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Memorandum

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ANM-160S		
ANM-190S		
FILE		

Subject: **ACTION**: Interim Guidance for Airworthiness Approval and Operational Use of Traffic Alert and Collision Avoidance System (TCAS I)

Date: JUN 16 1995

From: Manager, Aircraft Engineering Division, AIR-100
Manager, Air Transport Division, AFS-200

Reply to Attn. of: F C Rock: 267-9567

To: All Aircraft Certification Service Directorates
All Aircraft Certification Office Managers
All Aircraft Certification Service Standards Staffs

The attached interim guidance (draft Advisory Circular AC No. 20-TCAS) for the airworthiness approval and operational use of Traffic Alert and Collision Avoidance System (TCAS I) will be national guidance for the approval of these systems until such time as the Advisory Circular is published. This is necessary because:

(1) No Federal Aviation Administration guidance currently exists for the certification and installation of airborne systems.

(2) Certification of TCAS I installation have been approved by some ACO's.

(3) The draft AC will require some additional time for final coordination prior to publication.

The attached draft has been coordinated with the certification directorates, aircraft certification offices and AFS-200, all comments were addressed and included in the document where appropriate.

John K. McGrath

David R. Harrington

US Department
of Transportation
Federal Aviation Administration

INTERIM GUIDANCE

Subject: AIRWORTHINESS APPROVAL AND OPERATIONAL USE OF TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS I)

Date:
Initiated By: AIR-130

AC No: 20-TCAS
Change: DRAFT

1. PURPOSE. This advisory circular (AC) provides guidance material for the airworthiness approval and operational use of Traffic Alert and Collision Avoidance Systems (TCAS I). Like all AC material, this AC is not mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline a method of compliance with the rules. In lieu of following this method without deviation, the applicant may elect to follow an alternate method, provided the alternate method is also found by the Federal Aviation Administration (FAA) to be an acceptable means of complying with the requirements of the Federal Aviation Regulations (FAR). Because the method of compliance presented in this AC is not mandatory, the terms "shall" and "must" used herein apply only to an applicant who chooses to follow this particular method without deviation.

2. FOCUS. The material provided in this AC addresses the design aspects, characteristics, mechanization, testing, and the criticality of system failure cases for TCAS I. The guidance material is directed at systems which provide traffic advisories only (TCAS I) and where the operational performance standards are defined in technical documents that were developed by a joint air transport industry/government group (RTCA Special Committee SC-147).

3. RELATED FAR SECTIONS. §§ 91.3, 91.123, 91.213, 91.215, 91.217, 91.221, 91.413, 135.143, and 135.180. Portions of the 14 CFR FAR, as presently written, can be applied for the design, substantiation, certification, and operational approval of TCAS I. Sections which prescribe requirements for these types of systems include:

§ 25.301	Loads.
§ 25.303	Factor of safety.
§ 25.305	Strength and deformation.
§ 25.561	Emergency Landing Conditions--General.
§ 25.603	Materials.
§ 25.609	Protection of structure.
§ 25.629	Flutter, deformation and fail-safe criteria.

§ 25.1301 Function and installation.
§ 25.1303 Flight and navigation instruments.
§ 25.1307 Miscellaneous equipment.
§ 25.1309 Equipment, systems, and installations.
§ 25.1321 Arrangement and visibility.
§ 25.1322 Warning, caution, and advisory lights.
§ 25.1331 Instruments using a power supply.
§ 25.1333 Instrument systems.
§ 25.1335 Flight director systems.
§ 25.1351 Electrical Systems and Equipment--General.
§ 25.1353 Electrical equipment and installations.
§ 25.1355 Distribution system.
§ 25.1357 Circuit protective devices.
§ 25.1381 Instrument lights.
§ 25.1431 Electronic equipment.
§ 25.1541 Markings and Placards--General.
§ 25.1581 Airplane Flight Manual--General.
§ 25.1585 Operating procedures.

4. RELATED READING MATERIAL.

a. Advisory Circulars.

(1) AC 20-115B, RTCA, Inc., Document RTCA/DO-178B.

(2) AC 25.1309-1A, System Design and Analysis.

(3) AC 25-11, Transport Category Airplane Electronic Display Systems.

b. Technical Standard Orders (TSO).

(1) TSO-C112, Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment.

(2) TSO-C118a, Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I.

c. Industry Documents.

(1) RTCA DO-160C, Environmental Conditions and Test Procedures for Airborne Equipment; RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certifications; RTCA DO-197A, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance Systems I (Active TCAS I) for Revenue Passenger Operations. These documents can be purchased from RTCA, Inc., Suite 1020, 1140 Connecticut Ave., NW, Washington, DC 20036.

(2) Aerospace Recommended Practice (ARP) 926A, Fault Failure Analysis Procedure; ARP 1834, Fault Failure Analysis Guidelines for Digital Equipment; and ARP 1068A, Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft. These documents are available from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

5. BACKGROUND. The airline industry has been working through the Air Transport Association since 1955 to find a workable collision avoidance system. It was not until the mid-1970's, however, that research centered upon the use of signals from the Air Traffic Control Radar Beacon System (ATCRBS) airborne transponders as the cooperative element of a collision avoidance system. This technical approach allows a collision avoidance capability on the flight deck which is independent of the ground system. In 1981, the FAA announced its decision to proceed with the implementation of an aircraft collision avoidance concept called the Traffic Alert and Collision Avoidance System (TCAS). The concept is based upon agency and industry development efforts in the areas of beacon-based collision avoidance systems.

a. A family of airborne TCAS devices was developed having a range of capabilities to provide collision avoidance protection for a broad spectrum of aircraft types.

b. TCAS I. The TCAS I provides traffic alerting only. It provides traffic advisories (range, bearing, and relative altitude) to assist the pilot in visually acquiring intruder aircraft. TCAS I is intended for use by smaller commuter, business and general aviation aircraft.

c. TCAS II. The TCAS II provides traffic advisories and resolution advisories in a vertical direction to avoid conflicting traffic.

6. DEFINITIONS. The following definitions are applicable to this AC.

a. Advisory. A message given to alert the crew of converging aircraft and/or potential collision.

b. Air Traffic Control (ATC). A generic term for a joint civil/military system for controlling traffic within a specific area.

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

d. Alert. Indicator (visual or aural) which provides information to the flightcrew in a timely manner about a converging aircraft or a potential collision.

e. Failure. The inability of a system, subsystem, unit, or part to perform within previously specified limits.

f. False advisory. An advisory caused by a false track or a TCAS malfunction.

g. Intruder aircraft. A target that has been determined by the TCAS I logic to be a converging aircraft which requires a traffic advisory.

h. Master Minimum Equipment List (MMEL). An FAA document listing stipulations in accordance with 14 CFR FAR §§ 121.627(c) and 135.179 that provides authorization for the continuation of flight beyond a terminal point with certain equipment inoperative. Aircraft Evaluation Groups (AEG) develop MMEL's in conjunction with a Flight Operational Evaluation Board (FOEB) established for each aircraft type. FAA MMEL's serve as the basis for an operator to develop specific minimum equipment lists (MEL) applicable to its particular aircraft and operational requirements.

i. Mode A. Type of secondary surveillance radar (SSR) equipment which provides a selected 4096 code reply (nonaltitude) when interrogated.

j. Mode C. Type of secondary surveillance radar (SSR) equipment which provides a reply with aircraft altitude information when interrogated.

k. Mode S. Type of secondary surveillance radar (SSR) equipment which provides replies to Mode A and Mode C interrogations and discrete address interrogations from the ground or air.

l. Other traffic. Nearby aircraft which are within the selected display range that are not proximate traffic or traffic advisory and are within + or - 2700 feet vertically of the TCAS-equipped aircraft.

m. Proximate traffic. Nearby aircraft within + or - 1200 feet vertically and 5NM horizontally which does not cause a TA.

n. Threat. A target that has satisfied the threat detection logic and thus requires a traffic advisory.

o. Traffic. An aircraft equipped with an operating transponder within the surveillance range of TCAS.

p. Traffic advisory (TA). Information given to the pilot pertaining to the position of another aircraft in the immediate vicinity. The information is intended to assist in the visual acquisition of threat.

q. Traffic display. A display of the relative position of transponder equipped aircraft.

r. Traffic Density. Density is defined as the number of other transponder equipped aircraft within 5NM of the TCAS I test aircraft divided by the area of a circle of 5NM radius.

s. Traffic Alert and Collision Avoidance System (TCAS). A family of airborne devices meeting specified Technical Standard Order (TSO) requirements, as amended, which function independently of the ground-based air traffic control (ATC) system to provide collision avoidance information.

(1) TCAS I. A Traffic Alert and Collision Avoidance System providing only Traffic Advisory (TA's) to assist pilots in the visual acquisition of intruder traffic.

(2) TCAS II. A Traffic Alert and Collision Avoidance System which provides TA's and resolution advisories (RA) (recommended escape maneuvers) in a vertical direction to avoid conflicting traffic.

t. TCAS academic training (as applied within this AC). Training which exclusively addresses knowledge requirements (rather than skills), and is usually related to achieving satisfactory knowledge of TCAS concepts, systems, limitations, or procedures. TCAS academic training generally does not involve practicing or demonstrating skills or maneuvers. TCAS academic training generally is accomplished using a combination of classroom methods (standup instruction, slide/tapes, computer-based instruction tutorial, etc.), flight manual information, bulletins, or self-study. See Paragraph 12 for an expanded explanation of what should be taught.

u. TCAS event. For the purpose of this AC, one or more of the following occurrences or situations related to TCAS:

(1) Issuance of any TCAS TA as specified by a flightcrew (regardless of whether it is valid, unwanted, or nuisance);

(2) Other TCAS-related in flight traffic conflicts or potential conflicts as determined by a flightcrew;

(3) Near mid-air collision (NMAC) involving a TCAS-equipped aircraft;

(4) TCAS system failures related to a traffic conflict, potential traffic conflict situation, or TCAS general system performance;

(5) ATC system error involving a TCAS-equipped aircraft; or

(6) Other TCAS occurrences or situations related to potential TCAS or ATC system safety performance.

v. TCAS I Transition Program (TTP-I). A phased TCAS implementation and evaluation program established to assure timely and effective TCAS installation and use for U.S. air carrier aircraft and to assist in the integration of a large number of TCAS units in the National Airspace System (NAS).

7. SYSTEM DESCRIPTION. The TCAS I is an airborne traffic alert and collision avoidance system that interrogates ATC transponders in nearby aircraft and uses computer processing to identify and display potential and predicted collision threats. The system is designed to protect a volume of airspace around the TCAS I-equipped aircraft. The system will provide appropriate aural and visual advisories to assist the flightcrew in visually acquiring the threat aircraft when TCAS I predicts a penetration of the protected airspace. Traffic advisories indicate the relative positions of intruding aircraft that meet certain range and altitude criteria and are approximately 30 seconds from the closest point of approach. They assist the flightcrew in visually acquiring the intruding aircraft. The system provides a flight deck display. The traffic display indicates the relative position and altitude of ATC transponder-equipped aircraft. Traffic advisories can be generated for aircraft with operative Mode S, Mode C, or Mode A (non-altitude reporting) transponders. The TCAS I equipment is viewed as a supplement to the pilot who, with the aid of the ATC system, has the primary responsibility for avoiding mid-air collisions. The TCAS I system provides no indication of aircraft without operative transponders.

8. AIRWORTHINESS CONSIDERATIONS.

a. Certification Program. This AC provides guidance for the installation of TCAS I equipment. The system displays information and provides advisories in a number of formats. The degree of system integration to perform these functions is extensive and as a result, the applicant's program should be directed toward airworthiness approval either through the type certification or supplemental type certification process.

b. Certification Plan. A comprehensive certification plan should be developed by the applicant. It should include how the applicant plans to comply with the applicable certification requirements and should provide a listing of the substantiating data and necessary tests. Also, a system description and an estimated time schedule should be included. A well developed plan will be of significant value both to the applicant and the FAA.

c. Equipment Installation.

(1) Pilot control. The number and complexity of the controls should be reduced to a minimum consistent with safe system operation. Where possible, control functions should be performed automatically.

(i) Operation of controls. The operation of controls intended for use during flight, in all possible combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.

(ii) Accessibility of controls. Controls that are not normally adjusted in flight need not be readily accessible to flightcrew personnel.

(iii) A means to select the following modes of operation must be provided.

(A) A means to select standby (STBY) or OFF:

(B) A means to initiate the TCAS I self-test mode (flight deck location optional).

(iv) The following optional controls may be provided.

(A) Control to select the display of traffic within selected altitude bands and selected horizontal ranges.

(B) Selection of actual flight level (FL) or relative altitude of traffic.

(2) Antennas. The TCAS I should have, as a minimum, a top directional antenna.

(i) Directional antennas. For an aircraft installation, the TCAS I directional antenna should be located on the top forward fuselage as close to the centerline as possible. If more than one directional antenna is provided, locate the second antenna in a similar manner on the lower fuselage. The TCAS I antennas should be mounted on the aircraft with at least 20 db. isolation from other L-band frequency antennas. Since the antenna diameter may be large, some structural considerations may be necessary and a centerline offset resulting in an angular offset of up to 5 degrees is acceptable. The maximum height of the directional antenna is expected to be approximately 1 inch, and therefore is not considered susceptible to icing effects in the general area of the proposed installation. Otherwise, anti-icing provisions should be considered. For rotorcraft and propeller aircraft the location and performance of the directional antenna must be investigated for minimum blockage and to ensure that the rotor or propellers do not interfere with system operation.

(ii) Omni-directional antennas. If a specific system design requires use of an omni-directional antenna, the antenna should be mounted on the aircraft with at least 20 db. isolation from other L-band frequency antennas. These antennas may be standard ATCRBS transponder antennas.

(iii) Structural analysis. A structural analysis of the antenna installations showing compliance with the applicable FAR should be submitted to the FAA. This includes the structural provisions for a beam steering unit (if installed) if it is not mounted in a standard avionics rack.

(3) TCAS I processor. The TCAS I processor unit computes information to identify and to display potential and predicted collision threats. The TCAS I processor unit must comply with the environmental requirements and minimum performance standards specified in TSO-C118a. A manufacturer of TSO equipment may obtain authorization to produce equipment which deviates from the detailed criteria of the TSO if equivalent level of safety is demonstrated. The FAA aircraft certification office which is approving the initial TCAS I equipment must verify that the TCAS I processor design does not differ from the criteria specified in RTCA document DO-197A, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (Active TCAS I).

(4) Aircraft interfaces. The TCAS equipment should interface with existing aircraft systems within the following criteria:

(i) Pressure altitude. The TCAS I equipment should receive data input from the TCAS aircraft's pressure altitude system (equipment, sensor, etc.) to track own aircraft altitude. The pressure altitude data should be obtained from the most accurate source available in the aircraft and shall correspond to Mode C that is being transmitted by the aircraft's ATCRBS or Mode S transponder. It shall be shown that the resolution of the altimetry source is compatible with TCAS I The altitude source with the finest compatible resolution should be used. When available, the resolution should be in increments of 10 feet or less. Information should also be provided to indicate when the pressure altitude information is invalid. All altimetry data used for TCAS purposes is referenced to the standard atmospheric reference datum of 29.92 inches of mercury. The own aircraft altimetry data shall not be more coarsely quantified than that used for Mode C purposes. The altimetry source used for TCAS must meet the accuracy requirements of Part 43, Appendix E, of the 14 CRF, FAR.

(ii) Radio altitude information. Radio altitude information, if available, shall be provided to TCAS I to inhibit aural annunciations below 400 feet AGL and to allow automatic sensitivity level (SL) selection when close to the ground. Two sensitivity levels shall be provided. SL-A shall reduce the tau values used to determine when a TA should be issued. SL-A shall be automatically invoked using the following order of precedence: (1) when the TCAS aircraft is below 2000 feet above ground level (AGL) (if equipped with a radio altimeter) or (2) when the landing gear is extended(no radio altimeter installed) or (3) when the air speed is less than 120 knots (no radio altimeter installed and aircraft has fixed gear). SL-B occurs under all other flight conditions. On aircraft equipped with a radio altimeter, the TCAS I equipment shall provide logic to inhibit the display of altitude reporting intruders who are on the ground. This logic shall be used when the TCAS equipped aircraft is below 1700 feet AGL. This threshold shall include hysteresis of + or - 50 feet. Information shall also be provided to indicate when the radio altitude information is invalid.

(iii) Mutual Suppression Bus. A mutual suppression bus shall be provided with each TCAS installation. This bus shall serve to suppress own aircraft's transponder from replying to own aircraft TCAS interrogations and prevent TCAS from interrogating while own aircraft's transponder is replying to other interrogations

(iv) Other inputs. Other acceptable aircraft inputs include, aircraft compass, squat switch, landing gear position, suppression bus, and aircraft power, and etc..

(v) System failure display. An indication shall be provided to indicate failure of the TCAS I equipment or any of its sensors or displays.

(vi) Aircraft Identification. The unique aircraft Mode S identification code shall be provided to TCAS I if TCAS I processor is transmitting Mode S broadcast signals to increase its power-rate limits

(5) Traffic display. A display shall be provided to indicate the presence and location of intruder aircraft. The display should be capable of displaying three levels of intruder aircraft: those causing traffic advisory, proximate traffic, and other traffic. Proximate traffic is defined as any traffic within 5 NM in range and ± 1200 feet in altitude and not TA. Other traffic is defined as any traffic within the selected display range that is not a proximate or traffic advisory. As a minimum, the traffic display should depict the following information to aid in the visual acquisition of traffic and assist in determining the relative importance of each aircraft shown:

(i) Symbolic differentiation among traffic of different relative importance. (TA, proximate traffic, or other traffic.)

(ii) Bearing.

(iii) Relative Altitude (for altitude reporting aircraft only).

(A) Above or below own aircraft (+ and - signs)

(B) Numerical value.

(iv) Vertical rate direction of intruder aircraft (for altitude reporting aircraft only).

(v) Range. The selected range shall be depicted.

(vi) The display brilliance should be such that the display can be interpreted under all probable cockpit conditions of ambient light. Filters and brightness adjustments are acceptable means of obtaining adequate display visibility in daylight. The display brilliance should be adjustable for night time operations.

(vii) The display shall contain a symbol to represent the location of own aircraft. The color of the symbol shall be WHITE or CYAN and shall be different from that used for indicating proximate and other traffic.

(viii) A ring shall be placed at a range of 2 NM from own aircraft symbol when a display range of 10 NM or less is selected. The ring shall have discrete markings at each of the twelve clock positions. The markings shall be the same color as the own aircraft symbol and of a size and shape that will not clutter the display. Enhancement of the 3, 6, 9, and 12 o'clock symbols is permissible. In addition, an outer ring at the edge of the display area may be provided to delineate the edge of the usable display area.

(ix) Both color and shape shall be used to discriminate traffic by threat levels.

(x) The symbol for a TA is an AMBER filled circle and, when appropriate, a data tag and vertical trend arrow as described below.

(xi) The symbol for "proximate traffic" shall be a filled WHITE or CYAN diamond and, when appropriate, a data tag and vertical trend arrow as described below.

(xii) Other non-threat traffic within + or - 9900 feet of own aircraft may be displayed. The symbol for "other traffic" shall be an open WHITE or CYAN diamond and, when appropriate, a data tag and vertical trend arrow as described below.

(xiii) Overlapping traffic symbols should be displayed with the appropriate information overlapped. If display technology requires prioritization of symbols, this shall be accomplished to allow the maximum display of data.

(xiv) A data tag shall indicate the relative altitude, if available, of the intruder aircraft and shall consist of two digits indicating the altitude difference in hundreds of feet. For an intruder above own aircraft, the tag shall be placed above the traffic symbol and be preceded by a "+" character; for one below, the tag shall be placed below the traffic symbol and be preceded by a "-" character. The "+" or "-" character should be emphasized by using a slightly larger character set than used for the digits. The tag for co-altitude traffic should be displayed as the digits "00". "The "00" digits shall be placed above the traffic symbol if the intruder aircraft closed from above, and vice versa. If no trend information is available, the co-altitude "00" symbol should be placed below the traffic symbol. The "00" symbol is depicted without the + or - signs. The height of the relative altitude data tag shall be approximately 0.15 inches high. The color of the tag shall be the same as the symbol.

(xv) A vertical arrow shall be placed to the immediate right of the traffic symbol if the vertical speed of the intruder is equal to or greater than 500 fpm with the arrow pointing up for climbing traffic and down for descending traffic. The color of the arrow shall be the same as the symbol.

(xvi) Neither a data tag nor a vertical arrow shall be associated with the symbol for traffic which is not reporting altitude.

(xvii) The display shall be able to depict a minimum of three intruder aircraft simultaneously. The maximum number of intruders displayed simultaneously depends on the type and size of display. As a minimum, the display shall be capable of displaying aircraft that are within 8 NM of own aircraft.

(xviii) The display should provide at least two display ranges that can be selected by the crew.

(xix) When the range of the intruder causing a traffic advisory to be displayed is greater than the maximum range of the display, this shall be indicated by placing one half the traffic advisory symbol at the edge of the display at the proper bearing. Data tags and the vertical trend arrow shall be shown in the normal position relative to the traffic symbol.

(xx) The size of the TCAS symbology shall be approximately 0.15 inches in the vertical dimension. This applies to both the traffic symbol and the altitude data block.

(A) "No bearing" advisories shall be presented for an intruder generating a TA when the intruder's relative bearing cannot be derived. The "no bearing" advisory shall be an alphanumeric display shown in tabular form. The display shall be in the form of "TA 3.6 -05 " which translates to a TA at 3.6 nautical miles, 500 feet below. "No bearing" TA's against a nonaltitude reporting intruder shall include the range only, e.g., "TA 2.2" which translates to a nonaltitude reporting TA at 2.2 nautical miles. The advisory shall be centered on the display below the own aircraft symbol. The display shall include provisions to display at least two "no bearing" TA's. The alphanumeric text shall be displayed in amber. There is no requirement to display proximate and other traffic in the "No Bearing" table.

(6) Aural Alerts.

(i) Each TCAS I aural alert should be annunciated by a dedicated voice message which is compatible with other onboard aural alerting systems. The voice message will be annunciated over a cockpit speaker and through a headset at a volume adequate for clear understanding at high cockpit noise levels, but not excessively loud at low noise levels. The evaluation of the message annunciated through a cockpit speaker includes the case where a flight crew member is wearing a headset covering the outboard ear, when appropriate.

(ii) The TCAS TA should be annunciated by the voice message "TRAFFIC, TRAFFIC," stated once for each TA.

(iii) All TCAS I aural alerts should be inhibited using the following order of precedence:

(A) Below 400 feet AGL when TCAS is installed on an aircraft equipped with a radio altimeter.

(B) When the landing gear is extended (when no radio altimeter is installed).

(C) When TCAS I is installed in a fixed-gear aircraft without a radio altimeter, aural annunciation will be inhibited when the airspeed is less than 120 knots.

d. Software Verification and Validation. RTCA Document No. DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," March 1985, defines five levels of software and the documentation required to satisfy each level's certification requirement. The TCAS I equipment should be verified and validated to at least Level C.

e. Test and Evaluation (Initial Approval). Testing of the first of a manufacturer's TCAS I system for its initial approval in an aircraft should be conducted to verify that the design and installation performs its intended function under the expected operating conditions, that there are no adverse

interactions between the TCAS I and existing aircraft systems, and that prior approvals of present aircraft equipment have not been compromised. The applicant should provide a test plan that includes adequate testing to perform this verification. This test plan will generally require a combination of ground tests, basic flight tests, and flight tests involving planned encounters and surveillance. The use of other than a transport category aircraft with a transponder and Mode C or Mode S for these tests is acceptable. The test plan should contain, as a minimum, the following elements:

(1) Basic Ground tests.

(i) Bearing accuracy tests. Bearing estimation accuracy of the TCAS I system shall be demonstrated as installed in the aircraft. The bearing accuracy may be measured using a calibrated antenna range that allows precise echo-controlled, far-field, angle-of-arrival measurements at or slightly above zero degrees elevation and over 360 degrees in azimuth. The bearing accuracy may also be measured using a fixed transponder location while rotating the test aircraft on a compass-rose while measuring the bearing angles at 30 degree intervals. Alternately, the airplane is fixed and the transponder may be moved. Manual readout of the bearing estimate may be accomplished directly from a plan position display on the traffic advisory display. Alternatively, the bearing estimates may be automatically recorded or may be read from a special test display. A maximum error of ± 30 degrees in azimuth is acceptable; however, large errors are acceptable in the area of + and - 45 degrees from the tail and the area not visible from the cockpit. In these cases, aircraft structures may interfere with the signal path.

(ii) Sensor failures. Simulated failures of the aircraft sensors integrated with TCAS I should be evaluated to determine that the resulting system failure state agrees with the predicted results. These tests should be part of the ground test plan.

(iii) Electromagnetic interference (EMI). A flight deck EMI survey should be made to determine that the TCAS I equipment is not a source of objectionable, conducted, or radiated interference to previously installed systems or equipment, and that operation of the TCAS I equipment is not adversely affected by conducted or radiated interference from previously installed systems and equipment. Attention should be given to possible interference with TCAS I equipment from weather radar, particularly if operating in the C-band.

(iv) Cockpit layout. Evaluate the general arrangement and operation of controls, displays, circuit breakers, annunciators, and placards of the TCAS system.

(v) Self test. Evaluate the TCAS self test features and failure mode displays and annunciators.

(vi) Altimeter interfaces. Verify that the pressure altitude source and radio altimeter (if installed) are properly interfaced with the TCAS equipment.

(vii) TCAS display. Verify the performance of TCAS I traffic display by observing any available area traffic.

(viii) Evaluate the TCAS I system installation for satisfactory identification, accessibility, and visibility during both day and night conditions.

(ix) Determine that any configuration discretes associated with the TCAS I logic operate properly. (Changes in logic or function with aircraft configuration, altitude, or speed if accomplished by ground test equipment).

(2) Basic flight tests. Prior to any cooperative flight tests at any altitude involving the TCAS I-equipped aircraft and another aircraft, both aircraft should be flown in close formation to assure matched altimetry readouts. These flight tests should be flown at the speeds and altitudes to be used for the tests.

(i) During all phases of flight, determine if there is any mutual interference with any other aircraft system. Weather radar should be operating during the flight test.

(ii) Evaluate TCAS I aural messages for acceptable volume and intelligibility during both low and high cockpit noise levels (idle descent at low speed, and high power at V_{NE}, V_{mo}) with headset covering outboard ear (where appropriate). If the TCAS I SELF TEST is used to simulate voice announcements, ensure that the audio level is not changed by use of the TEST function.

(iii) Evaluate that the size and color of the TCAS I symbology is adequate in the flight environment.

(iv) Demonstrate for targets within the antenna coverage volume, that traffic information remains valid and usable when the aircraft is pitched ± 15 degrees and rolled approximately 30 degrees of bank during normal maneuvers by observing area traffic in the traffic advisory display.

(v) Evaluate the effective surveillance range of the traffic display, including target azimuth reasonableness and track stability. Use of targets of opportunity or a nontransport (low-speed) aircraft as a target for these tests is permissible.

(vi) Determine that any configuration discretes associated with the TCAS I logic operate properly unless previously demonstrated during ground tests. (Changes in logic or function with aircraft configuration, altitude, or speed.)

(vii) Perform the additional flight tests in paragraph 8 e (4) of this AC unless previously accomplished under TSO-C118a.

(viii) Evaluate TCAS I for noninterference during coupled Autopilot and Flight Director approaches to the lowest minimums approved for the aircraft.

(ix) Verify that the windshear and GPWS warnings (if installed) and TCAS I voice alerts are compatible. Also, verify that windshear warnings can be clearly understood when

TCAS I and GPWS voice announcements simultaneously occur. If TCAS I, windshear and GPWS aural warnings have been prioritized, the environmental alert priorities should be windshear, GPWS, and then TCAS I.

(x) Evaluate all selectable modes of the TCAS I to determine that they perform their intended function.

(xi) Reevaluate any previously installed aircraft systems that have required changes as a result of the TCAS I installation. (e.g., EFIS, FD, PFD, ND, IVSI, interface, etc.)

(3) Planned encounter flight tests. The objective of these flight tests is to demonstrate adequate TCAS I surveillance and to verify smooth, predictable TCAS I performance. Having established appropriate safety rules, static system leak test (if necessitated by having opened the system), and altimeter correlation between the encounter aircraft and the TCAS aircraft, the following encounters between the TCAS I aircraft and a dedicated intruder aircraft should be flown to ensure that the TCAS I performs its intended functions by generating TA's and is consistent with RTCA document DO-197A. The intruder aircraft should be equipped with transponders capable of Mode A and Mode C. These tests are also intended to expose the installed TCAS I system to a reasonable number of carefully controlled encounters which are likely in service. These tests cover the envelope of encounter speeds, altitudes, and geometries which have in the past identified flaws in surveillance, logic, and antenna mechanization that were not detected earlier by bench tests.

NOTE: Prior to any cooperative flight tests at any altitude involving the TCAS-equipped aircraft and another aircraft, both aircraft should be flown in close formation to assure matched altimetry readouts. These aircraft flight tests should be flown at the speeds and altitudes to be used for the tests.

(i) Sensitivity Level B(SL B) Encounters. The planned encounters should provide a mix of encounters with the intruder above and below TCAS.

(A) Intruder overtaking TCAS I aircraft.

(1) High closure rate.
(2) Low closure rate.

(B) Head-on.

(1) High and low closure rates.
(2) At 3,000 feet over calm water to evaluate multipath protection.

(C) Converging.

(D) Altitude crossing (intruder below TCAS and climbing and vice versa).

(E) Mode A intruder.

(1) Head-on.
(2) Converging.

(ii) SL A Encounters. While the TCAS I aircraft is operating in SL A, repeat the following encounters described in:

(A) 8.e.(3)(i)(A).

(B) 8.e.(3)(i)(B)(1).

(C) 8.e.(3)(i)(C).

(D) 8.e.(3)(i)(E).

(iii) Power switching. Evaluate the effect of electrical transients (bus transfer), during encounters. The TCAS I should not experience adverse effects. No false TA's should be generated as a result of electrical transients. Normal TCAS I functions and displays should be restored within approximately three seconds.

(4) Initial Certification Surveillance Flight Test For TCAS I

(i) General

(A) The bench tests in Section 2.4 of the TCAS I MOPS, DO-197A as amended by ARINC changes, are designed to verify TCAS I surveillance performance under carefully controlled conditions. A surveillance flight test should be performed to completely validate a TCAS I surveillance design.

(B) A flight test should be performed in a traffic environment in which TCAS I is normally expected to operate to provide the data for a complete TCAS I surveillance design validation. This environment should include the combined effects of multipath interference and the synchronous garbling and fruit interference that would result from an aircraft density of 0.08 transponder-equipped aircraft per sq. nmi.

(C) A flight test should also be performed in a traffic environment that substantially exceeds the normal operational environment of TCAS I to provide data to validate the ability of TCAS I to gracefully degrade its surveillance range and to maintain effective interference limiting.

(D) A flight test should be performed for each new TCAS I surveillance design, and whenever major modifications are made to the surveillance function of a previously certified TCAS I. Subject to agreement between the applicant and the certifying office, a major

modification is defined as one that is expected to impact on the ability of TCAS I to meet the surveillance performance criteria of paragraph (ii).(I) and (iii).(C). below. Since the surveillance functions to be evaluated by this test are sufficiently independent of installation factors such as aircraft type and specific antenna location, the flight test can be carried out using any small non-carrier aircraft. The results of the test are only applicable for initial certification for each manufacturers system.

(ii) Surveillance Validation Under Normal TCAS I Operating Conditions.

(A) Flight testing associated with validation of the complete TCAS I surveillance design can be accomplished in any terminal airspace that provides a transponder equipped aircraft density of 0.08 aircraft per sq. nmi. Flight paths should include a representative mixture of the following conditions.

(1) over-land flights at altitudes between 3000 and 6000 feet,

(2) over-water flights at altitudes between 3000 and 6000 feet for a duration that is at least 20 percent of the total required flight duration defined in (ii).(E). below, and

(3) approach and departure flights to the terminal airport

(B) If possible, the flight test should be conducted on a weekend between 10:00 a.m. and 3:00 p.m. when the ground visibility is greater than 5 nmi with a ceiling of at least 10,000 feet to ensure the required traffic density. The location selected by the applicant will be considered suitable if the applicant can demonstrate that the TCAS I surveillance test was conducted in a density of between 0.06 and 0.08 transponder-equipped aircraft per sq. nmi. averaged over a 15 min. period. In this case density is defined as the number of other transponder equipped aircraft within 5 nmi of the TCAS I test aircraft divided by the area of a circle of 5 nmi radius. Six real aircraft target tracks occurring simultaneously within 5 nmi of the TCAS I test aircraft is equivalent to a density of 0.08 transponder-equipped aircraft per sq. nmi. The location should also contain at least one FAA or military secondary surveillance radar located within 30 nmi of the TCAS I aircraft in order to provide a suitable fruit interference environment but not so many as to cause intruder aircraft to exceed a reply rate of 240 per second.

(C) Flight testing should be of sufficient duration to record at least 10,000 seconds of target track reports on targets-of-interest. The data should be accumulated during a continuous time period not exceeding 3 hours. A target-of-interest is defined as any target-of-opportunity that exhibits the following characteristics:

(1) within a 5 nmi range of TCAS I for active TCAS I surveillance,

(2) within a 10 nmi. range of TCAS I for passive TCAS I surveillance,

(3) within + 5 deg. elevation of TCAS I, and

(4) is altitude reporting and airborne:

(D) The number of actual flight hours required to collect 10,000 track-seconds of data depends on the aircraft density. For example, a one and one-half hour recording in a busy terminal airport area that has a demonstrated average density of 0.08 aircraft per sq. nm would result in approximately 10,000 track-seconds of data on targets-of-interest. It is expected that the applicant will have prior knowledge of the density conditions and will select the flight time necessary to record the appropriate amount of data.

(E) The recorded data for evaluation of the active surveillance mode should include as a minimum all raw reply reports prior to any duplicate reply elimination, reply merging, reply correlation, etc., processed surveillance track reports that have been declared established, traffic advisories, internal processor clock, and time-of-day. The recorded data for evaluation of the passive surveillance mode should include as a minimum a processed surveillance report for each SSR interrogation burst, traffic advisories, internal clock and time-of-day. Recorded flight data shall be provided to the FAA to permit an independent assessment of surveillance performance in accordance with paragraph (ii).(F). below. Details concerning the format and data types of the tape data to be provided should be coordinated with the FAA in a timely manner (i.e., 60 days or more in advance of the availability of the recorded flight data is recommended).

(F) The applicant should perform at least the following specific Post-flight data analysis:

(1) identify all recorded surveillance target track reports that are established and that satisfy the criteria for a target-of-interest.

(2) identify those established target-of-interest track reports that are associated with real aircraft.

(3) determine the total number of aircraft-seconds associated with real aircraft and the total number of true track-seconds (i.e., those update intervals in which an established surveillance track report was either coasted or updated with a valid reply) associated with real aircraft.

(4) determine the TCAS I surveillance track probability as the ratio of the total number of true track-seconds associated with real aircraft to the total number of aircraft-seconds associated with real aircraft.

(5) identify those established target-of-interest track reports that are not associated with real aircraft.

(6) determine the total number of track-seconds that are not associated with real aircraft. These are classified as false track-seconds.

(7) determine the TCAS I false track probability as the ratio of the total number of false track-seconds to the total number of aircraft-seconds associated with real aircraft.

(G) The data should also be examined to determine whether any single event such as crossing targets, multipath induced image targets, the inability to maintain track at closest point-of-approach, or a synchronously garbled target dominates the false track rate or the rate at which real targets are dropped. If the false tracks or dropped tracks are due mostly to one type of interference mechanism or geometric condition, it could indicate a design deficiency in this area even though the overall surveillance track probability and false track ratio is acceptable. If this condition exists, the applicant should present these data along with either an evaluation summary that indicates an acceptable design or an analysis and test results which validate any design changes made to correct the condition.

(H) An effective method of evaluating TCAS I data to determine overall surveillance statistics has been developed as a result of the initial design effort associated with TCAS II. This method uses high-resolution plots of range, altitude and bearing reply data verses time to first identify those reply reports that are associated with real aircraft. To accomplish this, the reply reports generated by TCAS I are examined visually in an attempt to recognize patterns in the reply data stream that represent real aircraft. To be effective, this technique requires experience in the analysis of TCAS I surveillance data and enough knowledge of the physical aspects of aircraft flight and of the mechanisms that cause false replies to be able to determine, with reasonable probability, whether a reply is false or real. Each of the identified real aircraft replies are then associated with a real aircraft by manually and visually tracing through the replies to form real aircraft plots. The real aircraft plot starts at the first observance of a real reply in the aircraft reply stream and terminates at the last observed real reply in this stream. An overlay of the manually-derived real aircraft plots on a similarly scaled plot of TCAS I processed tracks will identify the TCAS I track reports associated with real aircraft.

(I) The applicant should present to the certification office sufficient data in the form of reply plots, surveillance track plots, printouts, tabulations etc., to substantiate that the Mode C surveillance performance on targets-of-interest, measured as a result or the surveillance flight test, meets or exceeds the following acceptance criteria:

(1) active TCAS I surveillance probability for targets-of-interest > 75 percent

(2) active TCAS I false track rate for targets-of-interest < 2.0 percent

(3) passive TCAS I surveillance probability fox targets-of-interest > 75 percent

(4) passive TCAS I false track rate for targets-of-interest < 2.0 percent

(5) displayed surveillance track probability 75 percent

(6) displayed false (including duplicate) track rate < 2.0 percent.

Displayed track in (5) and (6) is defined as the merge of active and passive target reports into a single track.

The applicant should also present an evaluation summary on any single dominant failure event as discussed in (ii).(G), above.

(iii) Surveillance Validation Under TCAS I Overload Conditions.

(A) Flight testing associated with the validation or the overload capability of TCAS I can be accomplished in any terminal airspace that has an aircraft density of greater than 0.1 transponder equipped aircraft per sq. nmi., e.g. this density will causes a transponder reply rate in excess of 240 per second and is expected to have more than 15 TCAS II-equipped aircraft within 30 nmi. of the TCAS I aircraft. The Los Angeles basin area is one example of an acceptable terminal area suitable for validation of the TCAS I overload capability.

(B) Except for the recording requirements of (ii).(C) and the conditions expressed in (iii).(A) above, paragraphs (ii).(A) through (ii).(H) apply to the testing associated with the validation or the overload capability of TCAS I. The same data that was collected for validation of the requirements of (ii).(I) may be used, if applicable, for validation of the requirements of (ii).(C) additional testing and data collection may be conducted to the extent necessary to perform the validation of surveillance under overload conditions.

(C) The applicant should present to the certification office sufficient data in the form of reply plots, surveillance track plots, printouts, tabulations etc., to substantiate that the active TCAS I transmitted power level is reduced according to the requirements of the TCAS I MOPS, as amended by ARINC changes, when TCAS I is operating in the environment specified in (iii).(A) above and that the resulting active TCAS I surveillance performance under these conditions exhibits a graceful degradation consistent with the largest transmitted power level. The applicant should also present an evaluation summary on any single dominant failure event as discussed in (ii).(G) above.

f. Follow-On Approvals (STC or Amended TC). Flight of TCAS I systems for follow-on approvals (previously approved TCAS I equipment installed in a different aircraft type) should be conducted to verify that the design and installation performs its intended function under the expected operating conditions, that there are no adverse interactions between the TCAS I and existing aircraft systems, and that prior approvals of present aircraft equipment have not been compromised. The applicant should provide a flight test plan that includes adequate testing to perform this verification. This test plan will generally require a combination of ground tests, basic flight tests, and flight tests involving planned encounters with a Mode C-equipped aircraft, or the use of a suitably located fixed transponder. The test plan should contain, as a minimum, the following elements:

(1) Ground tests.

(i) Evaluate the general arrangement and operation of controls, displays, circuit breakers, annunciators, and placards of the TCAS I system.

(ii) Evaluate the TCAS I self test features and failure mode displays and annunciators.

(iii) Verify that the pressure altitude source and radio altimeter (if installed) are properly interfaced with the TCAS I equipment.

(iv) Measure the performance of the directional antenna for 360 degrees coverage at 30 degree intervals as specified under basic certification ground test.

(v) Evaluate the TCAS I system installation for satisfactory identification, accessibility, and visibility during both day and night conditions.

(vi) Determine that any configuration discretes associated with the TCAS I logic operate properly. (Changes in logic or function with aircraft configuration, altitude, or speed.)

(vii) Conduct a flight deck EMI survey to determine that the TCAS I equipment is not a source of objectionable conducted or radiated interference to previously installed equipment and vice versa.

(viii) Verify the performance of the TCAS system and display by observing any available traffic in the area. Verify that the symbology used to depict traffic is correct. Ensure that all available display modes and ranges are demonstrated.

(2) Flight tests.

(i) Proper operation of the traffic display should be verified by observing other traffic, proximate traffic, and at least one traffic advisory. Confirm that the appropriate aural alert occurs correctly with the traffic advisory. The advisories may be generated by;

(A) Planned encounters with an intruder aircraft operating a transponder with Mode C capability.

NOTE: Prior to any cooperative flight tests at any altitude involving the TCAS I-equipped aircraft and another aircraft, both aircraft should be flown in close formation to assure matched altimetry readouts. These checks should be flown at the speeds and altitudes to be used for the tests.

(B) Encounters with an operating Mode C transponder installed at a fixed ground location which reports an appropriate test altitude, or

(C) Encounters with aircraft targets of opportunity, or

(D) The use of suitable test equipment, during ground

tests.

(ii) During all phases of flight, determine if there is any mutual interference with any other aircraft systems.

(iii) Evaluate TCAS I aural message for acceptable volume and intelligibility during both low and high cockpit noise levels (idle descent at low speed, and high power at VNE VMO) with headset covering outboard ear and without headsets. If the TCAS I SELF TEST is used to simulate voice announcements, ensure that the audio level is not changed by use of the TEST function.

(iv) Evaluate the effective surveillance range of the traffic display, including target azimuth reasonableness and track stability. Use of a nontransport (low-speed) Mode C-equipped aircraft as a target or a fixed transponder or suitable test equipment for these tests is permissible.

(v) Determine that any configuration discretes associated with the TCAS I logic operate properly unless previously demonstrated during ground tests. (Changes in logic or function with aircraft configuration, altitude, or speed.)

(vi) Evaluate TCAS I for noninterference during coupled Autopilot and Flight Director approaches to the lowest minimums approved for the aircraft.

(vii) Verify that the windshear and GPWS (if installed) warnings and TCAS I voice alerts are compatible. Also, verify that windshear warnings can be clearly understood when TCAS I voice announcements and GPWS simultaneously occur. If TCAS I, windshear and GPWS aural warnings have been prioritized, the alert priorities should be windshear, GPWS and than TCAS I.

(viii) Evaluate all selectable modes of the TCAS I to determine that they perform their intended function.

(ix) Reevaluate any previously installed aircraft systems that have required changes as a result of the TCAS I installation (e.g., EFIS, FD interface, etc.)

g. Airplane Flight Manual Supplement (AFMS). The AFMS should provide the appropriate system limitations and emergency procedures and a comprehensive description of all normal modes of operation including what actions are expected by the flightcrew in each case. Information similar to that provided in paragraph 12.a. and 12.d. of this AC is considered appropriate for inclusion in the AFMS.

9. OPERATIONAL ISSUES.

a. Manuals and Other Publications. Airplane flight manuals, operating manuals, maintenance manuals, general policy manuals, or other manuals, publications, or written materials (e.g., operating bulletins) that may relate to TCAS use should be appropriately amended to describe TCAS equipment, procedures, and operational policies.

b. MMEL MEL.

(1) General. Operators formulate necessary TCAS revisions to their MEL(S) for each particular model aircraft. MEL revisions must be consistent with the FAA MMEL established for each aircraft type. Examples of MMEL and acceptable MEL provisions and a summary of the process for addressing the necessary changes to MEL items for TCAS are provided in appendix 2.

c. Aircraft with TCAS System Differences. Operators having aircraft with TCAS systems differences in displays, controls, or procedures, or involved with interchange operations, must account for those TCAS system differences. This is accomplished as part of an approved training program, or as otherwise specified in applicable FAA Flight Standards Board (FSB) reports concerning crew qualification pertaining to a particular airplane type.

d. Issues Unique to a Particular Operator. Operators should address any TCAS issues that may be unique to their particular route environment, aircraft, procedures, or TCAS display and control features. Examples include the following:

(1) Example of a "Procedural" Issue. Air carriers should describe any TCAS precautions that may be appropriate when operating in countries where transponder, Mode S, or TCAS policies are uncertain. In those cases, carriers should conform to the laws and regulations that govern the airspace being used. This guidance should be reflected in company flight operations manuals.

(2) Example of a "Unique TCAS System" Issue. TCAS "flight level" or "absolute" display of traffic altitude on a traffic display should not be used during operations when the altimeter is set to zero relative to the intended field of landing.

10. OPERATIONAL APPROVAL.

a. Approval Criteria. Operational approvals are based on criteria in this AC and, if applicable, training, maintenance, MMEL, or other operationally related criteria formulated by AEG's. If criteria for training or checking are other than as specified in this AC, the criteria may be found in FSB reports. Provisions for operations with inoperative equipment are specified by the MMEL for each aircraft type. Maintenance requirements are identified in this AC, except as otherwise described by a MRB report for specific aircraft, or in FAA-approved maintenance instructions identified in conjunction with an STC or manufacturer's Service Bulletin.

b. Approval Methods. TCAS operational approval is accomplished through FAA approval of pertinent training programs, checklists, operations manuals, training manuals, maintenance programs, MEL's, or other pertinent documents or document revisions applicable to the particular air carrier. Operators' TCAS programs are usually approved for each specific aircraft type. However, programs common to one or more types may be approved if TCAS program elements are common to different aircraft types (e.g., same TCAS systems, procedures, etc.).

c. Approval Procedures.

(1) Approval to use TCAS Assigned by an FAA POI. The POI usually serves as a central point of contact and coordinates with the PAI and PMI, as necessary, for review and approval of respective TCAS program elements. Operators should make early contact with their respective PI's to permit timely FAA response. Usually such contact is initiated at the time preparations are being made for TCAS system selection or purchase, and generally not later than TCAS TC/STC application.

(2) First operational Approval of TCAS in Each Aircraft Type. For the first approval of TCAS for a given aircraft type for any FAR Part 135 operator, POI's should contact the assigned AEG for that aircraft to assure that applicable criteria are available. If necessary, AEG's will identify any specific criteria in addition to the criteria specified by this AC. When necessary, such criteria are described in FSB report revisions, MRB revisions, or other pertinent documents. In addition, if not already completed, an appropriate revision will be made to the MMEL for that aircraft type.

(3) Subsequent Operational Approvals of TCAS for a Particular Aircraft Type. For subsequent operational approvals for a particular aircraft type, training, maintenance, MMEL, and other operationally related TCAS criteria, if needed, usually have already been established. Accordingly, PI's should apply criteria within this AC and any additional FSB, MRB, MMEL, or other pertinent criteria that were previously specified. If criteria do not adequately address a particular aircraft variant, TCAS system, or situation, PI's should contact the respective AEG for clarification or revision of the criteria applicable to a particular type.

d. How to Obtain Initial Operational Approval. In order for TCAS I to be used in air carrier service, operational approval must be obtained from the office of Flight Standards, Air Transportation Division. Requests for approval should be submitted to the responsible FAA AEG at the time TCAS I certification (TC or STC) application is made. The AEG personnel will conduct TCAS I system evaluations and submit findings to the Office of Flight Standards, Air Transportation Division, for recommended flightcrew qualification and training program approval. The AEG will also submit to the Office of Flight Standards, Air Transportation Division, for approval, TCAS I inoperative items to be included in the appropriate Master Minimum Equipment List.

11. FLIGHTCREW QUALIFICATION FOR USE OF TCAS.

a. General.

(1) TCAS Qualification Issues and Objectives. Air carriers should address the following issues and objectives to assure appropriate flightcrew TCAS qualification:

(i) Address necessary flightcrew knowledge of TCAS concepts, systems, and procedures (TCAS Academic Training).

(ii) Assess each pilot's ability to properly use TCAS (TCAS Initial Evaluation).

(iii) Maintain appropriate TCAS knowledge and skills.

(2) Acceptable Qualification Means. First time TCAS training and qualification should be addressed during initial, transition upgrade, recurrent, differences, or stand alone training and qualification programs, with TCAS topics addressed separately or integrated with other curriculum elements. For example, TCAS qualification may be keyed to specific aircraft during transition or upgrade training, or may be addressed in conjunction with general training (e.g., during initial "new hire" indoctrination), or may be addressed in conjunction with recurrent training or checking events (e.g., in conjunction with a competency check or line oriented flight training (LOFT)). TCAS qualification may also be addressed as a separate program.

(3) Credit for Use of Other Programs. Each operator intending to receive credit for TCAS training when the training is to be conducted by another operator, training center, or manufacturer, must be authorized to receive that FAR Part 135 credit by their respective POI. This is necessary even though the TCAS training may already be FAA approved for the other operator, training center, or manufacturer conducting the training. POI's may permit credit for use of other operator or training center programs if those programs have been approved by FAA and if aircraft, TCAS systems, procedures, and other relevant factors or circumstances are the same or equivalent to those of the operator seeking credit. If a POI is uncertain about the suitability of a proposed program for a particular TCAS system or aircraft type, the POI should consult, through established organizational procedures, with the appropriate division of the Flight Standards Service, the National Simulation Evaluation Team (NSET), or the assigned AEG, as applicable.

(4) Airplane Flight Manual: A Discussion of the FAA approved Airplane Flight Manual (AFM) TCAS I limitations including:

(i) Nontransponder-equipped aircraft.

(ii) Air traffic control interaction.

(5) Operational Procedures: An Overview of the Operational Procedures associated with the use of TCAS I. The training program should include a detailed discussion of the normal and abnormal procedures included in the AFM.

(i) Each feature of the TCAS I traffic display should be explained in sufficient detail to ensure that the flightcrew is aware of how to interpret the display.

12. TCAS I ACADEMIC TRAINING. The following subjects should be addressed through some appropriate means of TCAS academic training during the initial introduction of a crew member to TCAS. For subsequent programs, only the new, revised, or emphasis items need be addressed, as appropriate.

a. General Concepts of TCAS operation. The TCAS academic training should cover, in general terms, overall TCAS system theory. Crewmembers should understand basic TCAS logic operation and should understand the altitude separation thresholds. The training program should also address the meaning of TA's; the detection provided by TCAS against altitude reporting and nonaltitude reporting intruders; how the system protects against multiple aircraft; the continued applicability of the "see and avoid" concept.

b. Expected flightcrew response and level of protection provided by TCAS. Academic training should explain the normal, expected pilot response to TA's, use of displayed traffic information to establish visual contact, and constraints on maneuvering based only on TA's.

c. TCAS general limitations. There are system limitations which apply to all aircraft types that should be understood. System design limitations include the inability of TCAS to detect nontransponder-equipped aircraft.

d. ATC Communication and Coordination. Training should discuss timely communication and coordination with ATC-related to or following a TCAS event and when to contact ATC.

e. TCAS equipment components, controls, displays, audio alerts, and annunciations. Academic training should include discussion of TCAS terminology, symbology, modes of operation, and optional controls, failure annunciations, aural alerting system, and display features including any items particular to an air carrier's implementation or unique to its system.

f. Interfaces and compatibility with other aircraft systems. Training should discuss the role of transponders, radio altimeter, weather radar/electronic flight instrument system interfaces, including any items particular to an air carrier's implementation or unique to its TCAS I system.

g. Aircraft Flight Manual (AFM) information. The AFM revisions should include information on TCAS modes of operation, normal and abnormal flightcrew operating procedures, "see and avoid" and judgment issues, appropriate response to TA's, and AFM limitations.

h. MEL operating provisions.

i. Air carrier's TCAS event reporting policies for flightcrews.

j. Air carrier's maintenance logbook. Recording procedures for TCAS system failures, if not otherwise addressed by routine maintenance procedures of that operator.

k. Training

(1) The TCAS systems, displays, and procedures must be consistent with accepted FAA and industry guidelines. There must be no significant adverse training experience related to the particular TCAS system(s) to be used.

(2) The CBI materials must be used which provide realistic depiction of TCAS encounter scenarios. Scenarios must demonstrate use of proper TCAS procedures; depict "real time" (dynamic) traffic encounters; represent correct indications for TA's, displayed traffic and aural messages.

l. Training Center Approval. Training centers conducting FAR Part 135 training (i.e., contract training, aircraft manufacturers) may have TCAS elements of those programs approved if:

(1) Provisions of 11(b) and 11(c) above are shown to be met, or

(2) Equivalence to a previously approved FAR Part 135 program can be established. In this instance, circumstances, assumptions, and conditions for the program's use must also be equivalent to those applicable to the previously approved program.

m. Initial Evaluation of TCAS Knowledge and Procedures. Individual crewmember TCAS knowledge and procedures should be evaluated prior to FAR Part 135 TCAS use. Acceptable means of initial assessment include:

(1) Evaluation by an authorized instructor or check airman using a simulator or a training device capable of modeling traffic encounters, TCAS response, and pilot interaction, or

(2) Evaluation by an authorized instructor or check airman during line operation, training flights, operating experience, line or route checks, or

(3) Computer-based testing in which TCAS scenarios and responses are depicted, and for which a record documents acceptable knowledge of TCAS of that crewmember, or

(4) Other alternate methods acceptable to the Administrator. For alternate methods, the air carrier must demonstrate the equivalent effectiveness of the requested method(s) to one of methods (1) through (3) above. Alternate methods are approved by the POI.

(5) Instructors may be authorized to conduct the required initial TCAS crewmember evaluations if those individuals are TCAS qualified.

n. TCAS Recurrent Training. TCAS recurrent training should be integrated into and/or conducted in conjunction with other established recurrent training programs. Recurrent training for TCAS should include training meeting the requirements of paragraph 12 and should address any significant issues identified by line operating experience, system changes, procedural changes, or unique characteristics of which crews should be aware.

o. TCAS Recurrent Evaluation. Except in unusual circumstances, such as following major TCAS system or procedures modification, dedicated recurrent checking for TCAS is not required or necessary. Recurrent TCAS checking should be incorporated as necessary as an element of routine proficiency training or proficiency check programs.

p. TCAS Currency (Recency of Experience). Once crews have completed initial TCAS training and as long as recurrent training is accomplished in accordance with paragraph 12 above, specific TCAS currency requirements are not necessary.

q. Operational Experience (OE), Line Checks, and Route Checks. When TCAS-equipped aircraft are used for line checks, route checks, or in conducting OE to satisfy requirements of FAR part 135, check airmen should routinely incorporate proper TCAS use as a discussion, demonstration, or evaluation factor.

r. Line-Oriented Flight Training (LOFT). LOFT programs using simulators equipped with TCAS should be enhanced by incorporation of traffic conflicts requiring TCAS response. In addition, LOFT programs should consider proper crew vigilance for aircraft which may not be transponder or Mode C-equipped.

s. Crew Resource Management (CRM). The CRM programs should address effective teamwork in responding to TCAS events.

t. TCAS Academic Training Methods. Appropriate methods may be suited to each air carrier's program. No special methods related to academic training for TCAS are identified. Typically, a combination of ground instruction, manual information, flightcrew bulletins, and other such means is appropriate to address academic topics specified by the section above, TCAS Academic Training, paragraph 12.

u. Characteristics of Simulated TCAS Systems Training. There is no requirement to conduct TCAS I maneuver training since maneuvering based solely on TA information is not recommended. If TCAS I training is conducted in a simulator or training device, these devices should meet the following:

(1) Acceptable Characteristics. Training devices and simulators should have certain characteristics to be effective. This is due to the interactive nature of TCAS, and the correct display interpretation that is necessary. Thus, simulators or training devices used for TCAS training should have the following characteristics:

(i) The ability to functionally represent TCAS displays, controls, indications, and annunciations.

(ii) Ability to depict selected traffic encounter scenarios in "real time" simulating TCAS display and audio advisories.

(2) Simulated TCAS System Fidelity. For a particular TCAS system, training may be accomplished with simulators or training devices which represent the specific aircraft in which TCAS is installed, or represent an aircraft which is similar. For the purposes of TCAS training, simulators or training devices may use simplified algorithms or displays. It is not necessary to accurately model aircraft performance, depict intruder aircraft on the visual system, use actual TCAS logic, use identical

displays, simulate optional functions, or other such factors as long as use of the training device or simulator is effective, and simplification does not adversely affect crew performance.

(3) Training Device or Simulator Approval. *Training devices or simulators meeting FAA criteria are qualified for each operator by the NSET and approved for use by the POI. Any one or combination of the following devices or simulators which meet characteristics of paragraph (1) above, Acceptable Characteristics, may be used:

(i) Level A through D simulators;

(ii) Level 2 through 7 flight training devices; or

(iii) Dedicated TCAS training devices acceptable to the FAA (including those devices described in FAA Order 8400.10, Air Transportation Operations Inspector's Handbook, Volume 3, paragraph 443, "Aircraft Systems Integration Training" which are shown to be suitable for TCAS training).

*NOTE: Training Device and Simulator Levels are as defined by Airplane Simulator Qualification, AC 120-40, as amended; Advanced Qualification Program, AC 120-54, as amended; and FAA Order 8400.10.

13. TCAS I OPERATIONAL USE.

a. Pilot Responsibilities. TCAS is intended to ensure situational awareness, serve as a backup to visual collision avoidance, application of "right-of-way rules," and air traffic separation service. Flightcrews are expected to respond to TCAS in accordance with the following guidelines:

(1) Respond to TA's by attempting to establish visual contact with the intruder aircraft and other aircraft which may be in the vicinity. Coordinate to the degree possible with other crewmembers to assist in searching for traffic. For any traffic that is acquired visually, continue to maintain or attain safe separation in accordance with current FAR and good operating practices. In IMC it may be necessary to contact ATC and query them concerning an intruder. ATC should only be contacted in those situations in which a crewmember is unable to determine the location of an intruder.

(2) Pilots should not maneuver based solely on TA information. TCAS TA display information technically is inadequate for collision avoidance maneuvers and a pilot maneuver based only on this information may result in a loss of separation with the intruder (e.g., a turn towards the intruder instead of a turn away). Pilots should maneuver their aircraft based only on ATC guidance or positive visual acquisition of the conflicting traffic.

(3) The pilot not flying should monitor the TCAS display and provide range, bearing, and altitude updates on the intruder to the pilot flying. The pilot not flying and any onboard observers should also assist in the visual search for the intruder.

(4) Unless otherwise specified by the air carrier or FAA, pilots are expected to operate TCAS while "in flight" in all airspace, including oceanic, international, and foreign airspace.

(5) Note and accurately report TCAS encounters and system anomalies in accordance with operator policies, so that remedial improvements to TCAS or the NAS may be initiated.

(6) TCAS does not alter or diminish the pilot's basic authority and responsibility to ensure safe flight. Since TCAS does not detect aircraft which are not transponder-equipped or aircraft with a transponder failure, TCAS alone does not ensure safe separation in every case. It is particularly important that pilots maintain situational awareness and continue to use good operating practices and judgment when using TCAS. Maintain frequent outside visual scan and "see and avoid" vigilance.

b. Operator Responsibilities. Operators have the following general responsibilities regarding TCAS:

(1) Assure follow-up and evaluation of unusual TCAS events, and

(2) Periodically assess TCAS training, checking, and maintenance programs to ensure their correctness, pertinence, timeliness, and effectiveness.

c. TCAS Safe Operating Practices. The following TCAS "safe operating practices" have been identified:

(1) To preclude unnecessary transponder interrogations and possible interference with ground radar surveillance systems, TCAS should not be activated until just prior to taking the active runway for departure.

(2) Following landing and clearing of an active runway, the TCAS should be selected to the "standby" or "off" mode as specified by the carrier approved operating procedures. TCAS is not designed to assist in taxiing across active runways or at any other time for ground operations.

(3) During flight, TCAS displays which have a range selection capability should be used in an appropriate range setting for the phase of flight to enhance situational awareness.

14. TCAS EVENT REPORTING.

a. General. The FAA does not require specific reports when TCAS I TA's occur. However, operators and manufacturers are encouraged to develop procedures to ensure effective identification, tracking, and follow-up of significant TCAS-related events, as appropriate. Such procedures should focus on providing useful information to:

(1) Properly assess the importance of TCAS events;

(2) Follow up on information related to specific TCAS events as necessary; and

(3) Keep the industry and FAA informed on the performance of TCAS in the NAS, or where applicable in international operations.

b. Pilot Reports.

(1) "TCAS Specific" Reports. Pilots should make the following reports for TCAS TA's, as necessary.

(i) Upon query from ATC. Refer to the Airman's Information Manual, Section 4, ATC Clearances, paragraph 4-81c for guidance;

(ii) Reports, as specified by the operator, concerning TCAS anomalies, procedural difficulties, or system failures. Such reports typically are made by pilots through one or more of the following methods:

(A) Pilot/Observer Questionnaire;

(B) Logbook entry; or

(C) Other records used by that operator (e.g., "Captain's Report"). An example of a typical reporting form for TCAS event information is shown in appendix 1.

(D) A telephone call to the local FSDO

(2) Other Reports incidental to TCAS.

(i) NMAC Reports. Flightcrews should continue to submit NMAC reports in accordance with existing policies and procedures. Crews should be aware that there is no requirement to submit an NMAC report solely due to a TCAS event.

(ii) FAR §91.123 Reports. Unless required due to other circumstances, reports in compliance with FAR §91.123 regarding "emergency deviation from an ATC clearance" are not necessary solely as a result of a TCAS maneuver.

(iii) Aviation Safety Reporting System (ASRS) Reports. ASRS reports may be filed at the discretion of the flightcrew.

c. FAA Flight Standards Reports. FAA Flight Standards District Office (FSDO) inspectors and PI's report:

(1) Significant TCAS events to flight standards offices/PI's. PI's in turn report those events to operators and the Field Programs Division, AFS-500, as necessary; and

(2) TCAS generic problems to flight standards offices, AEG's, AFS-500, and the FAA TCAS Program Office, as appropriate.

d. FAA ATC Reports. FAA ATC personnel report the following:

(1) TCAS events to FSDO'S, as necessary;

(2) Any significant TCAS-related events regarding NAS-performance to the Air Traffic Procedures Division, ATP-100.

e. TCAS Manufacturer Reports. TCAS avionics manufacturers report problems found with specific TCAS systems in accordance with established service difficulty procedures. Generic problems should be reported to the Aircraft Engineering Division, AIR-100.

John K. McGrath
Manager, Aircraft Engineering Division

APPENDIX 1. SAMPLE TCAS EVENT REPORTING INFORMATION

(Optional for Crewmembers)

Name: _____ Phone: (W) _____ (H) _____

DATE TIME of EVENT _____ AIRLINE/FLT # _____ORIG

Phase of Flight _____ Submitted due to: ATC INQUIRY__ TA _____ OTHER

TA Data: Intruder Relative Altitude _____ Feet Position _____ o'clock

Own Aircraft: Altitude _____ Feet Position: _____ _____
(VOR) (RADIAL) (DME)

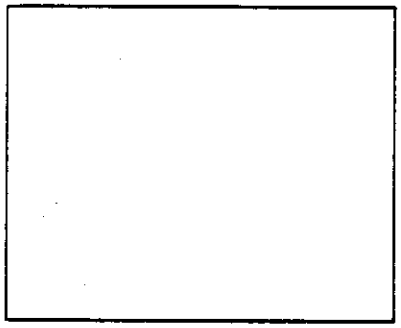
ATC Advisory _____ TA _____ Visual Contact

Please diagram the sequence of events for any TCAS events. Use the following codes to denote the sequence.

Location of Target

TA = Traffic Advisory

V = Visual Contact



WEATHER: IMC VMC DAY NIGHT/GEAR: UP DWN FLAPS

REMARKS: (Please provide comments/concerns you have regarding TCAS for this OR any previous encounter.)

Include items such as: ATC conflict, TCAS procedures, ATC procedures (i.e., noise abatement, parallel approaches), display symbology, cockpit workload, etc.).

_____

_____

_____

_____

APPENDIX 2. TCAS "MINIMUM EQUIPMENT LIST" (MEL) AND "MASTER MINIMUM EQUIPMENT LIST" (MMEL) PROVISIONS

1. Each operator intending to have authority to dispatch an aircraft with a TCAS system or component temporarily inoperative must do so in accordance with provisions of a MEL. MEL's are approved for each operator and type aircraft, within provisions of the FAA MMEL for that type. When proposed MEL provisions are consistent with the FAA MMEL, POI's may approve the MEL. If a less restrictive MEL or different MEL provisions are requested, a proposal for consideration of an FAA MMEL change must be forwarded to the AEG assigned for that aircraft type. No relief will be granted for the voice command portion of the TCAS system. The audio will be provided via a speaker which may also service windshear and ground proximity equipment. Enhanced features (those above and beyond the basic TCAS system) may be inoperative provided that the inoperative features do not degrade the system; for example, "Flight Level" traffic altitude selection feature for a traffic display.

2. EXAMPLE OF A TCAS MMEL PROVISION*

*NOTE: The provisos and repair category intervals are intended to grant the operator sufficient relief, especially during the early stage of the TCAS TTP. This is intended to promote the installation process, as well as support the use of a partial system. Both equipment reliability and operational experience will dictate if any revision to this MMEL relief should be considered after the installation phase is completed.

APPENDIX 2. TCAS "MINIMUM EQUIPMENT LIST" (MEL) AND "MASTER MINIMUM EQUIPMENT LIST" (MMEL) PROVISIONS (continued)

CHAPTER 34 NAVIGATION
Traffic Alert Collision Avoidance System (TCAS)

1) TCAS System	C - 0	*(M) May be inoperative provided the system is deactivated and secured.

APPENDIX 3. ACRONYMS AND ABBREVIATIONS

AC	Advisory Circular
ACO	Aircraft Certification Office
AEG	Aircraft Evaluation Group
AFS	Flight Standards Service (FAA)
AGL	Above Ground Level
AIR	Aircraft Certification Service (FAA)
ARD	Research and Development Service (FAA)
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
ATCRBS	ATC Radar Beacon System
ATP	Air Traffic Procedures Division (FAA)
CBI	Computer-Based Instruction
CHDO	Certificate Holding District Office
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FOEB	Flight Operation Evaluation Board
FSD	Flight Standards Board
FSDO	Flight Standards District Office
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ISA	International Standard Atmosphere
LIP	Limited Implementation Program
LOFT	Line-oriented Flight Training
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
MRB	Maintenance Review Board
MSL	Mean Sea Level
NAS	National Airspace System
NMAC	Near Mid-air Collision
nmi	nautical mile
NSET	National Simulator Evaluation Team
NTSB	National Transportation Safety Board
PAI	Principal Avionics Inspector
Pi	Principal Inspector
PMI	Principal Maintenance Inspector
POI	Principal Operations Inspector
RTCA	RTCA, Inc.
STC	Supplemental Type Certificate
TA	Traffic Advisory
TC	Type Certificate

TCAS	Traffic Alert and Collision Avoidance System
TSO	Technical Standard Order
TTP	TCAS Transition Program
VFR	Visual Flight Rule

CONTENTS

APPENDIXES