Using ADS-B IN to Realize Likeness-TCAS in General Aviation

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Abstract: Based on the core technology of ADS-B and the working principle of TCAS, an airborne avionics device of Likeness-TCAS suitable for general aviation is developed. The device uses ADS-B IN technology to obtain the traffic situational awareness of the cooperative target around the aircraft, display it in the form of graph on CDTI, and determine whether there is potential conflict between the two through the basic strategy of TCAS and alarm algorithm. If there is, alarm prompt will be generated, and the pilot will be provided with the most basic simple avoidance Suggestions.

1. Introduction

With the rapid development of general aviation industry, the safe operation of general aviation has been the subject of a very important project for general aviation management departments and operating units.

In recent years, compared with transport aviation, the safety situation of general aviation accidents in China is more serious. In 2015, there were 12 traffic accidents, 18 deaths. 10 traffic accidents in 2016, 19 deaths. 6 traffic accidents in 2017, 4 deaths.

A large number of general aviation flight accident investigation shows that the failure of engine and other key parts, human error of pilots, simple structure of general aviation aircraft, lack of advanced airborne equipment, and inability to provide accurate air traffic situational awareness for pilots are important reasons for the occurrence of flight accidents. In order to prevent similar accidents and improve the safety operation ability of general aviation, on the one hand, it is necessary to strengthen the safety maintenance of aircraft itself, improve the operational ability of pilots and reduce human error; on the other hand, it is necessary to install a safe and efficient airborne equipment for general aviation aircraft, improve the situational awareness of pilots, help pilots make accurate judgments in emergency situations, take correct operations, and improve the safety operation level of general aviation.

2. Likeness-TCAS

Traffic Collision Avoidance System (TCAS) is an aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. It is an airborne device independent of ground equipment based on secondary surveillance radar (SSR) transponder signals. It communicates with each other through transponders, detects and tracks the adjacent airspace, and provides warning and recommended avoidance measures to the pilot on potential conflicting aircraft.

The function of the TCAS system is to send an interrogation signal to a nearby aircrafts, to get a response to a signal from the aircrafts' transponder device, to get the ID, height, longitude, latitude and other data of the intruding aircraft. The TCAS computer determines the threat level of the intrusion aircraft relative to this plane by means of data analysis. If there is a potential threat, the TCAS system will advise the pilot, or issue a vertical maneuver, to guide the pilot, to avoid a collision with the intruders. If there is no threat, the TCAS system will show the relative position and trajectory of the intrusion aircraft. The function schematic diagram of TCAS is shown in Figure 1.

It is a type of airborne collision avoidance system mandated by the ICAO to be fitted to all

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aircraft with a maximum take-off mass (MTOM) of over 5,700 kg (12,600 lb) or authorized to carry more than 19 passengers.For general aviation aircraft, TCAS is not mandatory, so general aviation aircraft basically do not have TCAS function, and the safety of general aviation aircraft cannot be guaranteed. This is also an important factor that leads to frequent GA accidents.

The general aviation Likeness-TCAS system studied here has the basic function of conflict detection and alarm, which can help pilots acquire the awareness of traffic situation in the air, provide proximity warning for potential dangerous approaches, and use certain algorithms to give the most basic avoidance suggestions based on the information received by ADS-B IN.

Likeness-TCAS is the system that has the basic collision detection and alarm function, the technical core of which is that no matter whether the target is a static obstacle or a moving aircraft, it can ensure that the plane can timely detect and predict the conflicts that are expected to occur, and then give the alarm information [2,3]. In order to realize this function, conflict detection and alarm technology usually includes two functional modules: conflict detection module -- perceiving and detecting the surrounding environment, and extracting useful information such as longitude and latitude position, velocity, size and azimuth of obstacles; Avoidance alarm module -- based on the effective information detected, according to the flight interval regulation of air traffic management and control, the system presets the algorithm to calculate and predict the possible conflicts and give the alarm information.

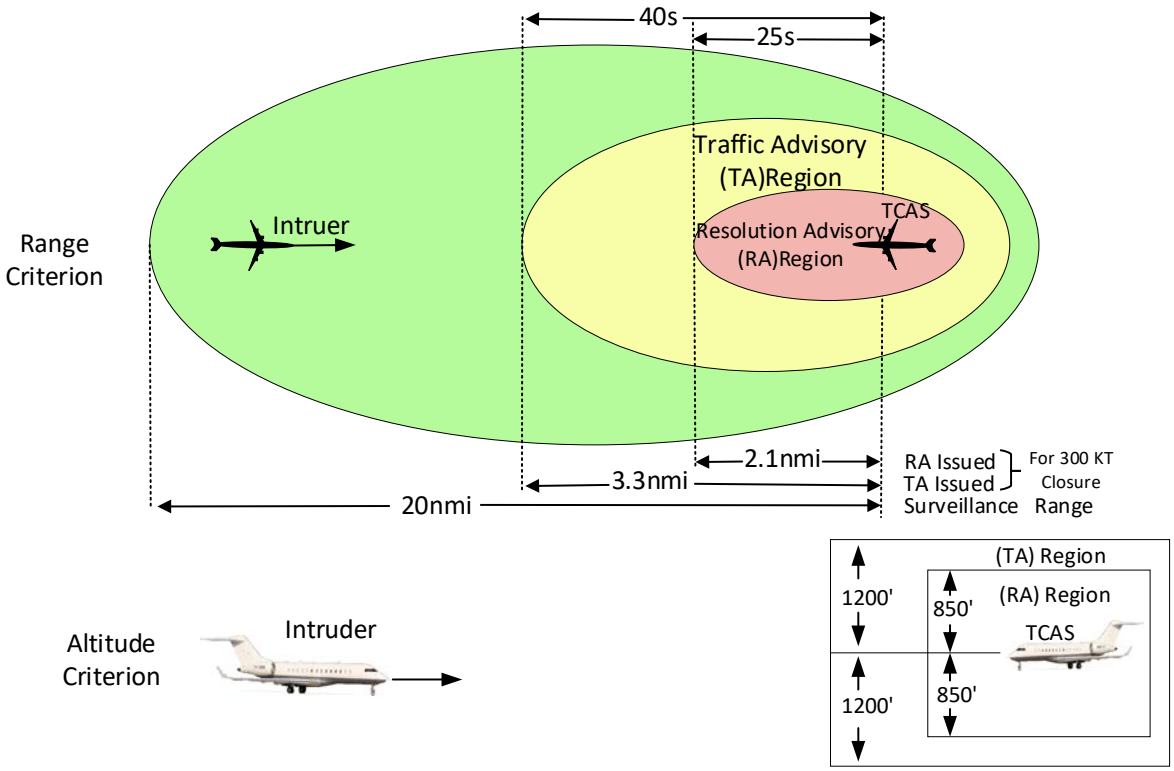

Figure.1 The function schematic diagram of TCAS

3. ADS-B In

ADS-B In is a next generation surveillance technology that provides the flight crew with an accurate picture of surrounding traffic. ADS-B Out aircraft provide broadcast messages of their identification, position, altitude, velocity, and other information. Aircraft equipped with ADS-B In capability can “see” these broadcasts from other ADS-B equipped aircraft and display them to improve the pilot’s situation awareness of other traffic, both airborne and on the ground. Suitably equipped surface vehicles may also be visible to ADS-B In capable aircraft. Aircraft that transmit on an alternate link or are transponder equipped are tracked by the FAA ADS-B ground system network and uplinked as ADS-R or TIS-B respectively.

ADS-B In avionics enable one or more of the following aircraft surveillance applications:

enhanced visual acquisition (EVAcq); basic airborne (AIRB); visual separation on approach (VSA), basic surface (SURF) (runways and taxiways, or runways only); In-Trail Procedures (ITP), ADS-B Traffic Advisory System (ATAS), and Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS). Refer to Table 1 to see which applications are supported by the four equipment classes.

The ADS-B In system includes at least one flight deck traffic display (i.e., CDTI) depicting the relative position and related information of ADS-B equipped aircraft in a plan view (bird's eye view), with the exception of audio only ATAS installations. The CDTI display may be presented on a dedicated display or integrated into and presented on an existing display (e.g., electronic flight information system (EFIS), multi-function display (MFD)).

4. Airborne Device Design

Key technologies of general aviation Likeness-TCAS mainly utilize GPS/GNSS high-precision positioning ability and ADS-B IN data communication ability to help general aviation aircraft to realize the following applications:

A) acquire situational awareness of air traffic;

B) maintain the aircraft's air safety interval;

C) understand the relative situation of other aircraft;

D) master the position of the aircraft itself.

4.1 Hardware

Avoid collision system shared ads-b monitor system of equipment, the host equipment, audio equipment, cockpit display traffic information (CDTI), power supply and other equipment, does not need to be added, and collision avoidance system should be similar to manually set "open/close anti-collision system" and "open/close collision voice prompt", and other functions, these functions can be done by setting the hardware buttons, can also be realized through software menu in the software.

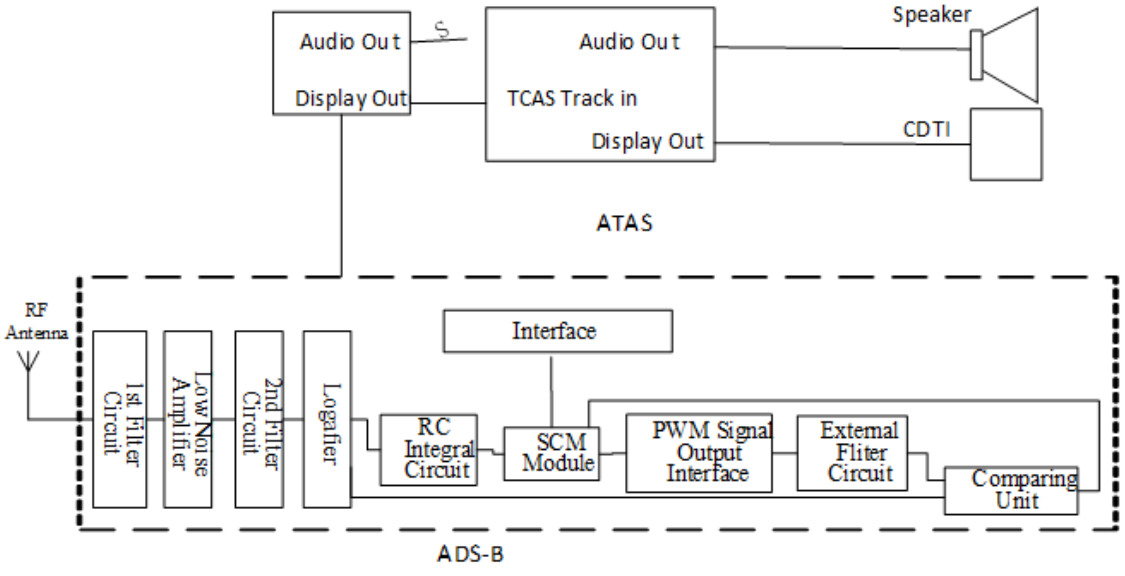

Figure.2 Intergrated Unit of TCAS based in ADS-B IN

4.2 Software development

General aviation anti-collision embedded monitoring system software, system software can be used as a function module in the monitoring system, the module contains more child module, such as monitoring within the scope of invasion of the plane and the distance from the plane calculation module, the invasion of the aircraft's flight path calculation module, the invasion of the aircraft and the aircraft collision detection module, the aircraft collision avoidance module in advance, general

emergency collision avoidance collision avoidance module, module, etc.

4.3 Display interface

CDTI shows all ADS-B data information from surrounding aircrafts by ADS-B IN airborne avionics. These aircrafts are displayed on the CDTI screen in the form of images. By clicking the small aircraft icon on the screen, more dynamic data information of the selected aircraft, such as altitude, heading and speed, can be further obtained, and the pre-flight trajectory of the selected aircraft (red) can be displayed. If the early-warning function of the aircraft is selected in the setting, the surrounding area of the aircraft will be alerted according to the set radius distance, and the early-warning algorithm of collision avoidance will be used to alert the aircraft falling into the early-warning space. The CDTI display interface is shown in figure 3.

Figure. 3 The Likeness-TCAS Display

5. Conclusion

With the increasingly standardized management of general aviation by CAAC, the mandatory requirements of ads-b as a general aviation monitoring means will also be fully implemented. Ads-b IN technology will be used to obtain the traffic situation around the aircraft, and ads-b-like TCAS system will be developed to provide conflict warning for general aviation aircraft and improve the safety of aviation operation. The flight verification experiment shows that the device has good alarm performance in the flight terminal area and can realize the basic function of conflict detection and alarm for potential flight conflicts.

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