

APPENDIX 1

Descriptive material and procedures contained in this AFMS example may, when appropriate, be replaced by reference in the AFMS to the TCAS II equipment supplier's pilot's operating guide. However, the AFMS reference to this guide must be specific; i.e., date, revision level; and not openended, e.g., "or later revision"; unless the pilot's guide is specifically FAA approved. Also, the AFMS must define the specific configuration approved from the various options contained in the pilot's guide; e.g., which model control panel, whether the pilot-initiated self-test is available in flight, range features, TA vertical display features, etc.

AIRPLANE FLIGHT MANUAL SUPPLEMENT (Example)

DESCRIPTION

The TCAS II is an on-board collision avoidance and traffic situation display system with computer processing to identify and display intruding and threatening collision aircraft, and issue resolution advisories in the form of vertical maneuver guidance on the pilot and copilot's instantaneous vertical speed indicators (IVSI). From the transponder replies, TCAS II determines relative altitude, range, and bearing of any ATCRBS or Mode S equipped aircraft with altitude reporting. From this, TCAS II will determine the level of advisory using standardized algorithms. The TCAS II will resolve multiple aircraft encounters. ATCRBS equipped aircraft which only reply with Mode A information will not provide altitude information; therefore, TCAS II will not issue resolution advisories for these aircraft but can issue traffic advisories. The TCAS II will not detect aircraft without transponders.

The TCAS II installation consists of one TCAS II processor, one top-mounted directional antenna, one bottom-mounted blade (or directional antenna), one Mode S transponder with control panel and top and bottom antennas, one traffic advisory display with control panel (if not combined with the IVSI/RA indicators), two resolution advisory displays, one overhead speaker for voice messages, (caution/warning lights), and associated wiring.

The TCAS II provides two levels of advisories:

If the traffic gets within 25 to 45 seconds, depending upon altitude, of projected Closest Point of Approach (CPA), it is then considered an intruder, and an aural and visual traffic advisory (TA) is issued. This level calls attention to what may develop into a collision threat using the traffic advisory display and the voice message, "TRAFFIC-TRAFFIC." It permits mental and physical preparation for a possible maneuver to follow and assists the pilot in achieving visual acquisition of the intruding aircraft.

If the intruder gets within 20 to 35 seconds, depending upon altitude, of CPA, it is considered a threat, and an aural and visual resolution advisory (RA) is issued. This level provides a recommended vertical maneuver using modified IVSIs and voice messages to provide adequate vertical separation from the threat aircraft or prevents initiation of a maneuver that would place the TCAS II aircraft in jeopardy.

The TCAS II is considered a back-up system to the "SEE-AND-AVOID" concept and the ATC radar environment.

The TCAS II resolution advisories are annunciated by the following voice messages, as appropriate, along with the expected pilot response:

(A) "CLIMB, CLIMB, CLIMB" (Climb at the rate depicted by the green (fly to) arc on the IVSI.)

(B) "DESCEND, DESCEND, DESCEND" (Descend at the rate depicted by the green (fly to) arc.)

(C) "MONITOR VERTICAL SPEED-MONITOR VERTICAL SPEED" (Spoken only once if softening from a previous corrective advisory.) Assure that vertical speed is out of the illuminated IVSI red arc.

(D) "REDUCE CLIMB-REDUCE CLIMB" (Reduce vertical speed to a value within the illuminated green arc.)

(E) "CLEAR OF CONFLICT" (Range is increasing, and separation is adequate; expeditiously return to the applicable ATC clearance, unless otherwise directed by ATC.)

(F) "CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB" (Climb at the rate depicted by the green (fly to) arc on the IVSI.) Safe separation will best be achieved by climbing through the threat's flight path.

(G) "REDUCE DESCENT-REDUCE DESCENT" (Reduce vertical speed to a value within the illuminated green arc.)

(H) "DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND" (Descend at the rate depicted by the green (fly to) arc on the IVSI.) Safe separation will best be achieved by descending through the intruder's flight path.

The following voice messages annunciate enhanced TCAS II maneuvers when the initial RA does not provide sufficient vertical separation. The tone and inflection connote increased urgency.

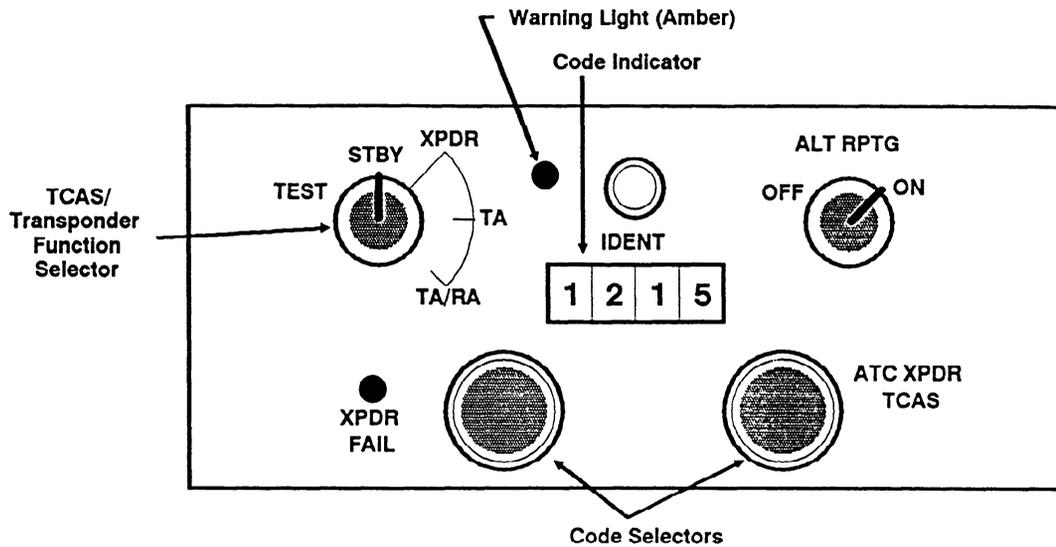
(A) "INCREASE CLIMB, INCREASE CLIMB" (Climb at the rate depicted by the green (fly to) arc on the IVSI.) Received after "CLIMB" advisory, and indicates additional climb rate required to achieve safe vertical separation from a maneuvering threat aircraft.

(B) "INCREASE DESCENT, INCREASE DESCENT" (Descend at the rate depicted by the green (fly to) arc on the IVSI.) Received after "DESCEND" advisory, and indicates additional descent rate required to achieve safe vertical separation from a maneuvering threat aircraft.

(C) "CLIMB - CLIMB NOW, CLIMB - CLIMB NOW" (Climb at the rate depicted by the green (fly to) arc on the IVSI.) Received after a "DESCEND" resolution advisory and indicates a reversal in sense is required to achieve safe vertical separation from a maneuvering threat aircraft.

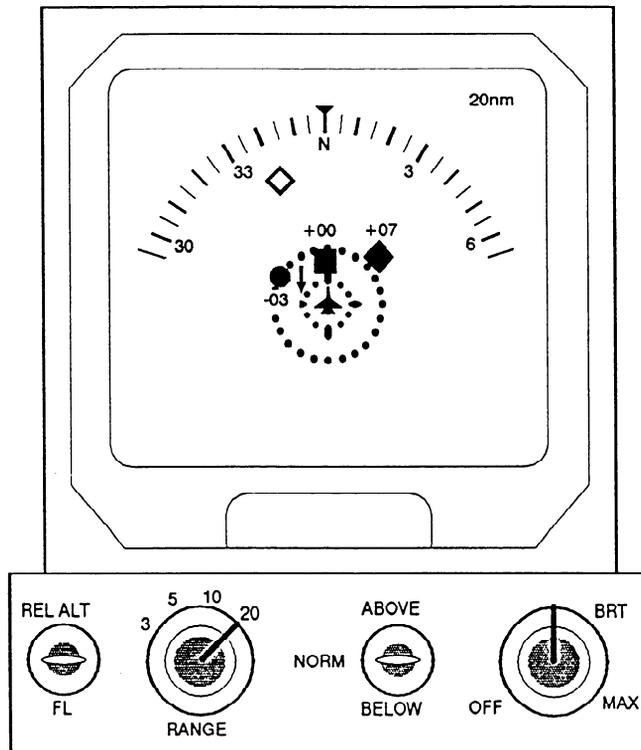
(D) "DESCEND - DESCEND NOW, DESCEND - DESCEND NOW"
(Descend at the rate depicted by the green (fly to) arc on the IVSI.)
Received after a "CLIMB" resolution advisory and indicates a reversal in
sense is required to achieve safe vertical separation from a maneuvering
threat aircraft.

Figure 1: TCAS/Transponder Control Panel (Example).



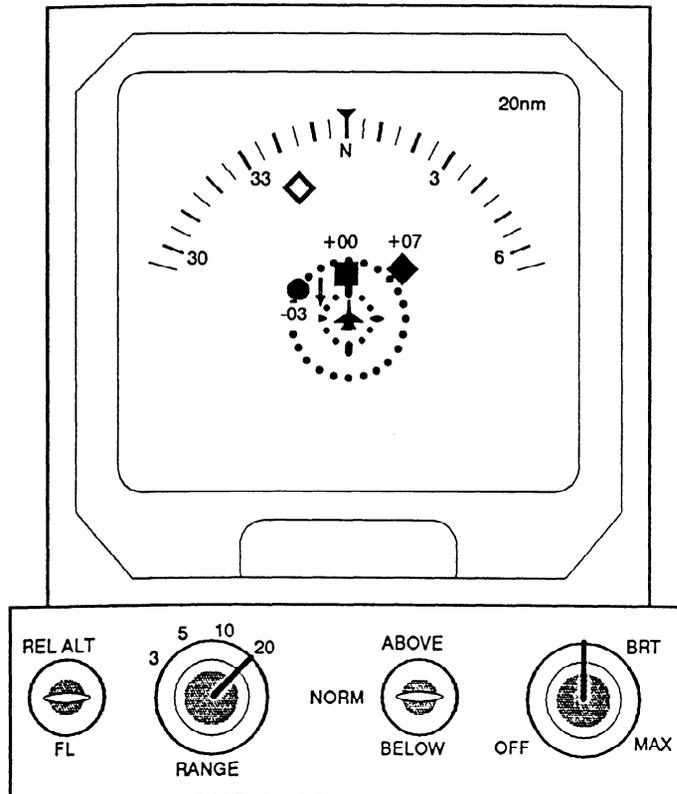
| TCAS/Transponder Function Selector | |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST | Holding the TCAS/Transponder function selector in TEST for 2 to 3 seconds will activate the system test sequence. In the TEST position, maintenance messages may be read on the display. Discretion must be used when selecting TEST in flight, since both TCAS II and the Transponder will be inhibited for approximately 20 seconds. The function selector is spring loaded to STBY. |
| STBY | Activates TCAS II and XPDR warmup cycles. |
| XPDR | Transponder is on. TCAS II is in warmup cycle. |
| TA | Transponder is on. Only the "TRAFFIC ADVISORY", or "TA", function of the TCAS II is on. No "RESOLUTION ADVISORIES" will be received in this position. The written warning "TA ONLY" will appear on the display, and the yellow "RA OFF" flag will be in view on both IVSI's |
| TA/RA | Transponder is on. All TCAS II functions are on. No TCAS flags should be present on either IVSI. |
| XPDR Fail Light (Red) | Indicates a transponder system failure when the transponder is on. Comes on during "TEST", but goes off after approximately 3 seconds if the transponder is OK. |
| Code Indicator | Indicates code selected with the code selectors. Warning Light (Amber) Indicates both transponders are on. |
| IDENT | Causes the word INDENT to flash in the aircraft data block on the ATC display. |
| ALT RPTG | Provides automatic altitude reporting of ATC. |
| Code Selectors | Select the transponder code. Left and right selectors consist of a large knob and a small knob. Each controls one digit of the code. |

Figure 2: TCAS II - Traffic Display (Example).



| | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arrows indicate that the target is climbing ↑ or descending ↓ at a rate of at least 500 fpm. | |
| Relative altitude is displayed in the proximity of the aircraft symbol in hundreds of feet. A "+" preceding the relative altitude indicates the target is above you, and a "-" indicates it is below you. | |
| Displayed Aircraft Symbols (Examples) | |
| | <i>Unfilled white diamond.</i> Non-threatening traffic without altitude reporting. If altitude reporting, the altitude data will be displayed. |
| | <i>Solid white diamond.</i> Proximity traffic 700 feet above. Non-threatening, altitude reporting traffic within 1200 feet vertically and 6nm horizontally. Aircraft without altitude reporting will be assumed to be co-altitude and will be displayed as a solid diamond when within 6nm even though they may not be within 1200 feet vertically. |
| | <i>Solid yellow circle.</i> "TA", 300 feet below, descending. At least 500 FPM. |
| | <i>Solid red square.</i> "RA", level at your altitude. |
| | <i>Ownship.</i> Airplane symbol in white just below the center of CRT. On a dedicated display or when in the TFC Mode on a combination TCAS/RADAR Display. |
| (Compass Arc) | This arc is a repeater of the Captains compass. (Not required for a TCAS II Display). |
| (Range Rings) | 3nm - Small ring with ticks at clock positions 5 NM - Large ring made of dots. |

Figure 2: TCAS II - Traffic Display (Example) (Con't).



| <u>Paddle Switch REL ALT/FL Switch</u> | |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| REL ALT | Paddle switch is spring loaded to the center position. Display shows REL ALT in hundreds of feet above (+) or below (-) your aircraft. |
| FL | Momentary contact allows display of traffic flight levels, referenced to 29.92, for 15 seconds. Your FL is displayed in lower left corner. Three digits are shown, except for negative flight levels which are shown as -xxx |
| <u>Range Knob</u> | |
| RANGE | The compass arc is always set at range selected by the range knob. Ranges of 3, 5, 10 or 20 nm are selected. |
| BRT Knob | Controls brightness of the displays. |
| <u>Above/Normal/Below Switch</u> | |
| ABOVE | Displays altitude reporting traffic from 2700 feet below to 9900 feet above. |
| NORM | Displays altitude reporting traffic from 2700 feet below to 2700 feet above. |
| BELOW | Displays altitude reporting traffic from 2700 feet above to 9900 feet below. |

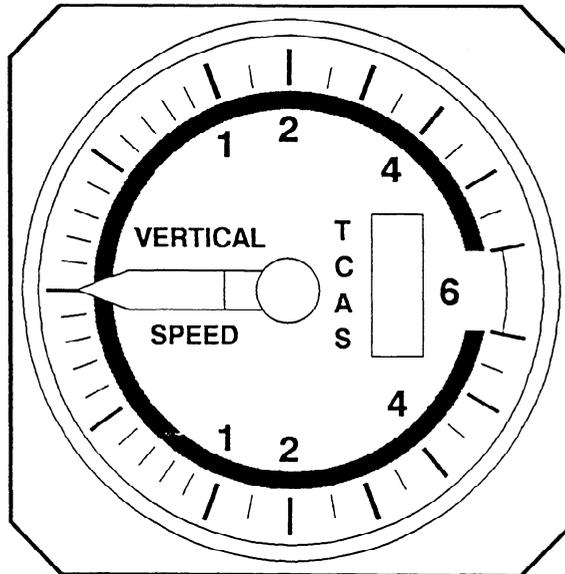
Figure 2: TCAS II - Traffic Display (Example) (Cont).**OFF-SCALE TRAFFIC ADVISORY**

In the event that TCAS II tracks an intruder that is outside the range of the display but has entered the Caution or Warning areas, one-half of the appropriate symbol will appear at the appropriate bearing at the edge of the display area. The symbol will appear in its proper color and have its data tag displayed, providing there is room. For example, a TA intruder with a high closure rate, and which is directly ahead and is 300 feet below your airplane will appear as an amber-filled half circle at the 12 o'clock position on the edge of the display area. The data tag "-03" will appear below the half symbol. If this intruder is above your altitude, the data tag is not visible. An off-scale RA intruder will appear as a red-filled half square with data tag, if possible.

NO BEARING ADVISORIES

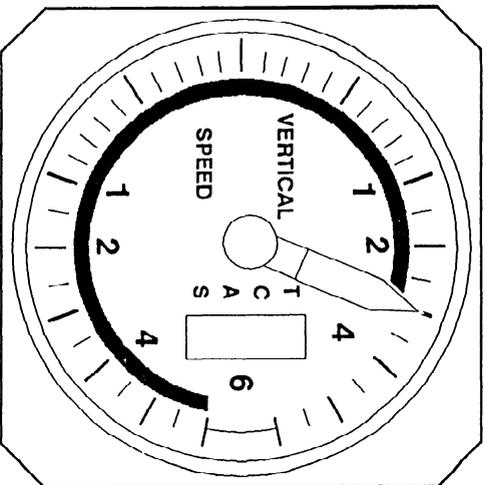
If and when TCAS II is unable to track the bearing of an intruder, the traffic advisory will appear in the lower center of the display just below the own-airplane symbol. The advisory will present appropriate color-coded traffic information. This phenomenon usually is caused either by temporary antenna shielding caused by steep bank angles or a failure in the TCAS II bearing antenna. Up to two lines of information can be displayed. "TA 5.2-06r" for example means an intruder is creating a Traffic Advisory 5.2 nautical miles away, 600 feet below, and climbing in excess of 500 FPM. "RA 0.6 00" means resolution advisory traffic is 0.6 nautical miles away at the same altitude. TCAS II's ability to compute a Traffic or Resolution Advisory is NOT degraded by lack of bearing information.

Figure 3: TCAS II Instantaneous Vertical Speed Indicator (Example)

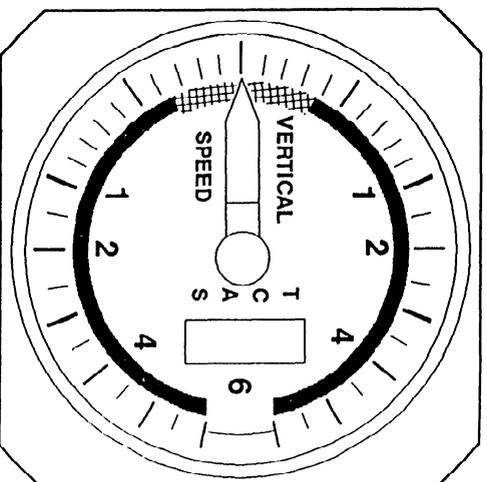


| | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>INSTANTANEOUS VERTICAL SPEED INDICATOR. Indicates vertical speed in feet per minute. The IVSI is a normal instantaneous vertical speed indicator, and the presence of the lights or the flags will not interfere with the ability of the needle to indicate vertical speeds.</p> | |
| | <p>RED/GREEN EYEBROW LIGHTS. Eyebrow lights are invisible until they illuminate as part of a TCAS II "RESOLUTION ADVISORY", or system "TEST". These lights indicate a vertical speed regime which will provide safe traffic separation. The green lights form a wider band than the red lights.</p> |
| <p>IVSI Status Window Flags</p> | |
| <p>T C A S</p> | <p>BLACK. Normal operation.</p> |
| <p>T C A S</p> | <p>AMBER FLAG. Indicates unusable TCAS II information.</p> |
| <p>T C A S</p> | <p>WHITE "RA OFF" FLAG. Always displayed when TCAS/TRANSPONDER function selector is in STBY, XPDR, or TA. Will also be displayed with selector in RA/TA in "RAs" are inhibited and/or inoperative.</p> |

Figure 4: TCAS II Examples - Preventive.

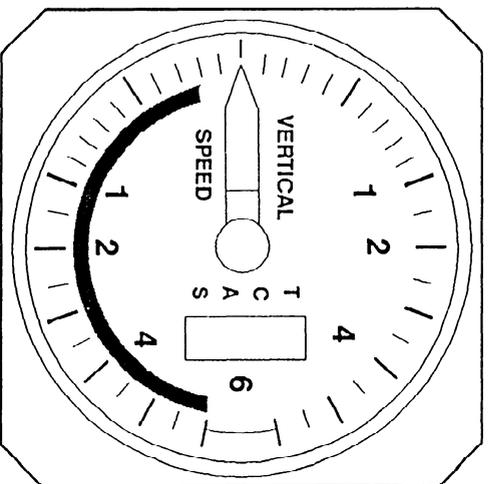


(a) Preventive
MONITOR VERTICAL SPEED.

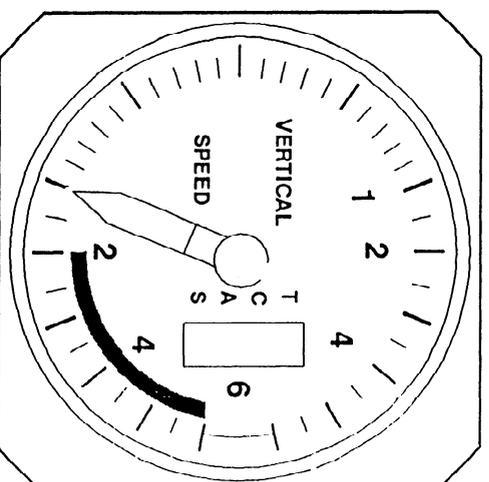


(b) Preventive
MONITOR VERTICAL SPEED.

Note: This multi-aircraft encounter is the only preventive RA that displays a green arc.

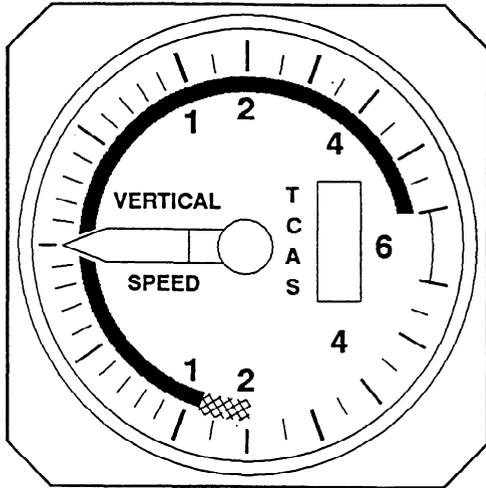
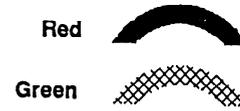


(c) Preventive
MONITOR VERTICAL SPEED.

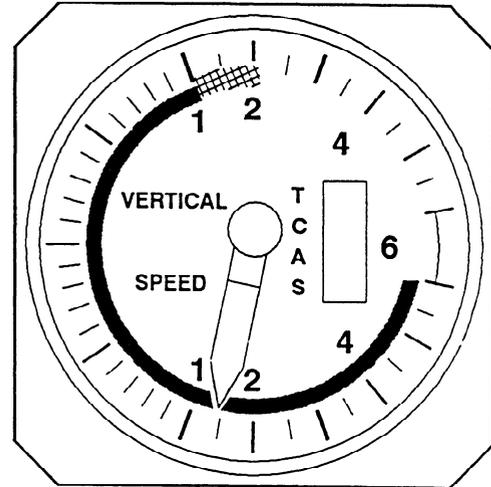


(d) Preventive
MONITOR VERTICAL SPEED.

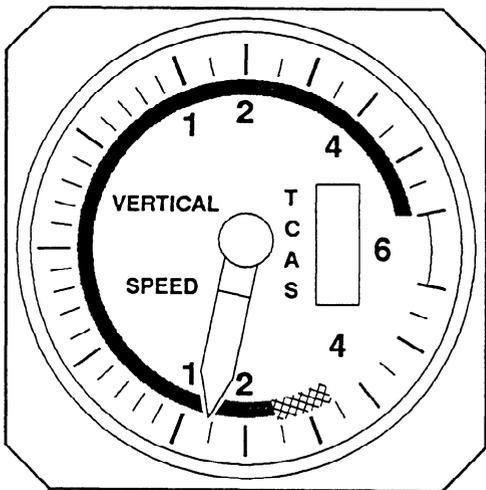
Figure 5: TCAS II Examples - Corrective.



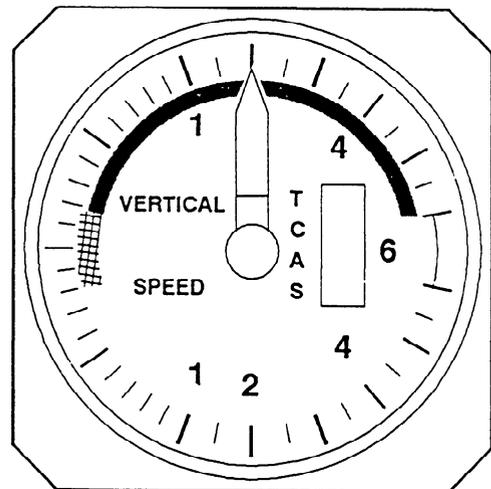
(a) Corrective
DESCEND.



(b) Corrective
CLIMB or CLIMB, CLIMB NOW.



(c) -Corrective
INCREASE DESCENT.



(d) Corrective
REDUCE CLIMB.

SECTION 1 - LIMITATIONS

- o Pilots are authorized to deviate from their current ATC clearance to the extent necessary to comply with a TCAS II resolution advisory (RA).

SECTION II - EMERGENCY PROCEDURES

- o No change from basic airplane flight manual.

SECTION III - PROCEDURES

1. TCAS II Flight Procedures:

- o Compliance with a TCAS II resolution advisory (RA) is necessary unless the pilot considers it unsafe to do so, or unless the pilot has better information about the cause of the RA and can maintain safe separation (e.g., visual acquisition of and safe separation from a nearby aircraft, obvious TCAS II system failure, etc.).

CAUTION

- Once a noncrossing RA has been issued, safe operation could be compromised if current vertical speed is changed, except as necessary to comply with the RA. This is because TCAS II-to-TCAS II coordination may be in progress with the intruder airplane, and any change in vertical speed that does not comply with the RA may negate the effectiveness of the other airplane's compliance with its RA.

* * * * * WARNING * * * * *

- Noncompliance with a crossing RA by one airplane may result in reduced vertical separation; therefore, safe horizontal separation must also be assured by visual means.

NOTE

The consequences of not following an RA may result in additional RAs in which aural alert and visual annunciations may not agree with each other.

- o Because of the limited number of inputs to TCAS II for airplane performance inhibits, in some instances where inhibiting RAs may be appropriate it is not possible to do so. In these cases, TCAS II may command maneuvers which may significantly reduce stall margins or result in stall warning. Therefore, the stall warning stick shaker must be respected when following an RA. Conditions where this may occur include:

- Bank angle in excess of 15 degrees.
 - One engine inoperative.
 - Abnormal configurations such as landing gear not retractable, etc.
 - Leaving airplane in inappropriate configurations when climb RA occurs.
 - Operation at airports outside of 0' to 5,300' MSL or temperatures outside of ISA \pm 50°F (27.8°C).
 - Speeds below normal operating speeds.
 - Buffet margin less than 0.3g.
- o The TCAS II RA algorithms are based on the pilot initiating the initial .25g incremental maneuver within approximately 5 seconds, and within approximately 2 1/2 seconds if an additional corrective RA increase or reverse is issued. (The reversal is based on a .5g incremental maneuver.)

NOTE

Evasive maneuvering must be limited to the minimum required to comply with the RA. Excessive responses to RAs are not desirable or appropriate because of other potential traffic and ATC consequences. From level flight, proper response to an RA typically results in an overall altitude deviation of 300 to 500 feet in order to successfully resolve a traffic conflict.

Preventive advisories are also posted after a corrective advisory has been satisfied and the TCAS II airplane is projected to have adequate altitude separation. The corrective RA is said to soften, indicating a gradual return to the original flight path or clearance is allowed. As the corrective advisory softens to a preventive advisory, the green arc is removed, the magnitude of the red arc decreased and "MONITOR VERTICAL SPEED" is announced. The new preventive RA restricts the rate (vertical speed) the pilot may use in returning to the original flight path. The RA may soften several times before "CLEAR OF CONFLICT"; "MONITOR VERTICAL SPEED" will be announced only after the initial downgrading of the corrective RA. Utilizing the softening advisory will greatly reduce the ultimate altitude deviation caused by the original corrective resolution advisory.

- o If a "CLIMB" RA is issued while in the landing configuration, initiate normal go-around procedure.

NOTE

Initiating go-around procedure for a "CLIMB" RA does not mandate a missed approach. It is intended to assure the airplane is properly configured for the expected maneuver. In most cases, the TCAS II event will be resolved with only minor deviation to the intended flight path, and sufficient time and altitude may exist to recover safely to the desired flight path.

- o The pilot should not initiate evasive maneuvers using information from the traffic display only or on a traffic advisory (TA) only without visually sighting the traffic. These displays and advisories are intended only for assistance in visually locating the traffic and lack the flight path trends necessary for use in evasive maneuvering. However, while climbing or descending, modest changes in vertical speed based on traffic display information is not considered evasive maneuvering.
- o Following a TCAS II "CLEAR OF CONFLICT" advisory, the pilot should expeditiously return to the applicable ATC clearance unless otherwise directed by ATC.

NOTE

There can be a case where the threat aircraft track or altitude information is lost during an RA. In this case, the RA will terminate without a "CLEAR OF CONFLICT" annunciation.

2. TCAS II OPERATION:Pilot-Initiated TCAS II Self-Test:

- o The TCAS II should be tested using the pilot-initiated self-test feature during cockpit preparation. A successful test is indicated by (provide test results from particular TCAS II system)
- o Use of the self-test function in flight will inhibit TCAS II operation for up to 20 seconds depending upon the number of aircraft being tracked.
- o The ATC transponder will not function during some portion of the self-test sequence.

Ground Operation:

- o The TCAS II should not be selected out of STBY to TA/RA until just prior to takeoff.
- o The TCAS II should be selected to STBY immediately after clearing runway following landing.

o TA Mode:

- o The TA position should only be used to preclude unnecessary RAs when intentionally operating near other aircraft such as to closely spaced parallel runways (less than 2500 feet apart).
- o In TA mode, RAs will not be issued.

WX-ONLY Mode:

- o When WX-ONLY mode is selected, traffic information, traffic advisories, and resolution advisories are inhibited on the weather radar scope. Therefore, this mode should be used only in the event TCAS interferes with weather information.
(This example is to show the kind of procedure to be developed. Procedures will vary depending upon installation; e.g., pop-up display modes, PFD/ND implementation, etc.)

3. TCAS II System Characteristics:

- o "CLIMB" RAs are inhibited with flaps greater than XX degrees.
- o When below 1000 feet AGL and "CLIMB" RAs are inhibited with flaps greater than XX degrees, the TCAS II will go into the TA only mode.
- o "INCREASE CLIMB" RAs are inhibited with flaps greater than XX degrees.
- o "DESCEND" RAs are inhibited below 1200 feet AGL while climbing and below 1000 feet AGL while descending.
- o "INCREASE DESCENT" RAs are inhibited below 1450 feet AGL.
- o All RA and TA voice messages are inhibited below 600 feet AGL while climbing and below 400 feet AGL while descending.
- o The TCAS II surveillance may not function at distances less than 900 feet.
- o During windshear and/or GPWS warnings, TCAS II switches automatically into a TA only no-voice mode. In this mode, RAs are not issued, current RAs become TAs, and TCAS II aural annunciations are inhibited.

4. TCAS II Abnormal Procedures:

- o RA OFF Flag in IVSI
 - Verify TCAS/transponder function selector is in TA/RA position.
 - If TA/RA is selected and "RA OFF" flag is in view, then the pilot with the operable IVSI (flag not in view) should be the pilot flying.
- o AMBER FLAG in IVSI
 - Check XPDR FAIL light.
 - If OFF select other altitude source.
 - If ON select alternate ATCRBS transponder. (TCAS II will no longer be available.)
- o XPDR FAIL Light Illuminated
 - Select alternate ATCRBS transponder. (TCAS II will no longer be available.)

(These examples are to show the kinds of abnormal procedures to be developed. Procedures will vary depending upon the installation; e.g., dual Mode S, etc.)

SECTION 4 - PERFORMANCE

- o No change from basic airplane flight manual.

Appendix 2SUPPLEMENTAL INITIAL CERTIFICATION FLIGHT TESTS

1. Surveillance Flight Tests. The bench tests in Section 2.4 of the TCAS II MOPS, DO-185, are designed to verify TCAS II surveillance performance under carefully controlled conditions. A surveillance flight test should be performed to completely validate a TCAS II surveillance design.

a. A flight test under environmentally stressful conditions should be performed to provide the data for a complete TCAS II Mode C surveillance design validation. The environment includes the combined effects of multipath interference, synchronous garbling and fruit interference as a result of high aircraft density, and ground interrogator interference from multiple ground interrogators.

b. A flight test should be performed for each new TCAS II surveillance design, and whenever major modifications are made to the surveillance function of a previously certified TCAS II. 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 II to meet the surveillance performance criteria of paragraph 1.k. below. The tests should be accomplished with all certifiable antenna configurations unless the applicant can demonstrate that a worst-case configuration has been evaluated. 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 a smaller non-carrier aircraft. The results of the test are only applicable for initial certification for each manufacturers system.

c. Flight testing should be accomplished in the Los Angeles basin area, particularly in the vicinity of the Long Beach and Santa Ana airports, since previous tests of TCAS II have shown that this area provides the stressful environment necessary for proper evaluation of TCAS II surveillance. 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% of the total required flight duration defined in 1(iv) below, and

(3) Approach and departure flights to Long Beach and Santa Ana airports.

d. The flight test should be conducted on weekends 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 highest peak traffic densities. Another location may be proposed by the applicant and will be considered as a suitable

alternative to the Los Angeles area if the applicant can demonstrate that the TCAS II surveillance test was conducted in an average density of at least 0.1 transponder-equipped aircraft per sq. nmi and a peak density of at least 0.2 transponder-equipped aircraft per sq. nmi. Density is defined as the number of other transponder-equipped aircraft within 5 nmi of the TCAS II test aircraft divided by the area of a circle of 5 nmi radius. Eight real aircraft target tracks occurring simultaneously within 5 nmi of the TCAS II test aircraft is equivalent to a density of 0.1 transponder-equipped aircraft per sq. nmi. The alternative location should also contain a minimum of three FAA or military secondary surveillance radars located within 30 nmi of the TCAS II aircraft in order to provide an interference environment similar to the Los Angeles area.

e. 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 in the forward quadrant,
- (2) within a 3.5 nmi range of TCAS in the right and left quadrants,
- (3) within a 2 nmi range of TCAS in the aft quadrant,
- (4) within +/- 5 deg. elevation of TCAS, and
- (5) is altitude reporting and airborne.

f. The number of actual flight hours necessary to collect 10,000 track-seconds of data depends on the aircraft density. For example, a one hour recording in the Los Angeles basin which has a demonstrated minimum average density of 0.1 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.

g. The recorded data 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 and resolution advisories, internal processor clock, and time-of-day. Recorded flight data should be provided to the FAA to permit an independent assessment of surveillance performance in accordance with paragraph 1.h. 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).

h. The applicant should perform at least the following specific post-flight data analyses:

- (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 II 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 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.

i. 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 this information and provide an evaluation summary that indicates an acceptable design.

j. An effective method of evaluating TCAS II 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 II 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 II 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 II processed tracks will identify the TCAS II track reports associated with real aircraft.

k. 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 of the surveillance flight test, meets or exceeds the following acceptance criteria:

- (1) TCAS surveillance probability for targets-of-interest >95%
- (2) TCAS false track rate for target-of-interest < 1.2%

The applicant should also present an evaluation summary on any single dominant failure event as discussed in l.h. above.

2. TCAS to TCAS Coordination Encounters. Planned TCAS II to TCAS II coordination encounters should be performed in order to evaluate the reliability of the overall air to air coordination data link for installed TCAS II and Mode S transponder equipments. The encounters should be flown at 3000 feet over calm water in order to increase the likelihood of multipath and in configurations that maximize the times during which a resolution advisory is present and coordination is taking place. Examples of such encounters are tail chases and side-by-side flights. If the lateral separation necessary for multipath is larger than the separation that maintains the RA, the aircraft can periodically turn in towards each other during side-by-side flights in order to continually initiate RAs. The encounters should be flown so as to involve a reasonable mix of the four quadrants of the TCAS II and transponder antennas. Each TCAS II aircraft should have sufficient recording capability to record the replies received in response to coordination interrogations. The recorded data should include at least 2000 TCAS coordination scans. The criteria for acceptable performance is as follows:

a. The probability of a single scan coordination link dropout should be no greater than 0.1%.

b. There should be no coordination link dropouts that exceed one scan in duration.

APPENDIX 3 TRANSPONDER TESTS

Using a suitable calibrated transponder test set, conduct the following tests:

TEST DESCRIPTION

0. Mode Test

Identifies modes of operation. Interrogations are made in Modes A, C, and S (uplink format 11) to determine which modes the transponder replies to. These are the modes tested during the Auto Test sequence.

1. Reply Delay

Interrogates with valid modes and verifies Reply delay minus Range delay (average of best 8 out of 13 replies) equals:

128.00 us (± 0.25 us) for Mode S.

3.00 us (± 0.50 us) for ATCRBS.

2. Reply Jitter

Interrogates with valid modes and verifies, using best 8 out of 13 replies. Reply Jitter (changes In Reply Delay) is less than or equal to:

0.05 us for Mode S

0.06 us for Intermode (All-Call)

0.10 us for ATCRBS.

3. ATCRBS Reply

Interrogates with ATCRBS (Modes A and C) interrogations and verifies:

F_1 to F_2 spacing is 20.3 us (± 0.10 us).

F_1 and F_2 pulse width between the 0.5 amplitude point on the leading and trailing edge is 0.45 us (± 0.10 us).

4. SLS Level

Interrogates with valid ATCRBS Interrogations including P_2 pulse. Interrogations are conducted with P_2 level at -9 dB and then again at 0 dB. Test verifies:

Transponder does not reply when P_2 level is at 0 dB (UUT is suppressed).

Transponder replies when P_2 level is at -9 dB (UUT is not suppressed).

5. ATCRBS Only All-Call

Interrogates with an ATCRBS only All-Call and verifies:

If Mode S is valid, no reply is received from a Mode S transponder.

If no Mode S, reply is received from an ATCRBS transponder.

6. Mode S All-Call

Interrogates with the ATCRBS (mode A)/Mode S All-Call. Address received in downlink format (DF) 11 is then used in an uplink format (UF) 4 interrogation to solicit a DF4 reply. The address received is decoded and compared with the address sent.

7. Invalid Mode S Address

Interrogates with Mode S interrogations using two addresses different from the address determined by the Mode S All-Call, UF11. Test verifies no reply is received. Addresses used are one greater and 256 greater than the correct address.

8. SPR On/Off

Interrogates with a Mode S interrogation with the Synchronous Phase Reversal (SPR) on, verifying correct reply is received. Then same interrogation is sent again with the SPR off, verifying no reply is received.

9. Mode S UF0

Interrogates with Mode S uplink format 0 (Short air to air surveillance, ACAS) verifying reply is received that has correct altitude (compared with Mode C altitude), address (compared with Mode Test address) and format.

10. Mode S UF4

Interrogates with Mode S uplink format 4 (Surveillance, altitude request), verifying reply is received that has correct altitude (compared with Mode C altitude), address (compared with Mode Test address) and format.

11. Mode S UF5

Interrogates with Mode S uplink format 5 (Surveillance, identity request) verifying reply is received that has correct identity (compared with Mode A identity), address (compared with Mode Test address) and format.

12. Mode S UF11

Interrogates with Mode S uplink format 11, verifying reply is received that has correct address (compared with Mode Test address) and format.

13. Mode S UF16

Interrogates with Mode S uplink format 16 (Long air to air surveillance, ACAS), verifying reply, if received, has correct altitude (compared with the Mode C altitude), address (compared with Mode Test address) and format. No reply to UF16 does not fail Mode S in Auto Test.

14. Mode S UF20

Interrogates with Mode S uplink format 20 (Comm A, altitude request) verifying reply received has correct altitude (compared with Mode C altitude), address (compared with Mode Test address) and format. No reply to UF21 does not fail Mode S in Auto Test.

15. Mode S UF21

Interrogates with Mode S uplink format 21 (Comm A, identity request) verifying reply received has correct identity (compared with Mode A identity), address (compared with Mode Test address) and format. No reply to UF21 does not fail Mode S in Auto Test.

16. Squitter

Verifies squitters are being received from the UUT every 0.8 to 2.4 seconds.

17. Frequency

Verifies frequency of transponder is 1090 MHz (\pm MHz). Frequency is displayed in the Auto Test screen.

18. Diversity

Verifies diversity isolation (power level difference between UUT "On" antenna squitters and "Off" antenna squitters) is greater than or equal to 20 dB. Diversity isolation is displayed in Auto Test screen.

NOTE: To insure \geq 20 dB dynamic range, test must be run within 50 feet (15.24 meters) of UUT antenna being tested.

19. MTL Difference

Verifies Receiver Sensitivity (MTL) to Mode A interrogations equals MTL to Mode C interrogations (\pm 1.0 dB).

20. Power

Verifies transponder's:

Peak output power (ERP) is greater than 48.5 dBm and less than 57.0 dBm.

Receiver sensitivity (MTL) is -73.0 dBm (± 4.0 dBm).

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