Skydel GSG-8: Advanced Spoofing

GSG-8 is the newest positioning, navigation, and timing test solution offered through Orolia's GSG family of simulators, and powered by Skydel Simulation Engine. It was developed to deliver the highest standard of Global Navigation Satellite System (GNSS) signal testing and sensor simulation performance in an easy to use, upgradable and scalable platform.

This document explains how to implement advanced jamming with Skydel.

1.1. Hardware configuration / Licenses required

Spoofing consists of faithfully recreating the signals from several satellites, then transmitting this "spoofing" signal to capture a local GNSS receiver (**Figure 1**). If the targeted GNSS receiver is unable to differentiate between real satellite signals and spoofed signals, the spoofing will trick the target receiver into believing it is in a different location.

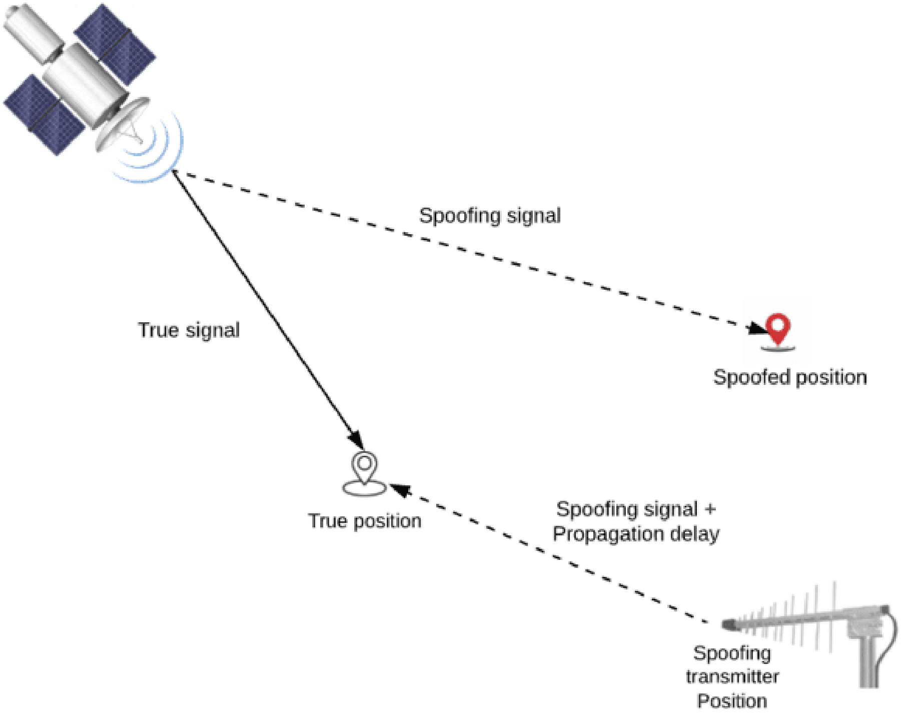
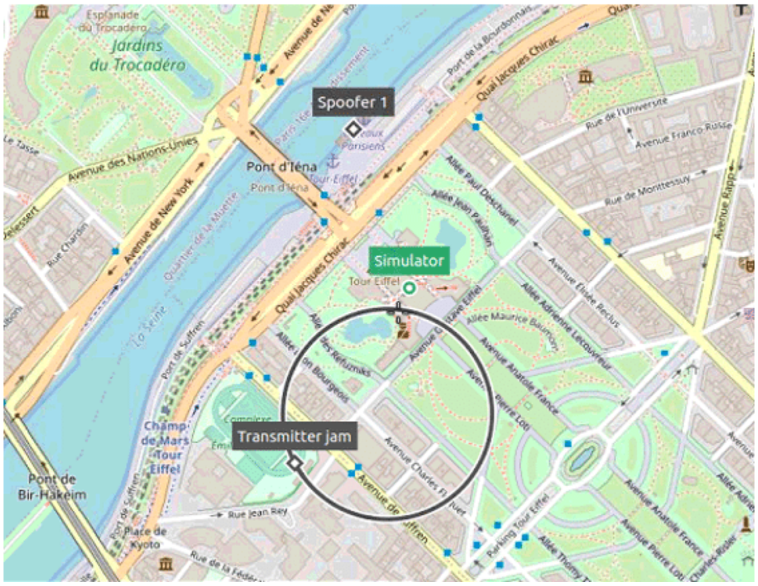
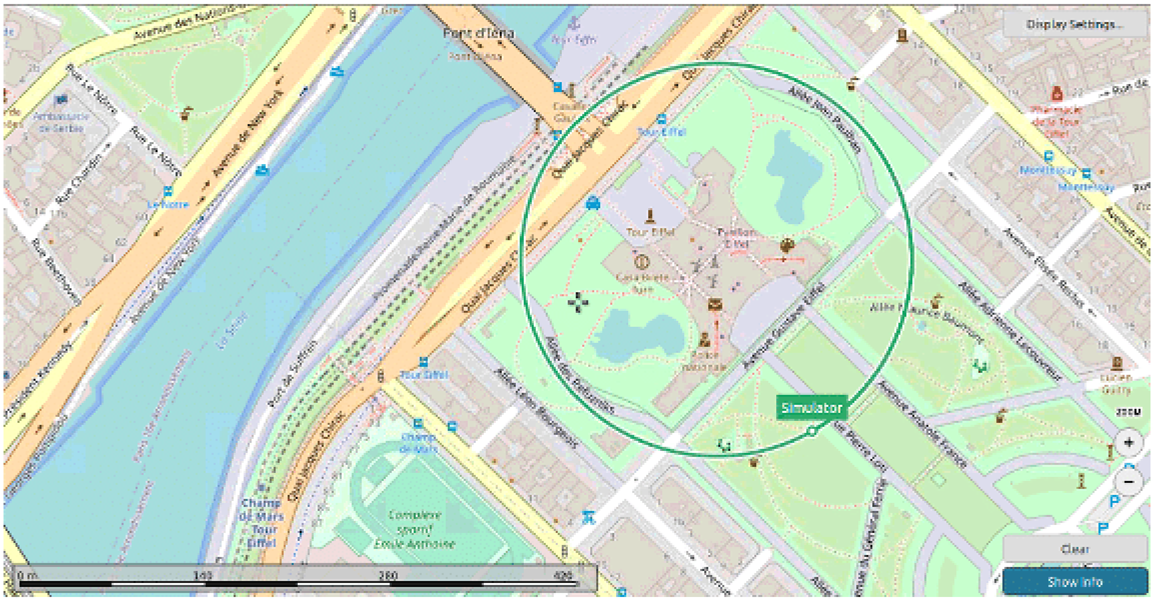


Figure 1: Spoofing scenario

For this simulation, we are going to place our vehicle at a fixed position in the center of the Eiffel Tower. Next, we will place our spoofer on a fixed boat 240 m from the vehicle. We will also add a jammer with a circular trajectory with a radius of 150 m.



Our goal by spoofing the receiver, is that it loses the true position of the simulator which is fixed and that it follows a wrong direction which is the trajectory described below.



The GSG-8 hardware models that can be used to run this simulation are:

GSG-821	GSG-831	GSG-842/Broadsim
2 RF Outputs	3 RF outputs	4 RF outputs
1 GPU/2 SDR	1GPU/3 SDR	2 GPU/4 SDR

To be able to carry out this scenario, the SKY-ADVSP and SKY-ADVJAM option must be activated in the Skydel simulation.

For this study case, we will illustrate a simple scenario of implementing spoofers with Skydel.

Here is the hardware configuration used for this scenario:

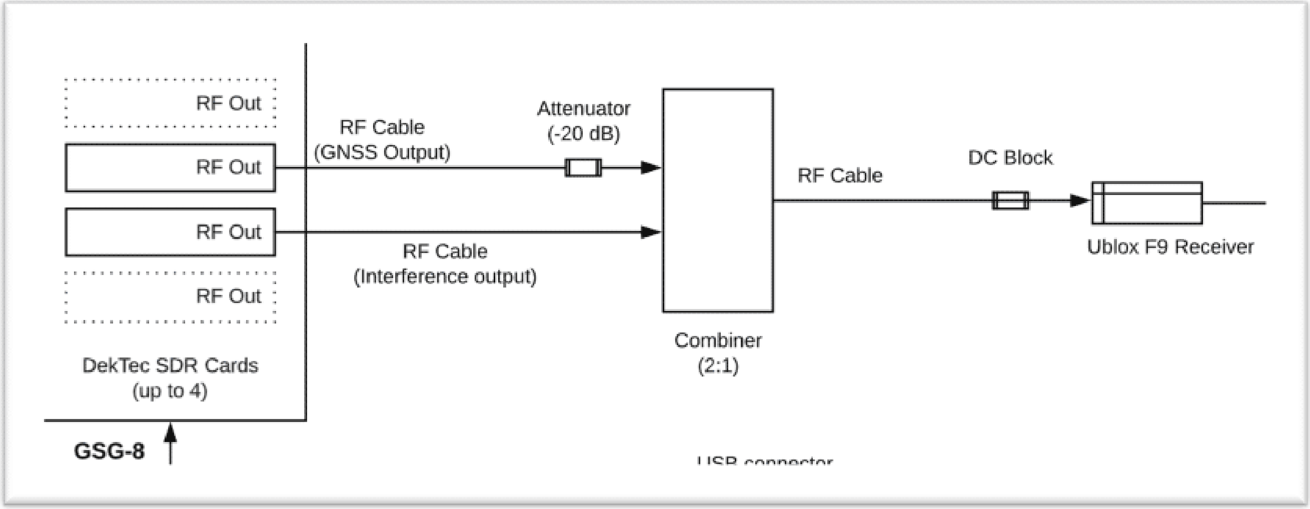


Figure 1: Hardware configuration of Skydel for a scenario with spoofers

1.2. Software configuration

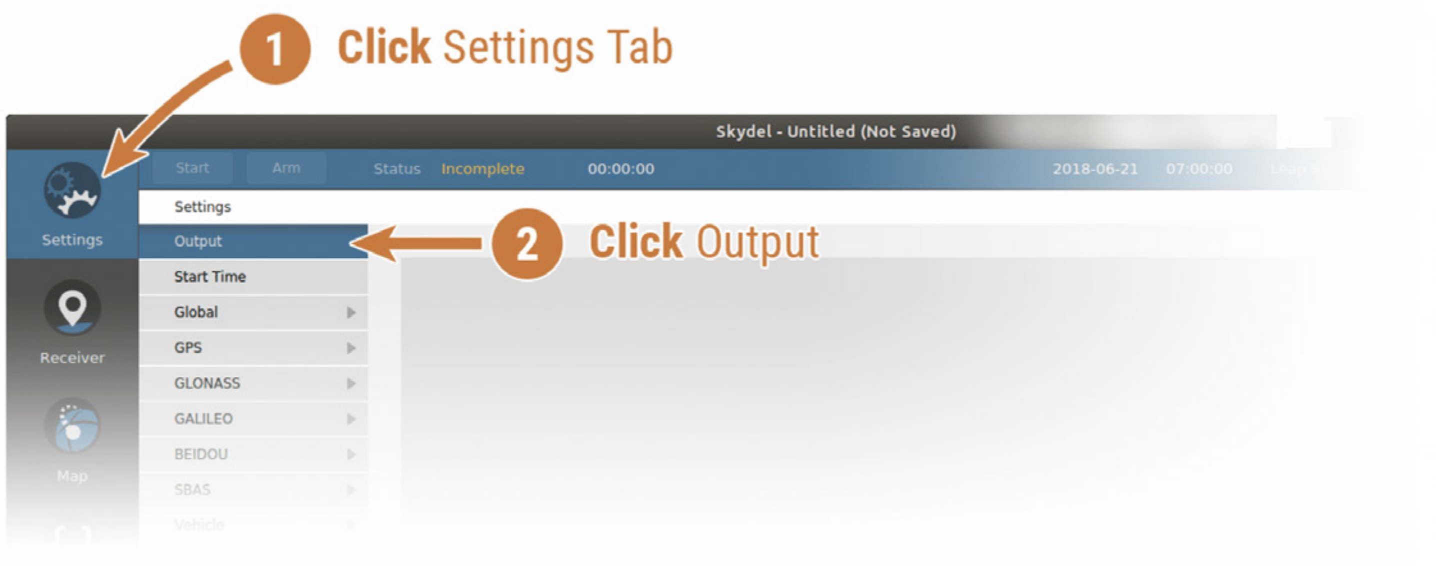
To achieve advanced spoofing in Skydel, at least two instances are required:

The truth instance, which manages the truth signal, the true position and the spoofing transmitter position.

The spoofing instance, which manages the spoofing signal and the spoofed position.

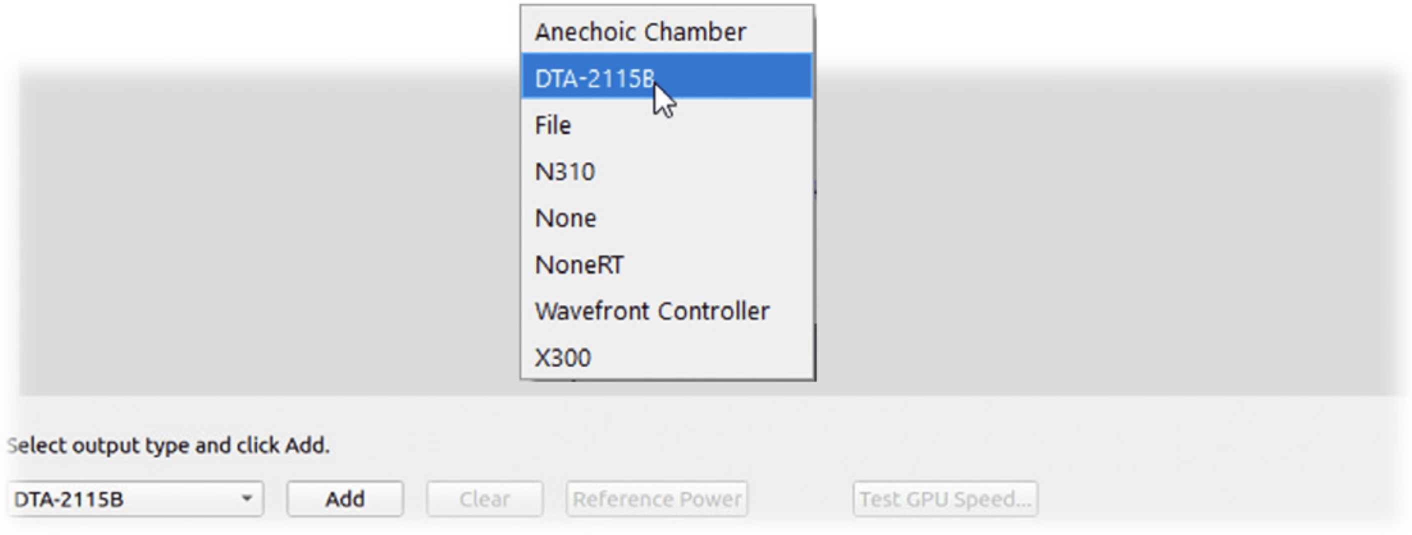
NOTE: This step is only necessary to add additional radios; a first radio will be preconfigured on your default configuration. Multiple setup options are possible; refer to the main **Skydel manual** for more information.

To add a radio, navigate to **Settings – Output.**

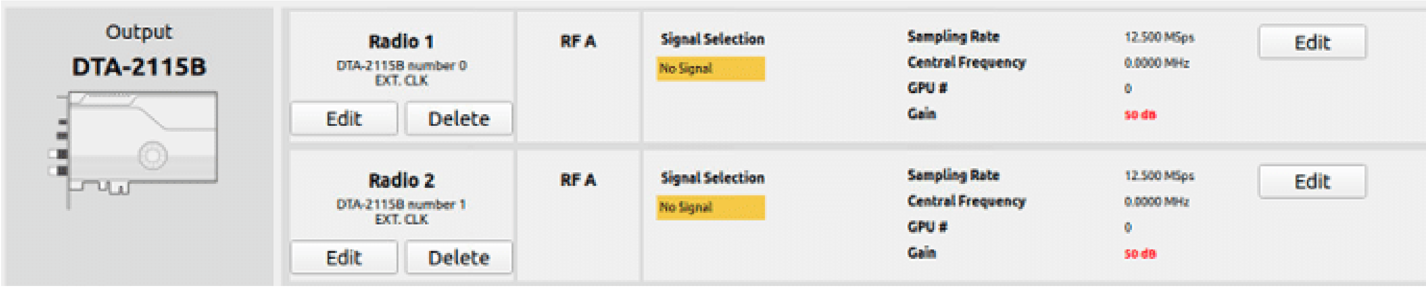

1 Click Settings Tab

2 Click Output

Select the **DTA-2115B** in the dropdown list and click the **Add** button twice.


Select output type and click Add.

The DTA-2115B will be added with a default device number O and default clock settings. If the default values are incorrect for your hardware setup, click **Edit** to make the necessary changes and click **OK** when done.



Output
DTA-2115B

Radio 1
DTA-2115B number 0
EXT. CLK

RF A

Signal Selection
No Signal

Sampling Rate: 12.500 MSps
Central Frequency: 0.0000 MHz
GPU #: 0
Gain: 50 dB

Radio 2
DTA-2115B number 1
EXT. CLK

RF A

Signal Selection
No Signal

Sampling Rate: 12.500 MSps
Central Frequency: 0.0000 MHz
GPU #: 0
Gain: 50 dB

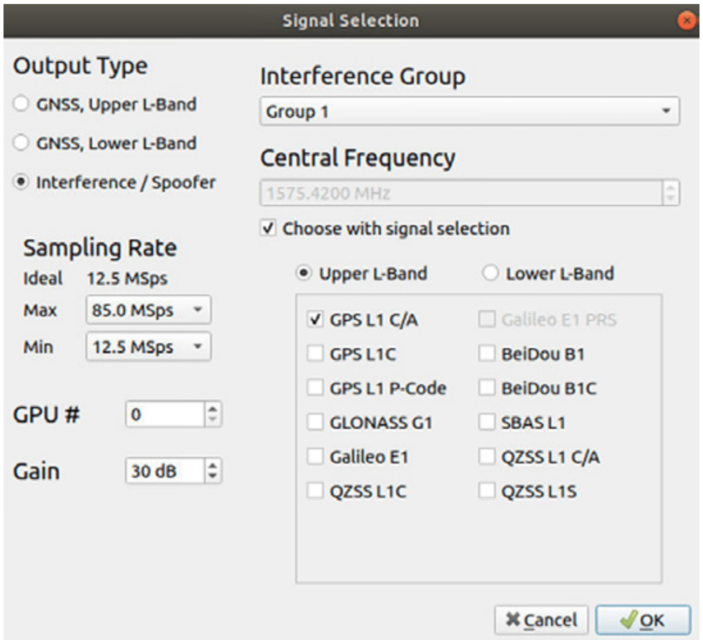
Select GNSS Signals

Click the Edit button for the RF A output of Radio 1, select **GPS L1 C/A** and check **Gaussian noise**.

Then click Edit on RF A output of Radio 2 and then select **interference/Spoofer** in the Output type.

Choose Group 1 and select **Choose with signal selection.**

Change the gain to **30 dB** and the minimum sampling rate to **12.5 MSps.**



Signal Selection

Output Type
○ GNSS, Upper L-Band
○ GNSS, Lower L-Band
● Interference / Spoofer

Sampling Rate
Ideal: 12.5 MSps
Max: 85.0 MSps
Min: 12.5 MSps

GPU #: 0

Gain: 30 dB

Interference Group: Group 1

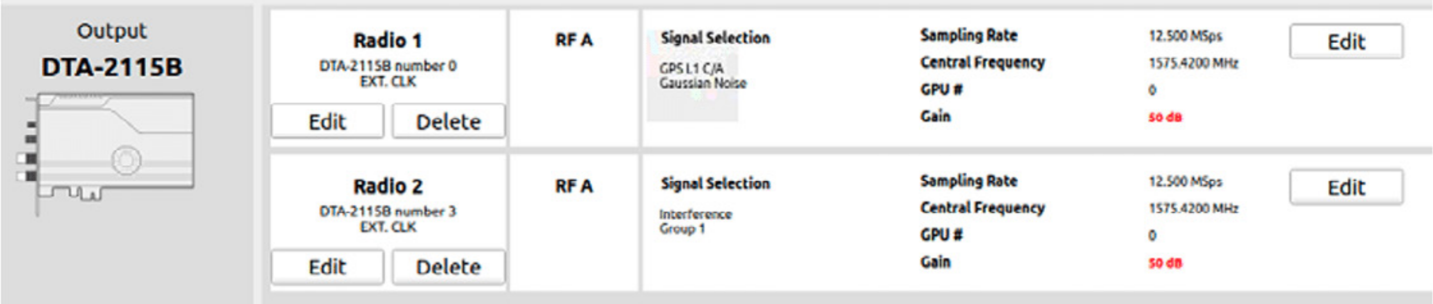
Central Frequency: 1575.4200 MHz

☑ Choose with signal selection

● Upper L-Band ○ Lower L-Band

☑ GPS L1 C/A
□ GPS L1C
□ GPS L1 P-Code
□ GLONASS G1
□ Galileo E1
□ QZSS L1C
□ Galileo E1 PRS
□ BeiDou B1
□ BeiDou B1C
□ SBAS L1
□ QZSS L1 C/A
□ QZSS L1S

Click **Ok** to close the Signal Selection dialog box. The output configuration should look like this:



Output
DTA-2115B

Radio 1
DTA-2115B number 0
EXT. CLK

RF A

Signal Selection
GPS L1 C/A
Gaussian Noise

Sampling Rate: 12.500 MSps
Central Frequency: 1575.4200 MHz
GPU #: 0
Gain: 50 dB

Radio 2
DTA-2115B number 3
EXT. CLK

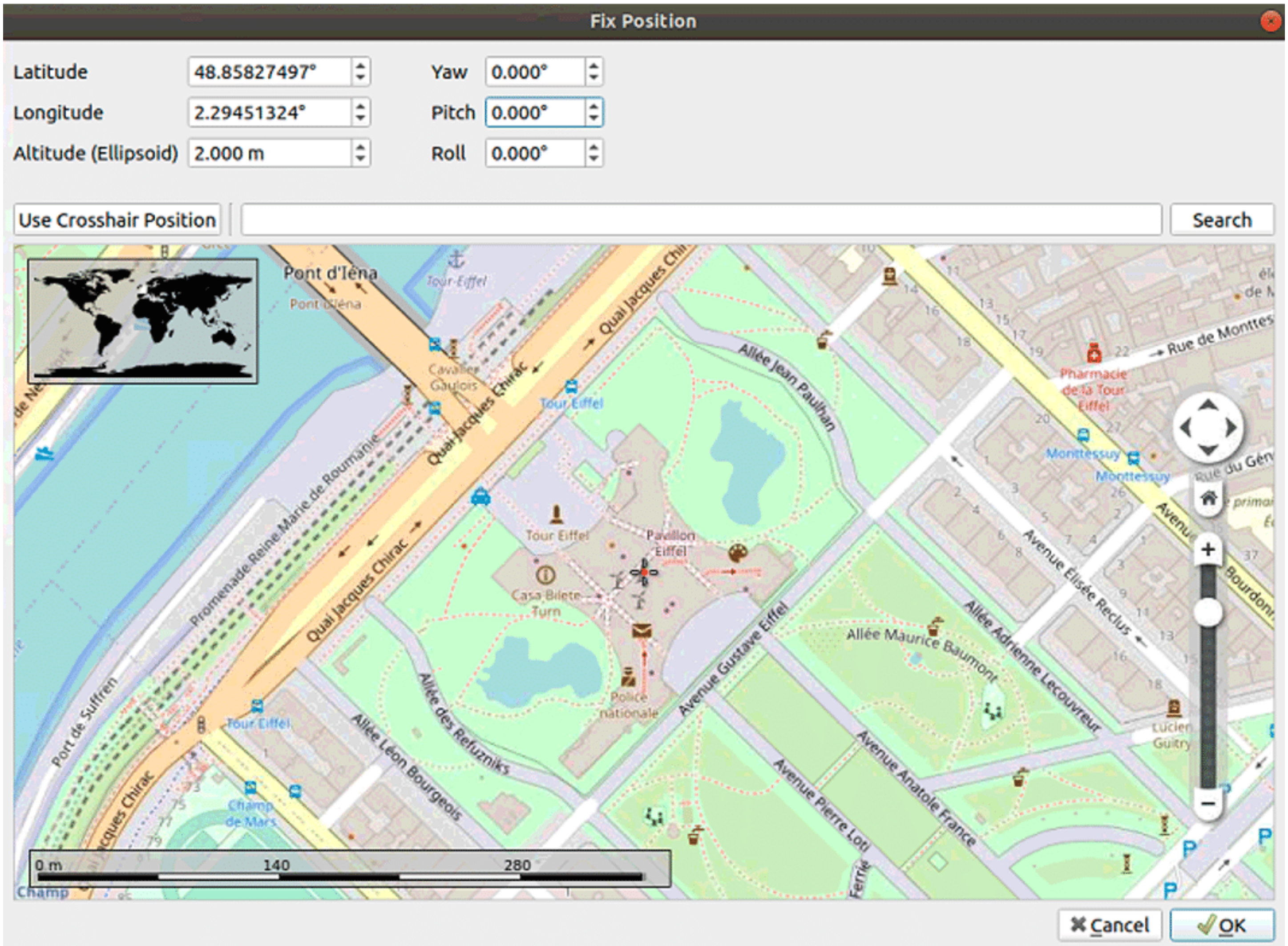
RF A

Signal Selection
Interference
Group 1

Sampling Rate: 12.500 MSps
Central Frequency: 1575.4200 MHz
GPU #: 0
Gain: 50 dB

Then go to the vehicle tab to define the simulated true position.

Select fixed for the trajectory and enter the following coordinates:



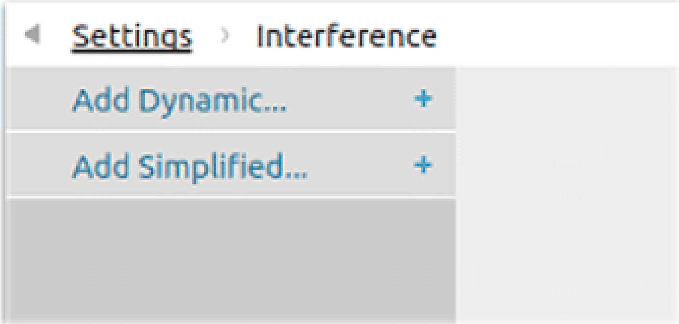
Fix Position

Latitude	48.85827497°	Yaw	0.000°
Longitude	2.29451324°	Pitch	0.000°
Altitude (Ellipsoid)	2.000 m	Roll	0.000°

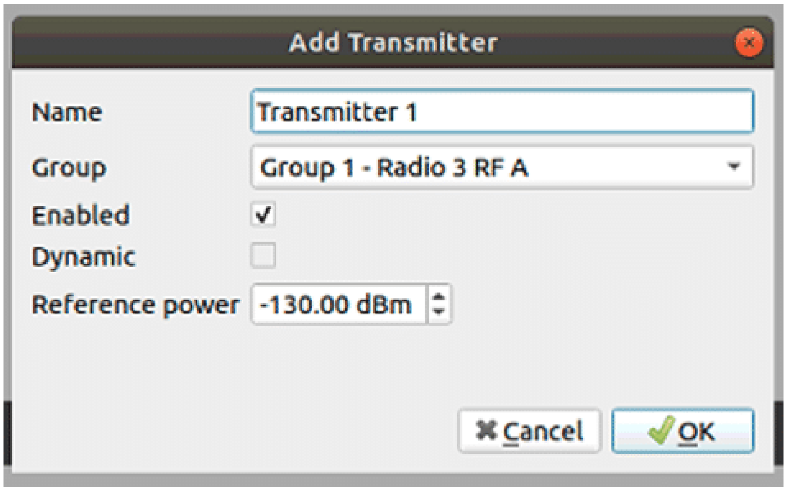
Add dynamic transmitter (jammer)

The next step now is to add a transmitter. Indeed, we add the transmitter because in some cases, it would first be necessary to jam the receiver to disturb it for a while and then activate the spoofer. Thus, the receiver can easily pick up the signal from the spoofer.

First, click on the **Settings – interference** submenu.



Click on **Add Dynamic...** and the Add Transmitter dialog box will appear.



Add Transmitter

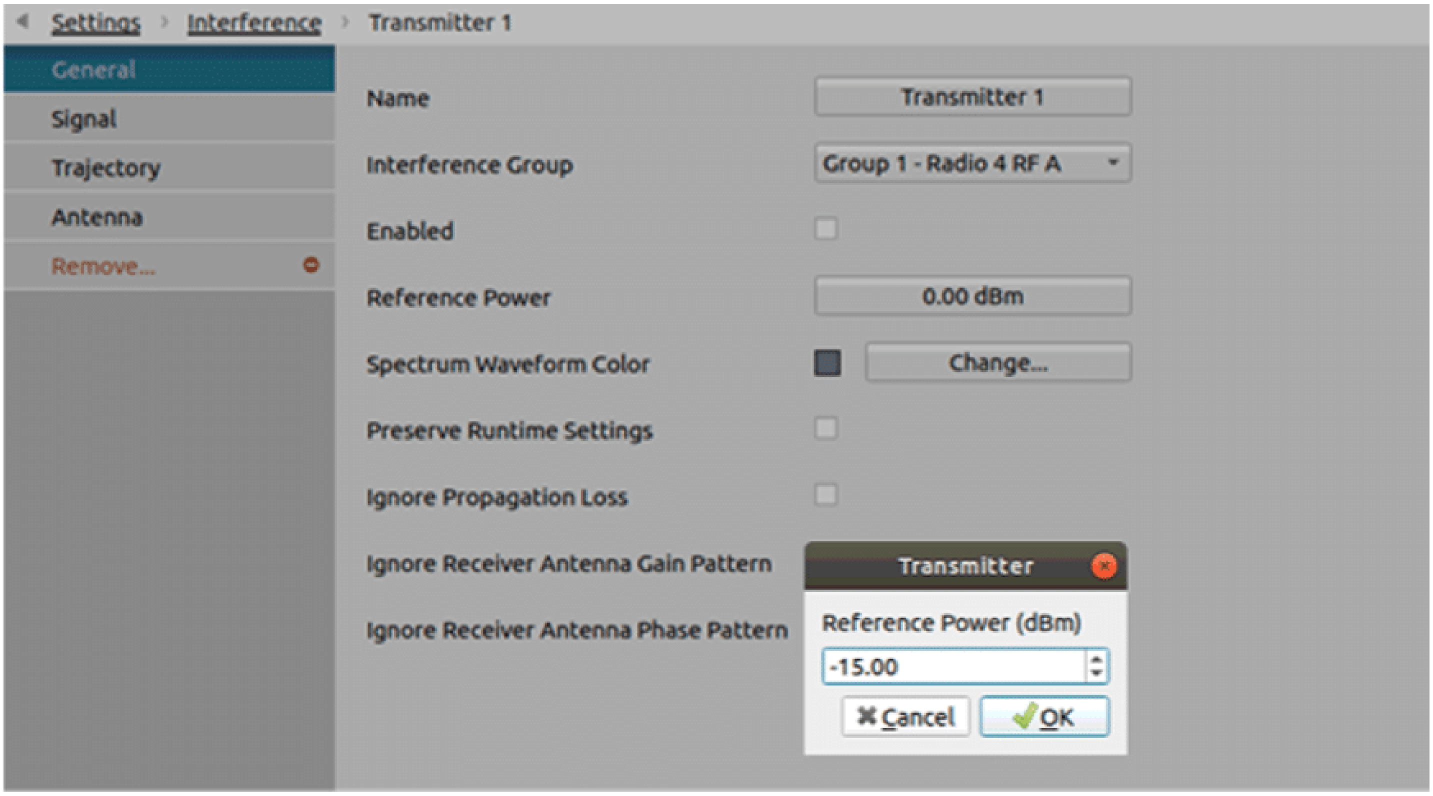
Name: Transmitter 1

Group: Group 1 - Radio 3 RF A

Enabled: ☑

Dynamic: □

Reference power: -130.00 dBm



Settings › Interference › Transmitter 1

Name: Transmitter 1

Interference Group: Group 1 - Radio 4 RF A

Enabled: □

Reference Power: 0.00 dBm

Spectrum Waveform Color: ■ Change...

Preserve Runtime Settings: □

Ignore Propagation Loss: □

Ignore Receiver Antenna Gain Pattern

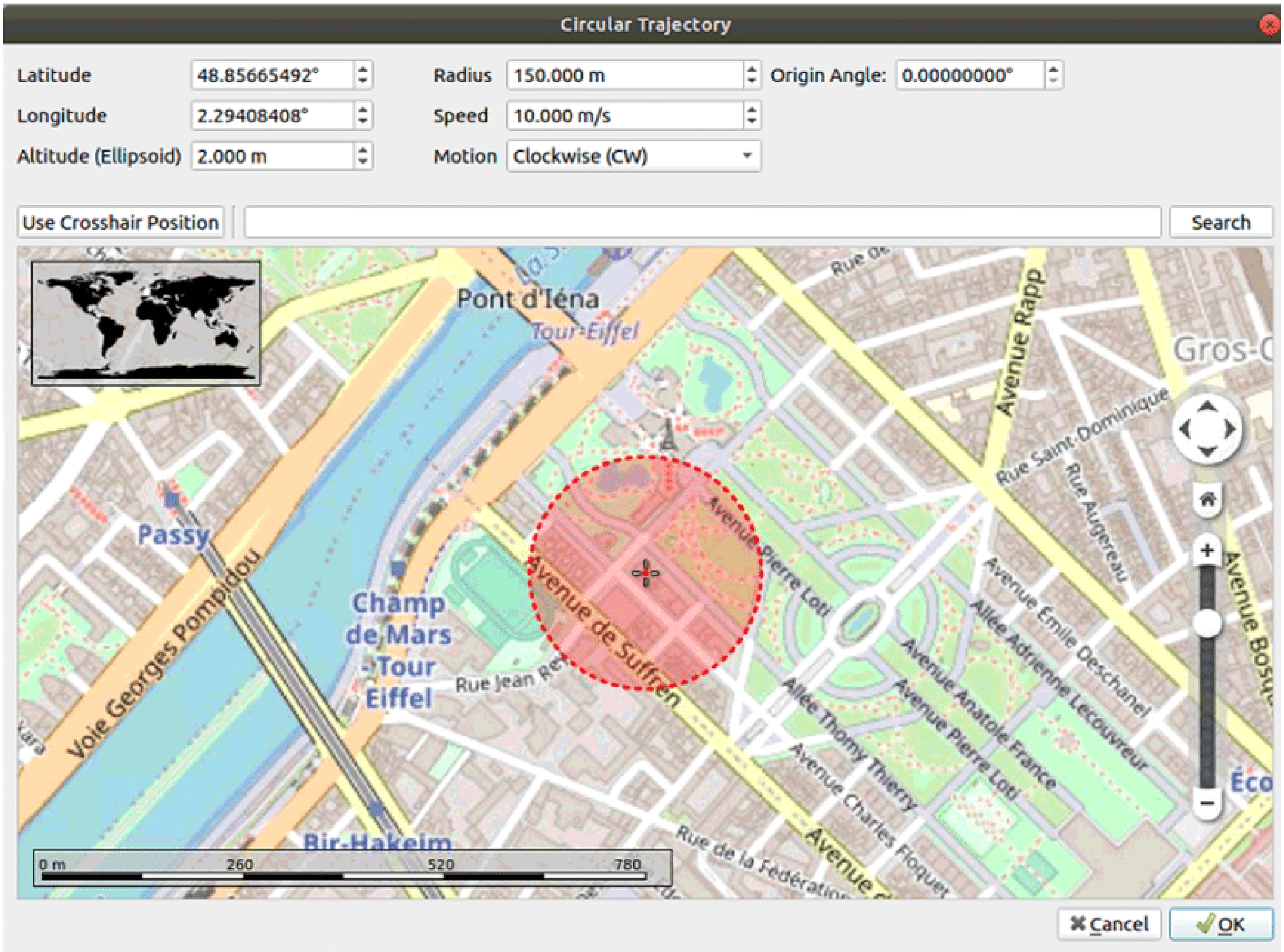
Ignore Receiver Antenna Phase Pattern

Transmitter

Reference Power (dBm): -15.00

Click the Trajectory button to display the transmitter trajectory page screen. Define the **circular** path with the following attributes:

- **dCenter:** 48.85699094 degrees north, 2.29621810 degrees west, 2 m above sea level.
- **Radius:** 150 m
- **Speed:** 10 m/s
- **Motion:** counterclockwise



Circular Trajectory

Latitude 48.85665492°

Longitude 2.29408408°

Altitude (Ellipsoid) 2.000 m

Radius 150.000 m

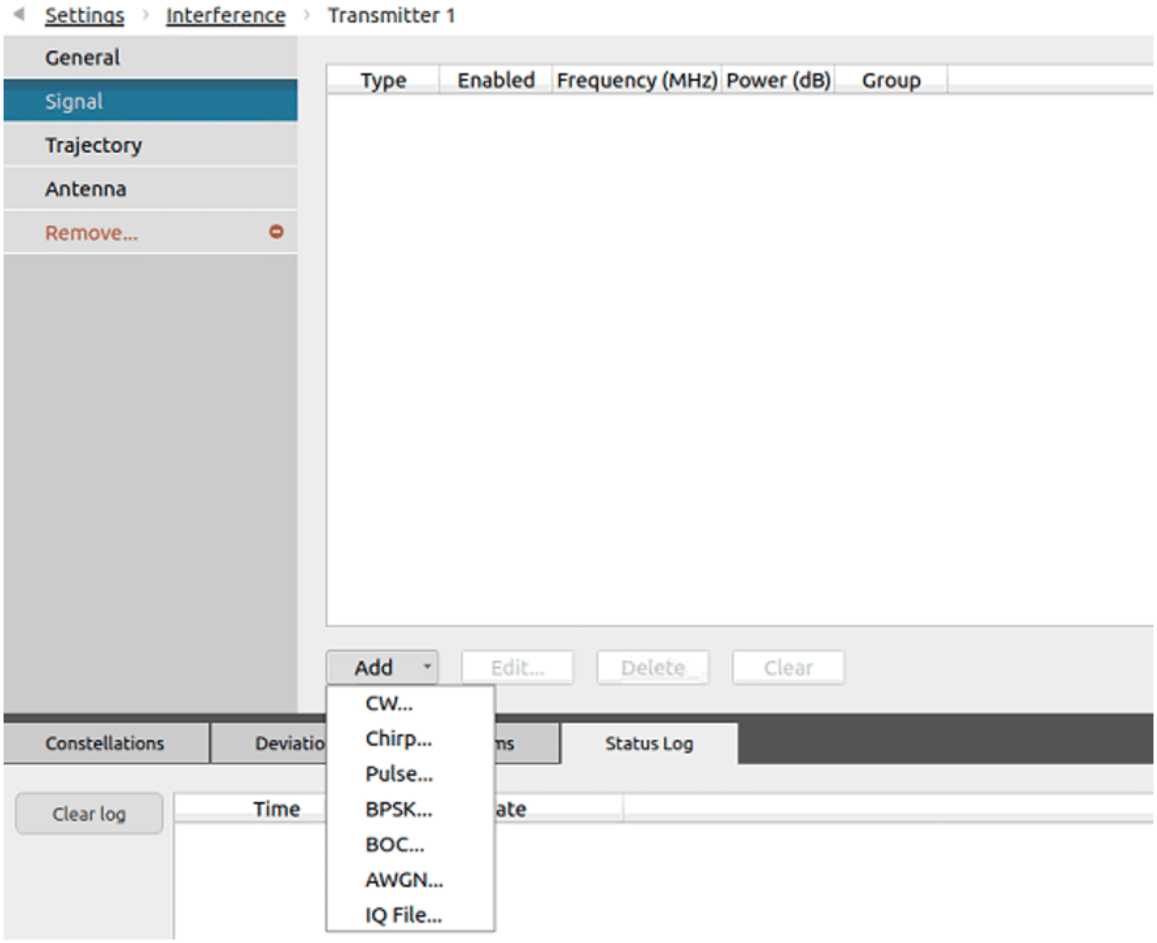
Speed 10.000 m/s

Motion Clockwise (CW)

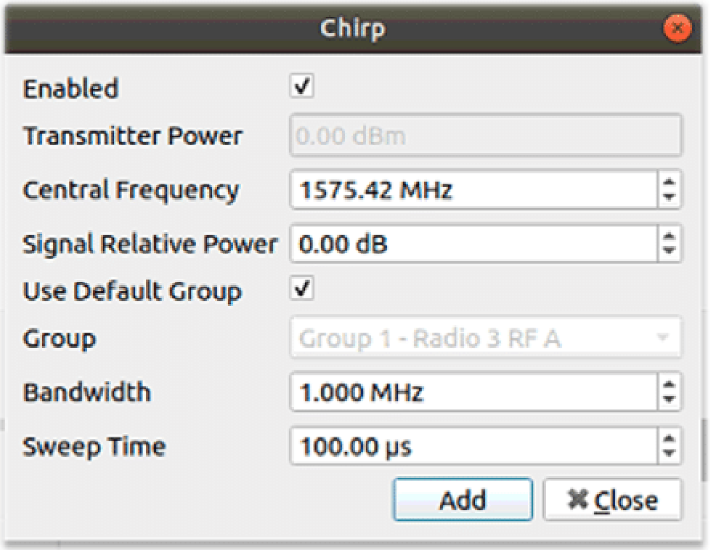
Origin Angle: 0.00000000°

Now we can add the signal that will be transmitted by the jammer.

Let’s add a Chirp signal. To add this signal, click Add on the **Signal** button.



When the chirp signal window opens, change the center frequency to 1575.42 MHz, which corresponds to that of the GPSL1 CA.

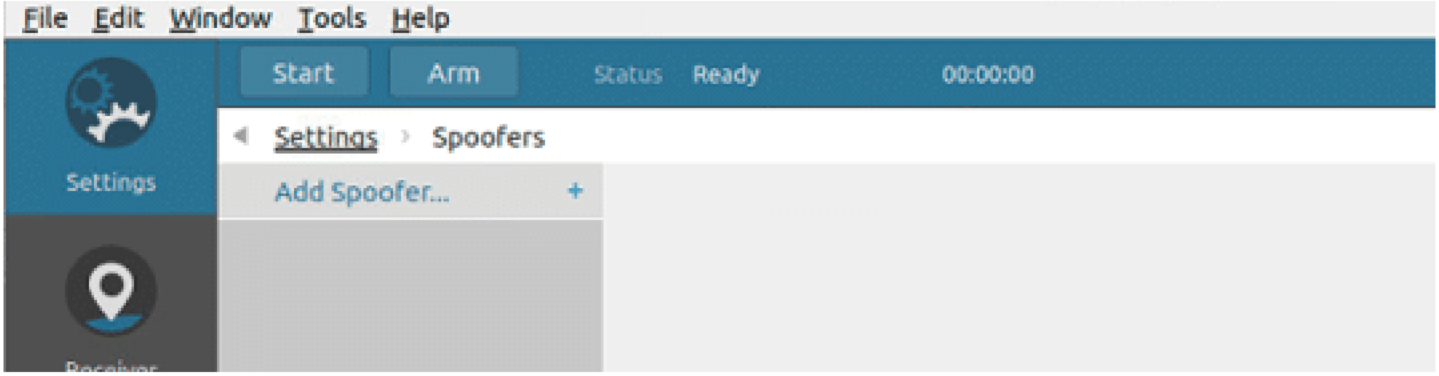


Enabled	☑
Transmitter Power	0.00 dBm
Central Frequency	1575.42 MHz
Signal Relative Power	0.00 dB
Use Default Group	☑
Group	Group 1 - Radio 3 RF A
Bandwidth	1.000 MHz
Sweep Time	100.00 µs

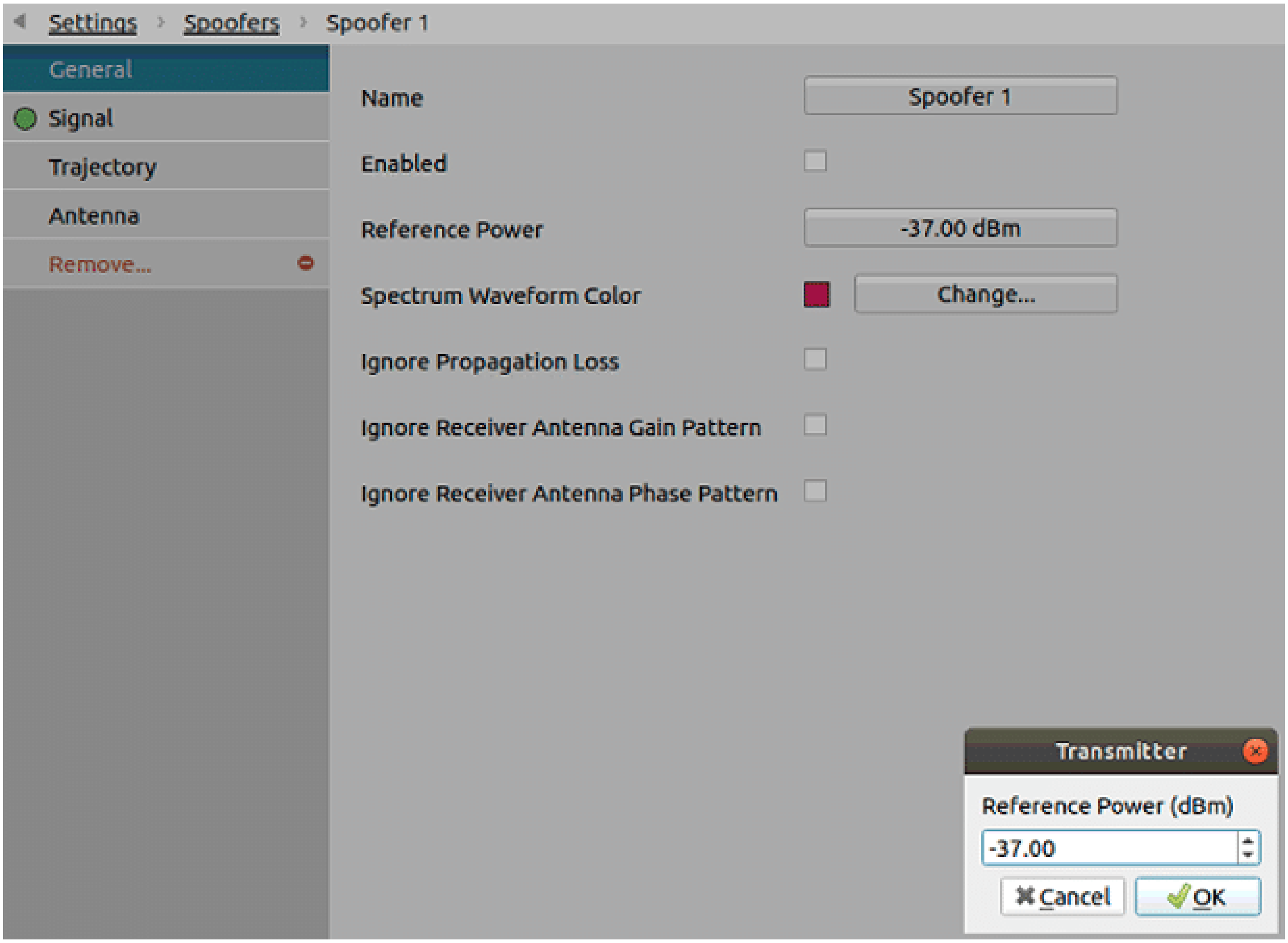
Add a spoofer

When the Advanced Spoofing feature is activated, you will see a new tab called Spoofers.

To add a spoofing transmitter, go into this tab and click on Add Spoofer.



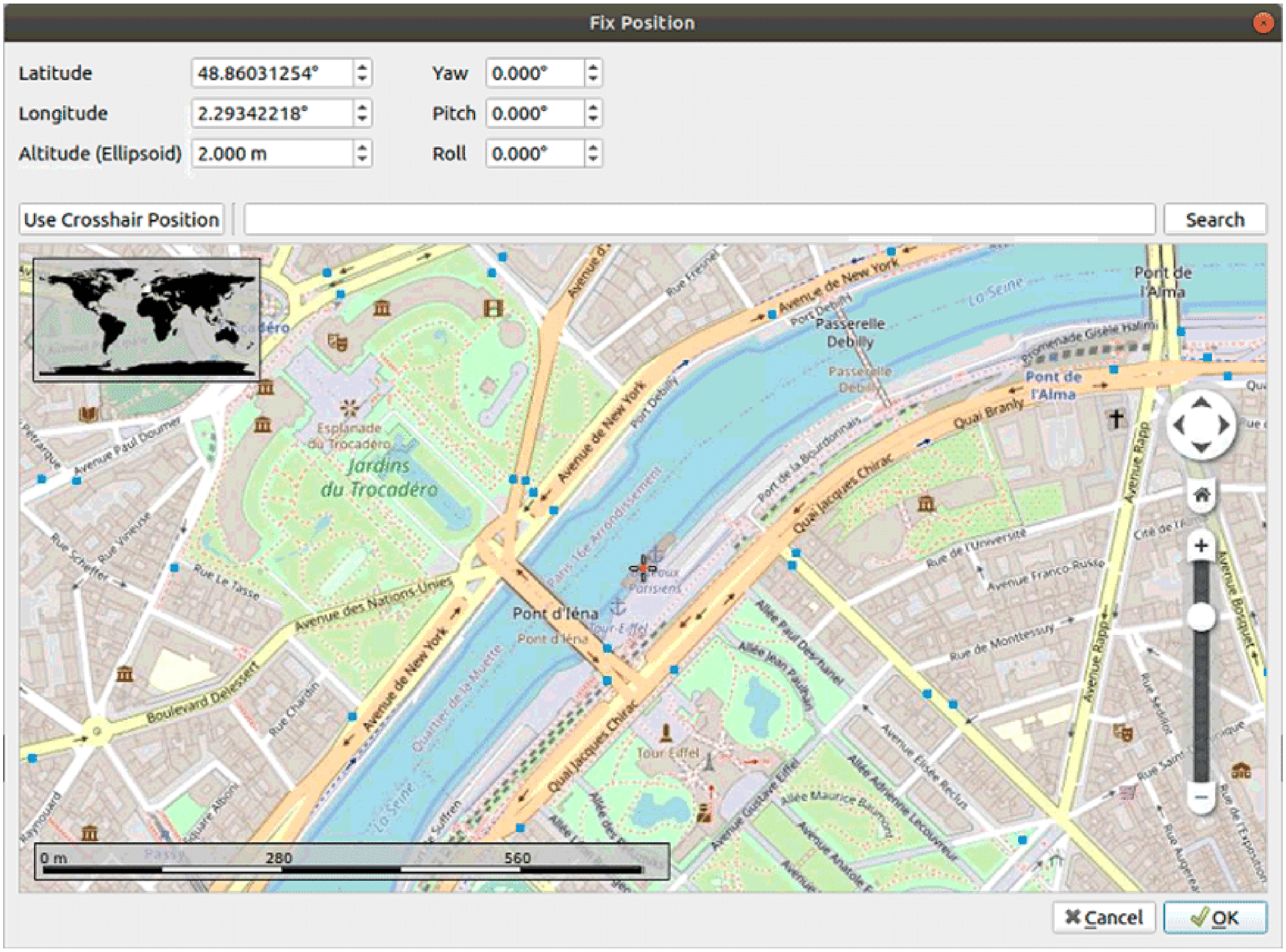
Then click on the general button of the spoofer window. Then set a value of -37 dBm for the Reference Power and click on Enabled to deactivate the spoofer.



Name	Spoofer 1
Enabled	□
Reference Power	-37.00 dBm
Spectrum Waveform Color	🟥
Ignore Propagation Loss	□
Ignore Receiver Antenna Gain Pattern	□
Ignore Receiver Antenna Phase Pattern	□

Reference Power (dBm)
-37.00

Click the Trajectory button to display the spoofer position page screen. Select fixed with the following parameters:



Fix Position

Latitude	48.86031254°	Yaw	0.000°
Longitude	2.29342218°	Pitch	0.000°
Altitude (Ellipsoid)	2.000 m	Roll	0.000°

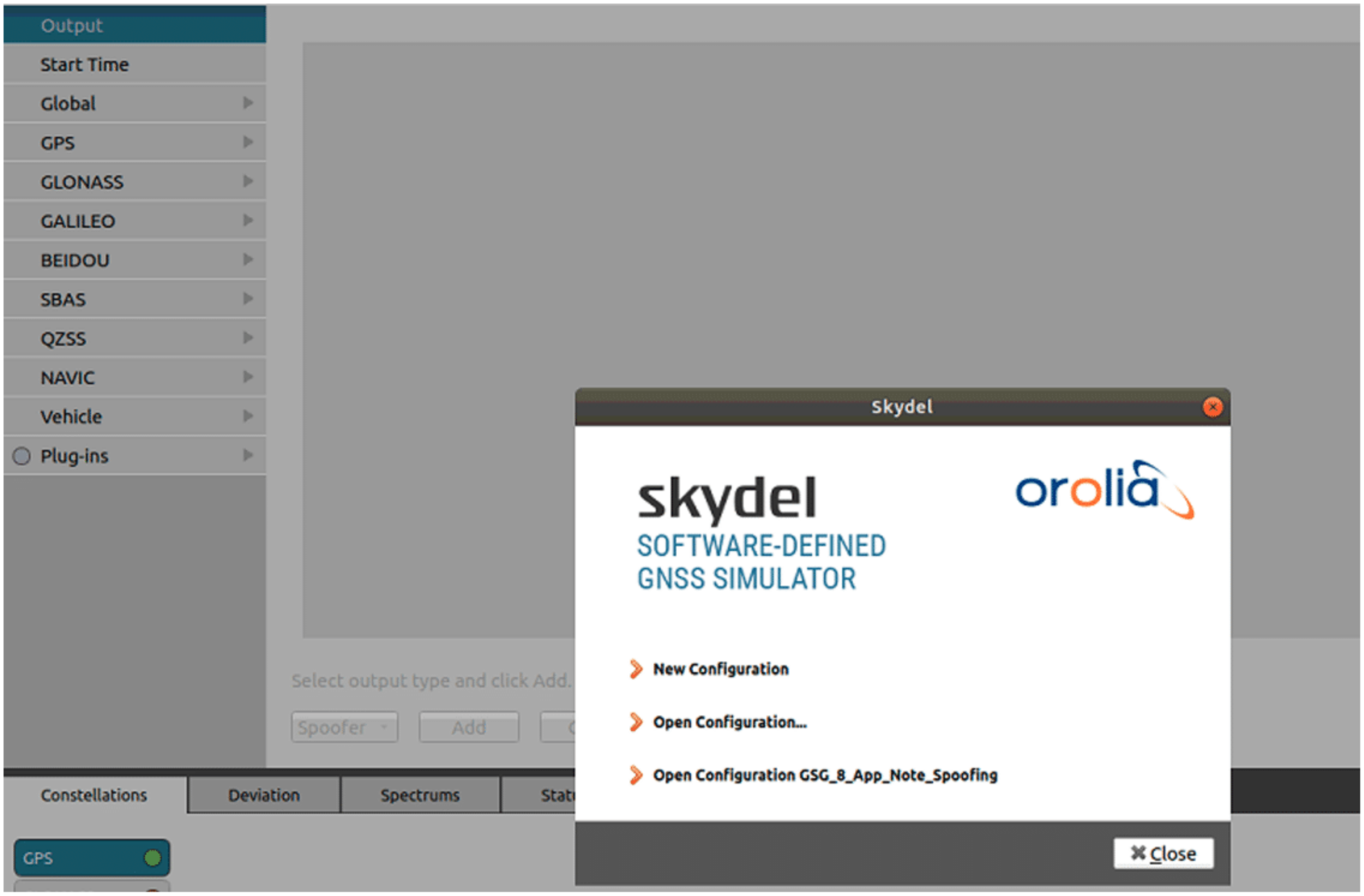
The spoofer parameters are now configured. The next step is to define the spoofing signal, transmitted by the spoofer.

To start a spoofing instance, search for the shortcut Skydel Spoofer on your operating system or start the application in a command line shell with the –spoofing argument.

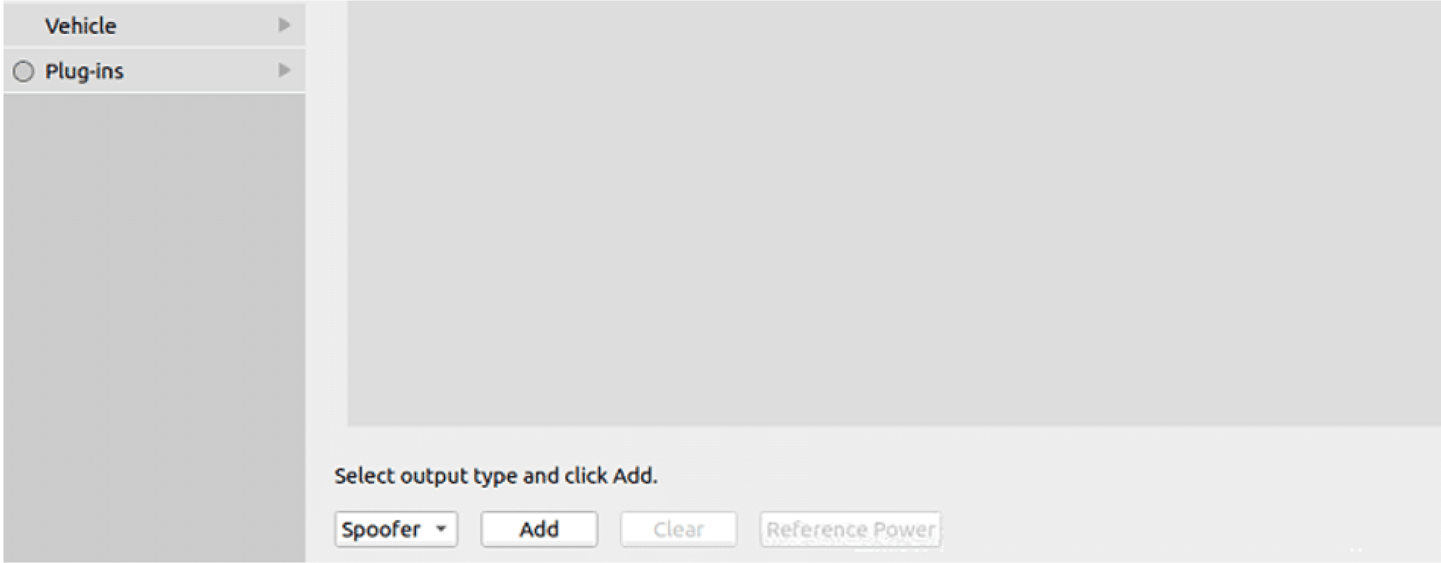
This instance is almost the same as a regular instance, with the following exceptions:

- There is only one type of output: Spoofer.
- The Spoofer output is assigned to an interference group that will be used in the main instance.
- Only GNSS signals can be configured. These are the definition of the spoofing signal.
- The Vehicle section defines the spoofed position.

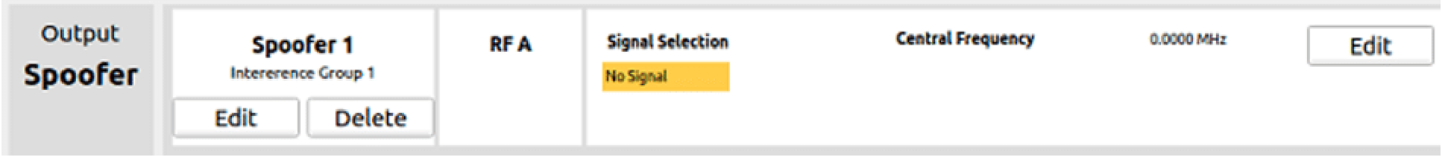
Open the spoofer instance and select new configuration:



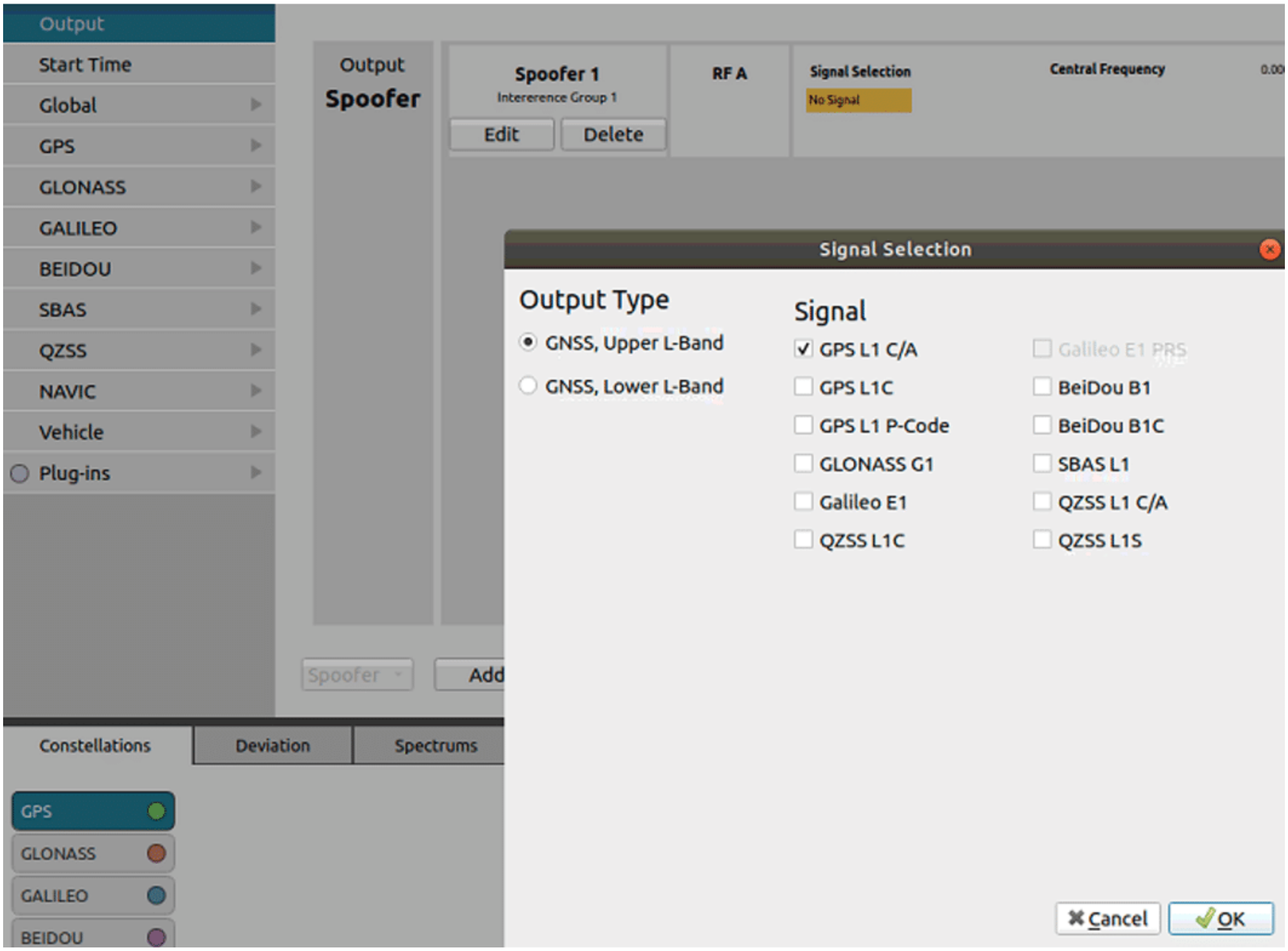
Click Add Spoofer to add a spoofer output.



Then click on edit to add a signal to the spoofer.

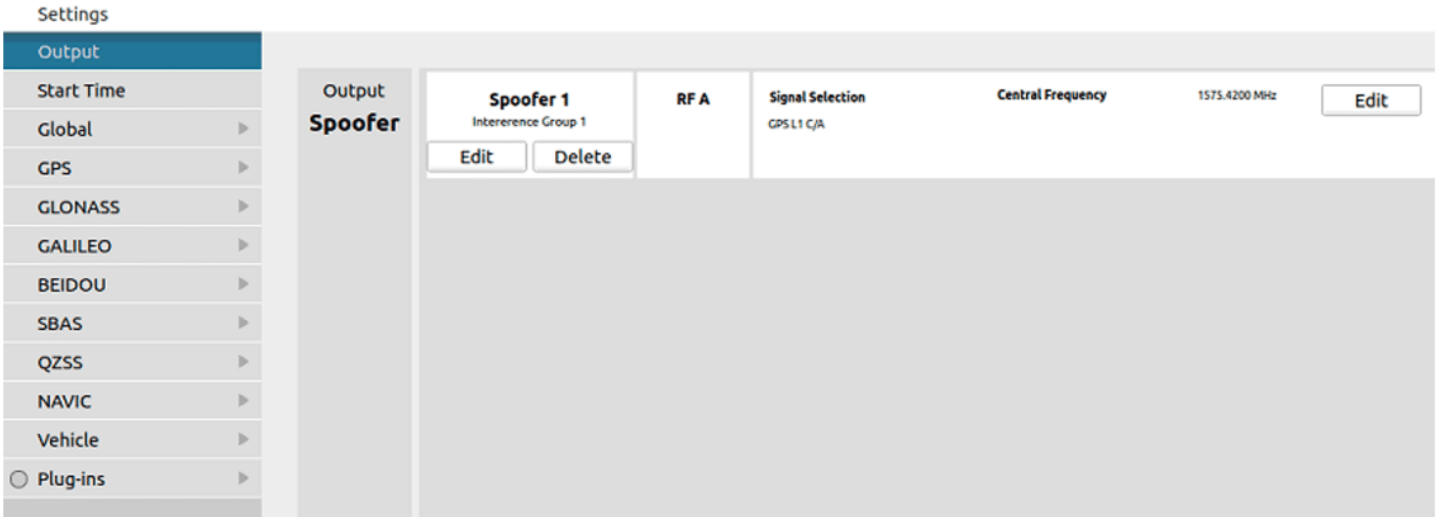


Then select GPS L1/CA in the Signal Selection.



Output Type
- ● GNSS, Upper L-Band
- ○ GNSS, Lower L-Band

Signal
- ☑ GPS L1 C/A
- □ GPS L1C
- □ GPS L1 P-Code
- □ GLONASS G1
- □ Galileo E1
- □ QZSS L1C
- □ Galileo E1 PRS
- □ BeiDou B1
- □ BeiDou B1C
- □ SBAS L1
- □ QZSS L1 C/A
- □ QZSS L1S



Settings

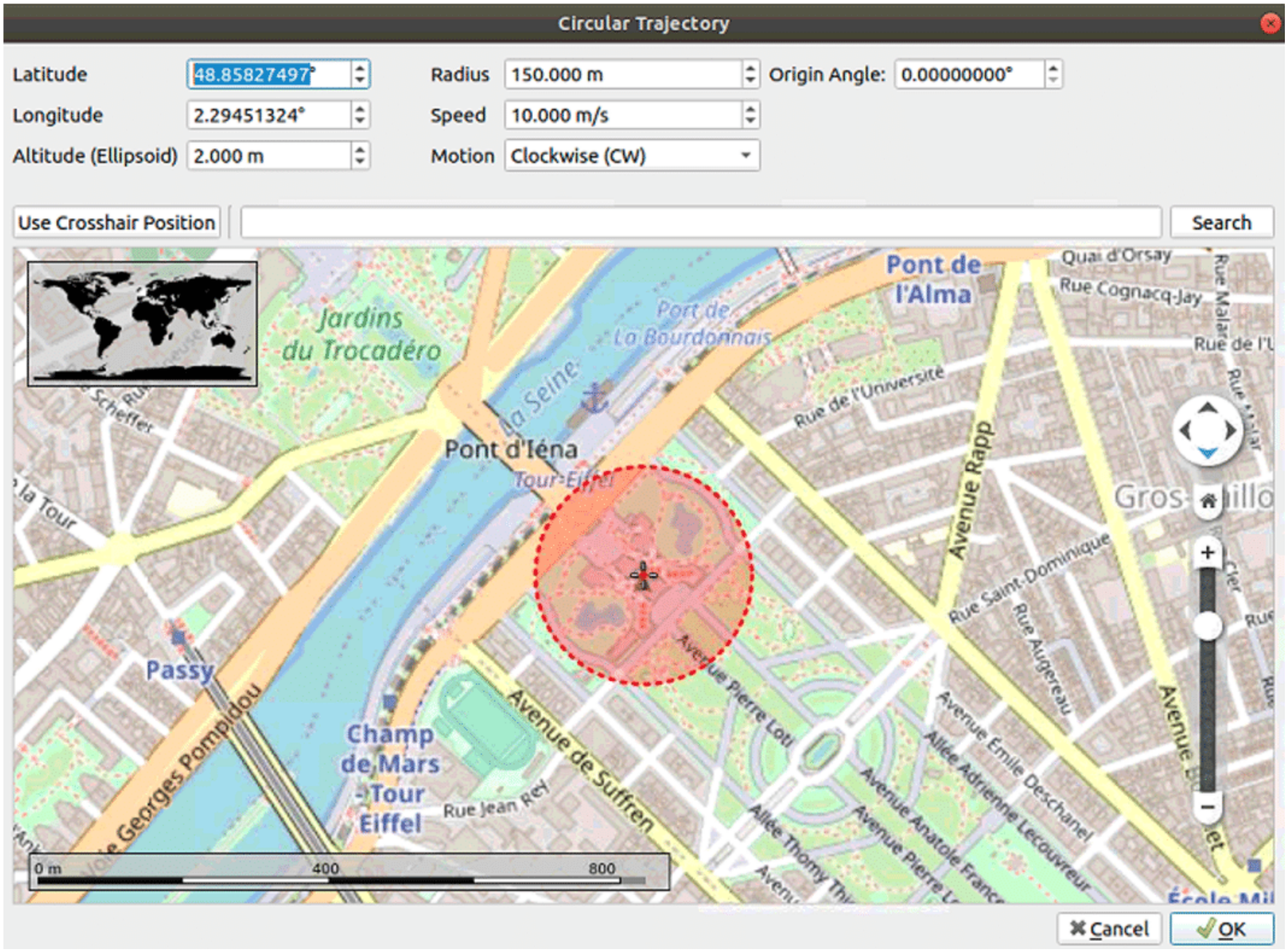
Output
Spoofer

Spoofer 1
Intererence Group 1

RF A

Signal Selection	Central Frequency	
GPS L1 C/A		1575.4200 MHz

Then go to the vehicle tab and select circular in the trajectory selection.



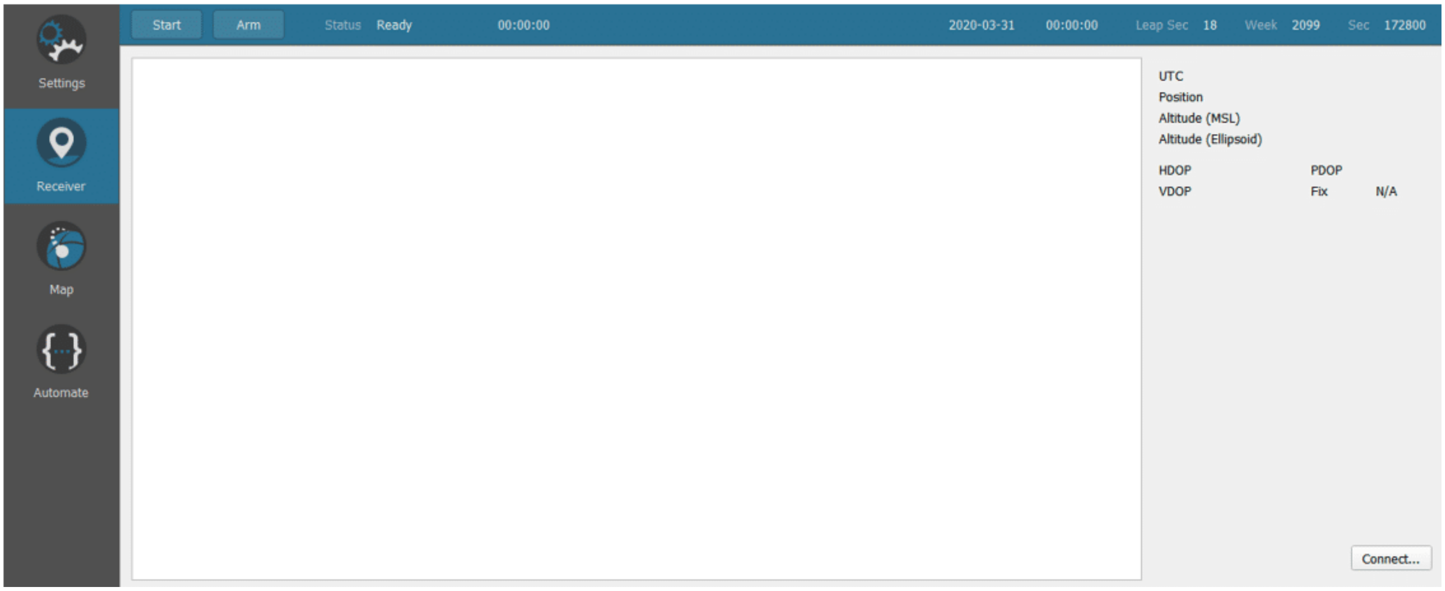
Circular Trajectory

Latitude	48.85827497°	Radius	150.000 m	Origin Angle:	0.00000000°
Longitude	2.29451324°	Speed	10.000 m/s		
Altitude (Ellipsoid)	2.000 m	Motion	Clockwise (CW)		

Add and configure a receiver

Let's start the simulator now and connect a receiver in order to view the simulator, the receiver, and the transmitter in the map tab.

The receiver we used for this example is a U-Blox receiver.



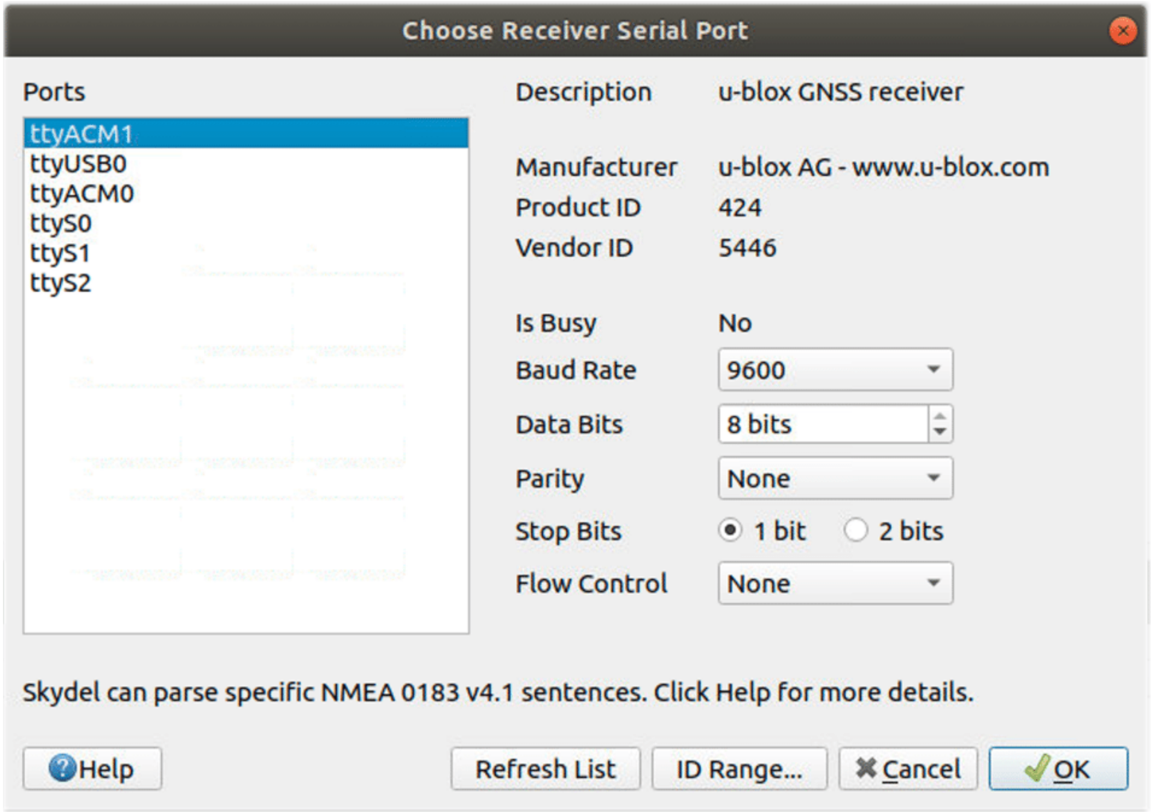
Status Ready 00:00:00 2020-03-31 00:00:00 Leap Sec 18 Week 2099 Sec 172800

UTC
Position
Altitude (MSL)
Altitude (Ellipsoid)

HDOP PDOP
VDOP Fix N/A

To configure it, go to the Receiver window of Skydel and click on connect.

Now select your receiver Serial port in the **Choose Receiver Serial Port** window:



Choose Receiver Serial Port

Ports
- ttyACM1
- ttyUSB0
- ttyACM0
- ttyS0
- ttyS1
- ttyS2

Description u-blox GNSS receiver

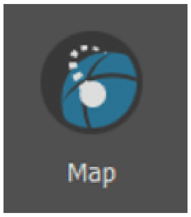
Manufacturer u-blox AG - www.u-blox.com
Product ID 424
Vendor ID 5446

Is Busy No
Baud Rate 9600
Data Bits 8 bits
Parity None
Stop Bits ● 1 bit ○ 2 bits
Flow Control None

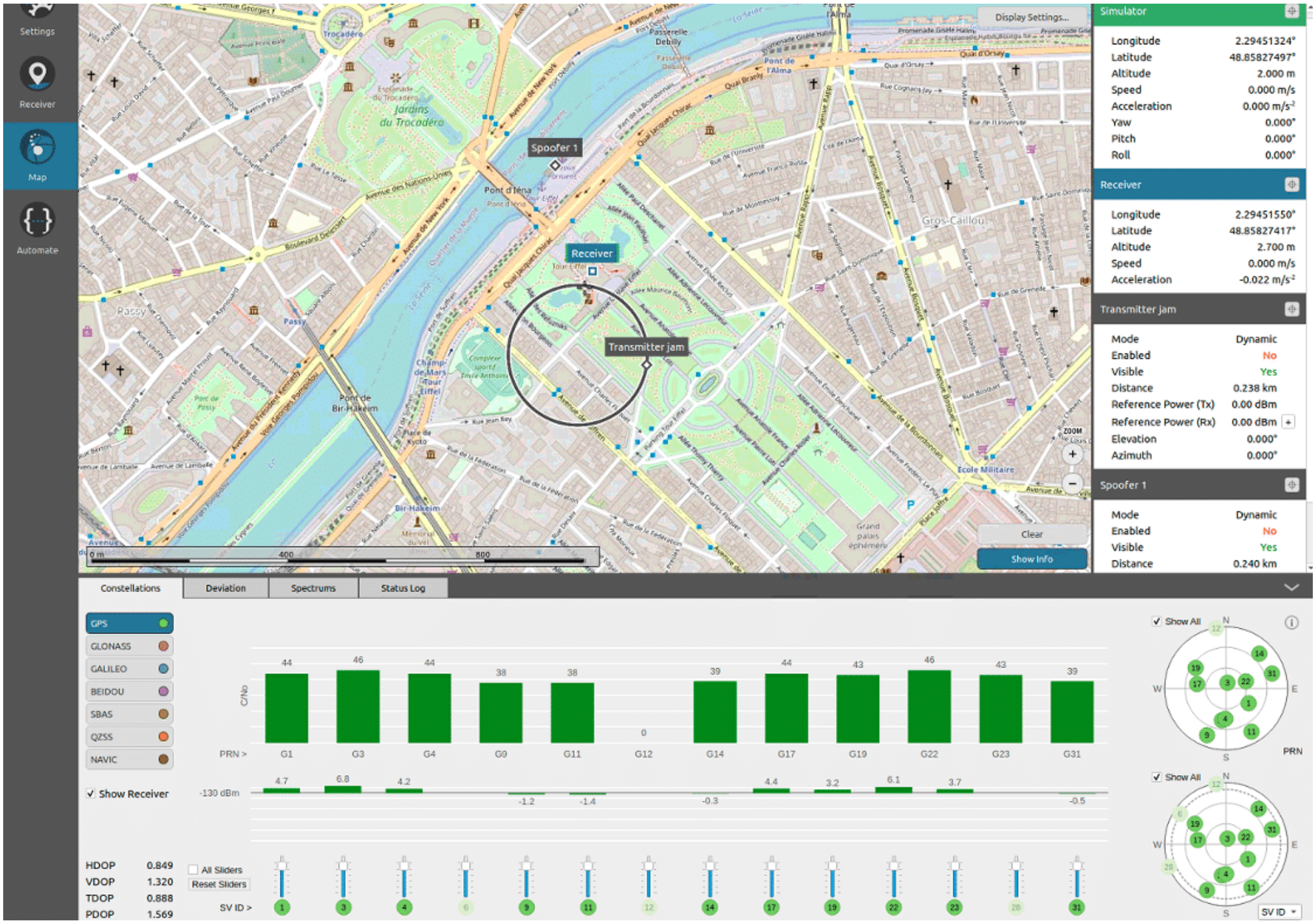
Skydel can parse specific NMEA 0183 v4.1 sentences. Click Help for more details.

Run the simulation

Click on the Skydel map tab:



If you open the transmitter information panel to the right of the map, you will see that the jammer and the spoofer are not activated.



Simulator	
Longitude	2.29451324°
Latitude	48.85827497°
Altitude	2.000 m
Speed	0.000 m/s
Acceleration	0.000 m/s²
Yaw	0.000°
Pitch	0.000°
Roll	0.000°

Receiver	
Longitude	2.29451550°
Latitude	48.85827417°
Altitude	2.700 m
Speed	0.000 m/s
Acceleration	-0.022 m/s²

Transmitter jam	
Mode	Dynamic
Enabled	No
Visible	Yes
Distance	0.238 km
Reference Power (Tx)	0.00 dBm
Reference Power (Rx)	0.00 dBm
Elevation	0.000°
Azimuth	0.000°

Spoofer 1	
Mode	Dynamic
Enabled	No
Visible	Yes
Distance	0.240 km

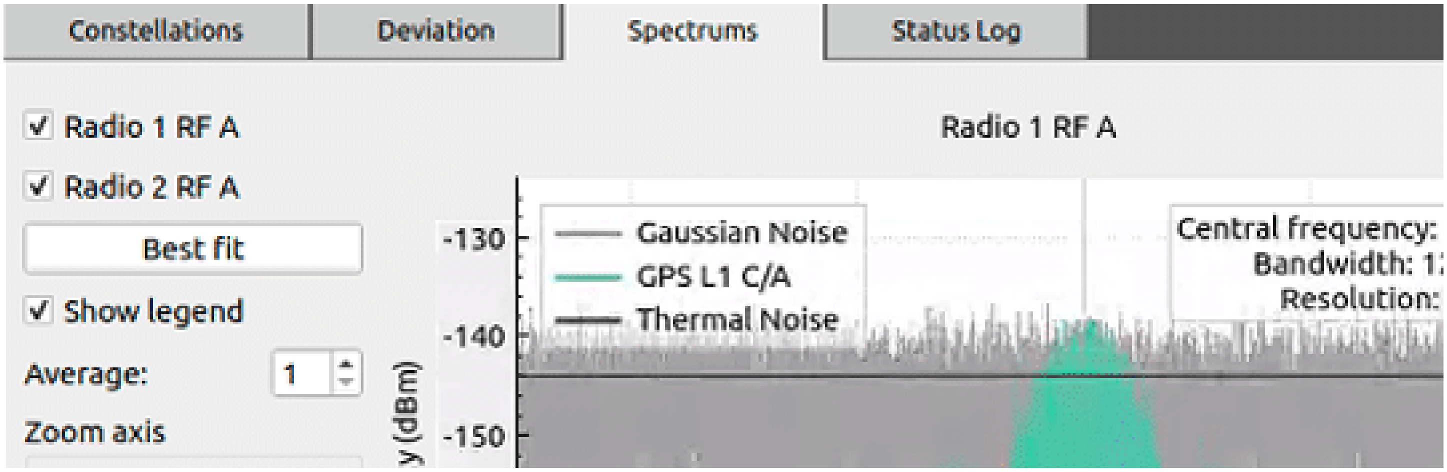
✓ Show Receiver

HDOP	0.849
VDOP	1.320
TDOP	0.888
PDOP	1.569

□ All Sliders

Reset Sliders

In the spectrum subtab, you will see that the GPS signal is being transmitted on the radio 1 RF A.



☑ Radio 1 RF A

☑ Radio 2 RF A

Best fit

☑ Show legend

Average: 1

Zoom axis

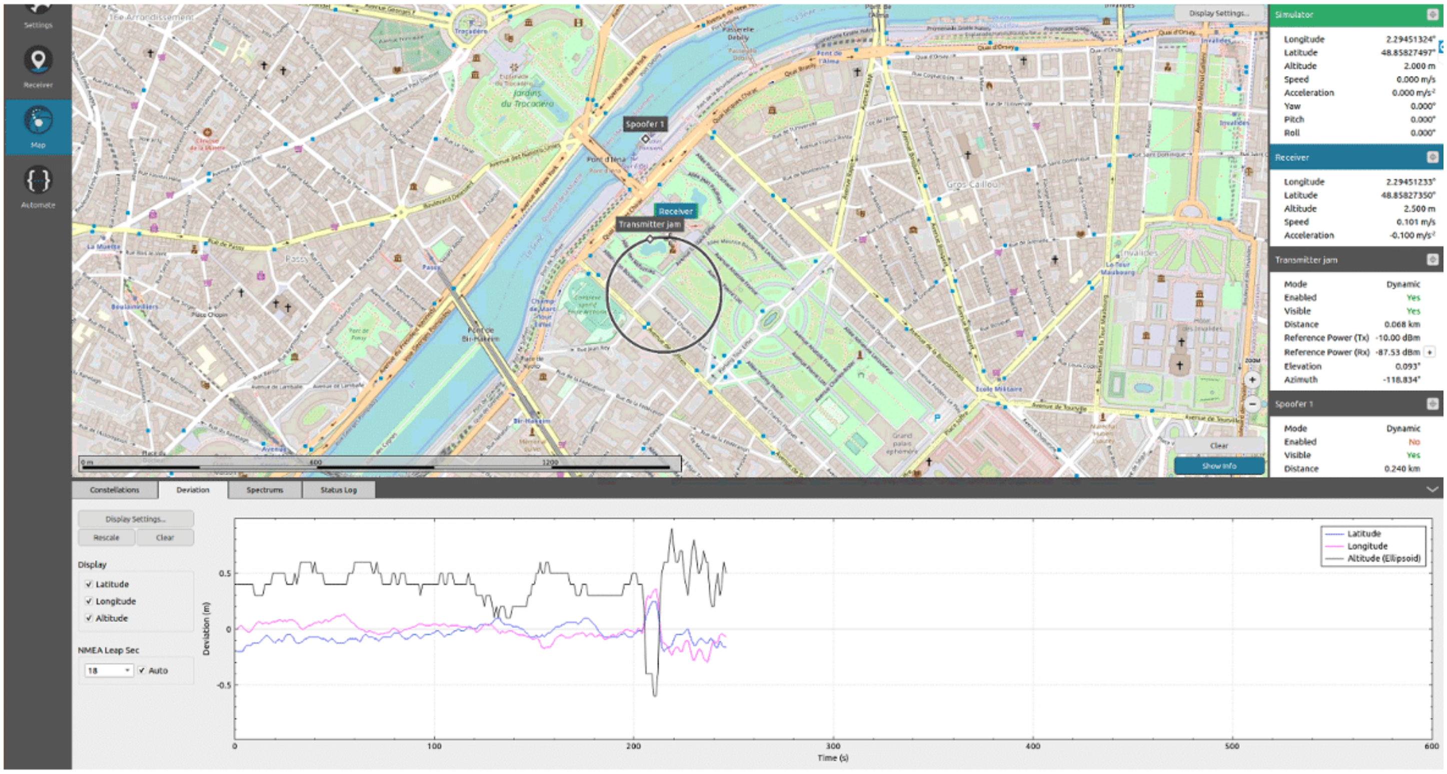
In this example, we will directly activate the spoofer with no intermediary jamming. Some receivers and configurations may need to be jammed to lose the true GNSS signal, before activating the spoofer.

Now, go to the **Transmitter's** General screen and enable the transmitter. You should now see the spoofed signal appearing in the RF B spectrum.

Transmitter 1 is now activated and can be seen appearing in the second window of the spectrum.

We can see that the receiver is fixed at the position of the simulator.

When we then activate the transmitter, we immediately perceive that the receiver begins to be affected.



Simulator	
Longitude	2.29451324°
Latitude	48.85827497°
Altitude	2.000 m
Speed	0.000 m/s
Acceleration	0.000 m/s²
Yaw	0.000°
Pitch	0.000°
Roll	0.000°

Receiver	
Longitude	2.29451233°
Latitude	48.85827350°
Altitude	2.500 m
Speed	0.101 m/s
Acceleration	-0.100 m/s²

Transmitter jam	
Mode	Dynamic
Enabled	Yes
Visible	Yes
Distance	0.068 km
Reference Power (Tx)	-10.00 dBm
Reference Power (Rx)	-87.53 dBm
Elevation	0.093°
Azimuth	-118.834°

Spoofer 1	
Mode	Dynamic
Enabled	No
Visible	Yes
Distance	0.240 km

Display Settings...

Rescale

Clear

Display

☑ Latitude

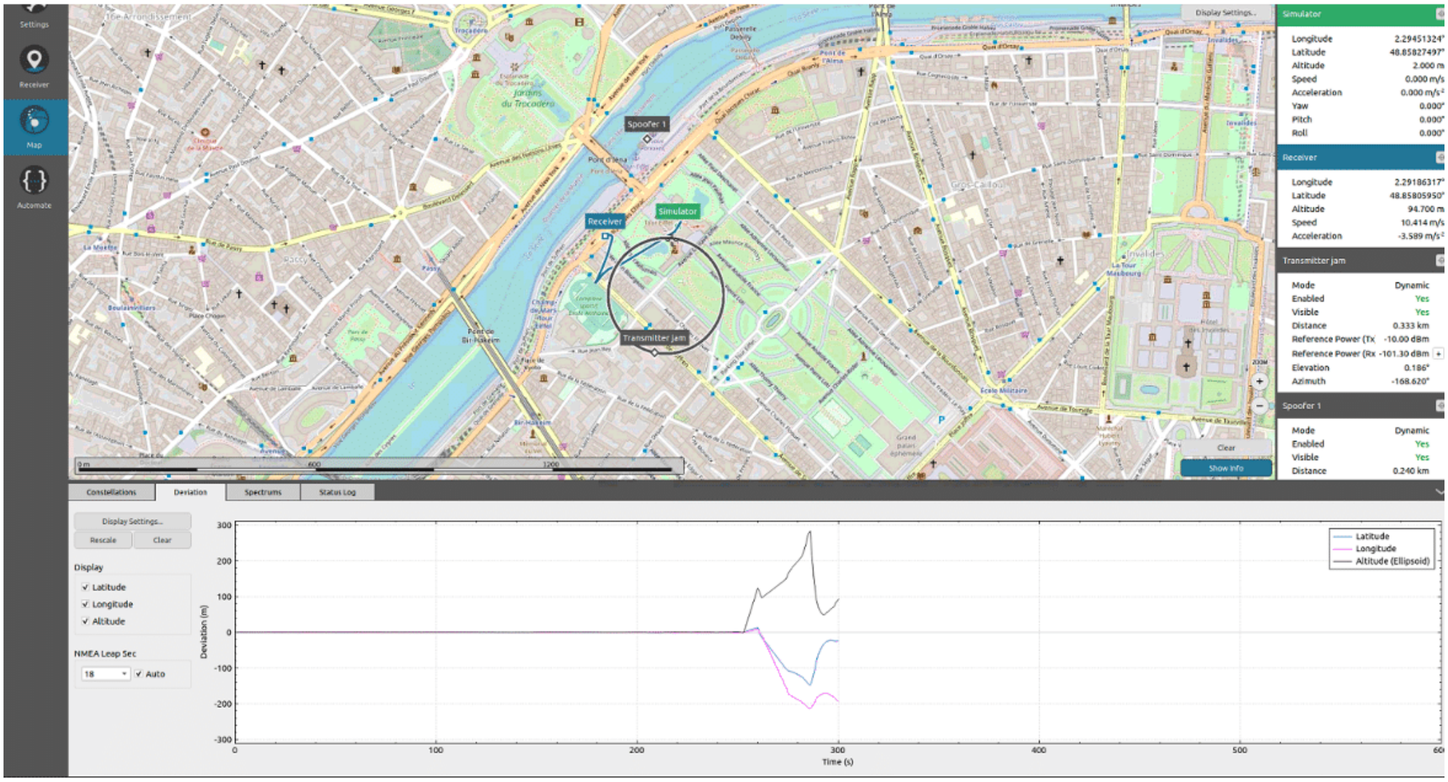
☑ Longitude

☑ Altitude

NMEA Leap Sec

18 ☑ Auto

We see after a few minutes the effect of spoofing on the receiver which begins to pick up the false signal from the spoofer.



Display
☑ Latitude
☑ Longitude
☑ Altitude

NMEA Leap Sec
18 ☑ Auto

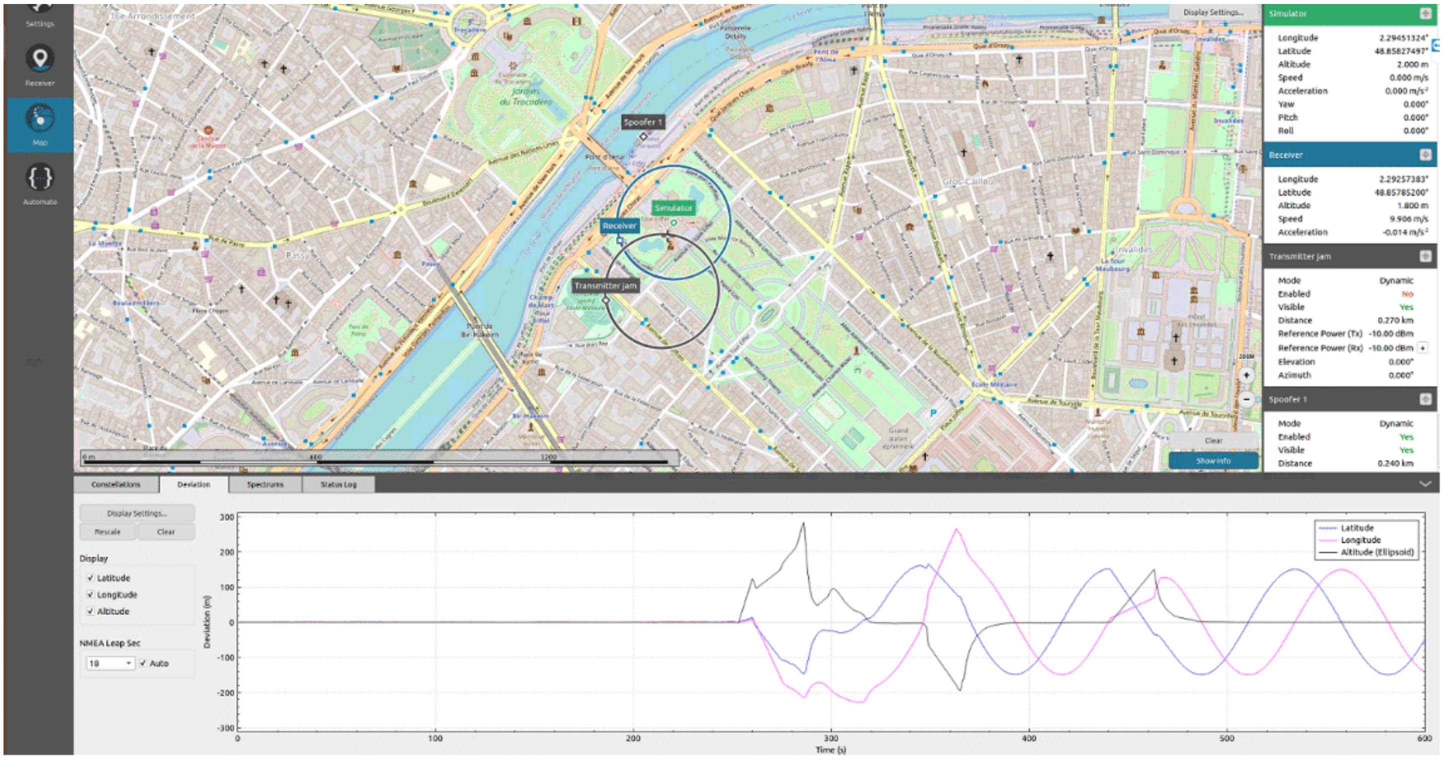
Simulator	
Longitude	2.29451324°
Latitude	48.85827497°
Altitude	2.000 m
Speed	0.000 m/s
Acceleration	0.000 m/s²
Yaw	0.000°
Pitch	0.000°
Roll	0.000°

Receiver	
Longitude	2.29186317°
Latitude	48.85805950°
Altitude	94.700 m
Speed	10.414 m/s
Acceleration	-3.589 m/s²

Transmitter jam	
Mode	Dynamic
Enabled	Yes
Visible	Yes
Distance	0.333 km
Reference Power (Tx	-10.00 dBm
Reference Power (Rx	-101.30 dBm
Elevation	0.186°
Azimuth	-168.620°

Spoofer 1	
Mode	Dynamic
Enabled	Yes
Visible	Yes
Distance	0.240 km

After some time, we can see that the receiver is completely spoofed and follows the wrong direction imposed by the spoofer.



Display
☑ Latitude
☑ Longitude
☑ Altitude

NMEA Leap Sec
18 ☑ Auto

Simulator	
Longitude	2.29451324°
Latitude	48.85827497°
Altitude	2.000 m
Speed	0.000 m/s
Acceleration	0.000 m/s²
Yaw	0.000°
Pitch	0.000°
Roll	0.000°

Receiver	
Longitude	2.29257383°
Latitude	48.85785200°
Altitude	1.800 m
Speed	9.906 m/s
Acceleration	-0.014 m/s²

Transmitter jam	
Mode	Dynamic
Enabled	No
Visible	Yes
Distance	0.270 km
Reference Power (Tx)	-10.00 dBm
Reference Power (Rx)	-10.00 dBm
Elevation	0.000°
Azimuth	0.000°

Spoofer 1	
Mode	Dynamic
Enabled	Yes
Visible	Yes
Distance	0.240 km

Conclusion:

In this application note, we have demonstrated how to easily set up a spoofing scenario with a GSG-8, and test the resilience of a receiver. From this simple Skydel scenario, even more advanced use-cases can be defined, with more jammers, spoofers, and complex attacks. These advanced scenario are easily configured with Skydel with less equipment required, compared with traditional simulators, where such scenarios are more complex, if not impossible.