Upgrading TCAS

A Eurocontrol-sponsored research project urges fast adoption of two improvements to reduce the risk of midair collisions.

REPORTS

Decision Criteria for Regulatory Measures on TCAS II Version 7.1

Eurocontrol Safety Issue Rectification Extension Plus Project (SIRE+ Project). Version 1.2. July 25, 2008. 47 pp. Figures, tables. Available via the Internet at <www.eurocontrol.int/msa/gallery/content/public/documents/SIRE+_WP7_69D_v1.2.pdf>.

The traffic-alert and collision avoidance system (TCAS) and air traffic control (ATC) radar coverage have made midair collisions of transport category aircraft rare. Nevertheless, the collision of a Tupolev Tu-154 and a Boeing 757 — both with TCAS installed — over Überlingen, Germany, in July 2002 showed that such events are still possible. To further reduce the risk, the European Organisation for Civil Aviation Equipment (EUROCAE) and RTCA have jointly developed revised minimum operational performance standards (MOPS) for traffic-alert and collision avoidance system II (TCAS II).

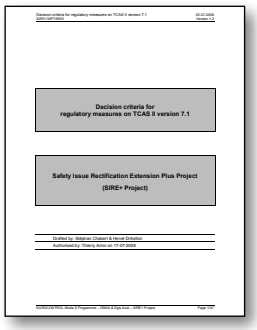
The new standards, known as TCAS II, version 7.1, are intended to improve pilot responses to resolution advisories (RAs) generated by the system. This paper by the SIRE+ Project, commissioned by Eurocontrol to study TCAS improvement, describes the rationale for the proposed TCAS II upgrade and urges a rapid transition to the new version.

There are two reasons in particular for changing the TCAS II MOPS, the paper says:

- The failure of TCAS to reverse some RAs when a reversal is required to resolve the collision; and,
- Frequent instances of flight crews' unintentional incorrect maneuvers in the wrong sense to "Adjust vertical speed" RAs. The "sense" of an RA is upward if it requires a climb or a limitation of the descent rate and downward if it requires a descent or a limitation of the climb rate.

"Due to the combination of these two safety issues, aircraft equipped with TCAS II version 7.0 face a midair collision risk … corresponding to one collision every three years in the European airspace," the paper says. "This exceeds the tolerable rate for catastrophic events related to equipment hazards by a factor of more than 25."

The first of the safety issues is designated SA01. "The design principles of TCAS II version 7.0 allow only one sense reversal, and care has been taken to ascertain the relative position of aircraft and their trajectories," the paper says. "Notably, reversing the ongoing RA is not permitted while aircraft are maneuvering in



the vertical dimension and are at co-altitude. This can lead to delaying the decision to reverse if both aircraft are climbing or descending at similar vertical speeds. In the extreme, no sense reversal can be issued although it would be required. This problem can occur either in encounters with an unequipped aircraft or in TCAS-TCAS encounters."

Safety issue SA01 can occur when two aircraft are flying at the same flight level and are converging. A very late ATC instruction then induces the crew of one aircraft to maneuver, thwarting the initial RAs.

This scenario was involved in the Überlingen accident.

The recommended modification to TCAS II for reducing the frequency of such errors, called change CP112E, "brings two significant improvements to the reversal logic of TCAS II. First, it introduces a monitoring of the aircraft vertical rate in order to detect any non-compliance with the RA sense. Then, it includes a better projection of the current aircraft trajectories to identify encounters where two co-altitude aircraft maintain similar vertical rates. The former is designed to solve occurrences of SA01 between two TCAS-equipped aircraft, while the [latter] is intended to address occurrences of SA01 with an aircraft not equipped with TCAS. If CP112E detects either situation, it relaxes the conditions for reversing the ongoing RA, so that it can occur at an earlier time than with current TCAS II version 7.0."

The second safety issue, designated SA-AVSA, occurs when flight crews unintentionally maneuver incorrectly in response to an RA of "Adjust vertical speed, adjust." The correct response is always a reduction in vertical speed — that is, a maneuver toward level flight.

"Several causes have been identified that can explain an unintentional opposite reaction to an AVSA RA, including a lack of training for this type of RA," the paper says. "However, the main factor remains the design of the AVSA RAs. First, the aural annunciation associated with AVSA RAs (i.e., 'Adjust vertical speed, adjust') does not give explicit instructions on the required maneuver. Then, some TCAS displays prove to be difficult to interpret when AVSA RAs are posted."

An example of this type of error occurred in French airspace in 2003. It involved an Airbus A320 level at Flight Level (FL) 270 (about 27,000 ft), heading south, and a second A320 cleared to climb to FL 260, heading north. The second aircraft's climb rate was about 3,300 fpm.

When passing through FL 253, its TCAS triggered an initial AVSA RA requiring a reduction in the climb rate to 1,000 fpm. However, the flight crew misinterpreted the RA and reacted by increasing the climb rate instead.

The closure rate increased between the two aircraft, and the initial AVSA RA was modified to a "Descend" RA. The flight crew followed this second RA, but the maneuver took some time to be effective and at the closest point separation was 300 ft vertically and 0.8 nm horizontally.

The proposed solution for the safety issue is designated CP115 and involves a change in the TCAS logic. Instead of a possibly confusing message of "Adjust vertical speed, adjust," and a display showing the adjustment in terms of a climb or descent rate, the RA would become a simple "Level off, level off."

The SIRE+ Project study examined various scenarios for starting and completing fleetwide implementation of version 7.1, and calculated the probabilities of collisions under each. Two specific scenarios, used as a reference for assessing all the possible start and completion times, represent possible extremes:

- The "do nothing" scenario — no implementation at all between the beginning of 2009 and the end of 2020.
- The "immediate full equipage scenario" — implementation is completed as early as the beginning of 2009.

Two specific scenarios, used as a reference for assessing all the possible start and completion times, represent possible extremes.

"When doing nothing, the number of collisions increases to more than five in 2020," the paper says. "The curve is not linear, because the number of flight hours flown in the European airspace is not constant and increases with time. This implies an increase in the risk of collision each year, as the probability of collision due to issues SA01 and SA-AVSA remains constant. If current TCAS II version 7.0 units are not upgraded to version 7.1, the estimates used in the present study indicate that the probability of a first collision at end of 2011 is very high.

"With the assumption of an immediate full equipage, the curve is also not linear for the same reason. The estimates used in the present study indicate that the probability of a first collision at the end of 2018 is very high. The number of collisions is, in January 2020, more than four times lower than if existing TCAS units are not upgraded."

The study evaluated various intermediate assumptions, including a "forward fit" process, in which version 7.1 is introduced only as new aircraft enter the fleet, and two retrofit processes: "The first one assumes a progressive retrofit of aircraft, whereas the second one assumes that airlines will wait before equipping, and then rush to retrofit their aircraft very late, close to the end of the transition phase."

The paper concludes, "The investigation of several possible scenarios for the implementation of TCAS II version 7.1 in Europe indicates that the requirement for the entry into force of this safety revision of the TCAS II equipment must be associated to an aggressive scheme in order to maximize the benefits it provides. This should notably include retrofitting the current European fleet, preferably on a progressive basis. A regulation solely based on forward fit brings only very limited benefits."

Further, the paper says, "The Überlingen accident and recurring severe incidents resulting from safety issues SA01 and SA-AVSA could have been avoided with TCAS II version 7.1. It is therefore strongly recommended that [implementation] of this new version be achieved as rapidly as possible."

WEB SITES

Safety Management: A Toolkit for Aviation, <www.casa.gov.au/sms/toolkit/index.htm>

Australian Civil Aviation Safety Authority (CASA) is offering a "tool kit [that] provides information and practical advice to help establish and maintain a safety culture in your operation," its Web site says.

The tool kit currently features three booklets and two DVDs. Instructions to order DVDs and view videos online are provided. Online viewing is free. Booklets may also be downloaded or printed and can be read separately or as an accompaniment to the DVDs. Both DVDs are in color and contain sound and supplemental text.

DVD 1 contains eight videos about safety management:

- Two give an overview of safety management, *Why and How to Implement a Safety Management System (SMS)* and *How CASA Inspectors Audit From a Systems Safety Perspective*;
- Four videos are case studies describing how four organizations — CHC Helicopters, Network Aviation, Skytrans Airlines and Quantaslink-Sunstate Airlines — apply SMS and safety culture best practices; and,

- Two videos are presentations by safety management specialists. James Reason discusses "how accidents happen" in *Managing Error and System Safety,* and in *The Long and Winding Road,* Patrick Hudson focuses on "safety case, safety culture and his experiences in the oil and gas industry."

DVD 2 contains nine videos that discuss industry best practices in organizations engaged in various aviation operations. In each video, company representatives describe how SMS was implemented in their organization and how employees operate in the SMS environment. Organizations include a company that provides airborne maintenance, a corporate jet charter company, air charter and airline companies, flight training centers and a helicopter company with multiple operations ranging from emergency medical assistance to offshore work.

The Web site contains SMS articles from the magazine *Flight Safety Australia* and a list of risk management and safety systems resources from Australia, Canada, the United Kingdom and the United States. Many of the materials are full text and can be printed or read online at no charge.

Readers can also subscribe to an SMS mailing list to receive updated information.

The International Federation of Air Line Pilots' Associations, <www.ifalpa.org>

The International Federation of Air Line Pilots' Associations (IFALPA) Web site says, "Our work, our aims and our commitment [are] achieving the highest standards of air safety worldwide. You will … find [on the site] information about the many training and other services we offer to pilots and the industry as a whole."

IFALPA has made portions of this Web site open to non-members: safety bulletins, briefing leaflets, IFALPA position statements, IFALPA's legal directory and other materials.

Briefing leaflets address various topics of pilot interest. Currently, leaflet categories

are airport and ground environment, aircraft design and operation, air traffic services, human performance and medicine, dangerous goods, security, and legal issues. Each category contains multiple titles.

Recent titles include "Use of External Lights to Mitigate Runway Incursion Risk" in the airport and ground environment category and "Health Preservation" in the human performance and medical category. Leaflets are one to 12 pages, in color, and free to download or print. Most of the leaflets have been issued in 2008.

Most safety bulletins are location- or equipment-specific, but some have general application, such as "Revised Guidance for In-Flight Passenger Electronic Equipment Fires" and "Cabin Air Quality Issues." Safety bulletins are archived to 2001.

Free wind shear posters — "Their Causes," "Warning and Alerting" and "Pilot's Rules" — can be downloaded and printed from the Web site.

Interested readers are invited to sign up to receive notification when new leaflets and other publications are added to the site.

IFALPA's journal, *InterPilot*, and *IFALPA News: The Global Voice of Pilots* are archived. They are in color and cover editions from 2005 to 2008. Issues may be printed, saved or read online at no charge.

— Rick Darby and Patricia Setze