



LABSAT 4 GNSS RESILIENCE TESTING UTILITY

User Guide

Version History			
Version	Revision Date	Description of Change	Author
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1. Introduction

The **LabSat 4 GNSS Resilience Testing Utility** is a software tool designed to support controlled GNSS interference and resilience testing. It enables users to add synthetic jamming and noise signals to existing LabSat 4 recordings, creating repeatable and well-defined test scenarios for evaluating GNSS receiver performance under adverse RF conditions.

2. GNSS Resilience Testing Overview

2.1 Why Test GNSS Resilience?

GNSS (Global Navigation Satellite Systems) are increasingly critical for modern infrastructure, transportation, timing systems, and countless applications. However, GNSS signals are vulnerable to interference due to their extremely low power levels at the Earth's surface (approximately -130 dBm).

Testing receiver resilience to jamming and interference is essential for:

- Validating equipment performance under adverse conditions
- Certification and compliance requirements
- Development of interference mitigation techniques
- Understanding failure modes and recovery behavior

3. System Requirements

3.1 Hardware Requirements

- Windows PC with minimum 8 GB RAM (16 GB recommended)
- Sufficient disk space (typically 2–3× original recording size)

3.2 Software Requirements

- Windows 10 or later
- Minimum .NET 8.0 runtime

3.3 Supported File Formats

LabSat 4 scenario files (.LS4 & .ini) are the only supported file format for use with this utility.

4. Installation and Launch

The LabSat 4 GNSS Resilience Testing Utility is provided as a standalone executable.

1. Download software from the [LabSat Website](#).
2. Unzip the downloaded folder to a local folder on the PC
3. Run the .exe file and follow the installation wizard instructions.
4. Once installed, launch the software.

5. User Interface Overview

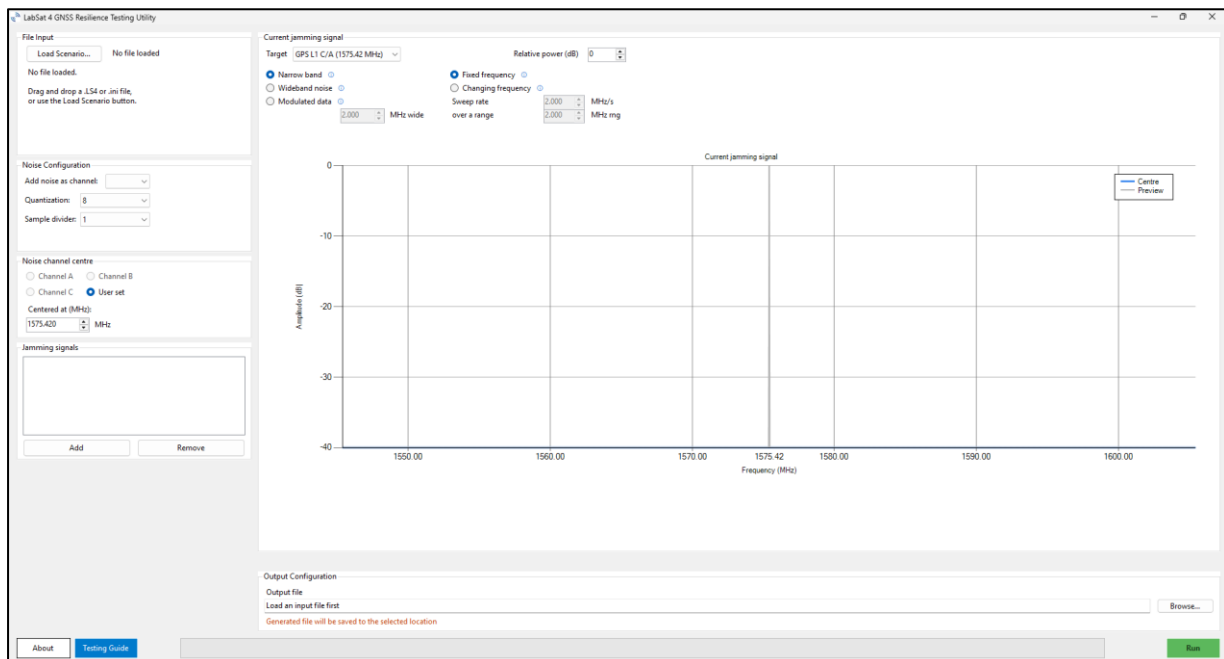


Figure 1 Application Window

- **File Information**

Displays loaded file details, channel configuration, quantization, duration, and detected associated external data files.

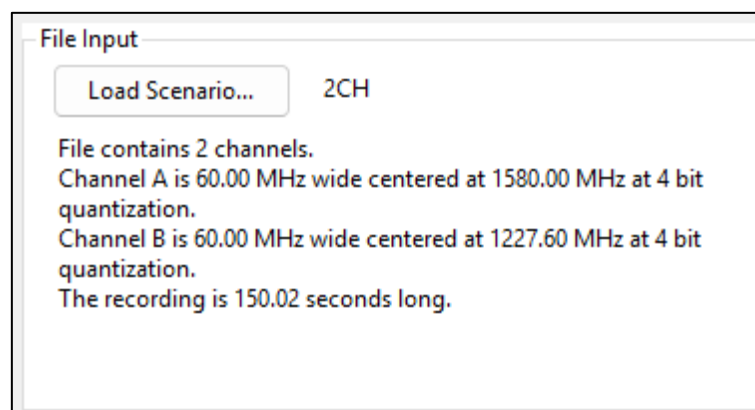
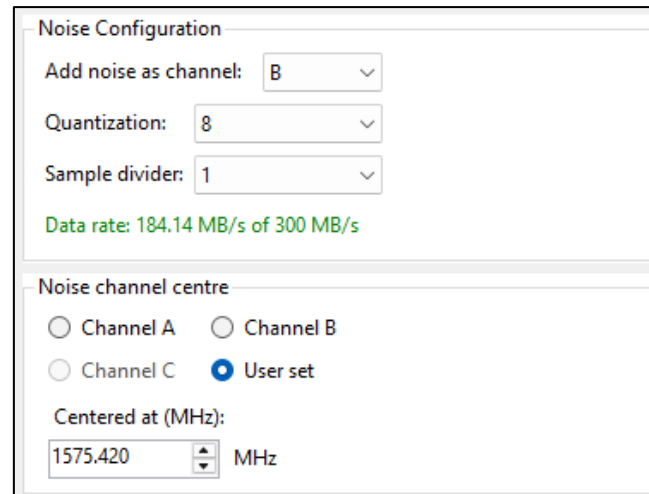


Figure 2 File information displayed when a file is loaded.

- **Noise Channel Configuration**

Used to define the noise channel and channel characteristics, including which channel the jamming signal should be added to, quantization, bandwidth division, and centre frequency.

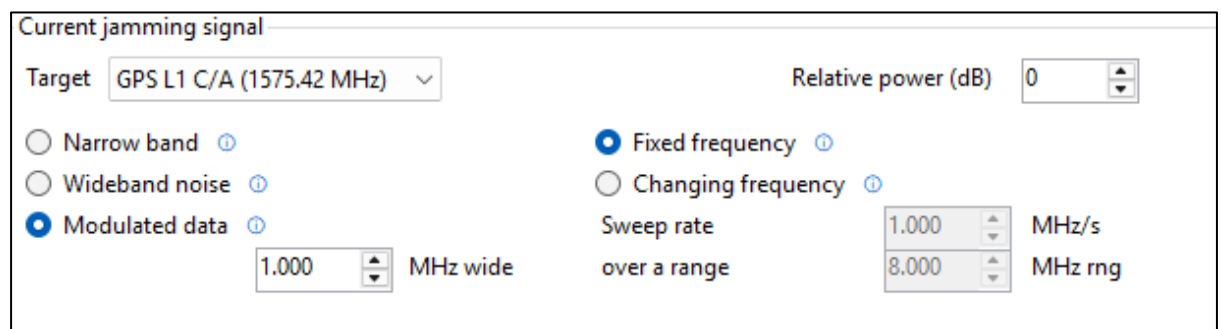


The screenshot shows a 'Noise Configuration' dialog box. It has two main sections. The top section, titled 'Noise Configuration', contains three dropdown menus: 'Add noise as channel:' set to 'B', 'Quantization:' set to '8', and 'Sample divider:' set to '1'. Below these is a green text label 'Data rate: 184.14 MB/s of 300 MB/s'. The bottom section, titled 'Noise channel centre', contains four radio buttons: 'Channel A', 'Channel B', 'Channel C', and 'User set'. The 'User set' radio button is selected. Below the radio buttons is a label 'Centered at (MHz):' followed by a text input field containing '1575.420' and a 'MHz' unit label.

Figure 3 Noise Channel Configuration

- **Jamming Signal Configuration.**

Used to define jamming signal type, frequency behaviour, bandwidth, sweep parameters, quantisation, and relative power.



The screenshot shows a 'Current jamming signal' configuration dialog box. It has a 'Target' dropdown menu set to 'GPS L1 C/A (1575.42 MHz)'. To the right is a 'Relative power (dB)' label and a text input field set to '0'. Below the target dropdown are three radio buttons: 'Narrow band', 'Wideband noise', and 'Modulated data'. The 'Modulated data' radio button is selected. To the right of these are two more radio buttons: 'Fixed frequency' and 'Changing frequency'. The 'Fixed frequency' radio button is selected. Below the 'Modulated data' radio button is a text input field set to '1.000' and a 'MHz wide' label. To the right of the 'Fixed frequency' radio button is a 'Sweep rate' label and a text input field set to '1.000' with a 'MHz/s' label. Below the 'Sweep rate' label is a text input field set to '8.000' with a 'MHz rng' label.

Figure 4 Jamming Signal Configuration

- **Signal Visualisation & Processing**

Displays a live spectral view of the currently configured jamming signal and added signals.

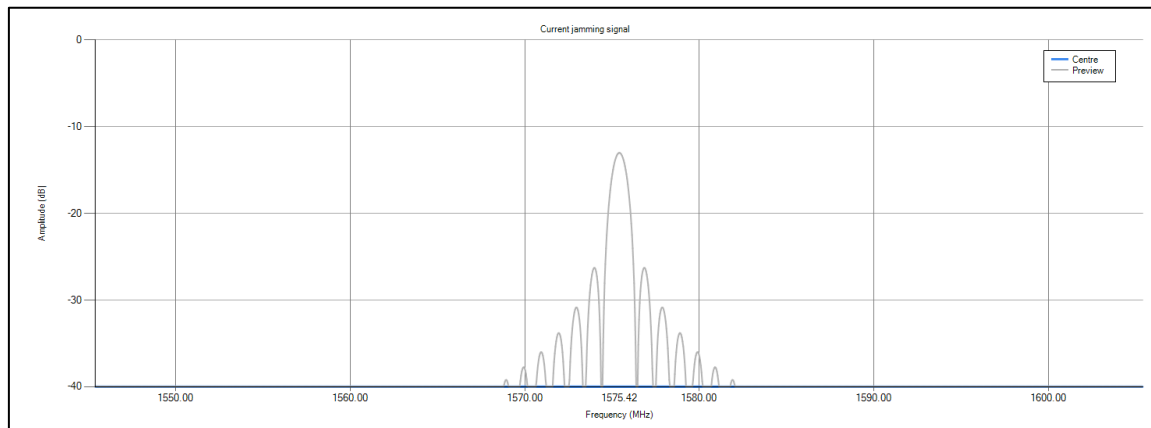


Figure 5 Chart showing a preview of the currently configured signal.

5.1 Live Jamming Signal Preview

The Current Jamming Signal chart provides a continuous live preview of the signal being configured.

- The preview is displayed in **light grey** and updates dynamically as parameters are changed.
- Parameters reflected in the preview include:
 - Signal type (narrowband, wideband, modulated)
 - Centre frequency or sweep range
 - Bandwidth
 - Sweep rate
 - Relative power (dB)
- Once the signal is added, it is displayed in the standard colour used for configured signals.

This feature allows users to visually confirm signal characteristics before committing them to the scenario.

The below example shows a jamming signal added (4MHz wide data centered at 1575.420 MHz +/-1.5 MHz at 1MHz/s at 0dB) shown in blue and yellow (centre and range). The screenshot also shows a preview of the jamming signal based on current selection i.e. Modulated Data 1MHz wide at fixed frequency 1575.420 MHz.

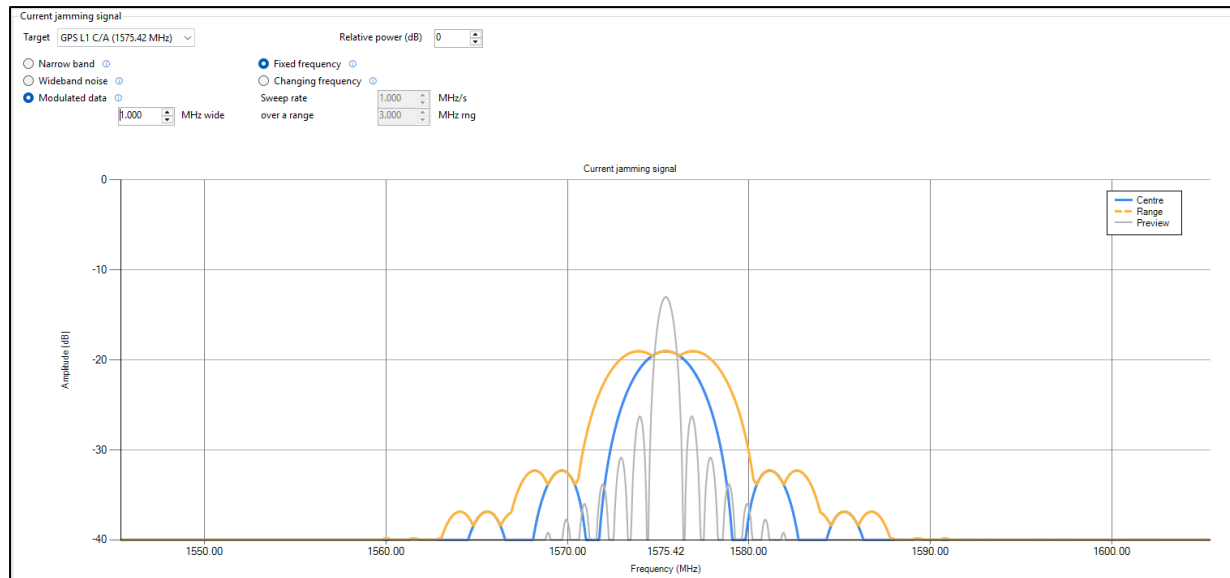


Figure 6 Chart showing an added signal as well as a preview of the currently configured signal.

6. File and Scenario Management

6.1 Loading Scenario Files

Drag and drop .LS4 or .ini files into the application window or use the **Load Scenario** option.

The loaded file details will appear in the top panel.

Note: Files cannot be processed directly from or to the LabSat 4 SSD.

6.2 Channel Handling Rules

Input Channels	Output Behaviour
1 Channel	Noise channel can be added as channel A or B
2 Channels	Noise channel can be added as channel A or B or C
3 Channels	Noise channel can be added as channel A or B or C

Warning: Replaced channel data cannot be recovered.

6.3 Associated External Data Files

If a LabSat 4 recording contains associated external data files, the utility will automatically detect and manage them during processing.

Supported associated file types include:

- .LS4D – Digital data
- .txt – log file CAN data

- `.ser` – log file RS232 data

When processing is performed:

- All detected associated files are copied to the output directory
- Files are renamed to match the processed output filename
- No modification is applied to the external data content

This ensures that processed recordings replay on LabSat 4 hardware with full functional parity to the original dataset.

A notification is displayed upon completion indicating which associated files were copied.

6.4 Output Files

- Processed files use the `_Processed` suffix by default – this can be manually changed.
- Corresponding `.ini` and associated data files use the same naming convention specified in the output configuration.
- A summary text file is generated alongside the output scenario with matching naming.

Note: Files cannot be processed directly from or to the LabSat 4 SSD.

7. Noise & Jamming Channel Configuration

7.1 Channel Selection

- Select Channel A, B, or C to implement the interference.
- Choose quantization (subject to LabSat 4 data rate limits) – recommended quantization for optimum performance on the noise channel is 8 or 12 bit, lower quantization can be used but may result in mild signal spike at the channel centre frequency.
- Set the centre frequency to match the target GNSS band.

7.2 Relative Power Configuration

Relative power is configured directly in decibels (dB).

- Accepted range: 0 dB to -30 dB

- Increment: 1 dB steps
- Manual entry via keyboard is supported

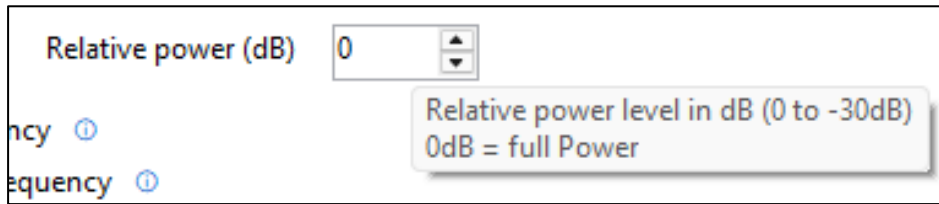


Figure 7 Relative power input.

7.3 Adding Multiple Jamming Signals

Multiple jamming signals may be combined into a single interference channel:

1. Configure a jamming signal
2. Observe the live preview on the spectrum chart
3. Click **Add** to register the signal
4. Repeat to build complex interference profiles

Each signal retains its own frequency, bandwidth, sweep behaviour, and relative power.

8. Jamming Signal Types and Parameters

8.1 Narrowband (CW – Continuous Wave)

- Single-frequency tonal interference
- Used for basic interference rejection testing

8.2 Wideband Noise (Barrage Jamming)

- Gaussian noise across a defined bandwidth
- Raises receiver noise floor across the band

8.3 Modulated Data (e.g. QPSK)

- Structured interference resembling communication signals
- Can cause false acquisition or tracking errors

8.4 Frequency Behaviour

- **Fixed Frequency:** Constant centre frequency
- **Swept Frequency (Chirp):** Frequency sweeps across a defined range and a defined rate

Definable parameters include sweep rate, sweep range, data width (MHz), and relative power.

9. Generating Modified Scenario Files

9.1 Data Rate Validation

The utility enforces the same operational data rate limits as the LabSat 4 hardware as defined [here](#).

Before processing begins, the selected configuration is validated to ensure:

- **Per channel data rate limits** do not exceed “*Per Channel Limit*”
- **Total system data rate limits** do not exceed “*Total Limit*”.

Limits for each possible channel number configuration are shown below:

Configuration	Total Limit	Per Channel Limit
1 channel	220 MB/s	220 MB/s
1 channel @ ≥ 60 MHz	185 MB/s	185 MB/s
2 channels	300 MB/s	150 MB/s
3 channels	300 MB/s	100 MB/s

If an invalid configuration is detected:

- The **Run** button is disabled
- A clear warning message explains whether the total or per-channel limit has been exceeded, as shown below:

File Input

Load Scenario... 1CH_60MHz_12bit_110859

File contains 1 channel 60.00 MHz wide centered at 1575.42 MHz at 12 bit quantization.
The recording is 2.42 seconds long.
The file contains digitized data types: CAN1 CAN2 RS232 DIGI

Noise Configuration

Add noise as channel: B

Quantization: 12

Sample divider: 1

Total: 368.28 MB/s | ChA: 184.14 exceeds 150 | Exceeds 300 MB/s

Figure 8 Example of noise channel configuration exceeding allowed limits.

- The user must adjust quantisation or sample divider (bandwidth) before proceeding.

9.2 Summary File Generation

A summary text file is generated alongside the processed output to support traceability and repeatability of tests.

The summary includes:

- Input file configuration
- Noise channel settings
- Detected associated external data files
- Summary of added signals, including:
 - Signal type
 - Centre frequency / sweep range
 - Bandwidth
 - Sweep rate (if applicable)
 - Relative power (dB) for each signal

Example:

2.000 MHz wide noise centered at 1575.420 MHz at -10 dB

Narrowband signal centered at 1575.420 MHz at -20 dB

10. Replay and Testing with LabSat 4

10.1 Transferring Files

Copy generated files to the LabSat 4 SSD. Methods for transferring files to and from the LabSat 4 SSD can be found [here](#).

10.2 Replay steps

You can replay the processed file via the LabSat 4 front panel or Web Server. More information [here](#).

10.3 LabSat 4 Web Server GNSS Monitor Page

The GNSS Monitor page on the LabSat 4 Web Server interface can be used during replay to aid in testing. This page will allow:

- Independent per channel power control (attenuation).
- Individual channel muting during replay



Instructions for connecting to the LabSat 4 Web Server via Ethernet can be found [here](#).

Detailed information on the GNSS Monitor page on Web Server can be found [here](#).

11. Recommended Test Scenarios

Scenario 1: Basic Interference Threshold

Objective: Determine the J/S (Jammer to Signal) ratio at which the receiver loses lock.

Setup:

- Use narrow band jamming at the L1 centre frequency (1575.42 MHz)
- Start at -20 dB relative power
- Increase in 3 dB steps

Measurements: Record C/N0, position error, and lock status at each level.

Scenario 2: Acquisition Under Jamming

Objective: Test the receiver's ability to acquire satellites in the presence of interference.

Setup:

- Apply jamming before starting the receiver
- Use wideband noise at moderate power level

Measurements: Time to first fix (TTFF), number of satellites tracked.

Scenario 3: Recovery After Jamming

Objective: Measure how quickly the receiver recovers after jamming ends.

Setup:

- Establish normal tracking
- Apply high-level jamming (0 dB) for 30-60 seconds
- Remove jamming and monitor recovery
 - The individual channel attenuation feature on the LabSat 4 Web Server includes the ability to 'mute' individual channels which can be used to achieve this.

Measurements: Re-acquisition time, position accuracy during recovery.

Scenario 4: Swept Frequency Jamming

Objective: Test resilience to frequency-agile interference.

Setup:

- Configure swept jamming across L1 band
- Sweep rate: 1-5 MHz/s

- Sweep range: 10 MHz centred on L1

Measurements: Tracking stability, position jumps during sweeps.

Scenario 5: Multi-Frequency Attack

Objective: Test receivers using multiple GNSS frequencies.

Setup:

- Add jammers on L1 (1575.42 MHz) and L5 (1176.45 MHz)
- Test with one band jammed, then both

Measurements: Fallback behaviour, accuracy with partial jamming.

Scenario 6: Real-World Interference Profile

Objective: Simulate common interference sources.

Setup:

- Use modulated jamming to simulate communication signals
- Apply intermittent jamming (on/off cycles)
 - The individual channel attenuation feature on the LabSat 4 Web Server includes the ability to 'mute' individual channels which can be used to achieve this.

Measurements: False position reports, timing errors

12. Best Practices for GNSS Resilience Testing

12.1 Test Environment

RF Shielding:

- Conduct radiated tests in an RF-shielded enclosure; conducted tests via cable do not require RF shielding
- Verify shielding effectiveness before testing
- Use filtered power and signal feedthroughs
- Maintain shielding integrity during test operations

Cable Connections:

- Use high-quality, calibrated RF cables
- Verify cable losses at frequencies of interest
- Include appropriate attenuators to protect receiver inputs

- Document entire RF chain with losses at each point

12.2 Test Methodology

Baseline First:

- Always establish receiver performance without jamming
- Record C/N0 levels for all tracked satellites
- Document position accuracy and stability
- Verify timing performance if applicable

Gradual Escalation:

- Start with lowest jamming levels
- Increase in controlled steps (3-6 dB increments)
- Allow receiver to stabilize at each level
- Document behaviour at each step

Multiple Trials:

- Repeat each test multiple times
- Use statistical analysis of results
- Account for constellation geometry variations
- Test at different times of day if possible

12.3 Documentation

Record All Parameters:

- Jamming type, frequency, bandwidth, power level
- Test date, time, and duration
- Receiver firmware version
- Antenna and cable configuration
- Satellite constellation (GDOP, number of SVs)

Performance Metrics:

- C/N0 degradation vs. J/S ratio
- Position error (horizontal and vertical)
- Time to lose lock / time to re-acquire
- Number of satellites tracked
- Any anomalous behaviour or failure modes

12.4 Interpreting Results

Key Thresholds:

- Degradation onset: First measurable performance impact
- Accuracy threshold: Position error exceeds specification
- Loss of lock: Receiver stops tracking
- Recovery time: Time to return to normal operation

Comparative Analysis:

- Compare results against manufacturer specifications
- Benchmark against other receivers if possible
- Consider application-specific requirements
- Document any unexpected behaviours

13. Safety, Legal and Compliance Considerations

All testing activities shall comply with applicable local regulations, with required permits obtained and compliance measures documented, and jamming signals shall never be transmitted over the air outside of an RF-shielded environment.

LabSat 4 GNSS Resilience Testing Utility is intended exclusively for authorized GNSS resilience testing, research, and development activities conducted in controlled laboratory environments.

Permitted uses include testing GNSS receiver resilience and robustness, research and development of interference mitigation techniques, educational and training activities in authorized facilities, and compliance testing and certification activities.

Prohibited uses include intentional jamming of, or interference with, operational GNSS systems; any activity that violates local, national, or international regulations; unauthorized interference with radio communications; and any malicious or harmful activity.

Unauthorized jamming or interference with GNSS signals is illegal in most jurisdictions and may result in severe civil and criminal penalties.

By using this software, the user acknowledges responsibility for ensuring compliance with all applicable laws and regulations. The authors and distributors assume no liability for misuse or illegal use of this tool.

Equipment shall be protected by maintaining appropriate signal levels, using DC blocks where necessary, monitoring for overheating during extended tests, and implementing clearly defined emergency shutdown procedures.