GNSS Interference Detection & Mitigation In Safety-Critical Terrestrial Transportation Systems

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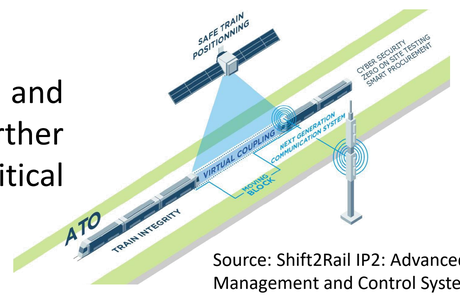
Localization In Safety-Critical Application

Context: The reliability of position and navigation has become very crucial in numerous applications related to public services, consumer products and safety-critical situations. It demands taking into account risks and threats associated with the positioning system to ensure a trustworthy solution, in particular to the satellite-based positioning system.
The Global Navigation Satellite System (GNSS) is recognized as a Game Changer technology that can potentially bring economical and ecological revolution in terrestrial transportation particularly in rail.
However, the performance of satellite-based positioning is very much linked to the operational conditions around the receiving antenna. The satellite signals are particularly prone to the signals that could come from the other radio systems operating close to the GNSS band and also due to the deliberate transmission of malicious signals from the Personal Privacy Devices (PPDs). As a result, these unwanted signals induce distortions that can lead to performance degradation and can even block the receiver from acquiring satellite signals in case of strong interference.

Objective: To contribute in the detection and mitigation of such malicious signals and to further contribute to the acceptance of GNSS in safety-critical applications.



Source: Shift2Rail IP2: Advanced Traffic Management and Control Systems

Radio Frequency Interference (RFI)?

Definition: Radio Frequency Interference (RFI) is the effect of **unwanted energy** due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any **performance degradation**, **misinterpretation**, or **loss of information** which could be extracted in the absence of such unwanted energy.

(ITU Radio Regulations, Section IV. Radio Stations and Systems – Article 1.166)

RFI Typical Sources

Non-intentional interference

Intentional interference

Cigarette jammer

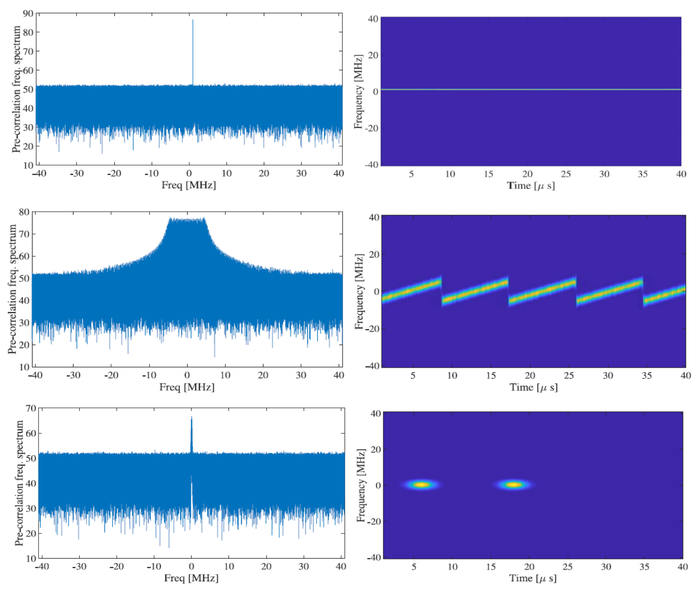
Portable jammer

More Details & Results

SCAN ME

- Kazim, S. A., Tmazirte, N. A., Marais, J. (2022, September). **Interferences in Safety Critical Land Transport Application: Notch Filtering vs Wavelet Transform, a deep analysis**. In *Proceedings of the 2022 International GNSS+ Conference of The Institute of Navigation*.
- Kazim, S. A., Tmazirte, N. A., Marais, J., & Tsaturyan, A. (2022, January). **On the impact of jamming on Horizontal Protection Level and Integrity Assessment for Terrestrial Localization**. In *Proceedings of the 2022 International Technical Meeting of The Institute of Navigation* (pp. 1343-1357).

Interference Signal Characteristics

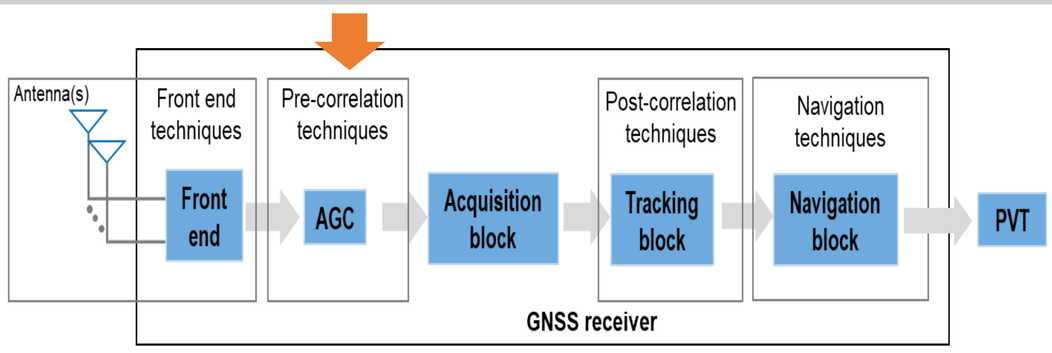


Unintentional interference
Other systems (signal harmonics)

Intentional interference
Jammer (chirp signal)

Unintentional interference
DME system (pulsed signal)

Where To Mitigate?

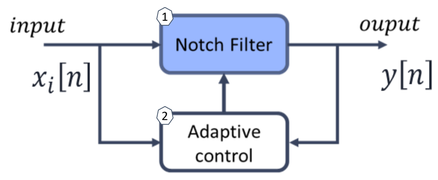


- Antenna level
- Pre-correlation level
- Post-correlation level
- Navigation level

Interference Suppression Techniques

1. Adaptive Notch Filter (ANF)

① **Notch filter** blocks narrow portion of the frequency while leaving other frequencies nearly undisturbed

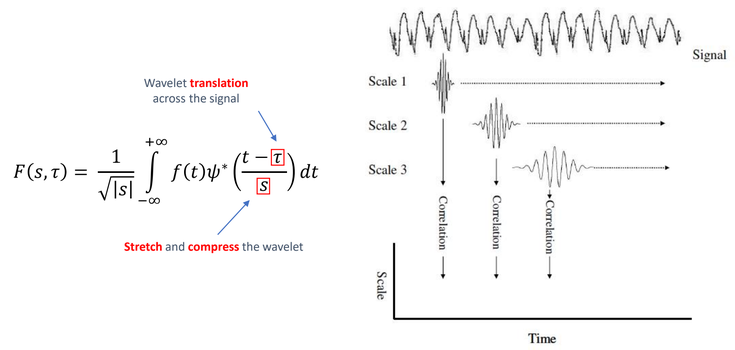


② **Adaptive control** decides the frequency content to remove.

Filter parameters

$Notch\ frequency\ (z_o)$
$Pole\ contraction\ factor\ (k_\alpha)$
$Adaptation\ step\ (\delta)$

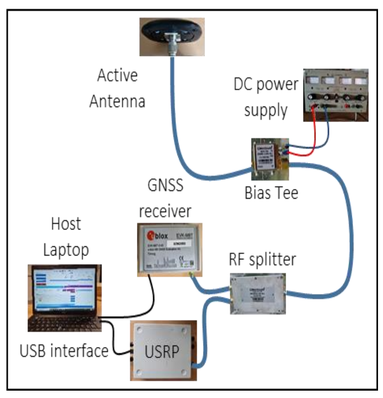
2. Discrete Wavelet Transform (DWT)



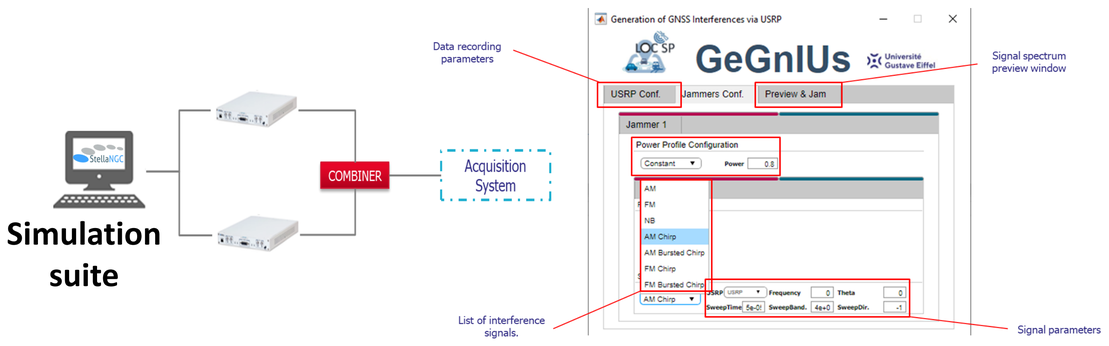
Wavelet families

Exp. Setup, Dev. Tools & Results

I&Q recording setup

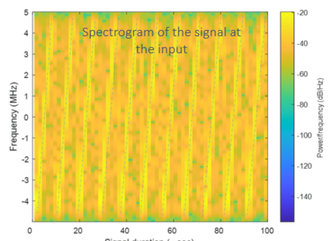


Interference signal generator interface



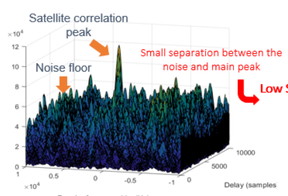
RESULTS

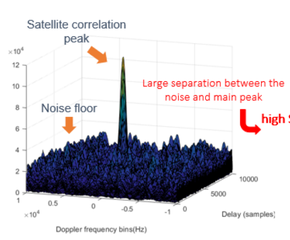
- Interference signal: Chirp



Dataset specification	
Center frequency (fc)	1575.42 MHz
Sampling frequency (fs)	10 MHz
Data type	8 bit (I&Q)
Total Signal duration	50 msec

Search Space for satellite 16





Overall satellite acquisition