Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C119c

Effective
Date: 4/14/09

Technical Standard Order

Subject: TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) AIRBORNE EQUIPMENT, TCAS II WITH OPTIONAL HYBRID SURVEILLANCE

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration or FAA) tell you what minimum performance standards (MPS) your traffic alert and collision avoidance system II (TCAS II) must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. All prior revisions to this TSO are no longer effective. Generally we will not accept applications after the effective date of this TSO. However, we may do so up to six months after it, if we know that you were working against the earlier MPS before the new change became effective.

b. TCAS II approved under a previous TSOA may still be manufactured under the provisions of their original approval.

c. Major design changes to TCAS II approved under this TSO will require a new authorization. See Title 14 of the Code of Federal Regulations (14 CFR) § 21.611(b).

3. REQUIREMENTS. New models of TCAS II identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements in RTCA, Inc. document RTCA/DO-185B, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II),* dated June 19, 2008, Section 2 as modified by appendix **1** of this TSO. If the TCAS II includes non-TSO function(s), it must meet the manufacturer's specified performance and test requirements for the non-TSO function (see paragraph **5q**). A non-TSO function is any function that is not covered by a TSO-approved minimum performance standard (MPS) and does not support the hosting article's TSO function(s).

> **NOTE:** If you plan to add non-TSO functionality into the hosting TSO article, you should coordinate this with the responsible ACO well in advance of your TSO application to avoid potential delays to your project.

a. Optional Hybrid Surveillance. In the new model of TCAS II, you may include optional functionality that meets the MPS qualification and documentation requirements in RTCA/DO-300, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance,* dated December 13, 2006, Section 2, as modified by appendix **2** of this TSO.

b. Functionality. This TSO's standards apply to equipment intended to be used in aircraft to provide a reliable traffic and collision avoidance function between transponder equipped aircraft.

c. Failure Condition Classification. Failure of the function defined in paragraph **3b** of this TSO is a *hazardous/severe-major* failure condition. Develop the TCAS II to at least the design assurance level equal to this failure condition classification.

d. Functional Qualification. Demonstrate the required performance under the test conditions in RTCA/DO-185B, Section 2 as modified by appendix **1** of this TSO. If including optional hybrid surveillance in your TCAS II, demonstrate the required performance under the test conditions in RTCA/DO-300, Section 2 as modified by appendix **2** of this TSO.

e. Environmental Qualification. Test the equipment according to RTCA/DO-160F, *Environmental Conditions and Test Procedures for Airborne Equipment,* dated December 6, 2007.

f. Software Qualification. If the article includes a digital computer, develop the software according to RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification,* dated December 1, 1992. Those articles containing software upgraded from an original product, compliant with the process described in RTCA/DO-178A, need only apply the requirements in RTCA/DO-178B to change software and all software affected by the change. Perform a change analysis to clearly identify components affected by the change. See RTCA/DO-178B Section 12 for more guidance on previously developed software.

g. Electronic Hardware Qualification. If the article includes a complex custom micro-coded component, develop the component to the guidance in FAA Advisory Circular (AC) 20- 152, *RTCA, Inc. Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware.* The hardware design assurance level should be consistent with the failure condition classification defined in paragraph **3c** of this TSO. Those articles containing hardware upgraded from an original product developed before RTCA/DO-254 was published (April 19, 2000), need only apply the requirements in RTCA/DO-254 to change hardware and all hardware affected by the change. Perform a change analysis to clearly identify components affected by the change. See RTCA/DO-254, Section 11, for more guidance on previously developed hardware.

h. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under 14 CFR § 21.609 before submitting your data package.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 21.607(d). Use serial number in place of optional date of manufacture as stated in 14 CFR § 21.607(d)(3).

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools),

(2) Each interchangeable element, and

(3) Each subassembly of the article that you determined may be interchangeable.

c. If the component includes a digital computer, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means to show the modification status.

> **NOTE:** Similar software versions, approved to different software levels, must be differentiated by part number.

d. Consider identifying deviations granted to the article by marking "Deviation. See installation/instruction manual (IM)" after the TSO number. You can abbreviate the marking to "(Dev. See IM)."

e. When applicable, identify the equipment as an incomplete system or state that the article performs functions beyond those described in paragraph **3b** of this TSO.

5. APPLICATION DATA REQUIREMENTS. As a TSO manufacturer-applicant, you must give the FAA aircraft certification office (ACO) manager responsible for your facilities a statement of conformance, as specified 14 CFR § 21.605(a)(1) and one copy each of the following technical data to support your design and production approval. (Under 14 CFR § 21.617(a)(2), LODA applicants submit the same data through their civil aviation authority)

a. Operating instructions and equipment limitations in an IM, sufficient to describe the equipment's operational capability. Describe any deviations in detail. If needed, identify equipment by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

b. Installation procedures and limitations in an IM, sufficient to ensure that the TCAS II, when installed according to the installation procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. Finally, the limitations must include a note with the following statement:

> The conditions and tests for TSO approval of this article are minimum performance standards. Those installing this article, on or in a specific type or class of aircraft, must

determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only according to 14 CFR part 43 or the applicable airworthiness requirements.

c. Schematic drawings of the installation procedures.

d. Wiring diagrams of the installation procedures.

e. List of components, by part number, that make up the TCAS II article. Include vendor part number cross-references, when applicable.

f. A component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed TCAS II. Include recommended inspection intervals and service life. Describe the details of deviations granted, as noted in paragraph **5a** of this TSO.

g. Material and process specifications list.

h. The quality control system (QCS) description required by 14 CFR §§ 21.143 and 21.605(a)(3), including functional test specifications. The QCS should ensure that you will detect any change to the equipment that could adversely affect compliance with the TSO MPS, and reject the item accordingly. (Not required for LODA applicants.)

i. Manufacturer's TSO qualification test report.

j. Nameplate drawing with the information required by paragraph **4** of this TSO.

k. List of all drawings and processes (including revision level) that define the article's design. For a minor change, follow the directions in 14 CFR § 21.611(a). Show any revisions to the drawing list only on our request.

l. Environmental qualifications form as described in the environmental qualifications document referenced in paragraph **3e** of this TSO for each component of the system.

m. If the article includes a digital computer: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary. We recommend that you submit the PSAC early in the software development process. Early submittal allows us to quickly resolve issues, such as partitioning and determining software levels.

n. If the article includes a complex custom micro-coded component: a plan for hardware aspects of certification (PHAC), hardware verification plan; top-level drawing, and hardware accomplishment summary. We recommend that you submit the PHAC early in the hardware development process. Early submittal allows us to quickly resolve issues.

o. Statement of software verification and validation levels as defined in RTCA/DO-178B.

p. The appropriate documentation as defined in RTCA/DO-178B, or equivalent, necessary to support the verification and validation of the computer software to the appropriate level(s). If the software is verified and validated to more than one level, submit the appropriate documentation for all such levels.

q. If the article contains non-TSO function(s), provide the following additional information.

(1) A description of the non-TSO function(s), including key performance specifications, as well as software, hardware, environmental, and other qualification levels.

(2) Interface requirements for the non-TSO function(s) and applicable installation test procedures.

(3) Installation and operating instructions/limitations, for the non-TSO function(s).

(4) Instructions for continuing airworthiness applicable to the non-TSO function(s).

(5) Results of test/analysis, as appropriate, to verify that the hosting TSO's performance is not affected by the non-TSO function(s).

6. <u>MANUFACTURER DATA REQUIREMENTS</u>. Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Equipment calibration procedures.

c. Corrective maintenance procedures within 12 months after TSOA or LODA.

d. Schematic drawings.

e. Wiring diagrams.

f. Material and process specifications.

g. Results of the environmental qualification tests conducted per **3e** of this TSO.

h. If the article includes a digital computer, the appropriate documentation defined in RTCA/DO-178B, including all data supporting the applicable objectives in RTCA/DO-178B, Annex A.

i. If the article includes a complex micro-coded component, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l.

j. If the article contains non-TSO function(s), the manufacturer must also make available items **6a** through **6i** as it pertains to the non-TSO function(s).

7. <u>FURNISHED DATA REQUIREMENTS</u>. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide the following:

a. One copy of the data in paragraphs **5a** through **5f** and **5l** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued airworthiness of the TCAS II.

b. If the article contains non-TSO function(s), also include one copy of the data in paragraphs **5q(1)** through **5q(4).**

8. <u>HOW TO GET REFERENCED DOCUMENTS</u>.

a. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org.

b. Order copies of 14 CFR part 21, Subpart O, from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh PA 15250-7954. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select “Access,” then “Online Bookstore.” Select “Aviation,” then “Code of Federal Regulations.”

c. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at www.rgl.faa.gov You will also find the TSO Index of Articles at the same site.

/s/ Susan J. M. Cabler

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APPENDIX 1. FAA MODIFICATIONS TO RTCA/DO-185B

1. This appendix lists FAA modifications to RTCA/DO-185B, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II)*

2. Change to Volume I

The following correction (highlighted in grey) is needed to DO-185B, Volume I, Section 2.2.5.3.3, page 134, in order to more accurately describe the behavior of the multi-aircraft logic when own aircraft is “projected in the middle”.

2.2.5.3.3 Multi-Aircraft Logic

Note: *Special rules are invoked when a TCAS-equipped aircraft is involved in a multiple-aircraft encounter. The pilot of the aircraft with "projected clear airspace above" is told to CLIMB, and the pilot of the aircraft with "projected clear airspace below" is told to DESCEND. Aircraft "projected in the middle" are told to limit their climb and their descent until the aircraft above or below are no longer in conflict.*

The selection of a positive DESCEND advisory in a multi-aircraft situation is also subject to the performance limitations of the TCAS aircraft when it is near the Descend Inhibit altitude threshold. In this case, a negative DON'T CLIMB will be selected instead of DESCEND.

The multi-aircraft logic has been designed to prevent premature level-off RAs when own is to pass between two threats vertically. This requires retention of a positive RA until certain criteria have been met so that vertical separation is maximized. The multi-aircraft logic also includes the ability to model and select Increase Rate RAs and sense reversals to better resolve situations that are deteriorating due to adverse maneuvers by own aircraft or one of the threats. (The ability to generate an Increase Rate RA is subject to the INCREASE CLIMB and INCREASE DESCENT inhibit indications and thresholds.) The logic also performs an unbiased evaluation of all new threats to select the optimum RA against all rather than constraining the RA to be selected against the second or third threat by the initial choice against the first.

3. Changes to Pseudocode

The pseudocode changes follow. Only a single pseudocode program is affected, Set_up_display_outputs (DO-185B, Attachment A, pages 8-P16 and 8-P17). Both the published DO-185B version (BEFORE) and the revised version (AFTER) of both the high-level and low-level pseudocode are shown below. The changes in the AFTER versions are highlighted.

In addition, the published version of the low-level pseudocode is missing a needed “G.” reference to the global data structure G, and that is also fixed and highlighted in grey.

HIGH-LEVEL PSEUDOCODE BEFORE

```
PROCESS Set_up_display_outputs;

    <Determine advisory annunciation precedence>
    IF (an RA is to be displayed this cycle)
        THEN  IF (increase rate RA issued)
                  THEN  CLEAR reversal, maintain rate, and altitude crossing flags;
                        IF (increase rate RA was not present last cycle)
                            THEN indicate that RA changed to increase rate this cycle;
                  ELSE  CLEAR indication that increase rate RA was present last cycle;
                        IF (RA requires maintenance of rate)
                            THEN  SET maintain rate indication;
                                  CLEAR sense reversal indication, if any;  <announce maintain>
                            ELSE  IF (previous cycle's RA was dual negative AND current RA is
                                          either single negative or positive)
                                      THEN CLEAR maintain rate indication;
                        IF (sense of previously displayed RA has been reversed)
                            THEN  CLEAR altitude crossing flag;  <Reversal needs to be
                                      announced even if the reversed RA is altitude crossing>
                                  CLEAR maintain rate indication;  <If reversing maintain RA>
                        IF (RA is preventive)     <Initial preventive neg. or VSL RA or weakening>
                                                  <Note:  All positive RAs are now corrective>
                            THEN  IF (RA is dual negative) <Don't Climb/Don't Descend>
                                      THEN  SET maintain rate indication;  <announce maintain>
                                      ELSE  CLEAR maintain rate indication;
                                            IF (positive Climb is weakening to negative Don't
                                                Descend OR (positive Descend is weakening to
                                                negative Don't Climb AND not in extreme low
                                                altitude condition))
                                                THEN  indicate that weakened RA is corrective;
                                                      <Results in green "fly-to" arc plus
                                                      corrective aural annunciation for initial
                                                      weakening>
                                  Set displayed-model-goal rate to 0 fpm;  <RA display device
                                          will use prescribed vertical rates for neg. & VSL RAs>
                            ELSE  IF (RA is corrective negative or VSL)
                                      THEN  CLEAR maintain rate indication;
                                            Set displayed-model-goal rate to 0 fpm;
              CLEAR clear of conflict flag;
        ELSE  CLEAR maintain rate indication;  <no RA is to be displayed this cycle>
              Set displayed-model-goal rate to 0 fpm;
              IF (an altitude-reporting threat became non-altitude-reporting during preceding RA)
                  THEN  CLEAR track drop and clear of conflict flags;
                  ELSE  IF (a threat's track was dropped during preceding RA)
                            THEN  CLEAR clear of conflict flag;
    PERFORM Load_display_and_aural_info; <Load display information to be sent to the RA display,
                                          TA display and aural annunciation subsystem.>
END Set_up_display_outputs;
```

HIGH-LEVEL PSEUDOCODE AFTER

```
PROCESS Set_up_display_outputs;

    <Determine advisory annunciation precedence>
    IF (an RA is to be displayed this cycle)
        THEN  IF (increase rate RA issued)
                  THEN  CLEAR reversal, maintain rate, and altitude crossing flags;
                        IF (increase rate RA was not present last cycle)
                            THEN indicate that RA changed to increase rate this cycle;
                  ELSE  CLEAR indication that increase rate RA was present last cycle;
                        IF (RA requires maintenance of rate)
                            THEN  SET maintain rate indication;
                                  CLEAR sense reversal indication, if any;  <announce maintain>
                            ELSE  IF (previous cycle's RA was dual negative AND current RA is
                                          either single negative or positive)
                                      THEN CLEAR maintain rate indication;
                        IF (sense of previously displayed RA has been reversed)
                            THEN  CLEAR altitude crossing flag;  <Reversal needs to be
                                      announced even if the reversed RA is altitude crossing>
                                  CLEAR maintain rate indication;  <If reversing maintain RA>
                        IF (RA is preventive)     <Initial preventive neg. or VSL RA or weakening>
                                                  <Note:  All positive RAs are now corrective>
                            THEN  IF (RA is dual negative) <Don't Climb/Don't Descend>
                                      THEN  SET maintain rate indication;  <announce maintain>
                                      ELSE  CLEAR maintain rate indication;
                                            IF ((positive Climb is weakening to negative Don't
                                                Descend OR (positive Descend is weakening to
                                                negative Don't Climb AND not weakening due
                                                to extreme low altitude condition)) AND not
                                                weakening due to multiaircraft "sandwich"
                                                encounter with both up-sense and down-sense
                                                VSLs)
                                                THEN  indicate that weakened RA is corrective;
                                                      <Results in green "fly-to" arc plus
                                                      corrective aural annunciation for initial
                                                      weakening>
                                  Set displayed-model-goal rate to 0 fpm;  <RA display device
                                      will use prescribed vertical rates for neg. & VSL RAs>
                            ELSE  IF (RA is corrective negative or VSL)
                                      THEN  CLEAR maintain rate indication;
                                            Set displayed-model-goal rate to 0 fpm;
              CLEAR clear of conflict flag;
        ELSE  CLEAR maintain rate indication;  <no RA is to be displayed this cycle>
              Set displayed-model-goal rate to 0 fpm;
              IF (an altitude-reporting threat became non-altitude-reporting during preceding RA)
                  THEN  CLEAR track drop and clear of conflict flags;
                  ELSE  IF (a threat's track was dropped during preceding RA)
                            THEN  CLEAR clear of conflict flag;
    PERFORM Load_display_and_aural_info; <Load display information to be sent to the RA display,
                                          TA display and aural annunciation subsystem.>
END Set_up_display_outputs;
```

LOW-LEVEL PSEUDOCODE BEFORE

```
PROCESS Set_up_display_outputs;

  IF (any bit in G.RA(1–10)EQ $TRUE)
    THEN  IF (G.ANYINCREASE EQ $TRUE)
              THEN  CLEAR G.ANYREVERSE, G.MAINTAIN, G.ANYCROSS;
                    IF (G.PREVINCREASE EQ $FALSE)
                      THEN  SET G.ANYCORCHANG, G.PREVINCREASE;
              ELSE  CLEAR G.PREVINCREASE;
                    IF ((G.RA(1) EQ $TRUE AND G.ZDMODEL GT P.CLMRT AND
                            G.ZDOWN GT P.CLMRT) OR (G.RA(6) EQ $TRUE AND
                            G.ZDMODEL LT P.DESRT AND G.ZDOWN LT P.DESRT))
                      THEN  SET G.MAINTAIN;
                            CLEAR G.ANYREVERSE;
                      ELSE  IF ((G.CLSTROLD EQ 4 AND G.DESTROLD EQ 4) AND
                                   (G.CLSTRONG EQ 0 OR G.DESTRONG EQ 0))
                              THEN  CLEAR G.MAINTAIN;
                    IF (G.ANYREVERSE EQ $TRUE)
                      THEN  CLEAR G.ANYCROSS;
                            CLEAR G.MAINTAIN;
                    IF (G.CORRECTIVE_CLM EQ $FALSE AND
                            G.CORRECTIVE_DES EQ $FALSE)
                      THEN  IF (G.RA(2) EQ $TRUE AND G.RA(7) EQ $TRUE)
                              THEN  SET G.MAINTAIN;
                              ELSE  CLEAR G.MAINTAIN;
                                    IF (G.CLSTRONG EQ 4 AND
                                      G.CLSTROLD EQ 8)
                                      THEN  SET G.CORRECTIVE_CLM,
                                                    G.ANYPRECOR;
                                      ELSE  IF (G.DESTRONG EQ 4 AND
                                                G.DESTROLD EQ 8 AND
                                                G.EXTALT EQ $FALSE)
                                                THEN  SET CORRECTIVE_DES,
                                                              G.ANYPRECOR;
                            G.ZDMODEL = 0;
                      ELSE  IF (G.RA(1 and 6) EQ $FALSE)
                              THEN  CLEAR G.MAINTAIN;
                                    G.ZDMODEL = 0;
          CLEAR G.ALLCLEAR;
    ELSE  CLEAR G.MAINTAIN, G.ANYINCREASE;
          G.ZDMODEL = 0;
          IF (ANYALTLOST EQ $TRUE)
            THEN  CLEAR ANYTRACKDROP, G.ALLCLEAR;
            ELSE  IF (ANYTRACKDROP EQ $TRUE)
                    THEN  CLEAR G.ALLCLEAR;
  PERFORM Load_display_and_aural_info;

END Set_up_display_outputs;
```

LOW-LEVEL PSEUDOCODE AFTER

```
PROCESS Set_up_display_outputs;

    IF (any bit in G.RA(1–10)EQ $TRUE)
        THEN  IF (G.ANYINCREASE EQ $TRUE)
                  THEN  CLEAR G.ANYREVERSE, G.MAINTAIN, G.ANYCROSS;
                        IF (G.PREVINCREASE EQ $FALSE)
                            THEN  SET G.ANYCORCHANG, G.PREVINCREASE;
                  ELSE  CLEAR G.PREVINCREASE;
                        IF ((G.RA(1) EQ $TRUE AND G.ZDMODEL GT P.CLMRT AND
                                G.ZDOWN GT P.CLMRT) OR (G.RA(6) EQ $TRUE AND
                                G.ZDMODEL LT P.DESRT AND G.ZDOWN LT P.DESRT))
                            THEN  SET G.MAINTAIN;
                                  CLEAR G.ANYREVERSE;
                            ELSE  IF ((G.CLSTROLD EQ 4 AND G.DESTROLD EQ 4) AND
                                          (G.CLSTRONG EQ 0 OR G.DESTRONG EQ 0))
                                      THEN  CLEAR G.MAINTAIN;
                        IF (G.ANYREVERSE EQ $TRUE)
                            THEN  CLEAR G.ANYCROSS;
                                  CLEAR G.MAINTAIN;
                        IF (G.CORRECTIVE_CLM EQ $FALSE AND
                                G.CORRECTIVE_DES EQ $FALSE)
                            THEN  IF (G.RA(2) EQ $TRUE AND G.RA(7) EQ $TRUE)
                                      THEN  SET G.MAINTAIN;
                                      ELSE  CLEAR G.MAINTAIN;
                                            IF (G.CLSTRONG EQ 4 AND
                                                G.CLSTROLD EQ 8 AND
                                                G.DESTRONG EQ 0)
                                                THEN  SET G.CORRECTIVE_CLM,
                                                              G.ANYPRECOR;
                                                ELSE  IF (G.DESTRONG EQ 4 AND
                                                              G.DESTROLD EQ 8 AND
                                                              G.CLSTRONG EQ 0 AND
                                                              G.EXTALT EQ $FALSE)
                                                              THEN  SET G.CORRECTIVE_DES,
                                                                            G.ANYPRECOR;
                                  G.ZDMODEL = 0;
                            ELSE  IF (G.RA(1 and 6) EQ $FALSE)
                                      THEN  CLEAR G.MAINTAIN;
                                            G.ZDMODEL = 0;
              CLEAR G.ALLCLEAR;
        ELSE  CLEAR G.MAINTAIN, G.ANYINCREASE;
              G.ZDMODEL = 0;
              IF (ANYALTLOST EQ $TRUE)
                  THEN  CLEAR ANYTRACKDROP, G.ALLCLEAR;
                  ELSE  IF (ANYTRACKDROP EQ $TRUE)
                            THEN  CLEAR G.ALLCLEAR;
    PERFORM Load_display_and_aural_info;

END Set_up_display_outputs;
```

4. Changes to State Charts

There are two transition tables that need to be updated to match the changes in the pseudocode. These are the Yes to No transition tables for the Corrective_Climb and the Corrective_Descend states on pages 125 and 127, respectively, of DO-185B Volume II. The original DO-185B form of those two transition tables are shown next, followed by the revised versions of those two tables with the changes highlighted.

Note that in addition to the changes made to match the pseudocode change, the subscript page references for the functions Climb_Goal and Descend_Goal are changed because the values printed in DO-185B are incorrect.

DO-185B, Volume II, page 125, Section 2.1.11.2, State Corrective_Climb BEFORE

Transition(s): Yes → No

Location: Advisory_Status$_{s-261}$ > Corrective_Climb$_{s-123}$

Trigger Event: Composite_RA_Evaluated_Event$_{e-C2}$

Condition:

		OR		
AND	Climb_RA_Weakened$_{m-374}$	T	T	.
	Climb_Goal$_{f-410}$ = 0 ft/min	F	T	.
	Own_Tracked_Alt_Rate$_{f-564}$ > Climb_Goal$_{f-410}$	T	.	.
	Own_Tracked_Alt_Rate$_{f-564}$ > –300 ft/min$_{(HYSTERCOR)}$	.	T	.
	Own_Tracked_Alt_Rate$_{f-564}$ ≤ 300 ft/min$_{(HYSTERCOR)}$	.	T	.
	Descend_Goal$_{f-411}$ = 0 ft/min	.	T	.
	Not_Meeting_Descend_Goal$_{m-411}$	.	.	T

Output Action: Corrective_Climb_Evaluated_Event$_{e-C2}$

Notes:

1. ***Description:*** *Transition out of corrective climb occurs for a weakened climb RA condition when either the own aircraft altitude rate exceeds a non-zero climb goal or the aircraft is considered level (i.e., within hysteresis) for a zero climb and descend goal. This transition also occurs whenever the aircraft is not meeting the current descend goal.*

2. ***Pseudocode Reference:*** *Corrective_preventive_test.*

DO-185B, Volume II, page 127, Section 2.1.11.3, State Corrective_Descend BEFORE

Transition(s): Yes → No

Location: Advisory_Status$_{s-261}$ > Corrective_Descend$_{s-229}$

Trigger Event: Corrective_Climb_Evaluated_Event$_{e-C2}$

Condition:

				OR	
AND	Descend_RA_Weakened$_{m-378}$	T	T	.	T
	Descend_Goal$_{f-411}$ = 0 ft/min	F	T	.	T
	Own_Tracked_Alt_Rate$_{f-564}$ < Descend_Goal$_{f-411}$	T	.	.	.
	Own_Tracked_Alt_Rate$_{f-564}$ < 300 ft/min$_{(HYSTERCOR)}$	.	T	.	T
	Own_Tracked_Alt_Rate$_{f-564}$ ≥ –300 ft/min$_{(HYSTERCOR)}$	.	T	.	.
	Climb_Goal$_{f-410}$ = 0 ft/min	.	T	.	.
	Not_Meeting_Climb_Goal$_{m-410}$	.	.	T	.
	Extreme_Alt_Check$_{m-378}$	.	.	.	T
	Multiple_Threats$_{m-403}$	.	.	.	F

Output Action: Corrective_Descend_Evaluated_Event$_{e-C2}$

Notes:

1. ***Description:*** *Transition out of corrective descend occurs for a weakened descend RA condition when (1) the own aircraft altitude rate is less than a non-zero descend goal, or (2) the aircraft is considered level (i.e., within hysteresis) for a zero climb and descend goal, or (3) the aircraft is not meeting the current climb goal, or (4) a descend RA is weakened to a zero climb rate goal under extreme low altitude against a single threat aircraft.*

2. ***Pseudocode Reference:*** *Corrective_preventive_test, Set_up_display_outputs, Extreme_altitude_check.*

DO-185B, Volume II, page 125, Section 2.1.11.2, State Corrective_Climb AFTER

Transition(s): Yes → No

Location: Advisory_Status$_{s\text{-}261}$ > Corrective_Climb$_{s\text{-}123}$

Trigger Event: Composite_RA_Evaluated_Event$_{e\text{-}C2}$

Condition:

		OR			
AND	Climb_RA_Weakened$_{m\text{-}374}$	T	T	.	T
	Climb_Goal$_{f\text{-}467}$ = 0 ft/min	F	T	.	T
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ > Climb_Goal$_{f\text{-}467}$	T	.	.	.
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ > –300 ft/min$_{\text{(HYSTERCOR)}}$	.	T	.	T
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ ≤ 300 ft/min$_{\text{(HYSTERCOR)}}$	.	T	.	.
	Descend_Goal$_{f\text{-}473}$ = 0 ft/min	.	T	.	.
	Not_Meeting_Descend_Goal$_{m\text{-}411}$	.	.	T	.
	Descend_Goal $_{f\text{-}473}$ < 100,000 ft/min$_{\text{(HUGE)}}$	.	.	.	T

Output Action: Corrective_Climb_Evaluated_Event$_{e\text{-}C2}$

Notes: ***1.*** ***Description:*** *Transition out of corrective climb occurs for a weakened climb RA condition when either the own aircraft altitude rate exceeds a non-zero climb goal or the aircraft is considered level (i.e., within hysteresis) for a zero climb and descend goal. This transition also occurs whenever the aircraft is not meeting the current descend goal or there is a simultaneous opposite-sense VSL due to a multiaircraft encounter.*

2. **Pseudocode Reference:** Corrective_preventive_test, Set_up_display_outputs.

DO-185B, Volume II, page 127, Section 2.1.11.3, State Corrective_Descend AFTER

Transition(s): Yes → No

Location: Advisory_Status$_{s\text{-}261}$ > Corrective_Descend$_{s\text{-}229}$

Trigger Event: Corrective_Climb_Evaluated_Event$_{e\text{-}C2}$

Condition:

		OR				
AND	Descend_RA_Weakened$_{m\text{-}378}$	T	T	.	T	T
	Descend_Goal$_{f\text{-}473}$ = 0 ft/min	F	T	.	T	T
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ < Descend_Goal$_{f\text{-}473}$	T	.	.	.	.
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ < 300 ft/min$_{(HYSTERCOR)}$	.	T	.	T	T
	Own_Tracked_Alt_Rate$_{f\text{-}564}$ ≥ −300 ft/min$_{(HYSTERCOR)}$	.	T	.	.	.
	Climb_Goal$_{f\text{-}467}$ = 0 ft/min	.	T	.	.	.
	Not_Meeting_Climb_Goal$_{m\text{-}410}$	.	.	T	.	.
	Extreme_Alt_Check$_{m\text{-}378}$	.	.	.	T	.
	Multiple_Threats$_{m\text{-}403}$	.	.	.	F	.
	Climb_Goal$_{f\text{-}467}$ > −100,000 ft/min$_{(HUGE)}$	.	.	.	.	T

Output Action: Corrective_Descend_Evaluated_Event$_{e\text{-}C2}$

Notes: **1.** ***Description:*** *Transition out of corrective descend occurs for a weakened descend RA condition when (1) the own aircraft altitude rate is less than a non-zero descend goal, or (2) the aircraft is considered level (i.e., within hysteresis) for a zero climb and descend goal, or (3) the aircraft is not meeting the current climb goal, or (4) a descend RA is weakened to a zero climb rate goal under extreme low altitude against a single threat aircraft, or (5) there is a simultaneous opposite-sense VSL due to a multiaircraft encounter.*

2. ***Pseudocode Reference:*** *Corrective_preventive_test, Set_up_display_outputs, Extreme_altitude_check.*

APPENDIX 2. FAA MODIFICATIONS TO RTCA/DO-300

1. This appendix lists FAA modifications to RTCA/DO-300, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance.*

2. Add section 2.2.11, Hybrid Surveillance Indication in the Data Link Capability Report.

> *Note: The Data Link Capability Report format specified in RTCA/DO-185B, Volume I uses bit 69 to indicate whether the TCAS unit is hybrid surveillance capable. Bit 69=0 indicates 'hybrid surveillance not fitted.' Bit 69=1 indicates 'hybrid surveillance fitted.'*
>
> *There are five TCAS-related bits in the Data Link Capability Report (Bits 48 and 69-72). These five bits are set or cleared as appropriate by the TCAS unit and sent to the Mode S transponder for downlink to a Mode S ground sensor. Execution of the default RTCA/DO-185B logic will clear bit 69, meaning that in order to set bit 69, an implementer must modify the TCAS logic so that bit 69 will be set to one when the logic is executed. For details, see RTCA/DO-185B Volume II, "Interface: Data_Link_Capability_Report," and RTCA/DO-185B Attachment A, "PROCESS Send_owndata_to_trans."*
>
> *If hybrid surveillance is implemented in an RTCA/DO-185B capable TCAS unit, then the implementer should ensure that TCAS sets bit 69=1 in the five bits sent to the transponder.*

3. Section 2.4.2.6, Test 1, Success Criteria, Intruder 1. **Update** Success Criteria with the text highlighted in gray, to clarify that it verifies the intended requirement for an acquisition interrogation.

> Intruder 1
> Verify that the acquisition interrogations have RL=0.
> No more than two interrogations spaced by 60 sec of intruder aircraft from T=10 to T=114 are performed against this intruder.
> All interrogations after T=10 are crosslink interrogations. UF=0, RL=1, and BDS=5.
> Only one interrogation every 10 sec of intruder aircraft from T=115 to T=200.
> After T=10 Surveillance Mode always marked as not Normal (Reduced).
> Verify that the passive data is provided to the CAS Logic/Displays by at least T=10.

4. Section 2.4.2.7, Test 1, Intruder Aircraft #2. **Update** the altitude and altitude rate values with the values highlighted in gray, to allow the altitude to cleanly pass through the altitude volume check while still meeting the success criteria/expected results. This change produces a smooth altitude rate, avoiding rate estimation errors due to quantization, to test the transition altitude criteria.

Test 1 – Passive to Active, Intruder Aircraft #2

Altitude = 19,500 ft at T=0
Altitude Rate = -1,500 FPM
Range = 2.9 NM
Relative Speed = 0 kt
At T=75 the intruder is terminated.

5. Section 2.4.2.7, Test 1, Intruder Aircraft #3. **Update** the altitude and altitude rate values with the values highlighted in gray, to allow the altitude to cleanly pass through the altitude volume check while still meeting the success criteria/expected results. This change produces a smooth altitude rate, avoiding rate estimation errors due to quantization, to test the transition altitude criteria.

Test 1 – Passive to Active, Intruder Aircraft #3

Altitude = 4,500 ft at T=0
Altitude Rate = 1,500 FPM
Range = 2.9 NM
Relative Speed = 0 kt
At T=75 the intruder is terminated

6. Section 2.4.2.7, Test 3, Intruder Aircraft #7. **Remove** relative speed changes at T=20. Change the relative speed with value highlighted in gray. Add the range jump for active surveillance highlighted in gray. The current test has too large of an acceleration at T=20 (from 0kt to -180kt) which may result in a coast transition and drop rather than a revalidation fail transition at T=40.

Test 3 – Passive to Active Abnormal Conditions, Intruder Aircraft #7

Altitude = 17,000 ft at T=0
Altitude Rate = 0 FPM at T=0
Range = 7.0 NM
Relative Speed = -144 kt at T=0
At T = 20 the active range jumps to 10 NM (moving the active range causes the active data to fail the revalidation).
At T=120 the intruder is terminated.

7. Section 2.4.2.7, Test 3, Success Criteria, Intruder 1. **Update** the maximum value of T when the altitude reporting status is changed, with the value highlighted in gray, to correct the timing issue while still meeting the success criteria/expected results. The altitude reporting status time is based on RTCA/DO-185A requirements.

Test 3 – Passive to Active Abnormal Conditions, Success Criteria, Intruder 1

Verify that the track is under passive surveillance.
By T=26, UF=0 and RL=0 for all interrogations.
The continuous track is maintained.
The altitude reporting status is changed between T=20 and T=33.

After T=26 the track is updated using active data and is non-altitude reporting.

8. Section 2.4.2.7, Test 3, Success Criteria, Intruder 7. **Update** the last verify statement with the text highlighted in gray, to clearly identify that the intruder's new track has a different track number than the old track.

Test 3 – Passive to Active Abnormal Conditions, Success Criteria, Intruder 7

Verify that the intruder is tracked using passive data from T=10 to T=20.

At approximately T=40 the intruder qualifies for revalidation based on the passive data having a closure rate and satisfies the 2nd condition (range tau) specified in §2.2.6.1.5. The revalidation attempt fails because the active range position does not follow the passive range position. As a result of the failed revalidation, the track must transition to active surveillance within 3 sec of the failed revalidation attempt, which must occur by T=46.

Verify that after the failed validation attempt but before the track becomes active that RFLG is set false. Surveillance Mode is NOT set to Normal until a new track based on active data is presented to the CAS logic.
Verify that only one track for this intruder (with the same Mode S address) is provided to the CAS logic for the entire test.

Verify that the new active track has a different track number than the passive track or that some other mechanism is employed to guarantee that the CAS logic treats the active track as a NEW track.

9. Section 2.4.2.7, Test 4. **Correct** the expected result with the text highlighted in gray, to identify the type of surveillance (passive) that was intended, but incorrectly identified as active.

Test 4 – Active to Passive Abnormal Conditions

The equipment manufacturer must design a test or analysis which demonstrates that the requirement in §2.2.7.1.2 that an aircraft not be a threat before transitioning to passive surveillance has been implemented. Because this is a precautionary requirement, test of this may not be possible at the "black box" level.

10. Section 2.4.2.10. Update the expected Planar Range, Slant Range and Bearing results for Intruder Aircraft No. 68 in Table 2, with the values highlighted in gray, because they were all incorrectly entered into the released version of the table.

Table 2. Airborne Position Decoding Values with Range and Bearing

Intruder Aircraft No.	Own Latitude (deg)	Own Longitude (deg)	Intruder Latitude (deg)	Intruder Longitude (deg)	Intruder Altitude (ft)	Planar Range (NM)	Slant Range (NM)	Bearing (deg)
68	-5	6.25	-5.1	6.25	11000	**5.9742**	**5.9766**	**180.000**

11. Section 2.4.2.11, Test 1, Success Criteria, Intruder 1. **Update** the Success Criteria with the text highlighted in gray, to clarify that it verifies the intended requirement for an acquisition interrogation.

> Intruder 1
> Verify that the acquisition interrogations have RL=0.
> No more than one interrogation of intruder aircraft from T=10 to T=59.
> At least by T=65 the intruder is interrogated once every 5 sec indicating a transition to active surveillance. Verify that the track is not dropped.

12. Section 3.3. Replace the second note of modification "a" with the following note to provide the most stressful environment to the hybrid surveillance and to keep RTCA/DO-300 in line with RTCA/DO-185B.

> *Note: Previous hybrid surveillance flights have shown that the New York City area provides the stressful environment necessary for proper evaluation of TCAS Mode S Hybrid surveillance. The most effective flight path has proven to be a 5 NM orbit over the John F. Kennedy Terminal Area. Other locations would be suitable as long as they meet the requirements specified here and in Ref. A.*