Collision Avoidance Systems : TCAS to ACAS and Safety Assessment Policy

Presented to: TSO Workshop

By: Pat Maggard, AIR-626C

Date: September 21, 2023

Outline

- **RTCA MPS Documents**
  - TCAS II to ACAS Xa Transition
- **FAA TSOs**
- **Evolution of TCAS II and ACAS Xa Safety Assessment Criteria**
- **ACAS Xa Outside of the US**
- **Going Forward**

TCAS II to ACAS Xa

- **Move from Traffic alert and Collision Avoidance System (TCAS II) to Airborne Collision Avoidance System (ACAS) Xa**
  - ACAS Xa is a NexGen system designed to:
    - Provide enhanced algorithms for conflict resolution
    - Provide interoperability with current and future Communication Navigation Surveillance / Air Traffic Management systems, including TCAS II

Previous Minimum Operational Performance Standards (MPS)

- **DO-185B as modified by Change 1 and 2**
  - MPS for Traffic Alert and Collision Avoidance System II (TCAS II Version 7.1)
- **DO-300A as modified by Change 1**
  - MPS for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance
- **DO-385 as modified by Change 1**
  - MPS for Airborne Collision Avoidance System X (ACAS Xa and Xo)

Latest MPS Documents

- **DO-385A**
  - **MPS for Airborne Collision Avoidance System X (ACAS X) (ACAS Xa and Xo)**

Updated MPS Concepts

TCAS II evolved to address shortfalls from earlier versions and added Hybrid (ADS-B) Surveillance. To support NextGen operations, ACAS Xa has further improved upon TCAS II

- **ACAS Xa adds:**
  - Improved risk ratio (lower probability of Near Mid-Air Collision, NMAC), reduced unnecessary alerts and reduced numbers of issued RAs

Updated MPS Concepts

- **Utilizes an Optimized Resolution Logic instead of a rules/heuristics-based approach**
- **Adds new surveillance sources like ownship position and ADS-B to the Secondary Surveillance Radar for accurate cooperative aircraft tracking**
- **Updated monitor of system operation based upon accident data lessons learned**

Overall these provide increases in safety and improved collision avoidance protection for user classes

TCAS and ACAS Xa TSOs

- **TSO-C119e (Historical)**
  - TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) AIRBORNE EQUIPMENT, TCAS II WITH HYBRID SURVEILLANCE
  - Last released June 6, 2016
  - FAA stopped accepting new aircraft TSO-C119e (TCAS II) applications – March 2022
- **TSO-C219 (Current)**
  - AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS) Xa/Xo
  - Effective February 28, 2020
  - No certifications granted or applied
  - No EASA equivalent ETSO was ever produced
- **TSO-C219a (Future)**
  - AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS) Xa/Xo
  - Will align with ETSO-C219a
  - In review process

Operating Rules for Collision Avoidance Systems

§ 121.356 Collision avoidance system.

If you operate any	Then you must operate that airplane with
(a) Turbine-powered airplane of more than 33,000 pounds maximum certificated takeoff weight	(1) An appropriate class of Mode S transponder that meets Technical Standard Order (TSO) C-112, or a later version, and one of the following approved units: (i) TCAS II that meets TSO C-119b (version 7.0), or takeoff weight a later version.
	(ii) TCAS II that meets TSO C-119a (version 6.04A Enhanced) that was installed in that airplane before May 1, 2003. If that TCAS II version 6.04A Enhanced no longer can be repaired to TSO C-119a standards, it must be replaced with a TCAS II that meets TSO C-119b (version 7.0), or a later version. (iii) A collision avoidance system equivalent to TSO C-119b (version 7.0), or a later version, capable of coordinating with units that meet TSO C-119a (version 6.04A Enhanced), or a later version.
(b) Passenger or combination cargo/passenger (combi) airplane that has a passenger seat configuration of 10-30 seats	(1) TCAS I that meets TSO C-118, or a later version, or (2) A collision avoidance system equivalent to has a TSO C-118, or a later version, or (3) A collision avoidance system and Mode S transponder that meet paragraph (a)(1) of this section.
(c) Piston-powered airplane of more than 33,000 pounds maximum certificated takeoff weight	(1) TCAS I that meets TSO C-118, or a later version, or (2) A collision avoidance system equivalent to maximum TSO C-118, or a later version, or (3) A collision avoidance system and Mode S transponder that meet paragraph (a)(1) of this section.

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- Aircraft accident history and their lessons learned have continuously contributed to improvements in avionics and in Collision Avoidance Systems
- One such accident in Brazil involved a Gol Boeing 737 and Embraer 600 ferry flight in 2006
  - Though many issues contributed to this accident, the Embraer pilots did not recognize that their transponder and TCAS were not operating
  - As a result, neither aircraft received any TCAS advisories prior to colliding in a head-on aspect
  - All 157 people on the Boeing 737 aircraft perished, although the Embraer landed safely

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- These incidents led the TCAS community to consider strengthening crew alerting and address identified safety concerns. These concerns included improper application of the severity of loss of the TCAS and indications related to non-operating mode

Clarification of TCAS Safety Philosophy

- **AC 20-151 – B to C (Sec. 2.1.1)**

We view TCAS II systems as a supplement to the pilot who has the primary responsibility for avoiding midair collisions. The TCAS II system provides no protection from threat aircraft without operative transponders.

TCAS II does not alter or diminish the pilot's basic authority and responsibility to ensure safe flight.

Nevertheless, TCAS II is a safety-enhancing system that has been introduced and refined in response to accident experience, and it is required by operating rules for certain aircraft. Therefore, we consider it important for TCAS II systems to perform their intended function with adequate reliability, and for flight crews to be made aware promptly and conspicuously when TCAS failure or loss of function occurs….

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- Failure Condition Classifications have evolved from earlier versions and merit review
- TSO-C119e and earlier versions only list a single failure condition (loss of function) to “provide a reliable traffic alert and collision avoidance function”
- There is nothing stated about the impact of not providing a Resolution Advisory (RA) when it should for a valid threat

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- Previous AC versions covered “incorrect RAs” and “false RAs”
- AC 20-151C expanded failure conditions
  - Emphasized un-annunciated loss of capability
  - Added definition for a **“Missing RA”**
    - A RA that does not occur or is late when a threat is present
  - Refined existing mitigations of see-and-avoid and ATC services to allow for higher failure probabilities than usual for the severity level
    - These mitigations do NOT allow the failure severity to be lowered to “minor” or “no safety effect”

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- The TSO-C219 for ACAS Xa incorporated the new failure condition classifications from AC 20-151C
  - Incorrect and Missing RAs: **Hazardous/Severe-Major**
  - False RAs: **Major**

Evolution of TCAS II and ACAS Xa Safety Assessment Criteria

- Instances of Applicants and ACOs incorrectly assessing unannunciated loss of TCAS II functionality as minor, or even “no safety effect”, have been encountered (and persist)
  - Unannunciated loss of function is a failure that can result in a Missing RA
- TCAS II and ACAS Xa must meet § 25.1301(a)(4) & comparable – must function properly when installed
- System failures (unannunciated and latent) are more likely to be introduced in software or in Airborne Electronic Hardware (AEH)
  - The Design Assurance Level where the system failure results in unannunciated missing or incorrect RA must be developed to Level B of DO-178C
  - The FAA has considered the mitigation provided by see-and-avoid and ATC services by allowing an increase in the probabilities of failure above typical DAL B levels

ACAS Xa Outside of US

- European Rule (EU No 1332/2011) requires the use of ACAS II version 7.1
  - TCAS II in US parlance
  - ACAS Xa not currently allowed – rulemaking in work
- The US(FAA) and Europe(EASA) have worked closely on synchronization and harmonization for the TSO/ETSO and AC/ACNS documents in support of the ACAS Xa

Going Forward

- TCAS II version 7.1 and ACAS Xa are allowed for compliance with current US operating rules
- FAA TSO-C219a is in review process
- EASA is in Rulemaking to allow ETSO-C219a
- AC in work to replace AC 20-151C
- Other ACAS X variants are in different stages of development
  - Xu – Unmanned aircraft
  - sXu – Small unmanned aircraft
  - Xr – Rotorcraft and AAM

Pat Maggard
816-329-4185
patrick.j.maggard@faa.gov

Matthew Haskin
202-267-2964
matthew.d.haskin@faa.gov

Gregg Nesemeier
202-748-4840
gregg.nesemeier@faa.gov