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Oceanic Traffic Optimization

M. Sbihi [1], O. Rodionova [1], D. Delahaye [1], M. Mongeau [1]

The North Atlantic (NAT) is the busiest oceanic airspace in the world. In its most part, Air Traffic Services (ATS) radar surveillance is unavailable and typical procedures have been established in order to ensure safe navigation. Aircraft wish to follow what is called the minimum-time route that depends on the position of the jet stream. Generally the preferred east-west trajectories lie further north than the west-east ones. So all USA-Europe flights, for instance, want to follow roughly the same route which is not possible. In order to accommodate as many flights as possible on, or close to, their minimum time tracks and to provide the best traffic control service, a system of tracks referred to as the Organized Track System (OTS) is constructed [1]. The OTS is set up on a diurnal basis is built according to the position of the jet stream. The USA-Europe network is located on the jet stream and the Europe-USA network avoid it. Each network consists of a set, typically 4 to 7, of parallel or nearly parallel tracks (see Figure 1).

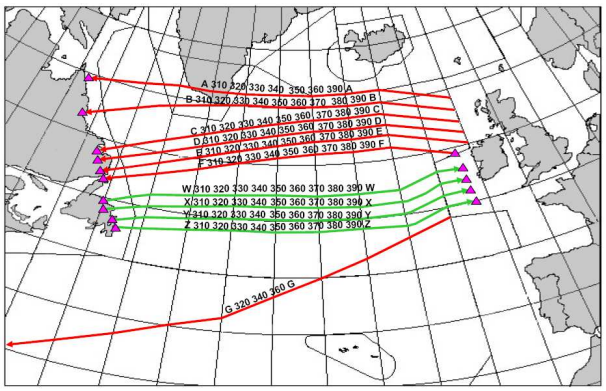

Figure 1: Track network on North Atlantic Ocean

The separation is maintained with respect to three dimensions:

- Vertical : 1000 feet (1ft $\simeq$ 0.30 m).
- Lateral: the distance between closest tracks is 60 NM.
- Longitudinal : the time separation between subsequent aircraft following the same track is 10 minutes. When an aircraft want to shift from one track to an adjacent track, the separation must be at least 15 minutes with aircraft located on such adjacent track (see Figure 2).

[1]Laboratory of Applied Mathematics, Informatics and Automatics for Aviation (MAIAA), Ecole Nationale de l'Aviation Civile (ENAC), 7 Avenue Edouard Belin, 31055 Toulouse cedex 4, France

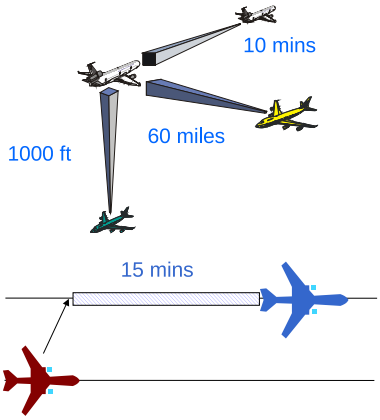

Figure 2: Oceanic Separation Standard

Longitudinal separation and traffic density reduce opportunities for an aircraft to shift from one track to another in order to reach its optimum oceanic exit point. As a consequence, the Track Network Exit may be congested when aircraft are allowed to follow the original final destination.

The transition from present ATC tools to airborne-based systems and procedures proposed by the American and European projects NextGen (Next Generation Air Transport System) and SESAR (Single European Sky ATM Research) can help to overcome these drawbacks. The key component of these projects is the Automatic Dependent Surveillance- Broadcast (ADS-B) technology [2] that combines aircraft's positioning source, aircraft avionics, and a ground infrastructure to create an accurate surveillance interface between aircraft and ATC (see Figure 3).

The new approach will allow to decrease significantly the oceanic separation standards [3]. Indeed, with ADS-B systems the consecutive aircraft following the same track would be separated only 2 minutes apart, and the aircraft performing a re-routing to the adjacent track would be separated only 3 minutes from the aircraft on its new track. Obviously, based on this new separation standard, aircraft will be able to change their tracks more frequently in order to optimize their routes.

The paper presents a mathematical optimization framework to tackle the problem. Our preliminary study focus on how ADS-B technology can help better utilize available capacity. Due to the induced combinatoric, we have developed a stochastic optimization process based on artificial evolution. Coding, recombination operators have been dedicated to such problem. The performed simulations prove that ADS-B equipage has a strong positive effect on the current traffic situation in North Atlantic oceanic airspace and offer many alternate routes. However, it is clear that when measured with other aviation metrics (e.g. fuel, equity,..) these routes may present different performance. In this perspective, we will point out some interesting future research problems that we think are important for applications.

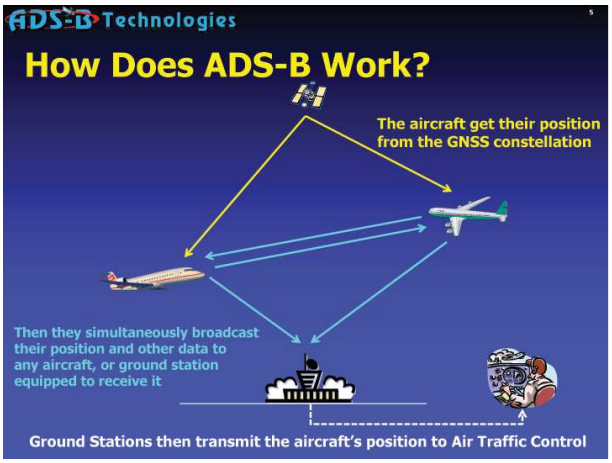

Figure 3: Automatic Dependent Surveillance-Broadcast operating principle

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