Model of Impact of Pulsed Interference on GPS L5/GALILEO E5a

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Context

- The processing of received *Global Navigation Satellite System* (GNSS) signals can be affected by received additive signals such as noise, multipath and interference. *Radio Frequency Interferences* (RFI) sources are of various sorts, as represented in Figure 1, and their nature and impact depend on the user application.
- In the context of civil aviation, it is critical to characterize these RFI affecting the airborne GNSS receivers in order to define minimum requirements to be imposed on these receivers, notably on the L5 band. In that context, numerous related activities in collaboration with ENAC have led to the elaboration of various ICAO, RTCA and EUROCAE standards considering RFI.
- Currently, the RTCA DO-292 [1] is being updated with several elements that are proposed to be revisited ([2], [3] and [4]). This was deemed necessary since the link budget margin is expected to be small. The objective of this thesis is to help with the update of these elements.

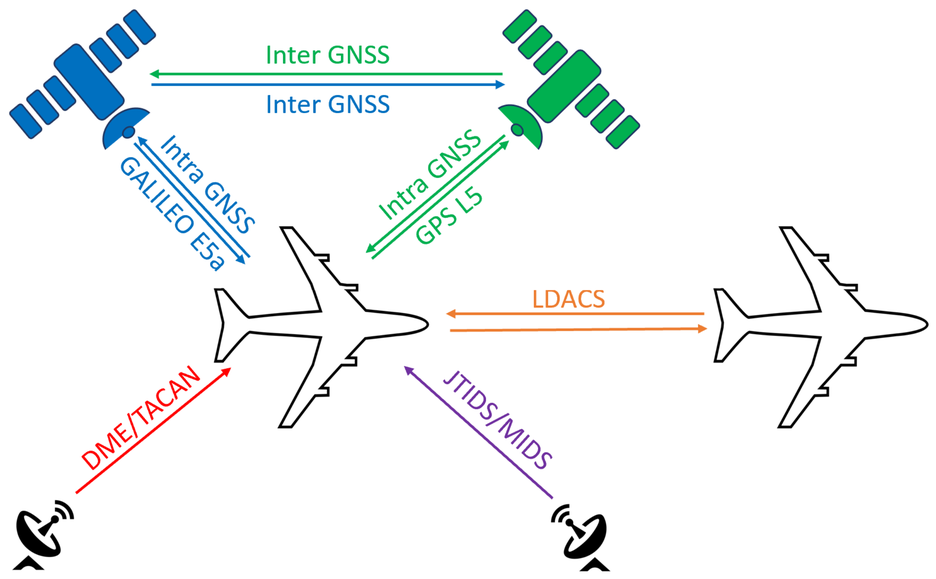

Figure 1: GNSS L5 Radio Frequency Interferences environment

Objectives

-Model a **DME/TACAN propagation channel** at low altitude **including multipath**
-Refine DME/TACAN and JTIDS/MIDS **collision model**
-Analyze the effect of the AGC on the blanker and propose an adapted **AGC loop**
-Analyze other interferences such as **L-band digital aeronautical communication system** (LDACS) and **Portable Electronic Devices** (PEDs)
-Validate the different models and equations using **real in-flight data**

First results: Model for DME/TACAN propagation channel at low altitude including multipath

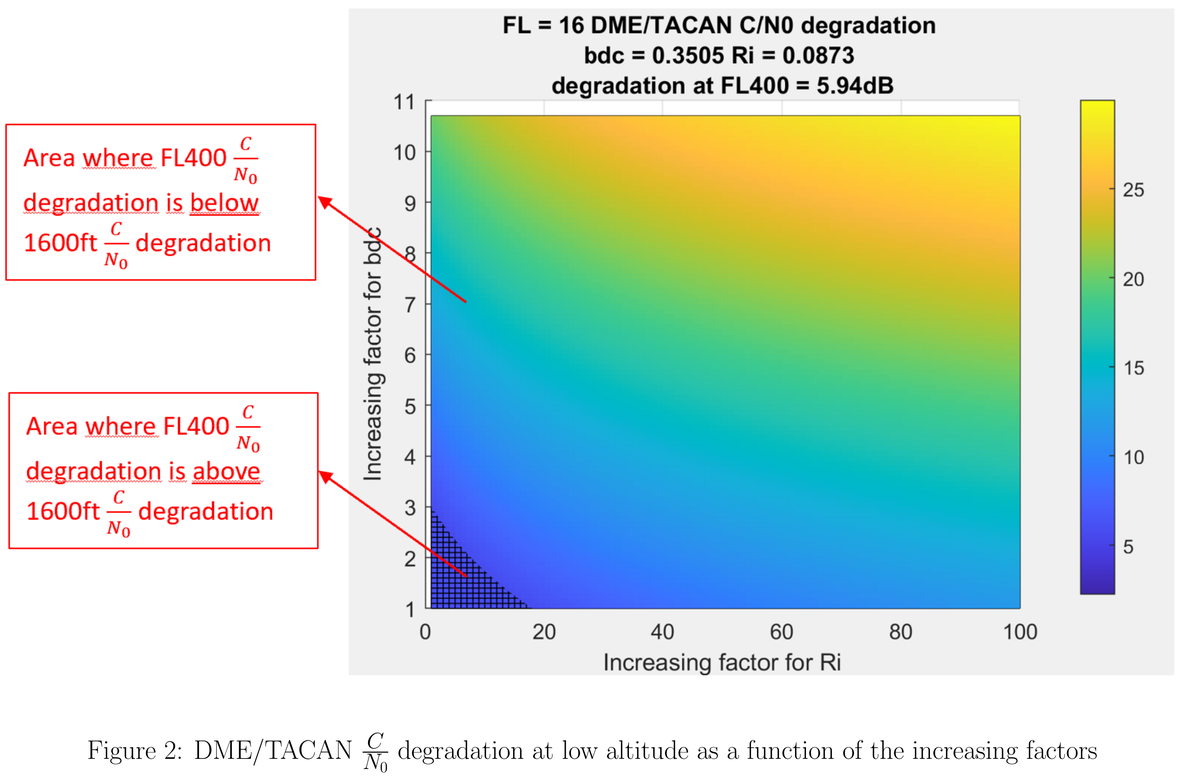

Figure 2: DME/TACAN $\frac{C}{N_0}$ degradation at low altitude as a function of the increasing factors

- GNSS L5/E5a interference environment is dominated by DME/TACAN and JTIDS/MIDS pulses causing a degradation of the effective Carrier to Noise $\frac{C}{N_0}$ observed by the receiver. These interferences are well characterized in the RTCA DO-292 [1] by the $\frac{C}{N_0}$ degradation they induce. A worst-case scenario had been found in 2004 at Harrisburg P.A, high altitude (FL400), where the $\frac{C}{N_0}$ degradation due to DME/TACANs was up to 6dB.
- However, none of these characterizations considered any DME/TACAN multipath effect. At low altitude, even if the aircraft is expected to see less DME/TACANs, the airborne GNSS receiver could be affected by multipath due to low altitude obstacles. A propagation model has recently been developed at ENAC, taking into account these multipath effects in the $\frac{C}{N_0}$ degradation computation.
- For example, Figure 2 provides the increasing factors for the *Blanking Duty Cycle* (bdc) and for the aggregate pulsed sources below-blanker interfering-signal-to-thermal-noise ratio R_I such that a low altitude hot-spot would exceed the FL400 worst-case scenario. The next step is then to characterize the type of obstacles needed to reach such values of R_I and *bdc*.

References

[1] *RTCA DO-292*, Assessment of Radio Frequency Interference Relevant to the GNSS L5/E5a Frequency Band, RTCA SC159, 29 July 2004

[2] Axel Javier Garcia Peña, Christophe Macabiau, Olivier Julien, Mikaël Mabilleau, Pierre Durel, *Impact of DME/TACAN on GNSS L5/E5a Receiver*, ITM 2020, International Technical Meeting, Jan 2020, San Diego, United States

[3] Axel Javier Garcia Peña, Christophe Macabiau, John Ashley, Dimitri Baraban, Mikaël Mabilleau, Pierre Durel, *Model and observation of the impact of JTIDS/MIDS on GNSS C/N0 degradation*, PLANS 2020 IEEE/ION Position, Location and Navigation Symposium, Apr 2020, Portland, United States. pp.584-595

[4] Axel Javier Garcia Peña, Olivier Julien, Paul Verlaine Gakne, Christophe Macabiau, Mikaël Mabilleau, Pierre Durel, *GNSS C/N0 degradation Model in Presence of Continuous Wave and Pulsed Interference*, ION GNSS+ 2019, 32nd International Technical Meeting of the Satellite Division of The Institute of Navigation, Sep 2019, Miami, United States.