A Wide Field of View Radar for Sense and Avoid on UAV using Space coloring Waveforms

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***Abstract*— Up to now, UAV are employed in crisis or war times. For training purposes, some areas are especially attributed for UAV deployment in a limited space area and in a limited time slot. In the future, both for emerging civilian applications and for training purpose, these limitations will no longer be acceptable and UAV will have to be inserted in the general Air Traffic. Thus, "Sense and Avoid" systems will be mandatory. The radar is the most pertinent non-cooperative "all-weather" sensor because it provides, by essence, accurate ranging, direction and closing speed. In this paper, we propose a low cost radar solution based on space coloring waveforms. This design allows the implementation of the radar within the UAV airframe without any moving parts.**

I. INTRODUCTION

UAV are light, easily and quickly deployable. These unmanned aircrafts usually carry surveillance sensors, even may perform some combat functions. Up to now, UAV are employed in crisis or war times. They can approach closely the area of interest without endangering an aircrew or a costly platform.

For training purposes, the UAV are flown in special areas, which are especially attributed for UAV deployment in a limited space area and in a limited time slot. In the future, both for emerging civilian application and for training purpose, the UAV will have to be inserted in the general Air Traffic without any disturbance to other aircrafts.

To realize this insertion, UAV will need to be fitted with "Sense and Avoid" systems, which are intended to replace the "eyes of a pilot", that is to say to carry out the "See and Avoid" task that does a "manned" crew.

Among the possible non-cooperative sensors, the radar is the most pertinent one. Indeed, it is an "all-weather" sensor and it provides accurate ranging, direction and closing speed.

This paper describes a low cost radar solution based on the use of space coloring waveforms with a dual array on transmit and Digital Beam Forming (DBF) on receive (coherent MIMO principles). The safety level for such function must be high: thus, full electronic exploration solutions without any mechanical moving parts are preferable.

II. SYSTEM REQUIREMENTS

A. General Requirements

Up to now, there is no formal regulation about such systems. Nevertheless, some preliminary hypotheses are admitted, based on current Air Rules. Such automatic systems will have to act as "human pilots" onboard. They shall have, at least, the same Field Of View than a pilot in a cockpit.

B. Reliability

The reliability is of prime importance. These systems shall merge both cooperative and non cooperative sensors like active radar. The discussion on data fusion is beyond the scope of this paper.

C. Main Tasks to be Carried out

1) The Traffic Insertion and Separation

Air navigation is mainly based on vertical and lateral separations:

- Vertical spacing greater than 500 ft (150 m);
- Horizontal spacing greater than 0.5 NM (925 m).

The vertical spacing is, by far, the most constraining one in terms of angular location accuracy.

The traffic insertion and separation task is mainly the most demanding task for a sense and avoid sensor.

2) The Collision Avoidance

In "emergency" conditions, the system shall avoid collisions with other aircrafts. A safety cylindrical area with a radius of 500 ft (150 m) is defined around each aircraft (A/C). A collision or a quasi collision (air-miss) occurs if an A/C enters in the safety area of another one.

The maneuver related to the collision avoidance is an emergency one carried out at "short range". If the traffic insertion function has properly worked out and all surrounding aircrafts have followed the Air Rules, this maneuver has been anticipated and no emergency maneuver would occur.

3) Other Desirable Functions

It is also advisable to provide additional weather and terrain avoidance functions.

III. MINIMAL RADAR REQUIREMENTS

Here we focus on the main non-cooperative sensor, namely the radar. The main requirements are:

1. Angular coverage equivalent to the Field Of View of a pilot in a cockpit: ±110° in azimuth and ±15° in elevation (section *II.A*).
2. Angular tracking accuracy allowing the computation of

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