



Interim Reports Give TCAS Mixed Reviews

During the first large-scale field testing of the traffic alert and collision-avoidance system (TCAS) in operation, controllers and pilots encountered vexing and potentially dangerous conflicts with some air traffic control procedures, including false alarms during arrivals and departures at some airports.

But they say TCAS will have great safety potential when the problems are resolved.

Editorial Staff Report

TCAS II is in use in a substantial portion of the U.S. commercial aviation fleet. Although most pilots and air traffic controllers generally agree that the system will add a positive margin of safety to air travel, many problems remain and there are serious obstacles preventing TCAS from reaching its full potential.

TCAS is an airborne, aircraft-to-aircraft collision avoidance system that electronically scans surrounding airspace, warns of potential intruders and recommends evasive maneuvers to avoid midair near-misses and collisions.

Following a year's large-scale field trials, the commercial aviation industry (and especially air traffic controllers) are nearly unanimous in agreeing that TCAS needs to be improved to reduce unnecessary alerts and excessive altitude deviations, and to avoid missed landing approaches. Nevertheless, there is also evidence that TCAS has already prevented several midair disasters.

Federal regulations mandate that all air carrier aircraft with 30 or more passenger seats have TCAS equipment installed by Dec. 31, 1993. Thus far, TCAS has been installed in about 70 percent of the nation's airliners and in at least 400 business and corporate aircraft. (TCAS II systems are designed for larger commercial air transports and recommend vertical avoidance maneuvers. A TCAS

III system, which would recommend both vertical and horizontal maneuvers, is under development.)

The international aviation community is closely monitoring the results of the interim program, as many countries consider whether to adopt the TCAS system. International airlines that operate within U.S. airspace are also subject to the TCAS mandate, and many carriers are well on the way to meeting the 1993 deadline.

However, a recently released interim report on TCAS results compiled by the TCAS II Transition Program (TTP) identified several areas where TCAS use has been found to be incompatible with existing air traffic control (ATC) procedures. The TTP was organized as a cooperative effort of the U.S. Federal Aviation Administration (FAA), the airline industry, avionics manufacturers, pilot groups and other industry representatives "to assess the operational performance of a large number of TCAS II units within the National Airspace System (NAS)."

The report said problems associated with ATC procedures included "high vertical-rate encounters, [alerts from] parallel runway operations, advisories issued when separation existed, excessive altitude displacements, loss-of-separation encounters and detection of aircraft on the ground."

Controllers polled during the TTP survey expressed “strong negative feelings toward the effectiveness and utility of today’s TCAS.” The report said controllers were particularly upset about situations where pilots responded to TCAS warnings without first notifying ATC.

“Some working controllers have indicated a desire to have TCAS disabled or operated in a TA-only (traffic alert-only) mode” until problems are resolved.

The data compiled from pilot questionnaires indicate a generally high level of acceptance. “The pilot comments indicate their acceptance of the TCAS concept and their belief that TCAS will enhance the safety of operations in the NAS. Pilots have expressed strong support for the system overall, but they consider some aspects of TCAS and its implementation unacceptable.”

A U.S. General Accounting Office (GAO) summary of surveys on the TCAS program also revealed mixed and often strident pilot and controller views on the current system. Responses to an FAA questionnaire from 2,400 pilots and 1,700 controllers underscored the concerns outlined in the TTP interim report.

“Controllers’ responses indicate a major concern about TCAS’s impact on their operations,” the GAO report said. “Controllers stated that the altitude deviations can cause aircraft to deviate to another sector, requiring rapid coordination between controllers, which increases their workload — a situation that controllers believe is unacceptable when air traffic is heavy.”

The GAO report said such incidents, along with other disruptions and delays, diminish pilot/controller confidence in the system.

Pilots also complain of frequent false alarms and aural distraction in the cockpit. The TTP report said pilots favored a reduction in TCAS advisories and modifications to eliminate false advisories in parallel runway situations and when ATC separation is being provided.

The FAA questionnaire results, reported by the GAO, identified three major concerns: “(1) TCAS has issued some resolution advisories that have caused pilots to unnecessarily leave assigned airport approaches, go around airports, and reenter landing patterns (30 instances), (2) pilots have made large altitude deviations (over 1,000 feet) in response to TCAS (86 instances), and (3) TCAS has issued unnecessary advisories while pilots were following established air traffic control procedures (359 instances).” The FAA results were based on responses from 2,400 pilots and 1,700 controllers.

The GAO, a federal oversight agency, said that 38 controllers it interviewed “agreed that TCAS is a good concept but that problems exist.” [The National Air Traffic Controllers Association has said that because TCAS disrupts air traffic, the system has thus far had a negative effect on air safety. It suggested recently that TCAS be used only in the traffic alert mode, citing numerous instances of “ghost targets” and “dangerous and unnecessary deviations commanded by TCAS that essentially overrule human controllers.” But the association has stated that air safety should improve if TCAS problems are corrected.]

The TTP interim report addressed many of the concerns voiced by controllers and pilots.

Examination of airport-vicinity TCAS problems indicated that “unnecessary RAs (resolution advisories) are being issued when an intruder aircraft climbs or descends at a high vertical rate to level off 1,000 feet below or above a level TCAS aircraft.” RAs are an indication given by TCAS that a vertical maneuver should (or should not) be performed to maintain safe separation. TA (traffic advisory) is a TCAS indication that an aircraft has entered or is projected to enter the protected area around one’s own aircraft (Figure 1).

The report said most reported TCAS RAs occurred during the departure (252) and arrival (546) segments of flight.

“The typical encounter results in a corrective RA in the cockpit of an arriving aircraft,” the TTP report said. Investigators monitored arrivals and departures at Dallas-Fort Worth International Airport to record the number of RAs issued. Arrival and departure procedures at Dallas

Resolution Advisories		
Upward Sense	Type	Downward Sense
Increase Climb to 2,500 fpm	Positive	Increase Descent to 2,500 fpm
Reversal to Climb	Positive	Reversal to Descend
Maintain Climb	Positive	Maintain Descent
Crossover Climb	Positive	Crossover Descent
Climb	Positive	Descend
•Don’t Descend	Negative vsl*	•Don’t Climb
•Don’t Descend > 500 fpm	Negative vsl*	•Don’t Climb > 500 fpm
•Don’t Descend > 1,000 fpm	Negative vsl*	•Don’t Climb > 1,000 fpm
•Don’t Descend > 2,000 fpm	Negative vsl*	•Don’t Climb > 2,000 fpm
<ul style="list-style-type: none"> Any combination of climb and descent restrictions may be given simultaneously (normally in multi-aircraft encounters). * Vertical speed limit 		
Source: U.S. Federal Aviation Administration		

Figure 1

require inbound flights to level at 11,000 feet while departing flights climb to level at 10,000 feet.

According to data collected at Dallas, a total of 43 corrective RAs were issued to TCAS-equipped aircraft in level flight. But of those 43 RAs, only 37 were followed by the air crews.

The TTP report speculated that in these instances, the crews either had the intruders in sight, the intruder's intentions were known to the TCAS aircraft crew or that ATC had informed the flight crews that there would be no conflict.

Researchers are currently working on a software logic change called "variable vertical threshold" that is expected to eliminate about 80 percent of false alarms generated by "encounter geometry" (Figure 2).

"In addition, pilots should be instructed to adhere to the practice of limiting vertical rates to less than 1,500 feet per minute in the last 1,000 feet before level-off," the report said.

TTP researchers also received more than 130 reports of TAs and RAs issued during parallel runway operations.

"These advisories can result in increased communications in the busy terminal environment, altitude displacements in crowded airspace, and, in some cases, missed approaches," the TTP report said. "All of these events result in distractions and an increased workload for controllers and disrupt normal operations."

Work is already under way to revise software to reduce the volume of "protected" airspace around the aircraft in order to reduce the number of TAs and RAs issued at low altitudes. "To minimize the occurrence of missed approaches or go-arounds, the airlines should use the results of the TTP to provide more specific guidance on the use of the TA-only mode of operation."

Another significant problem affecting ATC operations was identified as advisories issued when legal separations already existed.

"It is possible for a preventative RA to be issued when there is legal instrument flight rules (IFR) separation between two aircraft if the aircraft are not exactly on their assigned altitude," the TTP report said. The report said consideration should be given to eliminating initial (early

warning) preventive RAs, which would reduce the potential of a pilot initiating a maneuver that is not required.

Excessive altitude changes (of more than 700 feet) were also of major concern to controllers and flight crews, the TTP report said.

"While many controllers believe that any deviation is disruptive, all organizations participating in the TTP be-

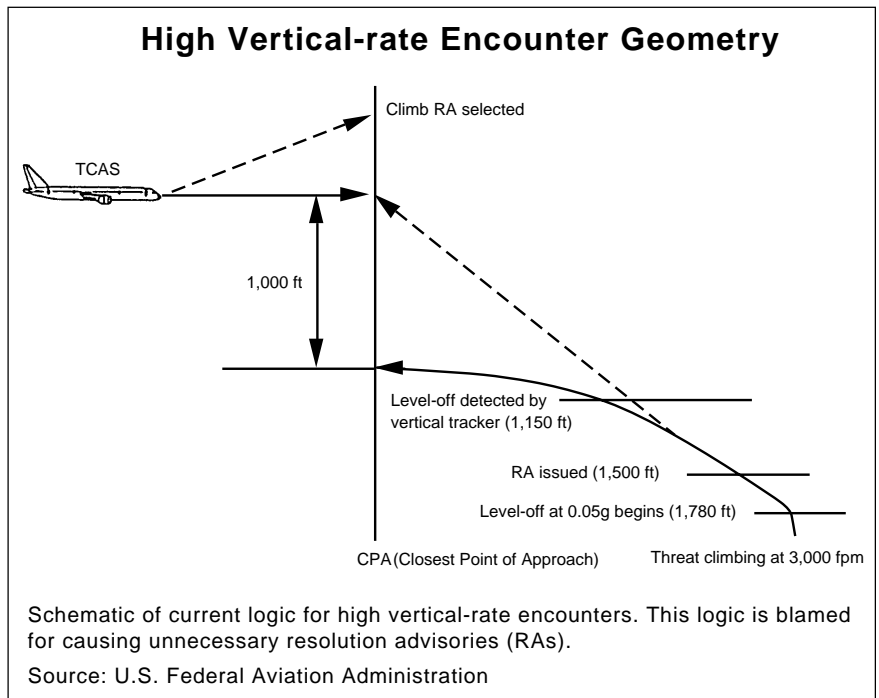


Figure 2

lieve that large altitude displacements are especially disruptive," the report said. It said display symbols and aural call-outs associated with a weakening RA are being reviewed to determine if they can be modified to minimize altitude displacement.

The GAO report noted that there is evidence that some pilots mistakenly believe that a "climb" or "descend" RA requires movement to the next legal altitude, which is 1,000 feet above or below their assigned level.

"Pilots may also not recognize or respond appropriately to TCAS's indication that they are clear of another aircraft and may therefore continue their climb or descent unnecessarily," the GAO report said.

It added that some reported deviations were exaggerated. The GAO said that of 23 reported altitude deviations in excess of 1,000 feet analyzed, "only five were actually over 1,000 feet."

Loss-of-separation encounters are also nagging problems, the TTP interim report said.

“This problem typically occurs when an RA is issued against one intruder and the response to the RA results in a loss of separation with a third aircraft that is not classified as a threat by TCAS,” the interim report said.

The report said that as more and more aircraft are equipped with TCAS, there will be an increase in TCAS-related loss-of-separation events. But it added: “Although the loss of separation is not desirable, the impacts of losing separation in this type encounter are less than the impacts of modifying the collision avoidance logic to issue RAs on the basis of criteria that are outside those currently used by TCAS.”

Irregular terrain near an airport can undermine TCAS software designed to determine that an intruder is on the ground, according to the TTP report. These advisories are a significant distraction to air crews and controllers because they are issued when the aircraft is at low altitudes.

The TTP report recommended that software changes be studied to determine the effect of increasing the altitude above which an intruder is considered to be airborne. It also suggested that TCAS operators should note in airport information manuals that collision advisories can be expected during arrivals and departures from certain runways.

The FAA also suggests that transponders be turned to “standby” or “off” when taxiing prior to takeoff or after landing to avoid triggering nearby airborne TCAS equipment.

Researchers have found that there is a need for additional training both in the control tower and in the cockpit.

The studies indicate that pilots need additional training in how to adjust TCAS controls and in how best to respond to corrective RAs, i.e., adjusting climbs and descents according to diminishing collision threats.

Controllers need to be informed about the capabilities and limitations of TCAS and need to be aware of the procedures pilots follow when they receive collision alerts. Studies indicate, for example, that not all airlines have implemented the same response requirements for pilots faced with an RA. Some operators, for example, require pilots to follow every RA, while others allow for more pilot discretion.

The FAA has been criticized for going ahead with TCAS implementation (under pressure from deadlines set by the U.S. Congress) despite tests that identified a high number of unnecessary alerts. The FAA counters that thorough tests were conducted to ensure TCAS’s overall safety.

There is also some industry concern that proposed modifications (software and other changes resulting from the TTP experience) will further complicate TCAS implementation and add safety risks.

The FAA, for example, expects to introduce modifications to reduce the length of time and distance at which TCAS sounds alerts, bringing TCAS parameters more in line with ATC separation standards. It contends the modifications can be accomplished safely while proceeding with the TCAS installation timetable.

The GAO report recommended that the FAA “fully verify and validate” all significant modifications in a coordinated effort with operators and manufacturers.

TCAS proponents say that once the system’s current problems are resolved, TCAS could eventually become a vital link not only in collision avoidance but in an overall air traffic system designed to ease congestion and increase capacity and efficiency. An FAA study on the future of air traffic management systems suggests that TCAS, when used in conjunction with satellite-based surveillance and navigation systems, will allow for reduced aircraft separation standards. ♦

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