Jammertest 2024
Test Catalogue

Jammertest Consortium

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Contents

Introduction

Jammertest is a Norwegian government initiative to create a tastbed for industry, academia and other authorities to ensure robust and intelligent use of Global Navigation Satellite Systems (GNSS). A testbed is a controlled environment where activities that are not allowed under normal conditions can be carried out safely under control of the authorities. Jammertest is a specific type of testbed where six Norwegian authorities have come together to create an environment where GNSS jamming, spoofing and meaconing is present under controlled conditions in a real world outdoor environment.

This test catalogue describes all centrally planned test cases that can be executed at the Jammertest event at Andøya. For Jammertest, a selected number of tests from this plan will be included in a transmission plan. The transmission plan, which becomes available just before the Jammertest event starts, describes what tests will take place where and at what time. After the Jammertest event the organizers will publish an after the fact transmission log that contains all tests that were run and at what time they were run. The time schedule during the live event will be given in local time, UTC time + 2 (CEST).

A machine readable test catalogue is available in a JSON format, and this (PDF) document is built based on the machine readable test catalouge. The numbering of the tests are (as good as possible) presistant, and will over the years indicate the same tests. New varieties of the tests will be given new numbers.
Tests are stacked together in larger test groups and test and varieties of tests are linked to test groups via a numbering system, in such a way that they fulfill this format: TestGroup.Test.TestVariety. Some tests have two numbers, test group and the specific test. Others may have three numbers due to the fact that a specific variety has been added. For example, if power is reduced, a new test variety is created and hence a variation number is added.

Naming of the jammers are linked to the jammer specifications document, that list all jammers with relevant information about the them. See the annexes for this.

This document is auto updated based on changes to the machine readable file, there is no version code apart from the time and date when the document is produced. In the Github repository all produced versions are stored in the history of this file.

Spesifications of tests

Tests are grouped into test groups. Within a test group there is a logical connection between the tests that related to the use case. Hence each test group has a *Rationale* why this is test group is created, that also gives a hint about what to expect when subjected to the specific test. As many tests are on the bleeding edge of GNSS disturbances, the *Rationale* section may be updated between Jammertests based on new knowledge and experiences.

Technical details are stored in the *Test setup* section of the document. The *Areas* section of the document refer to where the test can be run. Here participants need to keep track of in which area they where and this also gives and indication of which areas where the organizers are capable of running the tests. There is also a location out at sea (not numbered) that can be used for maritime related test groups, and a location at the airport in Andenes, for aviation related test groups (only for air planes).

For each test group a set of tests and test varieties are listed with their unique identification number, a name and a text that describes the test and teh rationale. An approximate power number is also included. If the test is an automated ramp test then the power range is given. A time estimate of how long the test takes to conclude is given in minutes. Between tests there are also grace periods to allow systems to regain normal operation. Grace times are not given exact as they are dependent on equipment and needs to be discussed with participants beforehand. They also depend on operational concerns. The actual grace time will be calculated from the transmission log after the fact. The location of the transmitter equipment is also given in the test, this is a coarse human readable description of where the transmitting antenna is located. All participants are encouraged to make their own notes on the location of the transmitting antenna if detailed information is needed. There is also a comment field that can be used to document any other relevant information related to the specific test.

For those wanting more information or have feedback about the test group a technical contact is provided for each test group.

0 Supplemental periods

0.0: Mandatory briefings

Rationale

In order for everyone to have a good time and ensure a safe event, there will be mandatory briefings.

Test description

These are the mandatory safety briefings. These briefings will also be used to go through the plan for the day and the afternoon brief will contain important observations from the day and a safety debrief.

Additional information

Mandatory!

Tests within this test group

0.0.1 Mandatory morning briefing

No RF interference expected.

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'N/A'

Transmitter equpment

'N/A'

0.0.2 Mandatory afternoon (de)briefing

No RF interference expected.

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'N/A'

Transmitter equpment

'N/A'

0.1: Grace period

Rationale

In order for equipment to return to normal operation after interference, a grace period is provided between tests.

Test description

This period can be used to make sure that equipment is ready for upcoming tests.

Tests within this test group

0.1.1 Grace period

No RF interference expected in this test.

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'N/A'

Transmitter equpment

'N/A'

1 Jamming

1.1: Continuous stationary low power jamming with commercially available jammers

Rationale

The main objective is to observe how the J/S signal affect the availability of PNT, and/or how it produces inaccurate PNT data, when the jamming signal (J) is generated by low-power jammers commercially available online. Additionally, as these types of jammers are the ones one is most likely to meet in the real world, capturing and storing the signals from these jammers for later use in labs could be useful.

Test description

All tests will be performed with the jammers place 1 to 1.5 meters above ground (like on top of a vehicle) and be turned on and kept active for two minutes before being turned off. A two minute break is included between tests. Unless otherwise stated, jammers will be in "maximum" posistion, meaning all relevant antennas are switched on and power is set to as high as possible.

Additional information

Spesification of jammers can be found in appendix A. Jammer power levels are based on 2023 measurements. Test bands/constellations refer to potentially afflicated frequency bands from the jammer in question.

Tests within this test group

1.1.1 Jammer S1.1

Test with jammer S1.1

Power or power range

Min: 0.01 W
Max: 0.0316 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C'

Transmitter equpment

'S1.1'

1.1.2 Jammer S1.2

Test with jammer S1.2

Power or power range

Min: 0.01 W
Max: 0.0316 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C'

Transmitter equpment

'S1.2'

1.1.3 Jammer S1.3

Test with jammer S1.3

Power or power range

Min: 0.01 W
Max: 0.0316 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C'

Transmitter equpment

'S1.3'

1.1.4 Jammer S2.1

Test with jammer S2.1

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.1.5 Jammer S2.2

Test with jammer S2.2

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1I', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.2'

1.1.6 Jammer S2.3

Test with jammer S2.3

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1I', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.3'

1.1.7 Jammer S2.4

Test with jammer S2.4

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1I', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.4'

1.1.8 Jammer U1.1

Test with jammer U1.1

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' G1'

Transmitter equpment

'U1.1'

1.1.9 Jammer U1.2

Test with jammer U1.2

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' G1'

Transmitter equpment

'U1.2'

1.1.10 Jammer U1.3

Test with jammer U1.3

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' G1'

Transmitter equpment

'U1.3'

1.1.11 Jammer U1.4

Test with jammer U1.4

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' G1'

Transmitter equpment

'U1.4'

1.1.12 Jammer H1.1

Test with jammer H1.1 with function settings set at high power and GPS L1+L2 wideband modulation.

Power or power range

Min: 0.0003 W
Max: 0.1 W

Test bands/constellation

'L1', ' L2'

Transmitter equpment

'H1.1'

1.1.13 Jammer H1.2

Test with jammer H1.2

Power or power range

Min: 0.0631 W
Max: 0.0631 W

Test bands/constellation

'L1', ' E1', ' B1C'

Transmitter equpment

'H1.2'

1.1.14 Jammer H3.1

Test with jammer H3.1

Power or power range

Min: 0.1 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1C', ' B1l'

Transmitter equpment

'H3.1'

1.1.15 Jammer H3.2

Test with jammer H3.2

Power or power range

Min: 0.1 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1C', ' B1l'

Transmitter equpment

'H3.2'

1.1.16 Jammer H3.3

Test with jammer H3.3

Power or power range

Min: 1 W
Max: 1 W

Test bands/constellation

'L1', ' E1', ' B1C', ' L2', ' L5', ' E5a', ' B2a'

Transmitter equpment

'H3.3'

1.1.17 Jammer H4.1

Test with jammer H4.1

Power or power range

Min: 0.3981 W
Max: 0.631 W

Test bands/constellation

'L1', ' E1', ' B1C', ' B1l', ' E6', ' G2', ' B3l', ' L2', ' G2', ' B2b', ' E5b', ' L5', ' G3', ' B2a', ' E5a/b'

Transmitter equpment

'H4.1'

1.1.18 Jammer H6.1

Test with jammer H6.1

Power or power range

Min: 0.631 W
Max: 0.631 W

Test bands/constellation

'L1', ' E1', ' B1C'

Transmitter equpment

'H6.1'

1.1.19 Jammer H6.2

TEst with jammer H6.2

Power or power range

Min: 0.3981 W
Max: 1 W

Test bands/constellation

'L1', ' E1', ' B1C', ' L5', ' G3', ' B2a/b', ' E5a/b', ' L2', ' G2', ' G3', ' B2b', ' B3l', ' E5b', ' E6'

Transmitter equpment

'H6.2'

1.1.20 Jammer H6.3

Test with jammer H6.3

Power or power range

Min: 0.3981 W
Max: 1 W

Test bands/constellation

'L1', ' E1', ' B1C', ' L5', ' G3', ' B2a/b', ' E5a/b', ' L2', ' G2', ' G3', ' B2b', ' B3l', ' E5b', ' E6'

Transmitter equpment

'H6.3'

1.1.21 Jammer H6.4

Test with jammer H6.4

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.1.22 Jammer H6.5

Test with jammer H6.5

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.5'

1.1.23 Jammer H6.6

Test with jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.6'

1.1.24 Jammer H8.1

Test with jammer H8.1

Power or power range

Min: 0.631 W
Max: 0.631 W

Test bands/constellation

'L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H8.1'

1.1.25 Jammer F6.1

Test with jammer F6.1 (with function settings set at full power and antennas F2 to F6).

Power or power range

Min: 0.5012 W
Max: 6.31 W

Test bands/constellation

'L1', ' E1', ' B1C', ' B1l', ' G1', ' L2', ' G2', ' B3l', ' B2b', ' E6', ' L5', ' E5a', ' B2a'

Transmitter equpment

'F6.1'

1.1.26 Jammer H1.3

Test with jammer H1.3

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1C'

Transmitter equpment

'H1.3'

1.1.27 Jammer H2.1

Test with jammer H2.1

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1C', ' L2'

Transmitter equpment

'H2.1'

1.1.28 Jammer H2.2

Test with jammer H2.2

Power or power range

Min: 0 W
Max: 0 W

Test bands/constellation

'L1', ' E1', ' B1C', ' L2'

Transmitter equpment

'H2.2'

1.2: Continuous stationary high-power jamming with CW

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting, as earlier tests have shown that errors can accumulate to a large extent in these phases (before availability disappears entirely).

Test description

The use of continuous high-power jamming will block GNSS signals in a large area at the event. The attendees may therefore test their equipment at different ranges to such a high-power jammer. There will be transmitted with a continuous wave (CW) modulation (single frequency component) using Right Hand Circular Polarized (RHCP) antennas. The CW signals will be placed at the centre frequencies of the relevant test bands. The use of a 20 W jammer will result in among the highest J/S ratios during the event. The attendees can change distance to the transmitter and observe the changes and try to identify the protection ratio for their GNSS receiving system.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.2.1 20 W CW: L1

20 W CW: L1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.2.2 20 W CW: L1, G1

20 W CW: L1, G1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1'

Transmitter equpment

'F8.1'

1.2.3 20 W CW: L1, G1, L2

20 W CW: L1, G1, L2

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2'

Transmitter equpment

'F8.1'

1.2.4 20 W CW: L1, G1, L2, L5

20 W CW: L1, G1, L2, L5

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2', ' L5'

Transmitter equpment

'F8.1'

1.3: Continuous stationary high-power jamming with sweep/chirp

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting, as earlier tests have shown that errors can accumulate to a large extent in these phases (before availability disappears entirely).

Test description

The use of continuous high-power jamming will block GNSS signals in a large area at the event. The attendees may therefore test their equipment at different ranges to such a high-power jammer. There will be transmitted with a sweep/chirp modulation using Right Hand Circular Polarized (RHCP) antennas. Sweep/chirp modulation means that the frequency component will sweep back and forth inside the specific frequency band with a given sweep rate. The chirp signal will have a sweet rate of 100 kHz and a bandwidth of 3 MHz, centred at the centre frequency of the relevant test band. The attendees can change distance to the transmitter and observe the changes and try to identify the protection ratio for their GNSS receiving system.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.3.1 20 W chirp: L1

20 W chirp: L1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.3.2 20 W chirp: L1, G1

20 W chirp: L1, G1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1'

Transmitter equpment

'F8.1'

1.3.3 20 W chirp: L1, G1, L2

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20 W chirp: L1, G1, L2

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2'

Transmitter equpment

'F8.1'

1.3.4 20 W chirp: L1, G1, L2, L5

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20 W chirp: L1, G1, L2, L5

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2', ' L5'

Transmitter equpment

'F8.1'

1.4: Continuous stationary high-power jamming with PRN

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting, as earlier tests have shown that errors can accumulate to a large extent in these phases (before availability disappears entirely).

Test description

The use of continuous high-power jamming will block out a large area at the event. The attendees may therefore test the range of such a high-power jammer. There will be transmitted with a Pseudo Random Noise (PRN) modulation using Right Hand Circular Polarized (RHCP) antennas. PRN signals have the same spectral form as the true signals sent from the GNSS satellites but with different spreading codes. The spreading codes are Binary Phase Shift Keying (BPSK) modulated onto the centre frequency of the relevant test bands. For Mbaud rates, see the annex. The attendees can

change distance to the transmitter and observe the changes and try to identify the protection ratio for their GNSS receiving system.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.4.1 20 W PRN: L1

20 W PRN: L1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.4.2 20 W PRN: L1, G1

20 W PRN: L1, G1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1'

Transmitter equpment

'F8.1'

1.4.3 20 W PRN: L1, G1, L2

20 W PRN: L1, G1, L2

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2'

Transmitter equpment

'F8.1'

1.4.4 20 W PRN: L1, G1, L2, L5

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20 W PRN: L1, G1, L2, L5

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1', ' G1', ' L2', ' L5'

Transmitter equpment

'F8.1'

1.5: Continuous stationary high-power jamming with "real world" PRN

Rationale

The type of jamming employed in this test is the same as real world signals observed in Europe, where the jammer parameters were found after demodulating a captured baseband stream.

Test description

The tests will be performed with BPSK modulation with a pseudo random symbol rate of 3 Mbaud at GPS L1 and 10.23 Mbaud at Glonass G1. The test cases refer to which centre frequency of the relevant test bands the signal will be centred at.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.5.1 20 W: L1 PRN (Mbaud of 3)

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20 W: L1 PRN (BPSK-modulated with Mbaud symbolrate of 3)

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.5.2 20 W: G1, PRN (Mbaud of 10.23)

20 W: G1 PRN (BPSK-modulated with Mbaud symbolrate of 10.23)

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'G1'

Transmitter equpment

'F8.1'

1.6: Stationary high-power jamming, ramp power with PRN

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level. This will allow for evaluation of the sensitivity thresholds for various systems and algorithms.

Test description

The transmitted power will be ramped up and down from a lower to a higher EIRP for each test, with 10 seconds hold time for each power level, with ramping steps of a certain amount of dB. If the last step doesn't add up to a whole dB step (e.g. from [...] 38, 40, 42 dBm to 43.0103 dBm (20 W)), it will be the exact amount of dB to realise the max power (e.g. a 1.0103 dB increment, not a 2 dB increment). The modulation will be PRN. The attendees should be at a stationary location with a known distance to the jammer, so they can observe how different levels will affect the PNT.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.6.1 0.1 µW to 20 W at 2 dB increments PRN: L1

PRN jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test band L1.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.6.2 0.1 µW to 20 W at 2 dB increments PRN: L1, G1

PRN jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1'

Transmitter equpment

'F8.1'

1.6.3 0.1 µW to 20 W at 2 dB increments PRN: L1, G1, L2

PRN jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1, L2.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1', 'L2'

Transmitter equpment

'F8.1'

1.6.4 0.1 µW to 20 W at 2 dB increments PRN: L1, G1, L2, L5

PRN jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1, L2, L5.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1', 'L2', 'L5'

Transmitter equpment

'F8.1'

1.7: Stationary high-power jamming, ramp power with CW

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level. This will allow for evaluation of the sensitivity thresholds for various systems and algorithms.

Test description

The transmitted power will be ramped up and down from a lower to a higher EIRP for each test, with 10 seconds hold time for each power level, with ramping steps of a certain amount of dB. If the last step doesn't add up to a whole dB step (e.g. from [...] 38, 40, 42 dBm to 43.0103 dBm (20 W)), it will be the exact amount of dB to realise the max power (e.g. a 1.0103 dB increment, not a 2 dB increment). The modulation will be CW. The attendees should be at a stationary location with a known distance to the jammer, so they can observe how different levels will affect the PNT.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.7.1 0.1 µW to 20 W at 2 dB increments CW: L1

CW jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.7.2 0.1 µW to 20 W at 2 dB increments CW: L1, G1

CW jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1'

Transmitter equpment

'F8.1'

1.7.3 0.1 µW to 20 W at 2 dB increments CW: L1, G1, L2

CW jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1, L2.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1', 'L2'

Transmitter equpment

'F8.1'

1.7.4 0.1 µW to 20 W at 2 dB increments CW: L1, G1, L2, L5

CW jamming with a power ramp from 0.1 µW to a maximum of 20 W at 2 dB increments, at the test bands L1, G1, L2, L5.

Power or power range

Min: 1e-07 W
Max: 20 W

Test bands/constellation

'L1', 'G1', 'L2', 'L5'

Transmitter equpment

'F8.1'

1.8: Stationary pyramid jamming with PRN for all GNSS bands sequentially

Rationale

This "pyramid" is intended to test the potential fallback behaviour of modern multi-constellation, multi-frequency receivers.

Test description

A jamming pyramid test of GNSS bands. The jamming is performed with PRN modulation and a constant power level. The pyramid steps will last for three minutes each, with a grace period of two minutes after each step. The test will jam most GNSS bands, incrementally adding bands ("pyramid steps") to the list of jammed signals, then removing them in the reverse order.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.8.1 20 W PRN pyramid: E6, E5b, L5, G2, L2, B1l, G1, L1

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20 W PRN pyramid jamming, starting with only E6 and adding bands all the way up to E6, E5b, L5, G2, L2, B1l, G1, L1. The test then continues by removing bands one by one in reverse order, until ending up with only E6. In total, it will look this: E6 - E6, E5b - E6, E5b, L5 - E6, E5b, L5, G2 - E6, E5b, L5, G2, L2 - E6, E5b, L5, G2, L2, B1I - E6, E5b, L5, G2, L2, B1I, G1 - E6, E5b, L5, G2, L2, B1I, G1, L1 - E6, E5b, L5, G2, L2, B1I, G1 - E6, E5b, L5, G2, L2, B1I - E6, E5b, L5, G2, L2 - E6, E5b, L5, G2 - E6, E5b, L5 - E6, E5b - E6

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'E6', 'E5b', 'L5', 'G2', 'L2', 'B1l', 'G1', 'L1'

Transmitter equpment

'F8.1'

1.9: Stationary inverted pyramid jamming with PRN for all GNSS bands sequentially

Rationale

This 'inverted pyramid' is intended to test the potential fallback behaviour of modern multi-constellation, multi-frequency receivers, in an opposite way than a normal pyramid test.

Test description

An inverted jamming pyramid test of GNSS bands. The jamming is performed with PRN modulation and a constant power level. The pyramid steps will last for three minutes each, with a grace period of two minutes after each step. The tests will jam most GNSS bands, incrementally removing bands ("pyramid steps") from the list of jammed signals, then adding them in the reverse order.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A.

Tests within this test group

1.9.1 20 W PRN inverted pyramid: E6, E5b, L5, G2, L2, B1l, G1, L1

20 W PRN inverted pyramid jamming, starting with E6, E5b, L5, G2, L2, B1l, G1, L1 and removing bands all the way down to only E6. The test then continues by adding bands one by one in reverse order, until ending back at the starting frequency bands. In total, it will look like this: E6, E5b, L5, G2, L2, B1l, G1, L1 - E6, E5b, L5, G2, L2, B1l, G1 - E6, E5b, L5, G2, L2, B1l - E6, E5b, L5, G2, L2 - E6, E5b, L5, G2 - E6, E5b, L5 - E6, E5b - E6 - E6, E5b - E6, E5b, L5 - E6, E5b, L5, G2 - E6, E5b, L5, G2, L2 - E6, E5b, L5, G2, L2, B1l - E6, E5b, L5, G2, L2, B1l, G1 - E6, E5b, L5, G2, L2, B1l, G1, L1

Power or power range

Min: 20 W
Max: 20 W

Test bands/constellation

'E6', 'E5b', 'L5', 'G2', 'L2', 'B1l', 'G1', 'L1'

Transmitter equpment

'F8.1'

1.10: Motorcade with low-power commercially available jammers (placed on stationary vehicle)

Rationale

These tests explore the impact on systems in DUT vehicles caused by a jammer placed on a parked car.

Test description

Jammers used in these tests are commercially available jammers. The jammers are to be placed on the roof of a vehicle, and DUT vehicles can then do driving tests based around this stationary jammer.

Tests within this test group

1.10.1 Driving while passing a parked car with GPS L1 & L2 jammer

Test performed with jammer S2.1. DUT vehicles will start at driving from a point where they are only marginally or not at all affected by the jammer.

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.10.2 Driving while passing a parked car with multi-band jammer

Test performed with jammer H6.4. DUT vehicles will start at driving from a point where they are only marginally or not at all affected by the jammer.

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.10.3 Vehicle starting in GPS L1 & L2 denied environment

Test perfomred with jammer S2.1. DUT vehicles will start up close to the parked car with the jammer, and then drive away.

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.10.4 Vehicle starting in multi-band denied environment

Test performed jammer H6.4. DUT vehicles will start up close to the parked car with the jammer, and then drive away.

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.11: Motorcade with low-power commercially available jammers (placed inside mobile vehicle)

Rationale

These tests simulate meeting a vehicle on the road with a jammer inside of it, to explore the impact on systems in DUT vehicles.

Test description

Jammers used in these tests are commercially available jammers and will be placed inside the jammer-carrying vehicle. DUT vehicles will act in motorcades during the tests and move as one unit relative to the jammer-carrying vehicle. In some specific tests, the jammer can be placed inside of a DUT vehicle, testing that one specific vehicle.

Tests within this test group

1.11.1 Driving with GPS L1 & L2 jammer in test vehicle

Test performed with jammer S2.1, where the jammer is placed inside the mobile DUT vehicle.

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1I', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.11.2 Driving with GPS L1 & L2 jammer in vehicle in front of the test vehicle

Test performed with jammer S2.1

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1I', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.11.3 Driving with GPS L1 & L2 jammer in vehicle behind the test vehicle

Test performed with jammer S2.1

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.11.4 Driving with GPS L1 & L2 jammer in vehicle overtaking the test vehicle

Test performed with jammer S2.1

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.11.5 Driving with GPS L1 & L2 jammer in vehicle being overtaken by the test vehicle

Test performed with jammer S2.1

Power or power range

Min: 0.0316 W
Max: 0.1 W

Test bands/constellation

'L1', ' E1', ' B1l', ' B1C', ' L5', ' E5a/b', ' B2a/b', ' G3'

Transmitter equpment

'S2.1'

1.11.6 Driving with multi-band jammer in test vehicle

Test performed with jammer H6.4, where the jammer is placed inside the mobile DUT vehicle.

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.11.7 Driving with multi-band jammer in vehicle in front of the test vehicle

Test performed with jammer H6.4

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.11.8 Driving with multi-band jammer in vehicle behind the test vehicle

Test performed with jammer H6.4

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.11.9 Driving with multi-band jammer in vehicle overtaking the test vehicle

Test performed with jammer H6.4

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.11.10 Driving with multi-band jammer in vehicle being overtaken by the test vehicle

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Test performed with jammer H6.4

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.4'

1.12: Low power jamming with commercially available multi-band jammers in different placements in the terrain

Rationale

The main objective is to simulate meeting several "more dangerous" jammers, multi-band jammers.

Test description

The test will use three multiband jammers, spaced out in the terrain in different places. Attendees can move around or station themselves so that they can experience the different constellation and observe how their equipment and systems behave in a complicated GNSS RFI environment.

Additional information

The precise positions for each jammer will have to be decided in field, to best accommodate participants wishes and practical concerns (like terrain). The coordinates for each position, X, Y and Z, will have to be written down in field to help later analysis of the test results.

Tests within this test group

1.12.1 All jammers stationary; activate Jammer F6.1, H6.5 and H3.3 sequentially

Sequential activation of jammers. Max/min power does not account for multiple jammers being active at once.

Power or power range

Min: 0.5012 W
Max: 6.31 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'F6.1', 'H6.5', 'H3.3'

1.12.2 All jammers stationary in new placements; activate Jammer F6.1, H6.5 and H3.3 sequentially

Sequential activation of jammers. Max/min power does not account for multiple jammers being active at once.

Power or power range

Min: 0.5012 W
Max: 6.31 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'F6.1', 'H6.5', 'H3.3'

1.12.3 Jammers F6.1 and H6.5 stationary, Jammer H3.3 mobile; all jammers activated simultaneously

Max/min power does not account for multiple jammers being active at once.

Power or power range

Min: 0.5012 W
Max: 6.31 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'F6.1', 'H6.5', 'H3.3'

1.13: Jamming attacks on ships

Rationale

The objective is to simulate the conditions of which a jammer can appear on ships like ferries.

Test description

Exact locations and tests will be chosen on site according to layout of ship and available time schedule.

Tests within this test group

1.13.1 Mobile jammer (H8.1) (L1 only) on the car deck outside car

Jammer H8.1

Power or power range

Min: 0.631 W
Max: 0.631 W

Test bands/constellation

'L1'

Transmitter equpment

'H8.1'

1.13.2 Mobile jammer (H8.1) (L1 only) on the car deck inside car

Jammer H8.1

Power or power range

Min: 0.631 W
Max: 0.631 W

Test bands/constellation

'L1'

Transmitter equpment

'H8.1'

1.13.3 Mobile jammer (H6.6) (L1+L2) - on the car deck outside car

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L1', ' L2'

Transmitter equpment

'H6.6'

1.13.4 Mobile jammer (H6.6) (L1+L2) - on the car deck inside car

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L1', ' L2'

Transmitter equpment

'H6.6'

1.13.5 Mobile jammer (H6.6) (multi-band) - on the car deck outside car

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.6'

1.13.6 Mobile jammer (H6.6) (multi-band) - on the car deck inside car

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.6'

1.13.7 Mobile jammer (H6.6) (multi-band) - on deck close to the ship's antennas (by the bridge)

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.6'

1.13.8 Mobile jammer (H6.6) (multi-band) - inside public areas of boat (under the bridge)

Jammer H6.6

Power or power range

Min: 1 W
Max: 1.58 W

Test bands/constellation

'L5', ' B2a', ' E5a', ' L2', ' G2', ' B3l', ' E6', ' L1', ' E1', ' B1C', ' B1l', ' G1'

Transmitter equpment

'H6.6'

1.14: Stationary high-power jamming, ramp power with PRN - Ramnan (200 W)

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level. This will allow for evaluation of the sensitivity thresholds for various systems.

Test description

The jammer will be placed at a mountainside. This will allow for attendees to evaluate the difference between signals arriving from in the horizontal plane and signals arriving with some elevation above the horizontal. Each test will last for 15.67 minutes, with a 15-minute break between each test.

Additional information

The jammer employed will be "Porcus Major" F8.1, see appendix A. The last step, from 52 dBm to 53.0103 dBm (200 W), will be a 1.0103 dB increment, not a 2 dB increment.

Tests within this test group

1.14.1 0.1µW to 200 W, 2 dB increments PRN: L1

Power ramp using F8.1

Power or power range

Min: 1e-07 W
Max: 200 W

Test bands/constellation

'L1'

Transmitter equpment

'F8.1'

1.14.2 0.1µW to 200 W, 2 dB increments PRN: L1, G1

Power ramp using F8.1

Power or power range

Min: 1e-07 W
Max: 200 W

Test bands/constellation

'L1', 'G1'

Transmitter equpment

'F8.1'

1.14.3 0.1µW to 200 W, 2 dB increments PRN: L1, G1, L2

Power ramp using F8.1

Power or power range

Min: 1e-07 W
Max: 200 W

Test bands/constellation

'L1', 'G1', 'L2'

Transmitter equpment

'F8.1'

1.14.4 0.1µW to 200 W, 2 dB increments PRN: L1, G1, L2, L5

Power ramp using F8.1

Power or power range

Min: 1e-07 W
Max: 200 W

Test bands/constellation

'L1', 'G1', 'L2', 'L5'

Transmitter equpment

'F8.1'

1.15: Stationary low-power jamming of L1-only and G1-only

Rationale

The main objective is to test receivers' ability to change between using GPS and Glonass when one or the other is denied.

Test description

A 20 MHz wideband (WB) white noise signal will be active on either L1 or G1. Signal power will be ramped up during the first test, and then kept at the achieved maximum power for the reminder of the tests.

Additional information

Each test will have a short break after it is completed. When L1-only and G1-only is combined in a test, the transmission will change from the first to the second instantly.

Tests within this test group

1.15.1 WB, L1-only

Low-power jamming

Power or power range

Min: 0.1 W
Max: 1 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

1.15.2 WB, G1-only

Low-power jamming

Power or power range

Min: 0.1 W
Max: 1 W

Test bands/constellation

'G1'

Transmitter equpment

'N/A'

1.15.3 WB, G1-only then L1-only

Low-power jamming

Power or power range

Min: 0.1 W
Max: 1 W

Test bands/constellation

'G1', 'L1'

Transmitter equpment

'N/A'

1.15.4 WB, L1-only then G1-only

Low-power jamming

Power or power range

Min: 0.1 W
Max: 1 W

Test bands/constellation

'G1', 'L1'

Transmitter equpment

'N/A'

2 Spoofing

2.1: Incoherent spoofing from stationary spoofer using synthetic ephemerides

Rationale

These are very basic attacks that can be performed with easily available software and hardware. These attacks can give an indication to the receivers' resiliency to spoofing attacks. Most receivers will probably see these attacks as noise initially, effectively working as a jamming signal.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use satellite ephemerides different from live sky satellites. Simulated signals may use one or more constellations and one or more signal bands.
Initial positions are either False (e.g. 70 N, 10 E) or True (target location at transmitter antenna location). Initial time is either False (e.g. a jump in time) or True (¡ 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several signal bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several signal bands). Static scenarios are a fixed position, while motion scenarios are a drive around the area. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

Additional information

Expected range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.1.1 Large position and time jump, gradually increasing signal strength

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Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated position: 70 N, 10 E Simulated start time: 01.10.2023 12:00

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.1.2 Large position and time jump

Signals: GPS L1 C/A Galileo E1 No jamming Position: 70 N, 10 E Simulated start time: 01.10.2023 12:00

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.1.3 Large position and time jump, with jamming

Signals: GPS L1 C/A Galileo E1 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Simulated position: 70 N, 10 E Simulated start time: 01.10.2023 12:00

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.1.4 Simulated driving (route 1)

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Transmitter location Simulated start time: 01.10.2023 12:00

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.1.5 Simulated driving, true reference time (route 1)

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Transmitter location Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2: Incoherent spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

These spoofing tests use ephemerides (navigation data) identical to those broadcasted by the actual satellites, but the transmitted spoofing signals do not align with those received from actual satellites. Receivers using the spoofed signals will generate jumps in the navigation solution, either in position, timing and/or velocity.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more signal bands.
Initial positions are either False (e.g. 70 N, 10 E) or True (target location at transmitter antenna location). Initial time is either False (e.g. a jump in time/date) or True (¡ 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several signal bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several signal bands).
Static scenarios are a fixed position, while motion scenarios are a simulated drive around the area. There will be a break between each test to allow receivers to reacquire fix onto real satellite signals. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

Additional information

Expected range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.2.1 Large position jump

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated position: 70 N, 10 E Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2.2 Small position jump, large time jump

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Simulated position: North end of the football field - 69.27701401, 15.969328354, 45 m hae. (Height Above Ellipsoid) Simulated start time: 01.10.2023 12:00

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2.3 Small position jump

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated position: North end of the football field - 69.27701401, 15.96932835, 45 m hae. (Height Above Ellipsoid) Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2.4 Flying (route 2) - "helicopter scenario"

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated start position: Over the sea 1 km N (Midnattskjæran) at 200 m height Simulated start time: Referenced to live GPS-signals Spoofing transmission will be corrected for signal delay to simulated start position. Helicopter at start position should see coherent signals.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2.5 Fixed position

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated position: Cemetery - 69.2824699, 15.9906568, 48 m hae. (Height Above Ellipsoid) Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.2.6 Large position jump #2

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated position: 69.25 N, 14,9 E Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.3: Coherent spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

These spoofing tests use ephemerides (navigation data) identical to those broadcasted by the actual satellites. The transmitted spoofing signals are intended to align (to within a few 100 ns) with those received from actual satellites at the target location. Receivers using the spoofed signals at rest at the target location will initially generate no major changes in the navigation solution, either in position, timing and/or velocity, compared to the solution estimated from actual satellite signals.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more signal bands.
Initial positions are True (target location at transmitter antenna location). Initial time is True (¡ 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several signal bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several signal bands).
For all tests in this group, spoofing transmission will be corrected for signal delay to simulated start position.
Static scenarios are a fixed position, while motion scenarios are a simulated drive around the area. There will be a break between each test to allow receivers to reacquire fix onto real satellite signals. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

Additional information

Expected range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.3.1 Simulated driving (route 1). GPS only with initial jamming.

Signals: GPS L1 C/A, L2C, L5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5'

Transmitter equpment

'N/A'

2.3.2 Simulated driving (route 1). Galileo only with initial jamming.

Signals: Galileo E1, E5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.3.3 Simulated driving (route 1) with initial jamming.

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 5 minutes of initial jamming (L1, G1, B1l, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.3.4 Simulated driving (route 1). GPS only.

Signals: GPS L1 C/A, L2C, L5 No jamming Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5'

Transmitter equpment

'N/A'

2.3.5 Simulated driving (route 1). GPS L1 and Galileo E1.

Signals: GPS L1 C/A Galileo E1 No jamming Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.3.6 Simulated driving (route 1)

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated start position: Bleik community house parking lot Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.3.7 Flying (route 4) - "drone scenario"

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated start position: 69.277014014, 15.969328354, 40 mhae. Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.3.8 Sailing (route 5) - ”ship scenario”

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming Simulated start position: Bleik harbour Simulated start time: Referenced to live GPS-signals

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

’L1’, ’L2’, ’L5’, ’E1’, ’E5a’, ’E5b’

Transmitter equpment

’N/A’

2.4: Incoherent time spoofing from stationary spoofer using synthetic ephemerides

Rationale

These are synchronized spoofing scenarios in the sense that the navigation solution (position, velocity and clock bias) should not initially change significantly for a receiver at the target location. The scenarios are incoherent in the sense that spoofing signals are different from those received from the actual satellites.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use satellite ephemerides different from live sky satellites. Simulated signals may use one or more constellations and one or more signal bands.
Initial positions are True (target location at transmitter antenna location). Some test scenarios may be started with jamming (lasting for 5 min, one or several signal bands). Some spoofing scenarios may be accompanied by continuous jamming (one or several signal bands).
There will be a small break between each test and a larger break after the test group is over to allow receivers to reacquire fix onto real satellite signals.

Additional information

Expected range/power of spoofing signals: A radius of approximately few hundred metres from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.4.1 Time offset 15 minutes from real time. GPS L1 and Galileo E1

Signals: GPS L1 C/A and Galileo E1 only.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.4.2 Time offset 15 minutes from real time.

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future". Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.4.3 Time offset -3 minutes from real time

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is - 3 minutes (180 seconds), so "back into the past". Spoofing power will start at -20 dBm and be stepped up to 15 dBm in one step.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.4.4 Static + Frequency step (spoofing signal transmission rate change). GPS L1 C/A only

Signals: GPS L1 C/A only.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

2.4.5 Static + Frequency step (spoofing signal transmission rate change)

Signals: GPS L1 C/A Galileo E1 5 minutes of initial jamming (L1, G1, B1l, L2, E5b, L5 with 2 W) prior to spoofing transmission. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Spoofing power will be at 0 dBm. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5: Coherent time spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

Scenarios in these tests is intended not to alter the navigation solution at for receivers at the target position for position and velocity estimates. Clock bias estimates should be affected by the frequency step in test 1 - 3, but not in 4 - 7.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more signal bands.
Initial positions are True (target location at transmitter antenna location). Initial time is True (¡ 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several signal bands). Some spoofing scenarios may be accompanied by continuous jamming (one or several signal bands).
There will be a short break between each test and a larger break after the test group is over to allow receivers to reacquire fix onto real satellite signals.

Additional information

Expected range/power of spoofing signals: A radius of approximately few hundred metres from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.5.1 Static + Frequency step (spoofing signal transmission rate change)

Signals: GPS L1 C/A Galileo E1 No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Frequency steps are added (10 ns/s), and starts five minutes after the spoofing starts. Spoofing power will be at -20 dBm.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5.2 Static + Frequency step (spoofing signal transmission rate change) with jamming

Signals: GPS L1 C/A Galileo E1 5 minutes of initial jamming (L1, G1, B1l, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Frequency steps are removed (10 ns/s) and starts five minutes after the spoofing starts. Spoofing power will be at 0 dBm.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5.3 Static + Nav data manipulation (clock/frequency related). L1/E1 only

Signals: GPS L1 C/A Galileo E1 No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Spoofing power will be at -20 dBm.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5.4 Static + Nav data manipulation (clock/frequency related). with jamming.

Signals: GPS L1 C/A Galileo E1 5 minutes of initial jamming (L1, G1, B1l, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5.5 Static + UTC-parameter navigation data manipulation.

Signals: GPS L1 C/A Galileo E1 5 minutes of initial jamming (L1, G1, B1l, L2, E5b, L5 with 2 W) prior to spoofing transmission. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Spoofing power will be at -20 dBm. Spoofing says that back in 2016, there was 19 leap seconds instead of 18.

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.5.6 Time offset 15 minutes from real time - harbour

Signals: GPS L1 C/A, L2C, L5 Galileo E1, E5 No jamming. Fixed spoofed position: Bleik harbour Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Min: 1 W
Max: 100 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equpment

'N/A'

2.6: Incoherent GPS position and time spoofing from mobile spoofer

Rationale

The objective is to simulate a vehicle-borne spoofing device "out in the wild", so that attendees can experience how a mobile spoofing source affects their (stationary or mobile) equipment and systems.

Test description

There will be a break between each test to allow receivers to reacquire fix onto real satellite signals (total of 50 min for each test). The spoofed signals will be on GPS L1 only. All spoofing tests will be combined with jamming on Glonass G1.

Additional information

Starting position will be approximately 69.194875 N, 15.837719 E in all scenarios.

Tests within this test group

2.6.1 Spoofer (in vehicle) stationary with moving spoofed position.

Spoofer (in vehicle) stationary; spoofed position starts static and approximately true. After 10 min spoofed position starts to move south with constant speed (15 m/s) while spoofer is still stationary.

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

2.6.2 Spoofer (in vehicle) stationary and then moving with fixed spoofed position.

Spoofer (in vehicle) starts stationary for 10 min, and then begins to drive south along Stavedalsveien (FV7702); spoofed position remains fixed and approximately as the true position from start throughout the test.

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

2.6.3 Spoofer (in vehicle) moving with fixed spoofed position.

Spoofer (in vehicle) moves south along Stavedalsveien (FV7702) from the start while being spoofed to a fixed position at 70 N, 10 E.

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

2.6.4 Spoofer (in vehicle) stationary and then moving with first fixed and then moving spoofed position.

Spoofer (in vehicle) starts stationary for 10 min, then vehicle begins to drive south along Stavedalsveien (FV7702); spoofed position is approximately true for the first 10 min, then starts to move directly south with constant speed (15 m/s) in a slightly different direction than the vehicle.

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1'

Transmitter equpment

'N/A'

2.7: Stationary incoherent spoofing with extreme timeshifts (+/- 1 to 2 years)

Rationale

Some equipment will use GNSS to synchronize time and this time and different subsystems can use this time for checking validity of licences, certificates etc.This test can be used to check for unintended effects of large time shifts on equipment and subsystems.

Test description

Providing a date 2 years back in time or 2 years ahead can cause denial of service for certain services.

Additional information

The effect on subsystems is not known and hence care should be taken to limit the range of the transmission to include only systems that we want to test.

Tests within this test group

2.7.1 Pos=True, Time=2 years backwards, Jamming=True, Scenario=Static+motion

Time will be shifted by 2 years in the past. The test will be preceded by jamming (L1, G1, B1l, L2, E5b, L5) The jamming will continue during spoofing except on L1/E1

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

2.7.2 Pos=True, Time=2 years forward, Jamming=True, Scenario=Static+motion

Time will be shifted by 2 years in the future. The test will be preceded by jamming (L1, G1, B1l, L2, E5b, L5) The jamming will continue during spoofing except on L1/E1

Power or power range

Min: 0.1 W
Max: 100 W

Test bands/constellation

'L1', 'E1'

Transmitter equpment

'N/A'

3 Meaconing

3.1: Stationary meaconing from single receiver

Rationale

The objective is to observe how equipment and systems behave under meaconing from a single receiver, with and without initital jammming. Attendees should try to observe PNT changes and/or loss of PNT, and monitor the changes when their equipment and systems are exposed to two different power levels. Maybe especially interesting is to see how the effects of movement and speed, coupled with other sensor data, will result the total output. Some tests might be repeated, so that it is possible to try to detect differences between for example stationary and mobile test objects, or to allow for configuration of other participants setups to test different variables in the same RFI environment.

Test description

GNSS re-transmission of real live sky signals from one receiver, where the GNSS environment will have wrong position with real satellite data, only slightly time delayed. The test will re-transmitt on the L1 and L2 bands, where the employed antennas for receivers RX1 and RX2 have cut-off frequencies at 1562 – 1588 MHz (L1) & 1216 – 1240 MHz (L2) and 1564 – 1586 MHz (L1) & 1218 – 1238 MHz (L2), respectivly. This means that GPS L1 and L2, Galileo E1, and Beidou B1 should be visible, that the Glonass G1 satellites shouldn't be visiable, and that some Beidou B1I satellites might be, especially on RX1. The tests are performed with constant transmission power, some with initial jamming and some without. There is planned a 10-minute break between each test. The meaconed position is for RX1: (TBD1) and for RX2: (TBD2).

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A. The meaconing setup employed, "M", is explained in Appendix XX.

Tests within this test group

3.1.1 RX1 at 1 W

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1 W meaconing from receiver RX1

Power or power range

Min: 1 W
Max: 1 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.1.2 RX1 at 1 W with initial jamming

1 W meaconing from receiver RX1 preceded by 5 min. jamming (PRN L1, L2, L5 and G1 at 20 W)

Power or power range

Min: 1 W
Max: 1 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.1.3 RX1 at 10 W

10 W meaconing from receiver RX1

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.1.4 RX1 at 10 W with initial jamming

10 W meaconing from receiver RX1 preceded by 5 min. jamming (PRN L1, L2, L5 and G1 at 20 W)

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.1.5 RX2 at 10 W

10 W meaconing from receiver RX2

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.2: Stationary meaconing from two receivers

Rationale

The objective is to observe how equipment and systems behave under meaconing from two receivers, with and without initital jammming. Attendees should try to observe PNT changes and/or loss of PNT, and monitor the changes when their equipment and systems are exposed to two different meaconed signals. Maybe especially interesting is to see if positions jump between the two meaconed posistions, stay stable or if two meaconed signals aid in GNSS RFI detection somewhat.

Test description

GNSS re-transmission of real live sky signals from two receivers (RX1 and RX2), with the same receivers specifications as listed in "Meaconing testgroup 1". The tests are performed with constant power outputs, some with initial jamming and some without. There is planned a 10-minute break between each test.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A. The meaconing setup employed, "M", is explained in Appendix XX.

Tests within this test group

3.2.1 RX1+RX2 at 10 W

10 W meaconing from receivers RX1+RX2, activated at the same time.

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.2.2 RX1+RX2 at 10 W with initial jamming

10 W meaconing from receivers RX1+RX2, activated at the same time, preceded by 5 min. jamming (PRN L1, L2, L5 and G1 at 20 W)

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.2.3 RX1+RX2 at 10 W at different times

10 W meaconing from receivers RX1+RX2, activated at different times. RX2 is turned on 5 minutes after RX1 is activated.

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.2.4 RX1+RX2 at 10 W alternating

10 W meaconing from receivers RX1+RX2, alternating continuously. RX1 is activated first, then turned off after 1 minute while RX2 is being turned on. RX2 is then turned off after 1 more minute and RX1 is turned on. The cycle is repeated for as long as the test is set up (for example 5 cycles).

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.2.5 RX1+RX2 at 10 W alternating with breaks

10 W meaconing from receivers RX1+RX2, alternating with breaks. RX1 is activated first and left on for 1 minute, before being turned off. Nothing is then transmitted for 1 minute (transmission break). After the minute, RX2 is turned on and left on for 1 minute before being turned off. After another transmission break of 1 minute, repeat the cycle. The cycle is repeated for as long as the test is set up (for example 3 cycles).

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.3: Stationary meaconing from a single or two receivers with pyramid ramping power

Rationale

The objective is to observe how equipment and systems behave under varying meaconing tranmission powers. Maybe especially interesting is to try to observe when the meaconing signal(s) is(are) strong enough to deceive the DUT receiver, and if the DUT receiver resumes to use the real GNSS signals at the same power levels on the way down of the power pyramid. It could also be of interest to see if the behaviour changes if two meaconing receivers are used instead of only a signle one.

Test description

GNSS re-transmission of real live sky signals from two receiver (RX1 and RX2), with the same receivers specifications as listed in "Meaconing testgroup 1". The tests are performed with a pyramid ramping in tranmsmission power, from 0.01 W to 10 W and back down to 0.01 W, in 5 dB steps. Each step is kept for 2 minutes before the power is increased or decreased. There is planned a 10-minute break between each test.

Additional information

The jammer employed will be F8.1 "Porcus Major", see appendix A. The meaconing setup employed, "M", is explained in Appendix XX.

Tests within this test group

3.3.1 RX1 at 10 W with pyramid ramping power

10 W meaconing from receiver RX1, with pyramid ramping power. Power is ramped up from 0.01 W to 10 W and then back down again to 0.01 W in 5 dB steps, with each step lasting for 2 minutes.

Power or power range

Min: 0.01 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'

3.3.2 RX1+RX2 at 10 W with pyramid ramping power

10 W meaconing from receivers RX1+RX2, with pyramid ramping power. Power is ramped up from 0.01 W to 10 W and then back down again to 0.01 W in 5 dB steps, with each step lasting for 2 minutes.

Power or power range

Min: 0.01 W
Max: 10 W

Test bands/constellation

'L1', 'L2'

Transmitter equpment

'M and F8.1'