ELECTRONICS & DEFENSE

DGA-MI
GNSS simulation training

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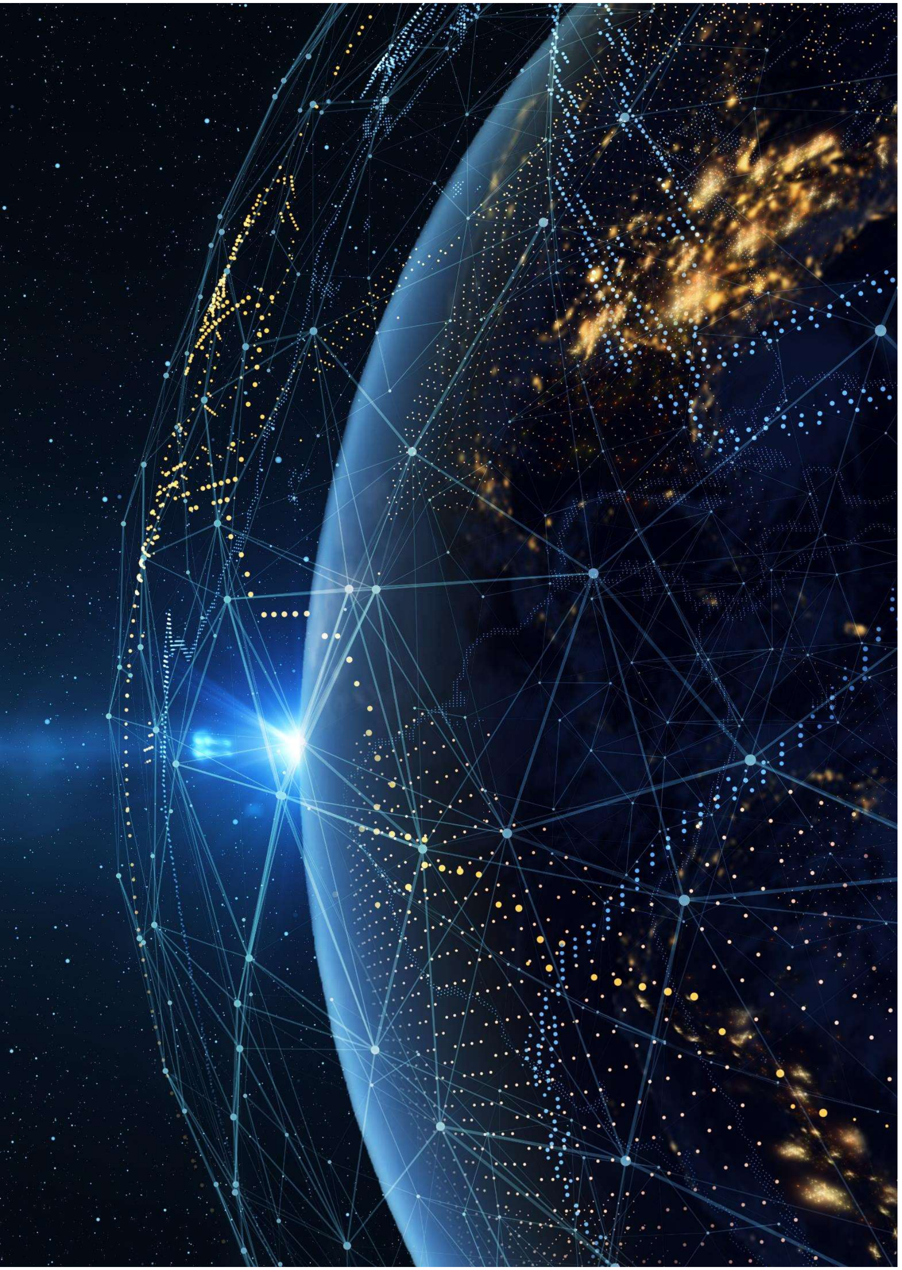
Agenda

First day

- Introduction & product overview
- Skydel introduction
- Basic simulation workshop
- Jamming & spoofing simulation

Second day

- Automation training
- Golden rules for Skydel
- Open workshop



Introduction & product overview

Safran: An Industrial High Technology Group

83,000
employees

€19.0
billion in revenues in 2022

125 years
of history: the oldest aerospace manufacturer in the world

No.3
aerospace company worldwide (excluding aircraft manufacturers)

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A Worlwide Presence

>80.000
employees
in **27** countries

Facilities

R&D and production

Support and services

Offices

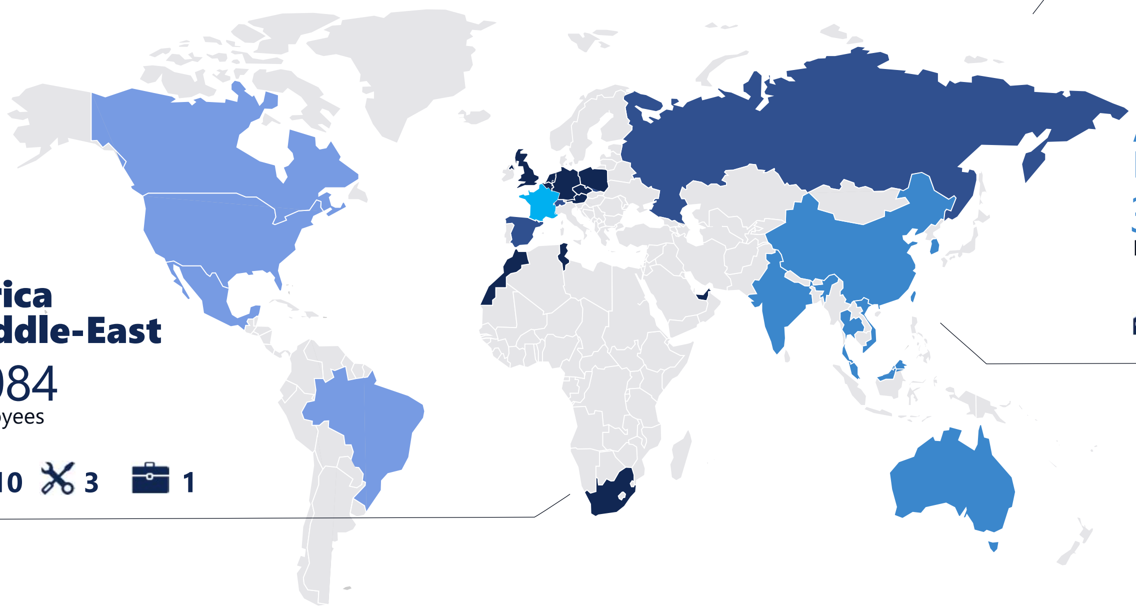
America
18,186
Employees
70 · 31 · 8

France
41,436
Employees
63 · 14 · 20

Europe (except France)
8,174
Employees
27 · 8 · 3

Africa Middle-East
5,084
Employees
10 · 3 · 1

Asia Pacific
3,975
Employees
8 · 8 · 2



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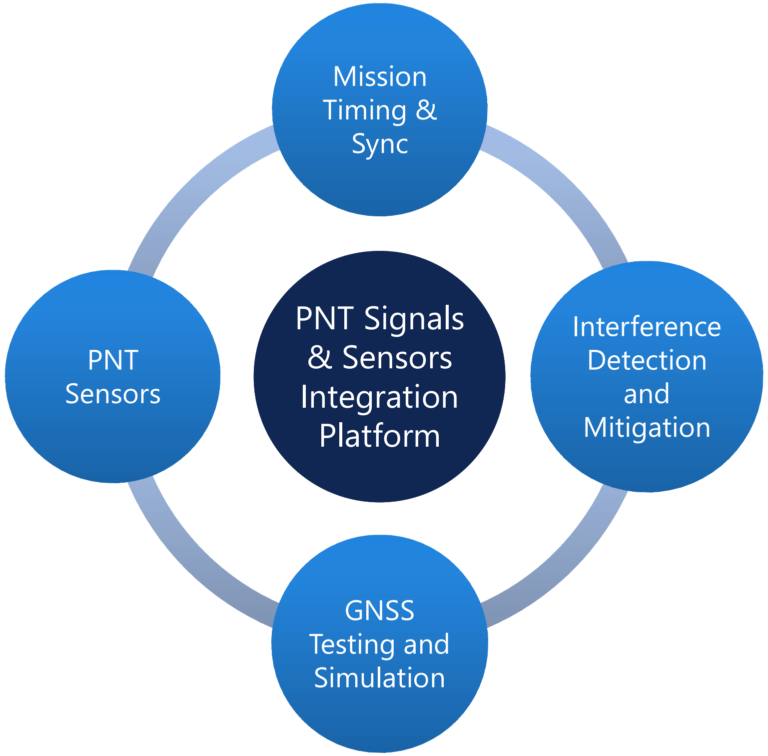
The world leader in resilient PNT

The only provider of complete Resilient Positioning, Navigation and Timing (PNT) solutions.

- Proven GNSS signal protection & countermeasure technology that is available now
- Continuous improvement cycle to adapt to emerging threats over time



Bolt-on, retrofit solutions that are ready to deploy

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The Safran Family of GNSS Simulators

From essential to advanced, we have the right solution for your application and your budget.

Skydel Simulation Engine

Powers Orolia's turnkey simulators, GSG-8 and BroadSim. Can be purchased alone to run on your own specific hardware

- 1000Hz simulation iteration rate
- Scalable to multiple GPU's
- Intuitive UI and automation
- Comprehensive API (Python, C#, C++, LabVIEW)
- Advanced jamming and spoofing
- IQ file generation and playback
- All-in-view simulation

Broadsim Solo

Multi-GNSS Simulations at your desk

- Compact form factor
- Single RF Output
- Advanced scenario creation
- AES-M-Code
- Scalable and affordable

GSG-7

High Performance and Capability Made Easy

- Small Size – 2U Rack Mountable or Bench Top
- In-Field Upgradeability
- All MF/MC Signals via Composite Port
- All-in-view satellites simulation
- 1000Hz simulation iteration rate
- Low-latency HIL
- Live sky time synchronization
- On-the-fly scenario reconfiguration
- 6 Degrees of Freedom (DoF) receiver trajectories
- Flexible licensing

GSG-8

Advanced GNSS Simulator for Critical Applications

- Encrypted EU signals
- 1-4 RF Outputs
- Rack mounted, 4U
- High-end performance
  Precision, resolution, motion
- Multi-constellation
- Multi-frequency
- Multi-vehicle
- Wide dynamic range
  Up to 0dBm transmit power
- High Dynamics and Aerospace features

BroadSim

Advanced GNSS Simulator for NAVWAR Applications

- Encrypted U.S. signals
  Y-Code, M-Code, MNSA
- 4 RF outputs (fixed)
- Same key features as GSG-8
- Easily declassify with removable drives
- Custom Linux OS
  Security, performance
- Trusted solution for U.S. Government, Military, and Industry alike

GSG/BroadSim Anechoic

GNSS Simulator System for Over-The-Air Testing in an Anechoic Chamber

- Tests CRPA/multi -element antennas, antenna electronics and entire PNT systems.
- 32 RF outputs and 16 dual frequency antennas
- Automatic antenna mapping
- Automatic time delay and power loss calibration
- Calibrate your entire system in minutes

GSG/BroadSim Wavefront

GNSS Simulator System for Conducted Testing

- Tests the jamming and spoofing resiliency of CRPA and multi-element antenna electronic systems
- Real-time automated phase calibration
- Generate spoofers, jammers, repeaters and alternate PNT sensors with just a few clicks
- Scalable from 4 to 16 elements
- Phase coherence: 1°1σ
- High dynamic range
- Calibrate your entire system in minutes

Powered by the Skydel Simulation Engine

Essential to NavWar Simulation

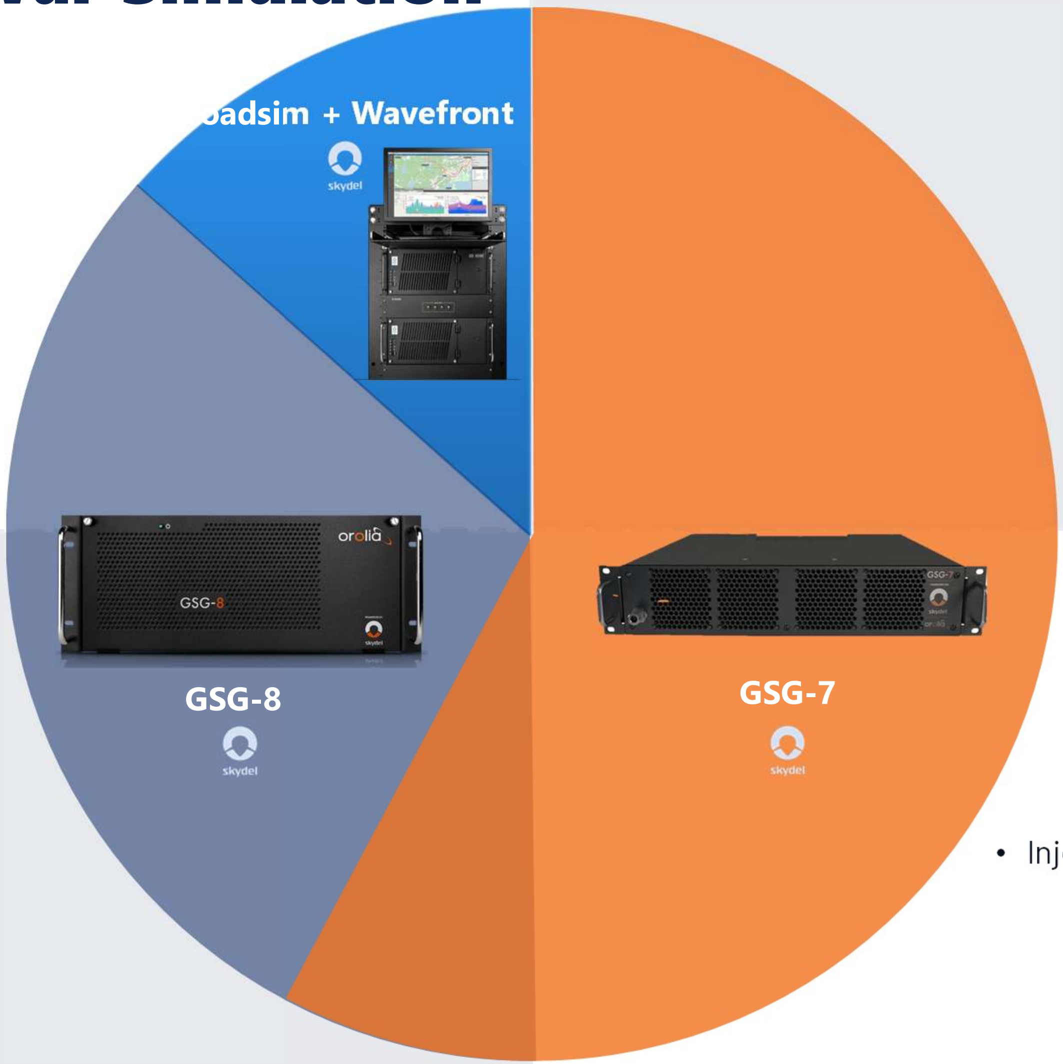
NAVWAR

Expert Capabilities + :

- CRPA Testing
- Anechoic
- Live Sky sync
- NAVWAR testing
- Mission readiness
- Cyber security

ESSENTIAL

- Essential testing for Integrators
- Go/No-Go Testing (Acceptance)
- Single RF



EXPERT

Advanced Capabilities + :

- High Dynamics (aerospace/defense)
- Advanced HIL (closed-loop)
- Multi-antenna/vehicle
- Advanced Jamming + Spoofing
- GNSS/IMU integration

ADVANCED

- Multi-constellation / Multi Frequency
- Inject errors using a pre-defined model (multi-path + interference/signal degradation)
- Test suites
- Open-Loop HIL
- Signal Editing Capabilities

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What are your needs?

Your GNSS simulation needs are evaluated by our services team in order to deliver you the most appropriate tools and configuration:

Possible requirements

- GPS
- Glonass
- Galileo
- Beidou
- SBAS
- Errors injection on GNSS signals
- RTK – Multi-Instance
- X? RF Transmitters
- Advanced Spoofing and Jamming
- Onsite training
- Support
- **Specific test case or/and Tool**

GNSS Simulation Approaches

Fixed, Allocated Hardware

- Traditional GNSS simulation approach
- Purpose designed hardware
- # of signals defined by FPGA channels
- Difficult to scale to larger systems
- Custom made hardware can be expensive when produced in small quantities

Open, Software-Defined Architecture

SKYDEL Design

- Maximum scalability and flexibility
- Agile/rapid software development process
- Innovation not limited by hardware design
- Hundreds of signals generated in GPU
- Mass produce high-end SDR and GPU with economy of scale
- Supports open-source contributions

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Skydel Simulation Engine

POWERED BY skydel

Shared software-defined benefits and interoperability

- Easy configuration with intuitive UI and automation
- Supports all major global constellations & frequencies
- Comprehensive API (Python, C#, C++, LabVIEW)
- Advanced signal customization and scenario creation
- Modify variables and parameters in real time
- Integrate interference with no additional hardware
- IQ file generation and playback
- 1000Hz simulation iteration rate
- Record and export user interactions as Python script

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Skydel Key Features

- **Multi-constellation / Multi-frequency**
  - GPS, GLONASS, GALILEO, BEIDOU, SBAS
  - Support for restricted signals (GPS & Galileo)
  - All-In-View simulation
- **Real-time GNSS simulator**
  - Simulation entirely GPU-generated
  - Most parameters can be modified at runtime
- **Powerful & simple automation**
  - Complete documentation API (Python, C#, C++)
  - Innovative automatic Python Scripting generation
- **Scalable platform**
  - Software Only, Turn-Key system
  - Multiple RF Output
  - Scenario Editor
- **Advanced interference simulation**
  - Full jammers dynamics
  - Power levels computed in real-time
  - Fully integrated into GNSS simulation
    - No additional H/W required
- **User-defined waveforms**
  - Chirp, CW, BOC, AWGN, BPSK & Pulse modulation + custom IQ file
  - Combine dozens of signals
  - Real-time results on spectrum
- **Test / Validation / Integration**
  - Multi-vehicles, multi-antennas
  - HIL Low Latency
  - 6 DoF and orbital trajectories

TURNKEY

Select a turn-key system from Orolia to give you ultra-high performance and long-term reliability with commercial-off-the-shelf (COTS) components.

CUSTOM

Already have the hardware needed to run Skydel? You can simply purchase a software license and be ready to go in no time by re-using your own PC and SDR.

Orolia works with applications teams to make a tailored solution for specific custom solutions based on Skydel.

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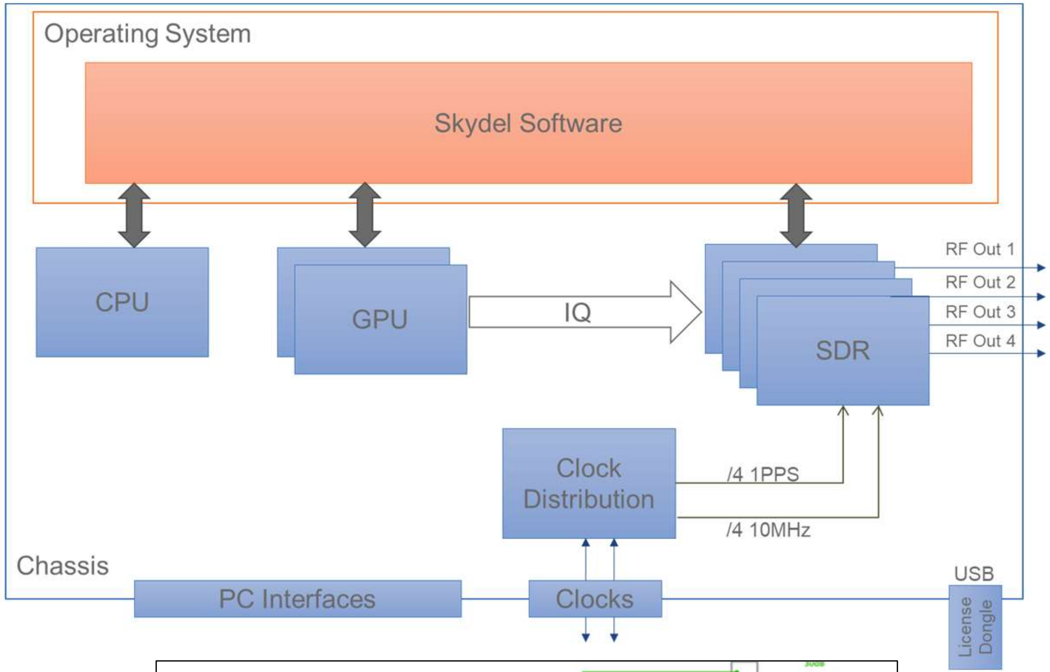
Overall Architecture

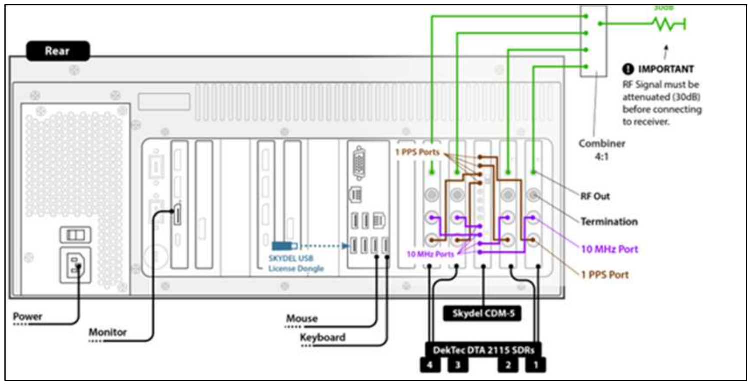
Orange - Software
Blue - Hardware

- Multiple GPUs possible
  - GSG-8 supports 1 or 2

- Multiple SDRs possible
  - Minimum 1 per frequency band
  - Additional for Jamming/Spoofing
  - GSG-8 supports 1-4

- Clock distribution supplies 10MHz and 1PPS signals to the radios





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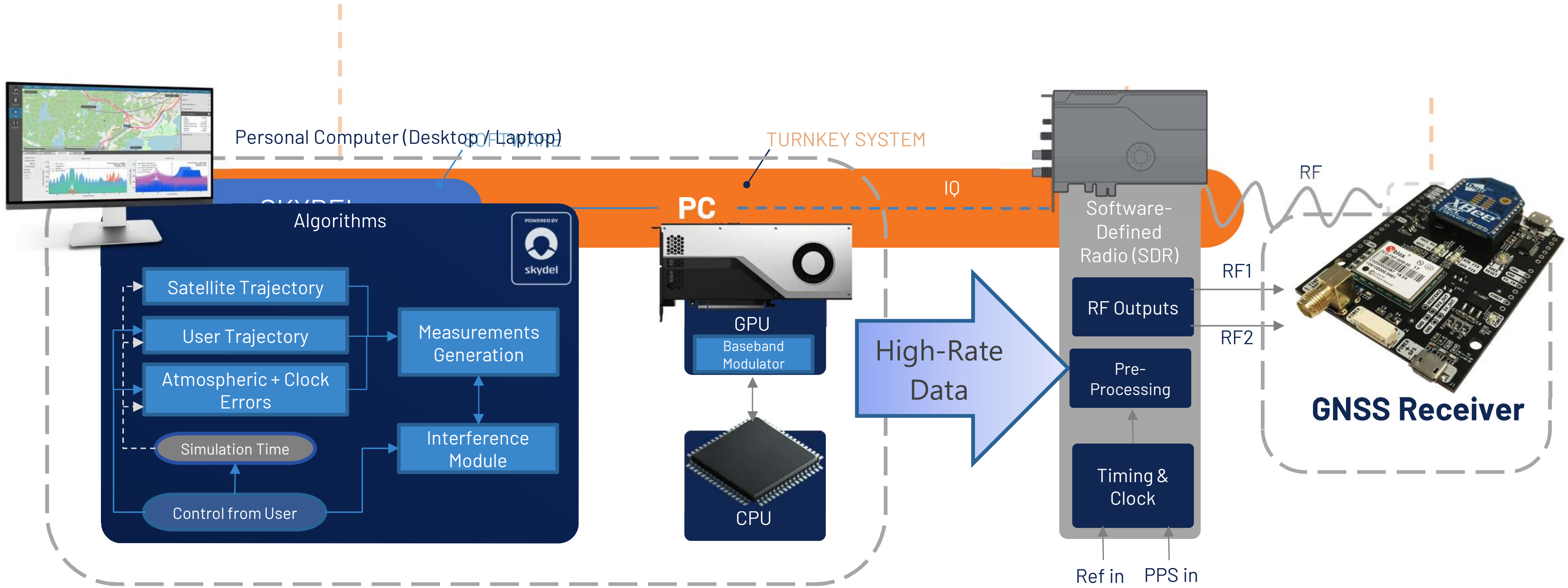
How Skydel Works

Skydel uses a PC's GPU to generate, in real-time, high-rate baseband signals that are converted to RF by the SDR.



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GSG-882 : Overall Architecture

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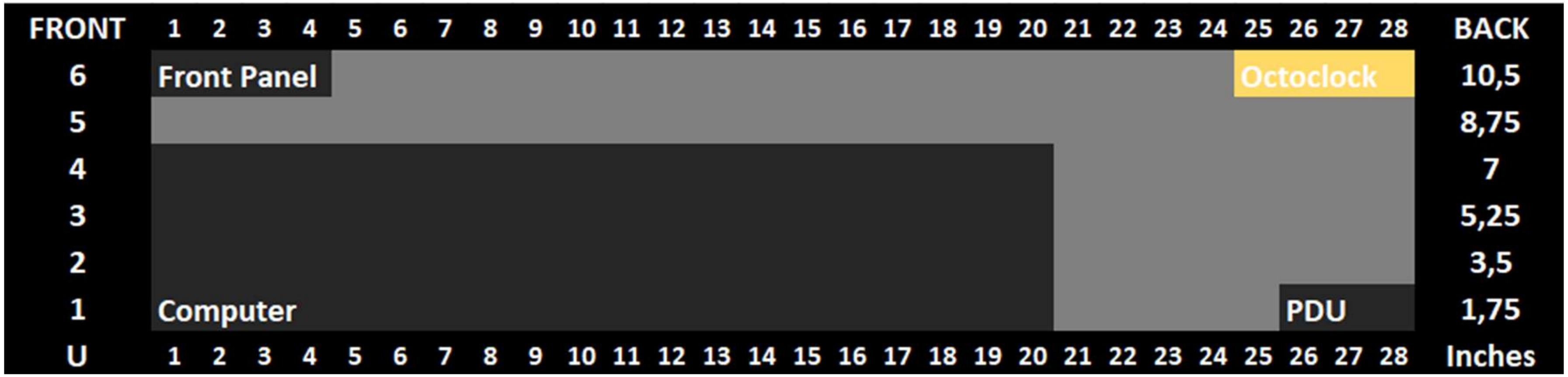
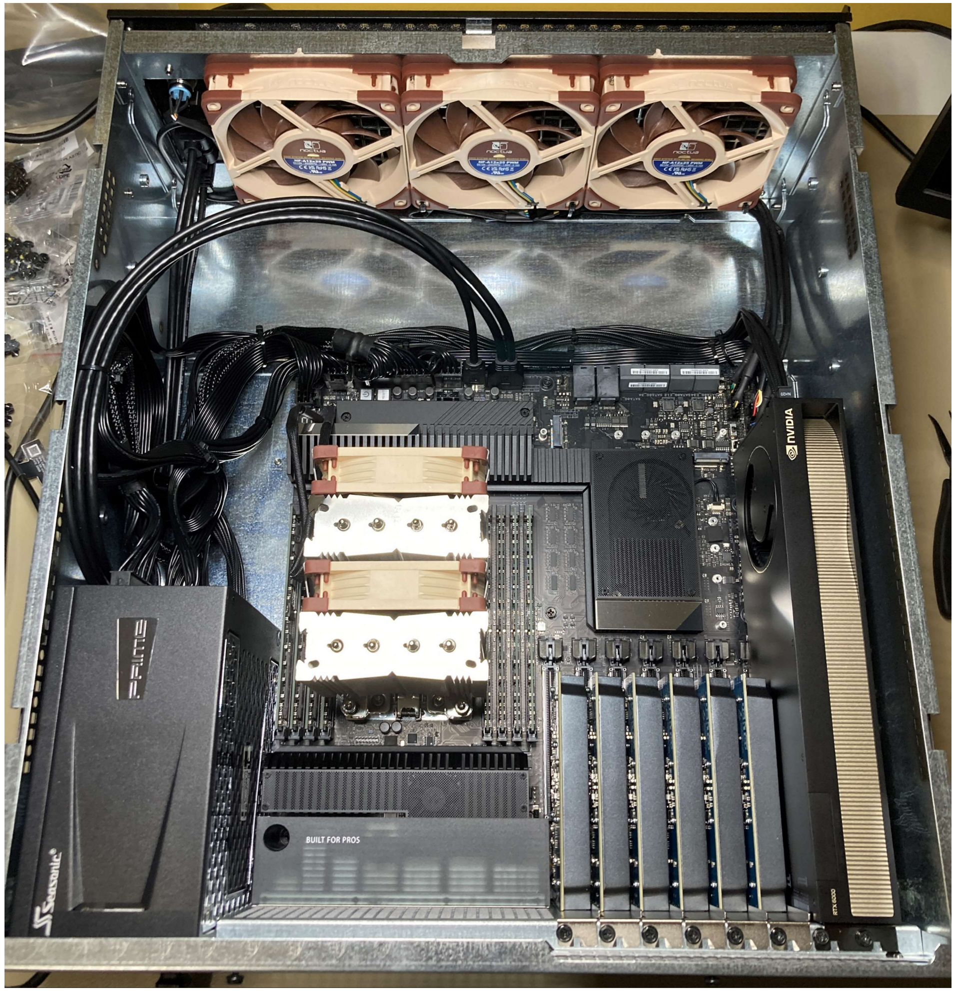
GSG-882 : Overall Architecture



Overall Architecture



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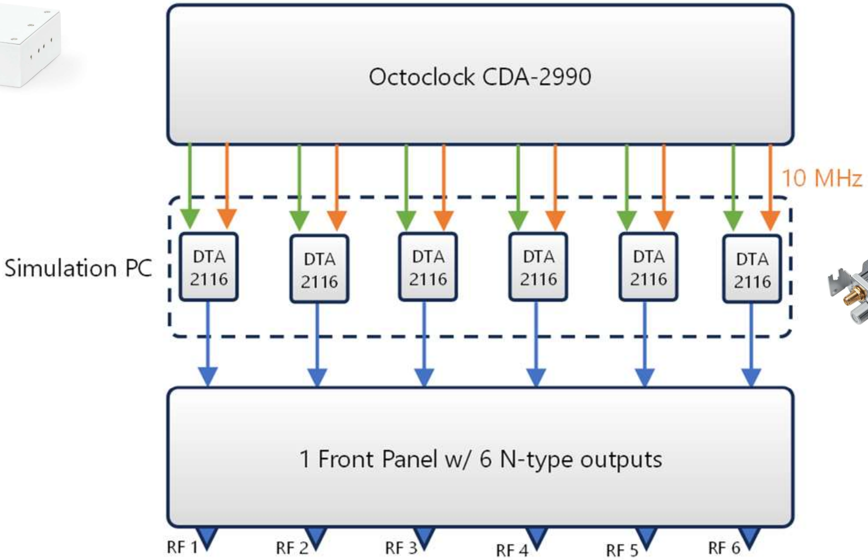
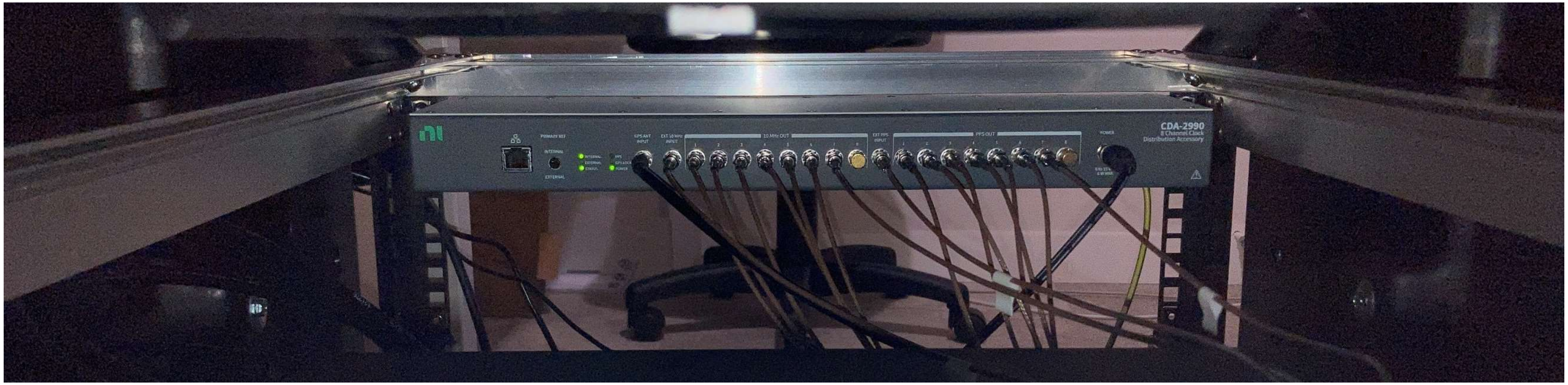
Overall architecture



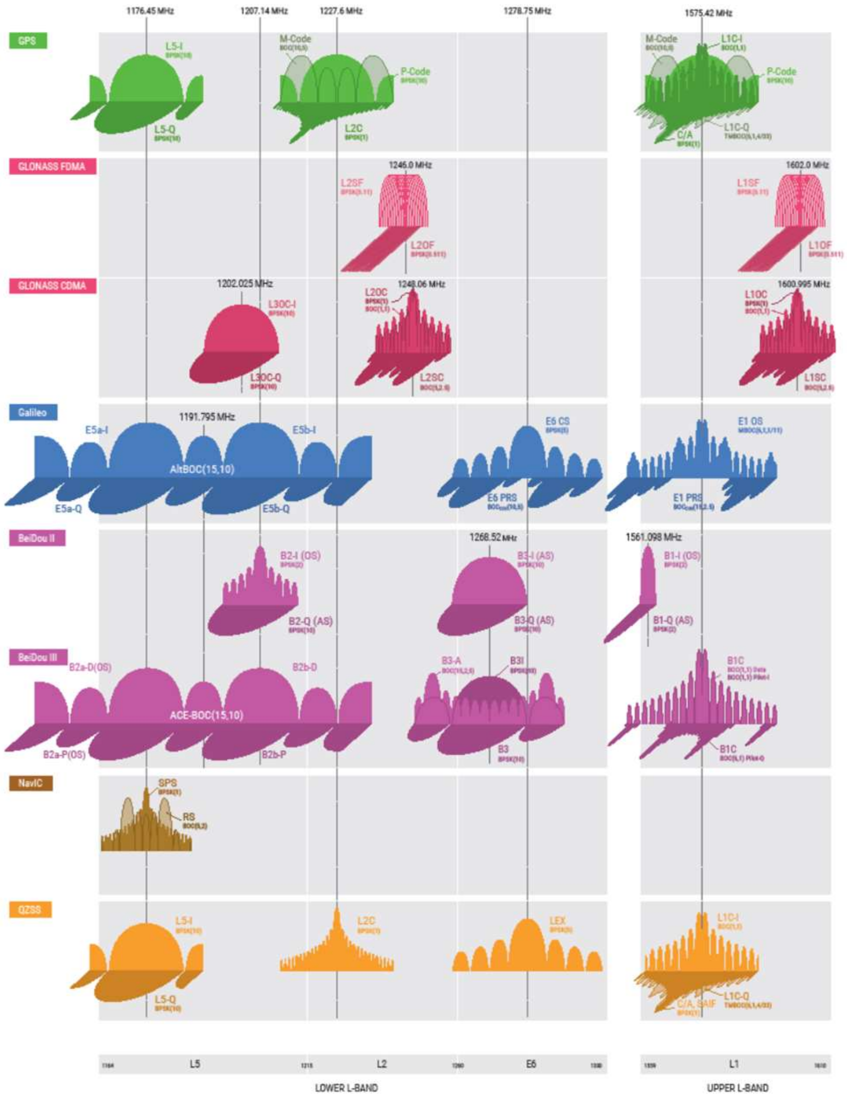
Clock distribution system

NI Octoclock CDA-2990



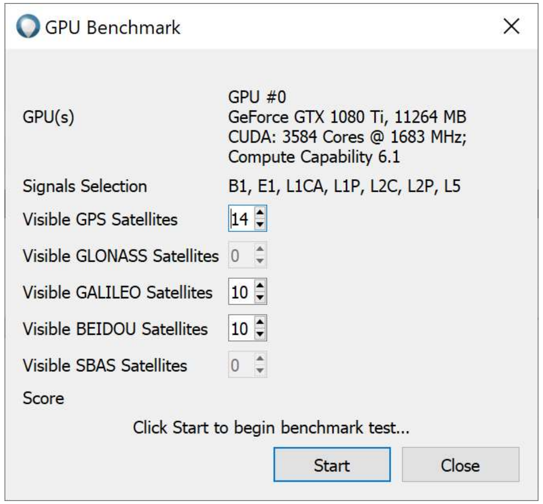
SKYDEL SPECTRUM POSTER

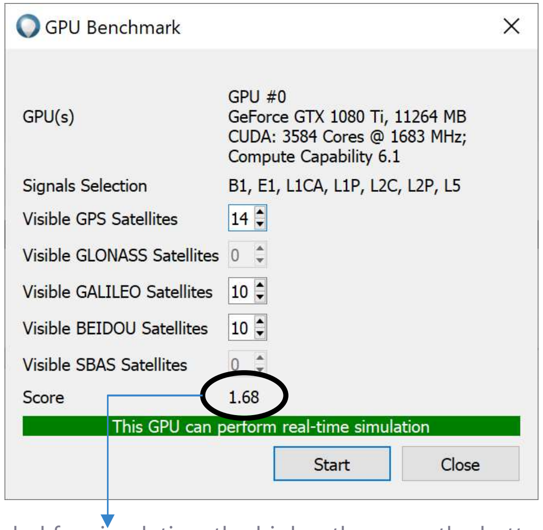
- Shows all of the GNSS signal and where they fall in the spectrum
- An easy way to see what signals are in the same frequency range
- https://www.skydelsolutions.com/en/resources/misc/gnss-spectrum-cheat-sheet/



Signals

- **Each signal is licensed separately**
- **The upper-GNSS band signal is a prerequisite for the lower-GNSS band signals**
  - Ex. GLONASS G1 is a prerequisite for GLONASS G2
- **Hundreds of signals simulated**
  - Approx. 150 to 300 signals per GPU
  - GPU benchmark feature included in software
  - A signal can be a GNSS signal, an interference signal, a multipath signal, a spoofing signal





Score > 1 needed for simulation, the higher the score the better

	Lower GNSS Band	**Upper GNSS Band**
GPS	L2P, L2C, L5	L1C/A, L1C, L1P
GLONASS	G2C/A, G2C, G3C	G1C/A, G1C
GALILEO	E5a, E5b, E6HAS	E1
BEIDOU	B2I, B2a, B3I	B1I, B1C
QZSS	L2C, L5, L6DE,S	L1C/A, L1, L1CB, S
NAVIC	L5	
SBAS	L5	L1

AVAILABLE
IN ROADMAP

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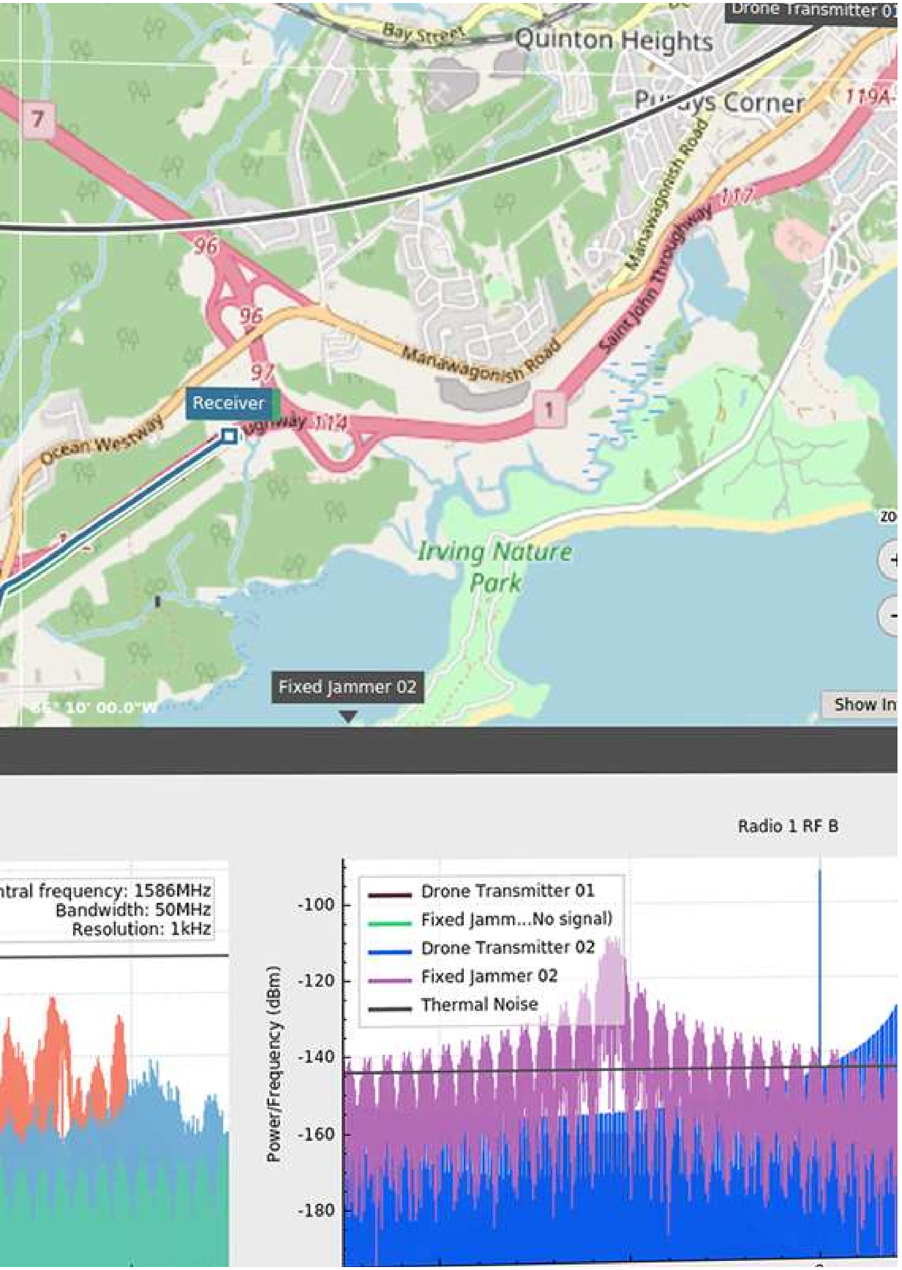

Basic Simulation

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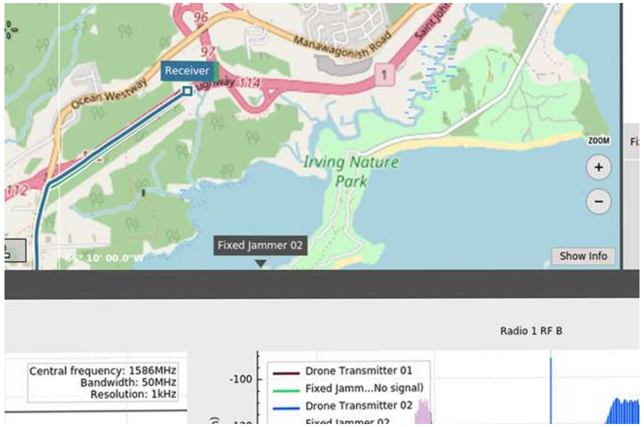
1.1

Introduction

Skydel Benefits



Software-Defined Flexibility

Option for a turnkey solution or reuse your own SDR

Massive Capabilities

Fully-featured GNSS simulator + unique software-defined characteristics

High-End Performance

1000Hz simulation iteration rate, high dynamics, real time, best in class accuracy

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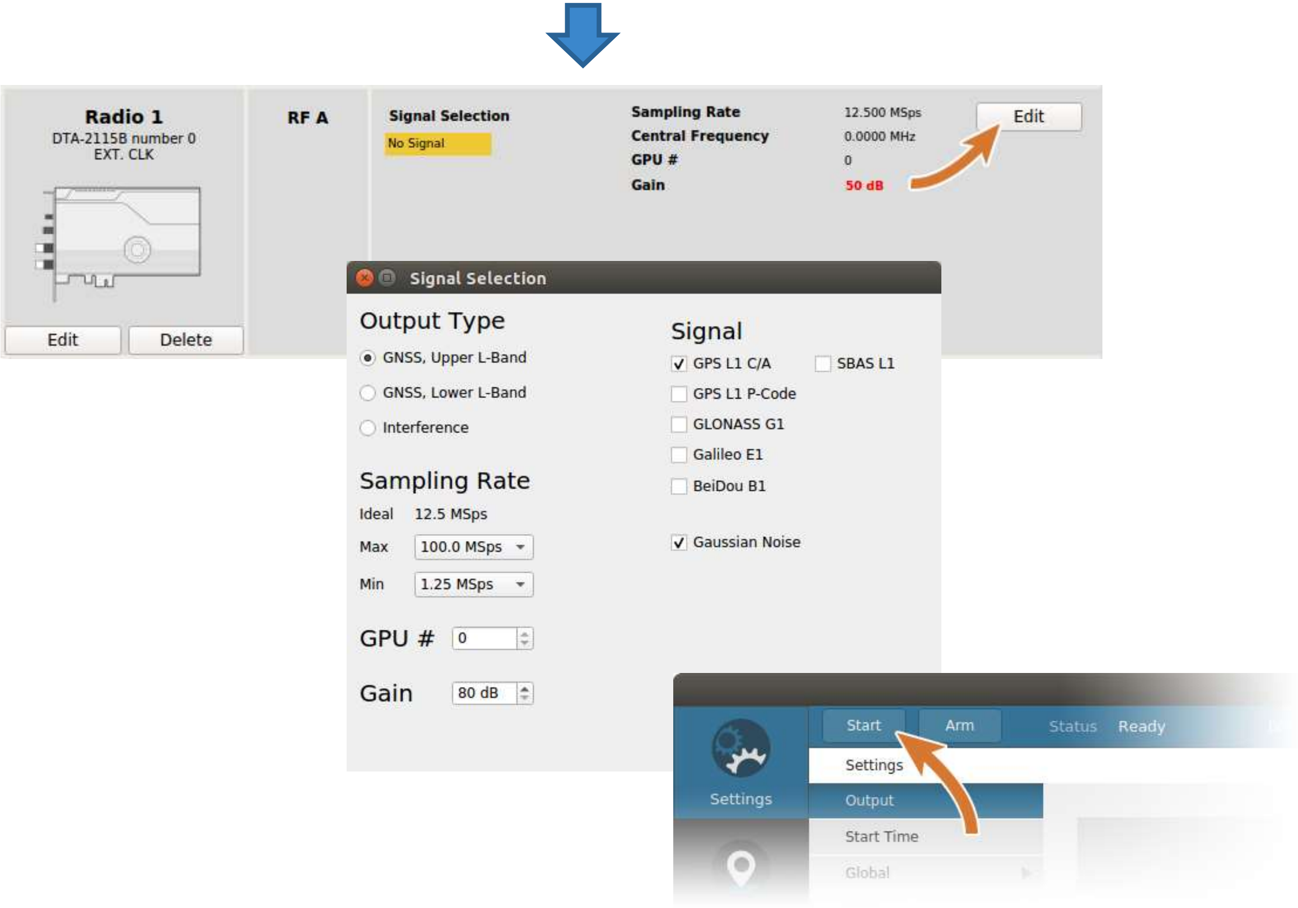
Starting Your First Scenario

1. Power Up GSG-8
2. Open Skydel
3. Set up hardware
4. Signal Selection
5. Start Scenario

Means Set up hardware first



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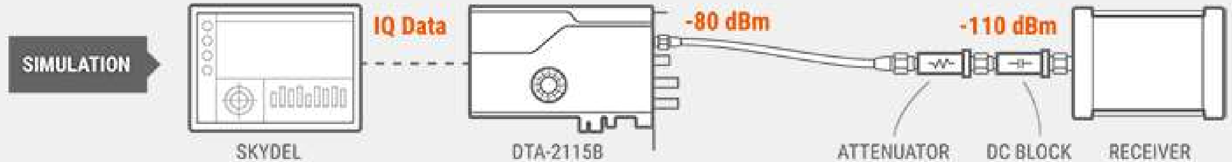
Set up hardware

Skydel

A typical use case with Skydel is to reproduce live sky conditions combined with an active antenna. To achieve that, use attenuators as described in the image below.

When Skydel simulates – -130dBm, DTA-2116 cards apply gain (default 50dB)



For GNSS signals, the default gain at the DTA-2115B RF output is 50 dB. To reproduce the intended power level at the receiver input, the signal should be attenuated by 50 dB. However, if you don't have a LNA and want to reproduce the power level after a LNA with 20 dB of gain, simply use 30 dB of attenuation.

For Interference/Jammer or for different output, the gain might be different. Always make sure the total attenuation matches the gain for each output.

Close

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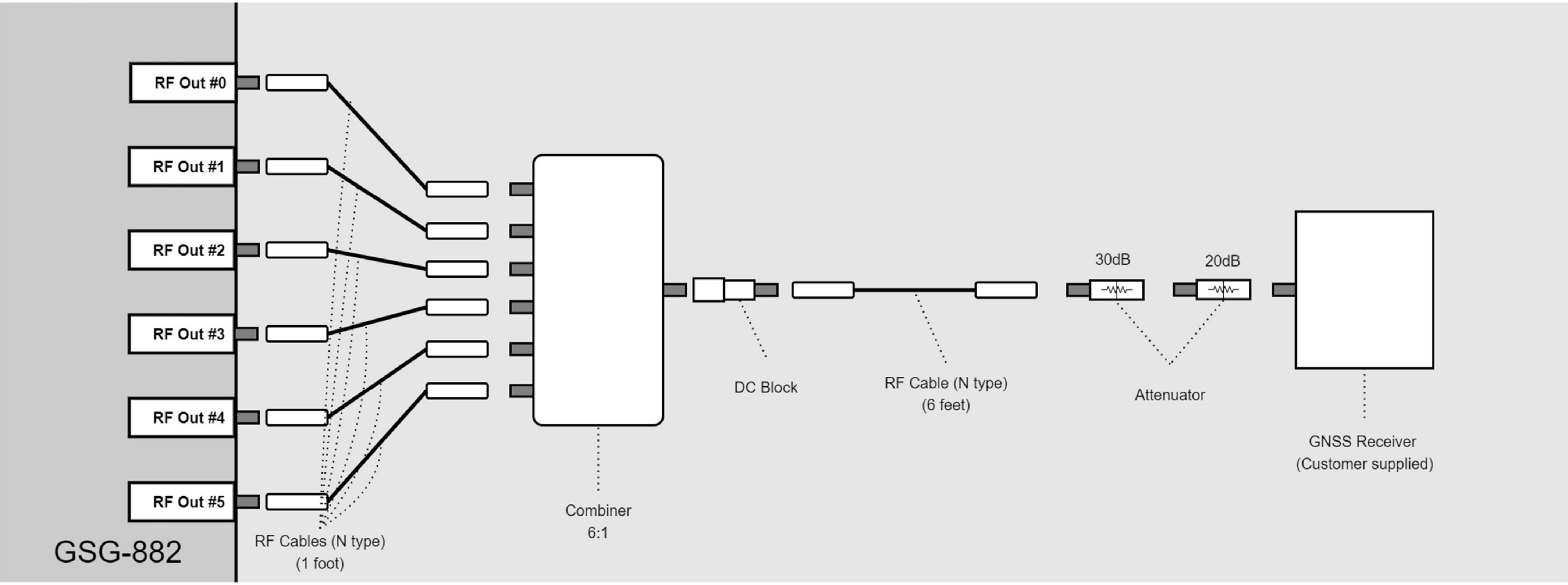
Connections

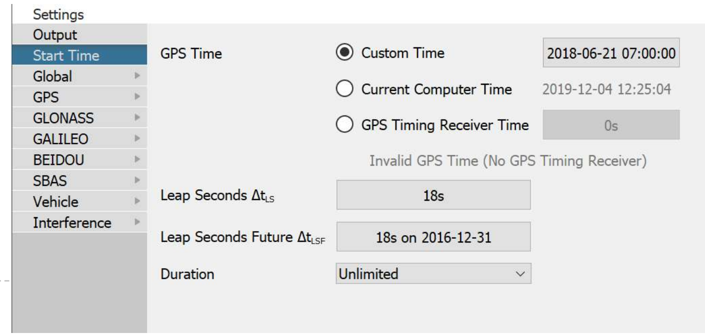


1.2

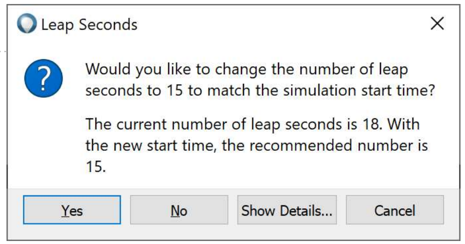
Start Time

Start Time Settings

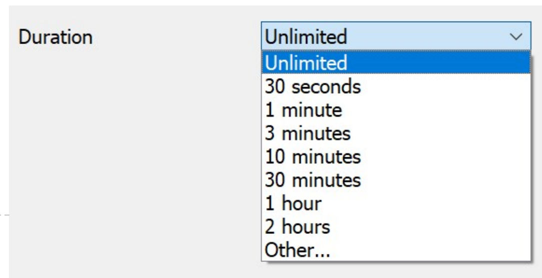
- **Custom Time**
- **Current Computer Time**
- **GPS Timing Receiver**
  - Requires external receiver
  - NMEA 4.1 Sentences RMC and GGA



- **Leap Second Settings**
  - set by date selected
  - Set custom values



- **Duration**
  - Set duration of scenario
  - "Unlimited" is currently ~20days



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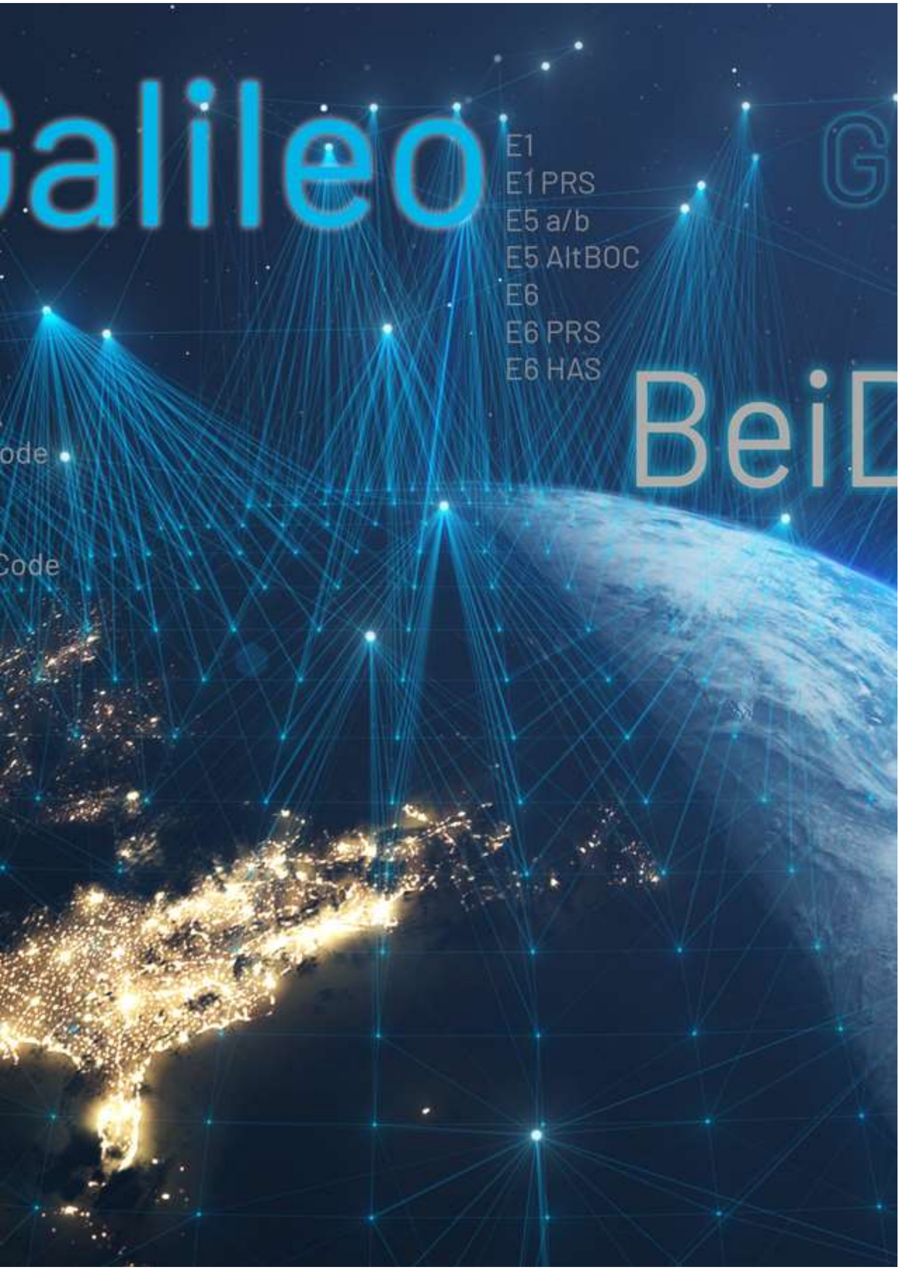

1.4

Constellation Parameters

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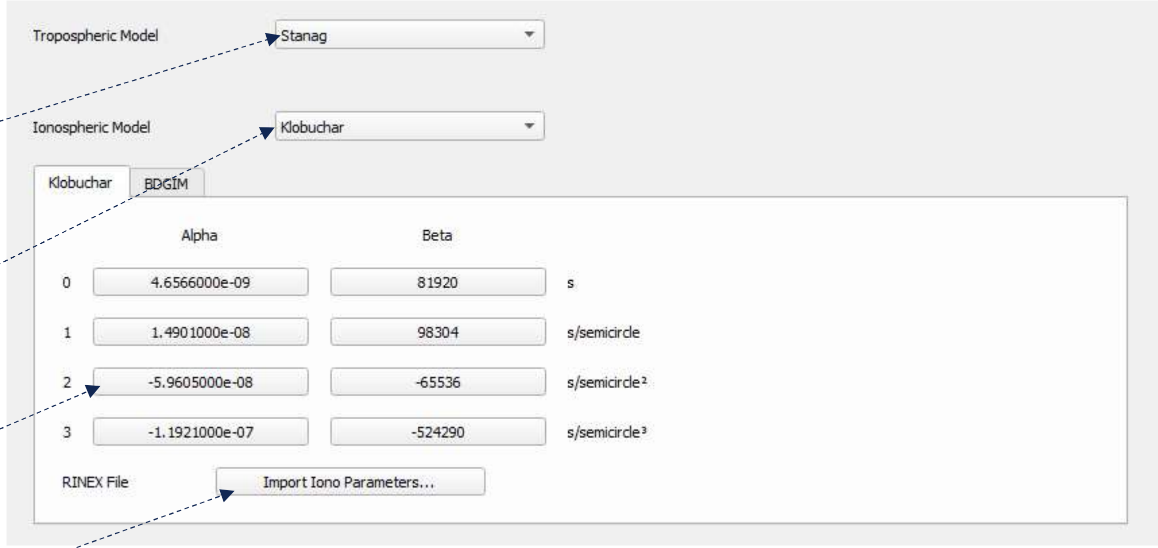
ATMOSPHERIC PARAMETERS

- TROPOSPHERIC PARAMETERS
  - Select simulated model 1
  - No parameters
- IONOSPHERIC PARAMETERS 2
  - Select simulated model
  - Define simulated and broadcasted Parameters 3
  - Can be imported from a RINEX File: 4
  - [CDDIS | | Data and Derived Products | GNSS | RINEX Version 3 (nasa.gov)]
- ADD IONO ERRORS 5



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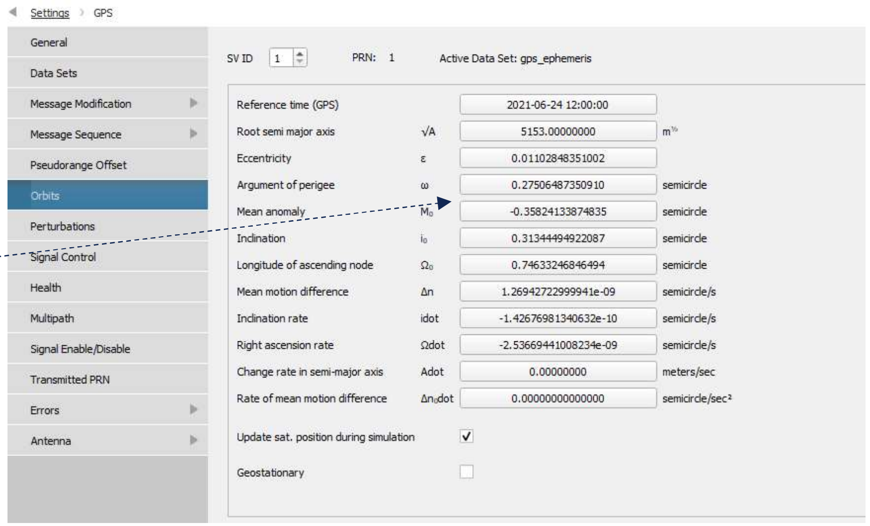
CONSTELLATION PARAMETERS

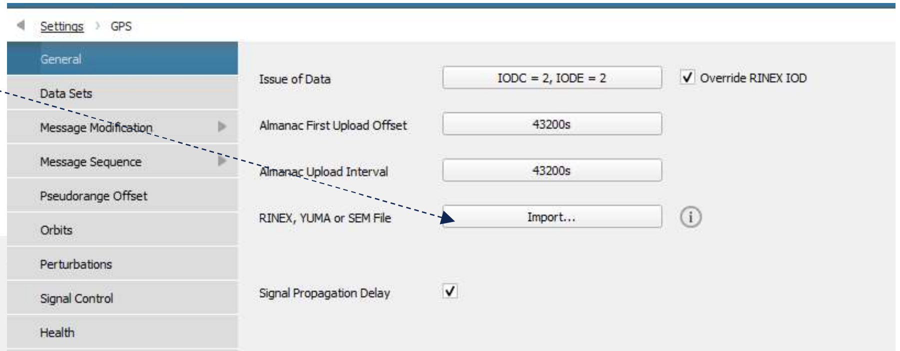
- SET KEPLERIAN PARAMETERS MANUALLY

1



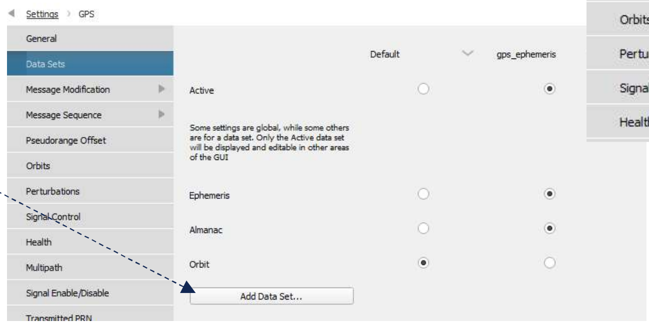
- LOAD RINEX FILE
- [CDDIS | | Data and Derived Products | GNSS | RINEX Version 3 (nasa.gov)]

2



- NEW DATASET FEATURE
- Apply different settings between:
  - Almanac
  - Ephemerides
  - Orbit

3



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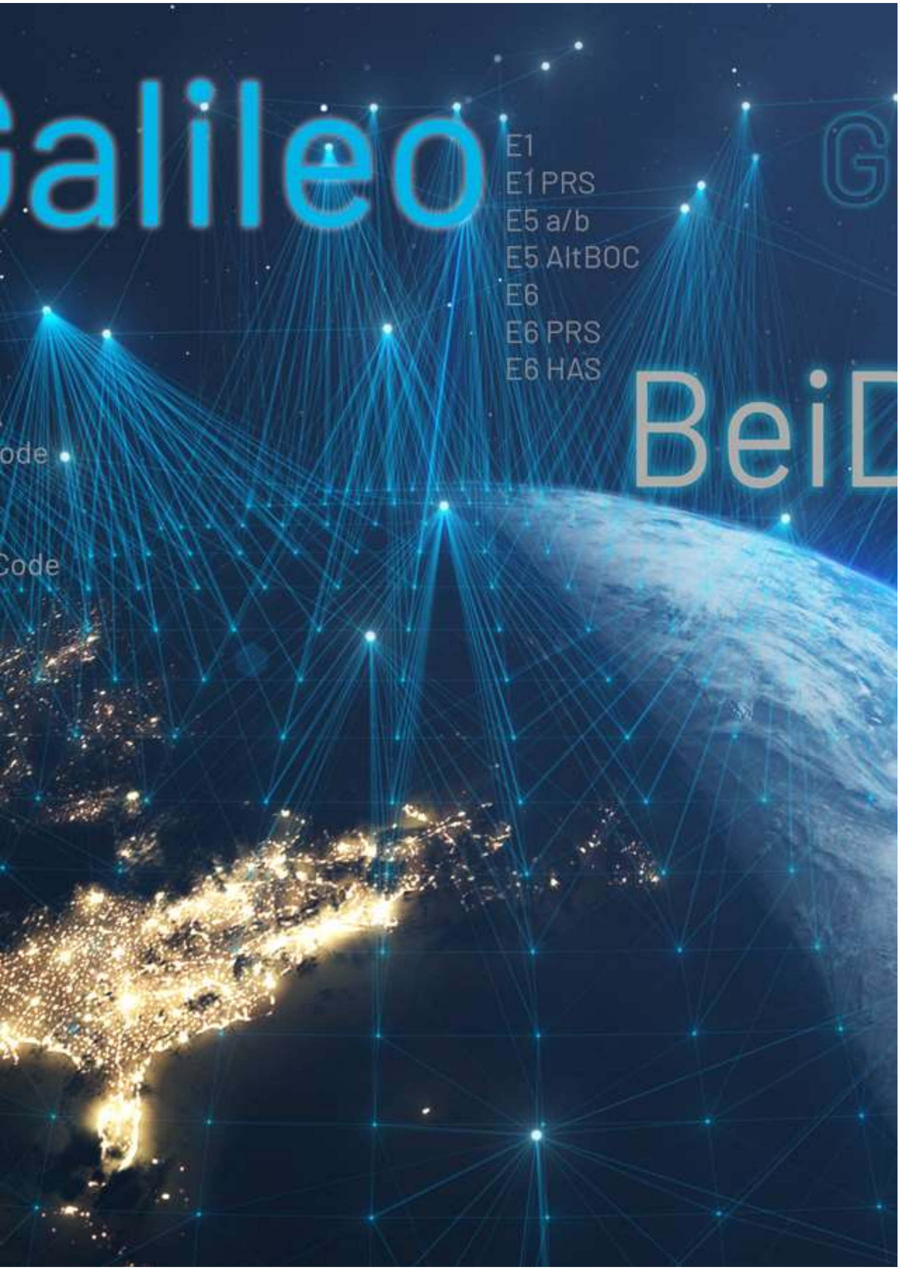


1.5

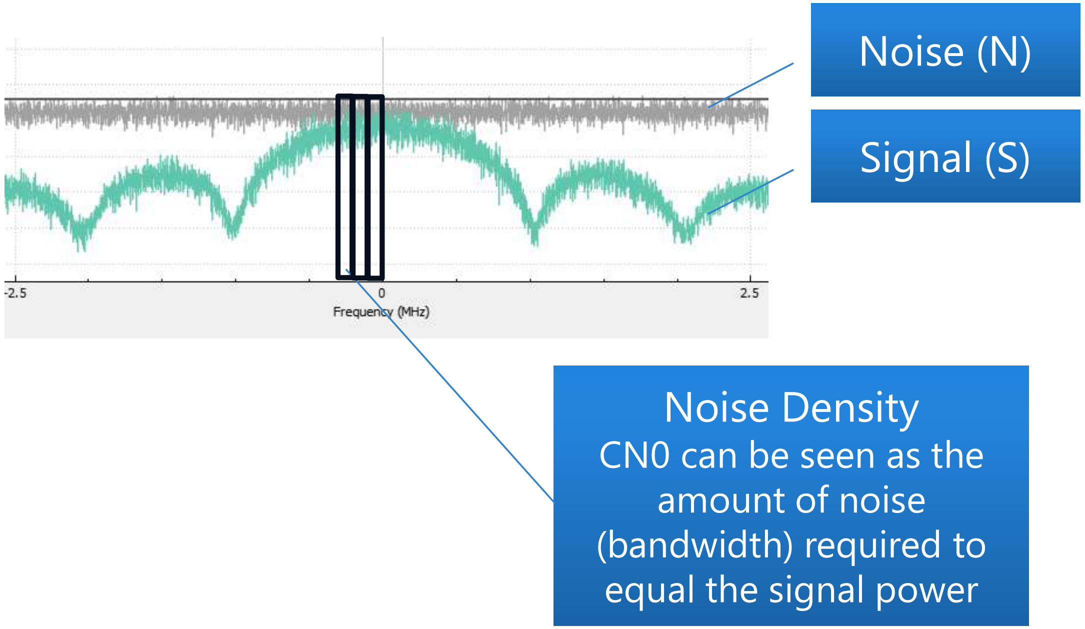
Gaussian Noise

SNR and CN0

SNR – Signal to Noise Ratio

SNR = S – N in dBW (or dBm)

- S is the Signal Power in dBW (or dBm)
- N is to Noise Power in dBW (or dBm)



CN0 – Carrier To Noise Density

SNR = S – N_0 in dBHz

- N_0 is the Noise power density in dBW/Hz (or dBm/Hz)

Example:

N0 = 10*log(k*T) ~= -174 dBm/Hz at 20 C (Thermal Noise)

S = -130 dBm (typical GNSS signal power receiver on earth)

Nominal $\textbf{CN0}_{\textbf{nominal}}$ = 44 dBHz (~25 kHz)

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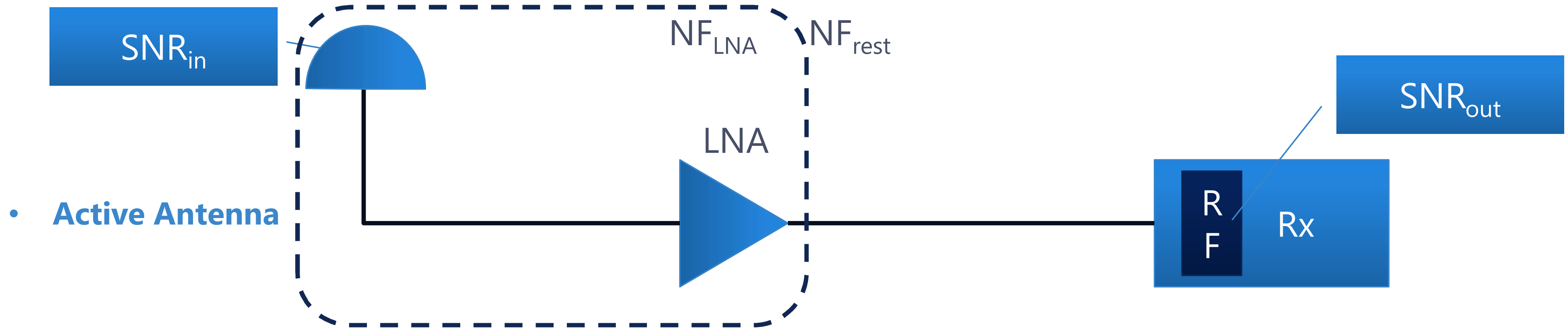
Noise Figure applied to a GNSS receiver – use case 1

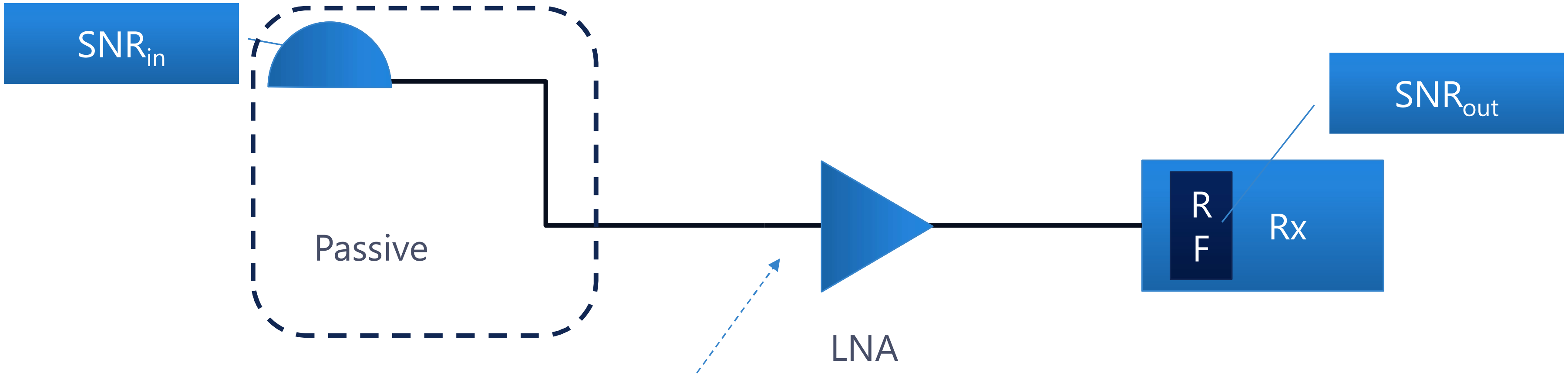


Gaussian noise recommended

Noise Figure applied to a GNSS receiver – use case 2

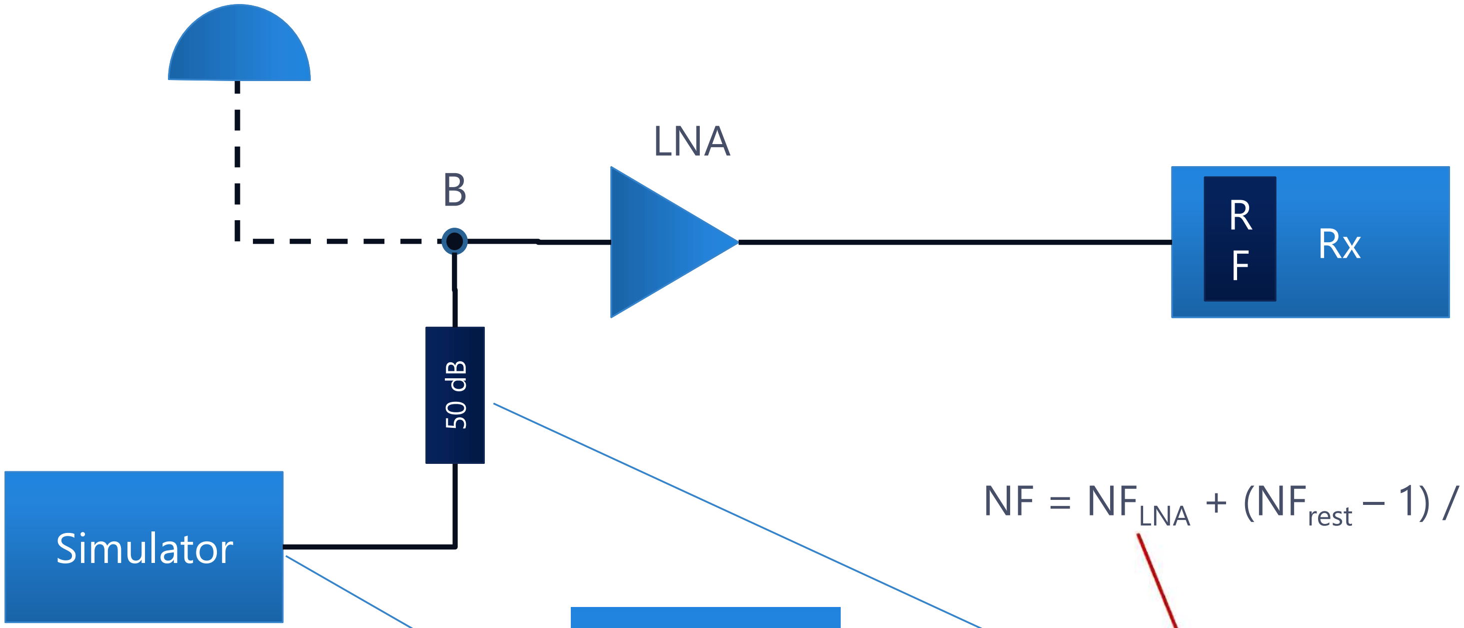
Case 2 – No LNA – all integrated (ex: Smartphones)

Noise Figure applied to a GNSS receiver – use case 3



If you want to simulate at this step, you need to calibrate your setup (can be complicated)

Standard simulator

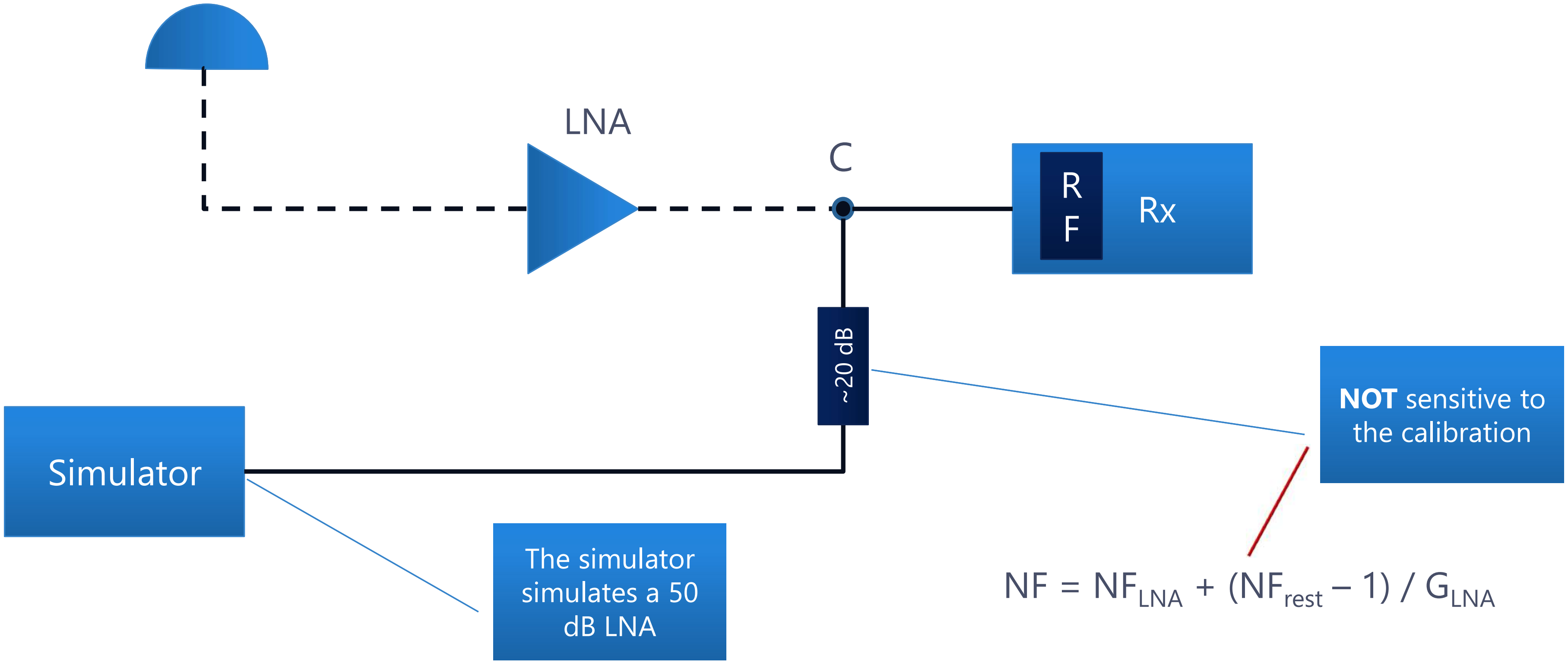


$$NF = NF_{LNA} + (NF_{rest} - 1) / G_{LNA}$$

Output of the simulator is 50 dB amplified

VERY sensitive to the calibration

Simulator with Gaussian Noise



$$NF = NF_{LNA} + (NF_{rest} - 1) / G_{LNA}$$

SETTING

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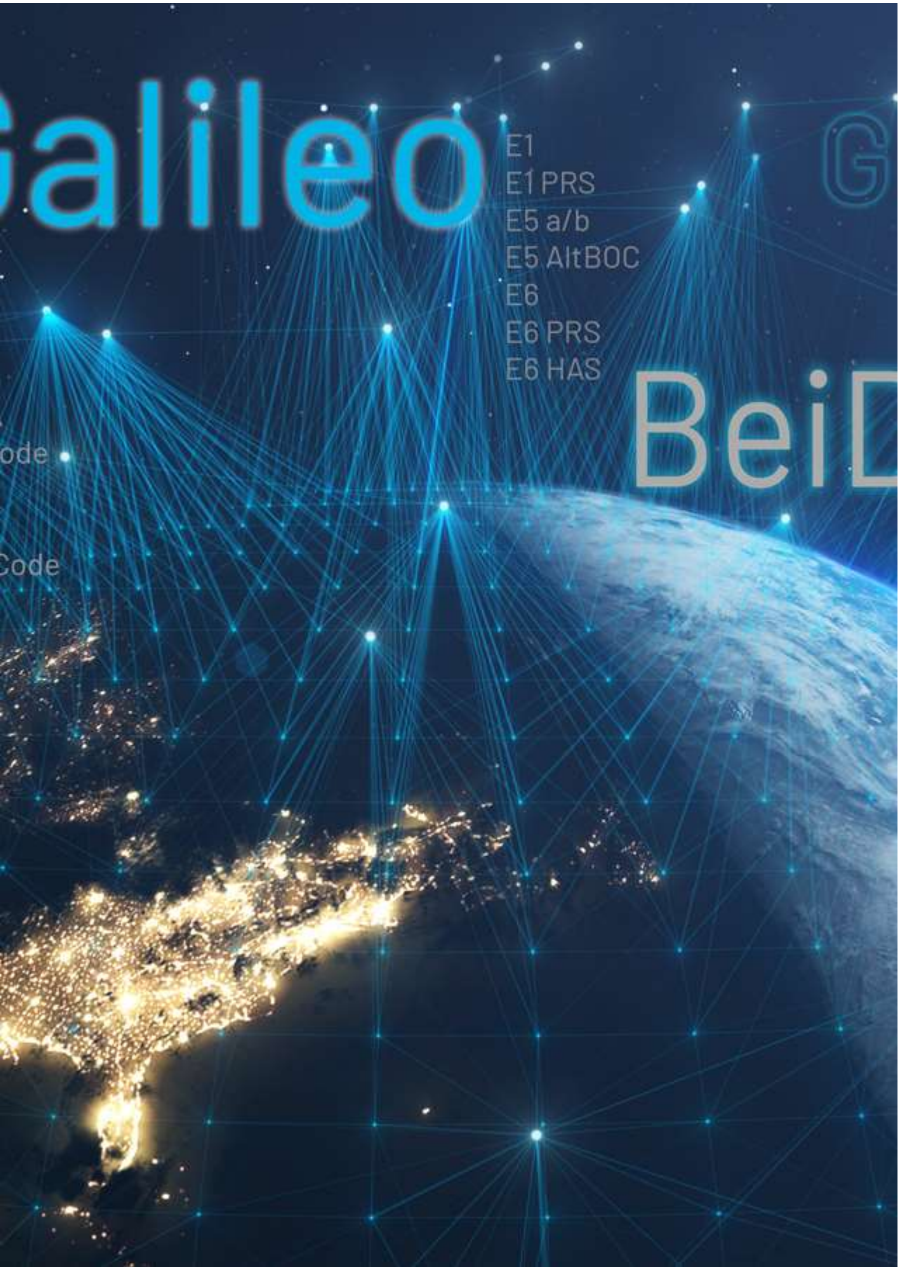
Conclusion

W/O Gaussian Noise	With Gaussian Noise
+ Test the real LNA used in the system - Requires fine calibration of the setup	+ No precise calibration required + No LNA required

The use of Gaussian Noise :

- Adds flexibility and simplifies use with different receivers and setups
- Allows you to use strong signals to compensate for long cables and splitters
- Mimics an active antenna, which is required by some receivers



1.3

Vehicle Trajectory

Trajectory Options

Fixed

- Enter Position Manually
- Select on Map

Circular

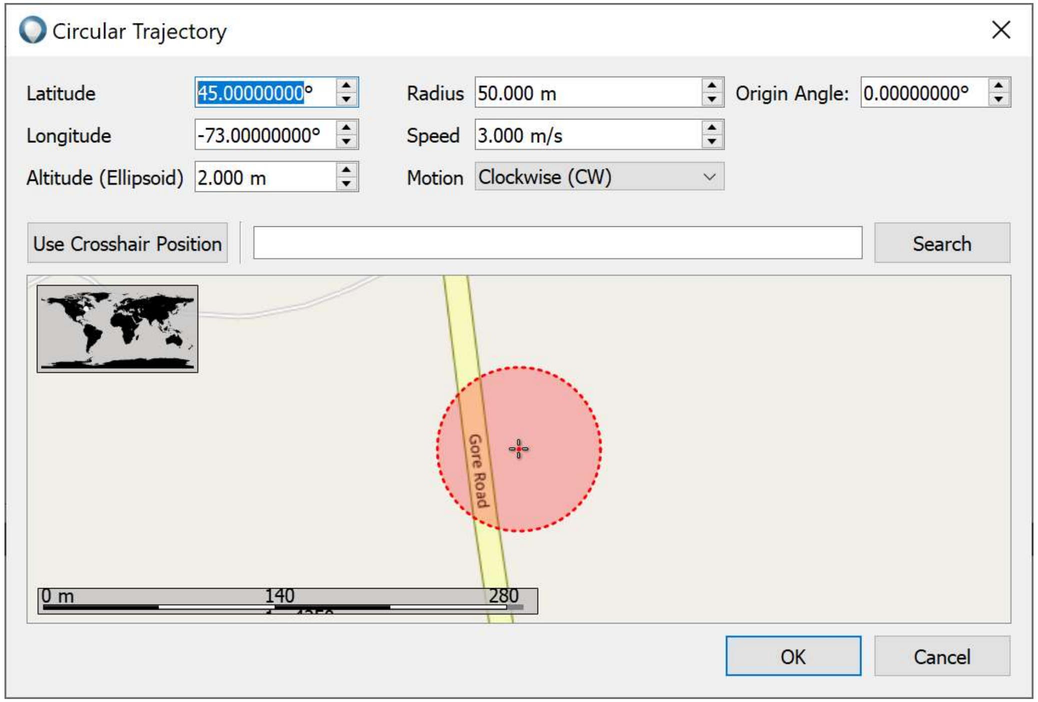
- Set Center Position
- Set Speed, Radius, and Direction
- Set Origin Angle

Track Playback

- Import NMEA *Currently not directly from StudioView
- Import CSV with timestamps

Vehicle Simulation

- Create new using Street Map
- Import KML
- Import CSV with speed limits



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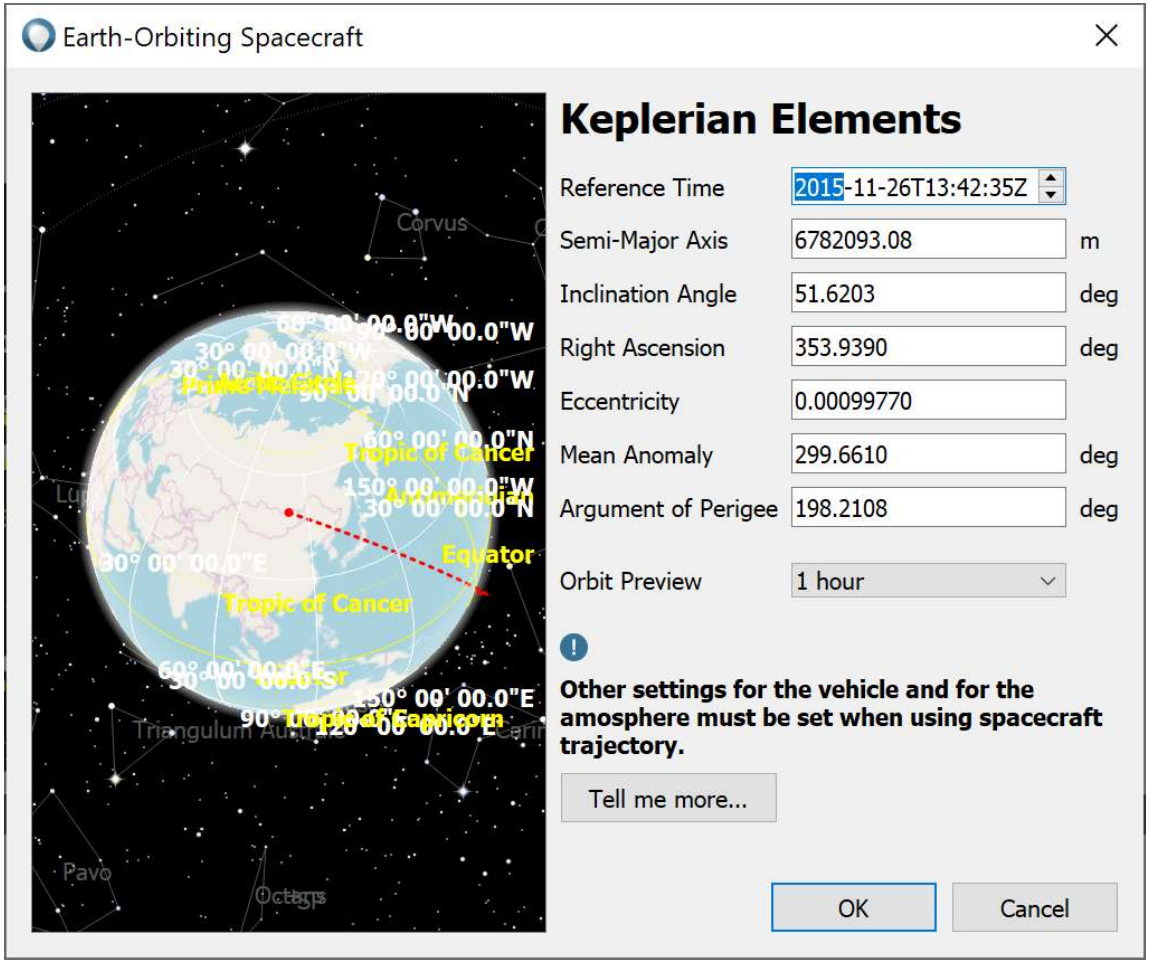
Trajectory Options

Hardware-in-the-loop

- Commands sent from remote client

Earth Orbiting Spacecraft

- Enter Reference Time
- Enter 6 Kepler orbit parameters
- Use the Tell me more... button to ensure other scenario parameters are set up correctly.



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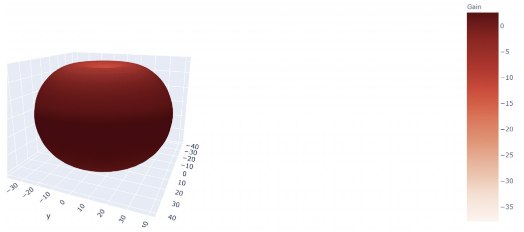
Vehicle Antenna

For all vehicle types, there is also the ability to modify the antenna

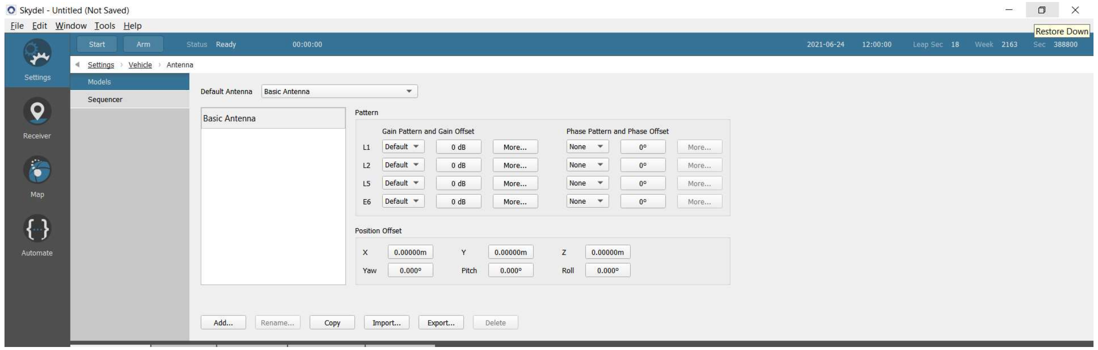
Skydel automatically populates this field with a basic GNSS antenna similar to below:

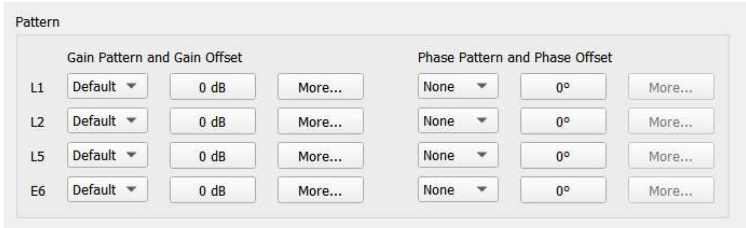


Fields can be modified as required

- Gain Pattern & Offset
- Phase Pattern & Offset
- Position Offset

Phase Pattern can be downloaded from ANTEX Files
Antenna Calibrations (noaa.gov)





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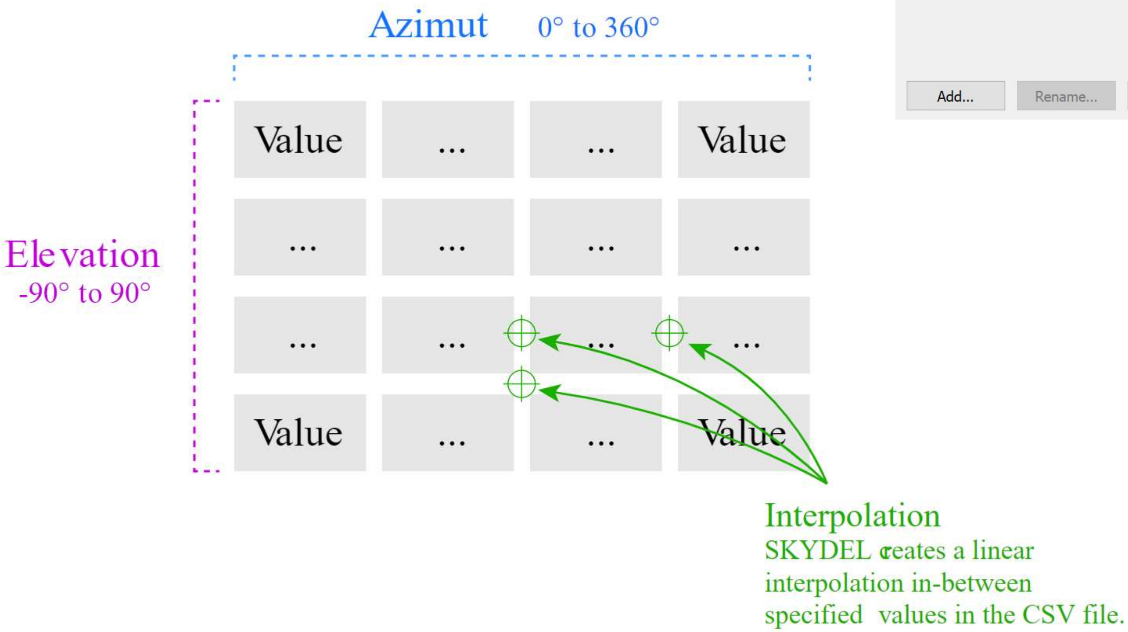
Vehicle Antenna Pattern

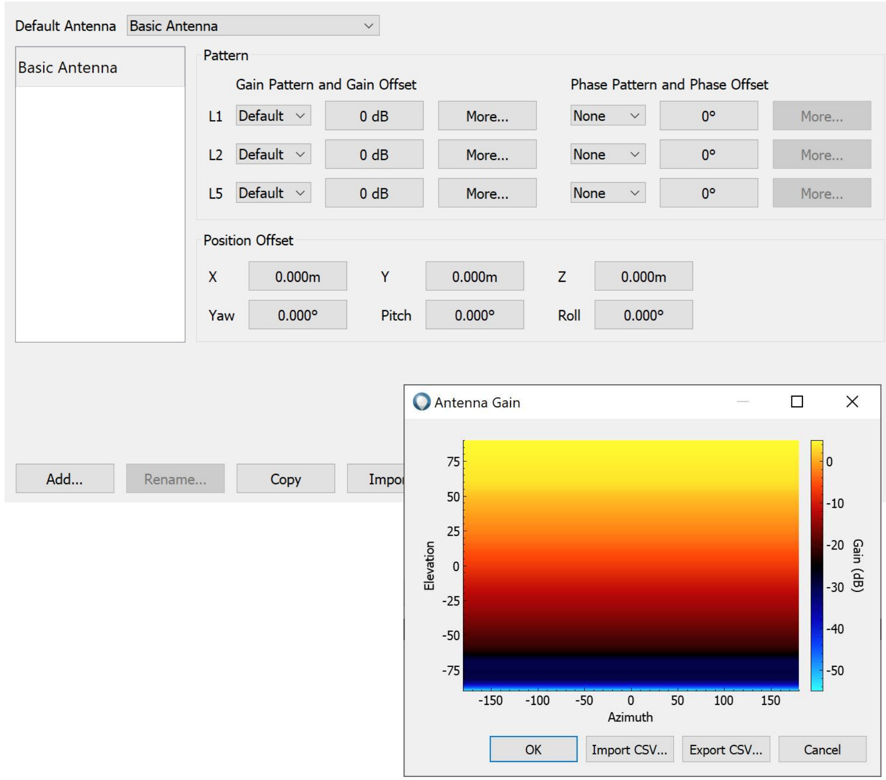
Gain/Phase Patterns and Offsets

- CSV file defines pattern
- Separate patterns possible per frequency band

Position Offset

- Lever Arm
- Orientation





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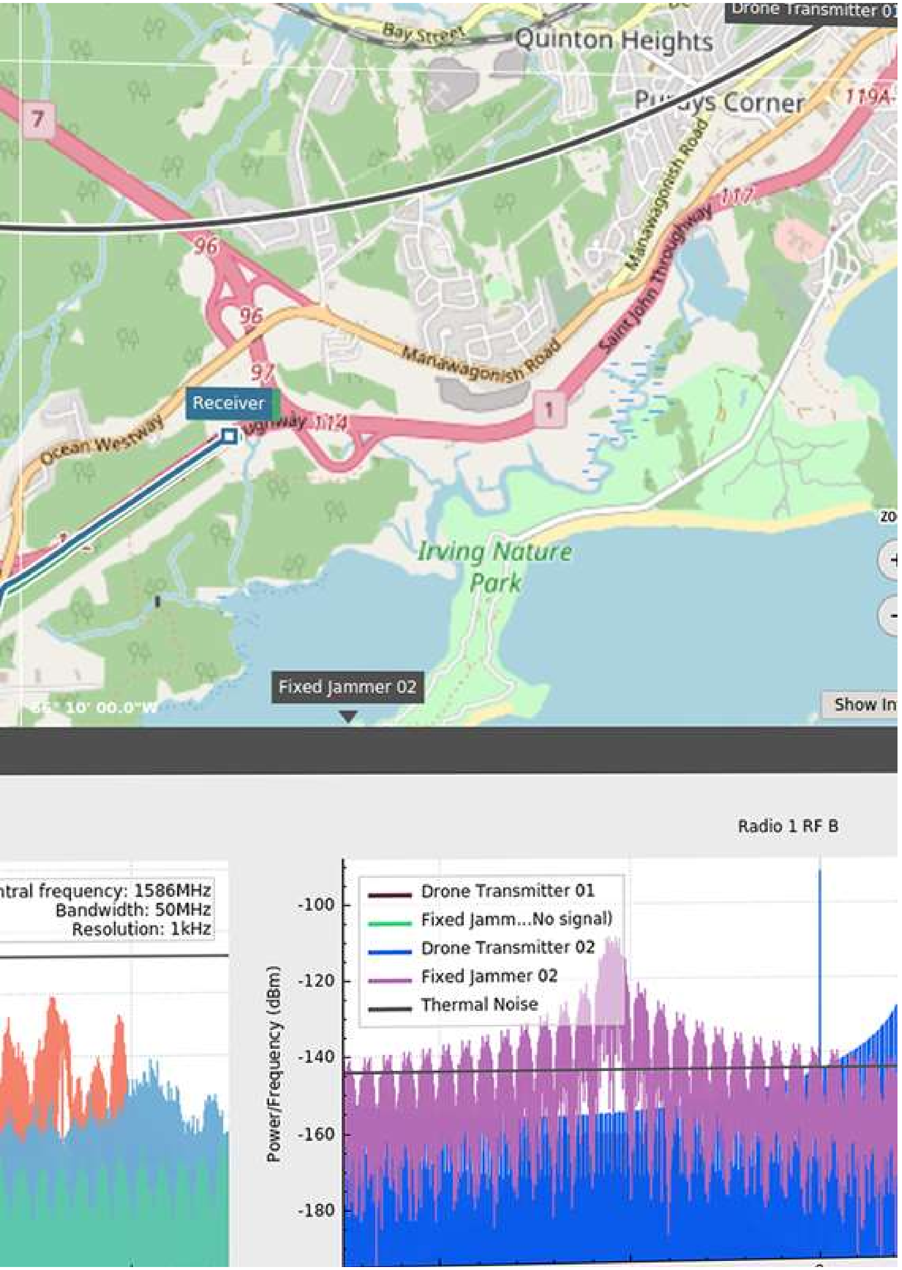


Advanced Jamming

Skydel Jamming & Spoofing

Simplified Jamming Source | Dynamic Jamming Source | Dynamic Spoofing

Basic Jamming

- Included in base license
- No position for the jammer
- Manual power level adjustments
- Jammer types: CW, Chirp

Advanced Jamming

- Optional feature
- Introduces transmitters
- Transmitter features:
  - Multiple dynamic transmitters
  - Transmit antenna patterns
- Propagation loss calculated automatically
- Jammer types: CW, Chirp, Pulse, BPSK, BOC, AWGN, IQ FILE

Advanced Spoofing

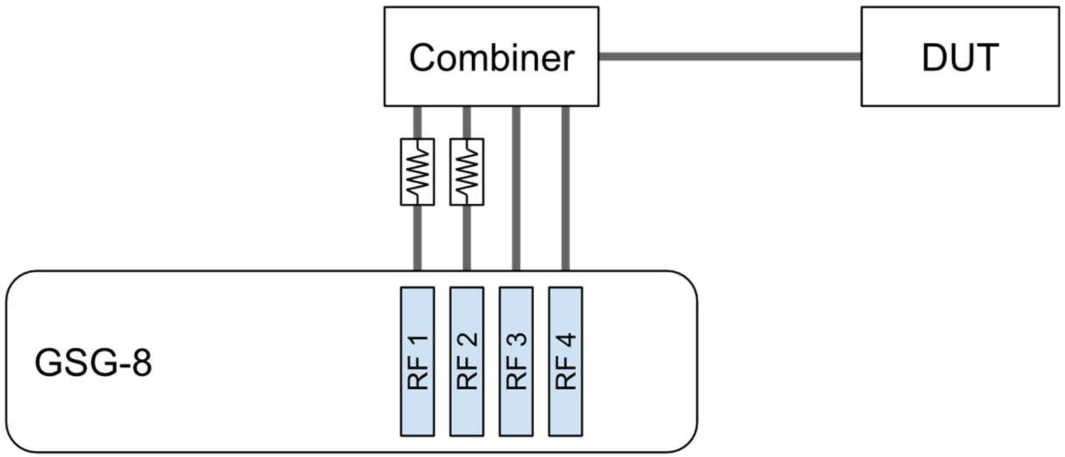
- Optional feature
- Uses transmitters enabled by Advanced Jamming feature
- License required per spoofer
- Automatic signal dynamics calculation
- Full control of all aspects of spoofer constellation
- Supports repeaters and custom spoofers

How Skydel unique?

- *No external devices required*
- *Does not require additional software*
- *See the results of the injected signal in same screen through receiver feedback*

Advanced Jamming

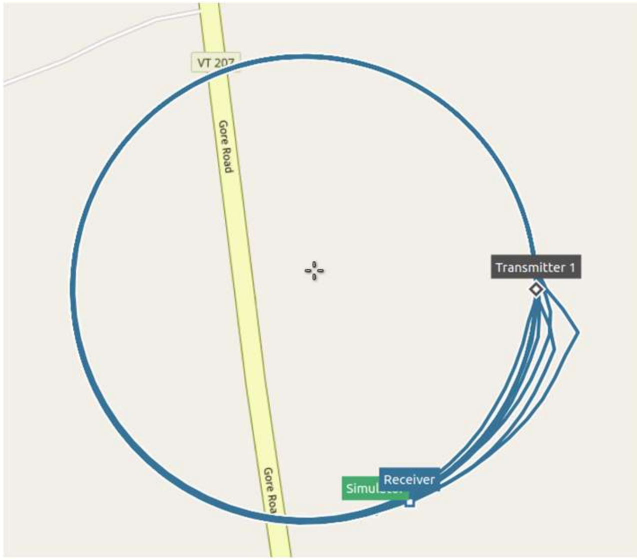
- Application note : https://safran-navigation-timing.com/document/skydel-gsg-8-advanced-jamming/
- Each RF output can do GNSS or Jammers
- J/S window can be adjusted with external attenuators



Jamming simulation

- Conventional Approach (simplified jammer)
  - Choose a basic jammer waveform (CW, AWGN, Chirp, etc.)
  - Fix the jammer to signal ratio (J/S)

- Advanced Approach (advanced jammer)
  - Build complex waveforms (combine multiple basic waveforms)
  - Jammer is fixed or mobile
  - All the signal dynamics are simulated
  - Use multiple jammers (5, 10, 100, etc.)



Most jamming test scenarios were defined with test solutions available at the time -> simple test cases.

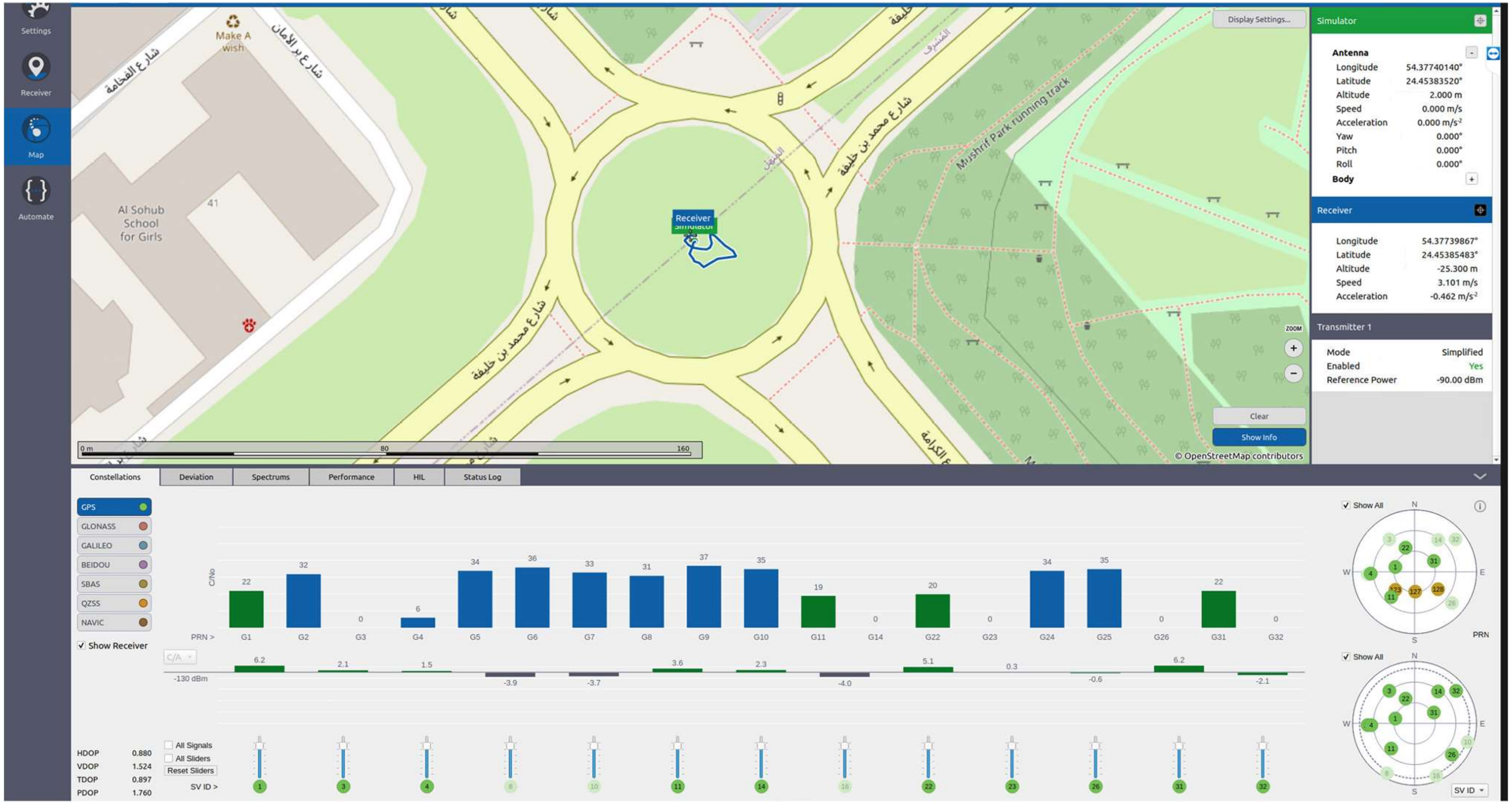
With recent availability of better jamming simulation software, test are evolving into more complex scenarios. Simplified jammer are easier to prepare, control and compare, but does it provide realistic data?

WORKSHOP 1 : TESTING THE LIMITS

Objective: Find the Jammer to Signal ratio that would make an ublox receiver lose tracking of L1CA
Steps:

- Add a GNSS output with L1CA
- Add an interference output at the same central frequency
- Add a simplified jammer and disable it
- Add a 1MHz AWGN & Chirp signals to it, centered on L1CA frequency
- Start the simulation and let the receiver lock on the GNSS signal
- Enable the jammer and gradually raise its power until the receiver lose track

WORKSHOP 1 : TESTING THE LIMITS



WORKSHOP 2: DYNAMIC JAMMING

Objective: Jam a receiver when it goes near a transmitter
Steps:

- Add a GNSS output with L1CA and an Interference output with the same frequency
- Set the vehicle to a circle trajectory with 150m radius and a speed of 10m/s
- Add a disabled dynamic transmitter with the same trajectory but a speed of 0m/s
  Note: this is a trick to make the transmitter at a fixed position on the vehicle's trajectory

- Add an AWGN signal to the transmitter at L1CA frequency. It needs to be stronger than in the previous example due to propagation loss
- Start the simulation and wait until the receiver locks on the signal
- Once there is a lock, enable the transmitter

- Other Step : Create a static location for your vehicule (ex base Station) and create a Dynamic Jammer with a circular trajectory approaching the receiver. Let enabled the transmitter and see the variations of the effect on the Receiver status.

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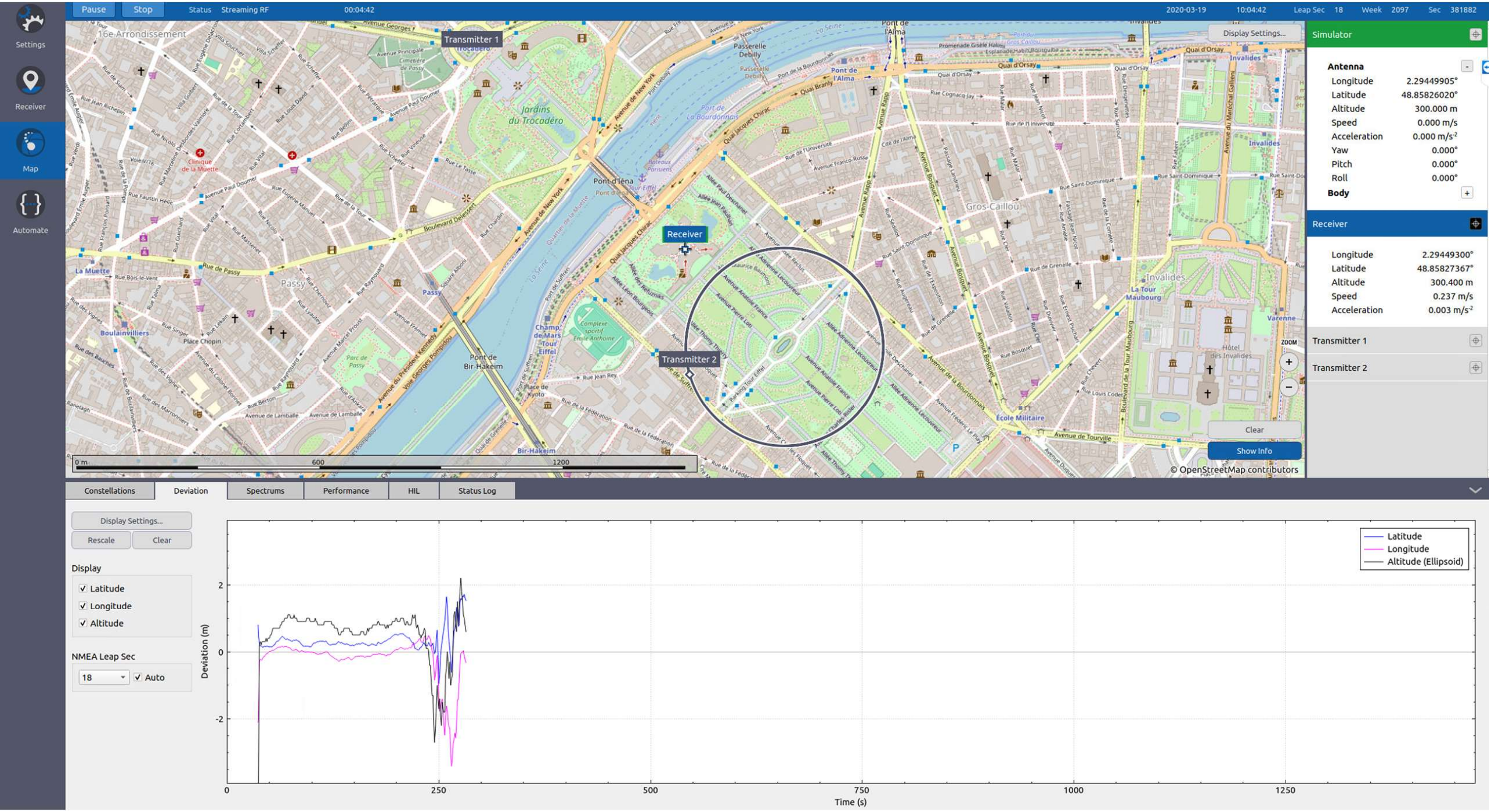
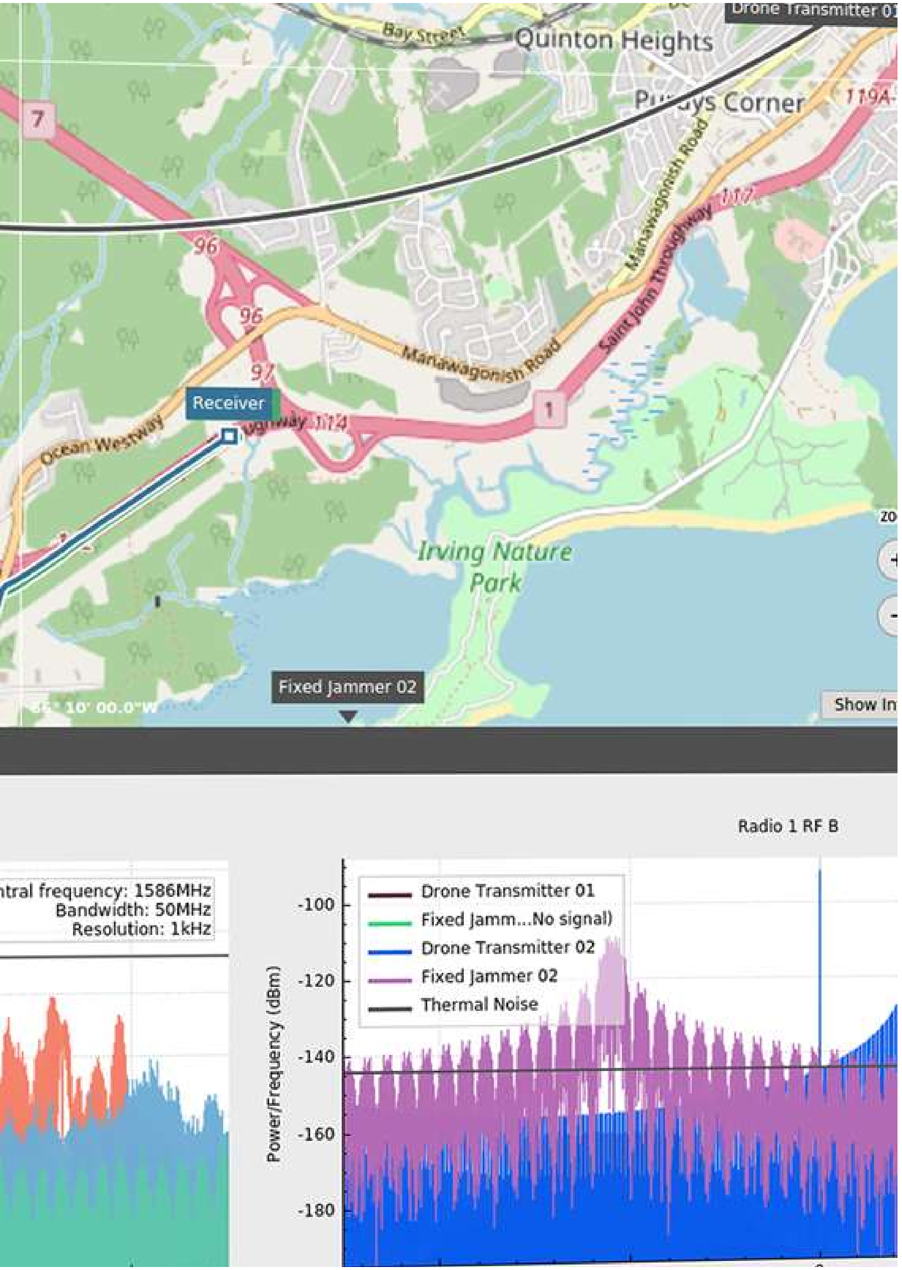

Settings
Receiver
Map
Automate
Pause
Stop
Status
Streaming RF
00:04:42
2020-03-19
10:04:42
Leap Sec
18
Week
2097
Sec
381882
Transmitter 1
Receiver
Transmitter 2
Display Settings...
Clear
Show Info
© OpenStreetMap contributors
0 m
600
1200
Simulator
Antenna
Longitude
2.29449905°
Latitude
48.85826020°
Altitude
300.000 m
Speed
0.000 m/s
Acceleration
0.000 m/s²
Yaw
0.000°
Pitch
0.000°
Roll
0.000°
Body
Receiver
Longitude
2.29449300°
Latitude
48.85827367°
Altitude
300.400 m
Speed
0.237 m/s
Acceleration
0.003 m/s²
Transmitter 1
Transmitter 2
Constellations
Deviation
Spectrums
Performance
HIL
Status Log
Display Settings...
Rescale
Clear
Display
Latitude
Longitude
Altitude
NMEA Leap Sec
18
Auto
Latitude
Longitude
Altitude (Ellipsoid)
Deviation (m)
Time (s)
0
250
500
750
1000
1250
2
0
-2



Advanced Spoofing

SPOOFING

Application note : https://safran-navigation-timing.com/document/skydel-gsg-8-advanced-spoofing/

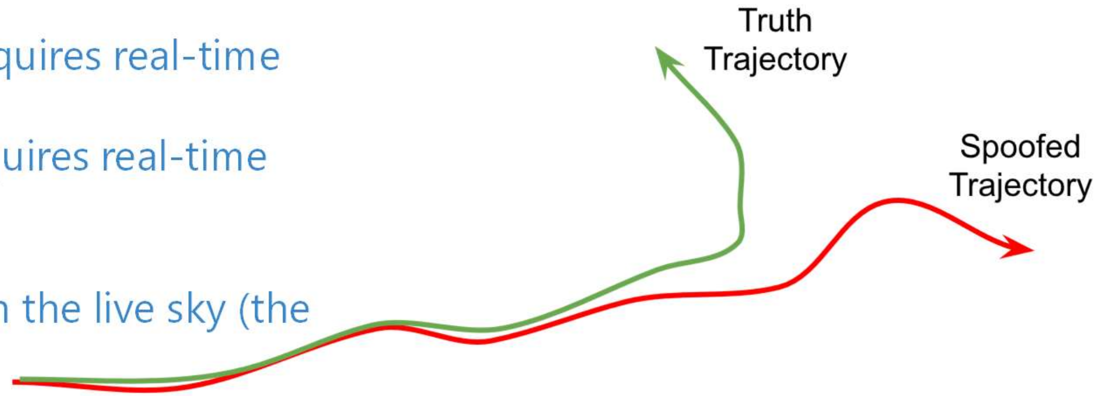
GNSS Spoofing is a fake GNSS signal which makes the receiver believe it is at a false location, or false time, or both.

For example, you can disrupt the real signal with a stronger signal and the receiver will track the spoofer.

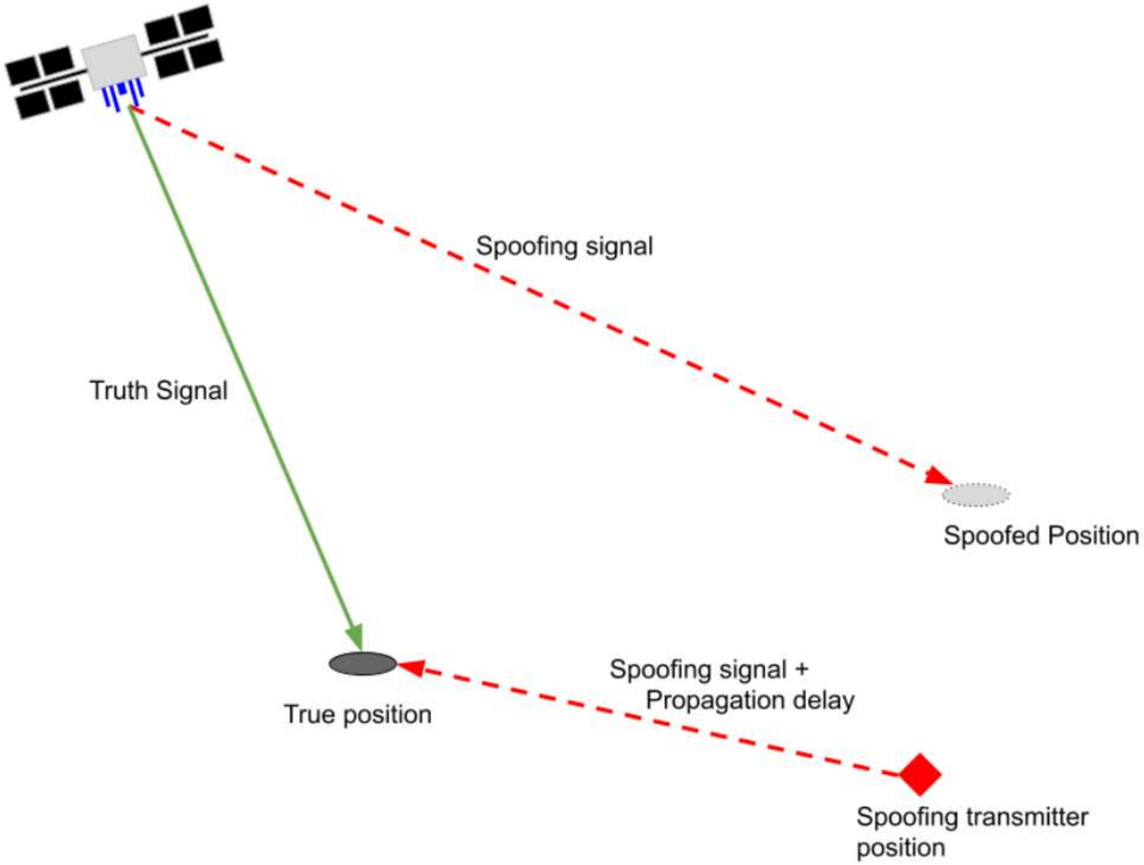
Ideal spoofing is undetectable. The receiver lock on the spoofed signal with minimal, or no detectable disruption on position, time, etc.

- Spoofer must simulate the target position -> requires real-time tracking of the target
- Spoofer must simulate the real-condition -> requires real-time decoding of the real GNSS signals

Luckily, in a test environment, we can simulate both the live sky (the truth signal) and the spoofer.



SKYDEL SPOOFING SCENARIO

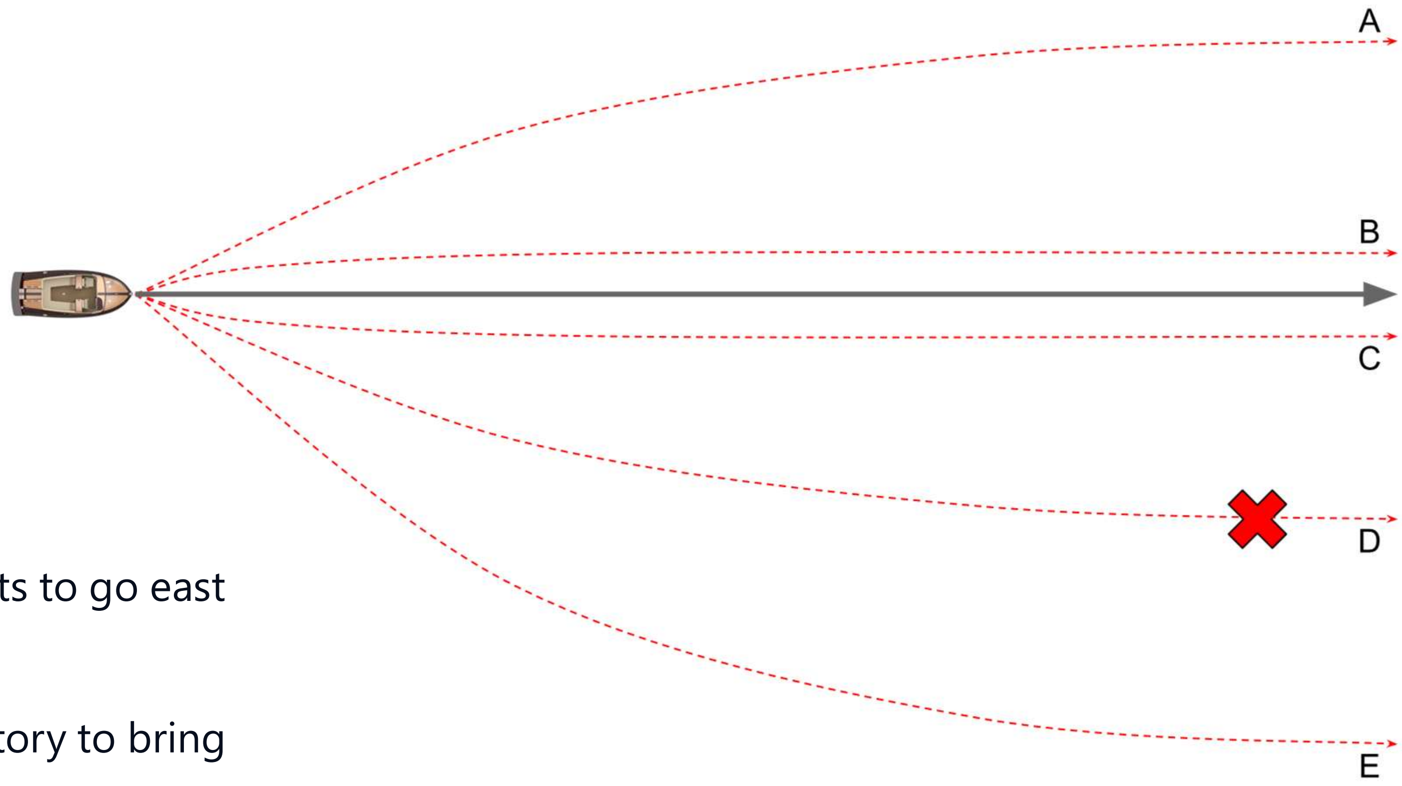


- A **receiver** receives a **truth signal**, from which it determines its **true position**.
- The **receiver** will also receive a **spoofing signal** from a device located at a **spoofing transmitter position**.
- The **spoofing signal** is a GNSS signal as perceived by a receiver located in a **spoofed position**.

To achieve advanced spoofing in Skydel, we start two instances:

- The **truth instance**, that will manage the **truth signal**, the **true position** and the **spoofing transmitter position**.
- The **spoofing instance**, that will manage the **spoofing signal** and the **spoofed position**.

SKYDEL SPOOFING SCENARIO

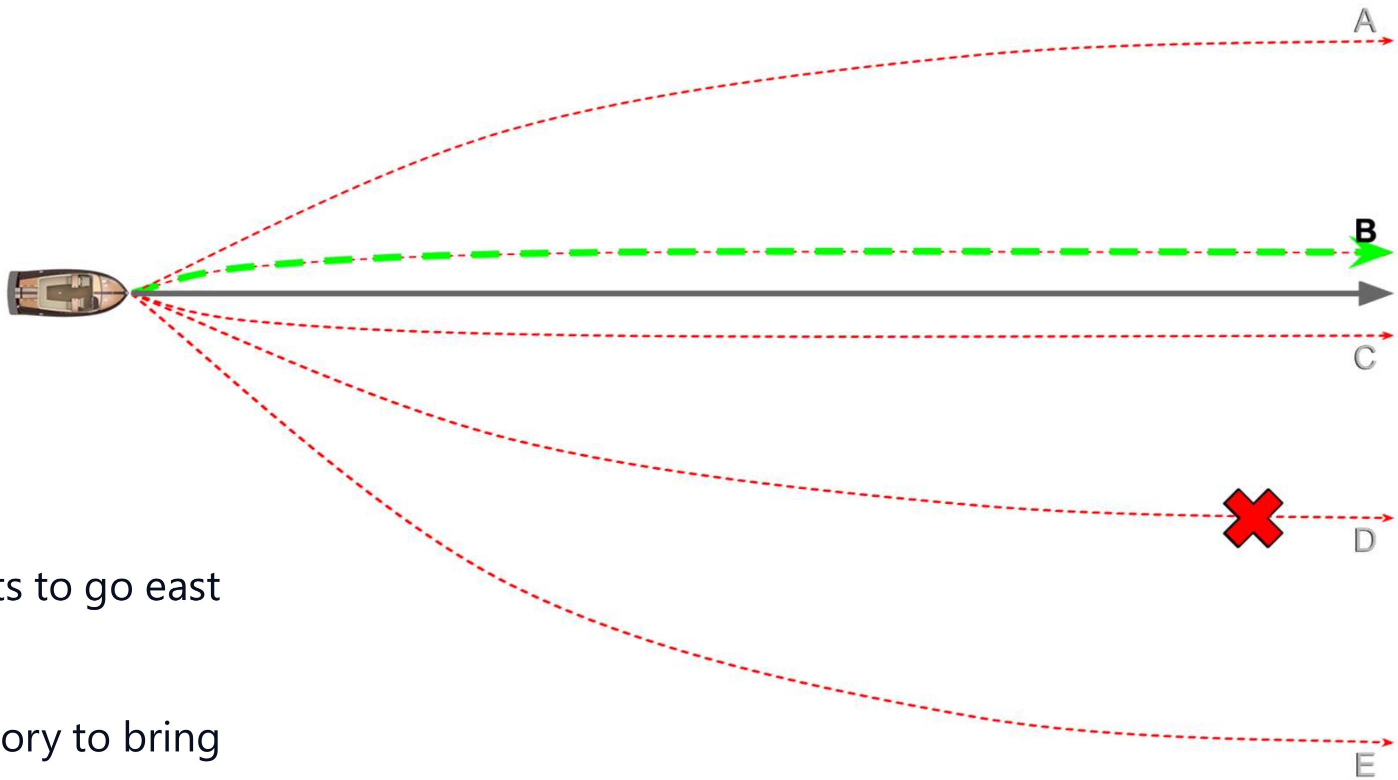


Imagine you know the captain wants to go east (the black arrow).

What should be the spoofed trajectory to bring the boat to the red cross?

A, B, C, D or E ?

SKYDEL SPOOFING SCENARIO



Imagine you know the captain wants to go east (the black arrow).

What should be the spoofed trajectory to bring the boat to the red cross?

The answer is **B**

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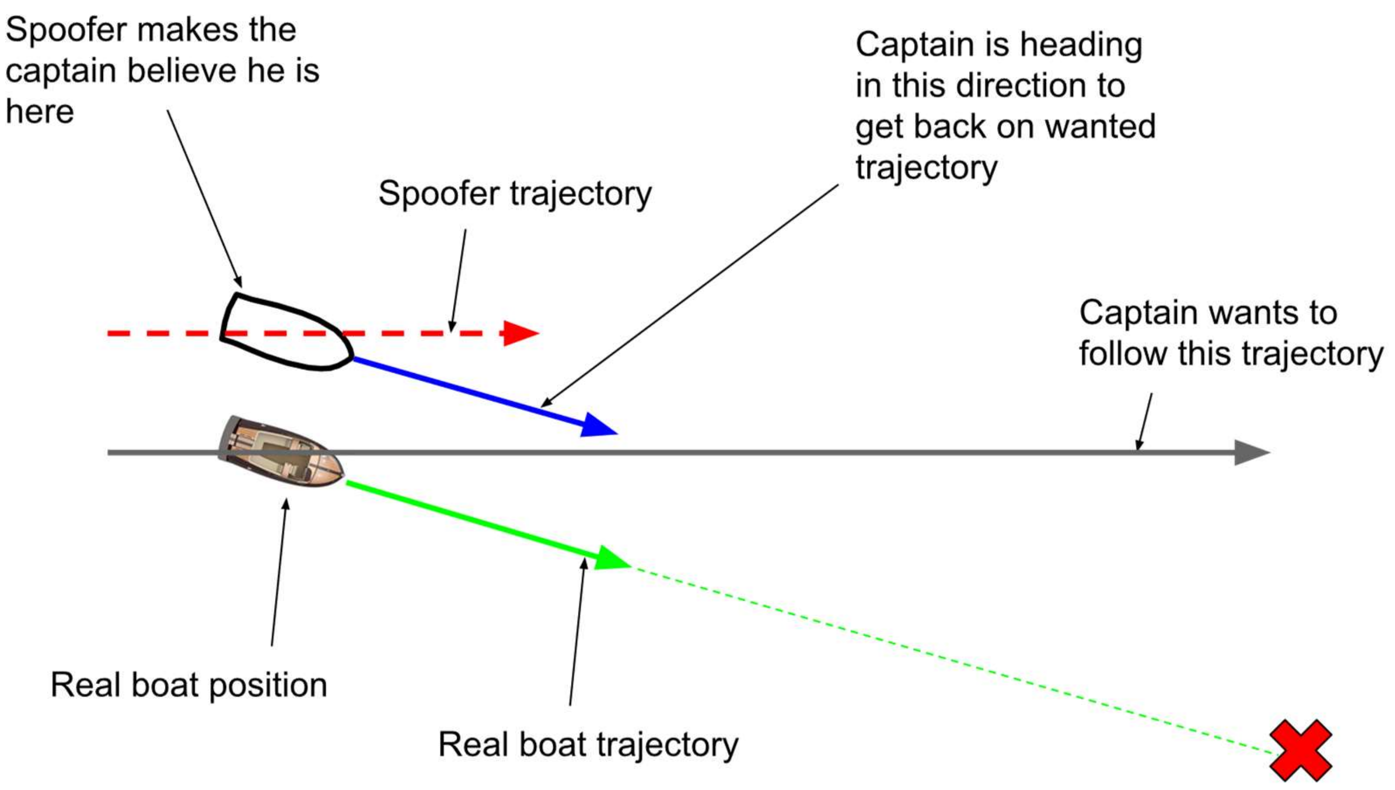
SKYDEL SPOOFING SCENARIO

Captain probably thinks he is fighting against wind, or current…



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WORKSHOP 1: POWER SPOOFING

Objective: Spoof a receiver with a more powerful spoofing signal
Steps:

- On the spoofer instance, add an output with L1CA
- Set the spoofed trajectory to circular
- On the main instance, add a GNSS output with L1CA and an interference output on the same band
- Add a spoofer close to the vehicle, set its power high enough to be ~5-10dB above the GNSS power level
  Note: You can see on the map page the spoofer's effective power
- Start the simulation

You can play around by disabling and re-enabling the spoofer

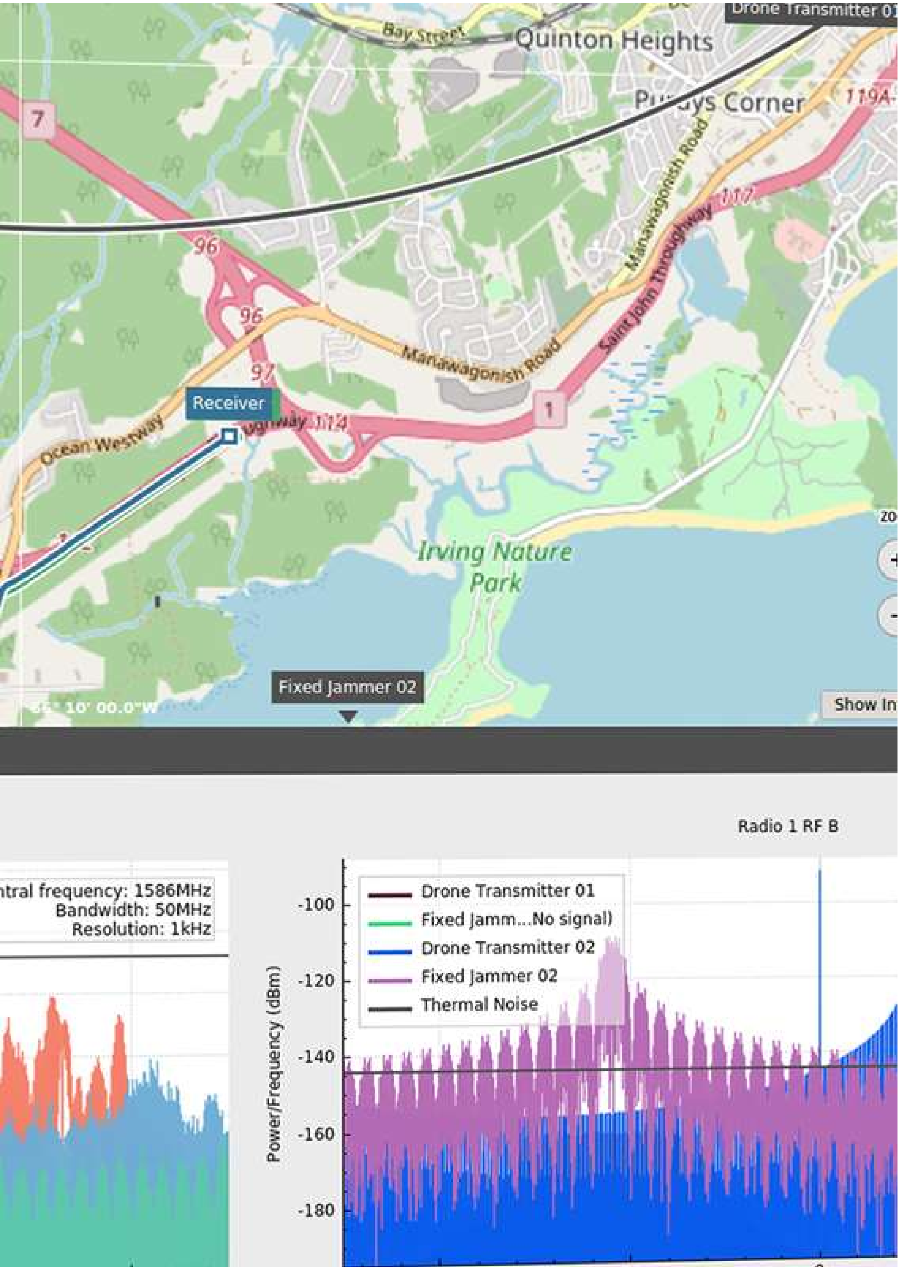
WORKSHOP 2: “Trajectory” SPOOFING

Objective: Spoof a receiver using pseudo range ramps
Steps:

- On the spoofer instance, add an output with L1CA
- Import NMEA file “spoofing_trajectory.txt” as the spoofing trajectory

- On the main instance, add a GNSS output with L1CA and an Interference output on the same band
- Import NMEA file “vehicle_trajectory.txt” as the vehicle trajectory

- Add a disabled spoofer, set it to ignore propagation loss and antenna pattern
- Start the simulation
- After 1 minute, enable the spoofer



NMEA output/Automation/ Inertial data

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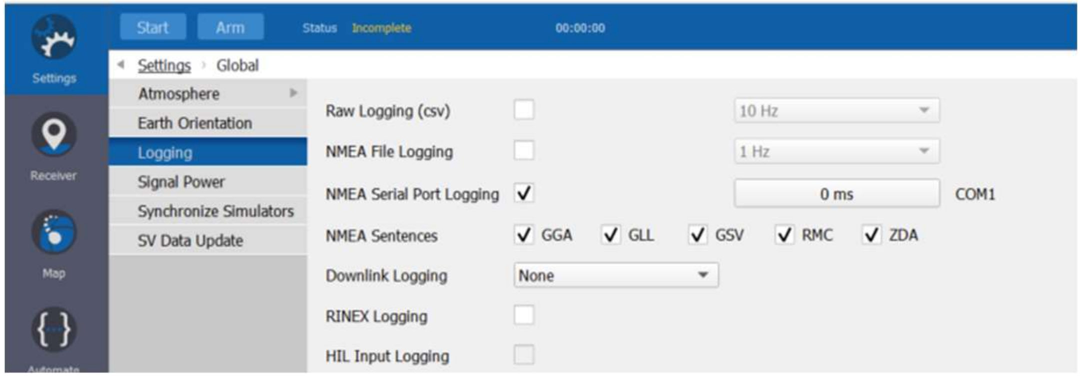
NMEA serial port output

NMEA serial port output

Configure your serial port
- Baud rate, data bits, parity, Stop bits, Flow Control

Enable NMEA Serial Port Logging
- Possibility to introduce a timing offset

Select the NMEA message type
- GGA,ZDA ,RMC,GLL,GSV



SKYDEL uses GPS time (not UTC) in its NMEA output. Also, the altitude in the GGA sentence is based on the ellipsoid model, not the mean sea level.

By selecting low baud rate, the NMEA sentences could exceeded the bandwidth of the serial port, which might result in other truncated broadcast in the future. To resolve the issue, you can increase the serial port baudrate.

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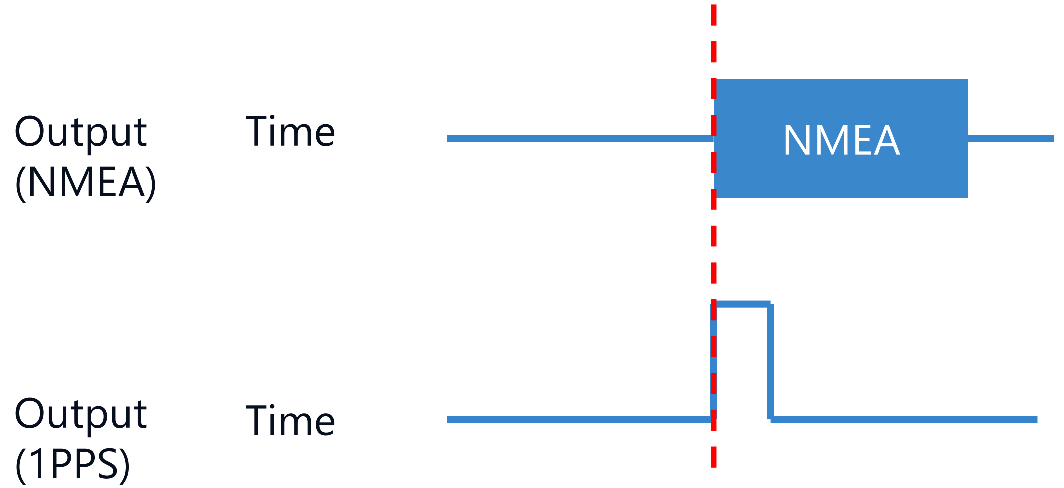
NMEA serial port output

Timing diagram – timing offset = 0ms (minimum)



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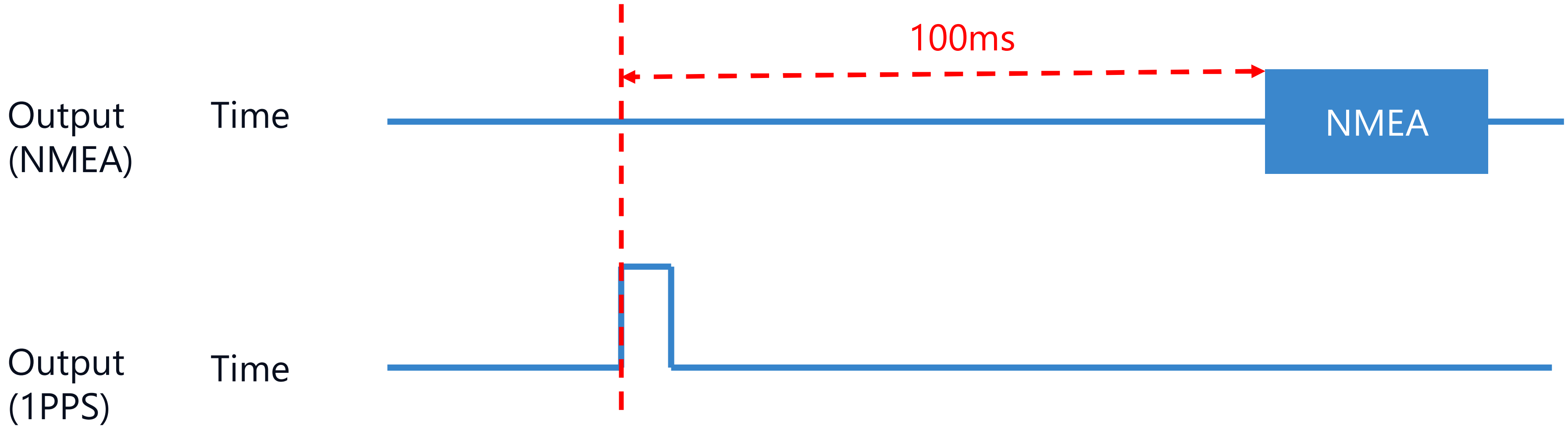
NMEA serial port output

Timing diagram – timing offset = 100ms (maximum)



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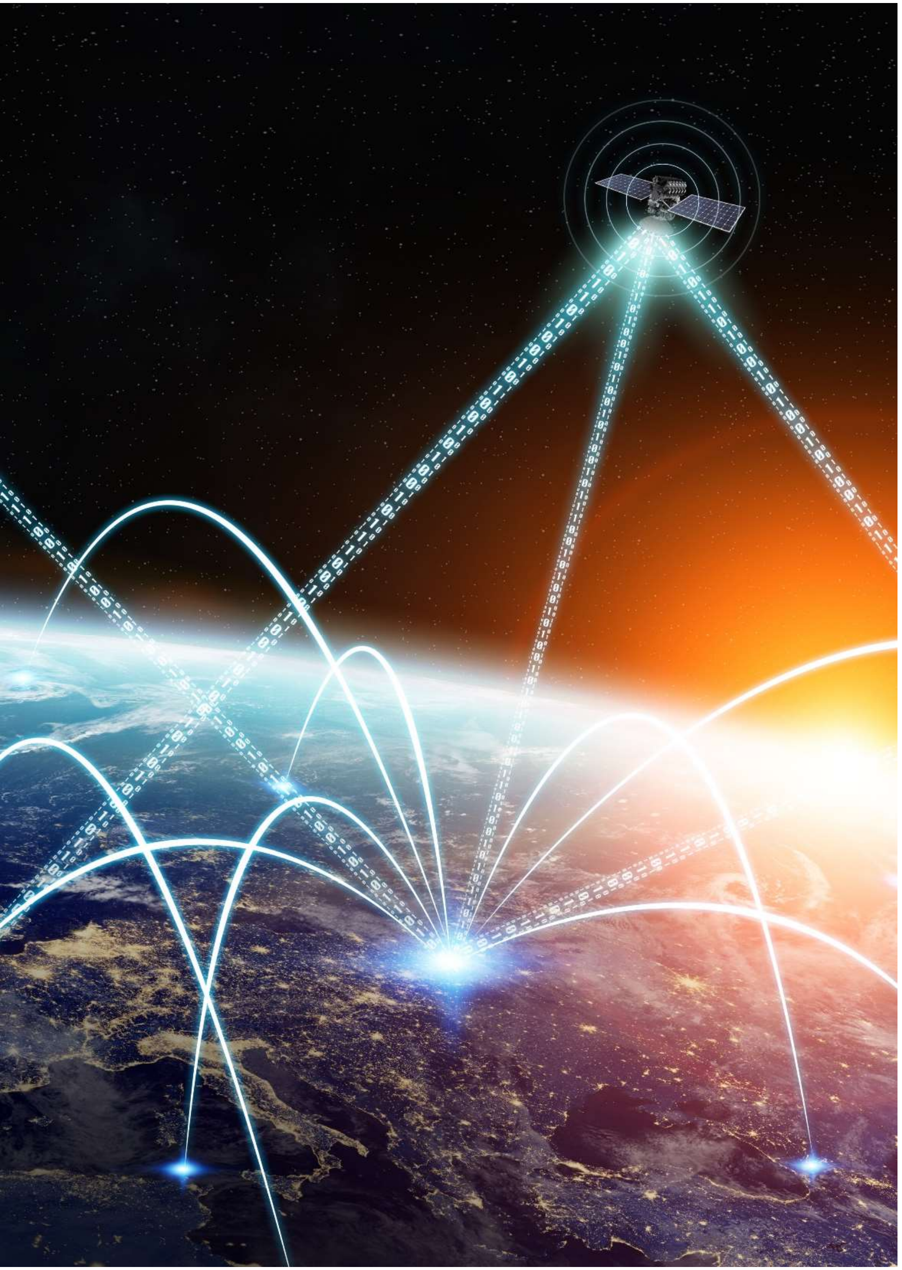


2.3

Automate

Skydel Automation

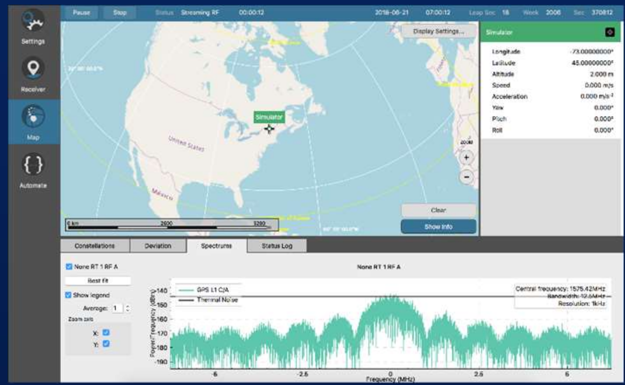
```
#REMOTE PROGRAM
…
{
   Call()
}
…
```

Skydel API
Open-Source
Library functions

SKYDEL can be controlled remotely

TCP / IP

SKYDEL



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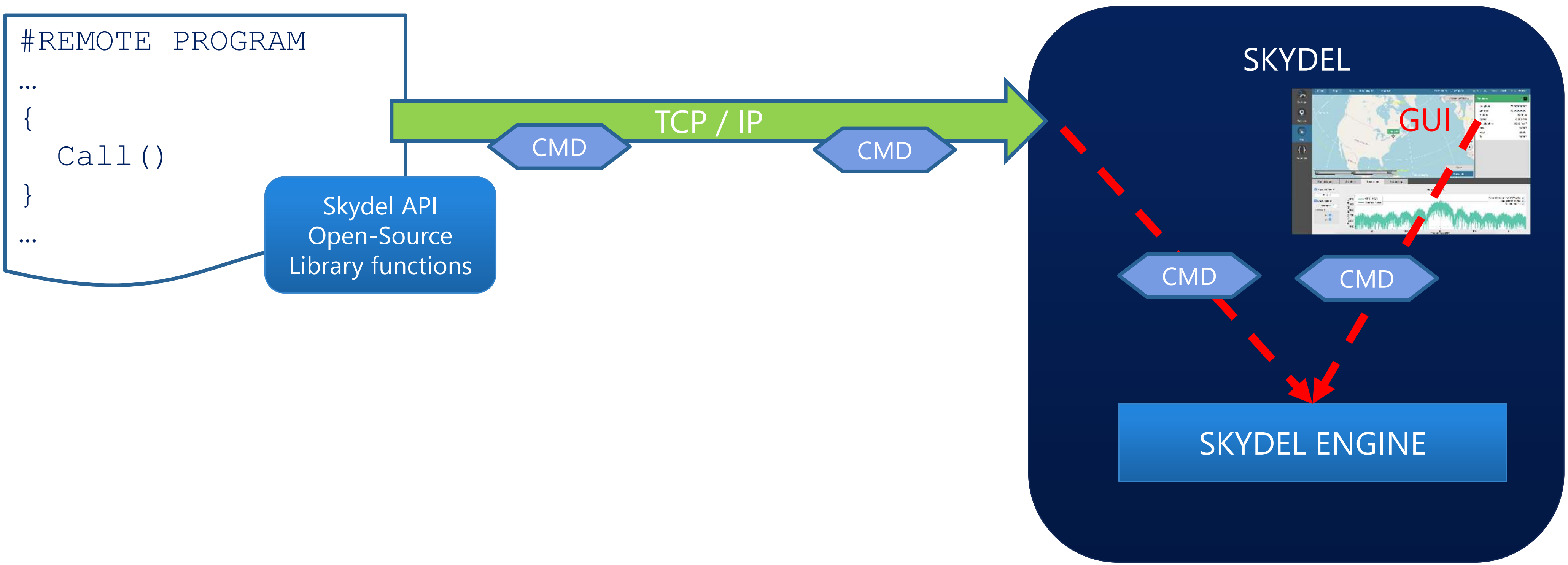
Skydel Automation - Commands

SKYDEL was built around the « Command Design Pattern »

In SKYDEL, all actions (either from GUI or Remote control) are sent to the engine by **Commands**



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Automate and Remote Control

USE-CASE 1:

- Repeated tests (ex: every day)

TEST 1

TEST 2

TEST 3

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Automate and Remote Control

USE-CASE 2:

Creating tests with little difference

```
// Test 1:
SetPower (-130)
// Test 2:
SetPower (-120)
// Test 3:
SetPower (-110)
```

Automate and Remote Control

USE-CASE 3:

Precise **time** setting a change during the simulation

```
// At time = 10.0s
SetPower(-130, 10.0)
...
```

Automate and Remote Control

USE-CASE 4:

Repeat test executed from GUI

Export list of commands to a script!

AUTOMATE AND REMOTE CONTROL

Question:

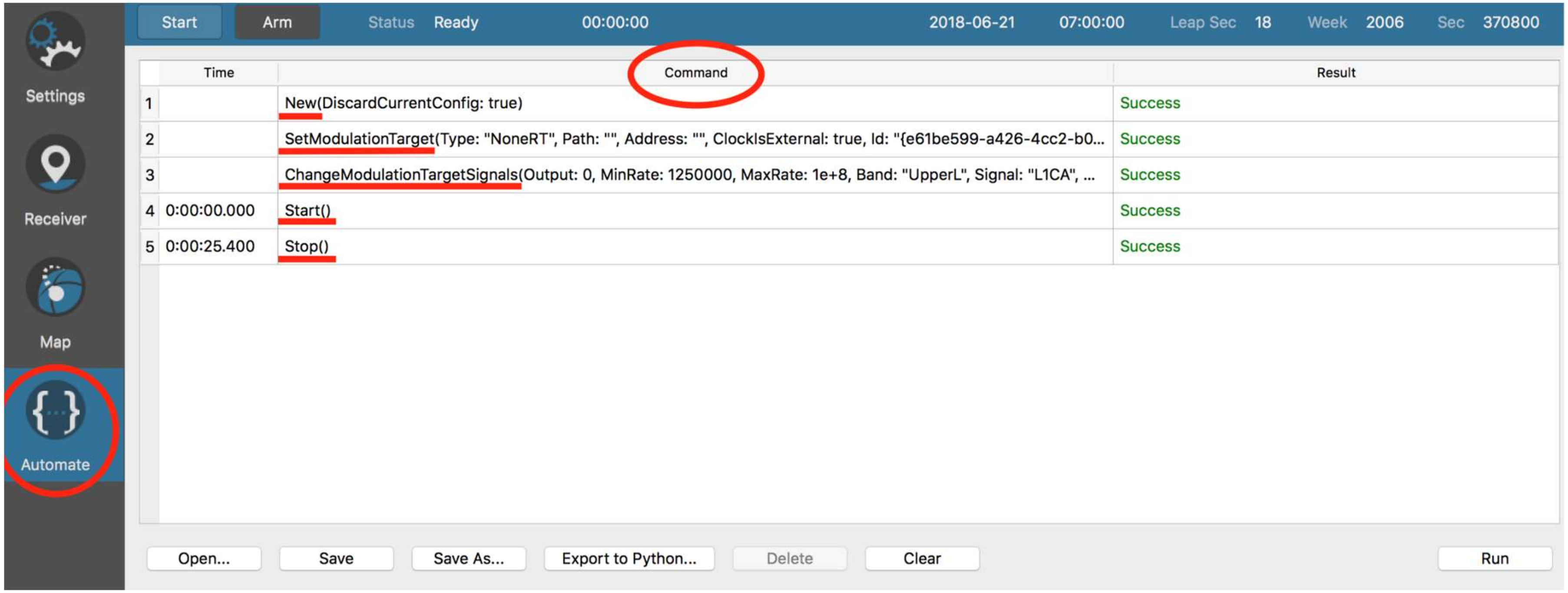
HOW DO YOU CREATE A REMOTE PROGRAM ?

Answer:

LEARN FROM THE GUI!

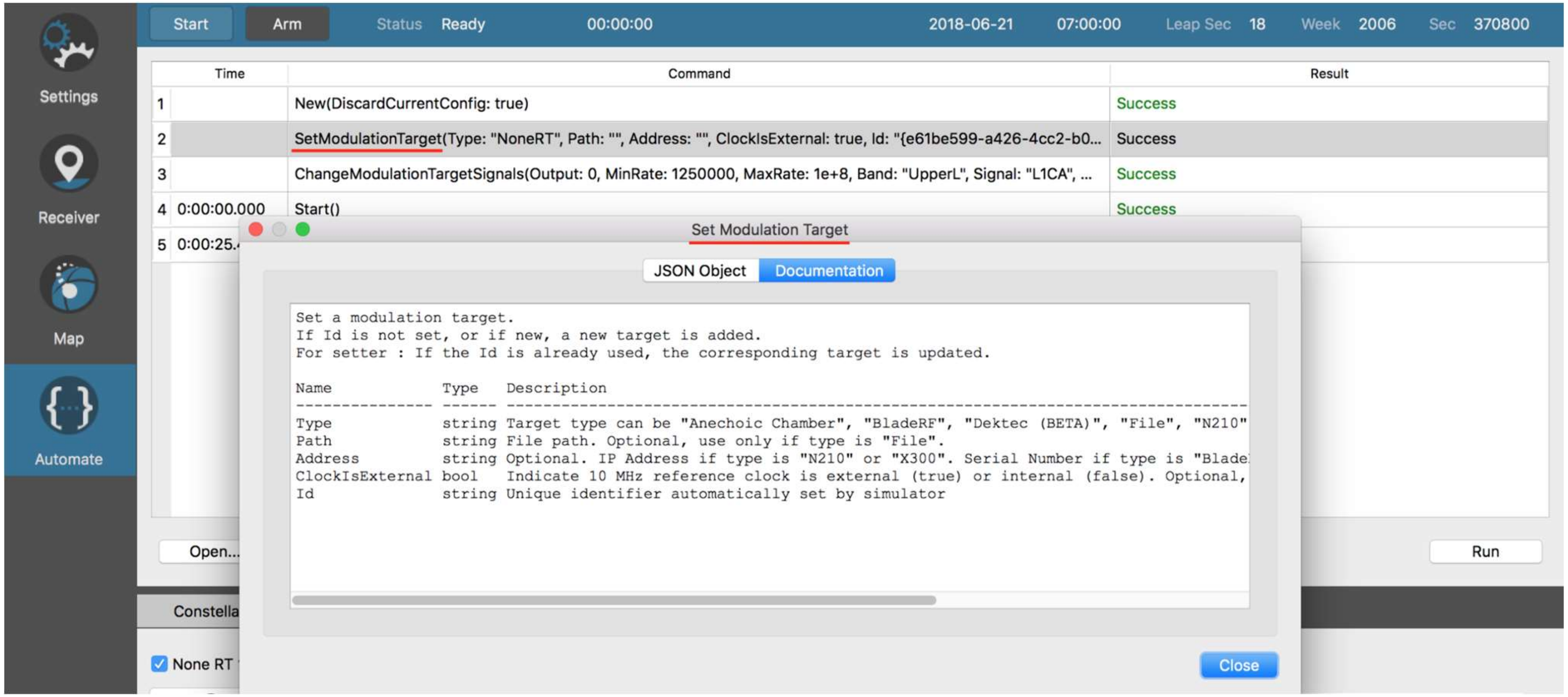
Skydel Automate – Learn from the GUI

In the SKYDEL GUI, you can learn how to use the **Commands** with the AUTOMATE Page.
All actions are transformed into **Commands** and logged into this page.



Skydel Automate – Learn from the GUI

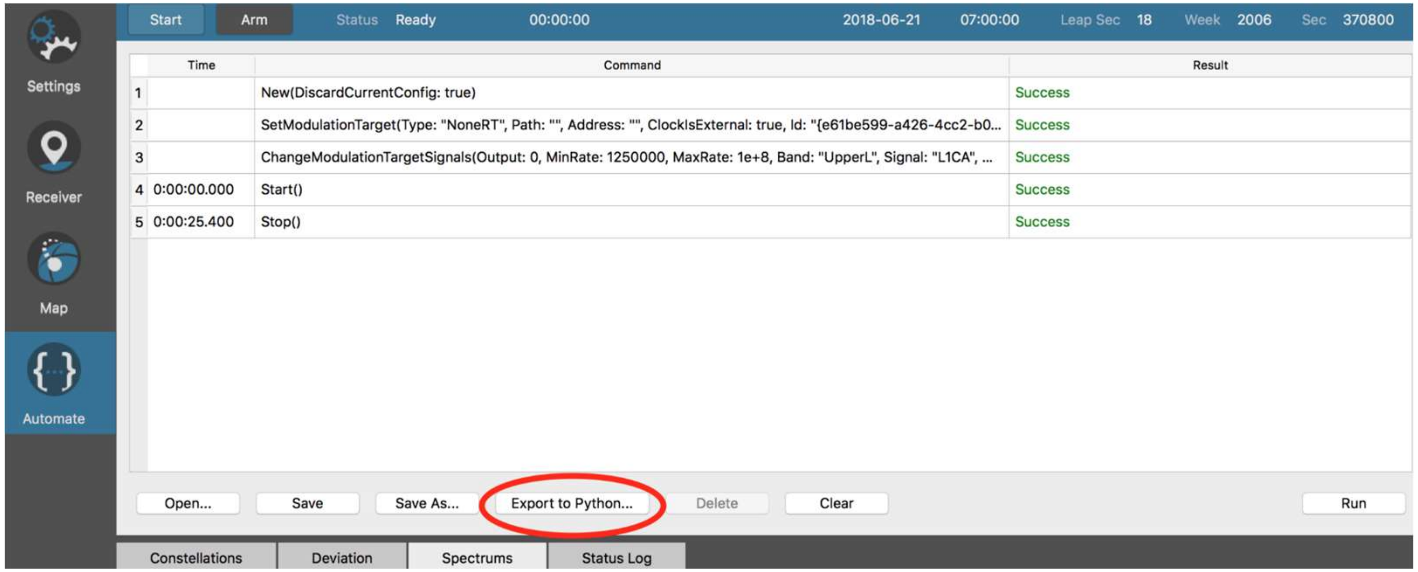
You can double-click on any command to get a detailed decription of all its parameters.



Skydel Automate – Learn from the GUI

More interesting: you can export all recorded commands to a **Python script**!

- The Python script can be launched locally or remotely to replay all the recorded commands
- The Python script can be modified at will (add loops, functions, change timestamps of commands)



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Automate Exercises

Create a Python script

Exercise 1:

1. Connect to SKYDEL
2. Create a new SKYDEL configuration
3. Add one Target output: Dektec DTA-2116
4. Enable GPS L1 C/A Signal
5. Start the simulation
6. Get power of one GPS SV
7. Set power of GPS SV to -135 dBm after 5 seconds
8. After 10 seconds, stop the simulation
9. Disconnect from SKYDEL

Inertial data

Inertial data

Open a terminal

Go to Document/Skydel-SDX/API/Python folder

Run the command : ***python3 inertial_data_display_tool.py***

It starts the simulation then it generates a logging file InertialDataSaving.csv which includes

- ***Elapsed Time (ms)***
- ***ECEF X,Y,Z (m)***
- ***Yaw,Pitch,Roll (rad)***
- ***Speed (m/s)***
- ***Heading (rad)***
- ***Odometer (m)***

Tips when using GSG-882

- **Connection : always use a DC block**
- **Check the output power level (reference power level + manual offset + radio gain)**
- **Jamming/Spoofing:**
  - **Select a trajectory for dynamic jammer/spoofer or it will not be generated**
  - **Check the sampling rate of the Interference/spoofer radio**
  - **Check “Preserve runtime settings” if you want to save the parameters during the simulation**
  - **You can connect the receiver to the Skydel spoofer instance to see the deviation with the spoofing trajectory**
- **Combination with live sky:**
  - **Use PTP/NMEA to synchronize the simulation starting time (app note : https://safran-navigation-timing.com/document/setting-a-timing-reference-for-synchronizing-gnss-simulations/)**
  - **Provide 1PPS & 10MHz with an external clock**
  - **Calibrate the input power level**
  - **Import the latest navigation RINEX available and run the simulation (first step)**
  - **Use dynamic RINEX to do simulation over several days (second step)**

Ressources

- **Quick starting guide : describe the hardware features, physical connections, and initial simulations of the GSG-MVC.**
- **Assembly guide : describe the assembly procedure for the GSG-MVC system**
- **Skydel user manual : https://safran-navigation-timing.com/manuals/skydel/**
- **Skydel forum : https://learn.safran-navigation-timing.com/**
- **Skydel fundamentals course : https://safran-navigation-timing.com/courses/skydel-fundamentals/**

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