MITIGATION OF TACAN/DME INTERFERENCES FOR L5/E5 SPACE-BORNE GNSS RECEIVERS IN LEO WITH FOCUS ON RADIO-OCCULTATION MISSIONS

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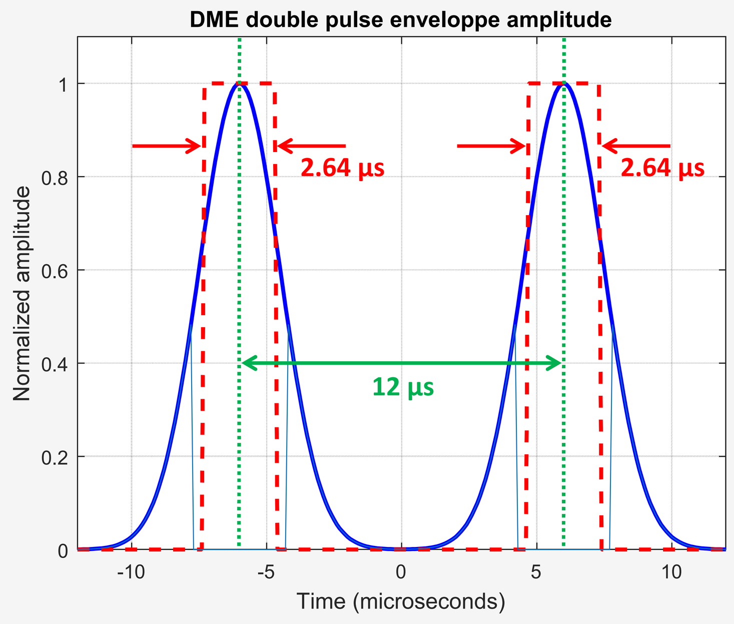
INTEREST: TACAN/DME beacons

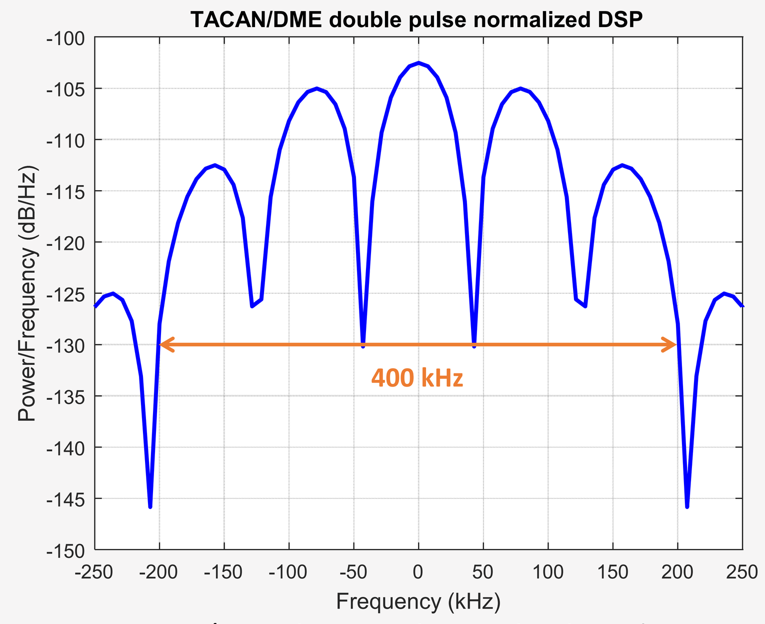
Ground transmitters for aeronautical uses

Max. double pulses per second rate
- 2,700 dpps for DME
- 3,600 dpps for TACAN

Max. EIRP
- 37 dBW for DME
- 40 dBW for TACAN

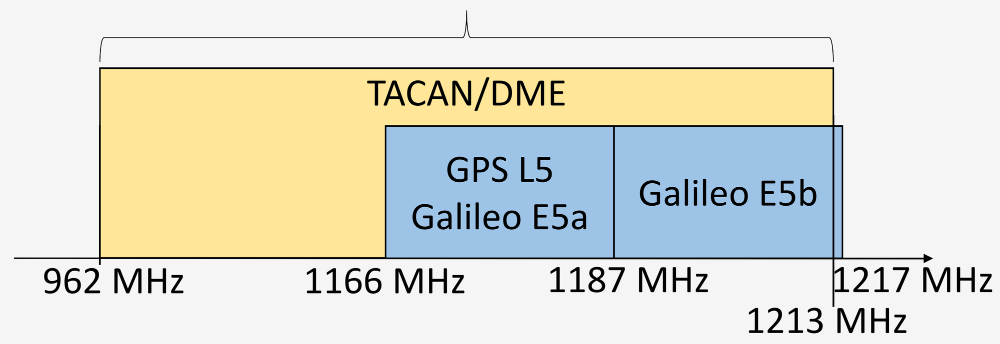


Ideal TACAN/DME double pulse enveloppe Equivalent peak power transmission length of 2.64 µs for each pulse (in red)



TACAN/DME theoretical normalized PSD (99.5% power over 400 kHz bandwidth, narrowband compared to L5/E5 spectrum)

252 channels in [962;1213] MHz
(1 channel every 1 MHz)

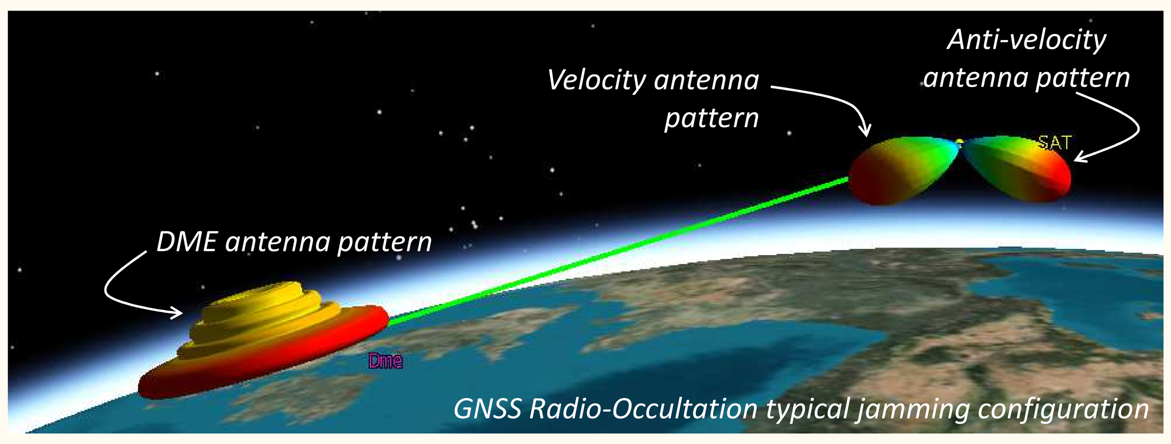


Overlap of the TACAN/DME and GPS L5/Galileo E5 frequency bands

CONTEXT: Radio-Occultation (RO) mission

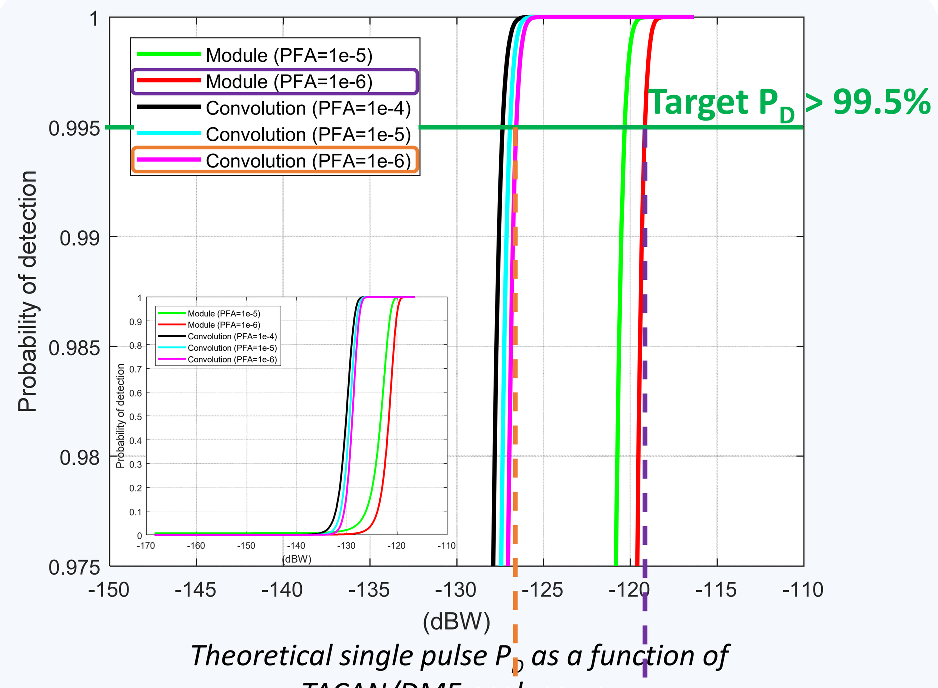
Antenna pattern: 11 dB gain antenna pointing toward the Earth limb (velocity and anti-velocity direction), tilted 20° below the horizon

Up to around 220 TACAN/DME transmitters can be visible at once by LEO users flying over the European hotspot (BENELUX) at 500 km altitude in a 95° inclined sun-synchronous orbit.

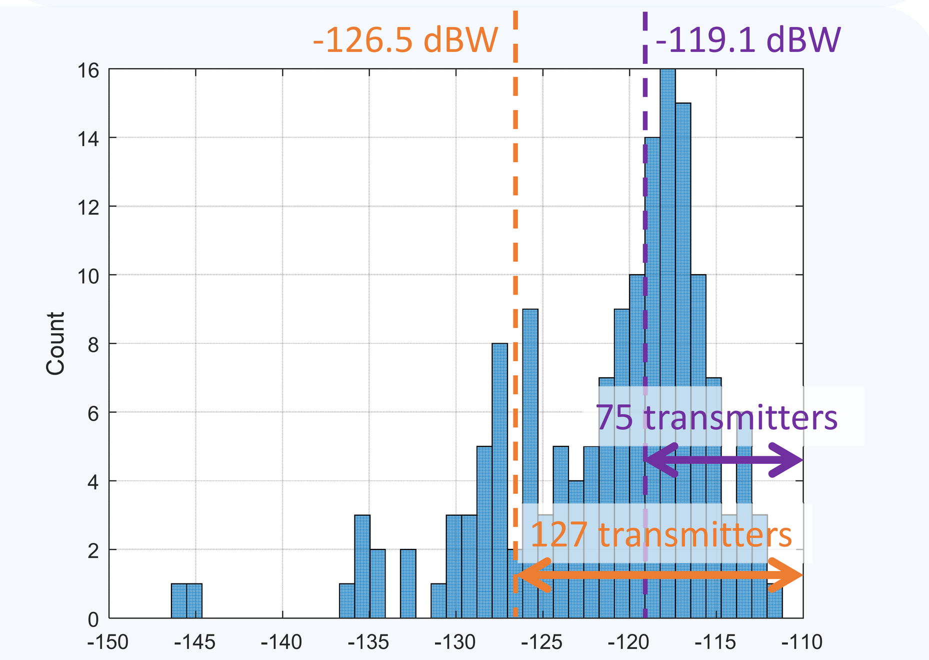


GNSS Radio-Occultation typical jamming configuration

PROBLEM: L5/E5 space-borne GNSS receivers dedicated to RO missions share their frequency band with many visible TACAN/DME transmitters, leading to non negligible interferences of the useful GNSS signals.



Theoretical single pulse P_D as a function of TACAN/DME peak power



Distribution of received TACAN/DME pulse peak power at the worst location (33°N, 11°E)

STUDIED TECHNIQUES TO MITIGATE THESE INTERFERENCES

C/No degradation simulation using the SSC (Spectral Separation Coefficient) Methodology [DR1]

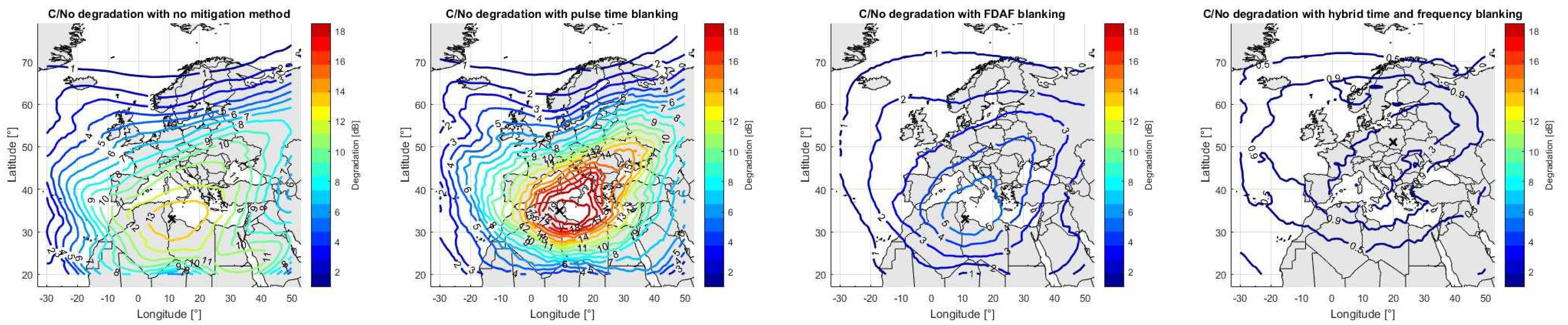
Methods for detection in the time domain

1. Direct threshold on the amplitude of the received signal
2. Threshold on the convolution of the received signal with the theoretical impulsion

Comparison of the simulation results for the studied mitigation techniques

Hypothesis: GPS L5/Galileo E5a; RF bandwidth: 20.46 MHz; sampling rate: 24 MSamples/s; N_0 = -201.5 dBW/Hz

Mitigation technique	Description	Configuration	Worst C/N_0 degradation *Lower is better*	Limitations
None	N/A	N/A	13.9 dB	N/A
Time domain pulse blanking	1. Detection in the time domain using the threshold on the amplitude 2. Blanking over a time window of width d_M	$P_{FA}=1x10^{-6}$ d_M=5.5 µs (99.0% of pulse power blanked)	18.1 dB (Δ=+4.2dB)	Too much blanking of the useful GNSS signal
FDAF (Frequency Domain Adaptative Filtering)	1. Detection in the frequency domain using FFT over successive fixed-length windows 2. Notch filtering of frequency width b_M 3. Calculation of the IFFT to go back to the time domain	$P_{FA}=5x10^{-3}$ b_M=450 kHz Windows of 10.67 µs (256 points)	5.8 dB (Δ=-8.1 dB)	C/N_0 residual degradation mostly due to undetected pulses
Hybrid time and frequency blanking	1. Detection in the time domain using the threshold on the convolution 2. Notch filtering of frequency width b_M centered on the maximum of the FFT over a time window of length d_M 3. Calculation of the IFFT to go back to the time domain	$P_{FA}=1x10^{-5}$ d_M=8 µs b_M=540 kHz (99.96% of pulse power blanked)	1.7 dB (Δ=-12.2 dB)	



Comparision of the C/N_0 degradation for the front receiver of a RO mission after application of a given mitigation technique (location of the worst C/N_0 degradation indicated with a black cross)

The hybrid time and frequency blanking method show the best performances for mitigation of TACAN/DME interferences in the L5/E5 frequency band for RO missions. Future works will cover detection method optimisation and the study of real signals.

Reference: [DR1] B. Titus, J. Betz, C. Hegarty and R. Owen, « Intersystem and Intrasystem Interference Analysis Methodology", ION GNSS 2003, 9-12 september 2003, Portland.