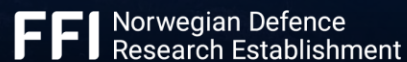


Jammertest 2024

Information meeting March 20th 2024





Tomas Levin
Senior principal engineer,
Norwegian Public Roads
Administration



Nicolai Gerrard
Senior engineer,
Norwegian Communications Authority



Heidi Andreassen
Project leader,
Testnor



Anders Rødningsby
Principal scientist
Norwegian Defence
Research Establishment



Harald Hauglin
Chief engineer,
Norwegian Metrology Service

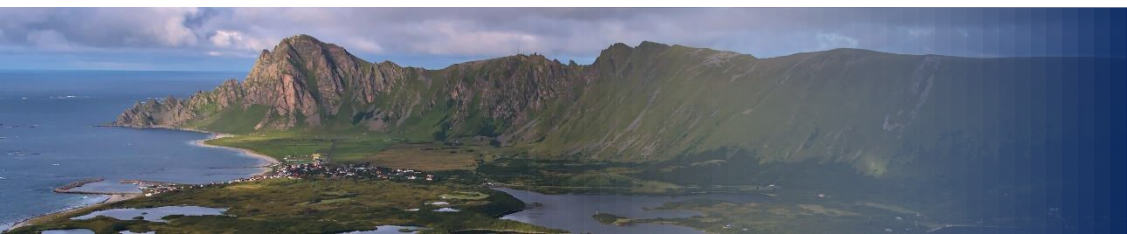


Christian Berg Skjetne,
Senior engineer,
Norwegian Public Roads
Administration



The world's largest open jamming, spoofing and meaconing test

Jammertest 2024 will be held on Andøya, Norway, from September 9th – 13th



Increased robustness through cooperation



What is Jammertest

Jammertest is an annual event hosted at Andøya, Norway. It is probably the largest open PNT/GNSS resilience test in the world. At the jammer test event, participants will be subjected to both simple and sophisticated jamming, spoofing and meaconing. We do this to allow actors from both public and private sector to test their PNT systems and products for potential weaknesses against both unintentional and intentional attacks.

The end product and the benefit for us authorities is more robust use of GNSS – that is why we do this!

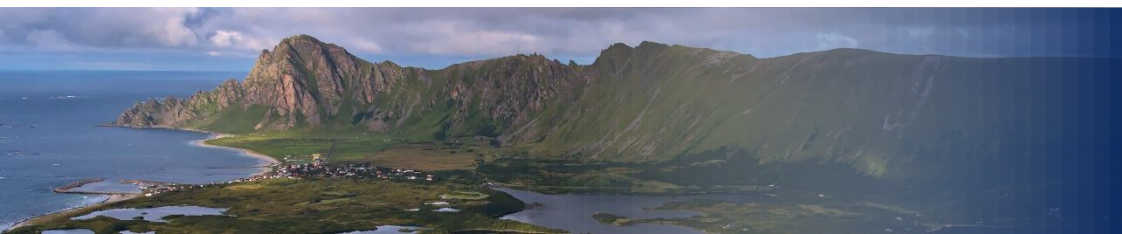
We want to create a collaborative environment that enable knowledge sharing.

Previous attendees at Jammertest have consisted of government authorities, academia, and industry stakeholders engaged in the utilization, development, or production of PNT (Positioning, Navigation, and Timing) products and services.

Previous participants have represented a diverse array of industries, including automotive, drones, helicopters, microchips, radars, telecom, time synchronization, and more.



What to expect from the test week





Products & Services Solutions Support Company

Technology | 08 Mar 2023

GNSS/GPS jamming and spoofing tests under actual conditions

A step further in improving the resilience of receivers against RF interference



<https://www.u-blox.com/en/blogs/insights/gnss-gps-jamming-spoofing>

“For autonomous vehicles, knowing its absolute position is crucial. [...] Participating in Jammertest 2022 on the northern shore of Norway is one way that we are ensuring that we have the best solution in the marketplace.”

– Stephan Zizala, CEO u-blox

Test areas

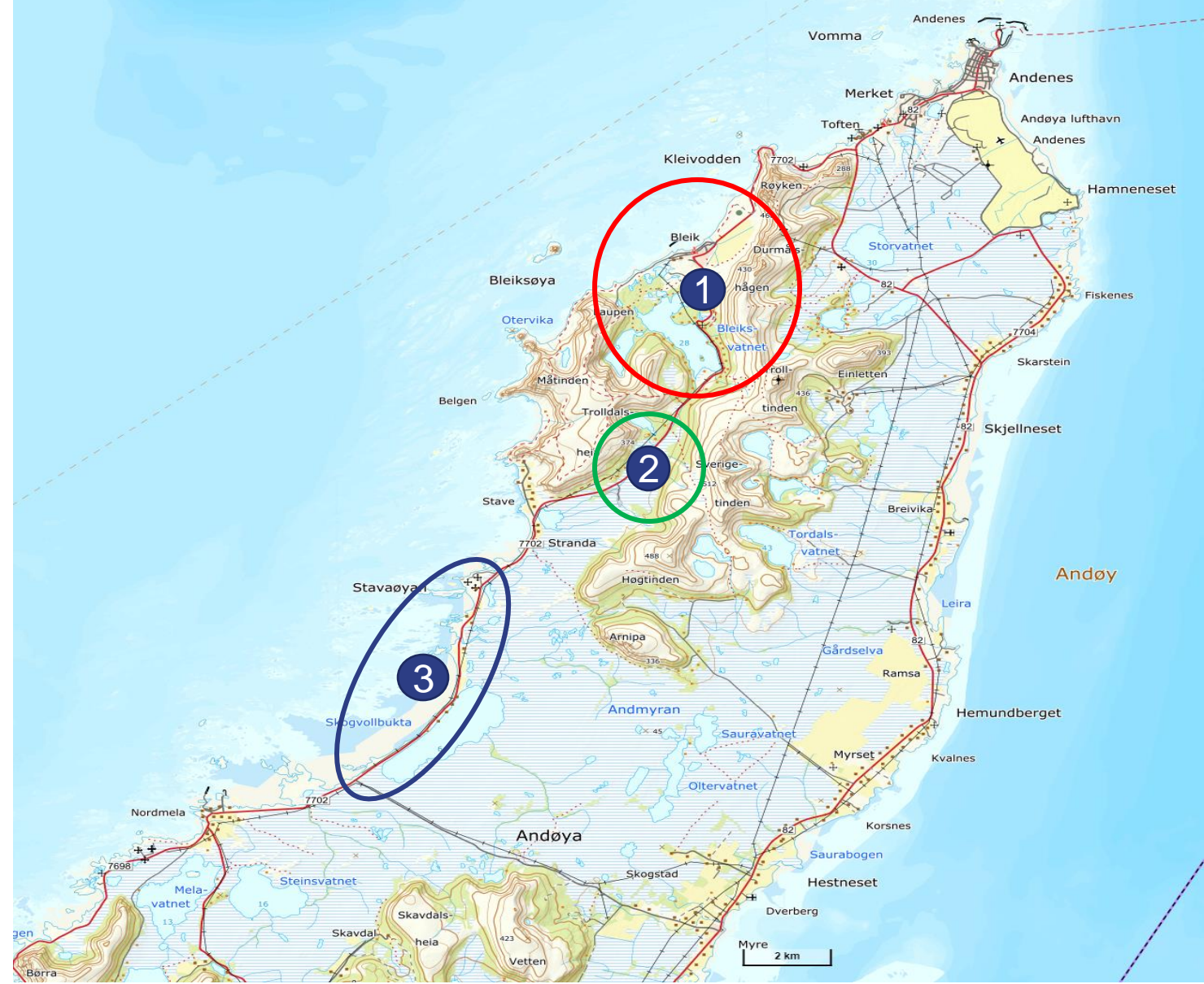
Three test locations, where we can work in parallel:

Test area 1: Main test area

Test area 2: Sand box

Test area 3: Motorcade

The city of Andenes (north on the map) is where most participants will have sleeping arrangements and where the airport is located



Test area 1: Main test area

Transmission activities:

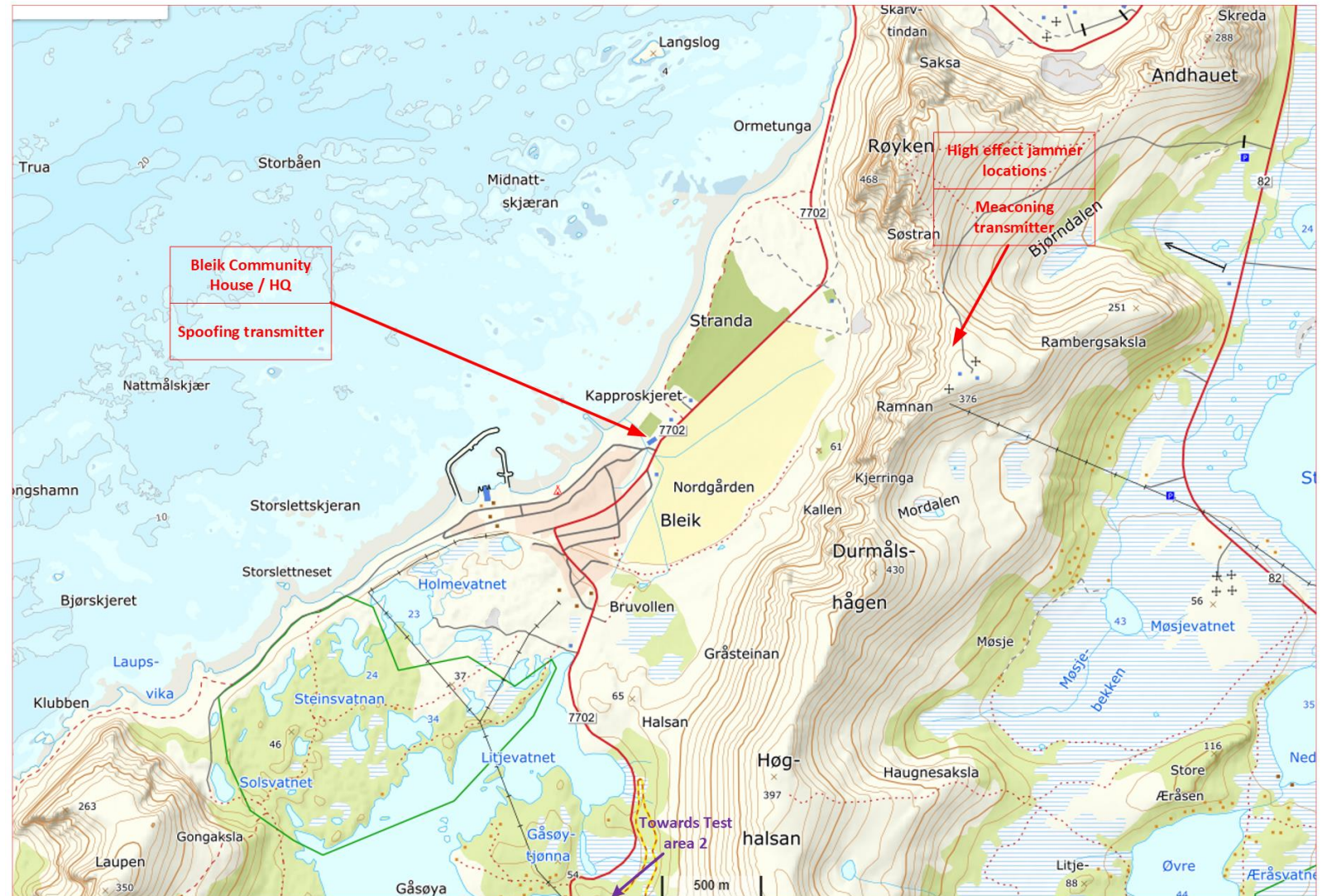
- High power jamming
- Meaconing
- Spoofing (position and time) from a simulator



Test area 1: Main test area

- Tests are centrally planned and run.
- Participants are free to roam and to set up equipment where they choose (but do not bother the local populace).
- Power, food, Wifi and toilets at the HQ.
- Participants with fixed testing/working stations normally set up at the HQ.

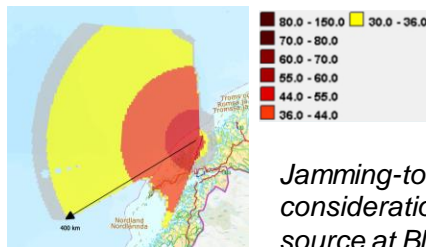
Test area 1



High power jammer

- Signal modulation:
 - CW – continuous wave (unmodulated signal)
 - PRN – Pseudo random noise
 - Chirp (frequency sweep)
- Power ramping
- Different combinations of frequency bands
 - Up to 8 channels
- Max 200W EIRP at each channel with directional RHCP-antennas

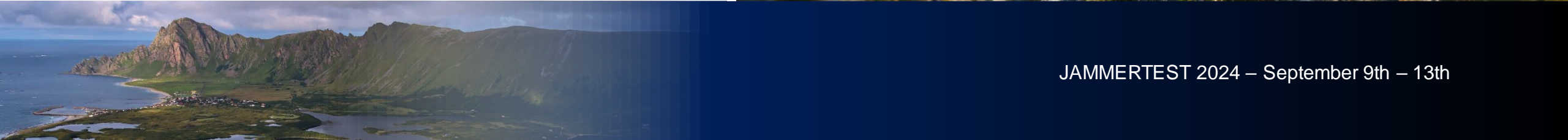
- Range:



Jamming-to-Signal-ratio (J/S) considerations with a 200 W source at Bleik at 40 000 ft. MSL

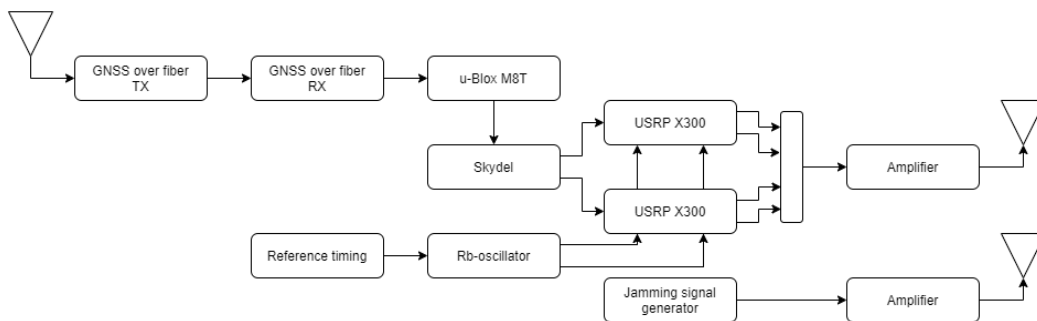


Photo: David Jensen

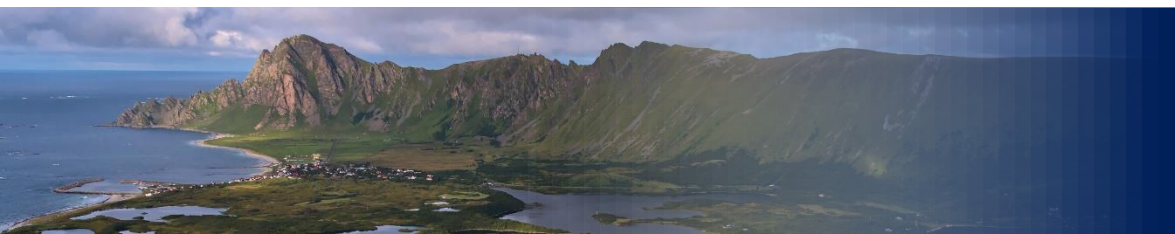
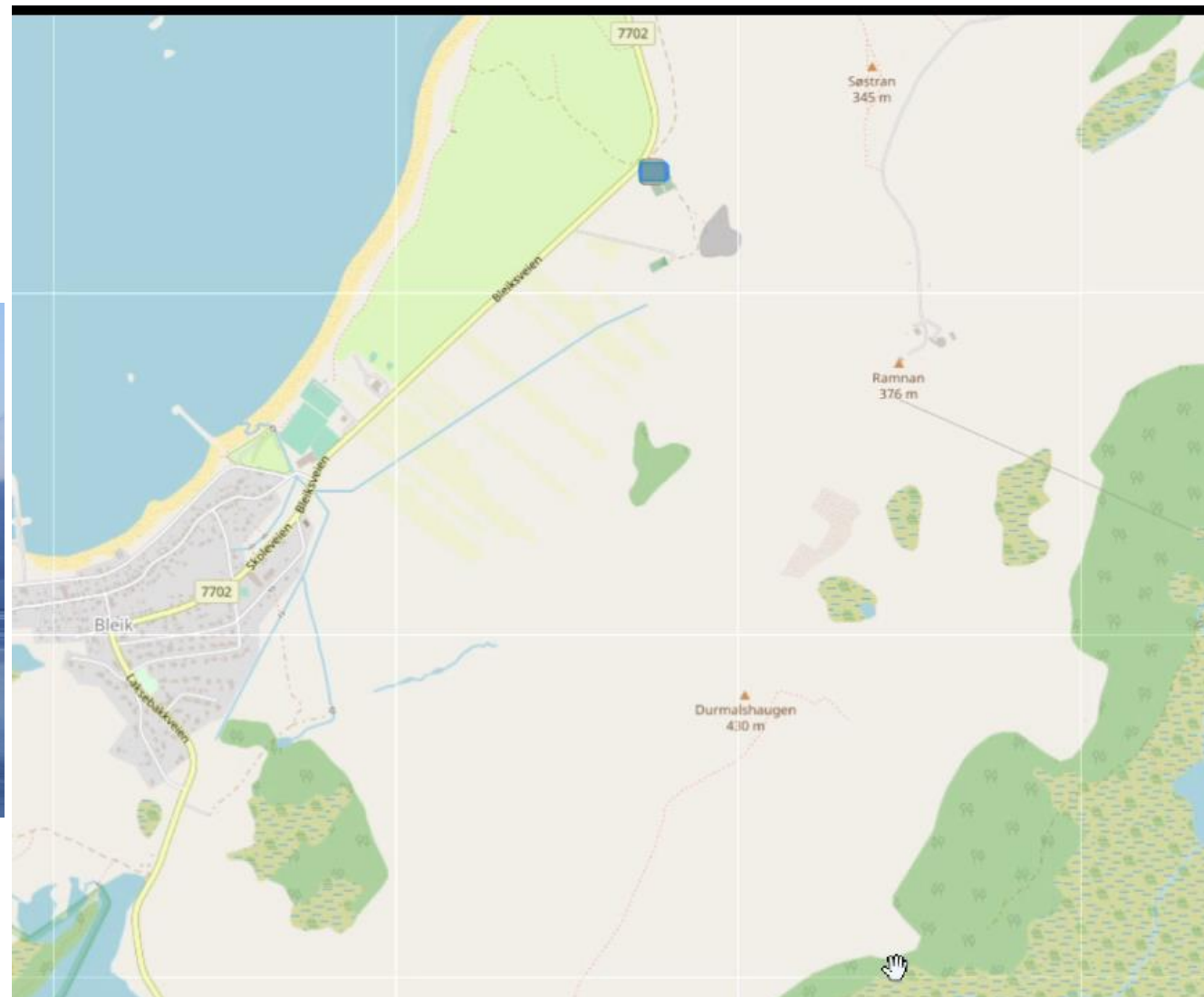
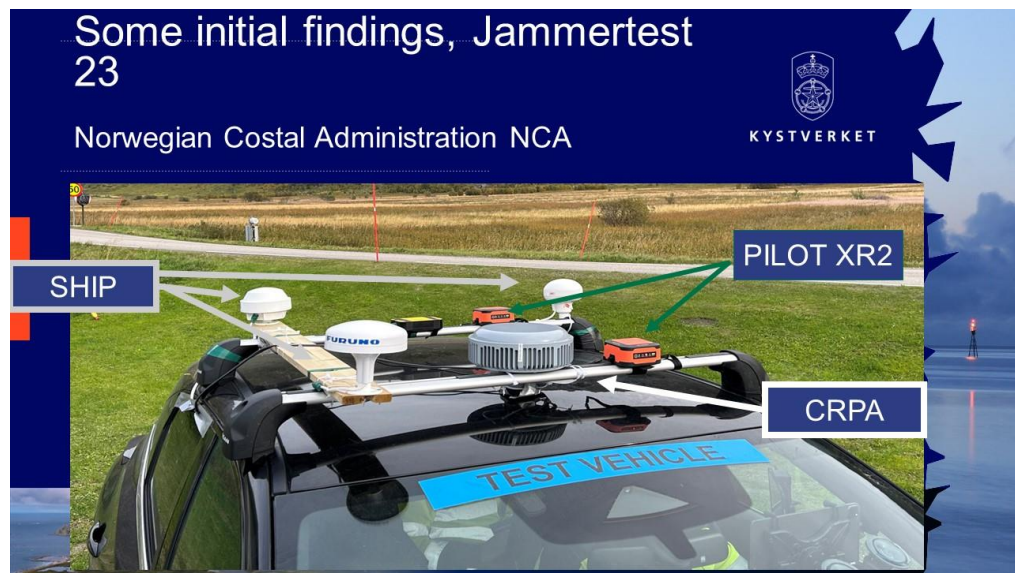


Spoofing

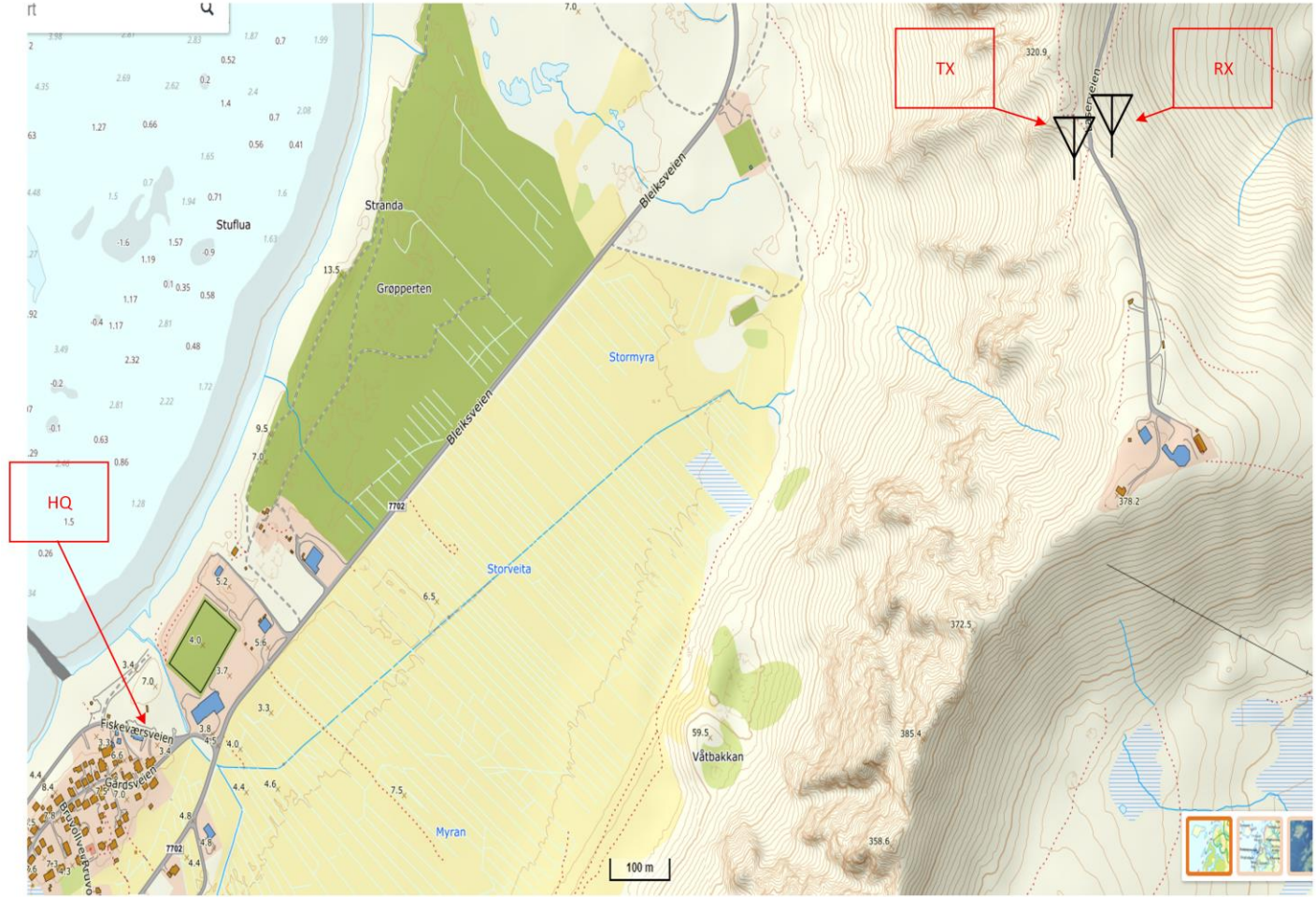
- Spoofing different combinations of frequency bands
- Jamming different combinations of frequency bands (before and/or during spoofing transmission)
- Power ramping
- Range: several hundred metres



Spoofing example



Meaconing example



Test area 2: Sand box

Transmission activities:

- Low power jamming with jammers like the ones (illegally) available online or produced by legal companies.
- (Potentially) SDR jamming

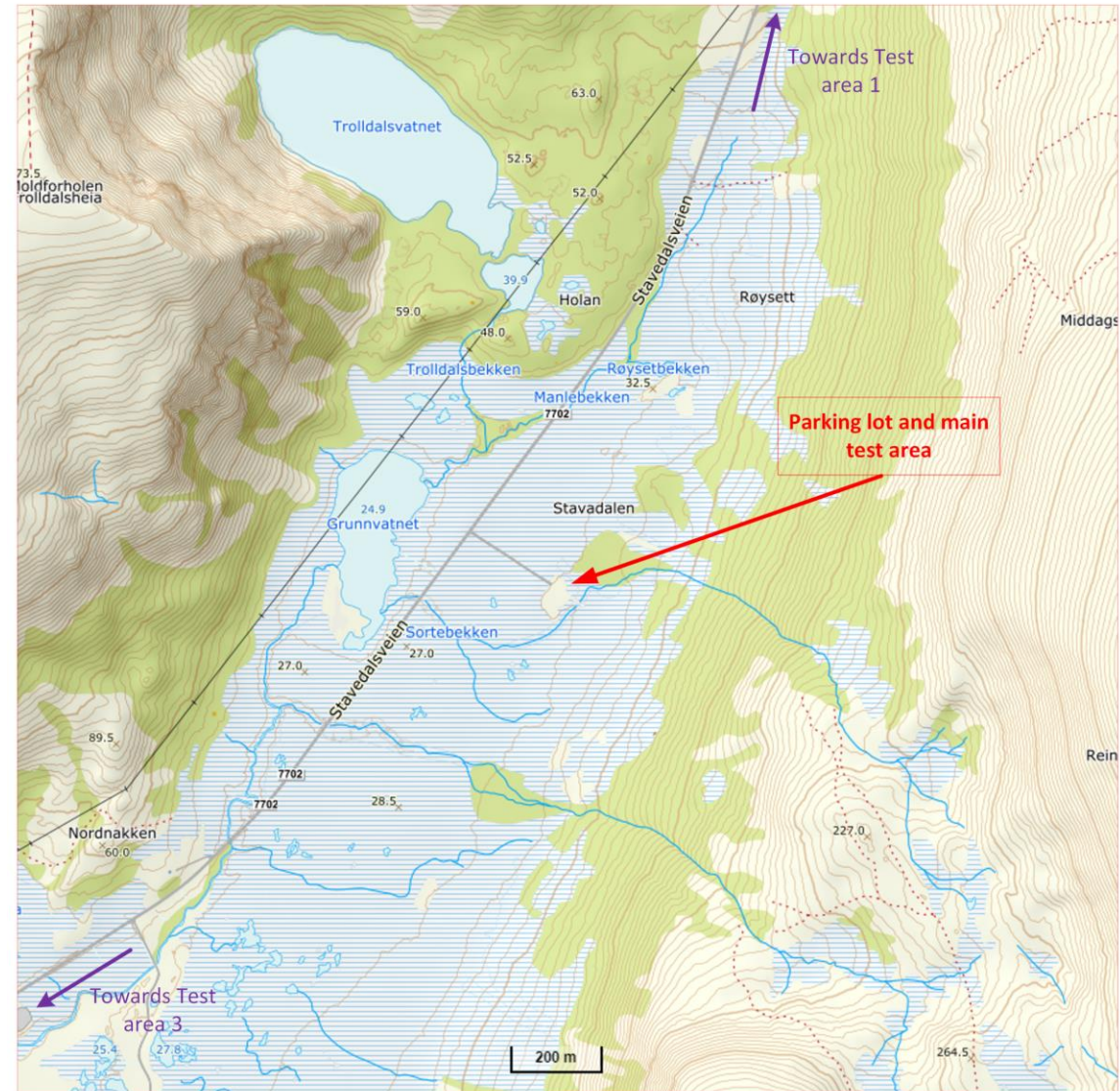


Photo: David Jensen

Test area 2: Sand box

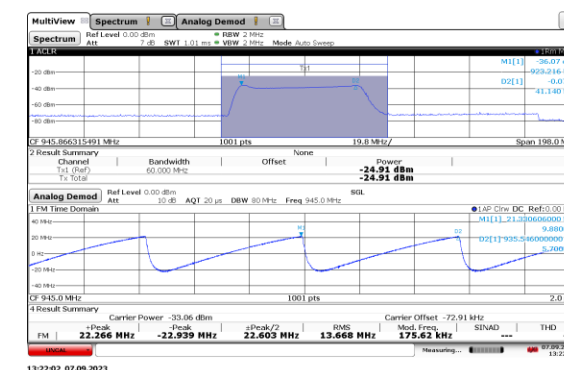
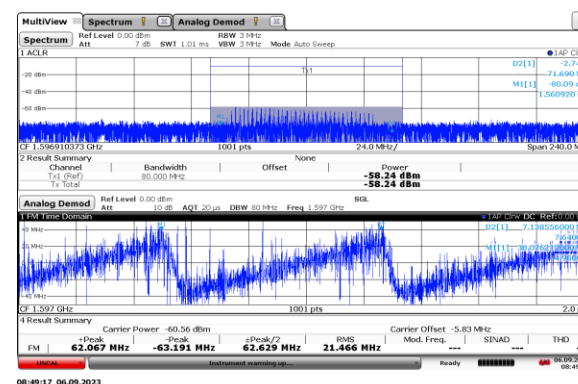
- Participants book time slots and jammers (jammers will always be operated by Norwegian authority personnel).
- Useful area for participant-specific tests.
- Useful area for UAVs and similar DUTs.
- Potential for SDR jamming.

Test area 2



Small handheld jammers (Nkom and FFI)

- Small, handheld jammers with 1 – 6 channels
- Up to 1W output power
- Mainly produced in China
- Cover GNSS bands and other frequency bands
- Modulation mostly sawtooth chirp
- Advanced jammer (with buttons) from NovAtel (Canada)



Test area 3: Motorcade

Transmission activities:

- Low power jamming with jammers like the ones (illegally) available online or produced by legal companies.
- Spoofing with SDR.



Photo: David Jensen

Test area 3: Motorcade

- Tests are mainly centrally planned and run (motorcade driving), with some flexibility for ad hoc driving scenarios.
- Long piece of road, useful for driving tests that require longer periods of driving.

Test area 3



Program overview: Time Schedule

Example from 2023

2024 will follow the same layout:

- (Mandatory) morning brief
- Morning test block (4h)
- Lunch
- Afternoon test block (4h)
- (Mandatory) evening debrief

Monday:

0900 – 1100 Registration and set up of your equipment

1100 - 1200 Welcome and safety briefing

1200 – 1300 Lunch at Samfunnshuset (Bleik communal house)

1300 – 1800 Afternoon test block

1800 - 1830 Evening brief, safety and sharing results

Tuesday, Wednesday, Thursday:

0800 - 0830 Morning safety briefing

0900 –1300 Morning test block

1300 – 1400 Lunch at Samfunnshuset (Bleik communal house)

1400 – 1800 Afternoon test block

1800 - 1830 Evening brief, safety and sharing results

Friday:

0800 - 0830 Morning safety briefing

0900 –1300 Morning test block

1300 – 1400 Lunch at Samfunnshuset (Bleik communal house), sharing results

1400 - 1600 Down rig of equipment and departure

If need of earlier set up times, contact the organisers and also indicate so in your application.

Program overview: Test block view of transmission plan

Example from 2023

Day	Test area 1	Test area 2	Test area 3
Monday	High power stationary jamming	Low power stationary jamming	Low power stationary jamming
Tuesday	High power stationary jamming Meaconing	Book time slots on hourly basis	Motorcade (with low-power jammers)
Wednesday	Stationary spoofing (mainly position, navigation)	Book time slots on hourly basis	Motorcade (with low-power jammers)
Thursday	Stationary spoofing (mainly timing)	Multi-jammer scenarios Book time slots on hourly basis	Mobile spoofing (SDR) (mainly position, navigation)
Friday	Repetitions, variations of previous tests	Book time slots on hourly basis	Book time slots on hourly basis

Test plan vs transmission plan

There will be distributed two documents to participants of Jammertest 2024, a test plan and a transmission plan.

Test plan

- A catalogue of tests (grouped together into test groups) with technical descriptions of transmissions, ideas for set up and rationale for tests.
- Annexes with technical details on for example all the jammers .

Transmission plan

- Specific test groups or tests are picked from the test plan and used to build a plan for the Jammertest week.
- The transmission plan tells one what test is done at what time and at which test location.

After the Jammertest week, a detailed time log will be distributed to all participants

If any potential participants have any ideas for tests and/or test groups (or other similar topics), contact the organisers!

The organisers want input to build tests, how to conduct them and what RFI environments are interesting, to make Jammertest as relevant as possible to all!



Test plan vs transmission plan

4	Continuous stationary high-power jamming with PRN	21	← <i>Example of test group</i>
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	← <i>Example of specific test</i>

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

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				



RF details overview from 2023 (to indicate what will happen in 2024)

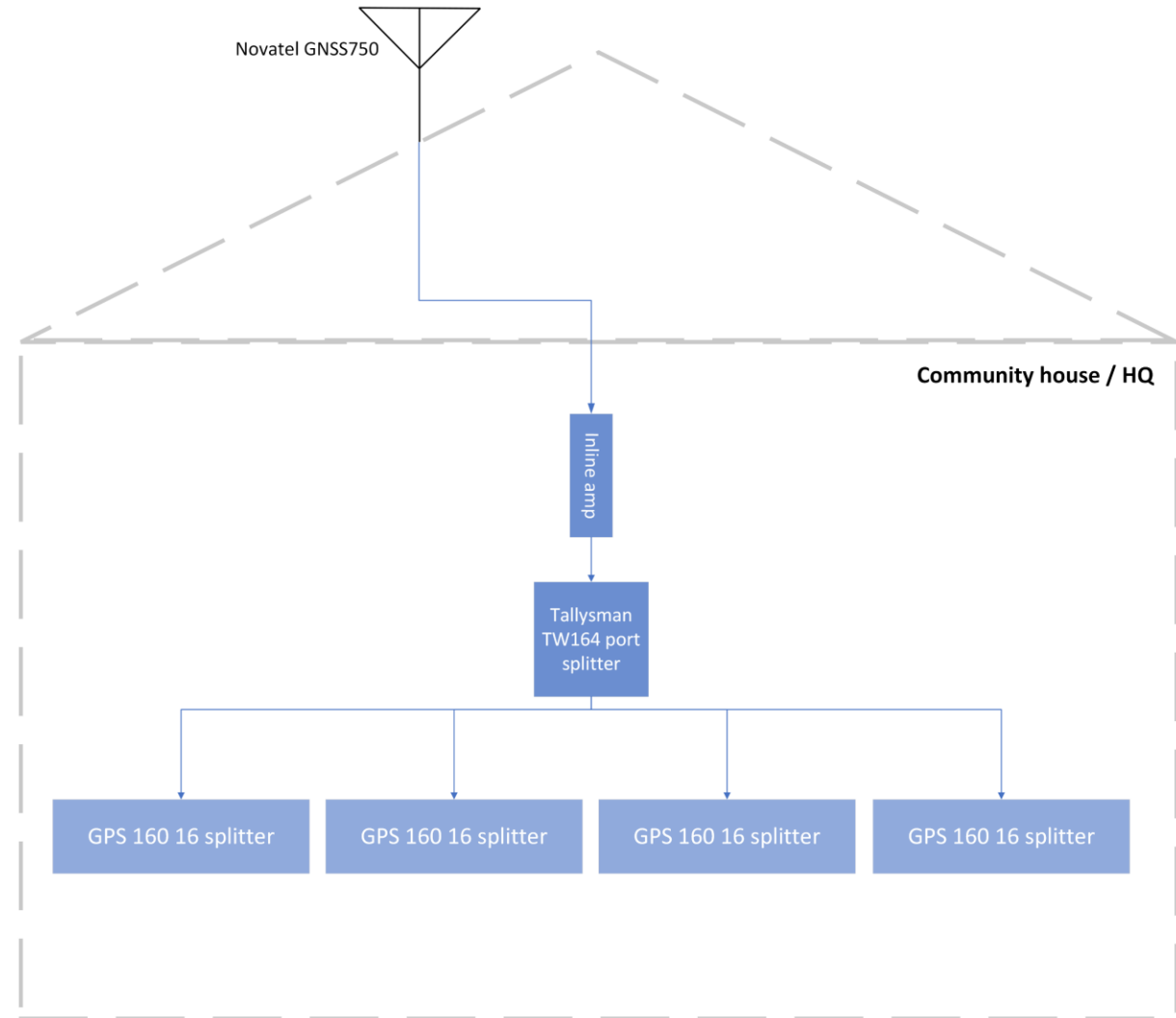
- High power jamming
 - Bands: E6, E5b, L5, G2, L2, B1I, G1, L1
 - Power: 0.1 μ W to 200 W
- Meaconing
 - Bands: GPS L1, L2
 - Power: 0.1 to 10 W
- Spoofing
 - Bands: GPS L1, L2, L5; Galileo E1, E5
 - Power: -35 dBm (31.6 μ W) to 25 dBm (0.316 W)
 - Effects
 - Time drift (frequency steps)
 - Time jump
 - Static position jump
 - Dynamic position route



RF feed

A RF feed from a GNSS antenna on the HQ roof will be set up to distribute signals to participants (who doesn't necessarily need their own antenna).

Contact the organisers if this is useful for you.



GNSS sync value chain represented at Jammertest 2023 timing room



GNSS system operator:



GNSS-chip system integrators:

GNSS-clocks, network time servers, sensor systems



Critical infrastructure end users:

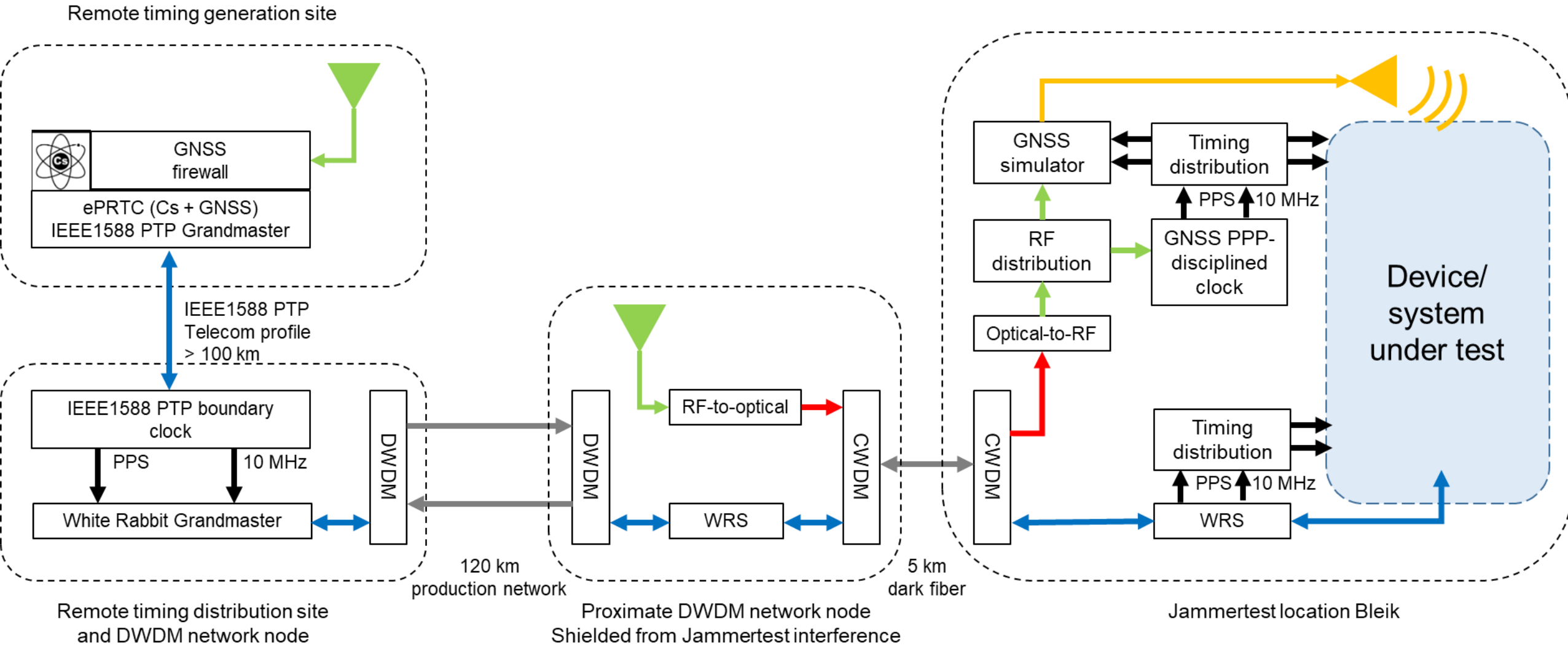
Power grid, 5G, air space surveillance, broadcasting



GNSS chip manufacturers:

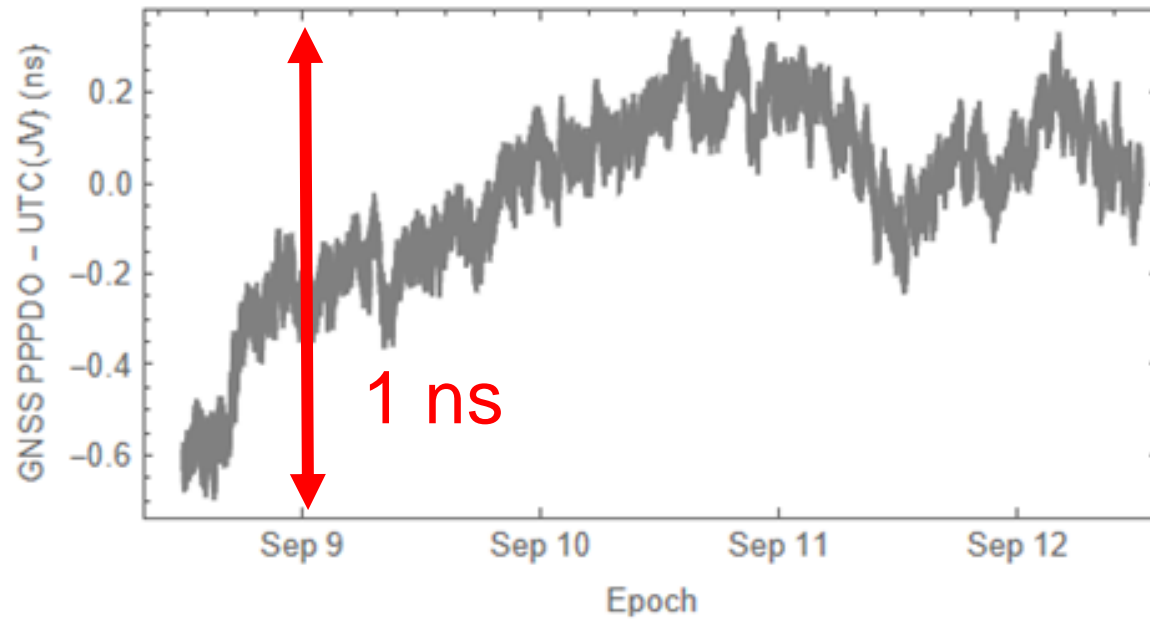


Jammertest 2023 reference timing setup: Two sources

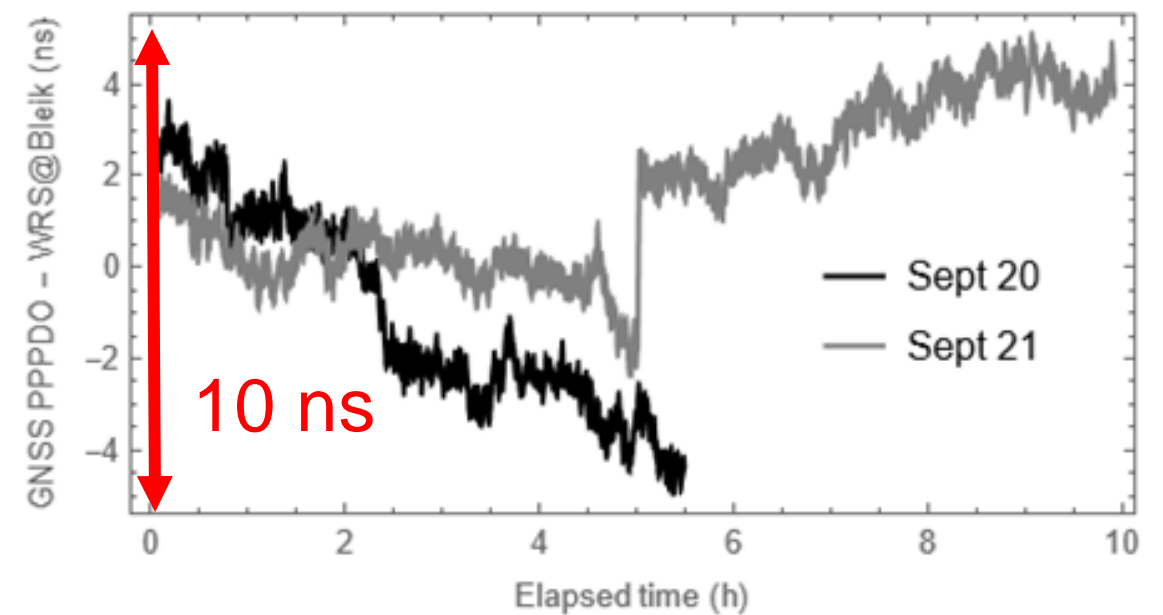


Jammertest 2023 reference timing performance

GNSS PPP (Atomichron) disciplined OCXO vs UTC(JV) in lab at Justervesenet



GNSS PPP (Atomichron) disciplined OCXO vs PTP network timing at Jammertest



Jammertest reference timing distribution

2023:

PPS distribution amplifiers
10 MHz distribution amplifiers

Ad hoc PTP from White Rabbit switch

Ad hoc undisturbed GNSS from fiber link

2024:

PPS distribution amplifiers
10 MHz distribution amplifiers

PTP access in several rooms?

PPS/10 MHz distribution in several rooms?

Undisturbed GNSS from fiber link?

A composite background image featuring a snowy mountain range. In the foreground, there are wind turbines on a rocky outcrop. To the left, a large ship is in the water. In the distance, a city skyline is visible. A satellite is in the upper right sky, and an airplane is in the upper left sky. The overall scene is a mix of natural and technological elements.

JAMMERTEST 2024 PLANNING TIPS

Aiden Morrison

What we were there to test and first tip

- Distributed localization system
 - Concept test for low-cost wide area monitoring
 - Five nodes over the primary test area
 - The data produced was exactly what we needed
- Tip 1: Talk to the organizers and past participants
 - When planning your tests their experience is useful
 - General and specific questions
 - For example, it was learned in 2022 that wireless links at 2.4 Ghz were vulnerable to disruption
 - Some operators of RTK equipment which used a wi-fi for correction streaming lost link



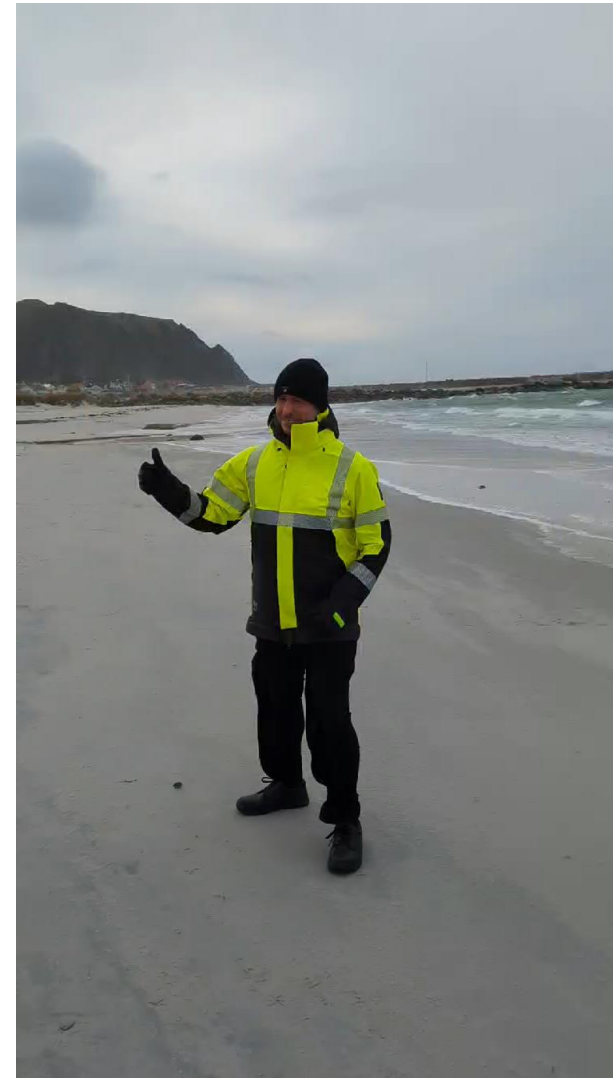
Second tip

- Lesson 2: Talk to the organizers early
- If you let them know what you want to do, they might be able to accommodate it
 - Other users might be asking for the same scenarios
 - It's still better to learn early even if the answer is 'no that's not feasible'

	<i>Test site 1 activities</i>	<i>Test site 2 activities</i>	<i>Test site 3 activities</i>
<i>Monday AM *</i>	<i>User setup</i>	<i>User setup</i>	<i>User setup</i>
<i>Monday PM</i>	<i>High power stationary jamming</i>	<i>User directed tests (reserved timeslots)</i>	<i>User directed tests (reserved timeslots)</i>
<i>Tuesday AM</i>	<i>Power ramp (0.1 μW to 20 W), High power stationary jamming</i>	<i>User directed tests (reserved timeslots)</i>	<i>Motorcades with stationary PPDs</i>
<i>Tuesday PM</i>	<i>Meaconing (0.1 W and 10 W)</i>	<i>User directed tests (reserved timeslots)</i>	<i>Motorcades with moving PPDs</i>
<i>Wednesday AM</i>	<i>Incoherent stationary spoofing, synthetic and true ephemerides</i>	<i>User directed tests (reserved timeslots)</i>	<i>Motorcades with stationary PPDs</i>
<i>Wednesday PM</i>	<i>Coherent stationary spoofing, true ephemerides</i>	<i>User directed tests (reserved timeslots)</i>	<i>Motorcades with moving PPDs</i>
<i>Thursday AM</i>	<i>Incoherent time spoofing, synthetic ephemerides</i>	<i>Multi-jammer scenarios</i> <i>User directed tests (reserved timeslots)</i>	<i>Vehicle borne SDR based spoofing</i>
<i>Thursday PM</i>	<i>Coherent time spoofing, true ephemerides</i>	<i>User directed tests (reserved timeslots)</i>	<i>Vehicle borne SDR based spoofing</i>
<i>Friday AM</i>	<i>PPD jammers and high-power jamming</i>	<i>User directed tests (reserved timeslots)</i>	<i>User directed tests (reserved timeslots)</i>
<i>Friday PM</i>	<i>Packing and cleanup</i>	<i>Packing and cleanup</i>	<i>Packing and cleanup</i>

Third tip

- Tip 3: Plan for 'energetic' weather
 - Wind
 - Rain
 - Gale force winds?
 - Gale force winds by a beach with fine white sand
 - This forcibly enters all exposed connectors (and eyes)



Fourth tip



- Tip 4: Bring supplies and spares
 - Suggested supplies: Power splitters, extension cords, tape, tools
 - Suggested spares: RF Connectors, antenna cables, storage disks, laptops, copies of software, Receivers
- Make sure your equipment can recover from time jumps, and you know how to reset it
 - Licensing: Do you have a time limited license?
 - Some equipment deletes those licenses on expiry → Your expensive brick produces very little data
- At least one incident of a receiver entering a faulted firmware state from low power RFI
 - Was not restored by a firmware reset/update and had to be sent back to the manufacturer

Fifth tip

- Tip 5: Start planning your logistics now
 - Export control paperwork, Separate shipment of equipment?
 - Plane? Driving? Ship? Train*(to Narvik, then driving 4+ hours)?



Our thanks to the NAVISP program members for their support



Teknologi for et bedre samfunn

Safety is our top priority

- Mandatory safety briefings every day
- Open air testing
- Rough weather
- High visibility clothing with
- company logo is mandatory



Communication

Several channels will be used during the test week:

- FM radio
- MQTT
- Chat
- Spectrum streaming



Follow us

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

Official Jammertest LinkedIn account: Jammertest



Application process now open

- Apply on <https://jammertest.no/>
- Limited capacity
- Individual application
- Technical test personnel will be prioritised
- No participation fee – participants cover their own costs
- Hotel booking codes will be provided upon admission

Deadline: April 15th

Admission will be given by May 1st



Test setup

15. How would you prefer your test setup? *

- Own test vehicle at the event
- Active participation at location 1
- Active participation at location 2
- Active participation in motorcade tests at location 3
- Static Indoor placement of test equipment, on location 1
- Access to "Reference timing signal", on location 1
- Access to "RF signal from shared antenna", on location 1
- Access for placement on a "fixed antenna rack", (instead of your own "tripod /antenna mast"), on location 1
- Annet

Logistics

- If you are in need of assistance regarding storage, shipping or other logistical questions, please specify in the application.
- Storage capacity is available close to the testing area.
- Be aware that this is a paid service upon request and availability.

Important links

- Customs: <https://www.toll.no/en/corporate/>
- Export controlled goods: <https://www.regjeringen.no/en/topics/foreign-affairs/export-control/id754301/>

Make sure to start early to plan your logistics and to check what rules apply.

Q&A

- Questions
- Feedback
- Inputs

Contact points:

Technical questions: Nicolai Gerrard, nge@nkom.no

Practical information and logistics: Heidi Andreassen, heidi@testnor.com

Questions

Can names on participants be changed?

Names can be changed, but this needs to be agreed upon by the organizers.

What is the address to the storage?

Equipment can be stored close to the test area. Specify in the application what assistance you need. Address to the storage will be shared after the admission. Be aware that this is a paid service from our suppliers.

Where will documents like the test plan be shared?

- Test plan from 2023 will be shared on the website jammertest.no

Do you still expect VIP session like last time?

- We plan to organize a VIP meeting for executives also this year.

Can we rely on cell coverage?

The cell coverage in the area is good, we also have access to WIFI in the HQ (Bleik Communal house).

Questions

Can we bring a boat as a test vehicle?

Yes, you can. However it is at your own risk and responsibility.

Can we use drones?

Check <https://luftfartstilsynet.no/en/drones/>

Will RTK feed like last year be available?

The Norwegian mapping authority will supply a C-post connection also this year.



Thank you for attending! 😊