Synthetized tropospheric total attenuation time series for satellite-to-aeronautical links from L to W band

Keywords : Tropospheric attenuation; Aeronautical channel.

Alberto Graziani, Carlos Pereira, Alessandro Vergani, Danielle Vanhoenacker-Janvier

Abstract – The synthetized attenuation time series together with the Complementary Cumulative Distribution of attenuation values play a crucial role for the design and validation of communication systems. ITU-R recommendations propose different models to characterize the channels. The ITU-R P1853 recommendation proposes a methodology for the synthesis of attenuation time series for ground stations. Based on the combination of different recommendations and external models, a time series generator produces the total attenuation for airborne platforms. The synthetized time series includes the combination of platform movements in the three dimensions and in the microwave frequency range.

Satellite services for aeronautical communication are currently available for different purposes: from passenger entertainment to aircraft data transmission up to Air Traffic Management (ATM) [1]. For this purpose the characterization of the aircraft-to-space link is crucial to guarantee all the proposed services. Due to the limitation in space, weight and dimension in airborne systems, the channel characterization is crucial and several contributions have to be considered, such as: atmosphere, aircraft attitude and ground scattering [2]. During the flight, the propagation terms affect the communication channel with different impact. For this reason, only an accurate analysis based on simulated time series can provide precise simulations of the link budget.

The model developed focuses on the effect of the troposphere in the aeronautical-to-space link, proposing a combination of ITU-R recommendations developed mostly for a ground-to-space link and adapting them for aeronautical scenario. Models are defined to evaluate the tropospheric propagation taking into account the variability in both time and space domain [3]. The models require several ancillary information which are available in terms of databases based on long terms observations and statistical representation.

Two main recommendations are used for the proposed model: the ITU-R P1853-1 [4] which defines models for the tropospheric total attenuation time series synthesis, and the ITU-R P2041 [5] which predicts the various propagation effects for planning airborne systems links.

As anticipated, the crucial aspect of the aeronautical-to-space channel model is the altitude dependence of the tropospheric effects. Considering a typical commercial aircraft flight, it results that most of the flight time is spent at altitudes above the troposphere where most of it effects are negligible, but during the phases of take-off, climb and then descend, approach and landing, the troposphere effects become crucial and relevant, in particular if adverse weather conditions are encountered.

The atmospheric tool is used to generate the time series based on real flight path of commercial aircrafts. In this analysis a European regional flight between Rome Fiumicino, Italy and Stockholm Arlanda, Sweden is used. The flight path coordinates and altitudes have been acquired from Flight Aware[1].

The simulation time corresponds to the combination of all the flight time plus a few minutes on the ground at the beginning and at the end, to represent the taxiing on the ground at the two airports.

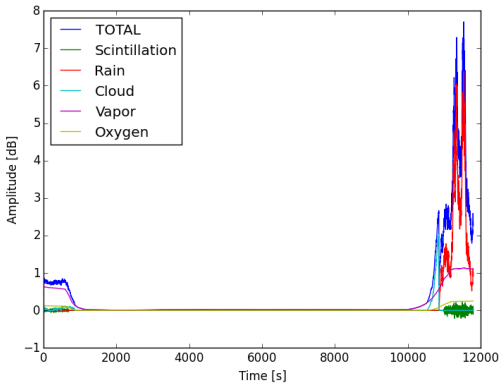

Figure 1: Simulation of time series of total attenuation encountered during a flight.

Fig.1 depicts the attenuation effects during the flight. The random generation of the input parameters of the time series generator results in a clear sky day in Rome and rainy conditions in Stockholm, with a strong combination of all the effects.

The model has been tested in various configurations, including a fixed position on earth in order to be validated with the classical earth-space links models.

In the frame of an ESA contract, this model is introduced in a full simulator of the aeronautical link, taking into account the attitude of the aircraft.

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