



Aviation Communication and Surveillance Systems

# TCAS II, TCAS 2000, TCAS 3000, TCAS 3000SP, and T<sup>2</sup>CAS (Change 7.1) PILOT'S GUIDE SUPPLEMENT

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## Record of Revisions

Rev	Date	Authorization	Description of Change
-	30 Oct 2009	ECR012042	Initial Release
01	15 Jan 2012	ECR 013640	Add TCAS 3000, TCAS 3000SP and T2CAS.

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## 1 INTRODUCTION

### 1.1 Purpose

This TCAS II, TCAS 2000, TCAS 3000, TCAS 3000SP, and T2CAS (Change 7.1) Pilot's Guide Supplement is mandatory reading for TCAS II pilot training. It is intended to give pilots an understanding of the new standards and to improve a pilot's response to resolution advisories (RAs).

**NOTE:** Refer to the complete TCAS II, TCAS 2000, TCAS 3000, TCAS 3000SP, and T2CAS Pilot's Guides to read a high level description of the system, its functions/application, and its functionality in the aircraft flight deck.

This document is a supplement to the ACSS Pilot's Guides identified in the list below.

**Table 1: ACSS Pilot's Guides Impacted by this Supplement**

Document Number	Title
8000264-001	T <sup>2</sup> CAS Pilot's Guide
8000723-001	MILITARY TCAS/ACAS II (Change 7) PILOT'S GUIDE
8006773-001	TCAS 2000/3000 Pilots Guide
8007175-001	SafeRoute Pilot's Guide (Class 3)
8007497-001	MILITARY TCAS/ACAS II (Change 7) Pilot's Guide (Traffic Collision and Avoidance System) TCAS 2000/3000 and Mode S/IFF
8007835-001	SafeRoute Pilot's Guide (Class 2) for Release 2.5
A28-1146-070	TCAS II Pilot's Guide
C28-3841-005-00	TCAS/ACAS II (Change 7) Pilots Guide

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## 2 DETAILED EXPLANATION

### 2.1 Overview

This document gives supplemental training information to help pilots understand recent refinements made to the TCAS II system. The new standards, known as TCAS II version 7.1, are intended to improve pilot's response to resolution advisories (RAs) generated by the TCAS II system.

TCAS II Change 7.1, as implemented by ACSS, includes two modifications that have particular significance for the pilot. These are:

- Reversal Logic Enhancements
- "Adjust Vertical Speed" Enhancement.

In addition to describing these two modifications, this supplement also describes a change to the "green arc on weakening" which can occur in extreme low altitude situations.

**Table 2: RA References in ACSS Pilot's Guide**

Document Number	Title	Rev	Relevant Sections
C28-3841-005-00	TCAS/ACAS II (Change 7) Pilots Guide	Rev - (Sep 99)	Section 6 – Flight Crew Response Section 7 – TA and RA Responses
8006773-001	TCAS 2000/3000 Pilots Guide	Rev 01 (Aug 07)	Section 6 – Flight Crew Response Section 7 – TA and RA Responses
8000264-001	T <sup>2</sup> CAS Pilot's Guide	Rev 04 (Jun 08)	Section 6 – Flight Crew Response Section 7 – TA and RA Responses
8007175-001	SafeRoute Pilot's Guide (Class 3)	Rev C (Sep 10)	Section 5 – Flight Crew Response to TCAS Advisories Section 7 – TA and RA Responses
8007835-001	SafeRoute Pilot's Guide (Class 2) for Release 2.5	Rev - (Sep 08)	Section 4 – Flight Crew Response to TCAS Advisories Section 7 – TA and RA Responses
8000723-001	MILITARY TCAS/ACAS II (Change 7) PILOT'S GUIDE	TBD	TBD
8007497-001	MILITARY TCAS/ACAS II (Change 7) Pilot's Guide (Traffic Collision and Avoidance System) TCAS 2000/3000 and Mode S/IFF	Rev - (Dec 07)	Section 6 – Flight Crew Responsibilities Section 7 – TA and RA Responses

## 2.2 Reversal Logic Enhancement

Change 7.1 incorporates enhancements to the reversal logic of TCAS II Change 7.0. The changes have an effect on pilot responses to situations involving encounters with an unequipped aircraft as well as TCAS-TCAS encounters.

With Change 7.1, TCAS II monitors RA compliance by monitoring the aircraft's vertical rate and uses two mechanisms to make sure that reversal RAs are triggered when necessary.

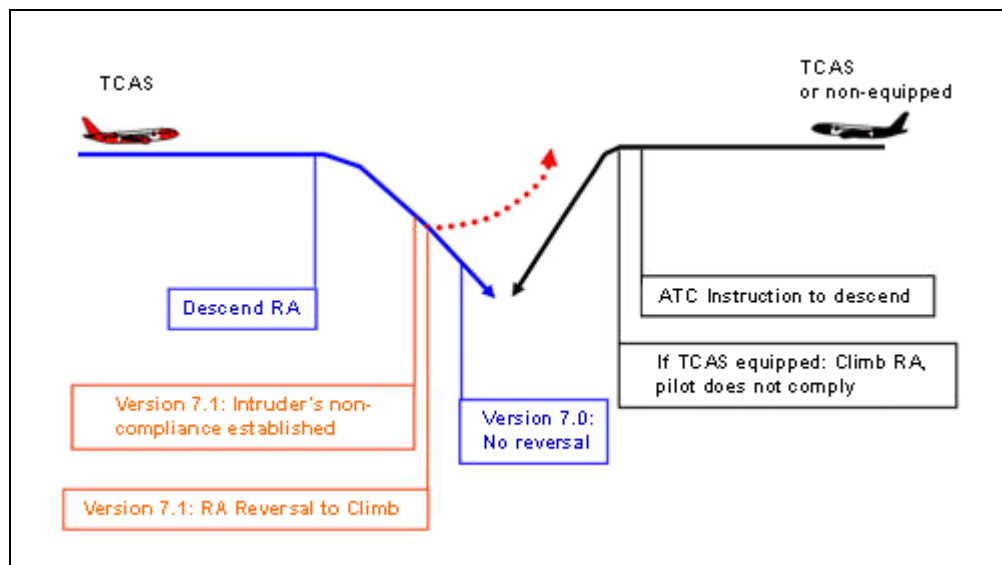
1. The system can detect if the flight crew is not responding correctly to an RA. As shown in Figure 2-1, this can result in two co-altitude aircraft climbing or descending at similar vertical rates. In this situation, TCAS II circumvents the "100 ft box" rule and allows a reversal RA for aircraft closer than 100ft vertically.
2. The enhanced TCAS II includes a prediction of the vertical separation at the closest point of approach, based on current vertical speeds. If the system detects that separation is close to or below the acceptable minimum, new logic relaxes the conditions for reversing the RA and lets it occur earlier than with the current TCAS II version 7.0.

Figure 2-1 shows two possible situations in which the new reversal logic can improve the outcome:

1. Own aircraft is obeying an RA to descend AND an unequipped intruder aircraft is descending in compliance with an ATC instruction.
2. Own aircraft is obeying an RA to descend AND a TCAS-equipped intruder aircraft is descending contrary to an RA telling the pilot to climb.

TCAS II with Change 7.1 does not trigger reversal RAs too early in the encounter. This leaves time for the initial RAs to be effective. Also, the system does not trigger RAs too close to the predicted closest point of approach in order to avoid unnecessary RAs.

For information on reversal RAs, refer to Table 2 on Page 2 for a list of applicable TCAS II Pilot's Guides.



**Figure 2-1: RA Reversal to Climb**



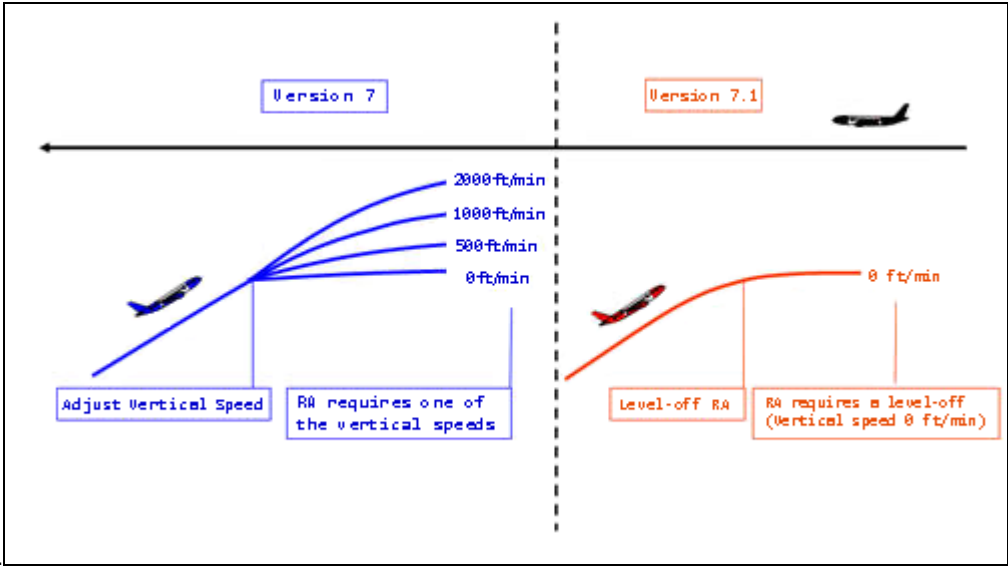
**2.3 “Adjust Vertical Speed” Aural Alert Enhancement**

Operational monitoring shows that pilots do not always respond correctly to the “Adjust Vertical Speed, Adjust” (AVSA) RAs.

The AVSA RA tells the pilot to reduce vertical speed to 2000, 1000, 500, or 0 feet/min. If a pilot increases vertical speed instead of reducing it, the situation could become worse.

With Change 7.1, a single aural “Level-off” RA that recommends a reduction in vertical rate to 0 fpm, replaces the multiple “Adjust Vertical Speed, Adjust” RAs. This solution is straightforward and the associated maneuver corresponds to the standard maneuver already performed in critical situations.

This solution replaces eight “Adjust Vertical Speed” RAs with two “Level-Off” RAs (one upwards, one downwards). The effect is shown in Figure 2-2 below. In this situation, the TCAS II system issues “Level-Off” RA to the climbing aircraft.



**Figure 2-2: RA Level Off**

This modification has the added benefit of simplifying the list of RAs posted by TCAS II, because RAs requesting a reduction of the vertical rate to 500, 1,000 or 2,000 feet/min are now unnecessary. In addition, this replacement also simplifies the TCAS procedure and training.

A corresponding visual enhancement has an effect on the RA display. The display output shows a green arc when an up sense and down sense are received at the same time (for example, when a single-threat encounter changes to a multi-threat encounter with threats above and below). See Figure 2-5 on 7.

## 2.3.1 Response to a Weakening RA

### 2.3.1.1 Response to Do Not Climb RA

See Figure 2-3.

**AURAL**      *LEVEL OFF, LEVEL OFF*

**VISUAL**      The VSI indicates the prohibited vertical speed by a red arc. The goal is to make the aircraft smoothly attain the recommended vertical speed indicated by the green arc.

**RESPONSE**      Promptly and smoothly reduce vertical speed to that shown on the VSI in green.



Figure 2-3: Level Off RA – Target Above

**NOTE:** In this example, the traffic symbols have been omitted for clarity. All TA, RA, proximate, and no bearing traffic are displayed during an RA.

### 2.3.1.2 Response to Do Not Descend RA

See Figure 2-4.

**AURAL**      *LEVEL OFF, LEVEL OFF*

**VISUAL**      The VSI indicates the prohibited vertical speed by a red arc. The goal is to make the aircraft smoothly attain the recommended vertical speed indicated by the green arc.

**RESPONSE**      Promptly and smoothly reduce vertical speed to that shown on the VSI in green.

**NOTE:**      In this example, the traffic symbols have been omitted for clarity. All TA, RA, proximate, and no bearing traffic are displayed during an RA.



Figure 2-4: Level Off RA – Target Below

### 2.3.1.3 Response to Maintain Level Flight RA

See Figure 2-5.

**AURAL**      *LEVEL OFF, LEVEL OFF*

**VISUAL**      The VSI indicates the prohibited vertical speed by a red arc. The goal is to make the aircraft smoothly attain the recommended vertical speed indicated by the green arc.

**RESPONSE**      Promptly and smoothly reduce vertical speed to that shown on the VSI in green.



**Figure 2-5: Level Off RA – Targets Above and Below**

**NOTE:** In this example, the traffic symbols have been omitted for clarity. All TA, RA, proximate, and no bearing traffic are displayed during an RA.

**2.4 “Green arc on weakening” RA**

In some very low altitude encounters, the “green arc on weakening” RAs must be removed in a descend RA scenario. In that same scenario, the aural alert changes from “Adjust Vertical Speed, Adjust” to “Monitor Vertical Speed”.

Before TCAS II Change 7.1, an aircraft that was descending in compliance with a “DESCEND” RA must reduce its vertical speed in response to an “ADJUST VERTICAL SPEED” RA at approximately 1000 AGL.

With the Change 7.1 modification, the RA issued to reduce vertical speed changes to “MONITOR VERTICAL SPEED” and a vertical speed command is issued to prevent a climb.

**2.4.1 Response to Preventive RA**

See Figure 2-6.

**AURAL**            *MONITOR VERTICAL SPEED– MONITOR VERTICAL SPEED*

**VISUAL**            Current vertical speed is not within the prohibited vertical speed shown on the VSI.

**RESPONSE**        The pilot must keep the vertical speed out of the RED arc in the VSI display.

**NOTE:**            During a Preventive advisory, if the vertical speed is allowed to enter the RED arc, a Corrective Resolution Advisory may result.



**Figure 2-6: Preventive RA Example**

**NOTE:**            In this example, the traffic symbols have been omitted for clarity. All TA, RA, proximate, and no bearing traffic are displayed during an RA.

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