U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Operational Use of Airborne Collision Avoidance Systems

Date: 11/20/24 **AC No:** 90-120
Initiated by: AFS-400 **Change:**

This Advisory Circular (AC) provides an acceptable means, but not the only means, to address operational use of Collision Avoidance Systems (CAS), including Airborne Collision Avoidance Systems (ACAS) and Traffic Alert and Collision Avoidance Systems (TCAS). Approval of an ACAS II for a Federal Aviation Administration (FAA) Type Certificate (TC) or Supplemental Type Certificate (STC) is comprehensively addressed in AC 20-151, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 and 7.1 and Associated Mode S Transponders. This AC provides information for Title 14 of the Code of Federal Regulations (14 CFR) part 91, 121, 125, 129, and 135 operators; and other aviation organizations regarding standard means acceptable to the FAA to establish and ensure continued compliance with 14 CFR as related to ACAS. This information is intended to promote timely and comprehensive program implementation, to encourage development of standard practices for the application of ACAS, and to provide for suitable followup for ACAS events. ACAS does not alter nor diminish the responsibility or authority of a flightcrew to ensure a safe flight. ACAS alone does not ensure safe separation in every case. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

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CHAPTER 1. GENERAL

1.1 Purpose of This Advisory Circular (AC). This AC provides an acceptable means, but not the only means, to address operational use of Airborne Collision Avoidance Systems (ACAS) in compliance with Title 14 of the Code of Federal Regulations (14 CFR) part 91, 121, 125, 129, and 135 requirements. Title 14 CFR uses the term Collision Avoidance System (CAS) or Traffic Alert and Collision Avoidance System (TCAS) to describe what Title 49 of the Code of Federal Regulations (49 CFR) and the international community has named ACAS. Other traffic awareness systems, such as Automatic Dependent Surveillance-Broadcast (ADS-B) Traffic Advisory System (ATAS), are not covered in this AC. CAS for unmanned aircraft, including Remain Well Clear (RWC) and Detect and Avoid (DAA) systems, are not covered in this AC.

1.1.1 This AC is not mandatory and does not constitute a regulation. However, if you use the means described in this AC, you should follow it in all important respects. The term "must" is used to indicate mandatory requirements when following the guidance in this AC. The terms "should" and "recommend" are used when guidance is recommended, but not required, to comply with this AC. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

1.2 Audience. This AC describes the ACAS operational approval process, acceptable methods for ACAS training, acceptable programs for maintenance, operational policies for ACAS use, appropriate actions for ACAS events, and criteria for foreign operator use of ACAS in U.S. airspace. This AC applies to:

- Air carriers operating under 14 CFR parts 121 and 135 and other organizations conducting air carrier training (e.g., training centers or aircraft manufacturers);
- Title 14 CFR part 91 subpart K (part 91K) fractional ownership operations;
- Operations of large airplanes under 14 CFR part 125;
- Foreign air carriers conducting operations in U.S. airspace under 14 CFR part 129;
- Title 14 CFR part 142 training centers;
- Aircraft operating under 14 CFR part 91 appendix G; and
- ADS-B Out equipment requirements where the operator chooses to install an ACAS.

1.3 Where You Can Find This AC. You can find this AC on the Federal Aviation Administration's (FAA) website at https://www.faa.gov/regulations_policies/advisory_circulars and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

1.4 What This AC Cancels. AC 120-55C, Air Carrier Operational Approval and Use of TCAS II, dated February 23, 2011, is canceled.

1.5 Summary of Changes. This AC includes the following changes:

- Defines TCAS and ACAS;
- Incorporates information from FAA Booklet HQ-111358, Introduction to TCAS II Version 7.1; and International Civil Aviation Organization (ICAO) Doc 9863, Airborne Collision Avoidance System (ACAS) Manual;
- Incorporates ACAS II changes, including ACAS Xa and ACAS Xa with Xo;
- Addresses minimizing TA-ONLY mode operation to emphasize ACAS II operation in Traffic Advisory (TA)/Resolution Advisory (RA) mode to the maximum extent feasible while airborne; and
- Incorporates Safety Management System (SMS) guidance and ACAS II operating features.

1.6 AC Feedback Form. For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

CHAPTER 2. ACAS DESCRIPTION AND OPERATION

2.1 ACAS Description. ACAS was developed as a safety-enhancing system to reduce the likelihood of midair collisions between aircraft. ACAS is a family of airborne devices that functions independently of the ground-based Air Traffic Control (ATC) system and provides collision avoidance for a broad spectrum of aircraft types. ACAS iterations include Traffic Alert and Collision Avoidance System (TCAS) I, TCAS II, and ACAS Xa. TCAS I and II differ primarily by their advisory capability, with TCAS II including recommended vertical maneuvers. ACAS Xa was developed as an evolutionary enhancement to TCAS II version 7.1. From a flightcrew perspective, ACAS Xa provides the same collision avoidance prevention as TCAS II but is designed to improve airborne collision risk mitigation while reducing unwanted Resolution Advisories (RA). In this AC, TCAS I will be referred to as ACAS I. TCAS II and ACAS Xa will be referred to as ACAS II unless there is a need to specify the iteration to show the changes between systems (e.g., TCAS II has limitations that are not present in ACAS Xa).

2.2 ACAS Types.

2.2.1 ACAS I provides Traffic Advisories (TA) that indicate on a display the bearing, range, and altitude relative to own-ship of nearby aircraft with an operating transponder to assist the flightcrew in the visual acquisition of what is referred to as an "intruder aircraft."

2.2.2 ACAS II provides both TAs for intruder aircraft and RAs for what is referred to as "threat aircraft." RAs are recommended vertical maneuvers, or vertical maneuver restrictions that maintain or increase the vertical separation between aircraft to mitigate the risk of airborne collision.

2.2.3 ACAS III is in development and will incorporate RAs with vertical and horizontal maneuvers for collision avoidance.

2.3 ACAS II Variants.

2.3.1 With the introduction of ACAS Xa, the FAA now permits four variants of ACAS II in U.S. airspace: TCAS II version 6.04A Enhanced, TCAS II version 7.0, TCAS II version 7.1, and ACAS Xa including optional ACAS Xo features. If an aircraft has an ACAS II installed, it must be TCAS II version 7.0, TCAS II version 7.1, or ACAS Xa to operate within Reduced Vertical Separation Minimum (RVSM) airspace. Operators conducting maintenance on ACAS units should consider upgrading to the latest version of ACAS. Operators flying outside of U.S. territorial airspace are advised to ensure that appropriate ACAS software updates are incorporated for compatibility with oceanic and international equipage and operation standards. International requirements differ by type of operation, type of aircraft, and airspace entry requirements. Refer to documents of the International Civil Aviation Organization (ICAO) and the Aeronautical Information Publication (AIP) of the Civil Aviation Authority (CAA) with jurisdiction of the airspace to be flown for more information.

2.3.2 A new family of systems called Airborne Collision Avoidance System X (ACAS X) was developed as the next evolution of collision avoidance to continue to be effective in

changing airspace, as well as to extend Collision Avoidance System (CAS) usage to new entrants. ACAS X adds versatility to allow for installation on other aircraft types, reduces advisories, and reduces 1030/1090-megahertz (MHz) spectrum saturation. This AC will be limited to the ACAS X variants known as ACAS Xa and Xo. ACAS Xo is ACAS Xa with added capability for certain operations (e.g., Closely Spaced Parallel Operations (CSPO)). See Table 2-1.

Table 2-1. Collision Avoidance System Nomenclature

Type	Iteration	Version	TSO
ACAS I	TCAS I	N/A	C118a
ACAS II	TCAS II	TCAS II v 6.04A Enhanced	C119a
		TCAS II v 7.0	C119b
		TCAS II v 7.1	C119c
		TCAS II v 7.1 w/ HS	C119d–e
	ACAS II	ACAS Xa	C219a
		ACAS Xa w/ Xo options	C219a
ACAS III	TBD	In development	TBD

2.4 Active Surveillance. ACAS, independent of any ground inputs, performs surveillance to provide the bearing, range, and altitude of nearby aircraft relative to own-ship. ACAS will receive squitters (nonsolicited data messages) from nearby aircraft operating a Mode Select (Mode S) transponder and send discrete interrogations to the individual transponders on a frequency of 1030 MHz. The transponders of the nearby aircraft respond to the interrogation using a 1090 MHz transmission. The reply from the interrogation is used to determine range and bearing of the aircraft from own-ship. If altitude reporting is included in the interrogation response, the ACAS processor is provided the pressure altitude of the aircraft (the height above a Standard Datum Plane (SDP), a theoretical level where the weight of the atmosphere is 29.92 inches of mercury (inHg)/1013.25 millibars (mb)). ACAS surveillance of nearby aircraft operating Mode A transponders uses responses to an all-call interrogation. All nearby Mode A transponders reply to the all-call interrogation. Due to the nondiscrete nature of Mode A transponder interrogation, ACAS uses various techniques to screen out overlapping replies. ACAS interrogates transponders within a nominal range of at least 14 nautical miles (NM). Surveillance range can be reduced in geographic areas with a large number of ground interrogators and/or aircraft operating ACAS II. ACAS will interrogate transponders that are closer to own-ship more frequently than aircraft that are farther away.

2.5 Passive Surveillance. ACAS Xa/Xo and some TCAS II versions incorporate passive surveillance utilizing Automatic Dependent Surveillance-Broadcast (ADS-B) Out, and optionally Automatic Dependent Surveillance-Rebroadcast (ADS-R), information. Passive surveillance reduces the amount of 1030/1090 MHz frequency congestion, as the

ACAS aircraft will interrogate the other aircraft less frequently until the range of the aircraft decreases to a predetermined distance, and ACAS II then switches to active surveillance. This combination between active and passive surveillance is known as Hybrid Surveillance (HS). ACAS Xa/Xo takes advantage of the improved accuracy of ADS-B surveillance by using ADS-B reports that have been validated by active interrogations to generate ACAS advisories. ACAS II does not use Universal Access Transceiver (UAT) 978 MHz for HS, and a UAT-only aircraft will not generate a TA or an RA. ACAS II does use ADS-B from 1090 MHz Extended Squitter (ES) for HS, and ACAS Xa may use validated 1090 MHz ADS-B for TA generation. RAs are generated only with active surveillance of an aircraft with an altitude reporting transponder.

2.6 Levels of Protection. The level of protection provided by ACAS II-equipped aircraft operating in TA/RA mode depends on the type of equipment that the other aircraft is equipped and operating, including mode selection. See Table 2-2, Levels of Protection.

2.6.1 Aircraft without an operating transponder will not be shown on the traffic display (unless own-ship is equipped with ADS-B In, and the other aircraft is broadcasting ADS-B Out), and there will be no advisories generated for such aircraft.

2.6.1.1 If own-ship is equipped with ACAS Xa with the ADS-B Only TA-ONLY (AOTO) option, and the other aircraft is equipped with ADS-B Out (1090 MHz, not 978 MHz UAT) but does not have an operational transponder. The AOTO option allows aircraft with operating ADS-B Out without an operating transponder to be displayed and to generate a TA. RAs will not be generated for this aircraft. Not all ACAS Xa systems include this functionality. Refer to the Aircraft Flight Manual (AFM) or Aircraft Flight Manual Supplement (AFMS) for details.

2.6.1.2 Some aircraft may be equipped with both ACAS II and ADS-B Traffic Advisory System (ATAS). ATAS may provide an advisory similar to a TA based on ADS-B Only. ATAS does not provide RAs. Refer to the AFM or AFMS for details.

2.6.1.3 If own-ship transponder is switched off or fails, own-ship ACAS II switches to standby, and own-ship may not be detected by ATC secondary surveillance radar or other aircraft operating ACAS.

2.6.1.4 Pilots of Visual Flight Rules (VFR) aircraft are advised to operate an altitude reporting transponder in all airspace classes to permit the aircraft operating ACAS to generate TAs and RAs, as appropriate.

2.6.2 An aircraft operating a transponder with altitude reporting will allow for the generation of an RA in an aircraft operating ACAS II.

2.6.3 An aircraft operating a transponder without altitude reporting, also known as non-altitude reporting aircraft, will not cause an RA to be generated regardless of actual collision hazard. Non-altitude reporting aircraft may cause a TA to be generated, but the data tag for the aircraft will be omitted from the traffic display.

2.6.3.1 If own-ship is above a pressure altitude of 15,500 feet, the non-altitude reporting aircraft is filtered out. In this case, non-altitude reporting aircraft will neither be displayed nor generate an advisory.

2.6.3.2 If own-ship altitude reporting is switched off or fails, own-ship will not be fully protected and may not be depicted on the traffic display of other aircraft operating ACAS. If the pressure altitude data fed to the transponder is incorrect, the error will be propagated in other aircraft ACAS and ATC systems. Consequently, ATC will not know the actual altitude of the aircraft, and ACAS advisories may be generated incorrectly, or ACAS may not generate advisories when needed. Flightcrews are advised to verify that the altimeter and transponder system has been correctly maintained and inspected and to monitor transponder operation, including altitude reporting.

2.6.4 If both aircraft are equipped with ACAS II, and both aircraft are operating in TA/RA mode, both aircraft can generate a coordinated RA that generates complementary vertical maneuvers or lack of maneuvers (e.g., one ACAS II unit generates a climb RA and the other a descend RA).

2.6.5 ACAS II does not generate horizontal maneuvers. This functionality is planned for ACAS III systems.

Table 2-2. Levels of Protection

	Own-Ship (equipment and operating mode)	
Other Aircraft (equipment and operating mode)	ACAS II (TA-ONLY) or ACAS I	ACAS II (TA/RA)
No Transponder/ Transponder Off	No ACAS protection	No ACAS protection
No Transponder, but Transmitting 1090 MHz ADS-B Out	ADS-B Only TA-ONLY (ACAS Xa only)	ADS-B Only TA-ONLY (ACAS Xa only)
Non-Altitude Reporting	TA (no protection above 15,500 feet pressure altitude)	TA (no protection above 15,500 feet pressure altitude)
Transponder with Altitude Reporting	TA	TA and RA
ACAS II (TA-ONLY) or ACAS I	TA	TA and RA
ACAS II in TA/RA Mode	TA	TA and coordinated RA

2.7 Advisory Thresholds.

2.7.1 TCAS II primarily uses the measure of the time to the Closest Point of Approach (CPA) rather than distance to determine when to generate a TA or an RA.

2.7.2 Time to CPA is also indicated by the Greek symbol tau (τ). Tau thresholds (trigger points for the generation of an advisory) vary with the altitude of own-ship, with less time to CPA at lower altitudes. The TA tau threshold varies from 20 to 48 seconds before the projected CPA, and the RA tau threshold varies from 15 to 35 seconds.

2.7.3 At close ranges and slow closure rates, TCAS II uses a fixed horizontal distance threshold called Distance Modification (DMOD) at or less than the relative altitude (altitude difference between own-ship and another aircraft) threshold called Z-axis Threshold (ZTHR) to determine when to generate a TA or an RA. DMOD thresholds vary with altitude of own-ship, with less distance at lower altitudes.

2.7.3.1 Fixed distance advisories are more likely to occur during CSPO, especially at higher elevation airports, where aircraft are in a higher Sensitivity Level (SL) during approach.

2.7.4 SLs are based on the altitude of the aircraft. The higher the altitude of the aircraft operating TCAS II is, the greater the time to CPA and larger the fixed distance thresholds (horizontal and vertical) become. ACAS Xa does not use SLs. ACAS Xa was designed to provide advisory thresholds similar to TCAS II across these altitude bands. See Table 2-3.

Table 2-3. TCAS II Advisory Thresholds

		Seconds to CPA (tau)		DMOD (NM/feet)		ZTHR (feet)	
Own Altitude (feet)		**TA**	**RA**	**TA**	**RA**	**TA**	**RA**
0–500	AGL	N/A	N/A	N/A	N/A	N/A	N/A
500–1000	AGL	20	N/A	0.3/1822	N/A	850	N/A
1000–2350	AGL	25	15	0.33/2005	0.20/1215	850	600
2350–5000	SDP	30	20	0.48/2916	0.35/2126	850	600
5000–10000	SDP	40	25	0.75/4557	0.55/3341	850	600
10000–20000	SDP	45	30	1.00/6076	0.80/4861	850	600
20000–42000	SDP	48	35	1.30/7898	1.10/6684	850	700
Above 42000	SDP	48	35	1.30/7898	1.10/6684	1200	800

2.7.5 ACAS Xa is designed to provide advisory thresholds that are like TCAS II, but ACAS Xa does not directly use time to CPA (tau), DMOD, or ZTHR. ACAS Xa uses an alternative risk-based approach for RA generation. ACAS Xa generates advisories based on perceived risk and filters out many potential RAs where the estimated risk is low.

2.7.5.1 ACAS Xo is an option on an ACAS Xa platform that has additional equipment and features intended for aircraft to desensitize RA thresholds in certain airport environments.

2.7.5.1.1 ACAS Xo provides a Designated No Alert (DNA) capability intended for use in visual separation procedures, such as visual approach procedures to closely spaced parallel runways that are likely to trigger unwanted RAs. TA and RA thresholds are suppressed for a single designated aircraft while full ACAS II TA/RA mode protection is provided against all other aircraft. The flightcrew visually acquires the traffic within 6 NM laterally before designating it as a DNA aircraft. If there is a multiple threat encounter involving the designated aircraft, DNA mode will suspend automatically. If the designated aircraft diverges from own aircraft by more than 6 NM, the aircraft will be undesignated.

2.7.5.1.2 The ACAS Xo CSPO-3000 function provides advisory threshold logic appropriate for use in Instrument Meteorological Conditions (IMC) during CSPO down to a runway centerline spacing of 3,000 feet and below a pressure altitude of 14,000 feet. When enabled, CSPO-3000 will still provide TAs and RAs on blundering designated traffic. CSPO-3000 mode is unavailable when own-ship is above a pressure altitude of 14,000 feet, and any time in TA-ONLY mode.

2.8 Types of ACAS RAs.

2.8.1 RA Generation. TCAS II uses projected separation at CPA based on tau, DMOD, and ZTHR to determine RA guidance. The RA is intended to provide adequate vertical miss distance from the threat aircraft while generally minimizing the disturbance to the existing flight path.

2.8.1.1 ACAS Xa threat logic estimates the potential collision risk based on the relative position and velocity of nearby aircraft and generates an RA when warranted. ACAS Xa provides the same advisories as TCAS II with some small variations in the aural annunciations (e.g., Maintain Vertical Speed RAs changed to the corresponding climb or descend advisory).

2.8.1.2 ACAS Xa is unchanged from TCAS II with respect to low altitude inhibits, handling of bearingless and non-altitude reporting aircraft, and interaction with higher priority alerts (e.g., stall warning, Terrain Awareness and Warning System (TAWS) “Pull Up” alert, or windshear warning).

2.8.1.3 ACAS Xa will generate RAs less often when compared to TCAS II while maintaining an equivalent airborne collision risk mitigation.

2.8.2 Multiple Threat Encounters. ACAS II is designed to handle multiple threat encounters (encounters where more than one threat is active at the same time). ACAS II will attempt to resolve these types of encounters by selecting a single or composite (initial and subsequent) RA that will provide adequate vertical separation from each of the threat aircraft.

2.8.3 Preventive or Corrective. RAs can be classified as preventive or corrective. Corrective RAs require a change in vertical speed while preventive RAs do not. Preventive RAs instead generate restrictions of vertical speeds.

2.8.4 Coordinated RAs. ACAS II uses explicit coordination, meaning that in an encounter where two ACAS II-equipped aircraft operating in TA/RA mode declare each other a threat, ACAS II will generate RAs based on a real-time exchange of the sense (vertical direction) of the RA. In coordinated ACAS II encounters, nominally, one aircraft will declare the other aircraft to be a threat slightly earlier than the other. The first aircraft that declares the other to be a threat verifies that a coordination message has not been received from the other aircraft, generates an RA based on the encounter geometry, and transmits an intent message (vertical direction of the generated RA) through the Mode S transponder to the other aircraft. The second aircraft, having already received an intent message from the first aircraft, will generate a complementary RA. The complementary RA generated is transmitted back to the other aircraft. Occasionally, the two aircraft declare each other as threats simultaneously, and both aircraft will generate an RA independently based on the encounter geometry. There is a chance that noncomplementary RAs are generated. When this happens, as a tiebreaking function, the ACAS II in the aircraft with the higher 24-bit Mode S transponder address will detect the selection of a noncomplementary RA and generate an RA in the opposite direction. ACAS II versions 7.0 and higher added the capability for ACAS II to issue RA reversals in coordinated encounters if the encounter geometry changes after the initial RA is issued.

2.8.5 Initial RAs. When ACAS II declares an aircraft a threat, ACAS II will check to see if a coordination message has been received from another ACAS II aircraft. If a coordination message is received, ACAS II will exclude noncomplementary RA possibilities. If a coordination message is not received, ACAS II logic is free to select an RA sense (vertical direction) and strength (the degree of restriction placed on the vertical flight path or the magnitude of the altitude rate change) that best fits the encounter. ACAS II is designed to generate the RA sense and strength that is the least disruptive to the existing flight path, while still providing the desired vertical miss distance (vertical separation). ACAS II logic prefers to generate an RA with a vertical path that will not cross through the vertical path of the threat aircraft. If ACAS II computes that crossing the vertical path of the threat aircraft is required to obtain the desired vertical miss distance, the generated RA will announce, “Crossing” (e.g., “Climb, Crossing Climb”).

2.8.5.1 TCAS II utilizes the range and altitude tracks of the threat aircraft to model the expected threat aircraft flight path from its present position to CPA. Then, an RA sense is selected that maximizes vertical miss distance. The RA

strength is selected to achieve the required vertical miss distance while minimizing ATC clearance deviations.

2.8.5.2 ACAS Xa logic considers imperfect sensor information when deciding if an RA is to be generated. ACAS Xa uses a probabilistic distribution to account for uncertainty in the position and velocity of other aircraft.

2.8.5.3 ACAS Xa logic considers the uncertainty of what the pilot of the other aircraft will do to balance safety (i.e., vertical miss distance at CPA) with operational considerations (e.g., mitigation of ATC clearance deviation).

2.8.5.4 ACAS Xa RA generation decision making is completed by combining the results from a precomputed lookup table (offline costs) with algorithms running on board (online costs).

2.8.6 Subsequent Advisories. After an initial RA, subsequent advisories will be generated to strengthen, reverse, weaken, or cancel the initial advisory.

2.8.6.1 **Strengthened Advisories.** ACAS II may generate a strengthened RA that increases the vertical speed required to comply with the RA (i.e., from "Climb, Climb" to "Increase Climb, Increase Climb") to achieve a satisfactory vertical separation at CPA. Strengthened advisories may be the result of an RA response by own-ship flightcrew that is delayed, weak, or noncompliant. A strengthened advisory may also result from a threat aircraft maneuvering vertically in a manner that thwarts the effectiveness of the initial RA.

2.8.6.2 **Reversal Advisories.** ACAS II may generate a reversal RA that reverses the direction of the previous RA (i.e., from "Climb, Climb" to "Descend, Descend NOW, Descend, Descend NOW") to achieve a satisfactory vertical separation at CPA. Reversal advisories may be the result of an RA response by own-ship flightcrew that is delayed, weak, or noncompliant. A reversal advisory may also result from a threat aircraft maneuvering vertically in a manner that thwarts the effectiveness of the initial RA. Flightcrews are advised to respond to reversals immediately, as the reversal RA is not likely to reverse again.

2.8.6.3 **Weakened RAs.** During an RA, if ACAS II determines that the response to an RA has provided the desired vertical separation prior to CPA, the initial RA will be weakened to minimize the displacement from the original altitude (i.e., "Level Off, Level Off").

2.8.6.3.1 Incidents have occurred where a flightcrew misinterpreted the "Adjust Vertical Speed, Adjust" RA of TCAS II version 7.0 and exacerbated the situation by increasing the vertical speed. These incorrect reactions have caused altitude deviations and losses of separation. The "Adjust Vertical Speed, Adjust" RAs require a reduction of the vertical speed. "Adjust Vertical Speed, Adjust" RAs are not present in TCAS II version 7.1/ACAS Xa, and are replaced with a "Level Off, Level Off" RA. The response to the "Level Off, Level Off" RA is to reduce the vertical rate to zero feet per minute (fpm). The

level off must be achieved promptly, not at the next Flight Level (FL). Flightcrews are advised after a "Level Off" RA to stay in level flight until a "Clear of Conflict" message or another RA is generated.

2.8.6.4 Clear of Conflict. After CPA is passed and the range between own-ship and threat aircraft begins to increase, or if ACAS II determines prior to CPA that there will be sufficient Horizontal Miss Distance (HMD) and/or Vertical Miss Distance (VMD), all RAs are canceled. ACAS will annunciate "Clear of Conflict," and all visual RA guidance is removed.

2.8.6.4.1 If ACAS II switches from TA/RA mode to TA-ONLY either automatically (e.g., low altitude inhibit or higher priority alert) or manually during an RA, the RA will be removed without the "Clear of Conflict" annunciation. In this case, the removal of the RA does not indicate a sufficient vertical or lateral separation has been achieved.

Table 2-4. Resolution Advisories, TCAS II Version 7.1 and ACAS Xa

Advisory	Aural
TA	Traffic, Traffic
Climb	Climb, Climb
Descend	Descend, Descend
Crossing climb	Climb, Crossing Climb — Climb, Crossing Climb
Crossing descend	Descend, Crossing Descend — Descend, Crossing Descend
Level off	Level Off, Level Off
Reversal climb	Climb, Climb NOW — Climb, Climb NOW
Reversal descend	Descend, Descend NOW — Descend, Descend NOW
Increase climb	Increase Climb — Increase Climb
Increase descent	Increase Descent — Increase Descent
Maintain rate	Maintain Vertical Speed, Maintain (TCAS v 7.1) Descend, Descend or Climb, Climb (ACAS Xa)
Crossing, maintain rate	Maintain Vertical Speed, Crossing Maintain (TCAS v 7.1) Descend, Crossing Descend/Climb, Crossing Climb (ACAS Xa)
Preventive (no change in vertical speed required)	Monitor Vertical Speed
RA removed	Clear of Conflict

2.9 Traffic Display. Traffic information may be depicted on a dedicated display, shared display, or a part-time (popup) display. Refer to the AFM/AFMS for details. Traffic display information is intended to assist flightcrews in the search for, and visual acquisition of, airborne aircraft to avoid collisions. ACAS serves as a backup to visual collision avoidance, the application of right-of-way rules, and ATC separation services. The nomenclature "advisory" notwithstanding, the FAA considers that TAs generally require immediate flightcrew awareness and potentially a subsequent flightcrew response. RAs generally require immediate flightcrew awareness and immediate flightcrew response by complying with the RA in a timely manner. In accordance with 14 CFR § 25.1322, TAs are displayed in a yellow or amber color and correspond to a Caution-level alert. RAs are displayed in a red color and correspond to a Warning-level alert. See Table 2-5, Traffic Display Symbology Examples.

2.9.1 Traffic Display Symbology.

2.9.1.1 Own-ship is displayed as a white or cyan aircraft-like symbol.

2.9.1.2 The Other Traffic symbol is displayed for an aircraft that is more than 6 NM laterally or more than 1,200 feet vertically from own-ship. Other Traffic is displayed as an open diamond (outline only) in white or cyan. ACAS may not display all other aircraft operating a transponder in areas of high-density traffic.

2.9.1.3 The Proximate Traffic symbol is displayed for an aircraft within 6 NM and within 1,200 feet relative altitude. Proximate Traffic is displayed as a filled diamond in white or cyan. ACAS may not display all proximate aircraft operating a transponder in areas of high-density traffic.

2.9.1.4 The Traffic Advisory (TA) symbol is displayed for an intruder aircraft that has crossed the time to CPA or fixed distance threshold for a TA. TAs will be displayed as a yellow or amber filled circle. ACAS Xa optional AOTO may be displayed differently than a nominal TA to inform the flightcrew that the AOTO TA will not progress to an RA.

2.9.1.5 The Resolution Advisory (RA) symbol is displayed for a threat aircraft that has crossed the time to CPA or fixed distance threshold for an RA. RAs will be displayed as a red filled square.

2.9.2 Data Tag.

2.9.2.1 Relative altitude is shown using two digits with a prefix of a plus sign (+) or a minus sign (-). The prefix depicts whether the relative altitude is above with a plus sign or below with a minus sign. The two digits are the altitude difference in 100-foot increments (e.g., +09 depicts an aircraft 900 feet above the own-ship). Coaltitude (i.e., aircraft at the same altitude as own-ship) is identified as 00 without a prefix. It is possible to display traffic up to 9,900 feet away in relative altitude dependent on display settings.

2.9.2.1.1 Though the data tag indicates the altitude difference in 100-foot increments, aircraft operating Mode S transponders, including own-ship, provide ACAS with pressure altitude information in 25-foot increments. The altitude data provided to ACAS is more current and more defined than the traffic information displayed to ATC.

2.9.2.1.2 Some ACAS provide the option to change the data tag from displaying relative altitude of an aircraft from own-ship to the reported pressure altitude of displayed aircraft, also known as the FL altitude. If this display mode is selected, the data tag shows the pressure altitude information of displayed aircraft in hundreds of feet using three digits (e.g., 125 for 12,500 feet pressure altitude).

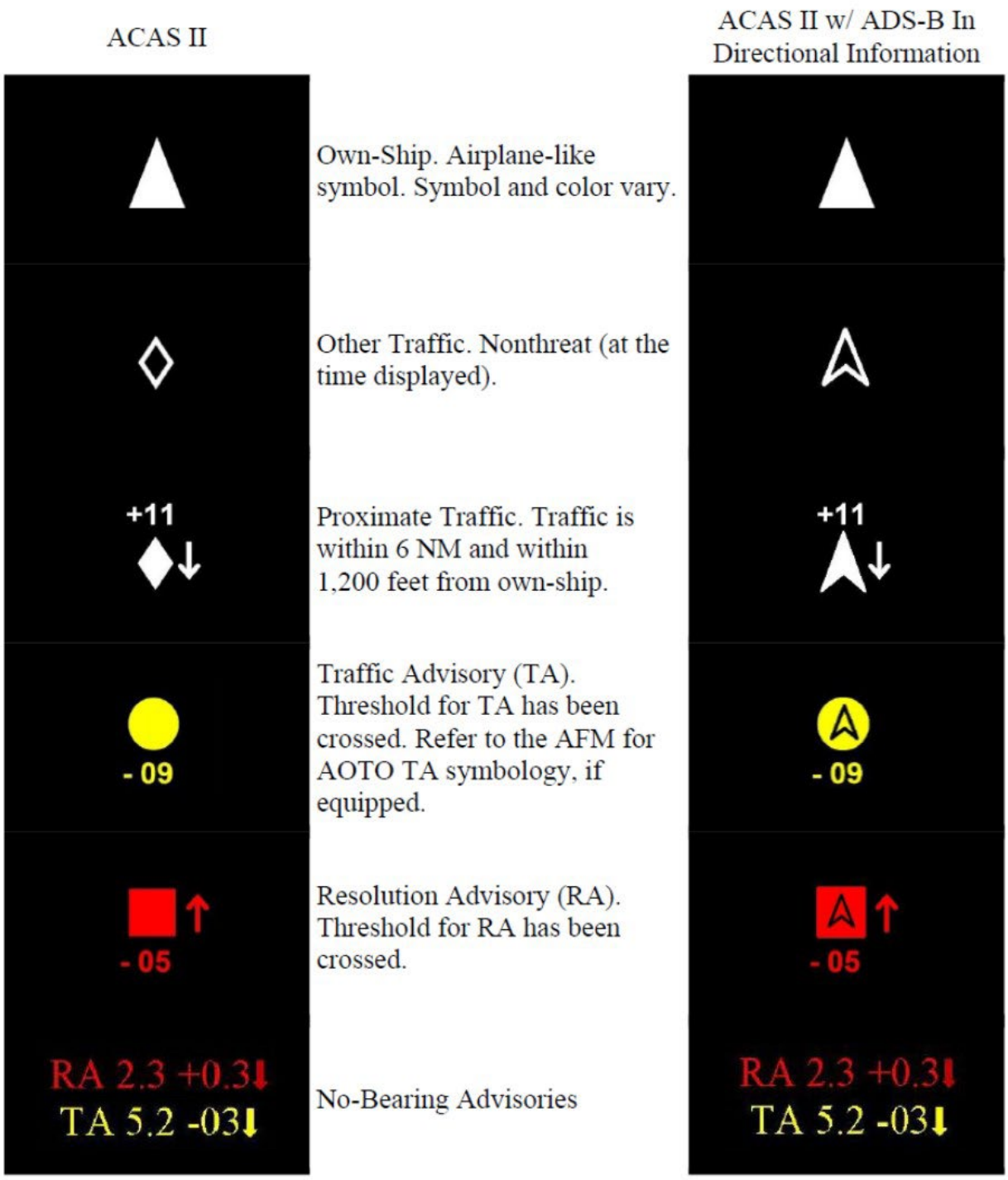
2.9.2.2 The trend arrow is a vertical arrow that points up or down next to the displayed aircraft symbol. A trend arrow pointing up depicts a threat aircraft climbing at a vertical speed more than 500 fpm. A trend arrow pointing down depicts a threat descending at a vertical speed more than 500 fpm.

2.9.2.3 If an aircraft is non-altitude reporting, the data tag is omitted, and the aircraft will be displayed as either other traffic, proximate traffic, or a TA when own-ship altitude is below a pressure altitude of 15,500 feet. RAs are not generated from non-altitude reporting aircraft. When own-ship is above a pressure altitude of 15,500 feet, there is no ACAS protection for a non-altitude reporting aircraft, and this traffic will not be displayed.

2.9.2.4 No-Bearing TAs or RAs may be generated when bearing information is not available. The No-Bearing advisory is displayed on the traffic display via a text string. The text string presents the TA or RA, the range in NM, the relative altitude in hundreds of feet, and the vertical speed arrow (e.g., TA 5.2 -06↑ represents an intruder generating a TA at 5.2 NM with a relative altitude of 600 feet below and climbing at a vertical speed of more than 500 fpm). The text is written in yellow or amber for a TA and red for an RA.

2.9.2.5 Certain Electronic Flight Information Systems (EFIS) ACAS installations operating in conjunction with track up or north up mode may require the flightcrew to make allowances for the difference between the aircraft heading and track when attempting to visually acquire nearby aircraft.

Table 2-5. Traffic Display Symbology Examples



2.9.3 RA Displays. The RA display provides guidance to attain or maintain the minimum vertical separation from a threat aircraft. The RA display depicts guidance for the vertical speed and/or pitch angle to be flown to comply with an RA, as well as the range of vertical speeds or pitch angles to be avoided during the RA.

2.9.3.1 RA/Vertical Speed Indicator (VSI) (round dial VSI). This implementation indicates the vertical speed to be flown to comply with an RA in a green arc on the VSI. Vertical speeds to be avoided during an RA are shown in red arcs on the VSI. See Figure 2-1, Resolution Advisory/Vertical Speed Indicator (round dial vertical speed indicator).

2.9.3.2 RA/VSI, Integrated Tape VSI on a Primary Flight Display (PFD). This implementation indicates the vertical speed to be flown to comply with an RA in a green zone on the vertical speed tape of the PFD. Vertical speeds to be avoided during an RA are shown in red zones on the vertical speed tape of the PFD. See Figure 2-2, Integrated Vertical Speed Indicator Tape on a Primary Flight Display.

2.9.3.3 Pitch Cues on the PFD. This implementation indicates the pitch angles to be avoided while responding to an RA. A red trapezoid, or another similar geometric shape, displayed on the PFD attitude indicator displays the range of pitch angles that are to be avoided to maintain or attain the VMD from one or multiple threat aircraft. The red trapezoid remains displayed for the entire duration of the RA. The trapezoid changes as appropriate when an RA is strengthened or weakened. See Figure 2-3, Pitch Cues on the Primary Flight Display.

2.9.3.4 Head-Up Display (HUD)/Helmet-Mounted Display (HMD). This implementation indicates the vertical flight path to be flown and avoided using a unique display symbology on the HUD/HMD similar to the pitch cues on the PFD.

2.9.3.5 Visual Advisories. Some implementations of ACAS II will have advisories displayed as textual messages in the primary field of view of each pilot. The corresponding message to an RA (e.g., DESCEND NOW) may be depicted on the PFD or similar display.

Figure 2-1. Resolution Advisory/Vertical Speed Indicator (round dial vertical speed indicator)

Figure 2-2. Integrated Vertical Speed Indicator Tape on a Primary Flight Display

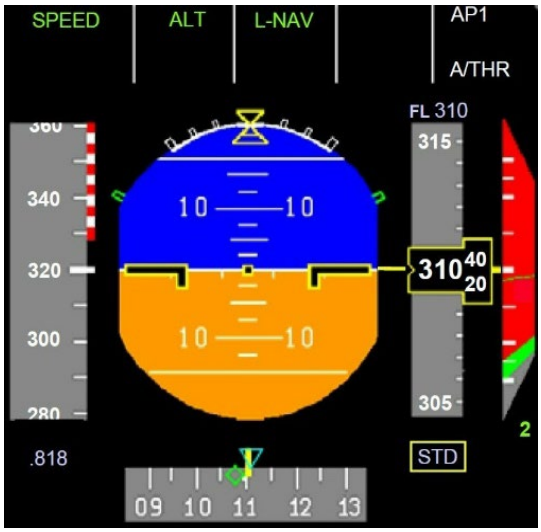
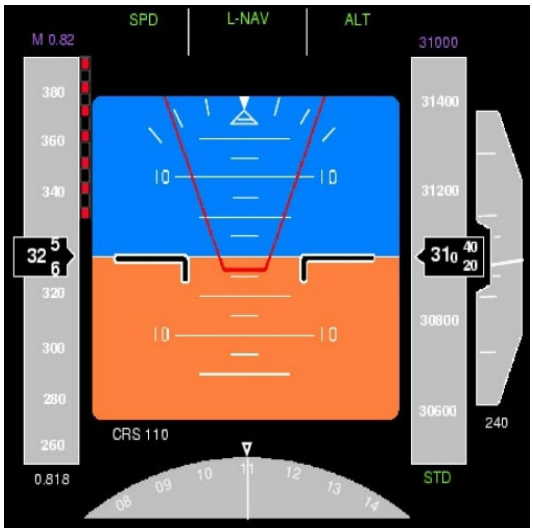


Figure 2-3. Pitch Cues on the Primary Flight Display



2.10 Examples of ACAS II Controls. Many ACAS II installations are combined with the transponder and ADS-B Out controls. Refer to the AFM/AFMS for details. ACAS II controls provide the following basic control functions (see Figure 2-4, Examples of ACAS II Controls):

2.10.1 ACAS Test. ACAS tests vary by model of ACAS implementation. Refer to the AFM/AFMS for details on how to perform an ACAS test and how a successful or failed ACAS test is annunciated.

2.10.2 ADS-B Flight Identification (FLT ID) and Transponder Code. Verify ADS-B Out is set to the FLT ID that matches exactly with the filed flight plan, and the transponder code is set appropriately.

2.10.2.1 Flightcrews are advised to operate with the transponder in the altitude reporting mode with ADS-B Out transmissions enabled at all airports any time the aircraft is positioned on any portion of the airport movement area.

2.10.2.2 Flightcrews are advised to operate ADS-B Out with the equipment turned on at all times in order to comply with 14 CFR §§ 91.225 and 91.227.

2.10.3 Transponder Selector. Aircraft with multiple transponders have a control to select the transponder in use (e.g., ATC 1, ATC 2 or ATC L, ATC R). The transponders are provided with a specific altitude information source (e.g., ATC 1 provided altitude information from the left side pilot).

2.10.3.1 Flightcrews are advised to use the altitude data source in use by the Pilot Flying (PF) to provide altitude information to ACAS and the ATC transponders. Using a common altitude source precludes the possible generation of unnecessary RAs due to differences between pressure altitude data sources.

2.10.4 Standby (STBY) Mode. Power is applied to the ACAS processor and the Mode S transponder, but ACAS and the transponder do not transmit.

2.10.4.1 There is an increased hazard for collision of ACAS-equipped aircraft when aircraft are not operating transponders or not operating the altitude reporting function of the transponder. Pilots are advised not to select the transponder to STBY or OFF in flight, especially in a nonradar environment in accordance with 14 CFR § 91.215.

2.10.5 Transponder (XPDR) Mode. The Mode S transponder is fully operational and will reply to all appropriate ground and ACAS interrogations. ACAS remains in standby.

2.10.6 TA-ONLY Mode. The Mode S transponder is fully operational. ACAS II will issue the appropriate interrogations and perform all tracking functions. ACAS II will only generate TAs. RAs are inhibited in TA-ONLY mode.

2.10.7 TA/RA or Automatic Mode. The Mode S transponder is fully operational. ACAS II will operate normally, issuing appropriate interrogations and performing all tracking functions. ACAS II will generate TAs and RAs when appropriate. ACAS II will coordinate RAs with other ACAS II-equipped aircraft operating in TA/RA mode.

2.10.8 Traffic (TFC) Display Mode. On ACAS equipment with the TFC display mode, the TA/RA mode provides only an ACAS popup function. Proximate traffic and other traffic are not displayed unless a TA or an RA is being generated. To display proximate and other traffic without a TA or an RA generated, the flightcrew selects the TFC display mode. The operation of ACAS II in TFC display mode or TA/RA mode is the same except for the display of proximate and other traffic. Refer to the AFM/AFMS for details regarding the limitations and advantages of each of the available mode selections.

Figure 2-4. Examples of ACAS II Controls

2.10.9 Display Range. Various systems will implement traffic information display ranges differently. Aural advisories and RA maneuver guidance will occur without regard to the display range. Flightcrew response is aided by situational awareness.

2.10.9.1 The display range selection does not affect the surveillance volume of ACAS.

2.10.9.2 Lower display ranges are advised for the terminal environment. Higher display ranges are better suited for the en route environment.

2.10.9.3 Some systems will show off-scale traffic as half the symbol at the limit of the range scale, at the respective bearing, while others will display a "Traffic Off Scale" or similar message.

2.10.9.4 It is recommended to select a lower range on the traffic display when an advisory is generated.

2.10.10 Altitude Range Selector. The Altitude Range Selector is a mode selection for the traffic display that filters displayed traffic based on relative altitude, and includes normal, above, and below modes. If an aircraft that was otherwise filtered from the traffic display due to a flightcrew setting generates a TA or an RA, the aircraft that generated the advisory will be displayed. It is recommended to select above when climbing and below when descending for situational awareness.

2.10.10.1 Normal mode or the normal altitude band filters the displayed traffic to within 2,700 feet of coaltitude.

2.10.10.2 Above mode or the above altitude band filters the displayed traffic to 9,900 feet above to 2,700 feet below coaltitude.

2.10.10.3 Below mode or the below altitude band filters the displayed traffic to 2,700 feet above to 9,900 feet below coaltitude.

2.10.10.4 Some display implementations have a selection of above and below and display traffic within 9,900 feet of coaltitude.

2.10.11 Popup Displays. Some ACAS manufacturers provide an optional display setting where the proximate traffic and other traffic are not displayed unless a TA or an RA is being generated. Refer to the AFM/AFMS for details regarding the limitations and advantages of each of the available mode selections.

2.10.12 Reported Altitude Selector. As an option, the data tag may indicate the pressure altitude of the displayed aircraft instead of the relative altitude to own-ship. If this option is implemented, a switch is provided to permit a flightcrew to select this type of altitude data tag. This mode, also known as Flight Level (FL) mode, is nominally temporary, and the display will switch back to relative altitude.

2.10.12.1 ACAS and transponders transmit and receive pressure altitude information (altimeter barometric scale setting 29.92 inHg/1013.25 mb), also known as QNE, from the selected pressure source (e.g., ATC L transponder selection for left side pilot pressure altitude source). Generation of TAs and RAs are not affected by the altimeter barometric scale setting. ACAS II TA and RA generation will function correctly without regard to the setting of the reported

altitude selector or whether the aircraft involved in a TA or an RA have mismatched altimeter barometric scale settings (e.g., the flightcrew of one aircraft has the altimeter barometric scale setting set to the barometric pressure as reported by a particular station (QNH), and the altimeter of the other aircraft is set to the atmospheric pressure at aerodrome elevation (or at runway threshold) (QFE)).

2.10.12.2 The reported altitude selector only changes the display of the traffic altitude and not the logic of ACAS. To alleviate possible confusion when the altimeter is set to reference zero feet at field elevation (QFE), the flightcrew is advised to set the traffic display to relative altitude (not FL).

2.11 ACAS Limitations.

2.11.1 Aircraft that are not operating a transponder will not be tracked nor displayed by TCAS II. ACAS Xa will display aircraft operating ADS-B Out, and with the AOTO option will generate a TA on a 1090 MHz ADS-B. RAs are not generated on aircraft operating ADS-B Only.

2.11.2 ACAS will not generate an RA for non-altitude reporting aircraft.

2.11.3 ACAS may display erroneous indications when a transponder or barometric altimeter system malfunctions (e.g., displaying an incorrect relative altitude on the traffic display).

2.11.4 ACAS may not display all proximate aircraft operating a transponder in areas of high-density traffic.

2.11.5 ACAS does not display aircraft on the ground and may not display an aircraft when own-ship ACAS estimates that the other aircraft is below 380 feet Above Ground Level (AGL), unless the other aircraft is operating with a Mode S transponder that reports airborne status.

2.11.6 Design implementation may result in some short-term errors in the tracked vertical speed of another aircraft during periods of high vertical acceleration by the other aircraft.

2.11.7 The bearing displayed by ACAS is not sufficiently accurate to support the initiation of horizontal maneuvers based solely on the traffic display (e.g., when two aircraft are converging at a 90º angle, the displayed aircraft appears to be converging with own-ship at a 45º angle on the traffic display).

2.11.8 In some situations (mainly due to high vertical closure rates) TAs will not precede RAs for one or both aircraft in an encounter.

2.11.9 TCAS II is designed to provide collision avoidance protection in the case of any two aircraft that have a horizontal closure rate up to 1,200 NM per hour (knots) and a vertical closure rate up to 10,000 fpm. ACAS Xa does not have a vertical closure rate limit.

2.12 ACAS Failures and Anomalies.

2.12.1 Operators are advised to ensure their flightcrews are aware of the specific failure cases and indications for the installed ACAS version and model. ACAS failure and status indications include the following (actual messages may vary; refer to the AFM/AFMS for more details). See Table 2-6.

Table 2-6. ACAS Status and Failure Indication Examples

TCAS TEST	TCAS Test (cyan or white). ACAS test is in process.
TCAS STBY	TCAS STBY (cyan or white). ACAS is in standby mode.
TA ONLY	TA Only (cyan or white). ACAS II is operating in TA-ONLY mode.
TCAS FAIL	TCAS Fail (yellow). ACAS has failed.
TD FAIL	TD Fail (yellow). Traffic display has failed.

2.12.1.1 ACAS II will automatically be set to standby or fail if the transponder or radio altimeter fails, or if the input from the barometric altimeter is lost.

2.12.1.2 In some installations, the loss of information from other onboard systems, such as an Inertial Reference System (IRS) or Attitude and Heading Reference System (AHRS), may result in a failure.

2.12.1.3 For ACAS II with Hybrid Surveillance (HS), in case of a failure or loss of Global Navigation Satellite System (GNSS) source, ACAS II will switch to active surveillance.

2.12.1.4 In rare cases, an RA can be generated due to self-tracking (i.e., when an aircraft tracks itself as a threat). The pseudo-traffic is then displayed at the same altitude and same position as own-ship. ACAS II will not track Mode S aircraft whose 24-bit aircraft address is the same as own-ship, and although a suppression bus should prevent own transponder from replying to Mode C interrogations, failures may occasionally occur. Self-tracking RAs may be operationally disruptive, as the flightcrew may comply with these RAs not knowing that they result from a failure and may cause large deviations from ATC clearances or instructions.

2.12.1.5 In rare situations, ACAS II may generate a false RA due to an ACAS II malfunction, surveillance, or tracking anomalies when a threat is not present. For instance, ACAS may sense another aircraft in the vicinity much closer than it is, and generate an RA. During an encounter, flightcrews may not have the time to determine if the RA is false. Flightcrews are advised to report any suspicious RAs so that the RA may be investigated to determine whether there is an underlying problem with the ACAS II equipment or design. See Chapter 4, ACAS Reports.

2.13 ACAS II Inhibits. Below is a listing of conditions where specific ACAS II functions are inhibited. Altitudes below have hysteresis values of ±100 feet to ensure that the ACAS II inhibit state does not oscillate rapidly.

2.13.1 When a stall warning, TAWS "Pull Up" alert, or windshear warning occurs, TA and RA aural annunciations will be inhibited, and ACAS II will automatically switch to the TA-ONLY mode of operation. ACAS II will remain in TA-ONLY mode for 10 seconds after the stall warning, TAWS "Pull Up" alert, or windshear warning is removed.

2.13.2 RAs are inhibited if ACAS II is set to TA-ONLY mode.

2.13.3 "CLIMB" and "INCREASE CLIMB" RAs may be inhibited when operating at the certified ceiling or in some flap and landing configurations. ACAS Xa does not inhibit climb RAs at the maximum certified ceiling.

2.13.4 "INCREASE DESCENT" RAs are inhibited below 1,450 feet AGL.

2.13.5 "DESCEND" RAs are inhibited below 1,100 feet AGL.

2.13.6 RAs are inhibited below 1,000 feet AGL. ACAS II switches to TA-ONLY mode automatically. If an RA was active at the time of mode switch, "Clear of Conflict" will not be annunciated.

2.13.7 TA aural annunciations are inhibited below 500 feet AGL. Display symbology of a TA may remain below 500 feet AGL for situational awareness.

CHAPTER 3. FLIGHTCREW RESPONSIBILITIES

3.1 Flightcrew Considerations. ACAS alone does not ensure safe separation in every case. ACAS does not alter nor diminish the responsibility or authority of a flightcrew to ensure a safe flight. The following actions optimize the safety functions of ACAS.

3.1.1 Flightcrews are advised to make frequent outside visual scans while using see-and-avoid techniques. Communication with Air Traffic Control (ATC) should be initiated as necessary.

3.1.2 Flightcrews are advised to operate ACAS while in flight in all airspace, including oceanic, international, and foreign airspace.

3.1.3 Flightcrews are advised, in the absence of a Resolution Advisory (RA), to comply with ATC clearances and instructions unless an amended clearance is obtained, or an emergency exists. If unable to comply with ATC clearances and instructions, flightcrews shall inform ATC as soon as possible.

3.1.4 Flightcrews are advised, in the absence of an RA, that complying with ATC turn instructions will not adversely affect vertical maneuvers required by an ensuing RA.

3.1.5 Flightcrews are advised to use the traffic display to increase their situational awareness of nearby traffic and to assist in establishing visual contact with other aircraft.

3.1.6 Flightcrews are advised not to report "TCAS contact," "we have it on TCAS," or other nonstandard colloquialisms after traffic information is received from ATC. Such a report provides no benefit to ATC. Correct responses to traffic information include "traffic in sight," or "negative contact."

3.1.7 Flightcrews are advised to use a range selection on the traffic display appropriate for the phase of flight (e.g., lower range settings for the terminal area, and higher range settings for climb/descent and cruise, as appropriate).

3.1.8 Flightcrews are advised to attempt to limit vertical speed to less than 1,500 feet per minute (fpm) when within 1,000 feet of assigned altitudes. This procedure will reduce the frequency of RAs and be in conformance with the Aeronautical Information Manual (AIM) and International Civil Aviation Organization (ICAO) guidance. One of the most common cases that cause unwanted RAs is when one or multiple aircraft are leveling off 1,000 feet from an aircraft operating ACAS II, and an RA is triggered due to high vertical rates when approaching the cleared altitude. Some aircraft may have Autopilot (AP) modes installed that are able to limit the vertical speed when approaching the selected altitude. Refer to the Aircraft Flight Manual (AFM)/Aircraft Flight Manual Supplement (AFMS) for more details on this feature.

3.1.9 Flightcrews are advised, prior to positioning on any airport movement area, to verify the Automatic Dependent Surveillance-Broadcast (ADS-B) Out is set to the Flight Identification (FLT ID) that matches the flight plan exactly, and the transponder code is set appropriately, prior to transmitting with ADS-B Out and transponder with altitude

reporting. Flightcrews are advised to keep ADS-B Out and transponder with altitude reporting enabled throughout the flight (i.e., from completion of the before starting engines or pushback checklist until the shutdown checklist).

3.1.10 Flightcrews are advised not to activate ACAS II (Traffic Advisory (TA)/RA mode or TA-ONLY mode) until just prior to taking the active runway for departure, and ACAS II should be deactivated immediately after clearing the runway after landing.

3.1.10.1 Routine usage of ACAS II on the ground unnecessarily contributes to 1030/1090-megahertz (MHz) frequency congestion and can degrade the performance of ATC radars and surveillance performed by ACAS of airborne aircraft.

3.1.10.2 Flightcrews may use TA-ONLY or TA/RA mode for a short period of time before crossing an active runway to aid in visual acquisition of airborne aircraft in the vicinity (some aircraft will not display when ACAS computes that the aircraft is below 380 feet Above Ground Level (AGL)). Traffic symbols may take several seconds to display after selecting TA-ONLY or TA/RA mode.

3.1.10.3 Refer to the AFM/AFMS for details regarding the use of an automatic mode switching selection.

3.1.11 Flightcrews are advised to operate ACAS II in TA/RA mode to the maximum extent possible while airborne. Any decision to operate ACAS II in TA-ONLY mode is to be carefully considered due to the degradation of ACAS II safety functions. If a flightcrew elects to use TA-ONLY mode, the flightcrew should ensure that ACAS II is returned to the TA/RA mode as soon as possible. The following are examples that may warrant the use of TA-ONLY mode in the National Airspace System (NAS):

3.1.11.1 In the event of a Minimum Equipment List (MEL) deferral requiring the use of TA-ONLY. Refer to FAA Master Minimum Equipment List (MMEL) Policy Letter 32 (PL-32), Traffic Alert and Collision Avoidance System (TCAS).

3.1.11.2 In the event of non-normal, abnormal, or emergency procedure scenarios; particular in-flight failures; or performance limiting conditions, as specified by the AFM or operator.

3.1.11.3 During takeoff toward known nearby traffic that is in visual contact and that could cause an unwanted RA during initial climb, such as a visually identified helicopter passing near the departure end of the runway.

3.1.11.4 At certain airports, during particular procedures, or in circumstances identified by the operator as having a significant potential for unwanted or inappropriate RAs.

3.2 TA Response. Respond to TAs by attempting to establish visual contact with the intruder aircraft and other aircraft that may be in the vicinity. If needed, adjust the range on the traffic display to ensure all available information on the intruder is shown. Coordinate to the degree possible with other crewmembers to assist in searching for traffic. Do not deviate from an assigned clearance based solely on TA information. For any intruder acquired visually, continue to maintain safe separation in accordance with current regulations and good operating practices.

3.2.1 Flightcrews are advised to utilize information from the traffic display to aid in visual acquisition of the intruder aircraft, including the bearing, range, relative altitude, and vertical speed trend.

3.2.2 Flightcrews are advised to utilize all available information to assist in visual acquisition, including air traffic controller traffic alerts or safety alerts.

3.2.3 The Pilot Flying (PF) is advised to continue to fly the aircraft and be prepared to respond to any RA that might follow. The Pilot Monitoring (PM) is advised to provide updates on the traffic location shown on the traffic display, using this information to assist in visual acquisition of the intruder.

3.2.4 Flightcrews are advised to confirm that the aircraft they have visually acquired is the aircraft that caused the TA to be generated using all available information.

3.2.5 Flightcrews are not advised to maneuver the aircraft based solely on the information shown on the traffic display due to limitations of bearing accuracy.

3.2.6 When visual acquisition is attained, right-of-way rules are used to maintain safe separation, unless an RA is generated. Flightcrews are not advised to initiate unnecessary maneuvers.

3.2.7 Flightcrews are advised caution when maneuvering based solely on visual acquisition, especially at high altitude or without a clearly defined horizon. Avoidance maneuvers based solely on a TA may cause the situation to deteriorate further. Visual assessment does not provide information on the intent or trajectory of the traffic and can be misleading (e.g., the pitch angle of a heavy aircraft at low speed makes it difficult to assess whether the aircraft is climbing, level, or descending).

3.2.8 Flightcrews are not advised to attempt to adjust the current flight path in anticipation of what an RA may advise.

3.2.9 TAs from TCAS I, an ACAS II in TA-ONLY mode, or ACAS Xa generating an ADS-B Only TA-ONLY (AOTO) advisory will not progress to an RA.

3.3 RA Response. Flightcrews are advised to comply with an RA to the degree displayed with an instinctive, immediate reaction. For ACAS II to work as designed, immediate and correct crew response to an RA is essential. Delayed response or reluctance of a flightcrew to comply with the RA due to ATC clearance provisions, fear of later FAA

scrutiny, or other factors could significantly decrease or negate the protection afforded by ACAS II.

3.3.1 Maneuvering in Response to an RA. When an RA occurs, the PF is advised to respond immediately by directing attention to the RA displays and to maneuver as indicated with positive control inputs, unless doing so would jeopardize the safe operation of the flight, or the flightcrew can ensure separation with definitive visual acquisition of the aircraft causing the RA. The PM provides updates on the traffic location, cross-checks between the traffic display, and monitors the response to the RA using proper Crew Resource Management (CRM).

3.3.1.1 For ACAS II to provide safe vertical separation, initial vertical speed response is required within 5 seconds of when the RA is first displayed based on a 0.25 g vertical acceleration. Some autoflight systems have the capability to respond automatically to RAs. These systems may respond with a lower vertical acceleration yet may provide a faster response time when compared to manual flight operations.

3.3.1.2 RAs take precedence over any ATC instructions, clearances, requirements to follow a specific route, right-of-way rules, cloud clearance rules for Visual Flight Rules (VFR), or other such criteria. If a flightcrew receives ATC instructions to maneuver that conflict with an RA, the flightcrew is advised to comply with the RA. Flightcrews that deviate from an ATC clearance or instruction in response to an RA are advised to notify ATC of that deviation as soon as practicable.

3.3.1.3 Flightcrews are advised to comply with an RA while complying with an ATC clearance, if possible, when an RA and ATC clearance or instruction are congruent (e.g., when a flightcrew is able, comply with an ATC instruction and level at the assigned altitude while responding to a reduce climb or reduce descent RA).

3.3.1.4 If an RA is generated while the aircraft is turning, and the turn makes achieving the required vertical rate difficult or impossible, the turn should be stopped (i.e., leveling the wings to increase the rate of climb). Stopping the turn may close the horizontal proximity to the threat aircraft, but ACAS is evaluating the encounter and will change the RA if required.

3.3.1.5 Maneuvering in response to an RA should be limited to the minimum required to comply with the RA. An excessive maneuver response to an RA is not desirable or appropriate due to other potential conflicts (e.g., multiple threat encounter) and ATC implications, as well as the hazard of injury to the occupants of an excessively maneuvering aircraft.

3.3.1.6 Vertical speed responses should be made to avoid red arcs on the Vertical Speed Indicator (VSI) or outlined pitch avoidance areas on the Attitude

Direction Indicator and, if applicable, to accurately fly to the green arc or outlined pitch guidance area.

3.3.1.7 Comply with RAs by disconnecting the AP (if necessary) and the autothrottle system (if necessary), using prompt positive control, and thrust inputs in the direction and with the magnitude that is generated by the RA.

3.3.1.8 Some autoflight systems have the capability to respond automatically to RAs. Pilots are advised to follow airframe manufacturer and/or operator flight path management policies and procedures in response to an RA.

3.3.1.9 During RAs, flightcrews should closely monitor the correct responses of the AP ACAS mode (if installed). The PF is advised to disengage the AP and fly the aircraft manually if the AP/Flight Director (FD) ACAS mode is not complying with RA vertical speed.

3.3.1.10 On aircraft with pitch guidance for RAs, comply with the RA pitch guidance, and verify the pitch guidance is appropriate for the RA. On aircraft without pitch guidance, achieve the required vertical speed (normally 1,500 fpm climb or descent) by first adjusting the pitch attitude using the suggested guidelines shown in the table below. Then, refer to the VSI and make all necessary pitch adjustments to place the VSI in the green arc. See Table 3-1.

Table 3-1. Initial Pitch Adjustment Response to a Resolution Advisory (Based on a Transport Category Airplane)

Indicated Airspeed	Pitch Adjustment
Mach 0.80	2°
250 knots below 10,000 feet	4°
Approach below 200 knots	5° to 7°

3.3.1.11 RAs are not coordinated with non-ACAS II-equipped aircraft (or ACAS II-equipped aircraft not operating in TA/RA mode). Threat aircraft may maneuver based on the see-and-avoid principle or ATC instructions. The threat aircraft may perform maneuvers that cause a change in the RA response.

3.3.1.12 During a coordinated RA, another ACAS II-equipped aircraft may incorrectly comply with ATC instructions contrary to the RA. This action may cause a change in the RAs generated for own-ship or multiple aircraft. Flightcrews are advised to respond immediately to any change in RA. Vertical speed response to an increase or reversal RA is required within 2.5 seconds after issuance of the advisory based on a 0.35 g vertical acceleration. Avoid red arcs or outlined pitch avoidance areas and fly to the green arc or outlined pitch guidance area.

3.3.1.13 The PM should advise the PF on the progress of complying with the RA-generated vertical speed. The PM and any onboard observers will assist in the visual search for the threat aircraft and continue to cross-check ACAS II displayed information with other available traffic information to ensure the RA response is being flown correctly using proper CRM.

3.3.1.14 If an initial corrective RA is downgraded to a weakened RA (e.g., a "Climb, Climb" RA downgraded to a "Level Off, Level Off"), flightcrews are advised to respond to the weakened RA by adjusting the vertical speed to the rate depicted by the VSI green arc. Flightcrews should keep the VSI needle out of the red arc and/or the pitch guidance symbol out of the outlined pitch avoidance area. Attention to the RA display and prompt reaction to a weakened RA will minimize altitude excursions and potential disruptions to ATC. A proper reaction to a weakened RA will allow for proper resolution of the encounter and reduce the probability of subsequent RAs against the threat aircraft or another displayed aircraft.

3.3.1.15 Flightcrews are advised that, when operating at maximum certified altitude with an aircraft that is not climb inhibited, the proper response to a climb RA is to climb. The flightcrew is advised to comply with the RA unless doing so would jeopardize the safety of the aircraft. Flightcrews are advised to consider their energy management and specific aircraft flight envelope protection features. A stall warning will inhibit an RA.

3.3.1.16 ACAS II installations programmed to not generate a climb RA when operating at the maximum certified altitude will generate a "DO NOT DESCEND" or "DESCEND, DESCEND" RA instead.

3.3.1.17 When a "Clear of Conflict" annunciation is generated, the flightcrew is advised to immediately return to their previously assigned clearance and advise ATC, or comply with any amended clearance issued. Immediately returning should not be mistaken for aggressively returning. Another RA may be generated due to a flightcrew aggressively returning to their clearance when the threat aircraft is still a factor.

3.3.1.18 Flightcrews are advised to execute a missed approach/go-around if, as a result of an RA, the flightcrew will not be able to maintain a stabilized approach to a landing within the available runway.

3.3.2 Not Responding to RAs/Disregarding RAs.

3.3.2.1 Response to a stall warning, windshear warning, or Terrain Awareness and Warning System (TAWS) "Pull Up" alert takes precedence over an RA maneuver.

3.3.2.2 Flight path requirements affected by terrain, such as an obstacle-limited climb segment or an approach to rising terrain, may conflict with an RA. Since the basis for many approved instrument procedures and Instrument Flight Rules

(IFR) clearances is avoiding high terrain or obstacles, it is particularly important that the flightcrew maintains situational awareness and continues to use good operating practices and judgment when complying with RAs.

3.3.2.3 Flightcrews of aircraft with autoflight systems with an RA mode are advised to understand how to disable the autoflight mode if the autoflight system response is incorrect or undesired. Flightcrews should exhibit correct flight path management in automated or manual flight operations.

3.3.2.4 RAs may occur while aircraft are separated in accordance with established standards. Even when closely spaced parallel approach procedures are correctly applied, unwanted RAs may occasionally occur. However, the safety benefit provided by ACAS II takes precedence over an occasional unwanted RA. There is always the possibility another aircraft that is not associated with the parallel approach procedure becomes a threat. The term "nuisance alert" is commonly used to describe an RA when it is not desired. This is a misnomer; ACAS II is operating as designed, and flightcrews are advised to comply with the RA. The evaluation of whether a generated RA is a valid threat may not be possible in real time.

3.3.2.5 RAs generated in the traffic pattern environment should not be dismissed as unnecessary and/or disruptive. These RAs inform the flightcrew that a hazard of collision exists.

3.3.2.6 By not responding to an RA, the flightcrew negates the safety benefits provided by own-ship ACAS and effectively takes responsibility for achieving safe separation. In so choosing, flightcrews are advised to consider the following cautions:

3.3.2.6.1 The traffic acquired visually may not be the same traffic causing the RA. Visual perception of the encounter may be misleading. The flightcrew is advised to respond to the RA to the degree displayed with an instinctive, immediate reaction, unless there is no doubt that the aircraft acquired visually is the threat aircraft, the threat aircraft is not a collision hazard, and there are no other complicating circumstances.

3.3.2.6.2 The traffic may also be operating ACAS II, and it may maneuver in response to an RA coordinated with own-ship ACAS II.

3.3.2.6.3 It is difficult to visually determine the vertical displacement of other aircraft, especially when ground reference information is unreliable or at cruise altitudes where the horizon is obscured. Therefore, disregarding RA information and maneuvering vertically based solely on visual acquisition may result in a loss of safe separation.

3.3.3 Maneuvering Opposite to an RA.

3.3.3.1 Maneuvers or lack of maneuvers that result in a vertical speed opposite to the RA could result in a collision with the threat aircraft.

3.3.3.2 The threat aircraft may also be operating ACAS II, and it may maneuver in an unexpected direction while responding to a coordinated RA that has been coordinated with own-ship ACAS II.

3.3.3.3 ATC may not be communicating or providing separation service with the threat aircraft. ATC may have less up-to-date altitude data than ACAS II. ATC does not know if an RA is generated unless notified by the flightcrew. It is possible for ATC to unknowingly issue instructions that are contrary to an RA. When one aircraft in an encounter maneuvers opposite to the RA and the other aircraft maneuvers as indicated by a coordinated RA, the collision risk increases. Flightcrews are advised not to maneuver contrary to the RA based solely upon ATC instructions.

3.4 ATC Clearances and Instructions.

3.4.1 ATC Instructions During an RA.

3.4.1.1 If an RA occurs concurrently with ATC issuing a climb or descend clearance, flightcrews are advised to comply with the RA even if it differs from the ATC climb or descend instruction.

3.4.1.1.1 ACAS II may be coordinating the RA with another ACAS II aircraft. ATC is not automatically informed of RAs. Midair collisions have resulted involving two aircraft operating ACAS II, where one flightcrew complied with the RA while the other complied with ATC instructions.

3.4.1.1.2 For Precision Runway Monitor (PRM)/High Update Rate Surveillance (HURS) close parallel approaches, the Attention All Users Page (AAUP) will state, “TCAS during breakout: Follow TCAS climb/descend if it differs from ATC, while executing the breakout turn.”

3.4.1.2 If an RA requires maneuvering contrary to right-of-way rules, cloud clearance rules for VFR, or other such criteria, flightcrews are advised to comply with the RAs to resolve the immediate traffic conflict.

3.4.1.3 If an RA maneuver is inconsistent with the current clearance, including altitudes published on arrival/approach/departure procedures, respond appropriately to the RA. Since ACAS II tracks all aircraft operating transponders in the vicinity, responding to an RA assures an avoidance maneuver for that threat aircraft and for other aircraft with altitude reporting transponders.

3.4.1.4 Flightcrews should keep deviations from regulations, clearances, and instructions to the minimum necessary to comply with an RA. While complying with the RA, if possible, comply with ATC clearances and instructions (e.g., turn to intercept an airway or localizer). Response to a stall warning, windshear warning, TAWS "Pull Up" alert, or an RA takes precedence over ATC clearances or instructions, or a requirement to follow a specific route.

3.4.1.5 Each flightcrew that deviates from an ATC clearance or instruction in response to an RA is advised to notify ATC of that deviation as soon as practicable and notify ATC when clear of conflict and returning to the previously assigned or amended clearance.

3.4.1.6 When a flightcrew informs a controller that they are responding to an RA, controllers are not to issue control instructions that are contrary to the RA procedure. After the controller has been informed of an RA, they may continue to issue control instructions and safety alerts, including terrain, obstructions, and ATC-issued traffic advisories, as appropriate.

3.4.1.7 Once the flightcrew that informed the controller of an RA has begun a maneuver in response to an RA, the controller is not responsible for providing approved separation between the aircraft that is responding to an RA and any other aircraft, airspace, terrain, or obstruction.

3.4.2 Clear of Conflict. When an RA is canceled, the "CLEAR OF CONFLICT" message is heard, and the flightcrew should advise ATC as soon as practicable that they are returning to their previously assigned clearance or should acknowledge any amended clearance issued. The flightcrew is advised to immediately return to their previously assigned clearance and advise ATC, or comply with any amended clearance issued.

3.4.2.1 Responsibility for approved separation resumes for the controller when:

- The flightcrew returns to the assigned altitude,
- The flightcrew informs the controller that the RA maneuver is complete and approved separation is met, or
- The flightcrew has executed an amended clearance and approved separation is reestablished.

3.5 Communicating an RA to ATC. To keep all parties on the frequency informed during an RA maneuver, radio communication should be in common phraseology. All transmissions should contain the name of the ATC facility, aircraft identification, and that they are responding to an RA. Communicating an RA is not required if the flightcrew complies with the RA while maintaining compliance with ATC clearances and instructions.

3.5.1 RA Generated That Affects an ATC Clearance.

3.5.1.1 When a flightcrew receives a new clearance that is subject to a preventive RA (e.g., "Do Not Climb, Do Not Climb") that will not allow the flightcrew to comply with clearance instructions, the flightcrew is advised to inform ATC by stating, "[name of the ATC facility], [aircraft identification], TCAS RA, unable to comply" (e.g., "Milwaukee Approach, Skyway 123, TCAS RA, unable to comply").

3.5.1.2 When a flightcrew receives a corrective RA to either climb or descend from their assigned altitude, or the RA otherwise affects the ATC clearance, the flightcrew is advised to inform ATC when beginning the excursion from the assigned clearance or as soon as workload allows. Flightcrews are advised to inform ATC by stating, "[name of the ATC facility], [aircraft identification], TCAS RA" (e.g., "Washington Departure, Hagar 55, TCAS RA").

3.5.2 Clear of Conflict. When the RA is clear, the flightcrew should advise ATC that they are returning to their previously assigned clearance or a subsequent amended clearance. Inform ATC by stating, "[name of the ATC facility], [aircraft identification], clear of conflict, returning to [assigned altitude]" (e.g., "Chicago Center, Freedom 456, clear of conflict, returning to Flight Level 410").

CHAPTER 4. ACAS REPORTS

4.1 Pilot Reports. All unusual ACAS events should be reported and investigated. The reports will help to identify potential technical deficiencies and prompt regulators to take appropriate action.

4.1.1 Mandatory Report. When operating under IFR, and an aircraft experiences an RA where compliance with the RA is necessary to avert a substantial risk of collision, a report to the National Transportation Safety Board (NTSB) is required per 49 CFR § 830.5.

4.1.2 ATC Query. Upon query from ATC, make radio or telephone communication as appropriate to complete an ATC Mandatory Occurrence Report (MOR) after a response to an RA per FAA Order JO 7210.632, Air Traffic Organization (ATO) Occurrence Reporting.

4.1.3 Near Midair Collision (NMAC) Reports. An NMAC is defined in the AIM as an incident associated with the operation of an aircraft in which a possibility of collision occurs because of a proximity of less than 500 feet to another aircraft, or a report is received from a pilot stating that a collision hazard existed between two or more aircraft. Flightcrews should be aware that there is no requirement to submit an NMAC report solely due to an ACAS event and that an ACAS report does not constitute an NMAC report.

4.1.3.1 It is the responsibility of the flightcrew to determine whether an NMAC did occur and, if so, to initiate an NMAC report.

4.1.3.2 Flightcrews involved in NMAC occurrences are urged to report each incident immediately by radio or telephone to the nearest FAA ATC facility or Flight Service Station (FSS).

4.1.3.2.1 Be specific, as ATC will not interpret a casual remark to mean that an NMAC is being reported.

4.1.3.2.2 The pilot should state, “I wish to report a near midair collision.”

4.1.4 FAA Hotline. The FAA Hotline accepts reports related to the safety of the National Airspace System (NAS), violations of 14 CFR, aviation safety issues, and FAA employees or FAA facilities. The FAA Hotline provides a single venue for FAA employees, the aviation community, and the public to file their reports. Visit the FAA Hotline website at https://www.faa.gov/about/office_org/headquarters_offices/aae/programs_services/faa_hotlines.

4.1.5 National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) Reports. A flightcrew that experiences a significant event regarding ACAS or collision hazards may file ASRS reports at their discretion at https://asrs.arc.nasa.gov.

4.1.6 Aviation Safety Action Program (ASAP). If a flightcrew that experiences a significant event regarding ACAS or collision hazards is part of an organization that cooperates in an ASAP, it is recommended that the flightcrew file a report to the Event Review Committee (ERC). Some organizations may not have an ASAP but may offer a similar voluntary safety reporting structure.

4.1.7 Operator Reports. Reports, as specified by the operator, concerning ACAS anomalies, procedural difficulties, or system failures are typically made by flightcrews, and may include the following:

- Pilot/observer questionnaire;
- Logbook entry and Aircraft Communications Addressing and Reporting System (ACARS); or
- Other records used by that operator, such as a captain's report. See Appendix D, ACAS Resolution Advisory (RA) Report, for details on suggested information to include.

4.2 FAA Response to Pilot Reports of ACAS Events.

4.2.1 FAA Investigations. The FAA will not initiate enforcement action solely based on an ACAS event, provided:

- As per 14 CFR requirements, the aircraft was equipped with ACAS, and the equipment was operating at the time of the event, as applicable.
- The flightcrew complied with ATC clearances and instructions per 14 CFR § 91.123 prior to and during the ACAS-related deviation.
- The flightcrew has successfully completed the FAA-approved air carrier ACAS training program, as applicable.

4.3 Manufacturer Reports.

4.3.1 Manufacturer Monitoring and Reporting. Manufacturers are encouraged to develop procedures to ensure effective identification, tracking, and followup of abnormal ACAS-related events, as appropriate. Such procedures should focus on providing useful information to properly assess the importance of ACAS events and following up on information related to specific ACAS events as necessary to keep the industry and the FAA informed of the performance of ACAS in the NAS and in international operations.

4.3.2 ACAS Manufacturer Reports. ACAS avionics manufacturers report problems found with specific ACAS installations in accordance with established Service Difficulty Report (SDR) procedures. Report generic problems, such as those that may relate to the definition of ACAS algorithms as defined by RTCA DO-185B, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II), and RTCA DO-385A, Minimum Operational Performance Standards for Airborne Collision Avoidance System X (ACAS X) (ACAS Xa and ACAS Xo), to the FAA Aircraft Certification Service (AIR) at 9-AVS-CAS-Issues@faa.gov.

CHAPTER 5. OPERATOR RESPONSIBILITIES

5.1 Operational Approval. Once the required aircraft and equipment certification activities have been completed, and prior to operating the installed ACAS equipment, aircraft operators operating under the provisions of 14 CFR part 91 subpart K (part 91K), and parts 121, 125, and 135 need to obtain operational approval from their assigned Certificate Management Team (CMT). The CMT is composed of the Principal Inspectors (PI) of the responsible FAA Certificate Management Office (CMO) or Flight Standards District Office (FSDO). Operational approval pertains to changes to operational and maintenance manuals, standard operational procedures, Minimum Equipment Lists (MEL), flightcrew training programs, maintenance training programs, and other areas necessary for safe and effective operation of ACAS. ACAS programs are usually approved for each specific aircraft type of an operator. However, programs common to one or more types may receive approval if ACAS program elements are common to different aircraft types, such as the same ACAS or procedures.

Note: An airworthiness Type Certificate (TC)/Supplemental Type Certificate (STC) of an ACAS alone does not constitute operational approval for use of ACAS under the provisions of 14 CFR parts 91K, 121, 125, and 135.

5.1.1 Approval Procedures.

5.1.1.1 PIs will review the programs of an operator using information developed by the Aircraft Evaluation Division (AED). The responsible Flight Standards offices review the training and maintenance programs, operational procedures, MELs, etc., to ensure consistency with criteria specified in the Master Minimum Equipment List (MMEL), Flight Standardization Board Reports (FSBR), Maintenance Review Board Reports (MRBR), and policy guidance from the FAA (e.g., ACs and FAA orders and notices, including FAA Order 8900.1, Flight Standards Information Management System).

5.1.1.2 The FAA reviews, accepts, or approves installations, flightcrew and maintenance training, maintenance programs, MELs, operations manuals, and other ACAS program elements, as required. Issuance of specific Operations Specifications (OpSpecs) for 14 CFR part 121 and 135 Certificate Holders (CH), Management Specifications (MSpecs) for 14 CFR part 91K program managers, or Letters of Authorization (LOA) for 14 CFR part 125 Letter of Deviation Authority (LODA) holders specific to ACAS is normally not required.

Note: OpSpecs may be influenced by ACAS equipage and operation. Refer to FAA Order 8900.1, Volume 3, Chapter 18, Operations Specifications, for more details.

5.1.2 Manuals and Other Publications. Aircraft Flight Manuals (AFM), operating manuals, maintenance manuals, general policy manuals, and other manuals, publications, or written materials (e.g., operations bulletins that may relate to ACAS use) should be

appropriately amended to describe ACAS equipment, procedures, and operational policies according to the appropriate regulation.

5.1.3 Operations Manual. If the AFM, Aircraft Flight Manual Supplement (AFMS), or Pilot Guide to the specific ACAS installation is not otherwise provided to the flightcrew while in flight, the operator should incorporate into the operational manual the description of operation, limitations, emergency procedures, normal procedures, and performance considerations. An operator defines how its flightcrews will operate ACAS II and respond to Traffic Advisories (TA) and Resolution Advisories (RA). The topics recommended to be addressed by these procedures include, but are not limited to:

1. Policy regarding vertical speed reduction near selected altitude or Flight Level (FL) when aware of nearby traffic at or approaching an adjacent altitude or FL.
2. Information provided by ACAS.
3. Policies regarding flight path management including autoflight systems, manual flight operations, and display cues to support flightcrew guidance upon an RA.
4. Limitations of maneuvers based on visual acquisition of other aircraft.
5. The proper response to ACAS advisories, including Crew Resource Management (CRM) policies for roles, responsibilities, and callouts.
6. The conditions where RA compliance is required, reflecting guidance published by the State Civil Aviation Authority (CAA).
7. Effects of improper use of ACAS and potential risks of an improper response to an advisory.
8. The return to an Air Traffic Control (ATC) clearance after an RA.
9. The interaction between ACAS and other aircraft systems.
10. Use of various operating modes (i.e., Standby, TA-ONLY, TA/RA) while airborne and on the ground including during emergency operations (i.e., engine failure).
11. ACAS operating conditions that may be unique to their particular route environment (e.g., barometric altitude set to the atmospheric pressure at aerodrome elevation (or at runway threshold) (QFE)), aircraft (e.g., response to an RA at the maximum certified altitude), procedures, or traffic display and control features.
12. Event reporting requirements and procedures.
13. Operators who have aircraft with ACAS differences in displays, controls, or procedures, or that are involved with interchange operations, and how the operator accounts for ACAS differences. Accomplish this as part of an approved differences training program, or as otherwise specified in applicable FAA FSBRs concerning crew qualification pertaining to a particular airplane type.

5.1.4 MMEL/MEL. Operators formulate necessary ACAS revisions to the MELs for each aircraft type. MEL revisions are to be consistent or more restrictive than the FAA MMEL established for each aircraft type and current Policy Letters (PL) (e.g., PL-32, Traffic Alert and Collision Avoidance System (TCAS)).

5.1.4.1 Refer to FAA Order 8900.1, Volume 4, Chapter 4, Section 3, MEL Requirements for 14 CFR Parts 91K, 121, 125, 125 LODA, and 135 Operations, for more details on the approval of MELs.

5.1.5 Maintenance Manual. Maintenance manual procedures for ACAS receive approval or acceptance as part of an operator's initial maintenance program approval or as a revision to that program.

5.1.5.1 This includes, but is not limited to, addressing installation; modification; correction of reported system discrepancies; MEL relief; return-to-service authorizations; and procedures for testing installed transponders and automatic pressure altitude reporting equipment on the ground in such a way that false aircraft are not generated in airborne ACAS (e.g., shielding of the transponder antennas).

5.1.5.2 The ACAS maintenance procedures of the operator should be consistent with the maintenance procedures of the ACAS or aircraft manufacturer.

5.1.5.3 ACAS maintenance procedures should include procedures to avoid unnecessary ACAS advisories due to transponder testing on the ground. Refer to AC 43-6, Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices, and Safety Alert For Operators (SAFO) 17002, Improper Transponder and Automatic Dependent Surveillance-Broadcast (ADS-B) OUT Equipment Testing.

5.1.5.3.1 The following ACs provide more detailed information and guidance concerning the proper procedures to follow when conducting operational testing of ACAS II, Automatic Dependent Surveillance-Broadcast (ADS-B), and transponders:

- AC 20-151, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 and 7.1 and Associated Mode S Transponders.
- AC 20-165, Airworthiness Approval of Automatic Dependent Surveillance - Broadcast OUT Systems.
- AC 20-172, Airworthiness Approval for ADS-B In Systems and Applications.
- AC 43-6, Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices.

5.1.6 Maintenance Training. To properly implement ACAS-related maintenance programs, an operator should provide adequate ACAS training of maintenance personnel in accordance with the appropriate regulations.

5.1.7 Flightcrew Training Manual. Air carriers should ensure appropriate flightcrew ACAS training. Training for ACAS II should include both ground and flight (e.g., flight

simulator) and should address any significant issues identified by operating experience, system changes, procedural changes, or unique characteristics, such as the introduction of a new aircraft, display system, or operations in airspace where high numbers of TAs and RAs have been reported. The flightcrew should demonstrate knowledge of ACAS concepts, systems, and procedures. The flightcrew should demonstrate proficiency in cognitive, procedural, and motor skills necessary to properly respond to ACAS.

5.1.7.1 There are no formal ACAS flightcrew evaluation requirements for flight testing or checking. An instructor should accomplish an evaluation of ACAS objectives during training. Operators should include routine ACAS operations in all evaluation environments, and check pilot/examiners should include ACAS as a routine discussion item.

5.1.7.2 ACAS knowledge training is typically conducted in a classroom environment. The knowledge demonstrations may be met by successfully completing written tests or providing correct responses to Computer-Based Training (CBT) questions. Combinations of these methods may be used if the required body of knowledge is completely covered.

5.1.7.3 ACAS maneuver training instructs flightcrews how to properly respond to ACAS displayed information. TAs and RAs are most effective when accomplished in a flight simulator equipped with a traffic display and controls similar in appearance and operation to those in the aircraft. Alternatively, the required maneuver can be carried out by means of an interactive computer-based trainer with a traffic display and controls similar in appearance and operation to those in the aircraft. This interactive computer-based trainer should depict scenarios where real-time responses are to be made. Line-Oriented Flight Training (LOFT) programs may be enhanced by interaction with ACAS. In addition, LOFT programs should consider proper crew vigilance for aircraft that may not be equipped with and operating a transponder or are non-altitude reporting aircraft. Advisories accomplished during LOFT are creditable toward first-time or recurrent qualification. Operators should ensure that their instructors could select all the required RA scenarios on their training devices at any applicable time (e.g., own-ship above 1,000 feet for an RA) during a simulator session.

5.1.7.4 CRM programs should address effective teamwork, including conducting effective preflight briefings on how to react to ACAS advisories and the proper reaction to a TA and an RA by the Pilot Flying (PF) and the Pilot Monitoring (PM).

5.1.7.5 First-time ACAS training should be accomplished for each ACAS-equipped aircraft type that a pilot is assigned. An operator may accomplish first-time ACAS qualification as a standalone module of ground and flight training or combined with initial, transition, or upgrade ground and flight training programs with the appropriate differences training.

5.1.7.6 An operator may accomplish recurrent ACAS training during recurrent ground and flight training. Recurrent ground training will be a standalone module. However, ACAS will be fully integrated with the recurrent flight training.

5.1.7.7 For recurrent training, it is recommended that flight training include responses to all RA types. Recurrent training is desirable in a Flight Training Device (FTD) or a simulator approved for the maneuvers. See Appendix B, Sample ACAS Ground and Flight Training Program, for a sample training program.

5.1.8 Continuing Operator Responsibilities. After operational approval has been obtained, operators have the following general responsibilities regarding ACAS:

5.1.8.1 Analyzing the implementation of ACAS, revisions to policies and procedures, and identifying hazards, changes in the operational environment, or ineffective risk controls.

5.1.8.2 Using a Safety Risk Management (SRM) program as part of a Safety Management System (SMS) to assess whether the risk is acceptable for permitting procedures such as the use of TA-ONLY mode during operations. See Appendix C, Safety Management System (SMS) Considerations for ACAS II TA-ONLY Mode Operations.

5.1.8.3 Monitoring and auditing of the operational environment to detect changes needed to processes and procedures, including training, checking, and maintenance programs to ensure their correctness, pertinence, timeliness, and effectiveness.

5.1.8.4 Communicating to operator personnel, as appropriate, when hazards or changes to policies and procedures are identified.

5.1.8.5 Ensuring all ACAS events reported to the operator are assessed.

5.1.8.6 Ensuring all required maintenance reports are completed and assessed for hazards.

5.1.9 Operator ACAS Event Reporting.

5.1.9.1 Operators are encouraged to develop procedures to ensure effective identification, tracking, and followup of significant ACAS-related events, as appropriate. Such procedures should focus on providing useful information to:

- Properly assess the importance of ACAS events.
- Follow up on information related to specific ACAS events, as necessary.
- Keep the industry and the FAA informed of the performance of ACAS in the National Airspace System (NAS) and in international operations.

5.1.10 Operator Maintenance Personnel Reports. Maintenance personnel are advised to report ACAS problems that relate to system performance, manufacturers, and/or vendors to the appropriate Principal Avionics Inspector (PAI).

CHAPTER 6. FOREIGN CARRIERS

6.1 General Requirements. Most foreign states mandate ACAS II equipage in compliance with ICAO requirements and guidance. The United States may require ACAS II equipage of U.S.-registered aircraft operating abroad, and foreign air carriers operating within the 12 NM territorial limit of the United States, its territories, or its possessions. The FAA cannot require the installation and use of ACAS II for any foreign aircraft operating outside of U.S. territorial limits.

6.2 ACAS Transponder Requirements. A foreign air carrier conducting operations within the United States, or foreign person operating U.S.-registered aircraft solely outside the United States in common carriage, should equip and operate ACAS transponders in U.S. airspace, as required by 14 CFR §§ 129.5, 129.14, and 129.18; ICAO Annex 6, Operation of Aircraft, Part I, International Commercial Air Transport—Aeroplanes; ICAO Annex 8, Airworthiness of Aircraft; and the FAA-issued OpSpecs, as appropriate.

6.3 ACAS Approval for Foreign Air Carriers. The FAA does not approve ACAS installation, training programs, MELs, or maintenance programs of 14 CFR part 129 air carriers operating non-U.S.-registered aircraft. Such authorizations are addressed as specified by the State of Operator and by ICAO. Compatibility of ACAS II and Mode S transponders with other aircraft and NAS facilities within U.S. airspace is essential. Compliance with these ACAS provisions ensures both ACAS II and procedural compatibility.

6.4 ACAS II RA Reporting Requirements. Civil aircraft of the United States operating anywhere, and foreign civil aircraft where the events occur within 12 NM of the United States, its territories, or its possessions, are also subject to 49 CFR § 830.5.

6.5 Standardization. Pilots are advised to use training and procedures for use of ACAS II, as specified by ICAO, this AC, or other equivalent criteria acceptable to the FAA, when operating in U.S. airspace.

APPENDIX A. ADMINISTRATIVE INFORMATION

A.1 Related Regulations.

1. Title 49 of the United States Code (49 U.S.C.) § 44716, Collision Avoidance Systems.
2. Title 14 of the Code of Federal Regulations (14 CFR):
   - Sections 1.1 and 1.2.
   - Section 61.156.
   - Sections 91.3, 91.111, 91.113, 91.123, 91.180, 91.213, 91.215, 91.217, 91.219, 91.221, 91.225, 91.227, 91.413, 91.703, 91.1023, 91.1045, and 91.1065; and part 91 appendix G.
   - Sections 119.7 and 119.49.
   - Sections 121.135, 121.345, 121.356, and 121.628; and part 121 appendix E and appendix F.
   - Sections 125.73, 125.201, 125.224, and 125.287.
   - Sections 129.5, 129.14, and 129.18.
   - Sections 135.23, 135.143, 135.179, 135.180, and 135.323.
3. Title 49 of the Code of Federal Regulations (49 CFR) §§ 830.5 and 830.15.

A.2 Requirements by 14 CFR Type.

A.2.1 Title 14 CFR part 121 air carrier requirements of equipage and operation of ACAS II for turbine aircraft are based upon maximum certificated takeoff weight of above 33,000 pounds. Some other aircraft operating under 14 CFR part 121 may require equipage and operation of ACAS I. Title 14 CFR § 121.356 also describes transponder requirements.

A.2.2 Title 14 CFR part 125 airplanes (large airplanes that are not conducting common carriage) have similar requirements to 14 CFR part 121 air carriers for equipage and operation of ACAS II. Title 14 CFR § 125.224 also describes transponder requirements.

A.2.3 Title 14 CFR part 135 air carrier ACAS equipage (approved ACAS I or ACAS II) requirements are based on passenger seat configuration for turbine aircraft. Title 14 CFR § 135.143 describes transponder requirements.

A.2.4 Title 14 CFR part 91 subpart K (part 91K) fractional ownership requirements of equipage and operation of ACAS depend on passenger seats or payload capacity. Airplanes with more than 30 passenger seats or a payload capacity of more than 7,500 pounds are subject to 14 CFR § 121.356. Airplanes with a lesser passenger and payload capacity are subject to 14 CFR § 135.180.

A.2.5 Title 14 CFR part 129 foreign air carriers and foreign operators of U.S.-registered aircraft engaged in common carriage have similar requirements to 14 CFR part 121 air carriers for equipage and operation of ACAS II. Title 14 CFR § 129.18 describes transponder requirements.

A.2.6 Title 14 CFR part 91 flights may be optionally equipped with ACAS. If the aircraft is equipped with an operable ACAS, ACAS shall be on and operating. If ACAS II is installed, then Automatic Dependent Surveillance-Broadcast (ADS-B), if installed, must be provided with an indication that ACAS II is operating, and an indication if a Resolution Advisory (RA) is in effect. If an aircraft is authorized for Reduced Vertical Separation Minimum (RVSM) and has Traffic Alert and Collision Avoidance System (TCAS) II installed, TCAS II must be version 7.0 or a later version.

A.3 Related Reference Material (current editions).

1. International Civil Aviation Organization (ICAO) Guidance (available at https://www.icao.int/publications/Pages/default.aspx):
   a. Annex 6, Operation of Aircraft:
      - Part I, International Commercial Air Transport—Aeroplanes.
      - Part II, International General Aviation—Aeroplanes.
   b. Annex 10, Aeronautical Telecommunications, Volume IV, Surveillance and Collision Avoidance Systems.
   c. Doc 4444, Procedures for Air Navigation Services—Air Traffic Management.
   d. Doc 8168, Procedures for Air Navigation Services—Aircraft Operations.
   e. Doc 9863, Airborne Collision Avoidance System (ACAS) Manual.
2. FAA Booklet HQ-111358, Introduction to TCAS II, Version 7.1 (Feb. 28, 2011).
3. FAA Orders and ACs:
   - FAA Order JO 7110.65, Air Traffic Control.
   - FAA Order 8900.1, Volume 3, Chapter 19, Section 8, Safety Assurance System: Special Training.
   - AC 20-151, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 and 7.1 and Associated Mode S Transponders.
   - AC 20-165, Airworthiness Approval of Automatic Dependent Surveillance - Broadcast OUT Systems.
   - AC 20-172, Airworthiness Approval for ADS-B In Systems and Applications.
   - AC 43-6, Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices.
   - AC 90-48, Pilots' Role in Collision Avoidance.
   - AC 90-114, Automatic Dependent Surveillance-Broadcast Operations.

- AC 91-70, Oceanic and Remote Continental Airspace Operations.
- AC 91-85, Authorization of Aircraft and Operators for Flight in Reduced Vertical Separation Minimum (RVSM) Airspace.
- AC 120-92, Safety Management Systems for Aviation Service Providers.
- AC 120-123, Flightpath Management.

4. Technical Standard Orders (TSOs) (available at https://drs.faa.gov):
   - TSO-C112f, Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment.
   - TSO-C118a, Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I.
   - TSO-C119e, Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II with Hybrid Surveillance.
   - TSO-C219a, Airborne Collision Avoidance System (ACAS) Xa/Xo.

     Note: ACAS installations may have been previously issued a TSO Authorization (TSOA) or Letter of Deviation Authority (LODA) under TSO-C119a–d and the corresponding ATCRBS/Mode S TSO.

5. RTCA, Inc. Technical Standards Documents (available for purchase at https://my.rtca.org/nc__store):
   - RTCA DO-181F as modified by Change 1, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment.
   - RTCA DO-185B, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II).
   - RTCA DO-197A, Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I).
   - RTCA DO-300A, Minimum Operational Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance.
   - RTCA DO-385A, Minimum Operational Performance Standards for Airborne Collision Avoidance System X (ACAS X) (ACAS Xa and ACAS Xo).

A.4 Accident History Related to the Development and Evolution of ACAS. This paragraph provides links to online information on significant historical accidents that have played a role in the development and evolution of ACAS. This paragraph does not provide a detailed narrative of those events, but rather enables interested readers to conduct further research into accidents that have influenced the development of ACAS by providing easy access to relevant information. The intent of providing links to this information is to provide access to historical lessons learned related to ACAS and to preserve key safety objectives for the system and facilitate its continued refinement.

1. Pacific Southwest Airlines Flight 182 Boeing 727 collision with a Cessna 172, near San Diego, on September 25, 1978 (NTSB Report AAR-79/05).
2. Aéromexico Airlines Flight 498 McDonnell Douglas DC-9 collision with a Piper PA-28-181, near Los Angeles, on August 31, 1986 (NTSB Report AAR-87/07).
3. Saudi Arabian Airlines Flight 763 Boeing 747 collision with Kazakhstan Airlines Flight 1907 Ilyushin IL-76, near Charkhi Dadri, India, on November 12, 1996.
4. German Air Force Tupolev TU-154 collision with a United States Air Force (USAF) Lockheed C-141, near the coast of Namibia, on September 13, 1997.
5. DHL Flight 611 Boeing 757 midair collision with Bashkirian Airlines Flight 2937 Tupolev Tu-154, near Überlingen, Germany, on July 1, 2002 (German Federal Bureau of Aircraft Accidents Investigation BFU Report AX001-1-2/02).
6. GOL Linhas Aéreas Flight 1907 Boeing 737-800 collision with an Embraer Legacy 600, near Peixoto de Azevedo, MT, Brazil, September 29, 2006 (Aeronautical Accident Investigation and Prevention Center CENIPA A-022/CENIPA/2008).

A.5 Acronyms.

Acronym	Term
14 CFR	Title 14 of the Code of Federal Regulations
49 CFR	Title 49 of the Code of Federal Regulations
49 U.S.C.	Title 49 of the United States Code
AAUP	Attention All Users Page
AC	Advisory Circular
ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Airborne Collision Avoidance System (also known as TCAS)
ACAS X	Airborne Collision Avoidance System X
ACAS Xa	ACAS X variant using “active” interrogations (used for fixed-wing aircraft)
ACAS Xo	ACAS X variant used for “operations” (tailors the guidance for designated aircraft to an operation)
AD	Airworthiness Directive
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-R	Automatic Dependent Surveillance-Rebroadcast
AED	Aircraft Evaluation Division
AFM	Aircraft Flight Manual
AFMS	Aircraft Flight Manual Supplement
AGL	Above Ground Level
AHRS	Attitude and Heading Reference System
AIM	Aeronautical Information Manual
AIP	Aeronautical Information Publication
AIR	Aircraft Certification Service
AOTO	ADS-B Only TA-ONLY
AP	Autopilot
ASAP	Aviation Safety Action Program
ASRS	Aviation Safety Reporting System
ATAS	ADS-B Traffic Advisory System
ATC	Air Traffic Control
ATCRBS	ATC Radar Beacon System
CAA	Civil Aviation Authority

Acronym	Term
CAS	Collision Avoidance System
CBT	Computer-Based Training
CH	Certificate Holder
CMO	Certificate Management Office
CMT	Certificate Management Team
CPA	Closest Point of Approach
CRM	Crew Resource Management
CSPO	Closely Spaced Parallel Operations
DAA	Detect and Avoid
DMOD	Distance Modification
DNA	Designated No Alert
DRS	Dynamic Regulatory System
EFIS	Electronic Flight Instrument Systems
ERC	Event Review Committee
ES	Extended Squitter
FAA	Federal Aviation Administration
FD	Flight Director
FL	Flight Level
FLT ID	Flight Identification
FOEB	Flight Operations Evaluation Board
fpm	Feet Per Minute
FS	Flight Standards
FSB	Flight Standardization Board
FSBR	Flight Standardization Board Report
FSDO	Flight Standards District Office
FSS	Flight Service Station
FSTD	Flight Simulation Training Device
FTD	Flight Training Device
g	Gravitational acceleration of 9.81 meters per second^2
GA	General Aviation
GNSS	Global Navigation Satellite System

Acronym	Term
HMD	Helmet-Mounted Display
HMD	Horizontal Miss Distance
HS	Hybrid Surveillance
HUD	Head-Up Display
HURS	High Update Rate Surveillance
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
inHg	Inches of Mercury
IRS	Inertial Reference System
LOA	Letter of Authorization
LODA	Letter of Deviation Authority
LOFT	Line-Oriented Flight Training
mb	Millibars
MEL	Minimum Equipment List
MHz	Megahertz
MMEL	Master Minimum Equipment List
Mode S	Mode Select
MOPS	Minimum Operational Performance Standards
MOR	Mandatory Occurrence Report
MRB	Maintenance Review Board
MRBR	Maintenance Review Board Report
MSpec	Management Specification
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NM	Nautical Mile
NMAC	Near Midair Collision
NSP	National Simulator Program
NTSB	National Transportation Safety Board
OpSpec	Operations Specification
PAI	Principal Avionics Inspector

Acronym	Term
PF	Pilot Flying
PFD	Primary Flight Display
PI	Principal Inspector
PL	Policy Letter
PM	Pilot Monitoring
PMI	Principal Maintenance Inspector
POI	Principal Operations Inspector
PRM	Precision Runway Monitor
QFE	The atmospheric pressure at aerodrome elevation (or at runway threshold)
QNE	The barometric pressure used for the standard altimeter setting (29.92 inHg)
QNH	The barometric pressure as reported by a particular station
RA	Resolution Advisory
RBDM	Risk-Based Decision Making
RVSM	Reduced Vertical Separation Minimum
RWC	Remain Well Clear
SA	Safety Assurance
SAFO	Safety Alert for Operators
SDP	Standard Datum Plane
SDR	Service Difficulty Report
SL	Sensitivity Level
SMS	Safety Management System
SRM	Safety Risk Management
SSR	Secondary Surveillance Radar
STBY	Standby
STC	Supplemental Type Certificate
TA	Traffic Advisory
Tau (τ)	Time to Closest Point of Approach
TAWS	Terrain Awareness and Warning System
TC	Type Certificate
TCAS	Traffic Alert and Collision Avoidance System (also known as ACAS)
TFC	Traffic

Acronym	Term
TOPA	TCAS Operational Performance Assessment
TSO	Technical Standard Order
TSOA	Technical Standard Order Authorization
UAT	Universal Access Transceiver
USAF	United States Air Force
UTC	Universal Coordinated Time
VFR	Visual Flight Rules
VMD	Vertical Miss Distance
VSI	Vertical Speed Indicator
XPDR	Transponder
ZTHR	Altitude Threshold (Z-axis Threshold)

A.6 Definitions.

A.6.1 Active Surveillance. Using ACAS interrogations and subsequent replies to update or acquire an ACAS track.

A.6.2 Airborne Collision Avoidance System (ACAS). A family of airborne devices meeting specified TSO and RTCA requirements that function independently of the ground-based ATC system to provide collision avoidance information.

A.6.2.1 **ACAS I.** An ACAS providing only TAs to assist pilots in the visual acquisition of intruder traffic. TCAS I is currently the only example of a developed ACAS I.

A.6.2.2 **ACAS II.** An ACAS that provides TAs and RAs, including vertical maneuvers that should or should not be performed to attain or maintain minimum safe vertical separation from a threat aircraft. TCAS II and ACAS Xa are currently the only examples of an ACAS II.

A.6.2.3 **ACAS III (in development).** An ACAS that provides TAs and RAs, including vertical and horizontal maneuvers that should or should not be performed to attain or maintain minimum safe separation from a threat aircraft.

A.6.3 ACAS II Maneuver Training. Part of flight training that includes the integration of ACAS II knowledge with the specific skills required to demonstrate satisfactory performance of a particular ACAS II procedure or maneuver, or series of procedures or maneuvers.

A.6.4 ACAS Academic Training (as applied herein). Part of ground training that exclusively addresses acquiring the required ACAS concepts, systems, limitations, or procedures knowledge (rather than skills), and demonstration of that knowledge. ACAS academic training generally is accomplished using a combination of classroom methods (standup instruction, computer-based instruction, tutorial, etc.), flight manual information bulletins, or self-study.

A.6.5 ACAS Event. For the purpose of this AC, one or more of the following occurrences or situations are related to ACAS:

A.6.5.1 **ACAS II Resolution Advisory (RA) or Traffic Advisory (TA).** Issuance of any ACAS II RA or TA as specified by a flightcrew.

A.6.5.2 **In-Flight Traffic Conflicts.** Other ACAS-related in-flight traffic conflicts or potential conflicts as determined by a flightcrew.

A.6.5.3 **Near Midair Collision (NMAC).** NMACs involving an ACAS-equipped aircraft.

A.6.5.4 **System Error.** ATC system error involving an ACAS-equipped aircraft.

A.6.5.5 **System Failures.** System failures related to a traffic conflict, potential traffic conflict situation, or ACAS general system performance.

A.6.5.6 **System Safety Performance.** Other ACAS occurrences or situations related to potential ACAS or ATC system safety performance.

A.6.6 Aircraft Certification Service (AIR) Office. The FAA offices responsible for oversight of design, production, airworthiness certification, and continued airworthiness programs for all U.S. civil aviation products and foreign import products.

A.6.7 Aircraft Evaluation Division (AED). The FAA offices that contribute an operational perspective to engineering activities and identify applicable operating regulations. In certification projects, a primary responsibility of AED is to evaluate, as appropriate, flightcrew type rating requirements, minimum equipment required for dispatch, and continued airworthiness. AED provides consultation, coordination, and assistance to AIR in certification programs and the development of Airworthiness Directives (AD).

A.6.8 Air Traffic Control Radar Beacon System (ATCRBS). Secondary surveillance radar system with ground-based interrogators and airborne transponders capable of operation on Modes A and C.

A.6.9 Altitude Threshold (ZTHR). The projected minimum altitude threshold or Z-axis Threshold (ZTHR) for the issuance of a preventive RA. The ZTHR varies with aircraft altitude.

A.6.10 Automatic Dependent Surveillance-Broadcast (ADS-B). A function on an aircraft or vehicle that automatically broadcasts its own-ship identity, state vector (horizontal and

vertical position and velocity), associated quality and performance parameters (accuracy and integrity), and other information. Broadcast links include the 1090 MHz Extended Squitter (ES) and the UAT broadcast on 978 MHz.

A.6.11 Bearing. The angle of another aircraft in the horizontal plane, measured clockwise from the longitudinal axis of own-ship.

A.6.12 Closest Point of Approach (CPA). The occurrence of minimum range between own-ship and another aircraft.

A.6.13 Coast. Condition that occurs when ACAS does not receive a reply to an interrogation from an aircraft where ACAS has established a track, resulting in the logic continuing the track based on previous track characteristics.

A.6.14 Coordination (as related to ACAS II). The process where ACAS II units in conflicting aircraft operating in TA/RA mode communicate with one another to generate complementary RAs to resolve an encounter (e.g., one ACAS generates a climb RA, and the other ACAS generates a descend RA).

A.6.15 Discrete. Separate, complete, and distinct signal.

A.6.16 Encounter. A situation when two or more aircraft are in proximity to each other so that an RA is generated on at least one of them.

A.6.17 False Advisory. An advisory determined by postevent analysis to have been caused by a false track or an ACAS malfunction.

A.6.18 Flight Standardization Board (FSB). The FAA board responsible for establishing or revising crew qualification requirements (e.g., training, checking, currency, and type rating(s)) for specific aircraft. FSBs are established for each large turbojet, turboprop, and special 14 CFR § 21.41 airplane type used in air transportation, as well as other 14 CFR part 25 airplanes, transport category multiengine helicopters, and large multiengine piston airplanes.

A.6.19 Flight Standards District Office (FSDO). A Flight Standards (FS) office staffed with personnel who serve the aviation industry and the public on matters relating to the certification and operation of air carriers and General Aviation (GA) aircraft.

A.6.20 Follow-On Supplemental Type Certificate (STC) (as related to ACAS). The following examples are follow-on STCs:

A.6.20.1 **ACAS II Installation.** A previously approved ACAS II installation that is installed in a subsequent type or model aircraft.

A.6.20.2 **Display Configuration.** Changes of display configuration; weather radar/ACAS display; supporting system inputs, such as radar altimeter; or other aircraft interfaces, such as TAWS, etc.

A.6.21 Horizontal Miss Distance (HMD). The horizontal range between two aircraft at the CPA.

A.6.22 Hybrid Surveillance (HS). Combined use of active and passive surveillance to update an ACAS track.

A.6.23 Initial Type Certificate (TC)/Supplemental Type Certificate (STC) (as related to ACAS). The first FAA ACAS airworthiness approval in accordance with a TC or an STC of any one or combination of the following components: an ACAS processor (computer), a directional antenna, and/or a Mode S transponder.

A.6.24 Intruder. An aircraft that has satisfied the ACAS TA generation criteria.

A.6.25 Maintenance Review Board (MRB). An FAA board responsible for establishing maintenance requirements for a specific aircraft type. MRB requirements are usually formulated in conjunction with information provided by the manufacturer and prospective operators through industry working groups. Responsible Flight Standards offices apply MRB requirements in reviewing and approving the maintenance program of an air carrier.

A.6.26 Master Minimum Equipment List (MMEL). An FAA document listing stipulation that may provide authorization for the continuation of flight beyond a terminal point with certain inoperative equipment. AED develops MMELs in conjunction with an FOEB established for each aircraft type. FAA MMELs serve as the basis for an operator to develop specific MELs applicable to its particular aircraft and operational requirements.

A.6.27 Mode A. ATCRBS SSR equipment or mode of operation that replies to interrogations with a 4-digit transponder code with 4,096 possible codes (non-altitude reporting).

A.6.28 Mode C. ATCRBS SSR equipment or mode of operation that replies to interrogations with aircraft pressure altitude information.

A.6.29 Mode S. Mode Select (S), SSR equipment, or mode of operation that replies to interrogations with transponder code, aircraft pressure altitude information, a discrete address, and other aircraft information.

A.6.30 Multiple Threat Encounter. An encounter involving two or more threats against own-ship being processed simultaneously by the ACAS.

A.6.31 National Airspace System (NAS). The common network of U.S. airspace; air navigation facilities; equipment and services; airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information, human resources, and material; and system components shared jointly with the military.

A.6.32 National Simulator Program (NSP). Program consisting of simulator evaluation specialists responsible for evaluating FSTDs to aid the POI in approving use of a specific FSTD in a training program.

A.6.33 Other Traffic. An aircraft that is more than 6 nautical miles (NM) laterally or more than 1,200 feet vertically from own-ship.

A.6.34 Passive Surveillance. The use of ADS-B Out position messages to update the ACAS track of other aircraft.

A.6.35 Pressure Altitude. The height above a Standard Datum Plane (SDP), a theoretical level where the weight of the atmosphere is 29.92 inches of mercury (inHg)/1013.25 millibars (mb). Aircraft transponders transmit and ACAS uses pressure altitude so that ACAS can function correctly with relative altitude between aircraft regardless of the barometric scale setting of the altimeter. When an aircraft is below Flight Level (FL) 180, ATC automation corrects the pressure altitude received from the transponder for nonstandard pressure to display the estimated indicated altitude of the aircraft to the controller.

A.6.36 Principal Inspector (PI). Refers to one of the following three FAA inspectors who is selected as primary for an air carrier:

A.6.36.1 Principal Avionics Inspector (PAI). The FAA inspector responsible for overseeing all avionics issues relative to a specific operator, including input on training programs, OpSpecs, MEL requests, etc.

A.6.36.2 Principal Maintenance Inspector (PMI). The FAA inspector responsible for overseeing all maintenance issues relative to a specific operator, including input on training programs, OpSpecs, MEL requests, etc.

A.6.36.3 Principal Operations Inspector (POI). The FAA inspector responsible for overseeing all operational issues relative to a specific operator, including training programs, OpSpecs approval, MEL approval requests, etc.

A.6.37 Proximate Traffic. Traffic shown on the traffic display that is within 6 NM laterally and 1,200 feet vertically of own-ship that does not meet the threshold for a TA or an RA.

A.6.38 Relative Altitude. The difference in altitude between own-ship and another aircraft. The value is positive when the other aircraft is higher and negative when the other aircraft is lower.

A.6.39 Resolution Advisory (RA). Aural voice and display information provided by ACAS II to a flightcrew, advising that a particular maneuver should or should not be performed to attain or maintain minimum safe vertical separation from a threat aircraft.

A.6.39.1 Altitude Crossing RA. An RA that directs a flightcrew to cross through the altitude of a threat aircraft to achieve safe vertical separation.

A.6.39.2 Coordinated Crossing RA. Initial RA coordinated between aircraft operating ACAS II and that direct the aircraft to cross in altitude.

A.6.39.3 Corrective RA. An RA that advises the flightcrew to either deviate from current vertical speed, such as climb when the aircraft is level, or to maintain an existing climb or descent rate.

A.6.39.4 Increase Rate RA. An RA that is issued after an initial climb or descend RA that indicates additional climb or descent rate is required to achieve safe vertical separation. An increase rate RA requires a climb or descent rate of 2,500 fpm.

A.6.39.5 Initial RA. First RA generated during an encounter.

A.6.39.6 Preventive RA. An RA that requires a flightcrew to avoid certain deviations from current vertical rate, such as a do not climb RA when the aircraft is level.

A.6.39.7 Reversal RA. An RA that indicates a change in the direction previously generated by ACAS II and that is required to achieve safe vertical separation (e.g., an initial descend RA that reverses to a climb RA).

A.6.39.8 Subsequent RA. A modified RA generated during an encounter after the initial RA but before a "Clear of Conflict" annunciation. Subsequent RAs may be weakened, strengthened, or reversed.

A.6.39.9 Weakened RA. An initial corrective RA that changes to an RA calling for a return to level flight because ACAS II has determined that safe vertical separation is projected (e.g., a climb RA weakens to a do-not-descend advisory once the desired vertical separation has been achieved).

A.6.40 Sense. A direction that an RA may take (either climb or descend) relative to the existing flight path of own-ship.

A.6.41 Significant ACAS Events. Significant ACAS events are those that meet any one of the following guidelines:

A.6.41.1 Altitude Excursion. There is an altitude excursion of more than 1,000 feet from an assigned level altitude.

A.6.41.2 Coordinated Crossing RA. ACAS II generates a coordinated crossing RA.

A.6.41.3 Descent RA. ACAS II generates a descent RA when own-ship is below 1,000 feet AGL.

A.6.41.4 Performance. ACAS is suspected of not performing as designed.

A.6.41.5 Reversal RA. ACAS II generates a reversal RA.

A.6.41.6 Loss of Standard Air Traffic Control (ATC) Separation. There is a loss of standard ATC separation resulting from compliance with an ACAS II-generated RA.

A.6.42 Squitter. Spontaneous transmission generated by Mode S transponders and ADS-B transmitters.

A.6.43 Standard Datum Plane (SDP). A theoretical level where the weight of the atmosphere is 29.92 inHg/1013.25 mb.

A.6.44 Supplemental Type Certificate (STC). An FAA certificate attesting to the fact that modification to the respective aircraft, engines, or other components meet 14 CFR airworthiness requirements.

A.6.45 Tau (τ). Greek symbol representing the time to CPA.

A.6.46 Traffic Alert and Collision Avoidance System (TCAS) I and II. See ACAS I and ACAS II.

A.6.47 TCAS Operational Performance Assessment (TOPA). Program to characterize and assess the performance of ACAS in the U.S. NAS and, when appropriate, make recommendations to improve operational performance.

A.6.48 Threat. An aircraft that has satisfied the ACAS II RA generation criteria.

A.6.49 Track. Estimated position and velocity of a single aircraft based on correlated surveillance data reports.

A.6.50 Traffic. Aircraft with an operating transponder capable of being tracked and displayed by an aircraft operating ACAS.

A.6.51 Traffic Advisory (TA). Aural voice and display information provided by ACAS to a flightcrew, identifying the location of nearby traffic that meets certain minimum separation criteria.

A.6.52 Type Certificate (TC). An FAA certificate attesting to the fact that the respective aircraft, engines, or other components meet 14 CFR airworthiness requirements.

A.6.53 Vertical Miss Distance (VMD). The relative altitude between own-ship and displayed aircraft at CPA.

APPENDIX B. SAMPLE ACAS GROUND AND FLIGHT TRAINING PROGRAM

B.1 Introduction. This appendix provides a set of training standards for ACAS flightcrew training. The information contained in this appendix related to Traffic Advisories (TA) is also applicable to ACAS I users. Training standards are divided into areas of instruction required for ground training (academics) and the performance objectives for the maneuvers required in flight training.

B.2 ACAS II Ground Training. ACAS II ground training should cover, in general terms, ACAS II theory to the extent appropriate to ensure proper operational use. Aircrews should understand basic concepts of ACAS II logic, Closest Point of Approach (CPA), time to CPA (represented by the Greek symbol tau (τ)), and altitude separation thresholds for the issuance of Resolution Advisories (RA), as well as the relationship between displayed traffic information and issuance of TAs and RAs. The ground training program should address the following:

B.2.1 Theories of Operation.

B.2.1.1 Objective. Demonstrate knowledge of how ACAS II functions.

B.2.1.2 Criteria. The pilot must demonstrate an understanding of the following functions:

1. Surveillance:
   a. ACAS II interrogates other aircraft operating a transponder within a nominal range of 14 nautical miles (NM).
   b. ACAS II surveillance range will be reduced in geographic areas with a large number of ground interrogators and/or aircraft operating ACAS II. A minimum surveillance range of 4.5 NM is guaranteed for airborne ACAS II aircraft.
2. Collision Avoidance:
   a. TAs can be generated against any aircraft operating a transponder even if the aircraft is non-altitude reporting (and own-ship is below 15,500 feet pressure altitude).
   b. RAs can be generated only in the vertical plane and only against aircraft that are reporting altitude.
   c. RAs generated against a threat aircraft operating ACAS II are coordinated to ensure complementary RAs are generated.
   d. Failure to respond to an RA deprives own-ship of the collision protection provided by its ACAS II. In encounters where both aircraft are operating TA/RA mode, failure to respond to an RA by one aircraft restricts the RA maneuvers available to the other ACAS II-equipped aircraft.

B.2.2 Advisory Thresholds.

B.2.2.1 **Objective.** Demonstrate knowledge of the criteria for issuing TAs and RAs.

B.2.2.2 **Criteria.** The pilot should be able to demonstrate an understanding of the methodology used by ACAS II to generate TAs and RAs and the general criteria for the issuance of these advisories, including the following:

1. ACAS II advisories are typically based on time to CPA. The separation standards provided by Air Traffic Control (ATC) are different from ACAS TA and RA thresholds.
2. In encounters with a slow closure rate, ACAS II advisories will be generated based on distance.
3. The timing of TA and RA generation varies with altitude. The threshold for TA and RA is longer at higher altitudes:
   a. TAs generally occur 8 to 15 seconds prior to an RA.
   b. RAs generally occur from 15 to 35 seconds before the projected CPA.
   c. RAs are chosen to provide the desired Vertical Miss Distance (VMD) at CPA. As a result, RAs may generate a climb or descent through the altitude of the threat aircraft.

B.2.3 ACAS II Limitations.

B.2.3.1 **Objective.** To verify the pilot is aware of the limitations of ACAS II.

B.2.3.2 **Criteria.** The pilot should demonstrate a knowledge and understanding of the ACAS II limitations, including the following:

1. ACAS II may neither track nor display aircraft that are not operating a transponder, including transponders that have failed.
2. ACAS II will automatically fail if the input from the barometric altimeter, radio altimeter, or transponder is lost.
3. In some installations, the loss of information from other onboard systems, such as an Inertial Reference System (IRS) or Attitude and Heading Reference System (AHRS), may result in an ACAS II failure. Individual operators should ensure their flightcrews are aware of what types of aircraft system failures will result in an ACAS II failure.
4. Some aircraft within 380 feet Above Ground Level (AGL) (nominal value) will not be displayed. If ACAS II can determine that an aircraft below this altitude is airborne, it will display it.
5. ACAS II may not display all proximate aircraft operating a transponder in areas of high-density traffic.

6. Because of design limitations, the bearing displayed by ACAS II is not sufficiently accurate to support the initiation of horizontal maneuvers based solely on the traffic display.
7. Because of design limitations, TCAS II may neither display nor generate an advisory against aircraft with a vertical speed of more than 10,000 feet per minute (fpm).
8. A stall warning, Terrain Awareness and Warning System (TAWS) "Pull Up" alert, or windshear warning takes precedence over a TA or an RA. When either a stall warning, TAWS "Pull Up" alert, or windshear warning is active, TA and RA aural annunciations will be inhibited, and ACAS II will automatically switch to the TA-ONLY mode of operation. ACAS II will remain in TA-ONLY mode for 10 seconds after the TAWS "Pull Up" alert or windshear warning is removed.

B.2.4 ACAS II Inhibits.

B.2.4.1 **Objective.** To verify the pilot is aware of the conditions that certain functions of ACAS II are inhibited.

B.2.4.2 **Criteria.** The pilot should demonstrate a knowledge and understanding of the various ACAS II inhibits, including the following:

1. Increase descent RAs are inhibited below 1,450 feet AGL.
2. Descend RAs are inhibited below 1,100 feet AGL.
3. All RAs are inhibited below 1,000 feet AGL.
4. All ACAS II aural annunciations are inhibited below 500 feet AGL.
5. The altitudes and configurations that inhibit climb and increase climb RAs. ACAS II can still generate climb and increase climb RAs when operating at the maximum altitude or certified ceiling. Responses to climb RAs while operating at the maximum altitude or certified ceiling are expected to be complied with in the normal manner.

Note: In some aircraft types, climb or increase climb RAs are never inhibited.

B.2.5 Operating Procedures.

B.2.5.1 **Pilot Knowledge.** The pilot should demonstrate the knowledge required to operate ACAS II and interpret the information presented by ACAS II.

B.2.5.2 **Training Topics.** This training should address the following topics:

B.2.5.2.1 Use of Controls.

1. Objective. To verify the pilot can properly operate all ACAS II and display controls.
2. Criteria. The pilot should demonstrate the proper use of controls, including the following:
   a. Aircraft configuration required to initiate a self-test.
   b. Steps required to initiate a self-test.
   c. Recognizing when the self-test was successful and when it was unsuccessful. When the self-test is unsuccessful, recognizing the reason for the failure and, if possible, correcting the problem.
   d. Recommended usage of traffic display range selection. Low ranges are used in the terminal area, and the higher display ranges are used in the en route environment and in the transition between the terminal and en route environment.
   e. If available, recommended usage of the above/below mode selector. Above mode should be used during climb, and below mode should be used during descent.
   f. Recognition that the configuration of the traffic display (i.e., range and Above/Below selection) does not affect the ACAS II surveillance volume.
   g. Selection of appropriate ranges on the traffic display to increase situational awareness of close-in traffic when an advisory is generated.
   h. If available, proper selection of the display of absolute or relative altitude and the limitations of using the absolute display option if a barometric correction is not provided to ACAS II.
   i. Proper configuration to display the appropriate ACAS II information without eliminating the display of other needed information.
   j. Selection of various ACAS II and transponder operating modes.

B.2.5.2.2 Display Interpretation.

1. Objective. To verify a pilot understands the meaning of all information that can be displayed by ACAS II.
2. Criteria. The pilot should demonstrate the ability to properly interpret information displayed by ACAS II, including the following:
   a. Other traffic (i.e., traffic within the selected display range that is not proximate traffic, a TA, or an RA).
   b. Proximate traffic (i.e., traffic that is within 6 NM and 1,200 feet).
   c. Non-altitude reporting aircraft.

d. ADS-B Only TA-ONLY (AOTO) traffic.

e. No-bearing TAs and RAs.

f. Off-scale TAs and RAs. The selected range should be changed to ensure that all available information on the intruder or threat aircraft is displayed.

g. TAs. The minimum available display range that allows the traffic to be displayed should be selected to provide the maximum display resolution.

h. RAs (traffic display). The minimum available display range of the traffic display that allows the traffic to be displayed should be selected to provide the maximum display resolution.

i. RAs. Pilots should demonstrate knowledge of the meaning of the red and green areas, or the meaning of pitch or flight path angle cues displayed on Primary Flight Displays (PFD), RA displays, Head-Up Displays (HUD), etc. For displays using red and green areas, demonstrate knowledge of when the green areas will and will not be displayed.

j. If appropriate, awareness that navigation displays oriented Track-Up may require a pilot to make a mental adjustment for drift angle when assessing the bearing of proximate traffic.

k. ACAS II symbology differences when incorporated with ADS-B In.

B.2.5.2.3 Use of the TA-ONLY Mode.

1. Objective. To verify that a pilot understands the appropriate times to select the TA-ONLY mode of operation and the limitations associated with using this mode.

2. Criteria. The pilot should demonstrate the following:

   a. Knowledge of the standard operating procedures for the use of TA-ONLY mode.

   b. Reasons for using TA-ONLY mode and situations where the use of TA-ONLY may be desirable.

   c. The TA aural annunciation is inhibited below 500 feet AGL. As a result, TAs generated below may not be noticed unless the TA display is included in the routine instrument scan.

B.2.5.2.4 Crew Coordination.

1. Objective. To verify pilots adequately brief other crewmembers on how ACAS advisories will be handled. This portion of the training may be combined with other training, such as Crew Resource Management (CRM).

2. Criteria. Pilots should demonstrate during their preflight briefing the procedures that will be used in responding to TAs and RAs, including the following:
   a. Division of duties between the Pilot Flying (PF) and Pilot Monitoring (PM), including a clear definition of who will fly the aircraft during a response to an RA;
   b. Expected callouts;
   c. Conditions where an RA may not be complied with and who will make this decision; and
   d. Communications with ATC.

Note: The operator should specify the conditions under which an RA need not be complied with.

B.2.5.2.5 Reporting Requirements.

1. Objective. To verify the pilot is aware of the requirements for reporting RAs to the controller and other authorities.
2. Criteria. The pilot should demonstrate the following:
   a. The use of the standard phraseology in this AC, and
   b. Where information can be obtained regarding the need for making written reports when an RA is generated.

B.3 ACAS II Maneuver Training. The scenarios included in the maneuver training should include initial RAs that require a change in vertical speed (corrective RA); initial RAs not requiring a change in vertical speed; maintain rate RAs; altitude crossing RAs; increase rate RAs; reversal RAs; weakened RAs; RAs generated while the aircraft is at a maximum altitude; and multiple threat encounters. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and maneuvering opposite to the direction called for by the displayed RA as follows:

B.3.1 TA Responses.

B.3.1.1 Objective. To verify the pilot properly interprets and responds to TAs.

B.3.1.2 Criteria. The pilot should demonstrate:

1. Proper division of responsibilities between the PF and PM. The PF should continue to fly the airplane and be prepared to respond to any RA that might follow. The PM should provide updates on the traffic location shown on the ACAS II traffic display and use this information to help visually acquire the intruder.
2. Proper interpretation of the displayed information. Both pilots confirm that the aircraft they have visually acquired is the aircraft that has caused the

TA to be issued. Use should be made of all information shown on the display, note being taken of the bearing and range of the intruder (amber circle), whether it is above or below (data tag), and its vertical speed direction (trend arrow).

3. All available information is used to assist in visual acquisition.
4. Unnecessary requests for traffic information are not made following TAs.
5. No maneuvers are made based solely on the information shown on the ACAS II display.
6. When visual acquisition is attained, right-of-way rules are used to maintain or attain safe separation. Unnecessary maneuvers are not initiated. The limitations of making maneuvers based solely on visual acquisition are understood.

B.3.2 RA Responses.

B.3.2.1 Objective. To verify the pilot properly interprets and responds to RAs.

B.3.2.2 Criteria. The pilot should demonstrate the following:

1. Proper division of responsibilities between the PF and PM. The PF should respond to the RA with the correct flight path management techniques, including manual flight operations or effective use of the autoflight system (when ACAS II mode is available). The PM should provide updates on the traffic location, check the traffic display, and monitor the response to the RA. Proper CRM should be used. If standard operating procedures require the Pilot in Command (PIC) to fly all RAs, transfer of aircraft control should be demonstrated.
2. Proper interpretation of the displayed information. The pilot recognizes any threat aircraft causing an RA (red square on the traffic display) and responds appropriately.
3. For RAs requiring a change in vertical speed, initiation of a response in the proper direction is made within 5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 0.25 g to obtain the required vertical rate. ATC is notified of the RA response without delay after initiating the maneuver using the standard phraseology.
4. Recognition of, and the proper response to, modifications to the initially displayed RA.
    a. For increase rate RAs, the vertical speed is increased within 2.5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 0.35 g.

b. For reversal RAs, the maneuver is initiated within 2.5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 0.35 g.

c. For weakened RAs, the vertical speed is modified to initiate a return toward level flight within 2.5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 0.25 g.

d. For RAs that strengthen, the maneuver to comply with the revised RA is initiated within 2.5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 0.25 g.

5. Recognition of altitude crossing encounters and the proper response to these RAs.

a. For RAs that do not require a change in vertical speed, that the vertical speed needle or pitch angle remains outside the red area on the RA display.

b. For maintain rate RAs, that the vertical speed is not reduced. Pilots should recognize that a maintain rate RA may result in crossing the altitude of the threat aircraft.

c. That if a justified decision is made to not comply with an RA, the resulting vertical rate is not in a direction opposite to the sense of the displayed RA.

d. That the deviation from the current clearance is minimized by leveling the aircraft when the RA weakens, and when "Clear of Conflict" is annunciated, executing a prompt return to the current clearance; and notifying ATC using the standard phraseology as soon as permitted by flightcrew workload after resuming the current clearance.

e. That, when possible, an ATC clearance or instruction is complied with while responding to an RA (e.g., if the aircraft can level at the assigned altitude while responding to a reduce climb or reduce descent RA, it should be done).

f. That when simultaneous conflicting instructions to maneuver are received from ATC and an RA, the RA is complied with, and ATC is notified using the standard phraseology as soon as permitted by flightcrew workload.

g. Awareness that ACAS II is designed to cope with a multiple threat encounter, and that ACAS II can optimize separation by climbing or descending toward one of them (e.g., ACAS II only considers aircraft that it considers a threat when generating an RA. As such, it is possible for ACAS II to generate an RA against one threat that results in a maneuver toward another aircraft that is not classified as a threat. If

the second aircraft becomes a threat, the RA will be modified to provide separation from that aircraft.).

h. The consequences of not responding to an RA and maneuvering in the direction opposite to the RA.

i. A prompt response is made when a climb RA is generated while the aircraft is at the maximum altitude.

j. If applicable, compliance with an Autopilot (AP) RA and demonstration of the ability to return to course, address mode conflict issues, etc.

B.3.3 Characteristics of Training Equipment Suitable for Maneuver Training.

B.3.3.1 **Acceptable Characteristics.** Flight Training Devices (FTD), simulators, and computer-based trainers should have certain characteristics to be effective. This is due to the interactive nature of ACAS II, the variety of encounter scenarios possible, the immediate and standardized pilot response required, and the instant and correct display interpretation that is necessary. Thus, training equipment used for ACAS II flight training should have the following characteristics:

- The ability to functionally represent traffic displays, controls, indications, and annunciations;
- The ability to depict selected traffic encounter scenarios, including traffic display and audio advisories;
- The ability to show proper ACAS II reaction to depicted scenarios and advisories; and
- The ability to interactively respond to pilot inputs regarding ACAS II advisories, including responses to RAs displayed on relevant vertical speed and pitch indicators.

B.3.3.2 **Simulator and ACAS II Fidelity.** For a particular ACAS II, one may accomplish maneuver training in ACAS II-qualified simulators or FTDs that represent the specific aircraft or an aircraft that has similar characteristics. For the purposes of ACAS II maneuver training, simulators or FTDs may use simplified ACAS II algorithms or displays and do not require ACAS II logic or an ACAS II processor. Traffic displays do not have to be identical but should be functionally equivalent to the specific aircraft in use by the operator.

B.3.3.3 **FTD or Simulator Approval.** The National Simulator Program (NSP) qualifies Flight Simulation Training Devices (FSTD) as meeting 14 CFR part 60 requirements, and the Principal Operations Inspector (POI) approves them for use in a training program. Any one or combination of the following ACAS II-qualified devices may be used:

- Level A through D simulators,
- Level 4 through 7 FTDs, or
- Other ACAS II training devices that are shown to be suitable for ACAS II training and are approved by the POI.

APPENDIX C. SAFETY MANAGEMENT SYSTEM (SMS) CONSIDERATIONS FOR ACAS II TA-ONLY MODE OPERATIONS

C.1 SMS. Per AC 120-92, Safety Management Systems for Aviation Service Providers, the defining characteristic of an SMS is that it is a Risk-Based Decision-Making (RBDM) system. An SMS is built by structuring the safety management of an operator around four components: safety policy, Safety Risk Management (SRM), Safety Assurance (SA), and safety promotion. Organizations that are required to comply with 14 CFR part 5 should use the SRM and SA components of an SMS to perform RBDM and monitoring on ACAS II use and the policies and procedures thereof. All operators are recommended to implement a formal process for gathering feedback on ACAS II use. This includes any irregularities, malfunctions, and lessons learned. An operator is recommended to use this formal process during design, installation, modifications, or improvements to procedures and/or training. In this appendix, an example will be discussed for SMS consideration for ACAS II TA-ONLY mode operations.

C.1.1 SRM. SRM provides a system for identifying hazards and mitigating risk based on a thorough understanding of the organization's systems and their operating environment.

C.1.1.1 When SRM is needed, an operator should apply SRM to the implementation of new systems, revision of existing systems, development of operational procedures, and identification of hazards or ineffective risk controls through the SA process.

C.1.1.2 SRM Processes. There are five processes necessary to control and mitigate risk: system analysis, hazard identification, safety risk analysis, safety risk assessment, and safety risk controls.

Example: SRM is recommended for an operator of an ACAS II-equipped aircraft if the operator were to consider advising their flightcrews to select TA-ONLY mode for approach at a specific airport. This procedure removes a risk control. A risk control is a means to reduce or eliminate the effects of hazards (in this case, the risk control offered by the Traffic Advisory (TA)/Resolution Advisory (RA) mode of the ACAS II). SRM is recommended to describe the system; identify the hazards; and analyze, assess, and control the risk.

C.1.1.3 System analysis and hazard identification proactively identify and address potential problems before the new or revised systems or procedures are put into place. In the example, the use of TA-ONLY mode presents hazards that an operator should identify for the system that they operate. The knowledge gained in the system analysis and subsequent risk analysis will later be used to develop a mitigating strategy.

C.1.1.4 Safety risk analysis estimates the severity and likelihood of a potential accident due to exposure to an identified hazard (in this case, a hazard associated with the selection of TA-ONLY mode on approach).

C.1.1.5 Safety risk assessment is completed once the risk has been analyzed. The operator should assess whether the risk is acceptable. A common tool used in risk assessment decisions is a risk matrix. A risk matrix enables an organization to assess risks, compare potential effectiveness of proposed risk controls, and prioritize risks where multiple risks are present by providing a way to integrate the severity of the outcome and the probability of occurrence. If the risk is found to be acceptable, then the system may be placed into operation and monitored in the SA process. If the operator decides the risk is not acceptable, the operator will need to follow the next step in SRM, where an operator will develop risk controls.

C.1.1.6 Safety risk control is conducted after hazards and associated risks are fully understood. Risk controls are utilized to reduce the likelihood or severity of a hazard and mitigate the associate risk. Risk controls should be designed for risks that are deemed unacceptable.

C.1.2 SA. SA works in partnership with SRM. In SA, the process continues with measuring and monitoring the performance of the system operation, with the designed risk controls in place. SA processes are a means of assuring the safety performance of the organization, keeping it on track, correcting it where necessary, and identifying needs for rethinking existing processes. SA requires monitoring and measuring safety performance of operational processes and continuously improving the level of safety performance. Strong SA processes will yield information used to maintain the integrity of risk controls. SA steps include system monitoring, data acquisition, analysis of data, system assessment, and corrective action. Data acquisition involves a variety of sources, including continuous monitoring, internal audits (by operational departments), internal evaluations (by other departments within the company), external auditing (third-party audits), investigations, and employee reporting and feedback systems.

Example: An SA process is recommended for an operator of an ACAS II-equipped aircraft if the operator is evaluating and monitoring the use of TA-ONLY mode for approach at a specific airport.

C.1.2.1 Continuous Monitoring. One source of data may be continuous monitoring. In the monitoring of the operational environment and operational processes, it comes to the attention of the operator that the flightcrews are not complying with the company policy.

C.1.2.2 Analysis of Data. Analysis involves examining data acquired from various sources to make inferences about the effectivity of the risk controls.

C.1.2.3 Safety Performance Assessment. In the assessment step, collected safety performance data has been analyzed, and the results are used for informed decision making. The assessment process is where these decisions are made. In this example, conformity with the risk controls appear to be unsatisfactory, and desired results are not being obtained. If this occurs, the SRM processes would be triggered.

C.1.2.4 The final step within SA is continuous improvement. This process is designed to ensure that the operator is correcting substandard safety performance identified during the safety performance assessment to continuously improve safety performance.

C.2 TA-ONLY Considerations for SMS.

C.2.1 RAs can occur while aircraft are separated in accordance with established standards. Even when closely spaced parallel approach procedures are correctly applied, unwanted RAs may occasionally occur. However, the safety benefit provided by ACAS II takes precedence over an occasional unwanted RA. Additionally, there is always the possibility another aircraft that is not associated with the parallel approach procedure becomes a threat. The term "nuisance alert" is commonly used to describe an RA when it is not desired. This is a misnomer; ACAS II is operating as designed, and flightcrews should comply with the RA.

C.2.2 Flight Standards (FS) has identified several considerations associated with operating ACAS II in TA-ONLY mode. An operator is advised to consider the following list during the SRM process. This list is nonexhaustive, and additional unique considerations, hazards, or ineffective risk controls are to be identified that are applicable to the environment of an individual operator:

1. Likelihood of aircraft positioned so that they are at risk for a collision, including uncontrolled/noncompliant (with Air Traffic Control (ATC) clearances or instructions) traffic.
2. Pilot reaction time to establish visual contact with the intruder aircraft.
3. Pilot reluctance to comply with an RA, in TA/RA mode, due to complacency associated with unwanted or expected RAs.
4. Difficulty of visually acquiring and monitoring an intruder aircraft in meteorological conditions that reduce the ability to accurately judge the flight path of the intruder aircraft (e.g., sun angle, haze, lack of defined horizon, and nighttime).
5. Difficulty of visually acquiring and monitoring an intruder aircraft on a parallel or converging approach course (i.e., intruder aircraft may possibly be adjacent or behind the flight path of own-ship).
6. Difficulty of ascertaining the flight path of the intruder aircraft (e.g., visual perception of the encounter may be misleading).
7. Difficulty understanding the flight trajectory of the traffic on an adjacent final approach segment or elsewhere due to traffic display bearing accuracy limitations.
8. In low closure rate scenarios (e.g., Closely Spaced Parallel Operations (CSPO)) with TA-ONLY mode selected, after receiving the initial TA, no auditory ACAS II advisories will be generated after the initial TA. The flightcrew may, over time, have reduced awareness of the flight path of the intruder aircraft.
9. Increased flightcrew workload during the approach phase (e.g., selecting TA-ONLY mode and monitoring the flight path of all intruder aircraft.)

10. Increased flightcrew workload during a missed approach/go-around/balked landing (e.g., selecting TA/RA mode and monitoring the flight path of possible adjacent missed approach traffic).
11. Lack of RA maneuver generation when TA-ONLY mode was selected on an approach, and the flightcrew fails to return to TA/RA mode in the event of a missed approach/go-around/balked landing.
12. If a flightcrew does not intend to respond to an RA and operates in TA-ONLY mode, other ACAS II-equipped aircraft operating in TA/RA mode will have maximum flexibility in generating RAs to resolve encounters.

APPENDIX D. ACAS RESOLUTION ADVISORY (RA) REPORT

Your participation in the reporting of ACAS events is essential to the success of ongoing evaluation of ACAS performance. Use the following information to guide your reporting of the ACAS event through the pilot report options outlined in this AC.

Reporting Pilot: _____ Date: _____/_____/_____ Time: _____ UTC
Origin: _____ Destination: _____ Call Sign: _____ A/C Type: _____
Registration Number: _____
Transponder Code: _____ ATC Control Name: _____
ATC Control Frequency: _____
Actual Altitude: _____ Cleared Altitude: _____
Own Position: _____ (Lat./Long. or Nav Aid/Radial/Distance)
Phase of Flight: □ Departure (Takeoff to 10,000 feet) □ Climb (10,000 feet to Cruise)
□ Cruise □ Descent (Cruise to 10,000 feet) □ Holding Pattern □ Approach (Below 10,000 feet)
THREAT AIRCRAFT (if known)
Call Sign: _____ A/C Type: □ Commercial □ General Aviation □ Military □ Other
Make/Model: _____ Actual Altitude: _____ Cleared Altitude: _____
Did you have the aircraft in visual contact? □ Yes □ No
If yes: □ Before TA / □ After TA. □ Before RA / □ After RA.
Was a TA generated? □ Yes □ No
Were multiple TAs generated against the same intruder? □ Yes □ No
Initial RA Generated: □ Descend, Descend □ Climb, Climb □ Monitor Vertical Speed
□ Climb, Crossing Climb □ Descend, Crossing Descend
□ Maintain Vertical Speed, Maintain □ Maintain Vertical Speed, Crossing Maintain
□ Adjust Vertical Speed, Adjust _____ feet/minute □ Level Off, Level Off
Did the initial RA change to any of the following?
□ Adjust Vertical Speed, Adjust □ Level Off, Level Off □ Increase Climb □ Increase Descent
□ Climb, Climb NOW □ Descend, Descend NOW □ Descend, Descend □ Climb, Climb
Range to threat aircraft at RA? _____ Bearing to threat aircraft at RA? _____
Relative altitude of threat aircraft at RA? _____feet
Estimated Closest Proximity: Range _____NM Altitude _____NM
Your response to the RA was: □ Climb □ Descend □ Change in Vertical rate □ Level Off
□ Turn □ No Response □ No Response Necessary
Was the event reported to ATC? □ Yes □ No
Did ATC provide traffic information on the threat aircraft? □ Before RA □ After RA □ No
Did the RA conflict with ATC instructions? □ Yes □ No
If you did not comply with the RA, please explain why:

_____
_____
REMARKS (please provide comments/concerns on this encounter):
_____
_____

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by contacting the Flight Technologies and Procedures Division at 9-AWA-AFS400-Coord@faa.gov or the Flight Standards Directives Management Officer at 9-AWA-AFB-120-Directives@faa.gov.

Subject: AC 90-120, Operational Use of Airborne Collision Avoidance Systems

Date: _____

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _____ on page _____.

☐ Recommend paragraph _____ on page _____ be changed as follows:

_____

_____

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

_____

_____

☐ Other comments:

_____

_____

☐ I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____