of the flight objectives and to minimize the element of risk.
- SSC/ESC is responsible for Flight Safety until all flight components have impacted or have reached a safe state.
- Flight Safety is associated with the containment of vehicle flight within approved operational areas and impacts (spent stages, payloads, balloons, payload/parachutes, etc.) within planned impact areas. Since the entire set of variables (vehicle aerodynamic/ballistic capabilities, azimuth and elevation angles, and wind) are unique, a Flight Safety analysis shall be performed for each mission.
- Flight Safety data must be prepared well in advance prior to a campaign and published in a Flight Safety Plan. This data shall describe the proposed vehicle flight and the means to conduct the operation safely.
- When launching a vehicle with a Flight Termination System (FTS), a Flight Safety Operation Plan shall be documented in addition to the Flight Safety Plan. It shall describe the proposed vehicle flight and the means to contain it safely.
- Ground operations that can affect public and aviation shall when applicable be treated in accordance to this chapter. Static rocket motor test is an example of such operation.

### 6.2 Risk Criteria

It is the policy of SSC that the risk associated with each test activity or each launch of rocket, balloon, UAS and other airspace vehicles at ESC shall meet the risk criteria established in this section.





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**6.2.1 Public Risk**

Probability of Casualty ( $P_c$ ) for individuals shall be below  $1 \times 10^{-6}$ .

The Expectation of Casualty ( $E_C$ ) shall be less than or equal to  $1.49 \times 10^{-4}$ .

For example, if the assessed risk falls between  $100 \times 10^{-6}$  and  $149 \times 10^{-6}$ , it would be rounded down to  $1 \times 10^{-4}$  and thereby satisfy the FAA criterion.

The probability of hitting an aircraft ( $P_i$ ) with debris capable of causing a casualty shall be below  $1 \times 10^{-6}$ .

**6.2.2 Mission Essential and Critical Operations Personnel Risk**

Probability of Casualty ( $P_c$ ) for individuals shall be below  $10 \times 10^{-6}$ .

The Expectation of Casualty ( $E_C$ ) shall be below  $300 \times 10^{-6}$ .

**6.2.3 Impact Risk**

The probability of spent stages, experiment bodies or other vehicle debris impacting on protected property areas shall be below  $1 \times 10^{-3}$ .

During activities utilizing the Estrange Impact Zone, the probability of spent stages, experiment bodies or other vehicle debris impacting outside Estrange Impact Zone shall be below  $1 \times 10^{-1}$ .

**6.2.4 Orbital Collision Risk**

The probability of collision between a launched object and any inhabitable object in orbit shall be below  $1 \times 10^{-6}$ .

The probability of collision between a launched object and any trackable object in orbit shall be below  $1 \times 10^{-5}$ .

If a launched object does not reach an altitude of 150 km an analysis does not have to be made.

**6.3 Requirements for Rockets, UAS and Other Similar Vehicles**

General requirements are:

- All activities are required to satisfy the risk criteria in Section 6.2 and any possible additional mission specific requirements obtained in the flight permission.
- The one  $\sigma$  Gaussian impact dispersion for vehicles that impact in the impact area, Appendix 2, shall be less than 17 km downrange and 15 km cross-range. Other combinations can be possible but need to be verified by the Range Safety Office.
- At least one tracking or other data source shall be utilized to determine impacts (either during the mission or through post-mission analysis) of vehicle components.
- If the positioning systems used only consist of skin tracking radars, a ceiling limitation shall be imposed to ensure visibility until the skin tracking radars have had adequate time to provide reliable data.



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### **6.3.1 Flight Proven Rockets Not Previously Launched From ESC**

If a range user wants to introduce a new rocket type to ESC, an application must be submitted to ESC according to the schedule found in Section 8.8. The application must contain flight history data such as overall performance, aerodynamic characteristics, thrust curves, wind-weighting, impact statistics, etc., as outlined in Section 8.3.

For all new rockets a Rocket Introduction Document must be prepared by Flight Safety personnel and reviewed by the County Administration of Norrbotten.

### **6.3.2 New Rockets**

If a range user wishes to launch a rocket type that is not previously flown an application must be submitted to ESC according to the schedule found in Section 8.8.

The application must contain written reports for at least the following topics:

- Two static tests regarding each propulsion system that will fly on the rocket
- Mechanical and structural matters
- Aerodynamics
- Avionics
- Possible FTS

See Section 8 for more information regarding data requirements.

The RSO will judge the flight worthiness based on the submitted data.

### **6.3.3 New UAS and Other Similar Vehicles**

Unmanned aerial systems operated at ESC shall comply with EU regulation 2019/947 – rules and procedures for operations of unmanned aircraft. The Swedish Transport Agency authorizes the UAS operations in Swedish airspace and the range user shall apply for an operational authorization from the Swedish Transport Agency. Before applying the authorization from the Swedish Transport Agency, the UAS shall be registered to its country of origin, the UAS shall possess an operational authorization from its country of origin, and the operations shall be approved by SSC.

If a range user wants to introduce a new UAS or other similar vehicle type to ESC, an application shall be submitted to SSC according to the schedule found in Section 8.5. The range user is advised to contact ESC well ahead before the application is submitted to ESC for support.

Each vehicle will be judged case by case.

### **6.3.4 Inherently Safe Requirements**

Operations are considered inherently safe if all the following are true:

1. The risk criteria in Section 6.2 are satisfied.
2. The vehicle does not contain a guidance or control system capable of exceeding a containment area.



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3. The predicted flight is based solely on launch and dispersion parameters and known system errors.
4. The vehicle has demonstrated reliability.
5. The vehicle has sufficient stability margins.
6. The vehicle can be accurately wind weighted to provide an acceptable impact location.

The RSO is responsible for determining if an operation is inherently safe.

### **6.3.5 Vehicle Stability Requirements**

For all nosecone/payload configuration vehicles with a guidance or control system a dynamic aero elastic analysis should be performed. This unless the configuration is of standard type frequently flown by the same rocket type.

Upon request from RSO, range users are obliged to present the detailed design for all systems (e.g. hatches, fins, etc.) that has the possibility to affect the flight worthiness of the vehicle.

## **6.4 Flight Termination System (FTS)**

An FTS is required for non-inherently safe vehicles with the capability to reach population centers. The requirements for inherently safe launch vehicles are presented in Section 6.3.4.

The Range Safety Office is responsible for overseeing the development of an FTS and approving the design and certification of the system, see [R1] *Esrange FTS Range Approval Process*.

The ESB is responsible for approving FTS to be used for a certain mission.

### **6.4.1 Standard Requirements**

The FTS shall satisfy the requirements of RCC Flight Termination Systems Commonality Standard (RCC 319), or a tailored set of equivalent requirements.

### **6.4.2 Autonomous Flight Safety System (AFSS) Requirements**

An AFSS may be used for range operations where the implementation meets vehicle and operational constraints, and the system is designed and qualified to standards approved by the RSO.

The AFSS shall undergo at least three (3) successful demonstration flights conducted with a certified ground-commanded Flight Termination System before it can be used at ESC unless an alternative flight demonstration approach is approved by the Range Safety Office.

During the first demonstration flight, the AFSS shall not be connected to ordnance or other components used to terminate flight (i.e., flown in shadow mode).



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During subsequent demonstration flights, the AFSS can be connected to ordnance or other components used to terminate flight but shall be operated in parallel with the ground-commanded Flight Termination System.

## **6.5 Operational Procedures for Rockets, UAS and Other Similar Vehicles**

### **6.5.1 Countdown Procedures**

For each specific mission, a countdown procedure will be established in close co-operation with the range user. The ESC Flight Director will conduct the countdown, and countdown status will be displayed on the ESC countdown monitors.

### **6.5.2 Esrangle Impact Zone Clearance During Rocket Launch**

For Esrangle Impact Zone clearance the following rules apply:

1. During any rocket launch, all personnel at ESC, must stay indoors from T-10 minutes until the MRSO declares that the base area is safe.
2. SSC must co-ordinate its operations with the County Administration of Norrbotten as well as with the Swedish Transport Agency. Close contact must be established during countdown with the Air Traffic Control.
3. The Extended Zone A has to be used when required to fulfill public risk criteria. An application for the utilization of the Extended Zone A has to be submitted to the County Administration of Norrbotten.
4. The Zone C of the Esrangle impact area may only be used for impacts during the period October 1 - April 30.
5. Information about Zones B and C are placed in mailboxes on the warning signs around the zones. In total there are also 21 shelters in the Zone B and C. These shelters are built in order to offer the local population protection during rocket launches.
6. Long term warnings to the public concerning coming launches for the next six months shall be distributed according to a separate distribution list not later than June 30 and December 31 each year.
7. Short term warnings to the public concerning each campaign shall be published in the local press not later than seven days before the first countdown.
8. Radio warnings to the public shall be announced on the local state-owned radio network before each countdown. When having launched, or cancelled a countdown, information shall similarly be distributed via the local radio network.
9. When starting a countdown, the warning light in the ESC wind tower shall be switched on to activate Zone A and remain switched on until launch, or until the countdown is cancelled. When the Extended Zone A is activated then the warning light at Skaitevaara and LC-3 also shall be used at the same time.



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10. When the increased risk level during a countdown begins, barriers and warning lights shall be activated. These shall continue to be activated until launch or until countdown is cancelled and we have returned to normal safety restrictions.
11. During a countdown the warning siren system on the ESC main building shall be used for activating Zone A at T-1 hour, T-45 minutes, T-30 minutes and T-15 minutes and thereafter, if there is a standby in the countdown, with an interval of 1 hour. When having launched or when the countdown has been cancelled, the danger over signal shall be sent on the siren. When the Extended Zone A is activated then the warning siren at Skaitevaara and LC-3 also shall be used at the same time.

### **6.5.3 Aircraft Restricted Area**

Prior to the launch the Aircraft restricted area ES R01 or ES R01A shall be activated, see APPENDIX 5.

### **6.5.4 Nominal Impact**

The nominal impact point for suborbital rockets will be chosen to minimize the expected casualties and the probability of impacts outside the range boundaries.

### **6.5.5 Wind Weighting**

Wind weighting requirements are:

1. All unguided vehicles must be wind weighted.
  - Vehicles not capable of reaching population centers may be launched without being wind weighted, provided the elevation angle is 80 degrees or less.
2. Attitude controlled vehicles must also be wind weighted, unless otherwise decided by the RSO.
3. The accuracy of the operational wind weighting system must be better than the errors used in the vehicle dispersion analysis.

### **6.5.6 Ground Launched Vehicles Without FTS**

#### **6.5.6.1 Launch Limitations**

Mission specific launch limitations shall be documented in the Flight Safety Plan. General limitations are:

1. All hazard areas shall be cleared.
2. Maximum allowed elevation angle is 89°.
3. For unproven vehicles, the maximum elevation angle setting is 83°. The effective azimuth shall be chosen such that the geographical advantages of the impact area are realized.
4. Launch shall not occur if wind limitations or allowed wind variations defined in the Flight Safety Plan are exceeded.



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5. Launch shall not occur if spent stages, experiment bodies or other vehicle debris are predicted to impact within defined safety circles around the range infrastructure.
6. The MRSO's decision to hold any launch due to safety reasons is inviolable.
7. The LO's decision to hold any launch due to safety reasons is inviolable.
8. The FD's decision to hold any launch is inviolable.

### **6.5.7 Vehicles With FTS**

When launching a vehicle with an FTS, a Flight Control Officer (FCO) shall be appointed, and a Flight Safety System (FSS) shall be configured to control the mission risk.

#### **6.5.7.1 Flight Safety Operation Plan**

A Flight Safety Operation Plan shall be prepared, establishing e.g.:

- The configuration of the Flight Safety System
- Launch limitations
- Flight limits
- Flight Termination Criteria for the mission

The flight limits define the areas in which the flight under certain conditions must be terminated.

#### **6.5.7.2 Flight Safety System**

All data systems that provide information used to evaluate range safety requirements shall undergo validation to ensure operational readiness.

The FSS is a system used to mitigate risk to the public. A Flight Termination System (FTS) may be a major part of the FSS.

Examples of important components of the FSS including an FTS are:

- Positioning sources
- Data handling
- Range safety displays
- Tele-command uplink
- Vehicle FTS

If an AFSS is used the complexity of the FSS may be reduced.

#### **6.5.7.3 Prelaunch Checks**

1. Flight Termination Systems for rockets, UAS and other similar vehicles must be tested to meet the requirements specified in relevant RCC documents.
2. Operational tests must be performed to verify that the vehicle system operates within the RF limits specified by link analysis.



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3. Ground support components of the flight termination command system must be certified.
4. Prelaunch checks must be performed to certify the complete FTS system operationally.
5. A functional test must be performed during the countdown process to certify the FTS.

**6.5.7.4 Launch Limitations**

Mission specific launch limitations shall be documented in the Flight Safety Operation Plan. General limitations are:

1. All hazard areas shall be cleared.
2. A launch may and shall only occur when the Flight Safety System is configured properly according to the Flight Safety Operation Plan. The configuration includes but is not limited to:
  - Positioning sources
  - Impact limits
  - Flight limits
  - Attitude limits
3. Launch shall not occur if wind limitations or allowed wind variations defined in the Flight Safety Operations Plans are exceeded.
4. Launch shall not occur if spent stages, experiment bodies or other vehicle debris are predicted to impact within defined safety circles around the range infrastructure.
5. At least two independent tracking systems are required to provide real time positional/IIP data during launch.
6. A ceiling limitation must be imposed to ensure visibility so that the tracking stations have adequate time to provide reliable data.
7. The MRSO's decision to hold any launch due to safety reasons is inviolable.
8. The LO's decision to hold any launch due to safety reasons is inviolable.
9. The FD's decision to hold any launch is inviolable.

**6.5.7.5 Flight Termination Criteria**

1. Flight termination is required when valid data shows that the launch vehicle has or will violate a flight termination boundary.
2. Flight may be terminated as a result of gross trajectory deviation or obvious erratic flight. This action may be taken if, in the judgement of the FCO, further flight is likely to increase the hazard potential.
3. Actions to be taken when having loss of data, such that the Flight Control Officer (FCO) cannot certify vehicle performance within Flight Safety limits, are specified in the Flight Safety Operation Plan for each particular mission.





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4. An orbital launch vehicle not capable of reaching a minimally acceptable orbit.
5. Other flight termination criteria may be enforced due to the uniqueness of a particular mission. These criteria shall be documented in the Flight Safety Operation Plan.

#### **6.5.7.6 Data Requirements**

1. Flight termination decisions are only made using valid data. Valid data may come from sources that are valid at launch or may become valid at a time in flight as designated by the FCO.
2. At least two independent tracking systems are required to provide real time positional/IIP data during launch.
  - The tracking systems must be designed in such a way that no single order vehicle failure mode or ground system failure mode could cause the loss of both systems.
3. If GPS is used to satisfy the two-tracking source requirement, all of the following shall apply:
  - Two independent paths exist from receipt of GPS satellite information to transmission of GPS position data via telemetry. This can be met through redundant and independent GPS antennas, receiving systems, and telemetry transmitting systems on the launch vehicle.
  - Two independent paths exist from the ground receiving antenna to the Range Safety Display System. This can be met through redundant and independent receiving ground antennas, telemetry decommutation and processing systems, and Range Safety Display Systems.
  - The vehicle GPS system meets the requirements specified in RCC 324 Range Safety Performance Standards, or tailored version that is acceptable by the Range Safety Office.
4. All systems, which provide information used to evaluate Flight Safety requirements, must be certified prior to launch.

#### **6.5.8 Notices Outside Esrange Impact Area**

For missions that extend beyond the impact area the range shall coordinate with the applicable agencies to issue a NOTAM and a NOTMAR as defined in the applicable Flight Safety Plan for each range operation.

#### **6.5.9 Weather Restrictions**

The MRSO must have clear and convincing evidence that the following constraints are not violated:

1. The electrical storm criteria stated in Section 5.3.7.
2. Weather restrictions established in the Flight Safety Plan.





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## 6.6 Requirements for Balloons

All balloon flights, for which ESC has the operational responsibility, must fulfil the following requirements:

1. The risk criteria in Section 6.2.
2. The concerned requirements of “SERA 923/2012 Appendix 2 unmanned free balloons”
3. The requirements referenced to in the obtained flight permission.

### 6.6.1 Additional SSC requirements for all balloon flights

1. If the balloon envelope is 4000 m<sup>3</sup> or more the balloon envelope shall be equipped with minimum an A-mode radar transponder or other by SSC approved real time tracker.
2. If the balloon envelope is 10000 m<sup>3</sup> or more the balloon envelope shall be equipped with minimum an A-mode radar transponder.
3. Plastic balloons shall be equipped with a radar reflector if it does not have radar transponder.
4. Plastic balloons shall be equipped with recovery tracking unit.
5. Plastic balloons shall be equipped with strobe light.
6. Plastic zero-pressure balloons shall be equipped with two independent cut down systems in order to terminate the flight.

### 6.6.2 Additional SSC requirements for all balloon flights classified as heavy in SERA regulation

1. If the payload weight is more than 150 kg the flight train is required to be equipped with a load sensing system for automatic cut down to ensure proper parachute function in case of balloon burst.
2. Always (not only during darkness) use flight-train with alternate- colored bands or pennants if flight-train is more than 15 meters.
3. Always (not only during darkness) use strobe-light on all separating parts.

## 6.7 Operational Procedures for Balloons

### 6.7.1 Countdown Procedures

For each specific mission, a countdown procedure will be established in close co-operation with the range user. The ESC Flight Director will conduct the countdown, and countdown status will be displayed on the ESC countdown monitors.



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**6.7.2 Access to the Launch Pad**

1. Access to the launch pad will be granted only to Mission Essential Personnel in order to minimize the risk for injuries, should an accident occur.
2. Only vehicles necessary for carrying through the operations will be permitted on the balloon launch pad.
3. The ESC Launch Officer will exercise control over all personnel involved in the launch pad activities.

**6.7.3 Predicted Trajectory**

Before each flight, a predicted trajectory must be produced and issued to all ATC's concerned. The MRSO is responsible for approving the predicted trajectory.

**6.7.4 Flight and Impact Clearance**

1. SSC must co-ordinate its operations with all Civil Aviation Administrations concerned.
2. SSC will handle applications for flight permissions prior to each campaign.
3. Close contact will be established with all ATC's concerned during balloon operations in order to acquire launch, flight, and cut down permissions.
4. SSC will rely on the concerned ATC for co-ordination with other air traffic.
5. Parachute systems which are used to take down flight objects should be capable to reduce the vertical impact velocity to less than 8 m/s.
6. For free falling solid objects the Estrange Impact Zone shall be used.
7. For areas that the initial trajectory is likely to pass over, all public must stay indoors.

**6.7.5 Pre-launch Checks**

A flight compatibility test (FCT) must be performed before the first countdown. If equipment is replaced or added after a FCT, a new FCT has to be performed.

Functional checks of flight systems must be performed during each countdown. Transponder codes and frequencies must be in agreement with the Flight Safety Plan.

**6.7.6 Launch Limitations**

Approval from the ATC concerned must be acquired prior to each launch of a balloon. Launch limitations documented in the Flight Safety Plan must be satisfied.

The LO, the MRSO and the FD has the authority to stop a balloon launch if the mission risk is decided too high.

**6.7.6.1 Weather Constraints**

For each specific flight, launch limits for wind speed and direction will be established, depending on size of balloon, payload weight, etc. The rules concerning electrical storm criteria, Section 5.3.7, are also applicable.



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**6.7.6.2 Tracking Requirements**

At least one tracking system must be operational during each launch.

**6.7.7 Flight Termination Criteria**

Controlled termination of a balloon flight may only be executed after approval from the MRSO. A flight termination point and time shall be selected that satisfies the risk criteria in the Flight Safety Plan. The time and location of the flight termination point shall be coordinated with ATC; ATC shall also give clearance to terminate the flight.

**6.7.8 Unacceptable Flight Trajectories**

Should for any reason an unacceptable flight trajectory occur, actions for a safe cut down of the flight must be enforced.

If the balloon is equipped with tele-command cut down, and the ascent speed is judged to be insufficient for a successful completion of the flight, cut down should be executed after approval from the MRSO.

If the balloon is equipped with tele-command cut down, and the actual trajectory is likely to cause an impact in a prohibited impact area, premature cut down must be executed. The decision will be taken by the MRSO and cannot be overruled even if the balloon is performing normally.

**6.7.9 Recovery Requirements**

The flight train must have at least one tracking system operational after landing.

The payload owner is responsible for giving necessary instructions to the recovery officer.



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**7 RANGE USER RESPONSIBILITIES**

1. Obtain approval prior to conducting any potentially hazardous operation.
2. Provide data to SSC for safety analysis (see Section 8).
3. Provide a written Campaign Requirements Plan.
4. Identify the minimum safety requirements for operations. If a range user determines that his/her safety requirements are more stringent than those imposed by SSC, the range user must coordinate these requirements through the SSC Project Manager.
5. Participate in discussions to familiarize SSC personnel with all aspects of the mission.
6. Participate in real time data evaluation for mission control and/or flight termination, as required by the Range Safety Office.
7. Notify the SSC Project Manager of all meetings connected to safety related issues, i.e. Design Reviews, Operational Planning meetings.
8. Participate in failure/anomaly investigations and provide post-flight data as required.
9. Provide a written waiver request to the SSC Project Manager for any requirements specified in this document that cannot be satisfied.
10. Identify range user's Project Manager or Safety Responsible to sign the document Estrange Safety and Security Compliance Confirmation.
11. Keep the range user's own personnel informed about the safety rules contained in this ESM.



## **8 ESRANGE SPACE CENTER SAFETY DATA REQUIREMENTS ON RANGE USERS**

### **8.1 Launch Vehicle and Payload Description Data**

#### **8.1.1 Hazardous Electrical Circuits**

The range user must provide the SSC Project Manager with one readily distinguishable copy of schematic and wiring diagrams of all pyrotechnic and other circuits which initiate hazardous systems. SSC must be promptly notified of any changes to hazardous electrical circuits.

#### **8.1.2 Mechanical Systems**

The range user must provide a description, including technical details and precautions, for all hazardous mechanical systems. Scale drawings must be supplied showing the location of these and all other hazardous systems (ordnance, pressure, etc.).

#### **8.1.3 Ordnance Devices**

For each EED, data sheets must be provided listing the minimum all fire current, maximum no fire current, recommended firing current, normal resistance, pin-to-case resistance, and, if available, the RF sensitivity characteristics. A technical description of all SAFE/ARM type devices (out-of-line Safe/Arm, SA connectors, mechanical restraints, etc.) employed must be provided. For ordnance devices such as: rocket motors, shape charges, detonating cord, etc., data sheets must be provided which identify the UN explosive classification, normal output characteristics, composition, or any other relevant information needed to perform safety analysis.

#### **8.1.4 Chemicals**

The range user must provide piping and instrumentation diagrams as required, a complete and accurate functional description of the system and information on components (tanks, fittings, valves). System safety features must be defined. A Safety Data Sheet for each chemical used on the project must also be provided.

#### **8.1.5 Pressure Systems**

The range user must provide a description of all pressure systems used on the project. Technical characteristics, including design pressures, internal volume and materials of construction must be provided. The range user must provide piping and instrumentation diagram of the system.

#### **8.1.6 Cryogenic Systems**

Cryogenic systems are defined as systems handling fluids colder than -150°C. Cryogenic systems are considered as chemical systems and pressurized systems hence relevant information on those topics must be provided. Further information about cryogenic systems can be found in Cryogenic Safety at Esrange Space Center [R2].



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## **8.1.7 Radiation Sources**

### **8.1.7.1 Non-ionizing (RF) Sources**

The range user must provide data on all non-ionizing emitters including frequency, type of emission, type of radiating antenna, and radiated power (both peak and average), modulation, deviation.

### **8.1.7.2 Ionizing Sources**

The range user must provide data on all ionizing sources as required by the Swedish Radiation Safety Authority.

### **8.1.7.3 Optical Sources**

The range user must provide data on all hazardous optical emitters (e.g. lasers) including wavelength, pulse width, pulse repetition frequency, divergence angle, and power output.

## **8.2 Operating Procedures**

### **8.2.1 Hazardous Systems**

Detailed procedures for handling, assembly, and checkout for all hazardous systems (ordnance, mechanical, pressure, chemical etc.) must be provided to the SSC Project Manager.

### **8.2.2 Recovery**

For recovery operations, procedures shall be provided with a description of the items to be recovered, reasons for recovery, hazards involved, and any recovery aids and their characteristics.

These procedures shall describe the methods employed to verify that all hazardous systems are in a SAFE condition during recovery operations.

A list of recovery aids such as chaff (frequency, quantity), locator beacons (frequency, power output, period of operation), dye marker (color persistence, time of deployment), flashing light (color, frequency, duration, candle power, directional characteristics), smoke (color, duration, time of deployment), radar reflective parachute (when deployed, size), or any other aids used should be included. Information on the desired period of recovery operations and the disposition of the recovered items shall also be provided.

### **8.2.3 Contingencies**

Contingency procedures must be provided prior to beginning operations. These contingency procedures include steps to be taken in the event of launch postponement, launch cancellation (including de-staging), hold or abort, booster ignition failure, emergency response, chemical spill cleanup, or any other contingency which may endanger personnel or property.

### **8.2.4 Approval**

All procedures for handling, assembly, and check-out of hazardous systems must be approved by the GSO/Launch Officer prior to use at ESC or at another location where ESC



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has the operational responsibility. Approvals must be obtained prior to performing any potentially hazardous operation.

## **8.3 Performance and Flight Worthiness Data Requirements**

### **8.3.1 General**

The specifications defined in this section are intended as a synopsis for information required performing a Flight Safety analysis. The actual requirements must be mission specific. The SSC Project Manager is responsible for coordinating data requirements with Flight Safety personnel.

### **8.3.2 Rockets, UAS and other similar Vehicles**

#### **8.3.2.1 Required Descriptions**

Provide a description of the mission.

Provide a vehicle description including a scaled drawing and operating procedures.

Provide a description of Loss of Signal (LOS) contingencies.

#### **8.3.2.2 Required Nominal Trajectory Inputs**

1. Mass Properties - weights, inertias, and center of gravity.
2. Propulsion - thrust and chamber pressure.
3. Aerodynamics - Cd, CNa, Cma, Cmq, Clp, and Cld.
4. Guidance and Control - guidance program, attitude gains, and attitude rate gains.
5. Launch parameters and a sequence of events (ignitions, burnouts, separations, etc.).
6. For UAS, supply nominal flight profile, including waypoints.

#### **8.3.2.3 Required Trajectory Outputs**

Output data is required in printed, plotted or computer medium format for each impacting body. The output should include:

1. Time, velocity, altitude, horizontal range, weight, thrust, drag, dynamic pressure, angle of attack, velocity vector elevation and azimuth angles, body attitude angles and rates, present position and instantaneous impact prediction latitude and longitude, "round earth" x, y, and z, slant range, azimuth, and elevation relative to the launcher, and control system forces, moments and deflections.
2. Provide stability and dynamics analysis including flexible body, static margins, and a roll rate vs. pitching frequency.
3. Provide the results of an aero elastic and structural analysis.
4. Provide a wind effect analysis and the method used for calculation. Provide data consistent with currently used ESC wind compensation methods.
5. Provide the results of a thermal analysis.





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6. Provide total dispersion data, either theoretical and/or empirical, in terms of one, two, and three sigma ellipses for all impacting bodies. The RSO must approve all techniques and values of error sources used in the dispersion analysis. A theoretical analysis must include the following effects: thrust offset, thrust misalignments, weight and impulse errors, uncompensated wind, launcher misalignments, guidance and control system errors, ignition delay, and any other errors unique to this vehicle. Provide flight history trajectory data on previous vehicle flights.

#### **8.3.2.4 Vehicle Malfunction and Break-Up Analysis**

For vehicle employing a guidance and FTS system a detailed analysis is required regarding failure modes and possible effects.

1. All possible malfunctions from either hardware or software failure during all phases of flight including the probability of those malfunctions occurring.
2. The trajectory deviations occurring from a malfunction.
3. Vehicle break-up analysis with a detailed debris catalog resulting from an aerodynamic break-up, FTS activation, explosion, or other similar event.
4. Risk of FTS malfunction.

The Range Safety Office shall agree on the specific parameters produced in the analysis.

#### **8.3.2.5 Orbital Vehicles**

For Orbital range operations the following needs to be provided:

1. At a chosen point in the trajectory, provide the minimal vehicle state vector that will allow the vehicle to be able to reach a minimally viable orbit.
2. Provide orbital insertion data for all components remaining in orbit.

#### **8.3.2.6 Distant Focusing Overpressure Analysis**

Provide an analysis that shows the start of aerodynamic breakup of the vehicle that can be used in the Distant Focusing Overpressure (DFO) analysis. The analysis shall be based on the Q-Alpha (dynamic pressure – angle of attack) limit of the vehicle.

Provide data regarding the remaining amount of propellant on board and the resulting TNT-equivalent from an intact impact for all times where this is possible.

#### **8.3.2.7 Toxic Release Analysis**

Provide toxic hazard analysis to include types and quantities of hazardous gases and by-products of combustion of solid and liquid propellants. Kerosene-based fuels are not considered hazardous chemicals in this context.

#### **8.3.2.8 Collision Avoidance**

For missions requiring COLA, provide 1 Hz trajectories for all orbital objects to include the spacecraft, boosters and any deployable out to 3 hours after launch. Trajectories are for all mission profiles/trajectories planned to be flown. The trajectories must be in the required format - Caliper Trajectory Covariance V2.0 file. Specification can be provided.





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**8.3.2.9 Other Requirements**

The range user shall be able to provide a physical and mathematical description of all vehicle guidance and control systems if so requested by Flight Safety personnel.

A Hazard Analysis could be required on critical systems, depending on systems. Identification of each potential hazard, the preventive measures to reduce each potential hazard, and a risk assessment for those potential hazards which cannot be eliminated by preventive measures should be included in the Hazard Analysis.

**8.3.3 Balloons**

The range user should together with SSC:

1. Identify launch site and launch window.
2. Provide payload, balloon and parachute characteristics.
  - Payload dimensions and total suspended weight.
  - Balloon material, volume, and weight.
  - Gross inflation weight. Totally lifted weight.
  - Provide payload/parachute weight, drag coefficient, and reference area.
3. Provide nominal trajectories and flight profiles.
4. Provide description of any balloon control system (such as a valve system).
5. Provide balloon flight history data.
6. On SSC request provide balloon system reliability data including number of flights, number and types of failures, and where the failures occurred (ascent, float, or descent).
7. Actual and predicted payload/parachute descent vectors. Actual balloon descent vectors if available.
8. Provide wind limitations for balloon launches.

**8.3.3.1 Structural Requirements for Balloon Gondolas**

The following design criteria should be used in planning gondola structures and suspension.

Gondolas must be designed so that all load-carrying structural members, joints, connectors, decks, and suspension systems can withstand the conditions listed below without ultimate structural failure.

- A load 10 times the weight of the payload applied vertically at the suspension point.
- For multiple-cable suspension systems, each cable must have an ultimate strength greater than five times the weight of the payload divided by the sine of the angle that the cable makes with horizontal (should be >30 degrees) in a normal flight configuration. Cable terminations, cable attachments, and gondola structural members must be capable of withstanding the load described above. Some



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exceptions to this criterion may be allowed for gondolas with more than four suspension points.

- A load five times the weight of the payload applied at the suspension point and 45 degrees to the vertical. This load factor must be accounted for in the direction perpendicular to the gondola's short side, perpendicular to the gondola's long side, and in the direction of the major rigid support members at the top of the gondola structure. If flexible cable suspension systems are used, they must be able to withstand uneven loading caused by cable buckling.
- A side acceleration of 5 g applied to all components and equipment attached to and/or onboard the gondola structure or any portion of the flight system below the balloon.
- One exception from above requirements is balloon flights classed as light and medium according to SERA regulations is the flight train strength. The flight train strength on those shall not exceed 230 N.

## **8.4 Telemetry Data Requirements for Vehicles with Flight Termination System**

The specifications defined in this section are intended as a synopsis for pre-flight and real time data requirements. The actual requirements are mission specific, and the range user is responsible for coordinating the TM data requirements with the Estrange Range Safety Office.

Vehicle health parameters:

1. Inertial Navigation System (INS) parameters, such as position, velocity, and acceleration. All reference systems must be defined
2. Inertial Navigation System initialization parameters
3. Guidance commands to flight control effectors, e.g. nozzle deflections in the pitch and yaw axes or aerodynamic surface deflections
4. Flight control effector position feedback
5. Vehicle attitude data including pitch, yaw and roll angles and rates
6. Engine chamber pressures
7. Control Circuit Status, e.g. flight termination receiver output command status
8. Global Positioning System (GPS) positional and velocity data
9. Indicators of separation or jettisoned events
10. Health status of any other on-board position sensors

On-board FTS health monitoring parameters:

1. Receiver signal strength, command, and pilot tone, or check channel status
2. Safe/arm status of each safe & arm device



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3. FTS battery voltage
4. FTS battery current
5. FTS battery temperature

## **8.5 Schedules for Providing Required Data**

The schedule defined in Section 8.8 shall be followed.

If deadlines are not met, the Range Safety Office may not be able to prepare all necessary safety procedures in time to support a proposed flight. In any case, the mission must not be conducted until adequate safety preparations are made.

## **8.6 Waivers from Other Ranges**

The range user shall inform ESC of any waiver for the launch vehicle or payload granted by another range and provide ESC a copy of the waiver.

## **8.7 Reviews**

Range user shall invite the SSC Project Manager to participate in Design and Mission Readiness Reviews for each mission. The range user shall notify Estrange Safety Office through the SSC Project Manager at least ten days prior to conducting such reviews. Safety participation in such reviews may prevent costly engineering changes and scheduling delays.

Should the SSC Project Manager not be represented at Design Reviews and Mission Readiness Reviews, a copy of the review material must be submitted to SSC Project Manager as early as possible following the review.



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## 8.8 Data Requirements and Review Schedule

<b>Time</b>	<b>Main events</b>
Kick-off	Project kick-off meeting. SSC Project Manager participates. Range user supplies preliminary information on hazardous materials and operations, required permits and waivers and other safety issues as well as information on planned mission.
T-9 months	For orbital vehicles, trajectory, payload and vehicle data must be submitted to SSC no later than T-9 months prior to the campaign.
T-6 months	For suborbital vehicles and balloons, the final information on hazardous materials as well as information on planned experiments shall be submitted by the range user.  For suborbital vehicles without flight heritage, all data needs to be submitted for the risk analysis by the range user.  For missions using FTS, the final version of the FTS Report shall be delivered to the Esrange Safety Office.
T-4 months	For suborbital vehicle or payload systems not previously launched from ESC, preliminary payload data and final motor data must be submitted no later than T-4 months prior to the campaign. All final data must be supplied no later than T-2 months.  For UAS, vehicle data and a flight profile must be submitted to SSC no later than T-4 months prior to the campaign.
T-2 months	For suborbital vehicles and payload systems, the range user supplies Campaign Requirements Plan. All final data on the vehicle or balloon system must be supplied by the range user to allow for mission approval by the Esrange Safety Board.  For static tests, all rocket engine test campaign data must be submitted to SSC no later than T-2 months.
T-2 months	Latest time to apply for frequency permissions.
T-6 weeks	Latest time to apply for balloon flight permissions.
T-7 days	Final recovery instructions for missions with planned impact.
T-2 days	Countdown procedure approved.
T-2 days	Pre-launch Meeting.
T-1 day	Test countdown for rocket vehicles.
T+1 day	Post-mission Meeting.
T+2 weeks	Esrange Space Center Post-mission Report published.
T+1 month	Post-flight FTS mission analysis delivered to Esrange Safety Office



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## 9 REFERENCE DOCUMENTS

The documents listed in this section contain provisions that constitute requirements of this standard. The latest issuances of the cited documents shall be used unless otherwise is stated.

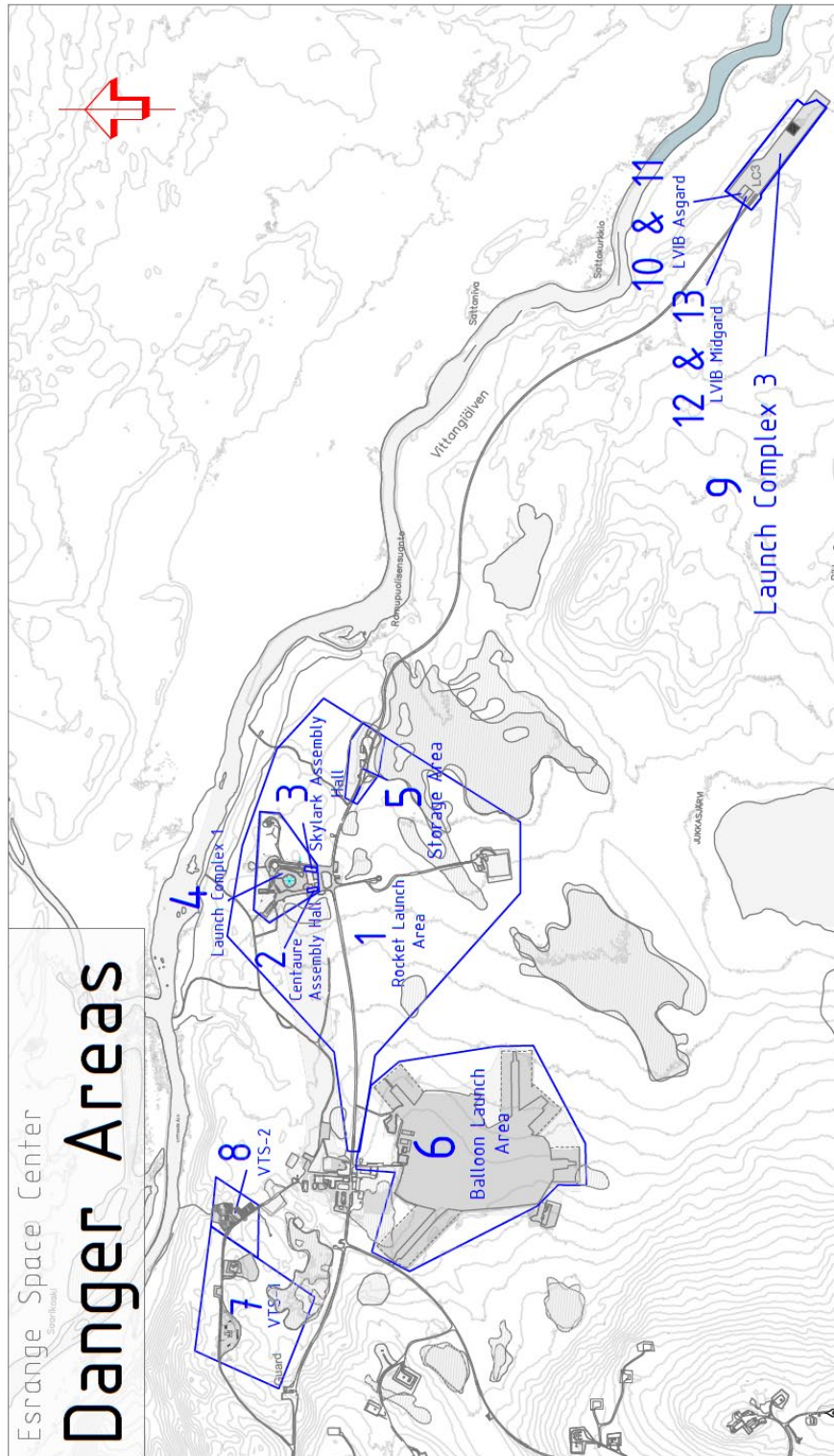
### 9.1 SSC Documents

- [R1] Esrange FTS Range Approval Process SCIENCE-878286732-26578  
<https://sscspace.com/uploads/Esrange-FTS-Range-Approval-Process-v2.pdf>
- [R2] Cryogenic Safety at Esrange Space Center SCIENCE-878286732-26684  
[https://sscspace.com/inc/uploads/Cryogenic-Safety-at-Esrange-Space-Center\\_1.pdf](https://sscspace.com/inc/uploads/Cryogenic-Safety-at-Esrange-Space-Center_1.pdf)



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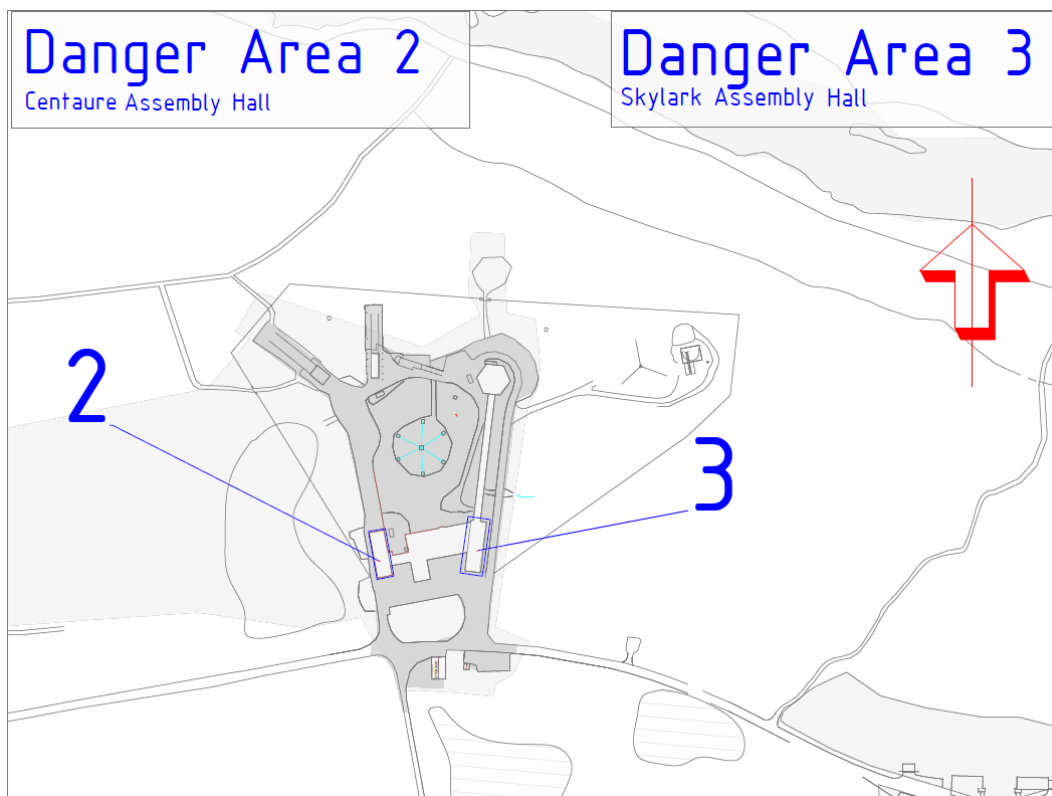
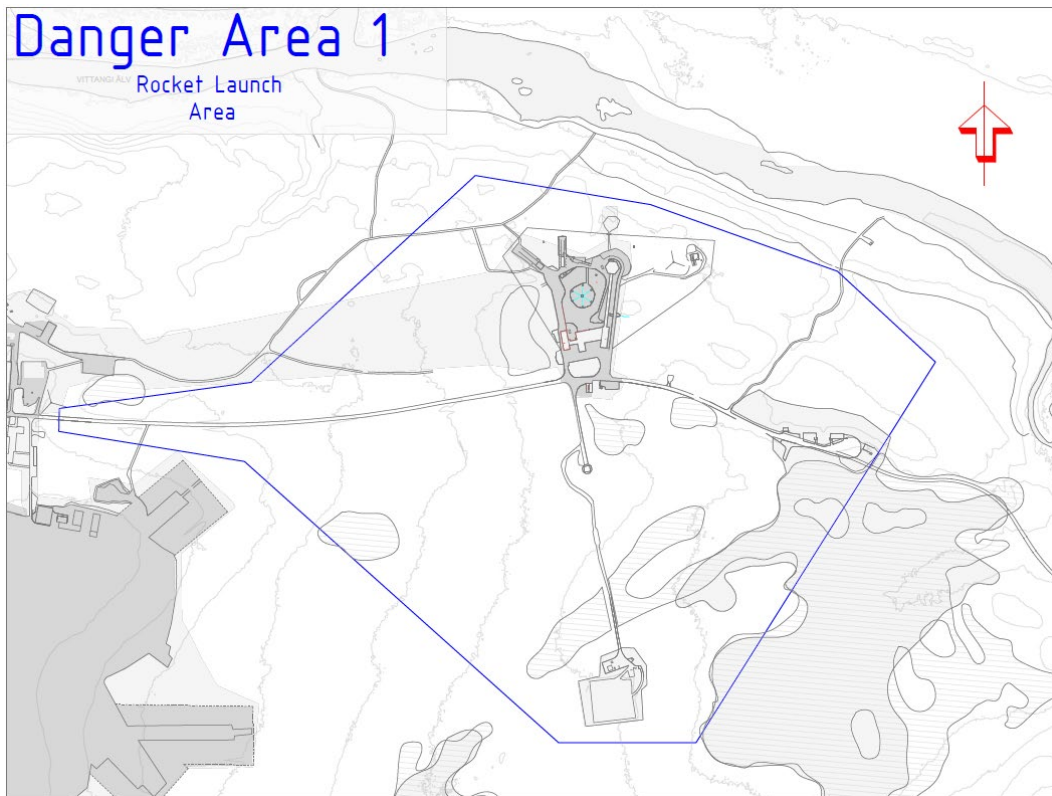
**APPENDIX 1. ESC DANGER AREAS.**





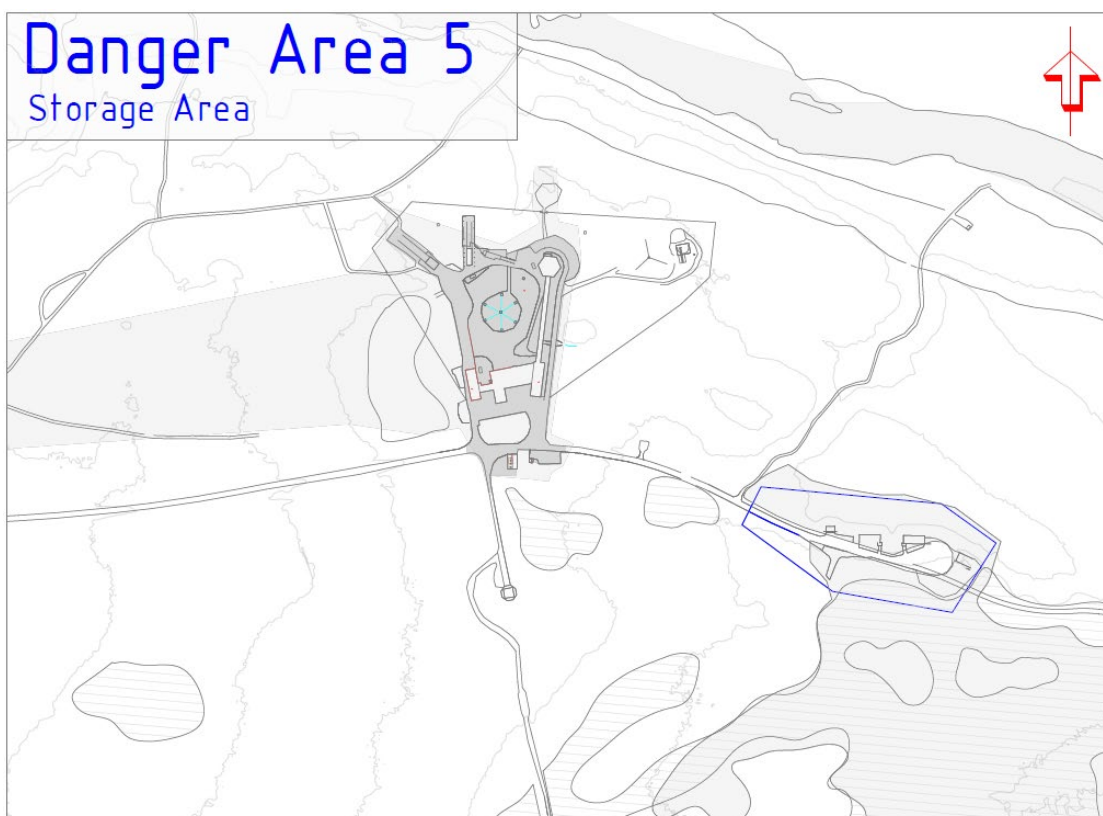
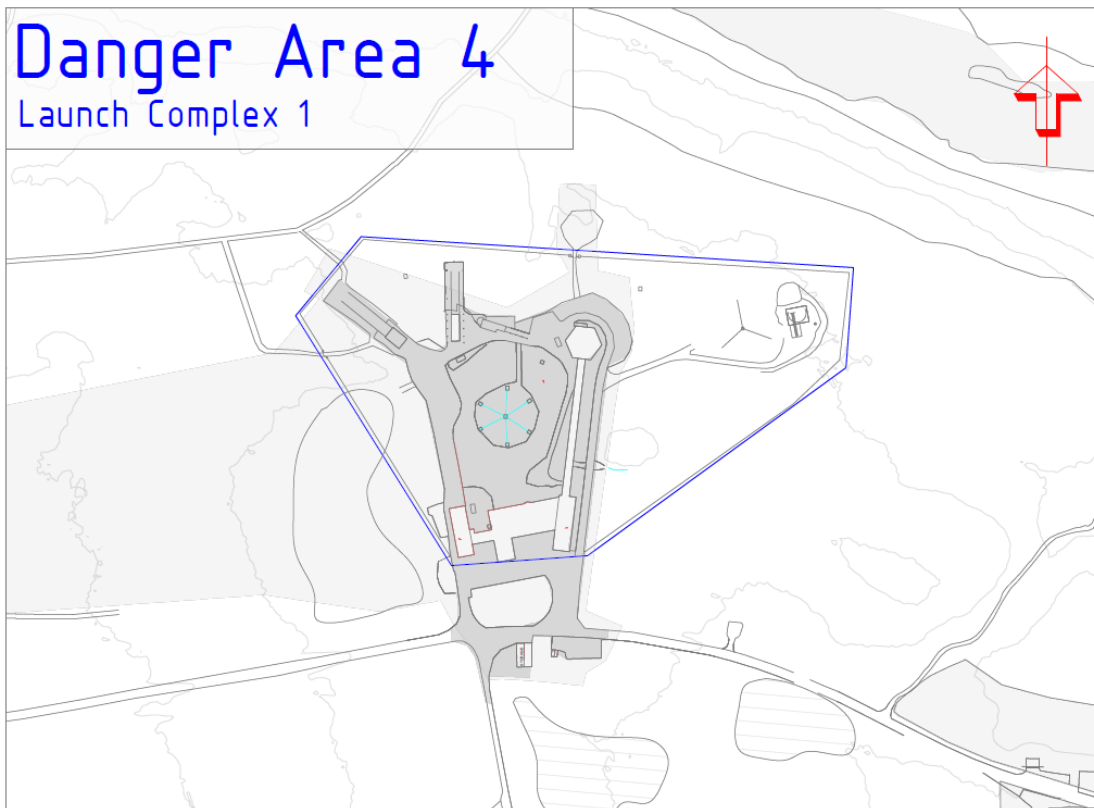


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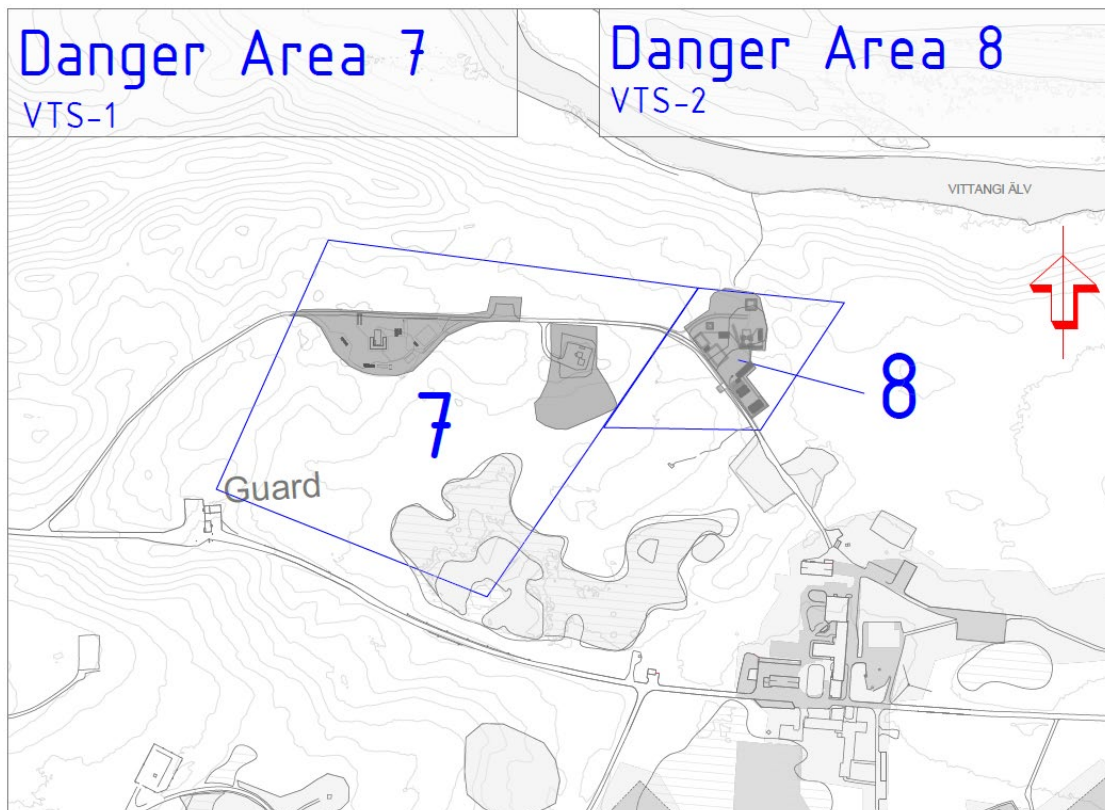
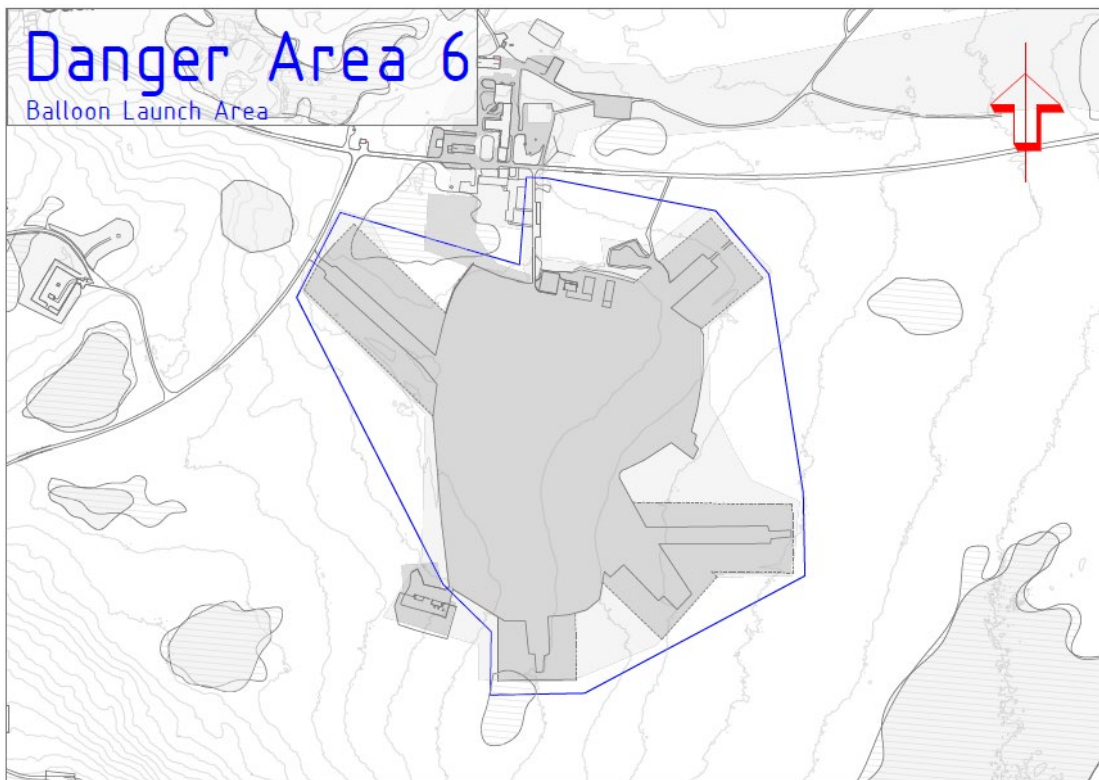
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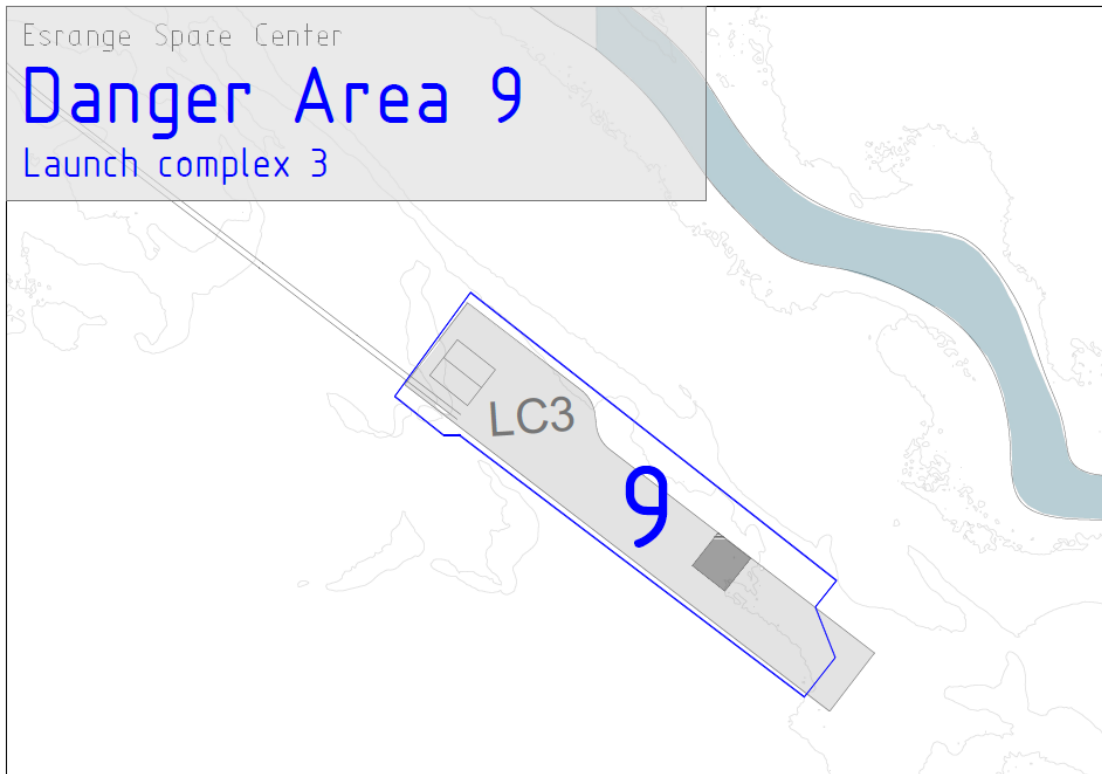


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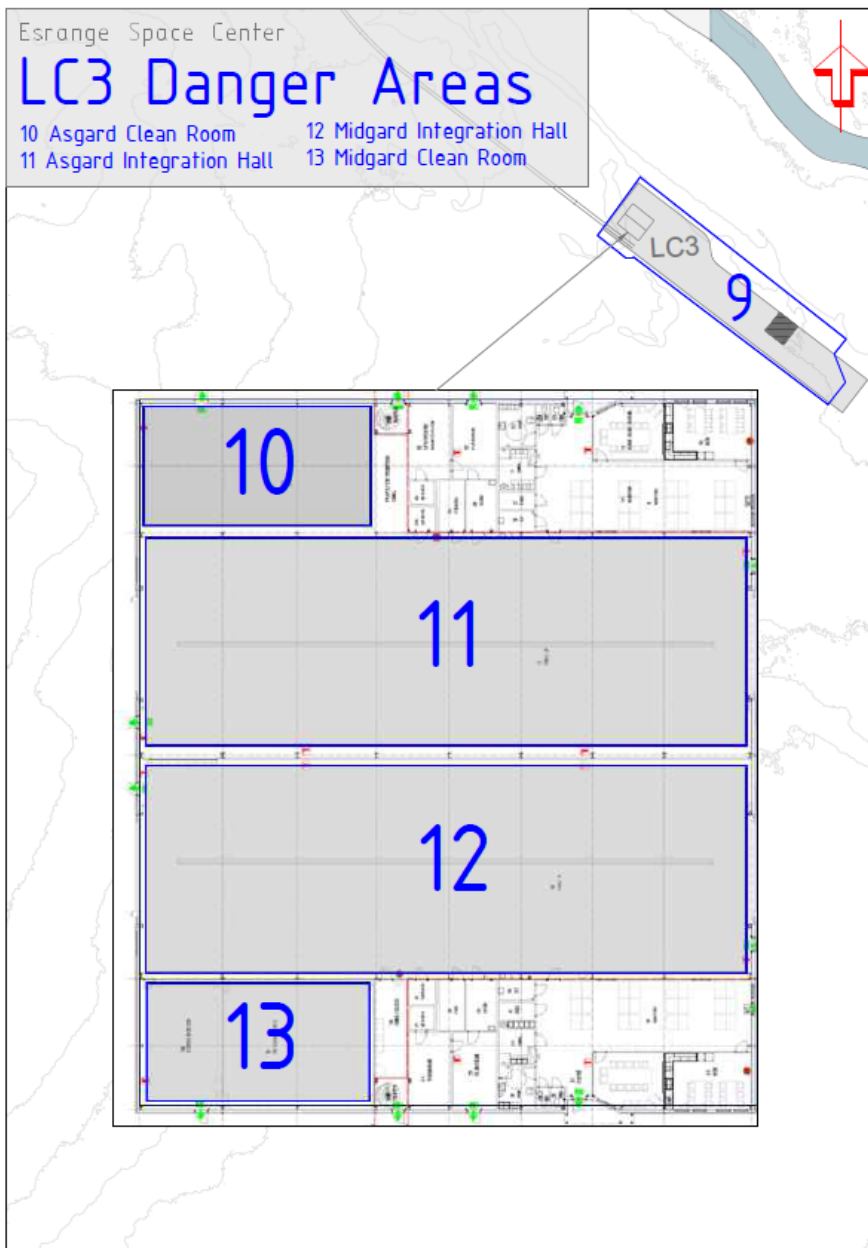


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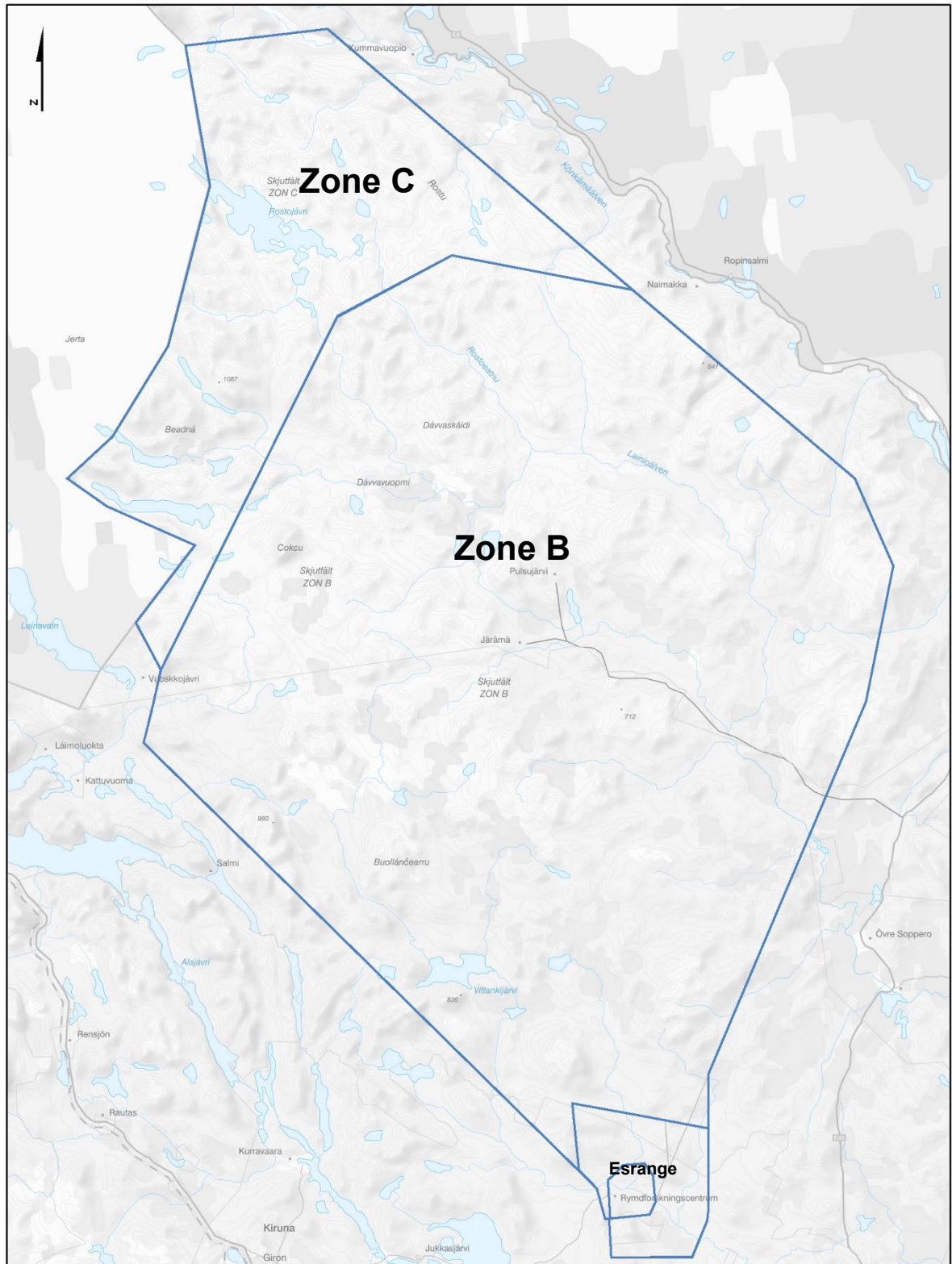


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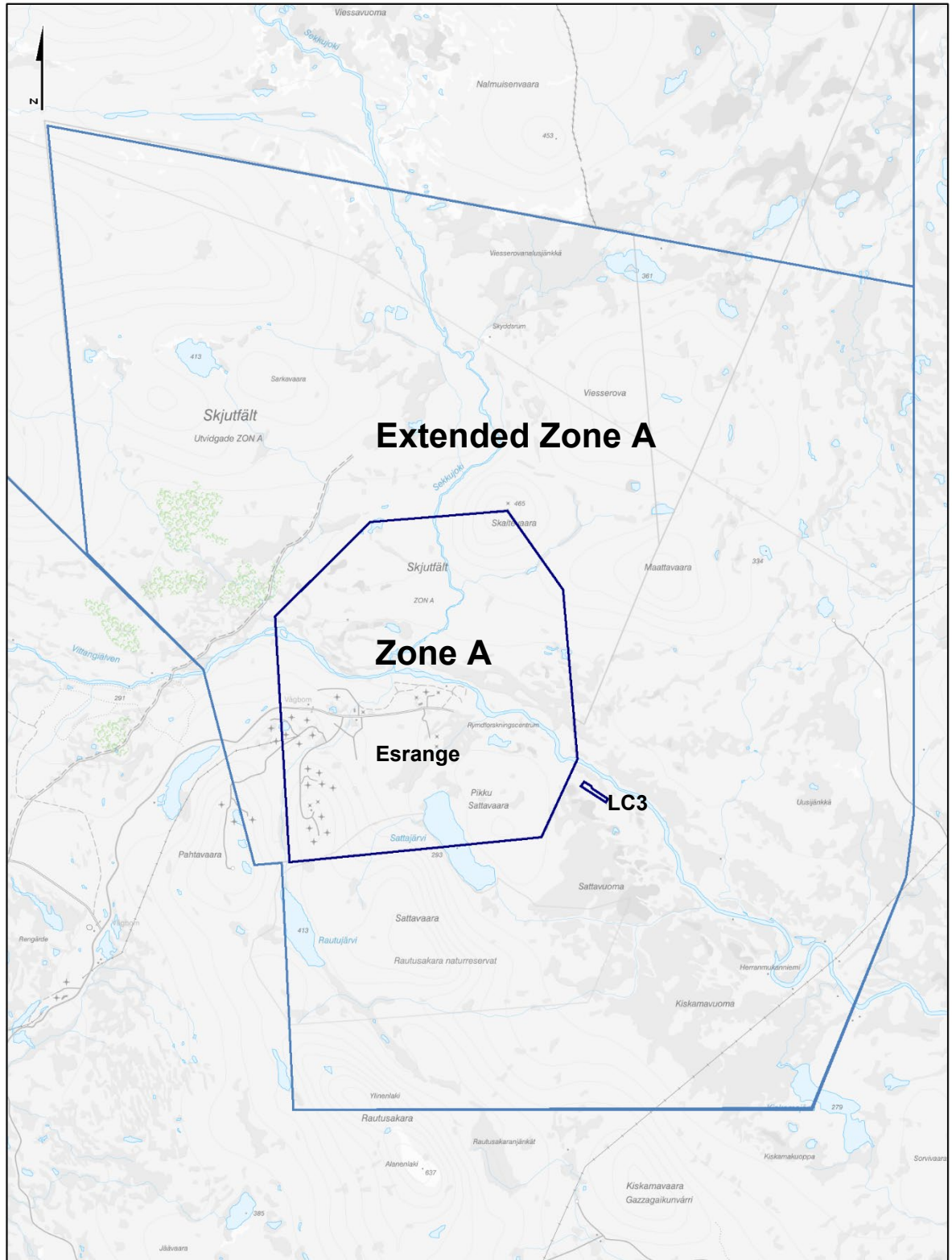
**APPENDIX 2. ESC ZONE B AND ZONE C.**





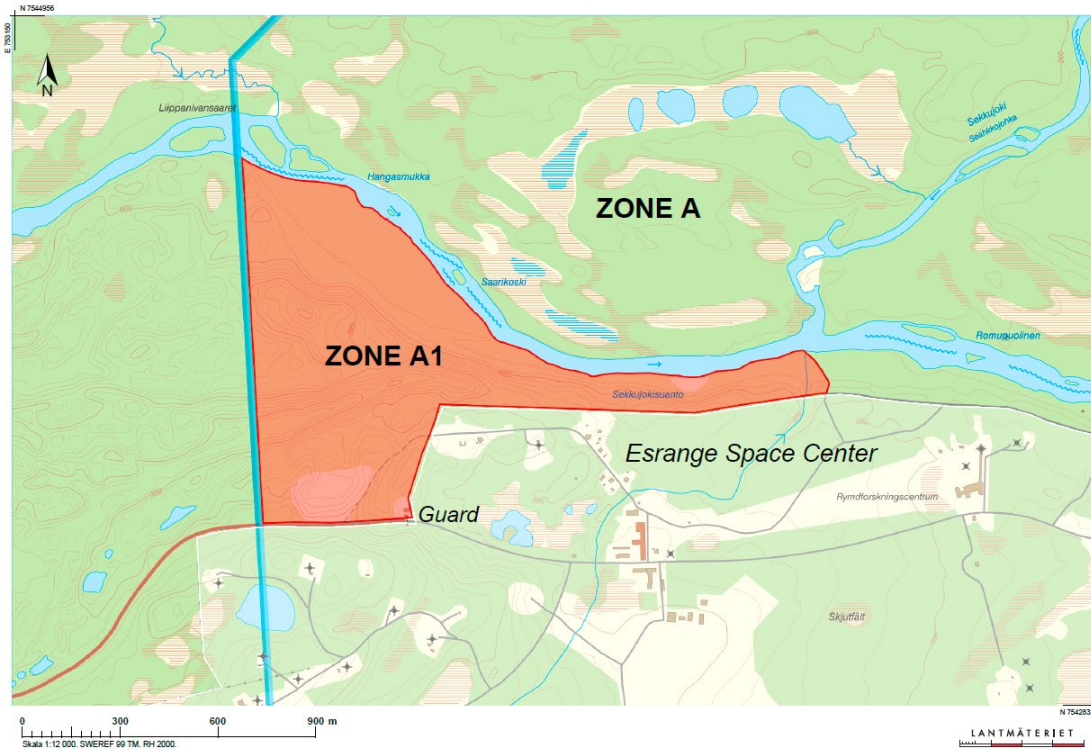
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**APPENDIX 3. ESC ZONE A AND EXTENDED ZONE A.**



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**APPENDIX 4. ESC MICROZONE A1.**



**APPENDIX 5. AIRCRAFT RESTRICTED AREAS ES R01 AND R01A.**

