A PROPOSAL FOR COLLABORATIVE NAVIGATION IN AIR CORRIDORS

João Marcelo de Castro Monteiro
Agência Nacional de Aviação Civil - ANAC
AOS 8, Bloco F, apt 603, Octogonal, Brasília – DF, (61) 991167567,
jomakamon@gmail.com

Felix Mora-Camino
MAIAA, ENAC the French Civil Aviation University
7 avenue Edouard Belin, 31055, Toulouse – France, Tel. (33) 562174000, Fax. (33) 56217435 felix.mora@enac.fr

ABSTRACT

With the expected huge increase in air traffic over the next decades, it is believed that a large proportion of traffic will be organized in main air streams operating under advanced CNS procedures. Many studies and proposals of solution for a future congested ATM are developed and presented in many scientific events and magazines, and one of the most considered is known as "Flow Corridors". In order to enable this type of traffic flow, with minimal or no interference at all of controllers, the airplanes must follow certain traffic specifications of the corridor and be able to maintain self separation and surveillance of the inside traffic. In such environment, self-controlled dense traffic, the navigation should be based on accurate and reliable systems throughout the entire corridor.

The current study aims to present a collaborative method to take advantage of the many measurements from surrounding airplanes to improve their navigation performance. For the purpose of this study, it is understood that collaborative navigation is characterized by the utilization of measurements performed by surrounding aircraft and exchanged to improve the navigation performance of the each of them. Said in another way, an airplane surrounded by other airplanes should experiment a better navigation performance than an aircraft flying alone.

The main objective of this study is to assess the possibility of using TCAS and ADS-B signals, already made available in commercial aircraft, as means to improve navigation performance. To improve navigation performance, an aircraft may use the information of distance between itself and other airplanes provided by TCAS, since the estimation of the absolute position of each airplane is available (ADS-B), and to create a

dynamic constellation similar to GPS where the satellites are replaced by the surrounding airplanes. In this situation, instead of having the ephemeris with the satellite position we have an ADS-B message with the aircraft position and instead of measuring the distance aircraft-satellite using the satellite clock and received message time, we use the TCAS to measure the distance between aircraft. The challenges of this approach are not only the level of uncertainty of each measurement system, but also the lack of synchronization between measurements.

The mathematical model to be used in this study is similar to the one used for GNSS positioning applications, with a slight difference adopted to fit the proposed method. The concept used by GNSS is the Time of Arrival (TOA) which means it measures the time that a signal sent by the transmitter (satellite) takes to reach the user receiver and multiplies by the speed of light to know the distance between them. This implies that in that case the information about distance satellite-user and satellite position are synchronized. However in the considered case, all surrounding airplanes send their ADS-B message at different times and even the distance measurement and position of a given aircraft are not synchronized. So, to apply a least square technique to provide an additional estimation of position for each aircraft, it is necessary first to synchronize all this information with respect to a unique time line, a reference aircraft time line.

Two different traffic scenarios were simulated for evaluation of performances: the first one (free route scenario) where the airplanes did not follow straight and parallel trajectories and the second scenario (corridor scenario) where the airplanes followed straight and parallel air lanes along a corridor. The performed simulations considered from 5 to 23 neighbour aircraft. The results showed that the accuracy obtained with the free route scenario was better than the corridor one. A possible cause for this difference was a more adequate constellation geometry, independently of the traffic being organized or not. The results showed that the method has a good accuracy above a certain quantity of surrounding aircraft. For example, in the case of the corridor scenario with 12 surrounding airplanes the resulting accuracy was of 30.5 meters.

These preliminary simulation results show the interest in performing further studies along this approach using more accurate input data and more realistic assumptions. The proposed collaborative navigation scheme has not been thought to replace GNSS as primary navigation mean, even because the method relies on the GNSS of other airplanes, but it could work as a backup system or even contribute to improve GNSS integrity and availability.