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THEORETICAL ASPECTS RELATED TO FLIGHT SAFETY SYSTEMS IN EARLY WARNING AIR TRAFFIC CONFLICT

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Abstract: *The quick evolution of global demographic component and the intense increase in the number of aircrafts of all types, resulted a significant congestion of air routes especially in areas near large airports. To meet the new demands of air traffic services we must modernize and implement new systems for flight safety. Air collision risk is still present and therefore is remarket the idea and concept of accepting a standardized and effective warning system.*

Keywords: *collision, traffic and resolution advisory, protected volume*

1. INTRODUCTION

Since the 1950s, international civil aviation forums discussed the concept and development of a system to avoid collisions. ICAO (International Civil Aviation Organization) has developed standards for ACAS (Airborne Collision Avoidance Systems).

ACAS is designed to operate independent of both the navigation systems of the aircraft and ground equipment used for the provision of air traffic services [1,2]. Airborne Collision Avoidance System (ACAS) is the ultimate method accepted at global level regarding search and solve critical situations of air traffic between aircrafts.

The system mainly consists of the implementation of ACAS equipment onboard TCAS (Traffic Alert and Collision Avoidance System) and pilot procedures regarding the use of these systems [2,3,4]. The alerts provided by ACAS depend on how sensitive is the aircraft transponder in the considered area:

- There can be no warning if the transponder is not working or is not compatible with ICAO standards;
- TA (Traffic Advisory), intended to help the pilot to visually identify aircraft in the area considered sensitive;
- RA (Resolution Advisory) are recommended pilot maneuvers, if the transponder reports the altitude (Figure 1).

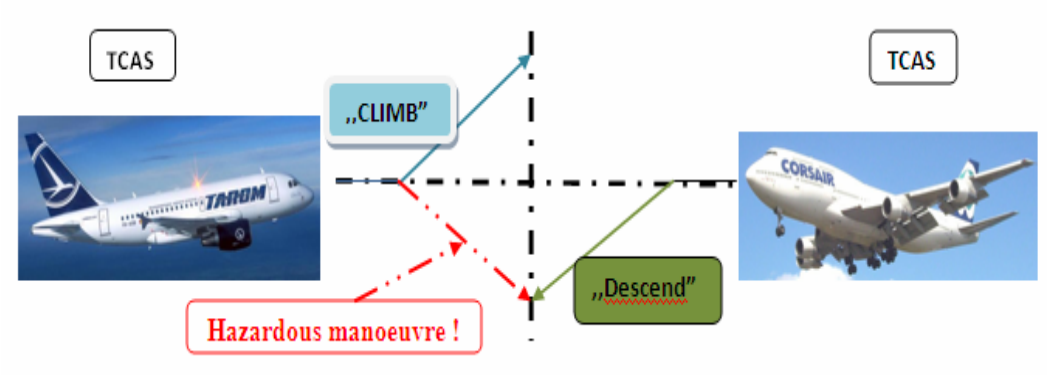

Fig.1 RA coordination example

2. ROLE

The functionality of TCAS is based on the transponder on board. The level of protection provided by TCAS equipment depends on the type of transponder which operates with the nearby aircrafts. So it is obvious that TCAS can provide protection against an aircraft not equipped with a transponder or is not operating [3,4,5, 6].

There are three types of standardized ACAS:
-ACAS I provides only TA;
-ACAS II provides TA and RA vertically;
-ACAS III provides TA and RA both vertically and horizontally.

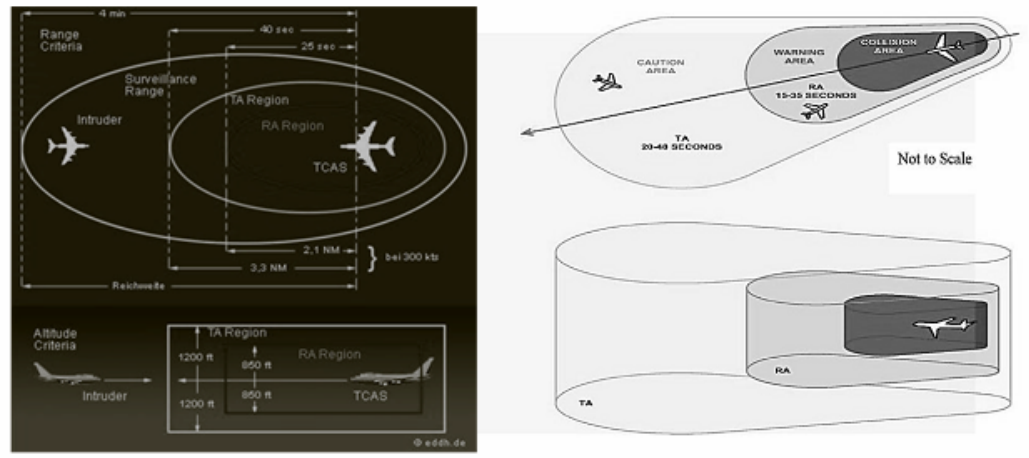

fig.2 The volume of ACAS protection between 5000 and 10000 feet

The protected volume (Fig. 2) is the represented by the airspace volume surrounding each aircraft equipped with TCAS. As shown in FIG. 2, τ is a threshold value expressed as the mean length up to the point of maximum proximity between the aircrafts or till it reaches the same altitude on both aircrafts [4, 5, 10].

In order to determine the distance and altitude, the aircraft is identified in a Cartesian coordinate system.

$$(a_n)_t=\left[(a_n)_{x,t};(a_n)_{y,t};(a_n)_{z,t}\right]^T \quad (1),$$

3D position of the aircraft equations of n and

$$(v_n)_t=\left[(v_n)_{x,t};(av_n)_{y,t};(v_n)_{z,t}\right]^T \quad (2),$$

3D expression rates where the indices x, y axes are horizontal coordinate system and z is the altitude.

On the horizontal dimension the amount of protection is not defined only by the distance threshold, but also for a estimated buffer τ . However it depends on the size and speed of the aircraft head intruder.

The first implementation of a mandatory collision avoidance system, TCAS II, was requested in the airspace of the United States starting with30 December 1993. All civil

aircrafts with turbine engine having on board more than 30 passengers flying in American airspace must be equipped with TCAS II.

In 1995, EUROCONTROL *Comitee of Management* has approved a policy implementing a mandatory program of ACAS II equipment in Europe. It was ratified by the Council of the European Air Traffic Control Projects Harmonisation and Integration Programme (EATCHIP) [6, 7, 8]. The approved policy requires that:

- starting from January 1, 2000, all civil fixed-wing aircraft and turbine engine having a maximum take-off over 15,000 kg or a maximum approved configuration for passenger seats more than 30, will have to equip themselves with ACAS II and
- starting from January 1, 2005, all civil fixed-wing aircraft and turbine engine having a maximum take-off over 5700 kg, or a maximum approved configuration for passenger seats more than 19, will have to equip themselves with ACAS II , [7, 8, 9].

3. COMPOSITION

TCAS II system components

A TCAS II (Figure 3) [1, 4, 11, 12].

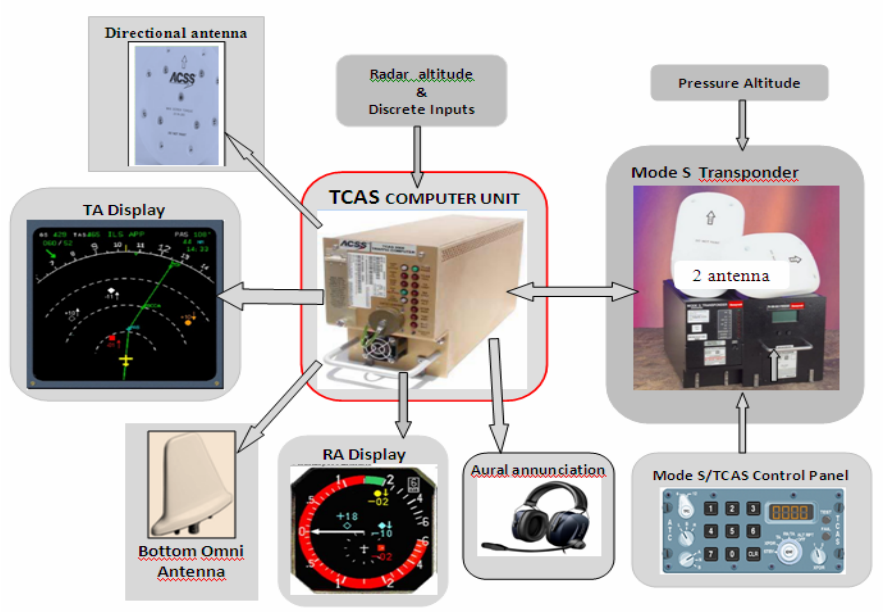

Fig.3 TCAS II system block diagram

Is composed of:

• a computer - which processes information regarding airspace surveillance, coordinates and tracking potential dangerous aircrafts, detect potential threats, calculate and determine avoidance maneuvers and making recommendations on avoiding collisions. Dual microprocessors are used to introduce surveillance system algorithms and collision avoidance to decide if a transponder response should be considered a threat and then to calculate the appropriate climb speed to avoid

the collisions. In addition data is transmitted to the screens of the pilots to inform them that they should be able to avoid the collision.

• TCAS control panel - built into the transponder. It is a 3-position selector: - Stand-by - TCAS off - TA Only - are issued only TA - Automatic or TA / RA - TCAS operation.

• two antennas - one mounted on top of the airframe, and the second at the bottom. Above is a directional antenna to increase surveillance aircraft in the sensitive area. These antennas are separated by the transponder antenna. Queries are transmitted on 1030 MHz and the responses are received on 1090 MHz, the same frequency used by SSR (Secondary Surveillance Radar).

• Connections that make it possible to receive information from other navigation systems of the aircraft:

• Mode S transponder connection - to generate complementary and coordinated RA when both aircraft are equipped with TCAS;

• Connection with altimeter - to provide pressure altitude, and / or ADC (Air Data Computer) if it is equipped with it;

• A radar altimeter connection - on one hand to restrict RA when the aircraft is near the ground, and on the other hand to determine whether the aircraft followed by TCAS is on the ground;

• Speakers - for warning sound. The speakers which are in the cockpit alert the crew by acoustic means, and are recommended by TCAS. Acoustic messages are detailed in the table below according to the type of recommendation: Traffic Advisory (TA) and Resolution Advisory (RA)

• Displays - to display relevant data.

4. CONCLUSIONS

• The implement of TCAS system on aircrafts has led to significant air safety, event which will require that all aircrafts around the globe to be equipped with these systems

• The operating characteristics of the system provides a significant improvement in the safety of flight, however, ACAS is not perfect. ACAS can not eliminate all risks of a collision.

• It was established the fact that the use of the information on the TCAS display, by pilots, as a aerial surveillance equipment is misinterpreted due to the fact that the shown information is approximate regarding the aircraft position relative to others around him.

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