

Small and Lightweight Innovative Obstacle Detection Radar System for the General Aviation: Performances and Integration Aspects

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ABSTRACT

Since 2011, ROD Ltd. and Boggi srl have started to cooperate in the field of airborne platform safety through the development and the integration of an innovative radar system, based on the radar system patented by in 2009 [1].

ROD Ltd. is a startup company, created in 2011, in order to commercialize an innovative Obstacle and Terrain Avoidance Sensor concept (OTASTM). Boggi srl is an EASA DOA (21.J.453) [2] that has developed the capability of designing and certifying aerospace components from small changes to complex systems such as Remotely Piloted Air System (RPAS) or mission avionics.

The direct experience of the operators in general aviation has shown that a number of accidents occur because of collisions with obstacles and, especially, but not only, with cables. During the years of 1997-2009, a total of 996 reported aviation accidents/collisions involving wires/power lines occurred in the United States. Of the 996 accidents, 301 involved at least one fatality [3].

This paper describes the OTASTM, a light-weight (<3 Kg) and low-power radar for terrain and obstacle detection for aircraft. It also describes the system and airworthiness aspects that have to be taken into consideration for the integration of this type of system on platforms.

The OTASTM solution is achieved by innovatively integrating proven technologies and purpose-built signal and data processing algorithms. One major innovation is to employ relatively low (L-band) radio frequency, which enables polarization sensitivity.

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CAUSES OF ACCIDENTS

The idea of a system that detects obstacles and reports information to the pilot originates from the direct experience of the operators and from observation of the annual FAA, EASA safety reports and the NTSB review [3], [4], [5], [6],

[7]. In order to better understand the lack of an obstacle detection system, it is worth considering some of the results of these studies:

- "Most of the aircraft involved in collisions are engaged in recreational flying, not on any type of flight plan."

- “Most collisions occur in VFR weather conditions during weekend daylight hours.”
- “The vast majority of accidents occurred at or near uncontrolled airports and at altitudes below 1000 feet.”
- “Pilots of all experience levels were involved in collisions, from pilots on their first solo ride, to 20,000-hour veterans.”
- “Most collisions occur in daylight with visibility greater than 3 miles.”

The table in [Figure 1](#) gives the statistics concerning the number of collisions with wire, in U.S. airspace, between 1970 and 2003. Between 1994 and 2003, on average, 1.24 fatalities and injuries occurs each collision with wire.

Table 4. Comparison of Wire Strike Statistics for Two Decades

Period	1970-1979	1994-2003
Total number of wire strikes	208	124
Number of fatalities	37	65
Number of serious injuries	52	45
Number of minor injuries	85	42
Total number of injuries and fatalities	174	152
Number of injuries and fatalities per wire strike	0.84	1.24

Figure 1. Table from the DOT/FAA/AR-08/25 [12]

PROJECT OUTLINE

The aim of this project is to develop a system that can resolve the problem of different flight hazards. Some of these hazards are mentioned in the call text:

- collisions with ground obstacles
- controlled flight into terrain

The rational underlying the idea of the project is that if a system can detect potential obstacles in the forward sector of the aircraft and report that information to the pilot in due time, then the pilot has a better awareness of the situation and can take the necessary actions to avoid possible collision situations.

The idea of a system that detects obstacles and reports information to the pilot originates from the direct experience of the operators and from observation of the annual EASA safety report [2]. Obstacles such as suspended wires pose a great challenge to pilots because they are particularly difficult to detect, even in good visibility. Other type of problems arise from being in challenging environments, for example mountains, but also when pilots fly outside their known fields and lose situation awareness during stressful situations, such as when flying in fog, clouds or with a high workload.

A recent case is that of a helicopter accident that occurred in the Italian Alps (August 2011), in which the blades of a single turbine helicopter, operating at very low altitude, hit rocks and a fatal accident occurred. Several other similar cases have occurred in the last few years in general aviation, including gliders that have lost visual control with the ground (and mountains) and have subsequently impacted the ground.

In the North Sea, during offshore transportation, helicopters have to approach small landing sites under adverse conditions and can accidentally hit cables or trusses. These occurrences are included in the last Annual Safety Review, related to the year 2011 and available on the EASA web site. EASA has dedicated two chapters to general aviation, in particular chapters 4: “General Aviation and Aerial Work”, related to aircraft with MTOW > 2250 kg, and chapter 5: “Light aircraft”, aircraft below 2 250 kg MTOM. In chapter 4, we can read that one of the most important categories of accidents is that of ‘Manoeuvring at low altitude’ (LALT), or related to fire fighting operations. In chapter 5, we again read, that one of the most important categories of accidents is that of ‘Manoeuvring at low altitude’ (LALT). This suggests that LALT is highly risky and that ‘Manoeuvring at low altitude’ means, in several cases, proximity to obstacles.

Technical Development

The project's main objective is to develop a radar system, focused on increasing pilot awareness and aircraft safety by surveying the volume in front of the aircraft. In order to accomplish the main goal, the project has to achieve the following scientific and technical objectives:

The project covers:

- definition of the operational requirements
- architecture of the system
- definition of anti-collision algorithms and the associated control laws
- functional simulation
- sensor/aircraft integration
- ground and flight tests
- airworthiness assessment

Being aware that such a system is applicable to various types and categories of aircraft, utilized in various fields and by different users, it is necessary to aim at simplicity and low cost. A fundamental aspect will be the interface with the pilot; it will be of utmost importance to ensure a clear and immediate “conversation” with the operator.

Radar Development

The radar is meant to detect, display and warn against potential collision with wires (especially high voltage power lines - HVPL), point obstacles (POs, including pylons, poles, structures and trees) terrain features and terrain proximity.

Pulse Doppler polarimetric radar, operating at L-band (around 1 GHz) has been designed. Special innovative algorithms were developed for distinguishing wires from other objects, assessing wires' orientations, fusing data of a number of wires' measurable attributes and creating an obstacle map for display. A partial demonstrator has been built and successfully field tested from a moving car.

The selection of L-band and polarimetric capability is mainly driven by the desire to exploit a unique feature of