Multistatic Passive Radar Geometry Optimization for Target 3D Positioning Accuracy

Francesca Gumiero[#1], Cinzia Nucciarone[#2], Valeria Anastasio [#*3], Pierfrancesco Lombardo[#4] , Fabiola Colone[#5]

[#] *INFOCOM Department, University of Rome "La Sapienza"*
Via Eudossiana 18, 00184 Rome, Italy
{[1]gumiero, [4]lombardo, [5]colone } @infocom.uniroma1.it
[2]cinzia.nucciarone@alice.it

[*] *SELEX Sistemi Integrati s. p. a.*
Via Tiburtina KM 12,400, 00131 Rome, Italy
[3]vanastasio@selex-si.com

Abstract— **The paper presents a design procedure for a multistatic passive radar system, that aims at its performance optimization, in terms of 3D positioning accuracy. Specifically, the proposed procedure considers the main features of the considered air traffic control scenario and the main physical and geometrical features of the passive radar receivers and guides the designer to select the geometry that maximizes the three-dimensional target positioning accuracy. The procedure can be applied to any type of sources of opportunity, the final accuracy results being inversely scaled by their frequency band occupancy. The proposed procedure has been applied to two different air traffic control scenarios, namely an en-route flight and an approach path. The results show that a multistatic passive radar system with just two or three transmitters of opportunity and a single receiver is able to localize targets with positioning accuracy comparable to conventional air traffic control systems.**

I. Introduction

Passive bistatic radar system joins the characteristics of bistatic radar and passive operation. It exploits signals of opportunity already available in the environment, that are emitted by different type of transmitters like FM, DAB, DVB-T [1]-[2] or satellite transmitters like GPS, or LEOS [3], or GSM signal [4], and usually aims at detecting air targets and measuring their position. The interest in passive radar systems presented a cyclical nature in the story of radars, the current increase of interest for this type of radar system is motivated by its very good characteristics, such as: low cost, reduced e. m. pollution, reduced vulnerability of receiver etc [5].

One of the limitations of passive radar systems is related to the transmitted waveforms being out of the control of the radar designer, together with their power level and frequency bandwidth. This requires a significant signal processing effort to control the final performance obtained by the system in terms of target detection and discrimination capability. Typically, by selecting an adequate transmitter with enough EIRP (Effective Isotropically Radiated Power) and frequency bandwidth occupancy, quite acceptable performance can be achieved in the range dimension. In contrast, the passive receiver (due also to the low frequency of the available signals of opportunity) typically operates with a wide beam antenna and – even using two antennas in an interferometric configuration – shows often a poor angular estimation accuracy. Similarly, to achieve target height estimation a further antenna is used in interferometric configuration with a vertical displacement, again providing low elevation estimation accuracy. An effective approach to increase the cross-range estimation accuracy is to use a multistatic passive radar system based on multiple transmitters and a single receiver. In fact, if the geometry of the multistatic system is appropriately selected, it is possible to achieve in the cross-range direction an accuracy comparable to the range accuracy. This includes selecting the transmitters to be used, among the available ones, and the optimum position for the passive radar receiver.

The study presented in this paper considers a passive multistatic radar system made up of two/three transmitters of opportunity (typically operating at different frequency channels) and a single passive receiver. This choice of geometry is especially attractive for its simplicity and low cost, however it requires that the geometry of the three bistatic couples is appropriately selected. An ad hoc strategy is proposed to identify the two/three transmitters and the correct receiver position that allow to achieve the maximum 3D positioning accuracy for targets in assigned air traffic control scenarios, taking into account the physical and geometrical receiver's features. In particular, this is an extension of the results presented in [6], where the approach was first devised, but with the strong limitation of being only restricted to the 2D case and totally neglecting both target height above ground and vertical speed component that is not negligible in a terminal area.

The paper is organized as follows. In section II the reference scenarios for the optimization are described there including the constellation of available transmitters. Proper constraints on the positioning of receiver are presented in section III. The optimization strategy is introduced in section IV, based on the local linearization of the localization equation. The results of the application of the proposed procedure to the considered reference scenarios is also reported to show its effectiveness in practical cases. Finally our conclusions are drawn in section V.