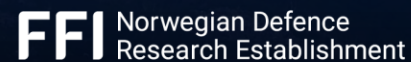


#jammertest

# Welcome to Jammertest 2024









Tomas Levin  
Senior principal engineer,  
Norwegian Public Roads  
Administration



Nicolai Gerrard  
Senior engineer,  
Norwegian Communications Authority



Christian Berg Skjetne,  
Senior engineer,  
Norwegian Public Roads  
Administration



Øystein Karlsen,  
Senior engineer,  
Norwegian Communications Authority



Siri Vasshaug,  
Senior adviser,  
Norwegian Public Roads  
Administration



Anders Rødningsby  
Principal scientist  
Norwegian Defence  
Research Establishment



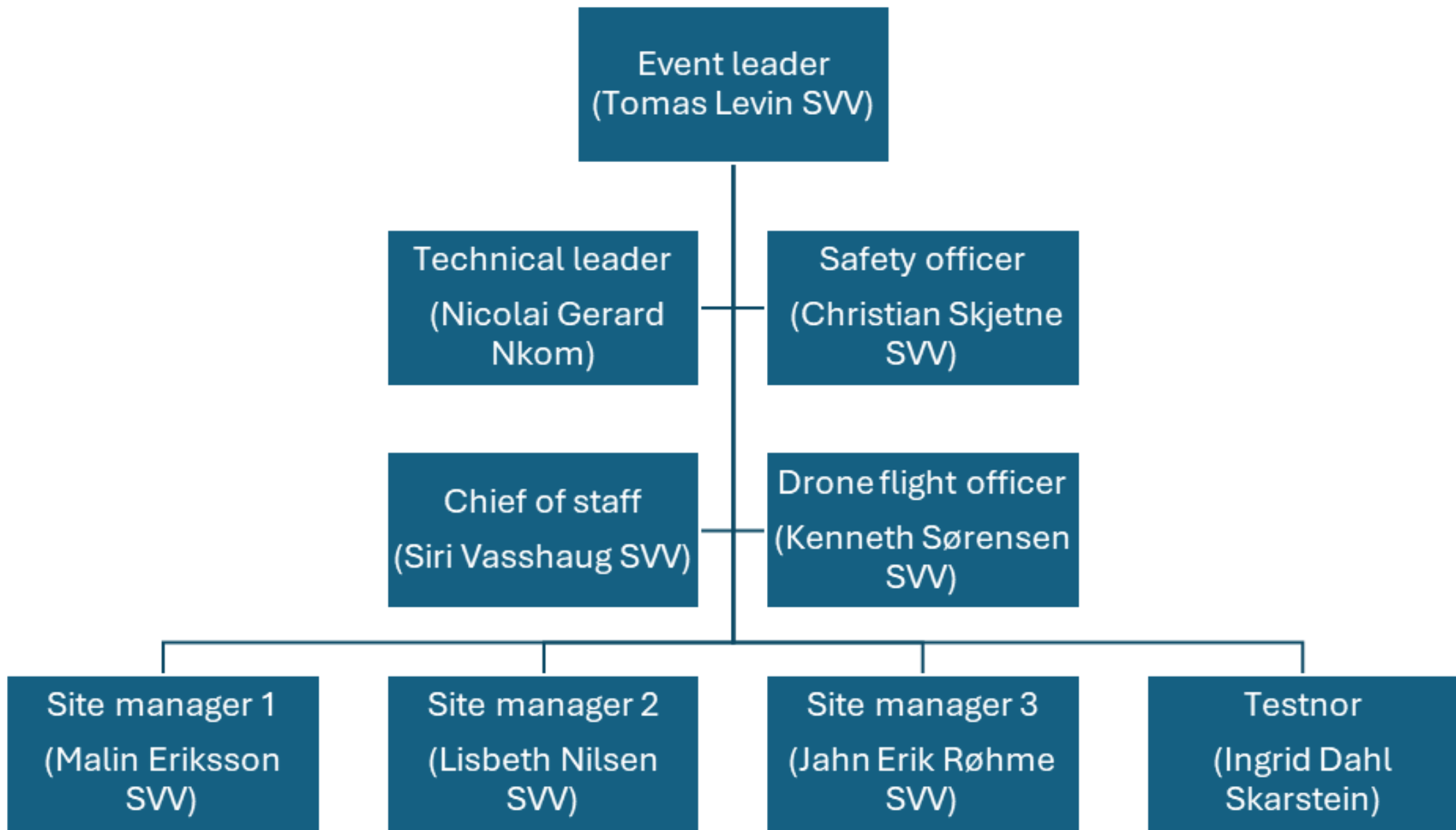
Harald Hauglin  
Chief engineer,  
Norwegian Metrology Service



Anders Martin Solberg  
Senior engineer,  
Norwegian Mapping Authority



Ingrid Dahl Skarstein  
Project leader,  
Testnor





# Agenda

- Welcome to Jammertest 2024
- Safety
- Code of conduct
- Test locations – explanation
- Technical program
- Communication
- Practical information
- Networking events & hospitality



An aerial photograph of a coastal town and a rocky island in the ocean. The town is situated on a green, hilly landscape with a white sandy beach and a blue bay. A road winds through the town. In the foreground, scientific equipment is mounted on a rocky outcrop, including several cylindrical sensors and a metal frame. The text "This is your home for week 37" is overlaid in white on the right side of the image.

This is your home for week 37



# Jammertest 2024: Record high interest with more than 250 participants from all over the world registered





# Industry

# Research

# Government

**KONGSBERG** **TELEDYNE FLIR** **LOCKHEED MARTIN**

**Andøya Space** **ERICSSON** **NOKIA**

**Telia** **telenor** **NRK** **TRG**

**septentrio** **SAFRAN** **LEONARDO**

**MEINBERG** **Trimble** **ROHDE & SCHWARZ** **RS**  
Make ideas real

**u-blox** **MICROCHIP** **RACELOGIC** **exail**

**FURUNO** **Honeywell** **CALIAN**  
Confidence. Engineered.

**isar aerospace** **SAAB** **EUTELSAT** **Ospirent**

**FUGRO** **HEXAGON** **NovAtel** **VECTORNAV** **helix GEOSPACE**

**Leica Geosystems** **ANavs** **InfiniDome** **TESTNOR**

**ni** **VOLVO** **ASCOM** **AD NAVIGATION**

**Elvia** **radonor** **SentiSystems** **roketSan**

**Adtran** **COMBITECH** **provinn.** **HawkEye<sup>360</sup>** **GUIDE**

**FFI** Forsvarets forskningsinstitutt

**FOI**

**RISE** Research Institutes of Sweden

**European Commission**  
Joint Research Centre

**Stanford University**

**NORGES ARKTISKE UNIVERSITET**  
UIT

**nlr**

**ISL**

**DTU** Technical University of Denmark

**KTH** VETENSKAP OCH KONST  
Royal Institute of Technology

**UNIVERSITY OF VIRGINIA**

**Universit  Gustave Eiffel**

**Vaasan yliopisto** UNIVERSITY OF VAASA

**NLS** FINNISH GEOSPATIAL RESEARCH INSTITUTE FGI

**NOKM** Nasjonal kommunikasjonsmyndighet

**Forsvarsdepartementet**

**Statens vegvesen**

**POLITIET**

**NORWEGIAN ARMED FORCES**

**FMV**

**Justervesenet**

**Statnett**

**dsb** Norwegian Directorate for Civil Protection

**Norsk Romsenter** Norwegian Space Agency

**esa** European Space Agency

**cnes** CENTRE NATIONAL D'ETUDES SPATIALES

**Luftfartstilsynet** **AVINOR**

**EUROCONTROL**

**KYSTVERKET**

**Kartverket**

**330 SKY** **UTREDDER LUKK**

**Federal Agency for Cartography and Geodesy**

**Ministry of Defence**

**DGA** DIRECTION G N RALE DE L'ARMEMENT

**PTS**

**Styrelsen for Dataforsyning og Infrastruktur**

**Erillisverket**

**RS(+)**



# Safety

High visibility clothing

High visibility clothing is **MANDATORY** and shall be used at all times when outside!



# Code of conduct

*We want this to be a week of working together, learning and having a good time !*

No requirement to share findings, but we **strongly** encourage you all to share as much as possible during Jammertest, and also publishing your results

**Friendly, inclusive and informal atmosphere**; be friendly, respect each other's boundaries, be curious and last but not least help each other, we are quite close to the end of the earth

Taking photos is generally allowed, but if you take pictures with persons or equipment in focus **ASK first!**

All **NPRA officials** in their distinct orange suits are first line contacts for any questions or feedback, just grab one of us and ask!

If you observe unacceptable behaviour from anyone, come talk to Siri (Chief of staff)

*Smile as much as possible 😊*



**Statens vegvesen**



# Program overview

## *Time Schedule*

### **Monday**

- ❑ 09.00 – 11.00 Arrival, registration and equipment deployment
- ❑ 11.00 – 13.00 Welcome and safety brief
- ❑ 13.00 – 14.00 Lunch at HQ (Bleik)
- ❑ 14.00 – 18.00 Afternoon test block
- ❑ 18.30 – 19.00 Evening debrief; safety and potentially sharing results
- ❑ 20.00 – 22.00 Networking dinner

### **Tuesday, Wednesday, Thursday**

- ❑ 08.00 – 08.30 Morning safety brief
- ❑ 09.00 – 13.00 Morning test block
- ❑ 13.00 – 14.00 Lunch at HQ (Bleik) and Stave
- ❑ 14.00 – 18.00 Afternoon test block
- ❑ 18.30 - 19.00 Evening debrief; safety and potentially sharing results

### **Friday**

- ❑ 08.00 – 08.30 Morning safety brief
- ❑ 09.00 – 13.00 Morning test block
- ❑ 13.00 – 14.00 Lunch at HQ (Bleik) and potentially sharing results
- ❑ 14.00 – 16.00 Down rig of equipment, goodbyes and departure

# Test areas

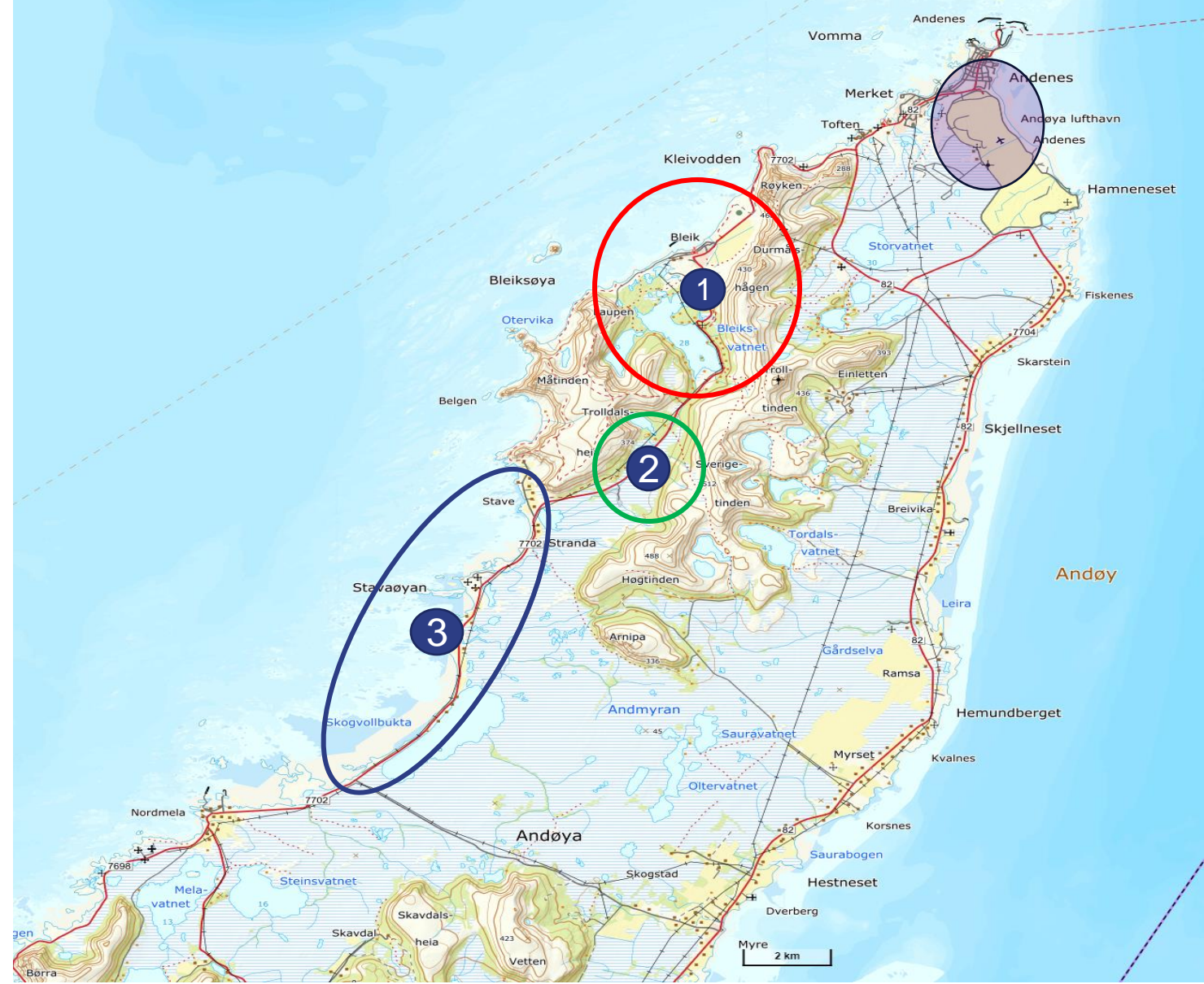
Three locations, where we can work in parallel:

Test area 1: Main test area

Test area 2: Sand box

Test area 3: Motorcade

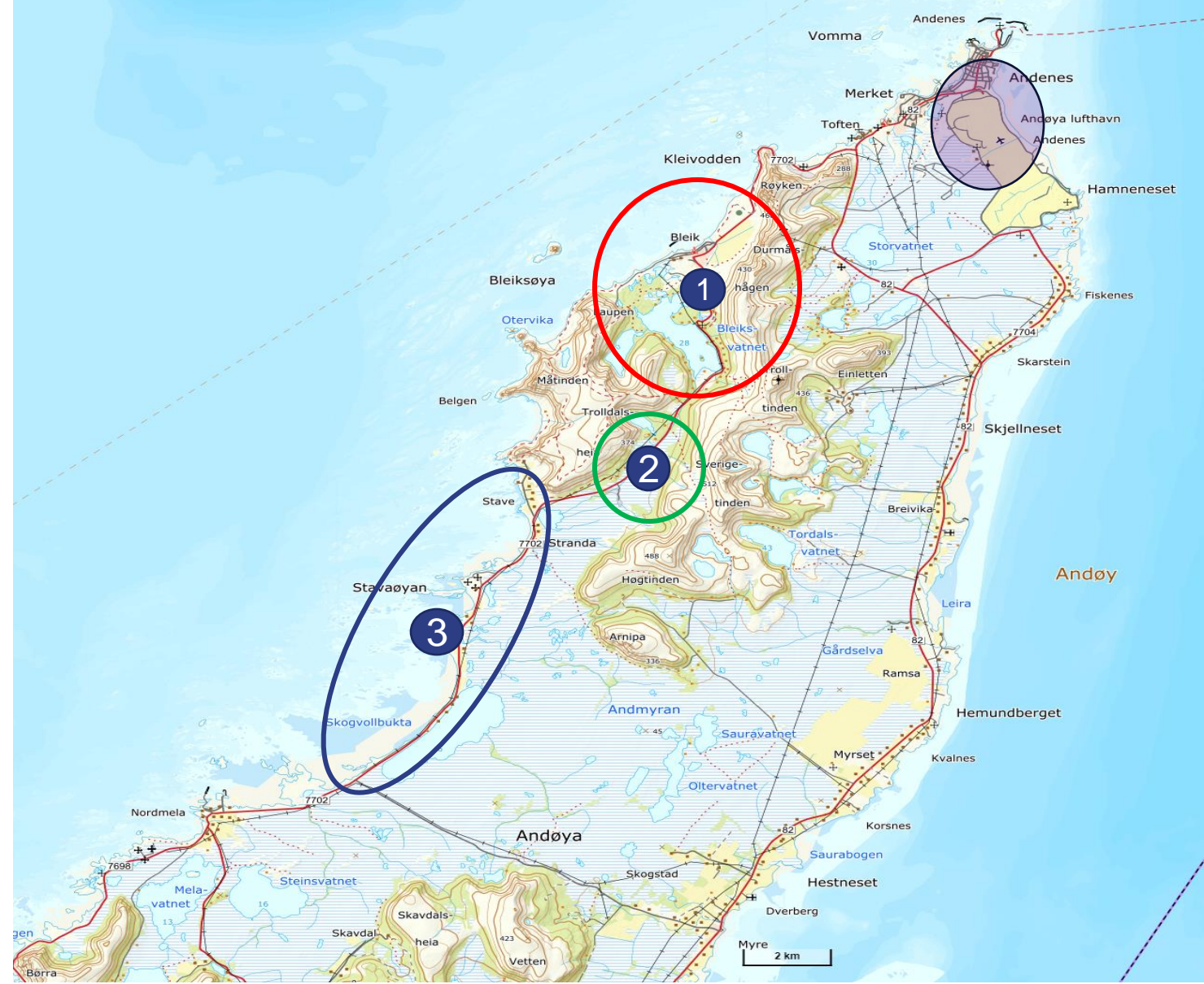
Additional transmissions done at airport, DUTs must be helicopter or airplane





# How to use the test areas

- All are **free to roam** between test sites
- To book time slots on Wednesday, **book** with reception / registration point
- If you know you want to use test site 2 and/or 3, **register** at reception / registration point
- All are **free to decide** where to spend their time and what to do
  - The **organisers create the GNSS RFI** environments
  - The **participants conduct tests freely** within these environments

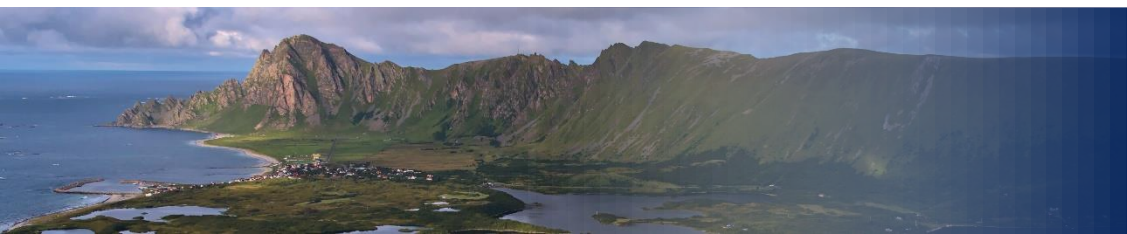


# Program overview

## *Test block view of transmission plan*

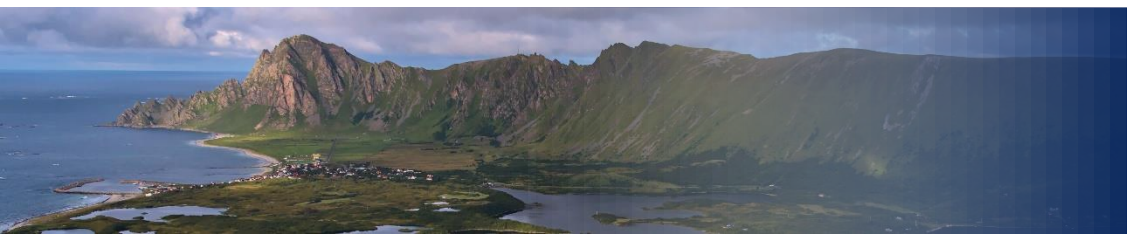
Day	Test area 1	Test area 2	Test area 3
Monday	High power stationary jamming	Low power stationary jamming	Motorcade (with low-power jammers)
Tuesday	Meaconing High power unintentional RFI Long-time high-power jamming (evening)	Circular multi-jammer scenarios Drone scenarios	Motorcade (with low-power jammers)
Wednesday	Stationary spoofing (mainly position, navigation) SBAS spoofing	Book time slots on hourly basis	Book time slots on hourly basis
Thursday*	Stationary spoofing (mainly timing)	Drone scenarios Circular multi-jammer scenarios (repetition)	Mobile spoofing (SDR) (mainly position, navigation)
Friday	Repetitions, variations of previous tests, special attacks	Low power stationary jamming Repetitions	

*\*Thursday's morning test block also has airport jamming transmissions*



# Monday's Transmission plan (09.09.24)

Site 1 - Bleik	Site 2 - Grunvatn		Site 3 - Stave
Briefing (mandatory!) - 08:00 - 08:30			
<b>14:00-14:10 - 1.2.1</b> Jammer F8.1 "Porcus Major": 50 W CW: L1	14:00-14:12 - 1.1.1 Jammer S1.1	14:16-14:28 - 1.1.4 Jammer S2.1	
<b>14:20-14:30 - 1.2.4</b> Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2, L5	14:32-14:44 - 1.1.8 Jammer U1.1	14:48-15:00 - 1.1.12 Jammer H1.1	
<b>14:40-14:50 - 1.3.5</b> Jammer F8.1 "Porcus Major": 50 W sweep: L1, sweep rate: 1 kHz, BW: 6 MHz	15:04-15:16 - 1.1.13 Jammer H1.2	15:20-15:32 - 1.1.16 Jammer H3.1	
15:00-15:10 - 1.3.8 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, L5, sweep rate: 1 kHz, BW: 6 MHz	15:36-15:48 - 1.1.18 Jammer H3.3	15:52-16:04 - 1.1.19 Jammer H4.1	15:00-18:00 Test 1.11.7 and 1.11.8 Driving in front/behind multi-band jammer (H 6.5) 18 available spots
15:20-15:30 - 1.4.1 Jammer F8.1 "Porcus Major": 50 W PRN: L1, Chiprate: 3 MHz	16:08-16:20 - 1.1.20 Jammer H6.1	16:24-16:36 - 1.1.21 Jammer H6.2	
15:40-15:50 - 1.4.4 Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1, L2, L5, Chiprate: 3 MHz	16:40-16:52 - 1.1.22 Jammer H6.3	16:56-17:08 - 1.1.23 Jammer H6.4	
16:00-16:14 - 1.6.1 Power ramping with Jammer F8.1 "Porcus Major": 0.2 $\mu$ W (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1	17:12-17:24 - 1.1.26 Jammer H8.1	17:28-17:40 - 1.1.27 Jammer F6.1	
16:25-16:39 - 1.6.4 Power ramping with Jammer F8.1 "Porcus Major": 0.2 $\mu$ W (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1, G1, L2, L5	17:44-17:56 - 1.1.29 Jammer H2.1		
16:50-18:05 - 1.8.1 Jammer F8.1 "Porcus Major": 50 W PRN pyramid: E6, E5b, L5, G2, L2, B1I, G1, L1			
Debrief (mandatory!) - 18:30 - 19:00			





If you are a  
bad  
man/woman  
...



these (Nkom)  
guys will come  
find you and stop  
you!



causing some  
unintentional  
interference.....



*(And maybe punish you...)*





# Test area 1: overview of Bleik and HQ



Photo: David Jensen



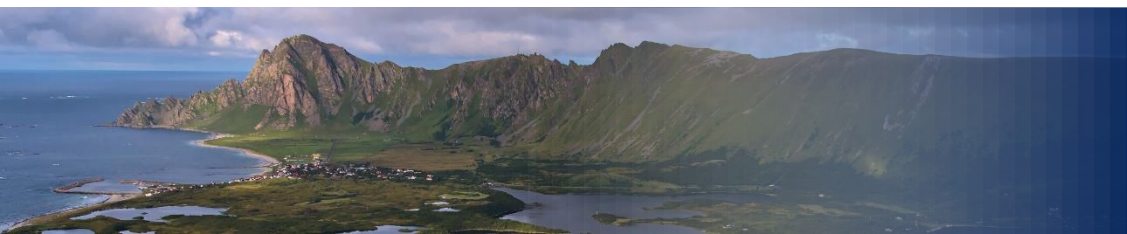
# Test area 1: overview of Bleik and HQ





Test area 1:

walking way  
from parking to  
HQ



# Live Youtube stream

[https://www.youtube.com/watch?v=DTZM\\_4PvKAA](https://www.youtube.com/watch?v=DTZM_4PvKAA)

(Time) phase difference ( $\Delta$  GNSS-time and JV time reference)

RF-feed antenna position (GPS+Glonass)

Log and MQTT

Spectrum

Youtube channel

The screenshot displays a YouTube live stream interface with several data visualizations and a log. The top left shows a 'Phase Difference (Linear residual)' graph with an averaging window of 20 seconds, plotting values from -5.00E-8s to +5.00E-8s over time. The top right shows a map of a coastal area with a red dot indicating the antenna position and blue lines showing movement paths. The middle right shows an 'incident log' with the following entries:

Time	Text
13:52:00	Application started
13:52:01	Connected to ROHDE&SCHWARZ,PR200,100.883/002,V03.1
13:52:02	0.3.1 Ad hoc test started at 2024-09-07T11:52 (recording)
13:54:44	Recording ended after 2 minutes
15:45:04	Test 0.3.1 ended
15:45:06	0.3.1 Ad hoc test started at 2024-09-07T13:45 (recording)
15:45:14	Recording ended after 8 seconds
16:18:31	Test 0.3.1 ended

The bottom middle shows a spectrum plot with dBmV on the y-axis (10 to 60) and frequency on the x-axis (1200 to 1600). The plot is divided into colored regions for different frequency bands: L5/E5a (red), G3/E5b (yellow), L2 (blue), G2 (red), E6 (blue), L1/E1 (blue), and G1 (red). The bottom right shows the YouTube channel information for 'Nasjonal kommunikasjonsmyndighet' with 317 subscribers, a 'Subscribed' button, and engagement icons for likes (5), comments, shares, and saves.

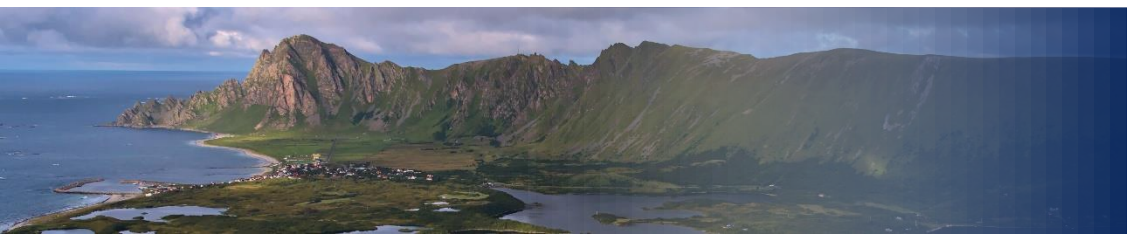
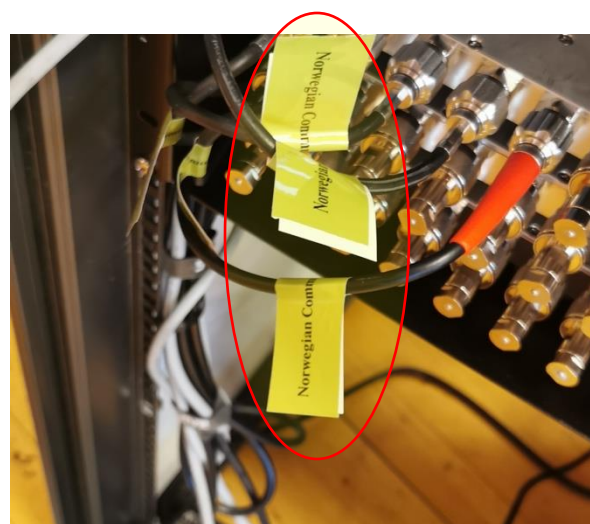




# Marking of cables and antennas

Mark all cables at all passings (like windows and cable tunnels), and connections (e.g. at distribution points)

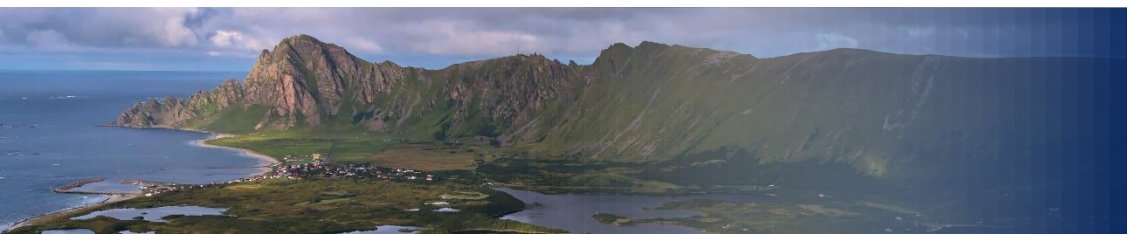
Mark all antennas



# Test area 2: Grunnvatn «Sandbox»



Photo: David Jensen





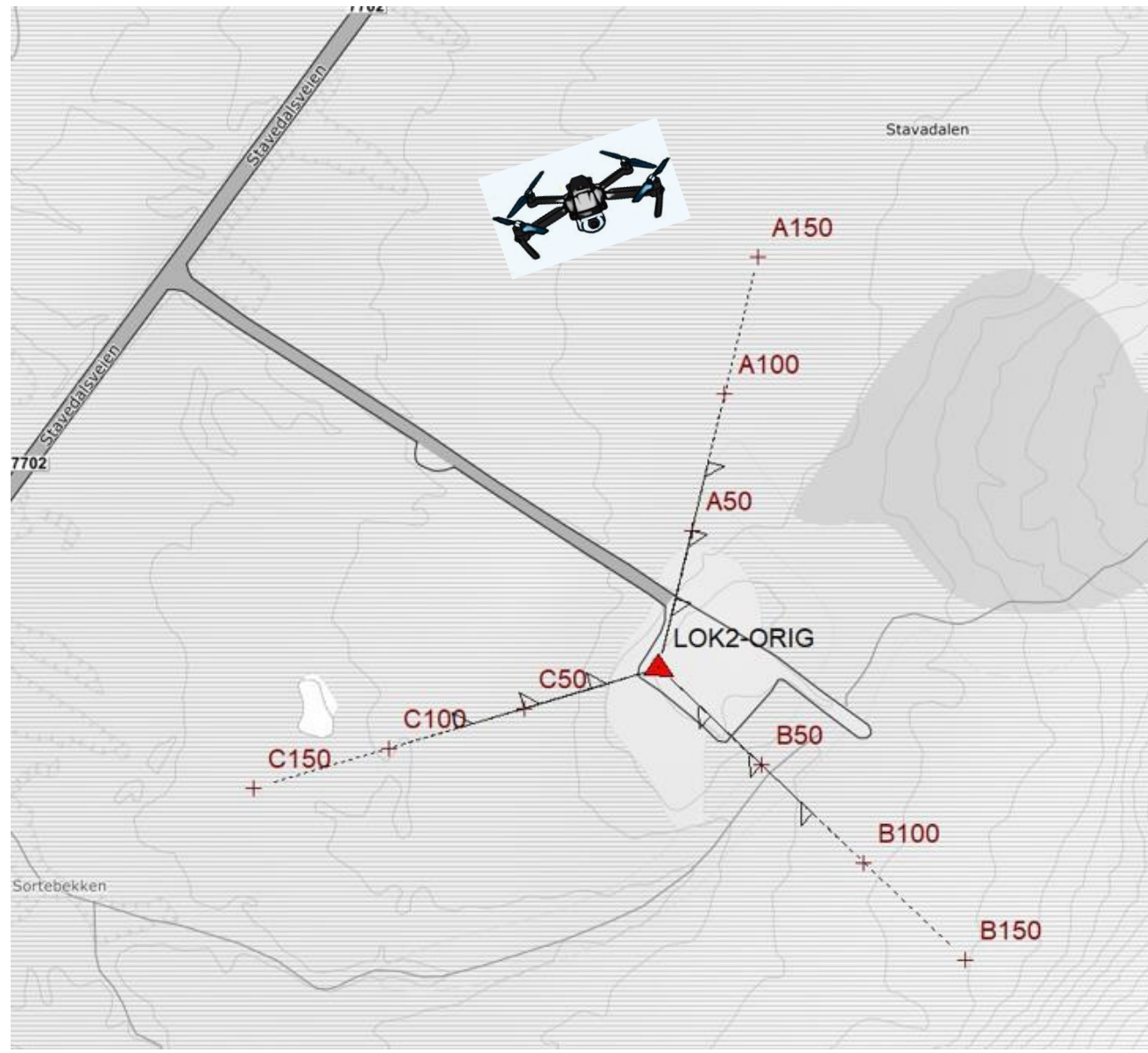
## Test area 2:

# Low power jammers

8 timeslots for booking

Centrally planned tests from  
testgroup 1, 1.19 & 1.20

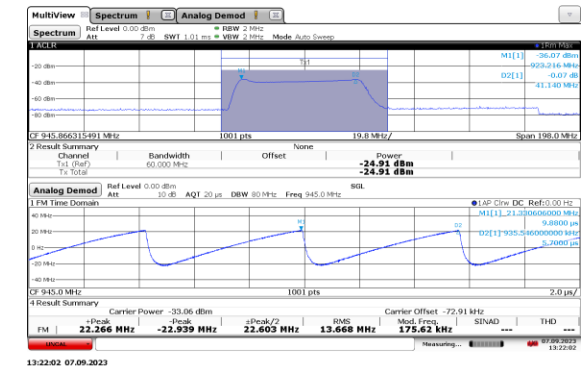
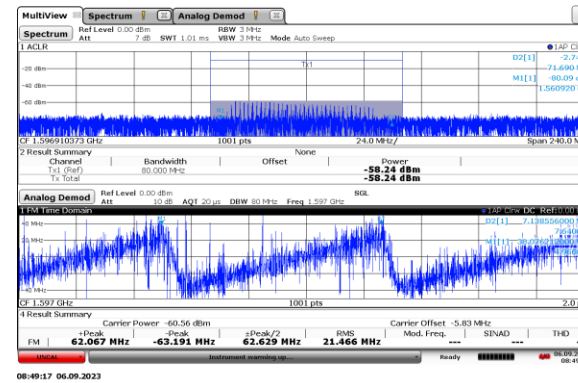
Please contact Testnor  
in the “Reception hall” for booking



# Small handheld jammers

## Testcatalog.pdf

- Appendix A for details on position markings for location 2.
- Appendix G for details on jammers.

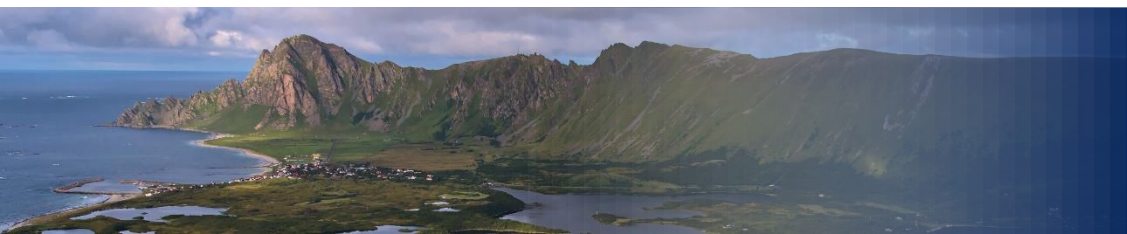




# Test area 3: Motorcade



Photo: David Jensen



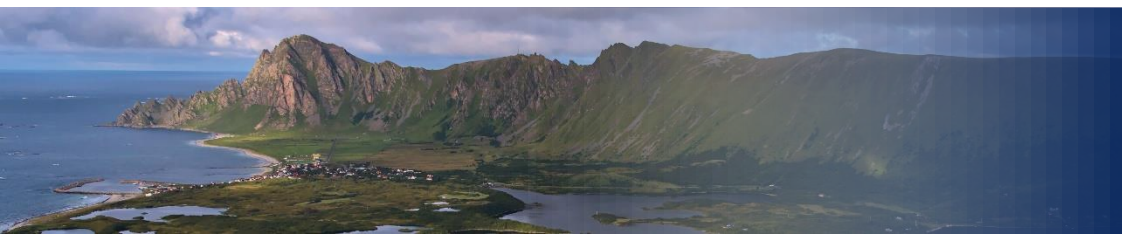
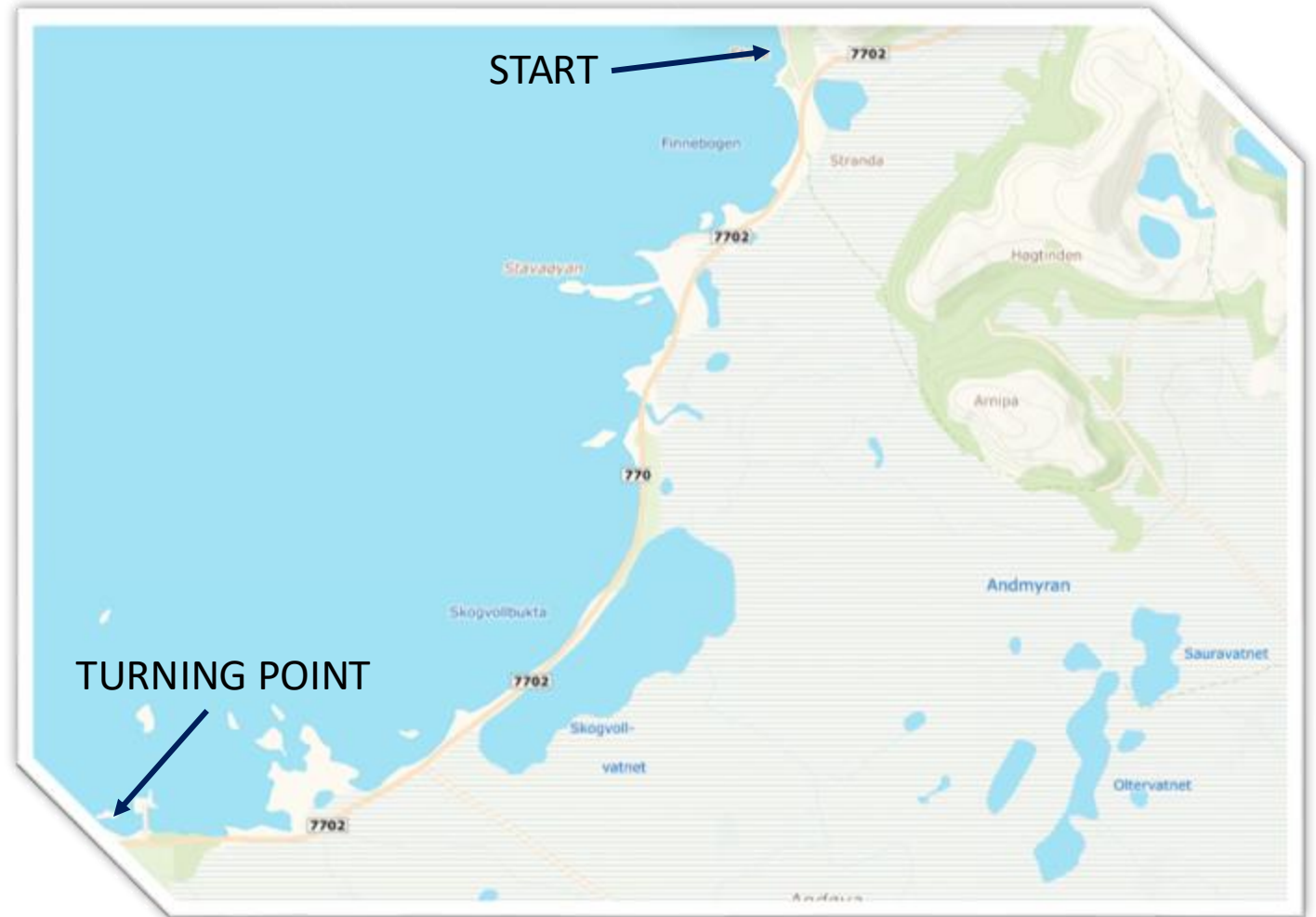
# The site – a public road



Road number: 770  
Distance: Approx 12 km

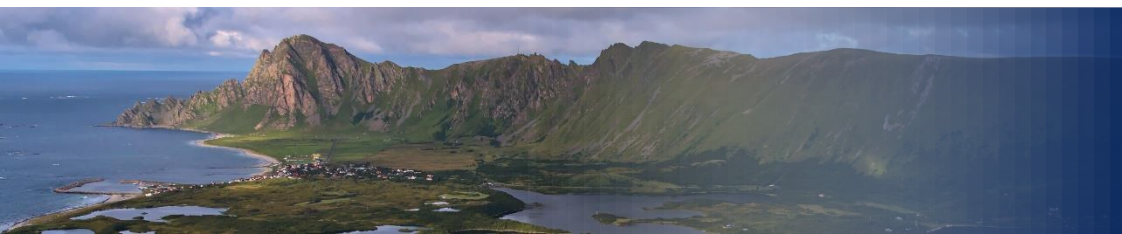
**Start:** Stave communal house

**Turning point:** Nordmela Landhandleri  
(small grocery store)





# Facilities





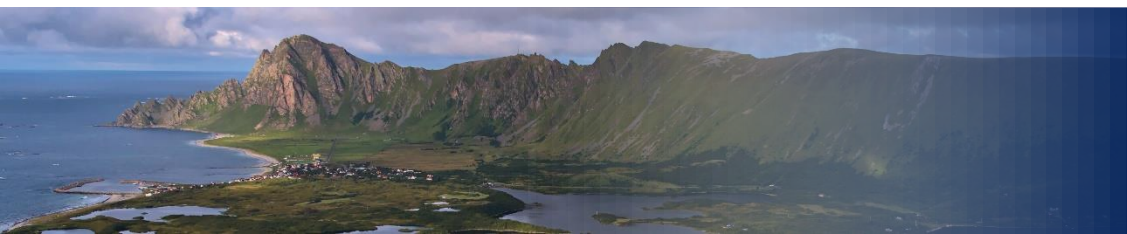
08:30 – 09:00	Mandatory brief, Bleik
09:00 – 10:00	Transport, set-up, safety briefing (if needed)
10:00 – 13:00	First test block
13:00 – 14:00	Lunch, at Stave
14:00 – 17:00	Second test block
17:00 – 18:00	Taking down equipment (and time for late-running test)
18:00 – 18:30	Transport back to Bleik
18:30 – 19:00	Mandatory brief, Bleik

## Daily Schedule

There will be a light snack served during the second test block.

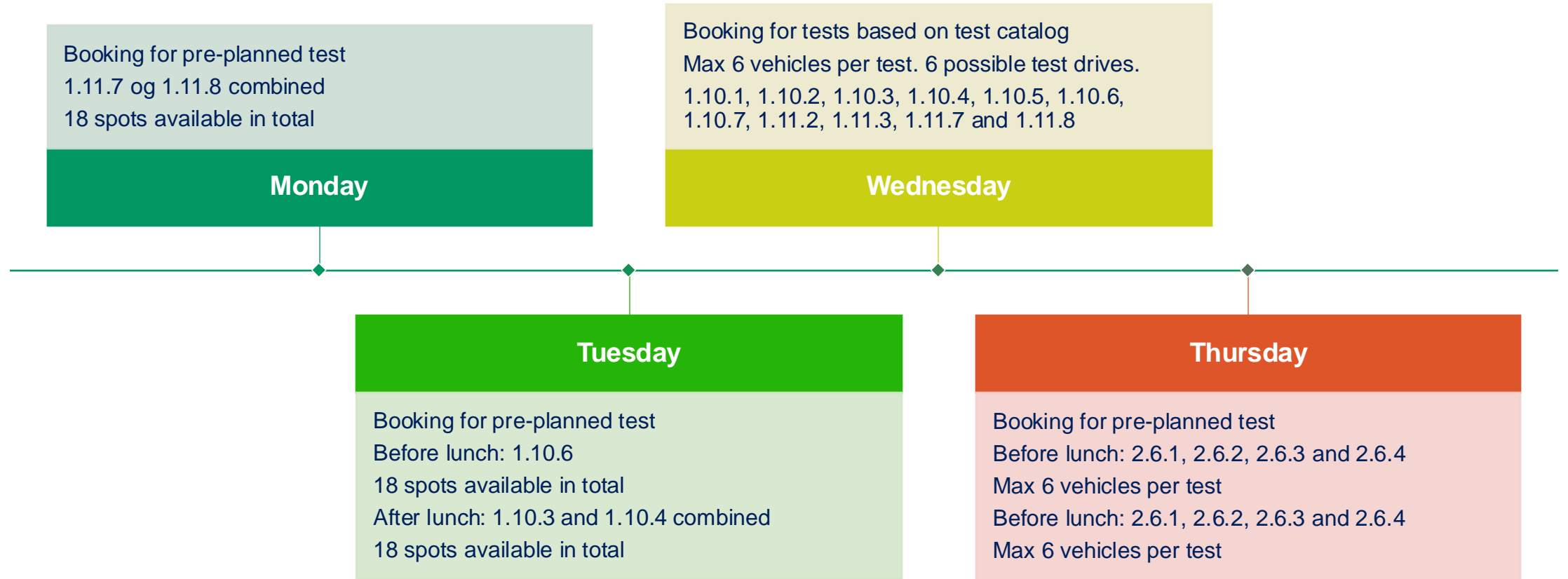
Coffee and tea will be available through out the day.

The shop at Nordmela is open, and we encourage you to spend some money here





# Pre-planned activities





# Important information - How to book

Contact Karolina, Ragnhild or Testnor  
at the registration on **Monday** at Bleik  
Communal house



Karolina, NPRA

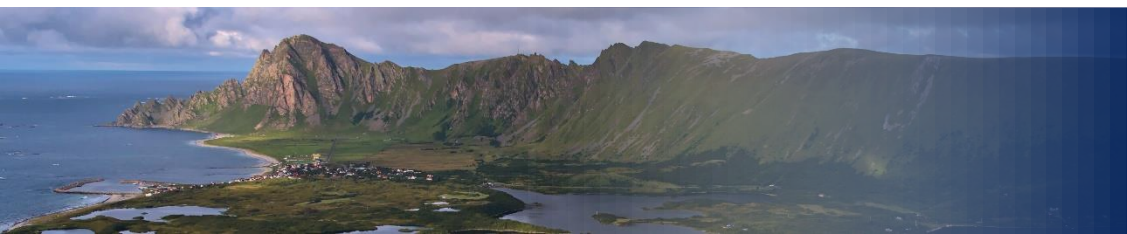


Ragnhild, NPRA

**Every other day** - contact Testnor

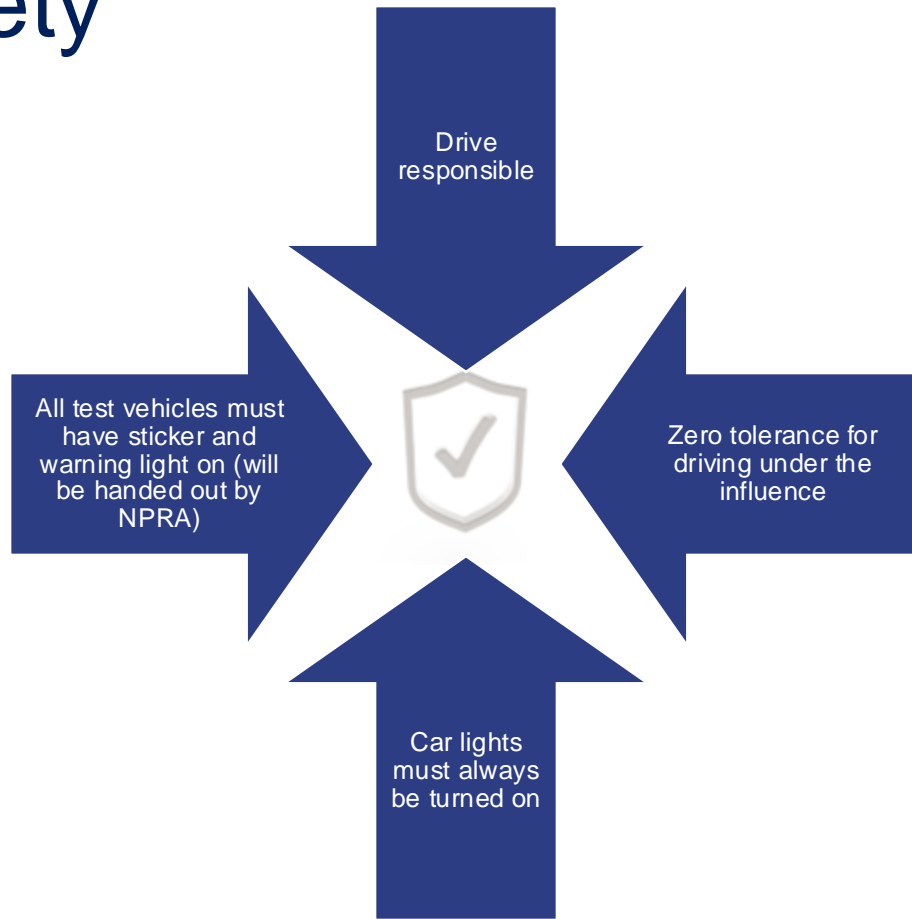


Ingrid, Testnor





# Safety



# Test catalogue

v.s.

# Transmission plan

*Example of how specific tests are used to build the transmission plan*

- 4 Continuous stationary high-power jamming with PRN ..... 21 ← *Example of test group*
  - 4.1 Preconditions and setup..... 21
    - 4.1.1 Test: 20 W PRN: L1 ..... 21
    - 4.1.2 Test: 20 W PRN: L1, G1..... 21
    - 4.1.3 Test: 20 W PRN: L1, G1, L2 ..... 21
    - 4.1.4 Test: 20 W PRN: L1, G1, L2, L5..... 21
    - 4.1.5 Test: 20 W PRN: 30-minute jamming of L1, G1, L2, L5..... 21 ← *Example of specific test*

Day	Time (location 1)	Location 1 (Bleik)	Time (location 2)	Location 2 (Grunvatn)	Time (location 3)	Location 3 (Stave)
Monday (18.09.23)		High power stationary jamming (jammer located at point A)		Book time slots on hourly basis		Book time slots on hourly basis
	13:00	2.1.1	13:00	Grunvatn - Slot 2.1	13:00	Stave - Slot 3.1
	13:20	2.1.4	14:00	Grunvatn - Slot 2.2	14:00	Stave - Slot 3.2
	13:40	3.1.1	15:00	Grunvatn - Slot 2.3	15:00	Stave - Slot 3.3
	14:00	3.1.4	16:00	Grunvatn - Slot 2.4	16:00	Stave - Slot 3.4
	14:20	4.1.1	17:00	Grunvatn - Slot 2.5	17:00	Stave - Slot 3.5
	14:40	4.1.4	18:00	Finished	18:00	Finished
	15:00	4.1.5				
	15:40	5.1.1				
	16:00	5.1.2				
	16:20	6.1.1				
	16:50	6.1.4				
	17:20	25 (all tests)				
	18:00	Finished				





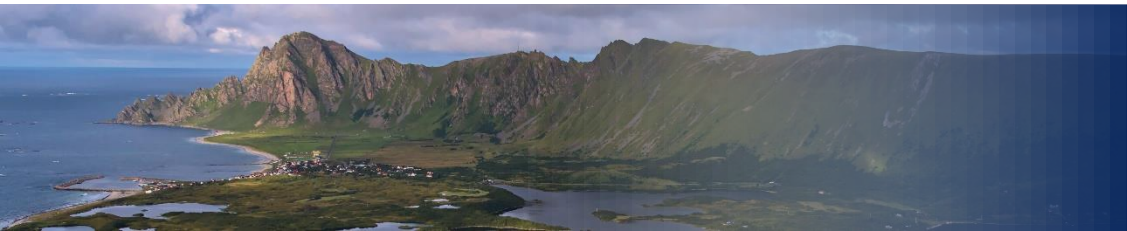
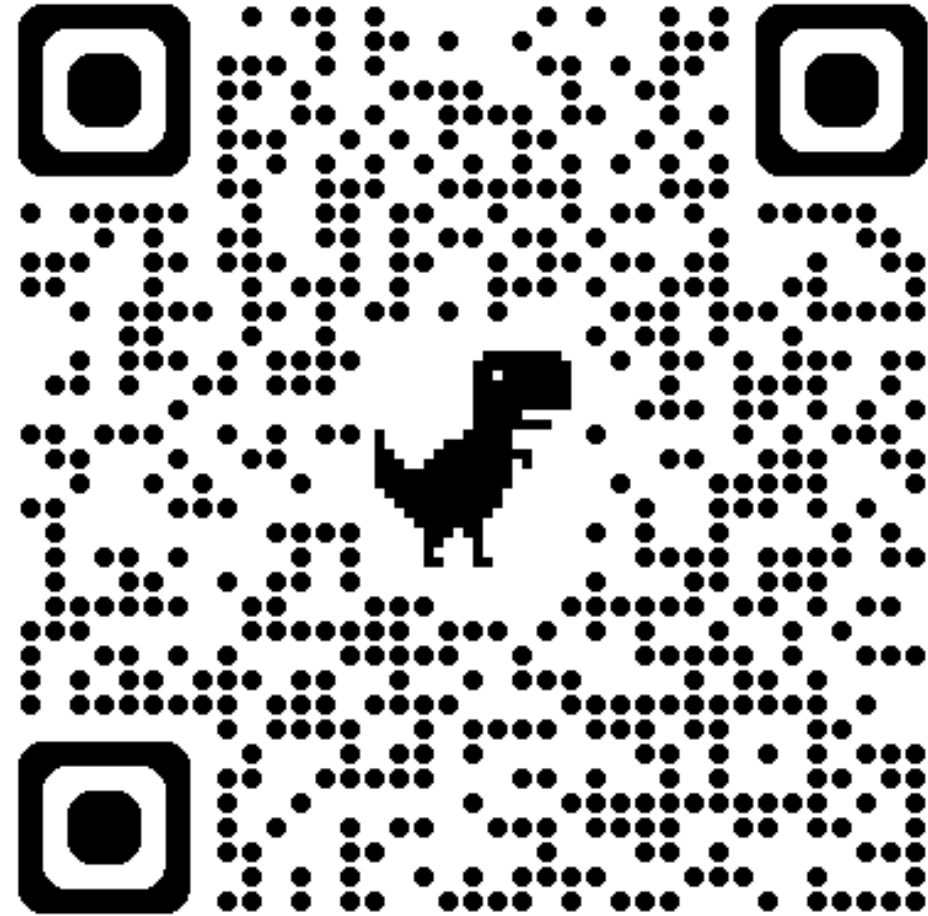
Test catalogue

and

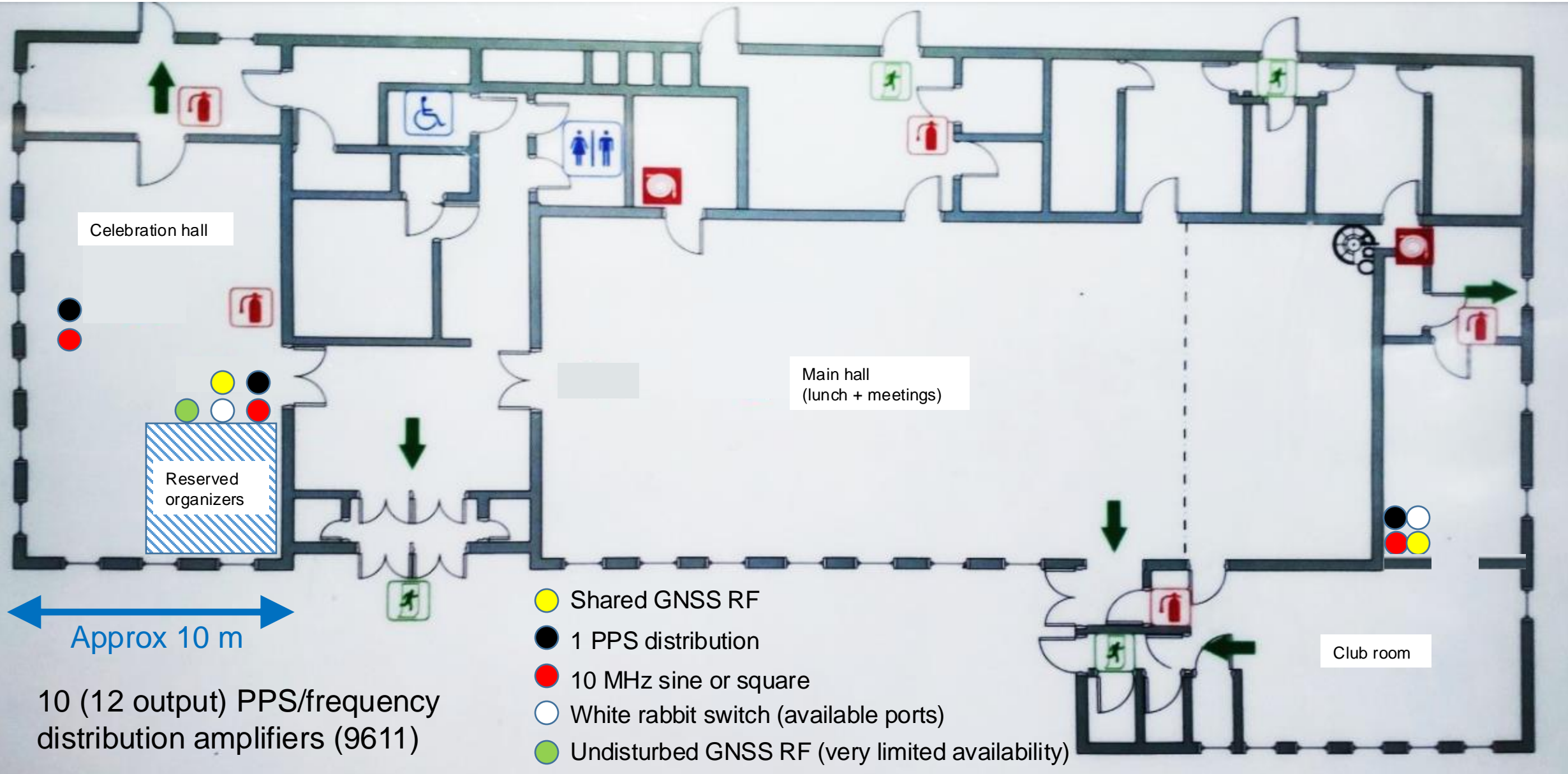
Transmission plan

to be found at

*[jammertest.no](http://jammertest.no)*



# Jammertest reference signal distribution at Bleik community house



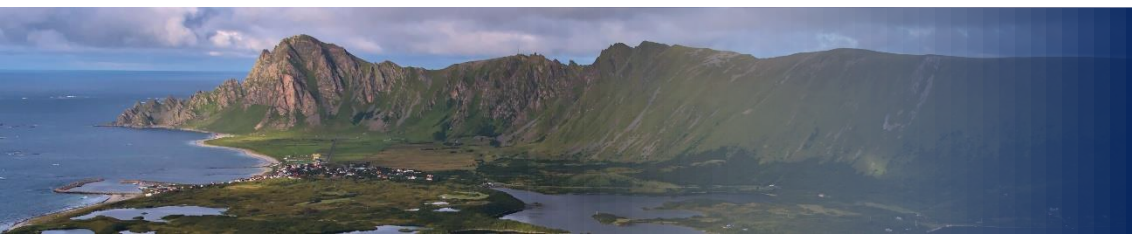


# RF and timing signal distribution

Updates will be published in Technical Appendix C

Access to White Rabbit Switch: Contact  
Justervesenet

Access to undisturbed GNSS RF: Contact  
Justervesenet



# GNSS correction data

The Norwegian Mapping Authority (NMA / Kartverket) provides GNSS reference (correction) data free of charge during the Jammertest week.

## **3 options (2 for real-time data, 1 for stored data):**

- CPOS (Network RTK service). Requires NMEA input from user equipment.
- RTCM data streams from individual GNSS reference stations nearby the test areas (distances ~ 10 - 60 km). Does not require NMEA input from user equipment.
- Stored RINEX data for post processing. A cloud storage folder ("Nextcloud") can be shared with participants upon request to [anders.martin.solberg@kartverket.no](mailto:anders.martin.solberg@kartverket.no)

More information and access details is published at (participant login needed)

<https://jammertest.no> > Jammertest 2024 > Program > GNSS reference data

The free access of real-time data will then be available until the end of Jammertest 2024. RINEX data will remain available several weeks after the event.

See also:

<https://www.kartverket.no/en/on-land/posisjon/user-guide-positioning-services>

<https://www.kartverket.no/en/on-land/posisjon/guide-to-cpos>



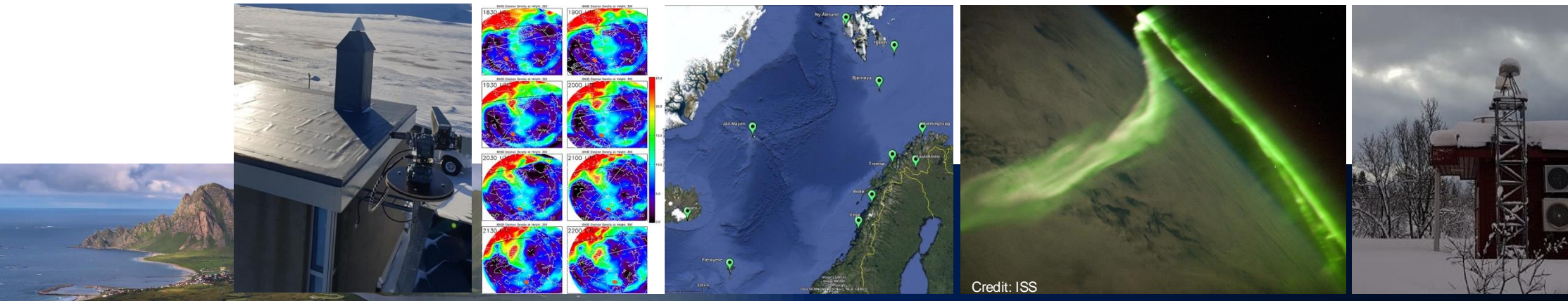
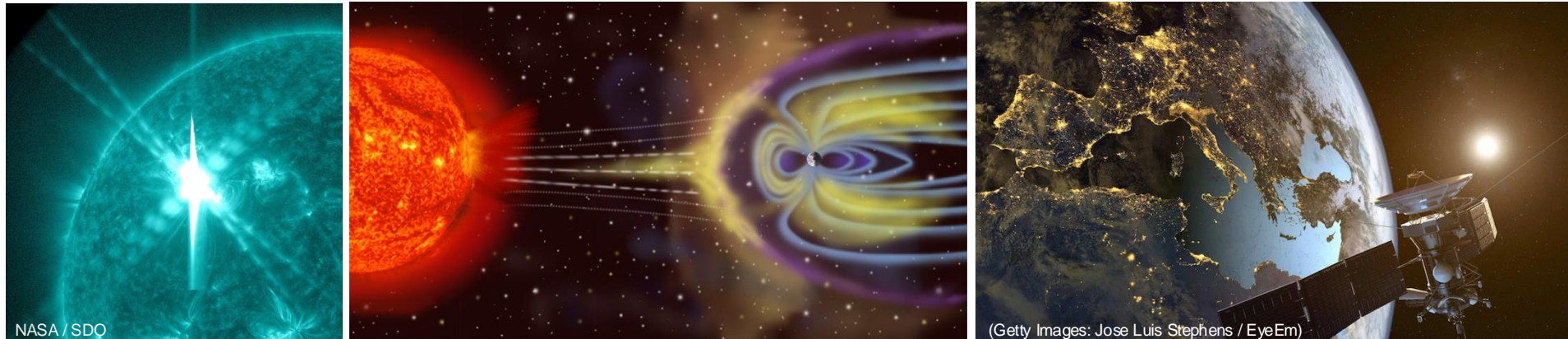




Kartverket

# Space Weather

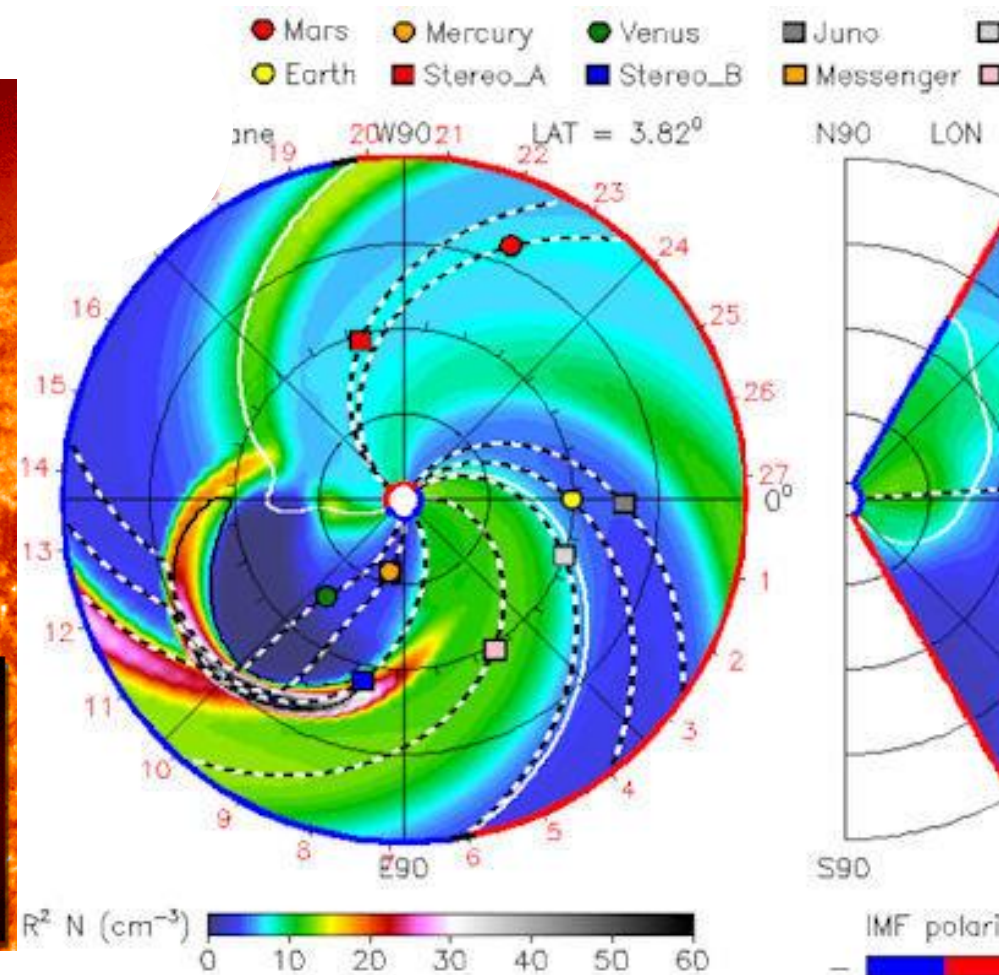
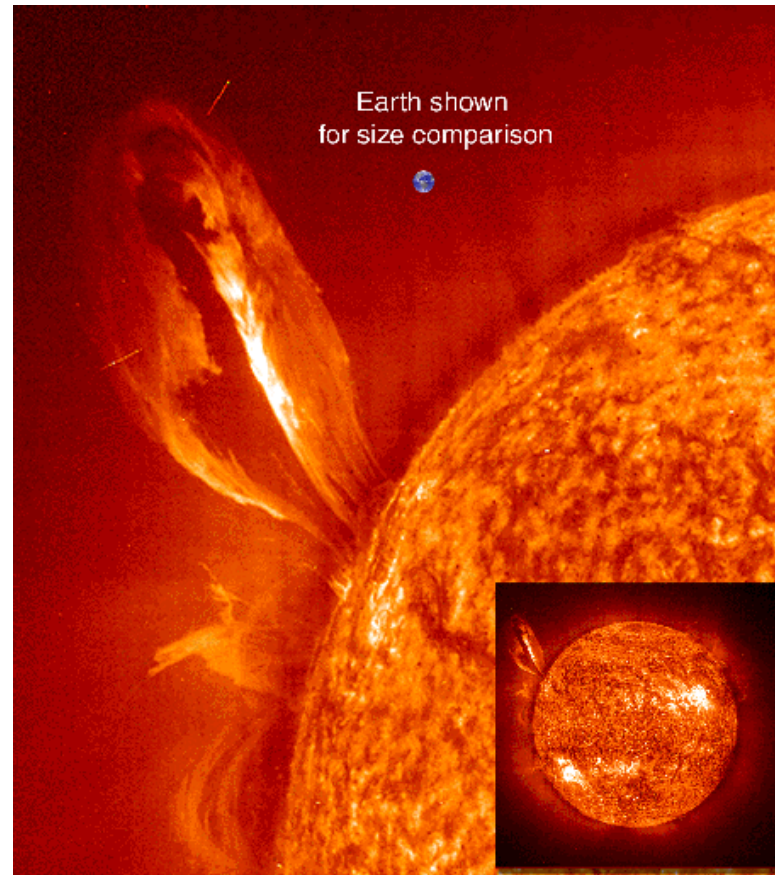
A super short introduction to space weather from a GNSS perspective





# Coronal Mass Ejections (CMEs)

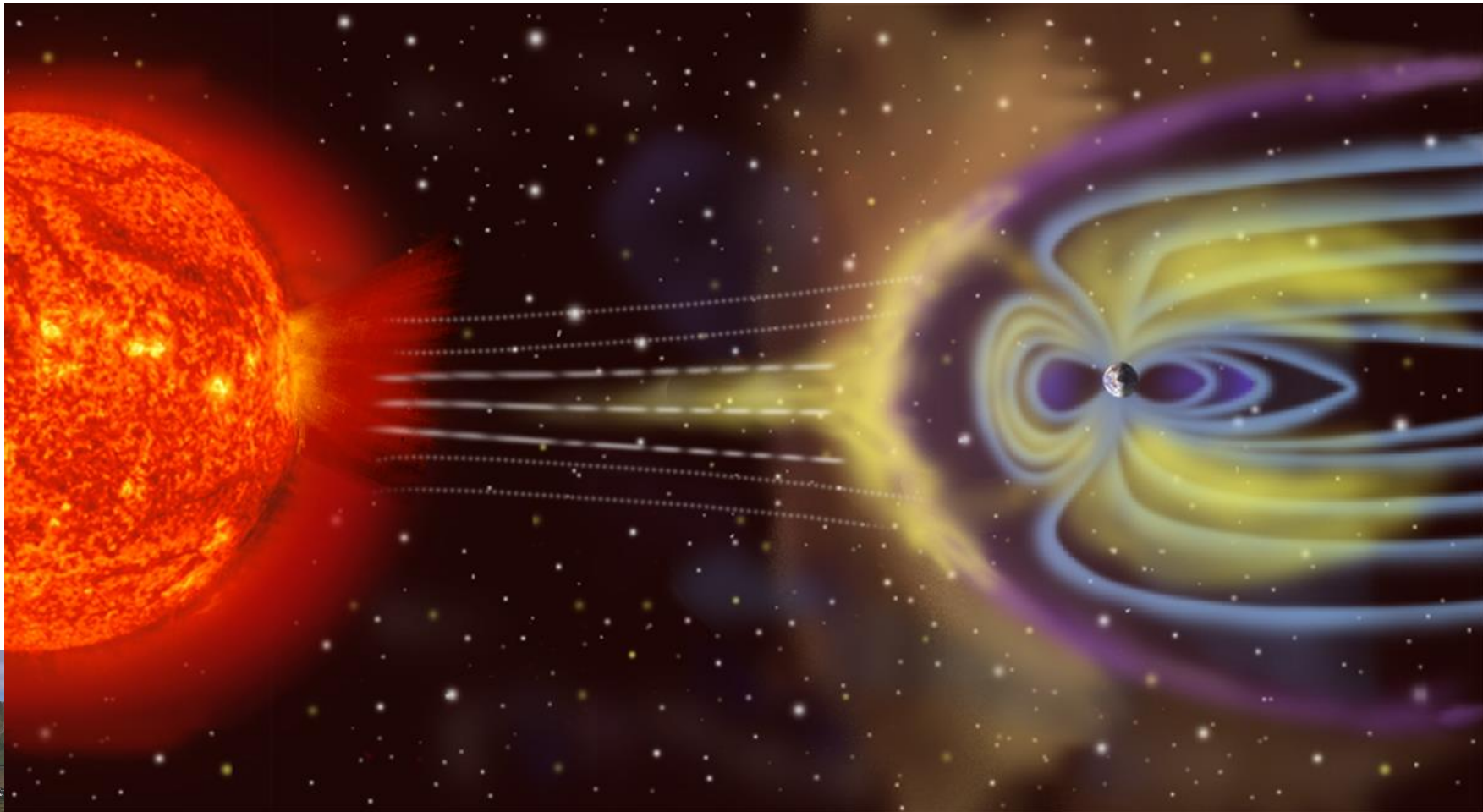
Giant clouds of plasma escaping from the Sun





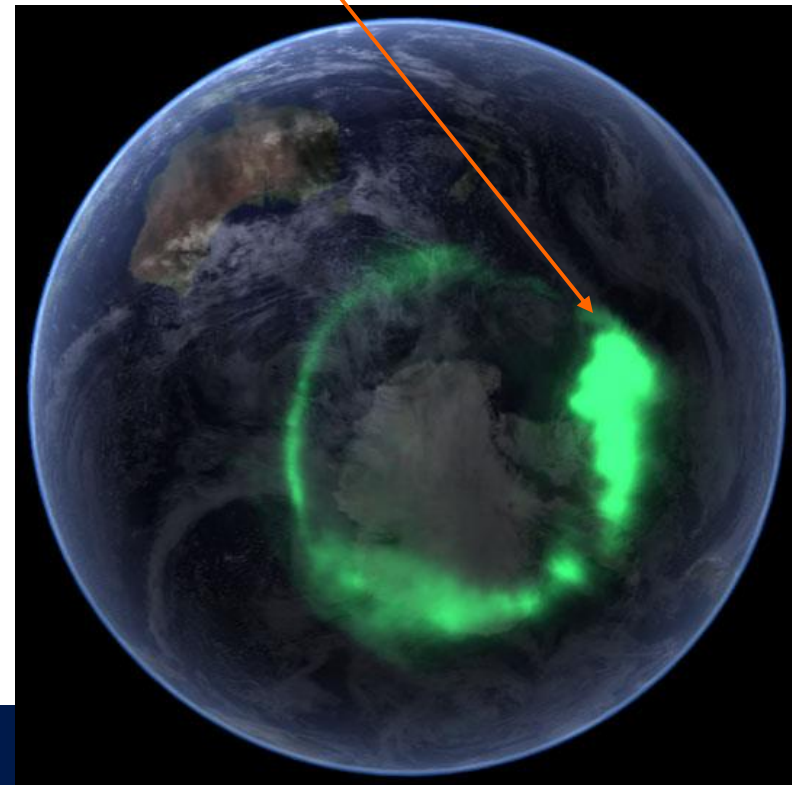
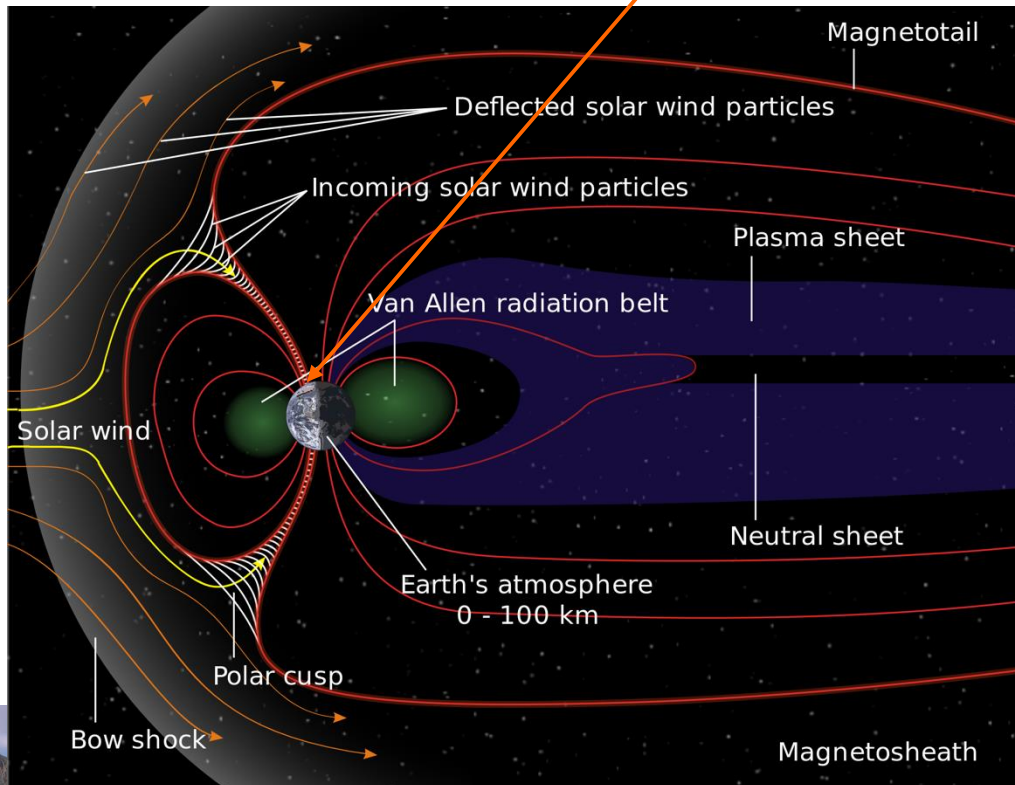
# Solar Wind vs Earth

The magnetic field of the Earth deflects most of the solar wind particles



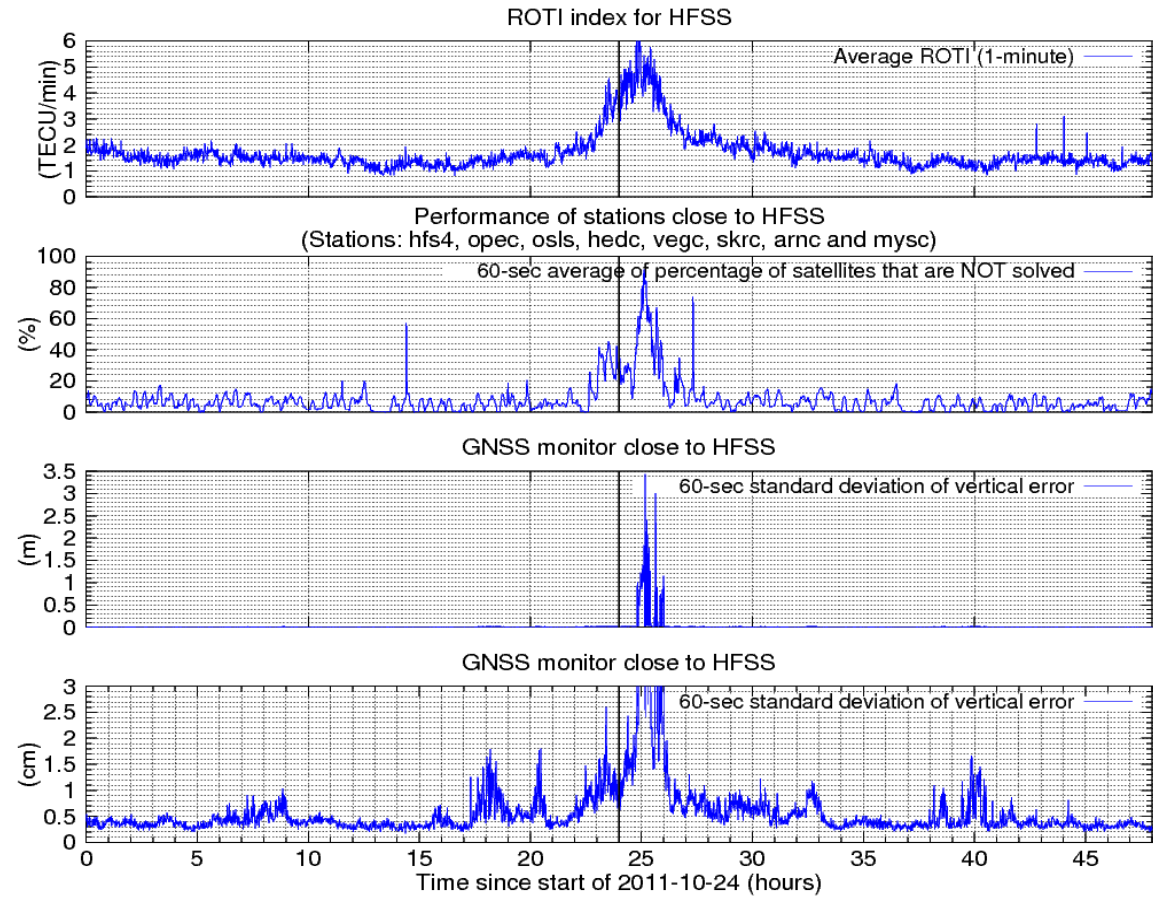
# Some high-latitude regions are particularly affected by space weather activity

- The Auroral Oval
- The Polar Cusp





# Example of impact on GNSS positioning using Network RTK G3 Geomagnetic storm in 2011



From the paper "Observed effects of a geomagnetic storm on an RTK positioning network at high latitudes" by Jacobsen et al. (<http://dx.doi.org/10.1051/swsc/2012013>)

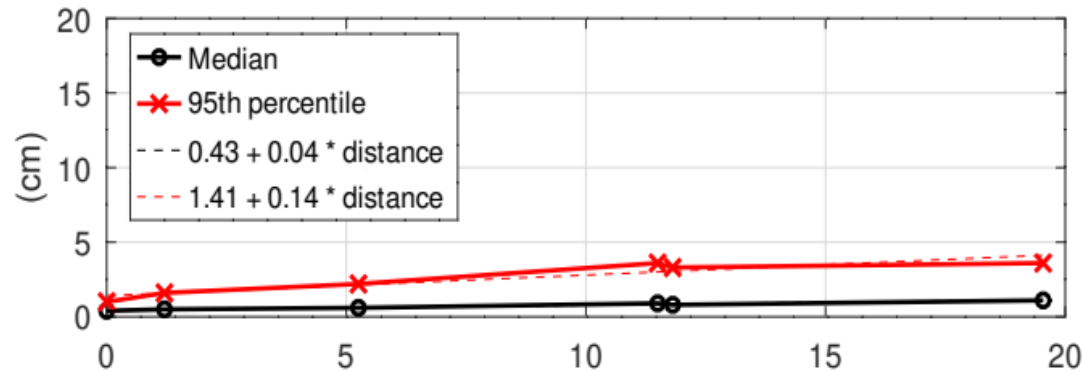


# Network RTK: Disruption scales with distance from network receivers, and is generally much worse at night

These graphs are based on data from an entire year (2021).

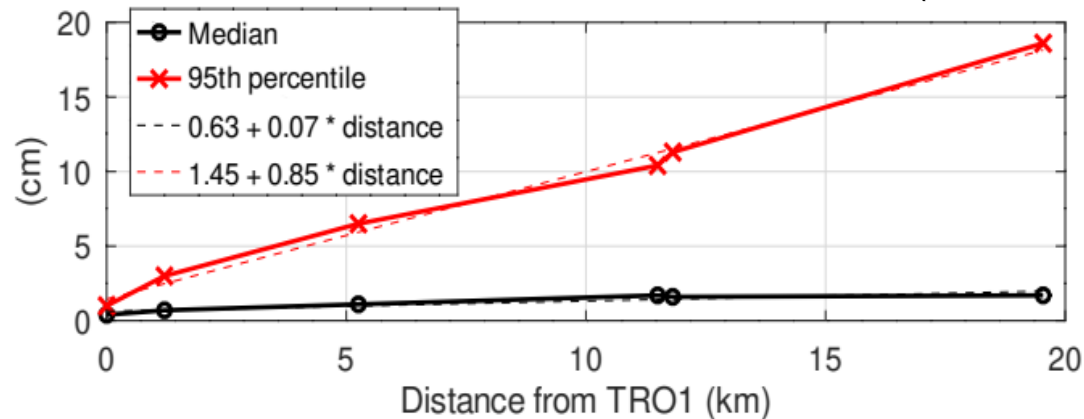
This quantifies normal condition near Tromsø, where minor ionospheric activity is common at night.

Absolute vertical error, Mag.Day-time (08 to 15 UTC)



NB: Local time = UTC + 1 h / 2 h

Absolute vertical error, Mag.Night-time (20 to 03 UTC)

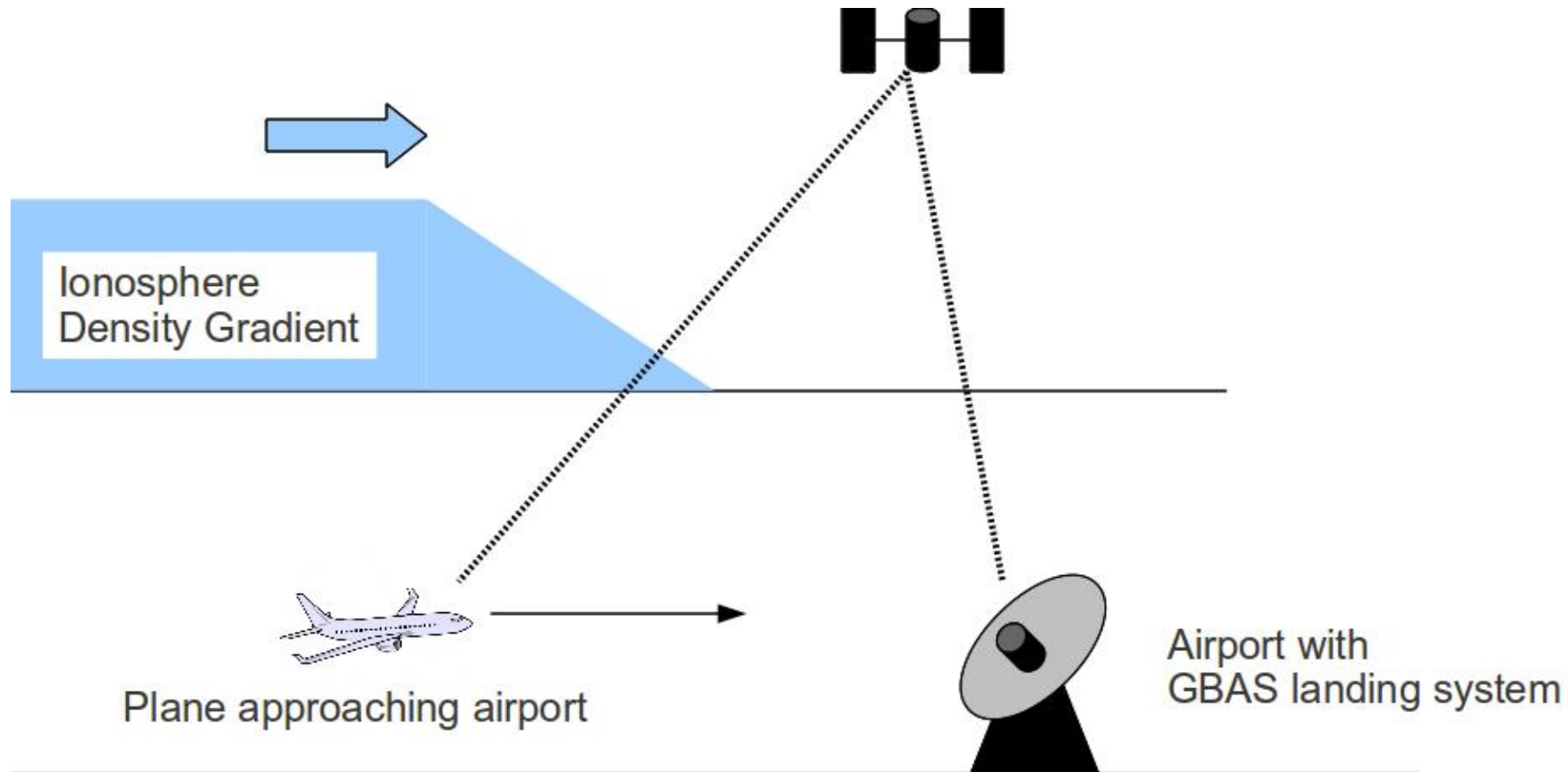


From the paper "Study of time- and distance- dependent degradations of network RTK performance at high latitudes in Norway" by Jacobsen et al. (<https://doi.org/10.1007/s42452-023-05325-8>)

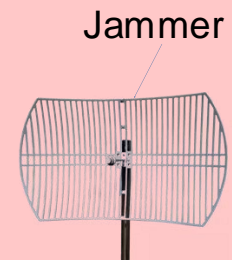
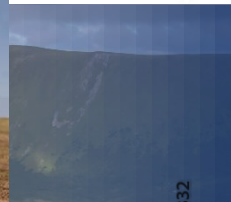
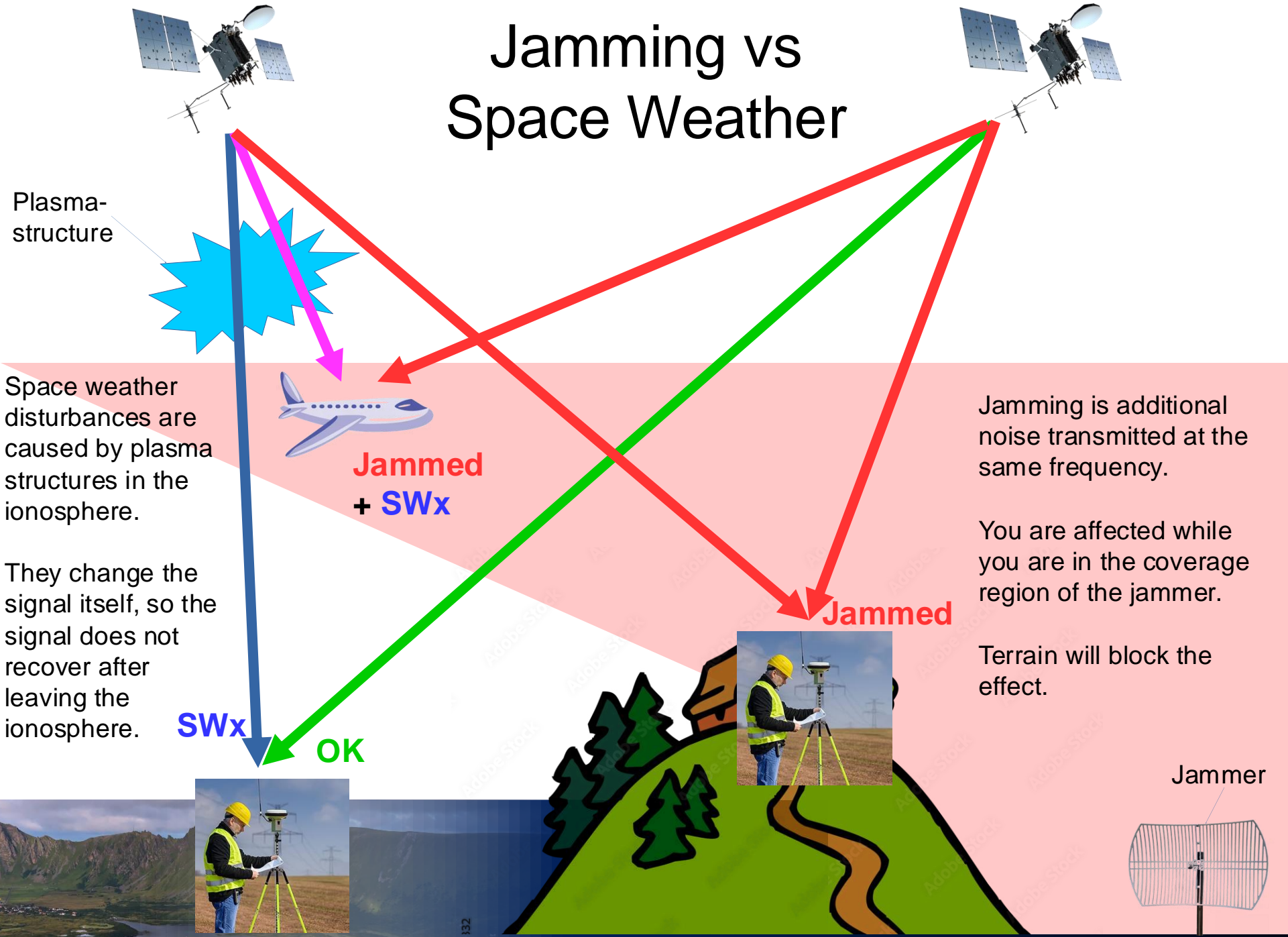




# Ionospheric gradients may threaten GNSS support systems



# Jamming vs Space Weather





# Ionosphere monitoring service

<https://sesolstorm.kartverket.no/moreplots.xhtml>

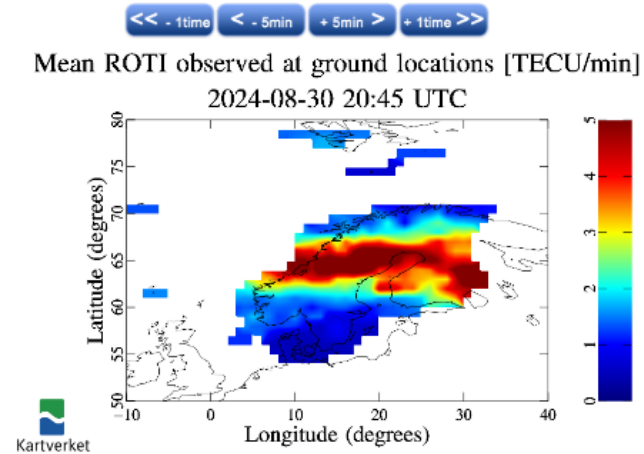
- Webpage in Norwegian language. Google Translate probably helps quite a lot. Captions in English.
- Data based on national reference stations networks in the Nordic countries.
- Interactive plots:
  - Rate-of-TEC Index (ROTI) at single layer ionospheric model height (350 km)
  - Rate-of-TEC Index (ROTI) at ground (“Forstyrrelser på bakken”)
  - VTEC
  - ...
- Map plots updated every 5 minutes.

seSolstorm 

Nå Arkiv Hjelp Om seSolstorm Nedlasting

[Øyeblikksfigurer](#)  
[Tidslinjefigurer](#)


Øyeblikksfigurer



Velg dato og figur

Her har du tilgang til arkiverte figurer. Du kan velge en dato fra kalenderen eller skrive direkte inn i datofeltet. Det er også mulig å gå fram eller tilbake ved å bruke knappene.

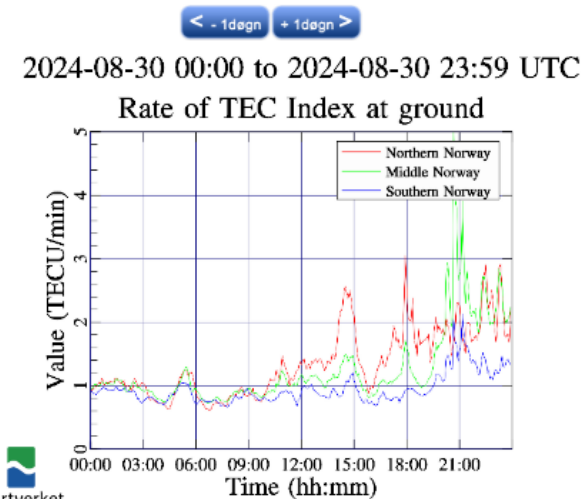
lokal tid

30/8/24 22:45 

- Alle
- Feilmargin i plasmainnholdet (GIVE)
- Ionosfærisk turbulens (ROTI)
- Forstyrrelser på bakken
- Plasmainnhold i ionosfæren (VTEC)
- Stor-skala romlige gradienter

ok

Tidslinjefigurer



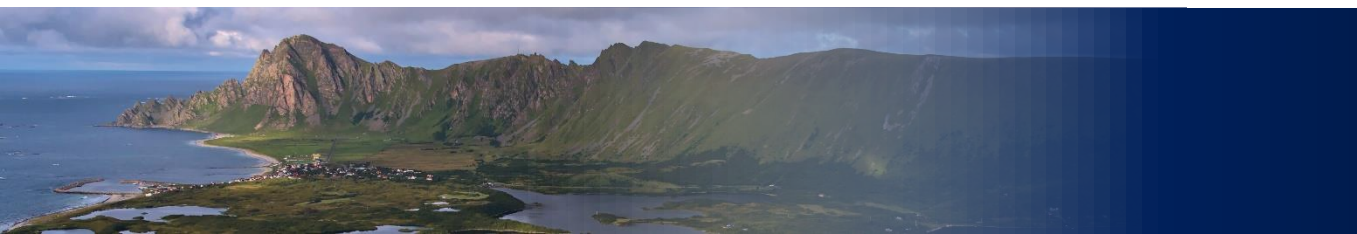
Velg dato for tidslinje

Her har du tilgang til arkiverte figurer. Du kan velge en dato fra kalenderen eller skrive direkte inn i datofeltet. Det er også mulig å gå fram eller tilbake ved å bruke knappene.

30/8/24 

- Begge
- Forstyrrelser på bakken
- Plasmainnhold i ionosfæren (VTEC)

ok



FM radio:  
*Radio Noise*  
99.0MHz





# Communication channels

## **Communication channels**

During Jammertest organizers and participants will use the following communication channels:

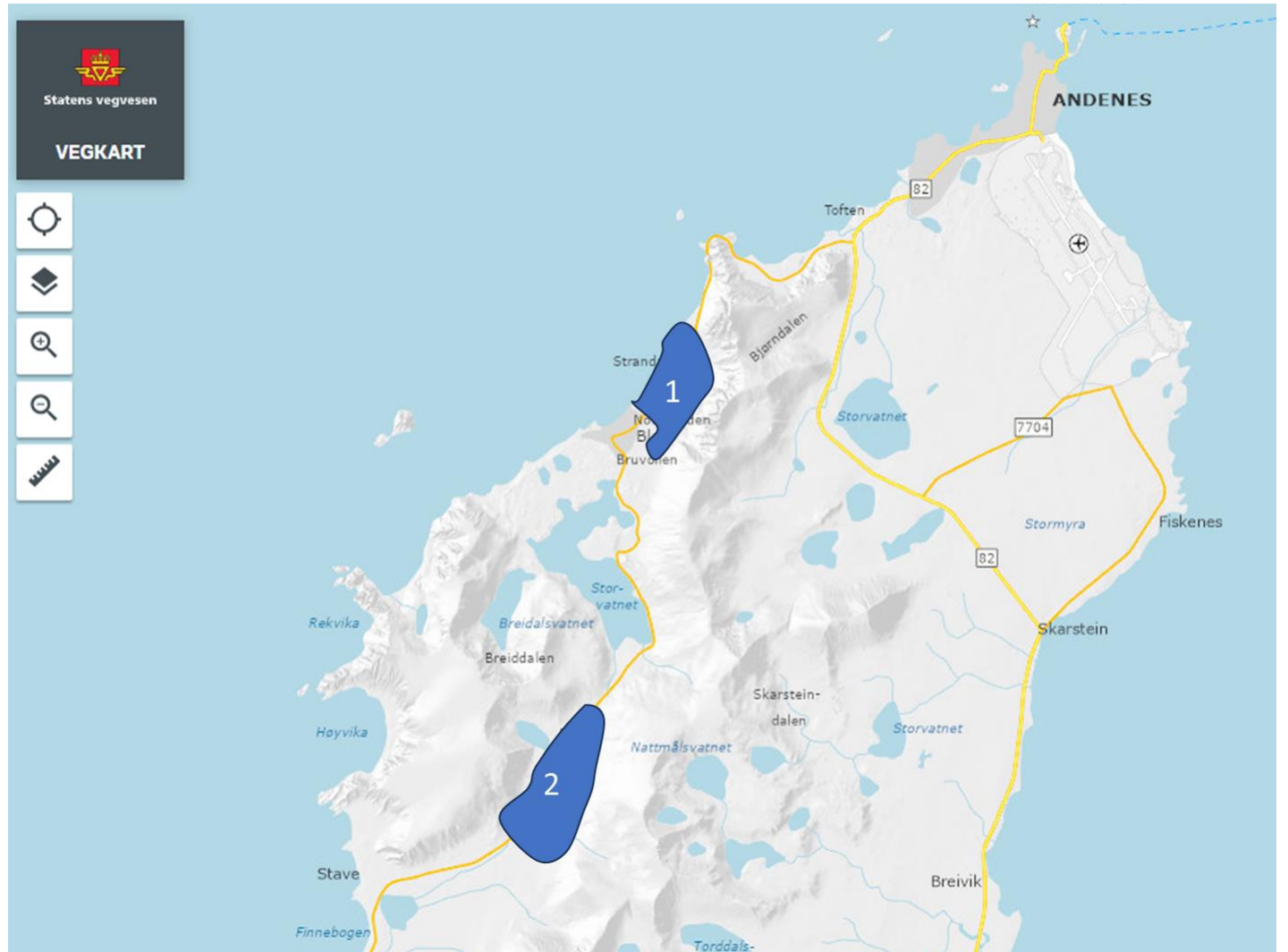
- Youtube Live spectrum stream
- Synology chat
- FM Radio
- MQTT live test log

# Drones

Only fly with Drone Flight Officers  
Permission

Maximum height 400 Feet (120 Meters)

Meet with the DFO after the briefing if  
you plan to fly!





Have you  
registered your  
vehicle?



# Lunch

**Bleik community house lunch: 13.00 – 14.00**

**Cakes: 15:00**

**Stave community house 13 – 14.00 (50 pax)**

**Cakes: 15:00**





# Social gatherings

**Monday: 20.00**, Fyrvika, Andenes Pizza buffet NOK 300 (approx. €25) per person, pay at the door.

**Tuesday: 18.30-20.00**, Possible to buy dinner at, Andøya Space, Bleiksveien 46, Andenes

**Wednesday:**

Options for dinner:

- Utsikten Bar og Bistro, Nordmela
- Arresten, Andenes
- Restaurant Lysthuset, Andenes

**Thursday: 18.30**, Tapas evening & sharing of results, Bleik communal house

# Fyrvika Andenes 20.00

Fyrvika Andenes As



Fyrvika Andenes As  
5,0 ★★★★★ (3) ⓘ

Oversikt Anmeldelser

Veibeskrivelse Lagre I nærheten Send til telefonen Del

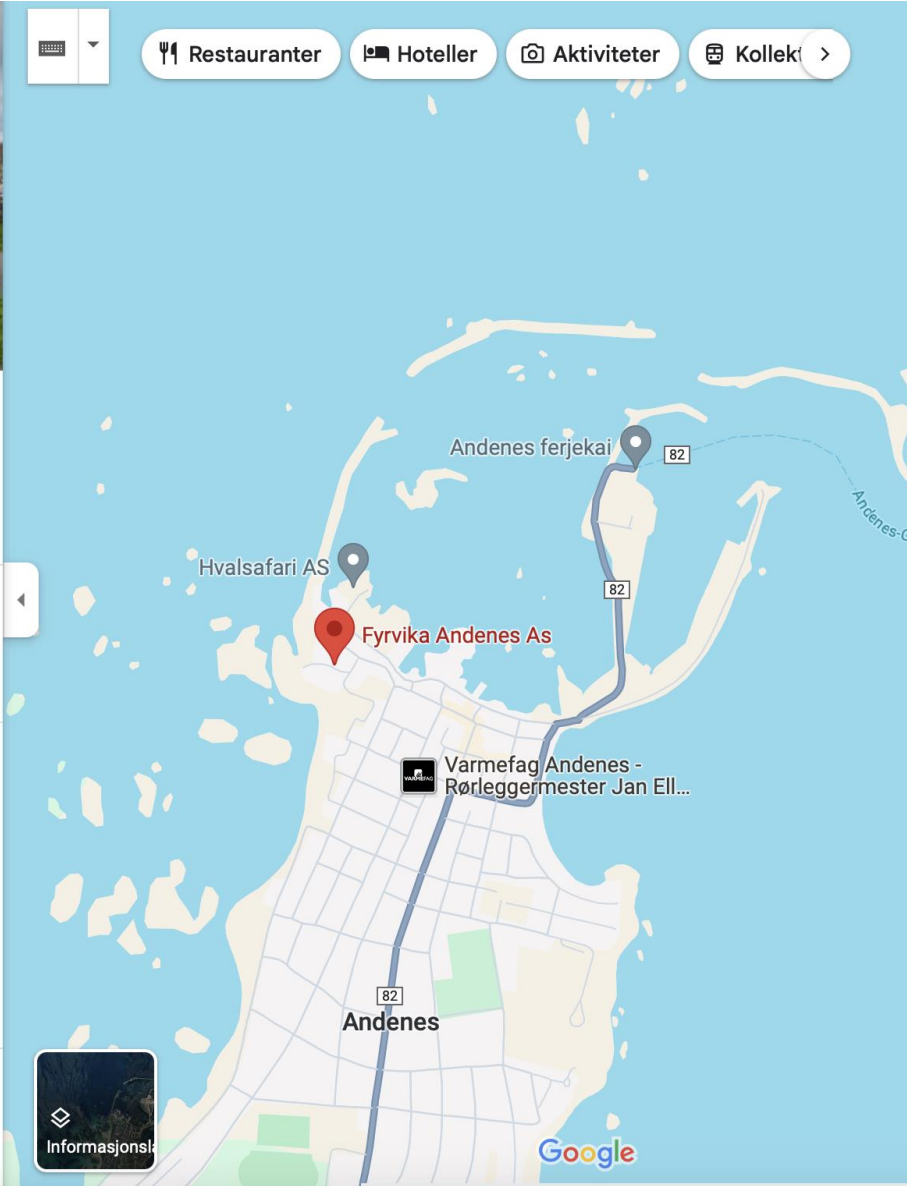
Linds gate 2, 8480 Andenes  
84F8+6V Andenes  
Gjør krav på denne bedriften

Foreslå en endring

Legg til manglende informasjon ⓘ

Legg til bedriftens telefonnummer

Restauranter Hoteller Aktiviteter Kollekt



Andenes ferjekai  
Hvalsafari AS  
Fyrvika Andenes As  
Varmefag Andenes - Rørleggermester Jan Ell...  
Andenes

Informasjons

Google



# Share your experience form Jammertest

Official website: <https://jammertest.no/>

Official Jammertest LinkedIn account: Jammertest

Share your **#jammertest** experience on LinkedIn



Have fun today!