Version 1.2
24 August 2022

ESRANGE USER'S HANDBOOK

Volume III
Launch Range Instrumentation

CHANGE LOG

Version	Issued	Changes
1.2	24 August 2022	Document Id added
1.1	21 May 2021	Minor typos; author and title added in file info
1	7 May 2021	Full re-write of Volume, new issue

APPROVAL

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

Lennart Poromaa Digitally signed by Alf Lennart Poromaa
Date: 2022-08-24 12:40:59+02:00

PREFACE

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

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

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

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

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

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

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

Volumes in Esrange User's Handbook

Vol. I - General Information	Vol. II - Safety
Vol. III - Launch Range Instrumentation	Vol. A - Abbreviations and References
Vol. IV - Scientific Ground Instruments	
Vol. V - UAS	Vol. VI - Stratospheric Balloons
Vol. VII - Sounding Rockets	Vol. VIII - Propulsive Development Testing
Vol. IX - Spaceport	
Vol. X - Satellite Telemetry, Tracking & Control	

Table of Contents

1 INTRODUCTION

The definition of Launch Range Instrumentation at Esrange Space Center (ESC) is the instrumentation used to support launch and flight operations of UAVs, Stratospheric Balloons, Sounding Rockets and Space Launch Vehicles (i.e., the operations that are explained in more detail within Volumes IV through IX).

2 FREQUENCY COORDINATION

To avoid interference between radio signals, Esrange has a frequency management system based on approvals issued by the Swedish authorities. Please contact the relevant Project Manager for matters regarding radio frequency transmissions.

For all transmitters that are to be used on the range, technical data must be submitted to Esrange at least two months before the desired start of use. The range user must describe:

- Frequency
- Bandwidth
- Power
  - » Transmitter output power and antenna gain

  or
  - » Effective Isotropic Radiated Power (EIRP)
- Duty cycle (if applicable)
- Duration the transmitter will be used

2.1 Recommended Frequencies

Any frequency can be applied for, but depending on the use of that particular frequency within Sweden it may not be approved. However, the possibility to obtain approval is higher for the frequencies identified in the table below, as they are commonly used at Esrange:

Frequency	Bandwidth	Power	Note
173 – 174 MHz	25 kHz	<10 mW	TM downlink for small payloads
400 – 445 MHz	25 kHz	< 2 W	
1445 – 1515 MHz	1 MHz	<4 W	
2300 – 2400 MHz	10 MHz	<10 W	TM downlink

2.2 Discouraged Frequencies

Frequencies between 2025 and 2110 MHz, as well as between 2200 and 2300 MHz are strongly discouraged, as ground stations at Esrange are communicating with a large number of satellites every day via links in these frequency bands.

Frequencies between 3600 and 3800 MHz are allocated to the Swedish national 5G network and will therefore likely not be approved for use.

3 TELEMETRY

Telemetry acquisition, storage and delivery can be provided by ESC, if desired.

Importantly:

- Processing and monitoring for Flight Safety purposes will be performed in real-time
- All downlinked data will be stored and delivered for post-flight analysis

The Esrange TM Station is flexible and can be configured for different missions, and is normally capable of supporting more than one mission simultaneously. The station complies with the IRIG-standard and is capable of receiving several RF downlinks in P-, L- and S-band. The signals are recorded, demodulated and distributed to customers.

Received data can be distributed over an IP network or as a PCM stream (NRZ-L or Bi-Φ) to customers located in the Scientific Center, sounding rocket blockhouse or any of the balloon buildings. Switching between signal sources can be done during flight for best possible data reception. The station can also extract position data from the telemetry and distribute it over PosNet.

Fig. 1 - Esrange telemetry station during MAXUS 9 countdown

3.1 Antenna systems

The Esrange TM Station currently consists of three auto-tracking antennas, while on a typical sounding rocket launch one or two systems are used.

Name	Freq. range (MHz)	Ant. dia. (m)	G/T [minimum] (dB/K)	Beam width (°)	Polarization	Track speed (°/s)	Acceleration ((°/s²)	Track mode
EMP	L / S	2.4	8 (S)	6 (L) 4 (S)	RHC/LHC	20	20	Auto / Manual
KEOPS	L / S	5	12 (S)	2.4 (L) 1.8 (S)	RHC/LHC	30	30	Auto / Manual
ORBIT	L / S	3.7	11 (S)	3.5 (L) 2.5 (S)	RHC/LHC	25	25	Auto / Manual

3.1.1 EMP antenna

The EMP antenna is located on the roof of the Main Building, with line of sight to all sounding rocket launch pads. The antenna is a 2.4 m parabolic reflector with acquisition aid (20° width) and has receiving capability on L- and S-band frequencies.

3.1.2 KEOPS antenna

The Kiruna Esrange Optical Platform System (KEOPS) antenna is located outside the main Base Area on Pahtavara hill, 3 km from the main building. This location offers a beneficial horizon profile with coverage close to the typical sounding rocket payload impact location in the downrange impact area. The antenna is a 5 m parabolic reflector and has receiving capability for L- and S-band frequencies.

3.1.3 Orbit antenna

The Orbit antenna is located inside a radome on the roof of the Satellite Station building and has line of sight to all of the sounding rocket launch pads and the balloon launch area. The antenna is a 3.7 m parabolic reflector and has receiving capability for L- and S-band frequencies. It can also be equipped with a transmitter for S-band, with a maximum transmission power of 200 W.

3.2 Receivers

The RF receivers used at Esrange are highly configurable to suit different campaign requirements. All equipment complies with RCC standards. The primary receivers consist of five Cortex RTRs and two Cortex RX-1s, configured to suit each campaign. For redundancy, backup and/or tracking, Microdyne 700 MR & MRB are used.

The Cortex RTRs and RX-1s include:

- Dual channel S-band, L-band and P-band tuners
- Pre- and post-detection combiners
- Demodulators for BPSK, QPSK, OQPSK, PCM-PM, PCM-FM, FM, SOQPSK and FQPSK demodulation
- Bit synchronizers for up to 30 Mbps
- Automatic Frequency Control
- Viterbi decoders
- Reed Solomon decoders
- 3 Frame synchronizers
- Telemetry to Ethernet

3.3 Recording

All received telemetry signals are recorded by the Esrange TM station. The main recorders are two Wideband DRS8500s, following the IRIG-106-chapter 10 standard. Analog TV is also recorded on digital recorders.

The Wideband DRS8500s include:

- IF channels
- 8 Analog channels
- 8 Digital PCM channels

All data is time-stamped with UTC time.

3.4 Telemetry for Orbital Launches

ESC will provide tracking and telemetry downlink during lift-off and flight until the launch vehicle has achieved the target orbit or reached a safe end state.

The primary purpose of the SSC-provided antenna network will be to meet Flight Safety requirements. As such, the network will be configured to cover the entire powered portion of the ascent trajectory, up until the LV has reached a safe end state.

If desired, tracking and telemetry during payload insertion into orbit can also be handled separately (i.e., not as part of the spaceport service) by SSC's Satellite Management Services division.

3.5 DLR telemetry station

If requested and approved by DLR it is also possible to use the DLR TM station. The station is located close to the Main Building, overlooking the sounding rocket launch pads. It is capable of L- and S-band tracking and can receive, demodulate, process, record and distribute the telemetry data.

4 RANGING

Ranging is a position measurement system, combining the PCM phase shift in telemetry frames and the antenna pointing angles for determination of a rocket's positions. The system requires a stable oscillator onboard to be able to measure accurate positions. Ranging is possible from either the EMP or Orbit antennas, as well as the DLR TM station.

5 TELE-COMMAND

The sounding rocket payload tele-command (TC) uplink (SCI TC) accepts an input of either an analogue or a digital signal. The system is completely redundant (two separate chains) with automatic fallback to the secondary chain.

There is also a dedicated TC uplink for the FTS system, which is completely redundant (two separate chains) with automatic fallback to the secondary chain.

The antennas for both the sounding rocket payload TC and the FTS TC are fixed pointing with an inclination ideal for sounding rocket flights into the downrange impact area.

The table below shows data for the different TC systems at Esrange.

Type	Freq. (MHz)	EIRP (dBm)	Modulation	Deviation (kHz)	Interface	Polarization
SCI TC	410-450	70.7	Digital CPFSK, GMSK or analogue FM (with or without ALC)	<180	Analogue input (50 Ω BNC female), Digital balanced (100 Ω TRB female), and digital un-balanced (50 Ω BNC female)	LHC
FTS	448	73.8			N/A	LHC

6 RADAR

6.1 Tracking radar

If requested and approved by DLR, C-band tracking radar support can be available by using a mobile RIR 774C radar from DLR MORABA.

The radar has both skin and transponder tracking capability.

6.2 Surveillance radar

If requested and approved by FMV, surveillance radar support can be available, using a mobile radar from FMV that has both skin and transponder tracking capability.

7 FTS

7.1 Flight termination

The Flight Termination System (FTS) used at Esrange complies with the IRIG standard and is tone based with stationary antennas pointing in the rocket inclination angle. There are 20 different tones that can be sent in combinations or series, supporting both the IRIG analogue and High Alpha standards.

The FTS ground system is able to send SAFE, ARM and DESTRUCT commands to the on-board FTS system. During rehearsals/functional testing, any FTS initiator devices are put in a safe condition so that the ARM and DESTRUCT commands can be end-to-end tested.

The FTS ground system is fully redundant with no single point of failure. The ground system includes two identical and parallel transmitter strings for the FTS channel.

7.2 FTS standard

In order to be compatible with the Esrange FTS ground system, the launch vehicle's on-board FTS will need to comply with the RCC 319-14 and IRIG 208-06 standards.

The Esrange ground system Command Exciter/Encoders support IRIG, High Alpha. Enhanced Flight Termination System tones are also planned to be supported in the future.

7.3 Autonomous FTS

Any Autonomous FTS (AFTS) that has shown sufficiently high reliability can be flown independently without a conventional FTS as a backup. An AFTS that has never been flown before would need to first be flown in a shadow mode, together with a conventional FTS as the primary system. After the AFTS has achieved sufficient reliability, it could be flown as the primary system with a conventional system as a backup. The Esrange Range Safety Office will determine how many flights are required before a specific AFTS design can fly fully autonomously. This will also depend on the flight history of the relevant launch vehicle.

7.4 Termination methods

Thrust cut-off is typically considered a sufficient method for launch vehicles with liquid propellant engines and no other means are currently anticipated to be required from a Range Safety perspective.

Acceptable flight termination method(s) will be considered on a case-by-case basis, since acceptability is affected by both the launch vehicle (i.e., design and size) and the mission profile.

8 OPTICAL SYSTEMS

Additional information to be added in the next revision.

9 TIMING

Reference frequencies and time code signals are generated in a central facility located in the Main Building. The system is synchronized to meet international standards and monitored at all times. All generated time code signals are based on GPS reference time from a NTP server.

The system is based on a reference frequency of 10 MHz and can deliver secondary references of 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, 5 MHz and 10 MHz. Other available time codes are IRIG A, B & H and NASA 36.

10 BASE-WIDE COMMUNICATION NETWORK

The Esrange main Base Area, as well as KEOPS and LC-3, are all connected with each other via a communication network consisting of combinations of optical fibers, coaxial cables and twisted pairs (TP). All switches are redundant and there is a dedicated UPS for all communication equipment at the base.

Some of the core network connections are described in the table below:

From	To	Type	Note
Main building	Sounding rocket launch area	Single mode fiber TP coaxial cable	204 fibers 400 TP 10 coax
Main building	Balloon launch area	Single mode fiber TP	168 fibers 200 TP
Main building	Satellite Station	Single mode fiber coaxial cable	48 fibers 10 coax
Main building	KEOPS	Single mode fiber	48 fibers
Sounding rocket launch area	LC-3	Single mode fiber	96 fibers

In many cases, additional communication cables of different types can be installed if requested by a range user (sufficiently far in advance).

11 POSNET

PosNet is a network spanning around Esrange, dedicated to distributing the current location of a launch vehicle or balloon in flight. Every source of position is distributed, and it is possible to utilize the sources in a priority order set for each client. This position is used to slave devices such as antennas to point in the right direction.

12 OPERATIONAL COMMUNICATION UNITS

Fig. 2 - Operational communication units: Top:Intercom, Bottom: GO/NO-GO

12.1 Intercom

During a sounding rocket or stratospheric balloon mission, all stations involved are equipped with at least one intercom unit for communication between stations. Each unit has a loudspeaker and a microphone or a headset. There are different channels or party-lines available on every unit depending on where the unit is located. The party-lines are divided into rocket or balloon usage. The Public Address (PA) and the shortwave radio are also connected to the intercom system.

12.2 GO/NO-GO

During countdowns, all involved stations are equipped with a GO/NO-GO indication panel. This is to simplify the decision making for Launch Operations in time critical moments.

During rocket launches all stations send a terminal count GO-indication if they are ready. This confirms that everything is clear to conduct launch and is performed 30-180 seconds before launch. Any problems are indicated by a red NO-GO button.

13 VIDEO MESSAGE SYSTEM

A large number of video monitors are installed within Esrange premises and are used to inform all stations and people at Esrange during campaigns. The basic information consists of Universal Time and countdown time (Relative Time). In addition, short messages can also be displayed.

Fig. 3 - Video message system with countdown information

14 PUBLIC ADDRESS

To ensure that important information is communicated to everyone located at Esrange, loudspeakers are installed indoors and outdoors around the base.

This page is intentionally left blank

Esrange Space Center - The most versatile space center in the world !

SSC
Esrange Space Center
PO Box 802
SE-981 28 Kiruna
SWEDEN

+46 980 720 00

info@sscspace.com

www.sscspace.com

Photo: Marcus Lindh