

---

## Abstract

This thesis is focused on the Mode S Multilateration (MLAT) systems for the Air Traffic Control (ATC) operations, specifically on their layout design and on the process of cooperative targets localization performed by them. It addresses the development of new design and localization strategies. The design strategies are based on the application of metaheuristic optimization techniques, whilst the localization ones are based on the application and combination of regularization methods along with some current localization algorithms.

The design strategies are composed of an effective, general procedure to emplace both the standard and enhanced MLAT receiving stations on a surveillance volume, and a set of design strategies to be used with such a proposed procedure. This procedure uses the metaheuristic of Genetic Algorithms (GA), and is intended to obtain useful design parameters that allow optimal system configurations that provide suitable performance levels. Furthermore, the procedure developed in this thesis is able to evaluate and improve previous system designs, as well as possible system enhancements. For this context, we overcome several issues like the lack of a general model that relates the system performance parameters with those ones that can be simulated on a computer, the setting of the design problem as a computer optimization one, the development and application of the numerical tools to analyze and evaluate the MLAT systems performance, the complexity evaluation of the resulting computer optimization problem, and the application and modification of the GA components for solving such a optimization problem. To validate the contributions in this context, some simulations are performed on a real airport scenario.

The localization strategies are composed of a set of developed regularized location estimators, a set of developed additional improvements, and the use of some current localization algorithms. These strategies can be used for both surface and wide areas surveillance, and solve some practical problems like the loss of position accuracy when using a small number of stations, or

for small areas where the stations are close to each other (e.g., airport surface surveillance), and the mitigation of some errors due to multipath effect. Moreover, the proposed localization strategies are found to be highly statistically and numerically efficient, in contrast to current ones that are efficient in only one sense (i.e., statistically or numerically). For this context, we overcome several issues like the identification and evaluation of the numerical causes of the above mentioned problems, the analysis of the current localization algorithms, the adaptation of the regularization methods theory for solving the localization problem, the development of some numerical additional tools that allows the real time implementation of such proposed algorithms, and the combination of the current algorithms with the proposed ones. To validate the contributions in this context, some simulations with both simulated and real data scenarios are performed.

**Keywords:** Multilateration, Passive Localization, Mode S, Airport Surveillance, Combinatorial Optimization, Metaheuristic Techniques, Radar Architectures and Systems, Air Traffic Control, Regularization Methods, Inverse Problems.