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CHAPTER 15 – TRAFFIC COLLISION AVOIDANCE SYSTEM (TCAS)

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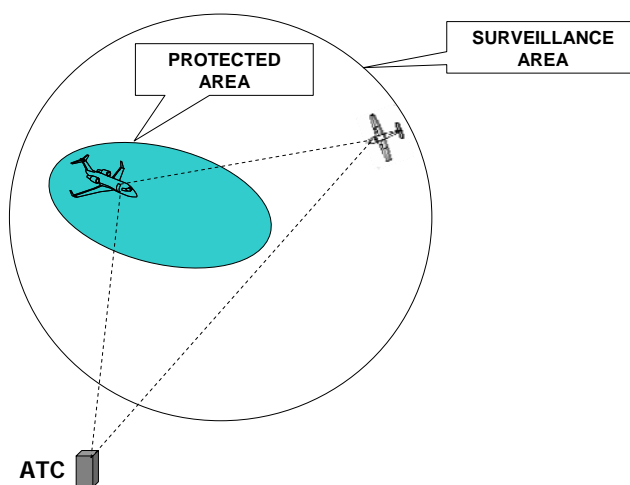
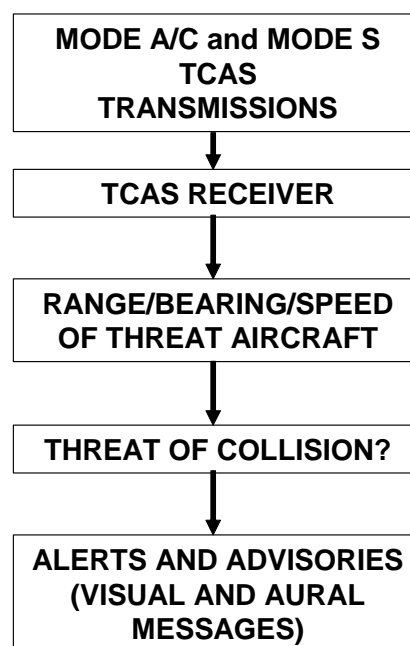
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CHAPTER 15: TRAFFIC COLLISION AVOIDANCE SYSTEM

SUMMARY OF TCAS

TCAS is an airborne system that identifies and displays potential collision threats from nearby aircraft. TCAS interrogates Mode A/C and Mode S transponders in nearby aircraft and uses the replies to recognize threats. TCAS protects a volume of airspace around the aircraft and when the system predicts a penetration of the protected airspace, visual and aural advisories are provided. The prediction is based on an analysis of the intruding aircraft's relative position and rate of closure derived from the transponder replies.



The system maintains surveillance within a sphere determined by the transmit power and receiver sensitivity of the TCAS.

Within the surveillance area is an egg-shaped volume of airspace around the aircraft which TCAS protects. Its volume and shape depend on the speed and path of both protected and intruder aircraft.

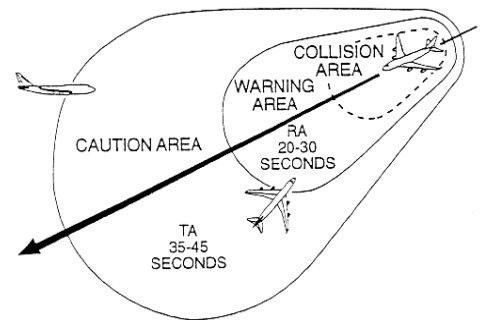
The edge of the protected area is defined by the minimum time the flight crew needs to discern a collision threat and take evasive action.

TCAS ADVISORIES

If an intruder penetrates the protected area, two types of advisories are provided -TRAFFIC ALERTS (TA) and RESOLUTION ADVISORIES (RA) :

TRAFFIC ALERTS provide the flight crew with the relative bearing and distance to intruding aircraft that are approximately 40 seconds from the closest point of approach. This alert provides guidance to the flight crew to aid in visual acquiring the intruding aircraft and no manoeuvres are commanded,

RESOLUTION ADVISORIES will provide threat resolution information in the form of a vertical manoeuvre (corrective) or restricted vertical speed range (preventive) that will increase aircraft separation when the threat aircraft is within about 25 seconds from the closest point of approach.

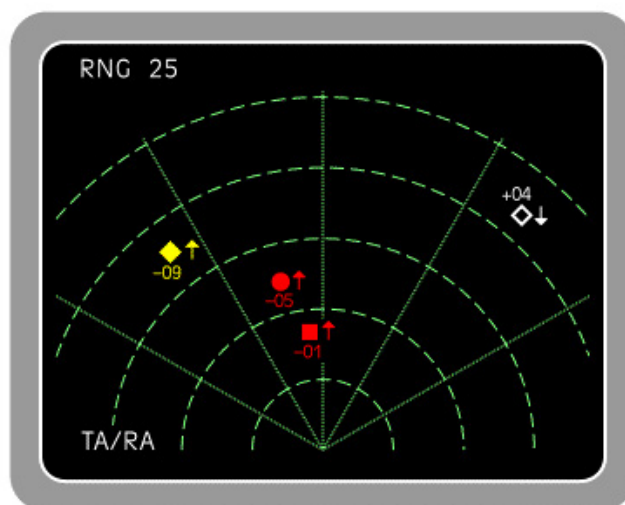


TYPES OF DISPLAYS

There are a variety of ways of displaying TCAS generated alerts and advisories. Traffic displays indicate the relative position of transponder-equipped aircraft around the TCAS equipped aircraft. Resolution advisory displays show the appropriate vertical manoeuvre or restricted vertical speed range to avoid a threat.

The following types of display may be used;

1. Combined Weather Radar and TCAS Traffic Display



2. TCAS Traffic Display as an option on the EFIS ND (Navigation Display)



3. Combined VSI and TCAS Display - which can show both Traffic Alerts and Resolution Advisories.



Aircraft that are within the Warning Area (20-30 secs) appear as red square symbols and resolution advisories that are colour coded are generated behind the VSI scale:

RED: The vertical speed region to be avoided.

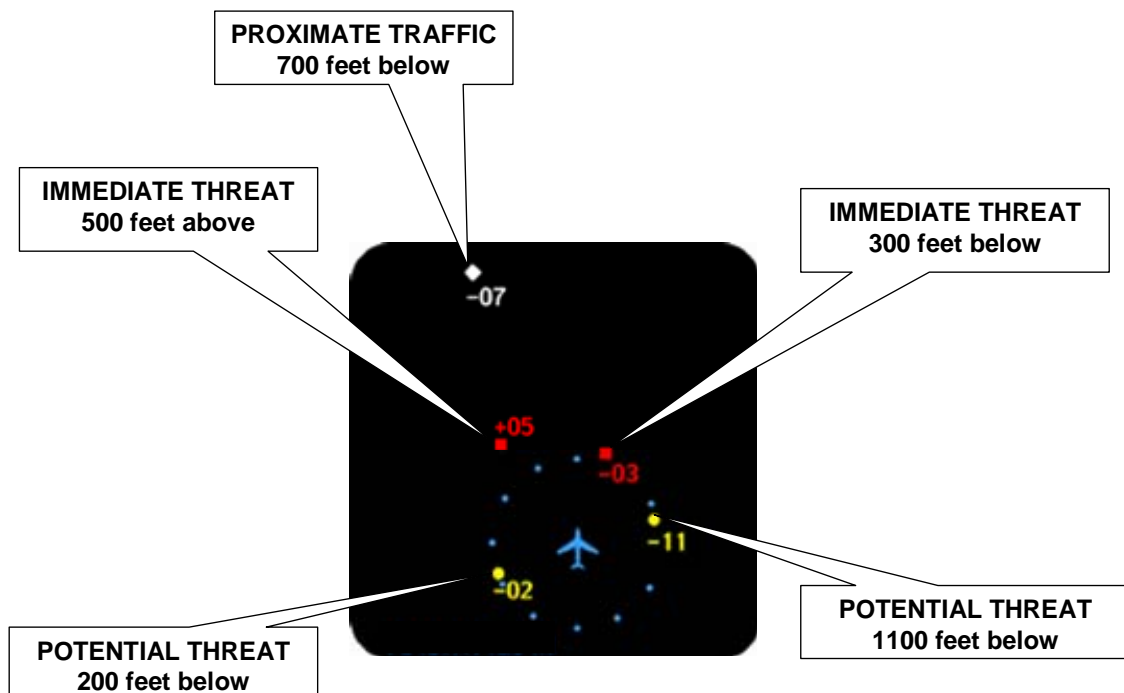
GREEN: The vertical speed region to "fly to", if a change of vertical speed is required.

The resolution advisory in this display indicates that the aircraft should climb to avoid the traffic that is ahead and 300 feet below.



TRAFFIC SYMBOLS

1. WHITE OPEN DIAMOND - Other Traffic i.e. no threat
Other aircraft is within ± 2700 feet and within the selected range.
2. WHITE OR BLUE SOLID DIAMOND - Proximate Traffic Other aircraft is within ± 1200 feet and within 6nm.
3. YELLOW or AMBER SOLID CIRCLE - Traffic Alert i.e. Potential Threat.
Intruder will penetrate the host aircraft's protected airspace. There is enough time for the crew to visually acquire the traffic.
4. RED SOLID SQUARE - Resolution Advisories i.e. immediate threat.
Evasive action will be required. Follow the required vertical manoeuvre or restricted vertical speed range.



THE PRINCIPLE OF TCAS

TCAS uses secondary radar principles. It interrogates Mode A/C or Mode S transponders on other aircraft and determines from the replies the range, altitude and approximate bearing of intruder aircraft. From this information, TCAS computes the collision hazard each aircraft represents.

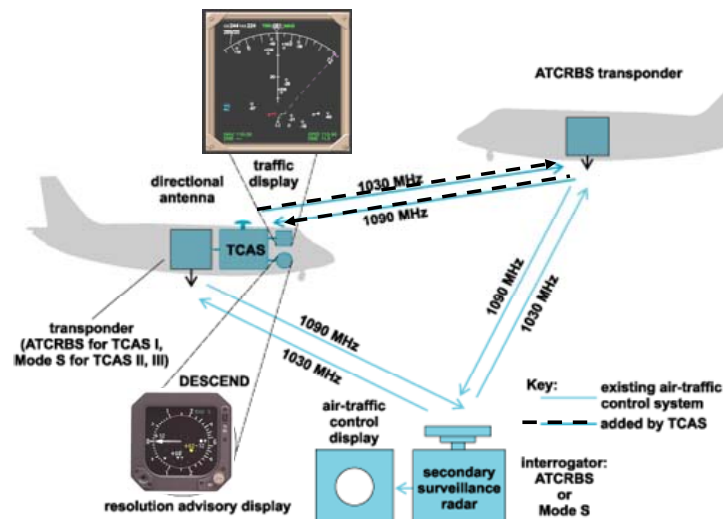
Transponder modes determine the pulse format of interrogations which initiate transponder replies. The secondary surveillance radar (SSR) system using Mode A/C interrogates the aircraft about its identity and altitude by transmitting two sets of pulses. The first set of pulses spaced 8 microseconds apart is called Mode A and interrogates for identity, The second set of pulses called Mode C spaced 21 microseconds apart interrogates for altitude. The airborne transponder responds to the interrogations by encoding identity or altitude, depending upon mode and transmits a set of reply signals in the form of a group of pulses which is received, decoded and displayed at the ATC ground station.

Mode S used by TCAS enhances the operation of the Mode A/C system by adding a data link capability, discrete interrogation capability and performance improvements. Mode S data link capabilities include aircraft-to-aircraft information exchange as well as air-to-ground and ground-to-air. The aircraft-to-aircraft capability of Mode S permits TCAS aircraft to coordinate evasive action in a potential collision situation. TCAS generates resolution advisories without aircraft-to-aircraft coordination for threat aircraft equipped with operating Mode A/C transponders. Only traffic alerts can be generated for aircraft not providing altitude information i.e. with inoperative Mode C. TCAS provides no advice or warnings of aircraft without operating Mode A/C or Mode S transponders.

TCAS OPERATION

- The TCAS equipped aircraft regularly transmits a Mode S interrogating signal that identifies the transmitting aircraft.
- Both TCAS (Mode S) and SSR (Mode A/C) aircraft will respond and the TCAS aircraft will form a roll call of aircraft in the vicinity.
- The TCAS installation includes a directional aerial using which the bearing of responding aircraft can be measured.
- The range of responding aircraft is measured by noting the round trip time for interrogation and reply, using the known speed of radio waves.
- The altitude of intruding aircraft is detected by TCAS from the Mode C replies.

- TCAS then generates appropriate visual/aural resolution advisories and traffic alerts. Each aircraft within the surveillance area is processed individually.
- If the intruder is TCAS equipped, a coordinated evasive procedure is generated via Mode S.



TCAS AUDIO MESSAGES

When an intruding aircraft is detected, the flight crew will be notified visually on the display screen of the potential threat. There will also be an aural annunciation of "TRAFFIC TRAFFIC" if the aircraft poses a threat. If evasive action later becomes necessary, the traffic alert is followed by a resolution advisory which will provide a corrective action that could include an aural annunciation of "CLIMB, CLIMB" or "DESCEND, DESCEND". When the threat clears, the display will show the now non-threatening target and advise aurally "CLEAR of TRAFFIC, CLEAR of TRAFFIC"

The following is a list of TCAS audio messages:

- TRAFFIC / TRAFFIC/ TRAFFIC
- CLIMB / CLIMB / CLIMB
- CLIMB CROSSING CLIMB/ CLIMB CROSSING CLIMB
- REDUCE CLIMB / REDUCE CLIMB
- DESCEND / DESCEND / DESCEND
- DESCEND CROSSING DESCEND / DESCEND CROSSING DESCEND
- REDUCE DESCEND / REDUCE DESCEND
- MONITOR VERTICAL SPEED / MONITOR VERTICAL SPEED

- INCREASE CLIMB / INCREASE CLIMB
- INCREASE DESCENT / INCREASE DESCENT
- CLIMB-CLIMB NOW / CLIMB-CLIMB NOW
- DESCEND-DESCEND NOW / DESCEND-DESCEND NOW
- CLEAR OF CONFLICT

TCAS CONTROL PANEL



The panel controls the TCAS and associated transponder(s).

The functions of the switches are as follows:

- **TEST** – Activates the TCAS system test sequence. Test indications appear on displays but without transmissions taking place
- **STBY** - On but not transmitting, Note that although ATC procedures may require that transponders are left in STANDBY on the ground, the radiation level of an operating transponder poses no danger to personnel in the vicinity, unlike weather radar.
- **XPDR** - Transponder on but TCAS in standby.
- **TA** - TA only. i.e. Resolution Advisories are inhibited.
- **TA/ RA** - Full transponder / TCAS operations
- **ABOVE** - Surveillance + 9900 feet to -2700 feet relative to our aircraft.
- **N** - Surveillance + 2700 feet to -2700 feet relative to our aircraft.
- **BELOW** - Surveillance + 2700 to -9900 feet relative to our aircraft.
- **ABS REL** – Target aircraft altitude is shown as absolute (amsl) or relative to present altitude
- **FAIL** -Indicates failure of transponder, control panel, antennas or air data system.

- **IDENT** - When IDENT is pressed a further pulse is transmitted after the second framing pulse for about 20 seconds. This causes the response on the controller's screen to have a distinctive form so allowing the aircraft that has been instructed to SQUAWK IDENT to be readily identified.
- **L R** - Selects LEFT or RIGHT transponder and air data computer (maybe marked #1 or #2).

ACAS I, ACAS II AND ACAS III

The TCAS equipment described in this chapter is TCAS II. It may also be described as ACAS II (Airborne Collision Avoidance System). TCAS II or ACAS II is the current generation equipment fitted to airline aircraft, providing collision avoidance manoeuvre advice in the vertical plane. ACAS I is a low cost system for smaller aircraft. It is passive and relies upon the intruder aircraft's transponder replies to ATS interrogations. ACAS III which is under development will be able to provide resolution advisories in the horizontal plane, in addition to the vertical advisories provided by ACAS II.

It should be noted that ACAS (TCAS) cannot advise of threats from aircraft that are not fitted with, or are not operating, SSR.

WORKSHEET - TRAFFIC COLLISION AVOIDANCE SYSTEMS

1. With reference to TCAS operations, ATC expects:
 - a) pilots to take avoiding action as soon as a Traffic Advisory is generated and before visual contact is made with the intruding aircraft.
 - b) that when a Resolution Advisory and an ATC instruction are received simultaneously by a crew, action will be taken in accordance with the ATC instruction.
 - c) pilots to respond immediately to a Resolution Advisory but avoiding action should be the minimum necessary for conflict resolution.
 - d) that pilots will only manoeuvre in a direction opposite to that given in a Resolution Advisory in day, visual met. conditions.
2. The surveillance area covered by TCAS is an egg-shaped volume with a maximum forward distance of about:
 - a) 5 nm
 - b) 10 nm
 - c) 30 nm
 - d) 120 nm
3. TCAS equipment has only a limited capability of accurately resolving the bearing, heading and vertical rate of an intruder. Which can be accurately resolved?
 - a) Only bearing
 - b) Only heading
 - c) Only vertical rate
 - d) None
4. For TCAS to generate a Resolution Advisory, the minimum equipment level of the intruder aircraft is an active _ _ _ _ transponder.
 - a) Mode A
 - b) Mode A/C
 - c) Mode S
 - d) TCAS

5. Which of the following statements is correct?
- a) Pilots are strongly advised to always anticipate the avoidance manoeuvre that will be determined by TCAS in order that the required change in pitch altitude can be made prior to the generation of the Resolution Advisory.
 - b) Nuisance advisories may occur as a result of deficiencies in the equipment or data with which it is provided.
 - c) Clearance should be obtained from ATC before following a Resolution Advisory that requires a deviation from an approved flight path.
 - d) Manoeuvres should never be made in a direction opposite to that given in an RA.
6. The annunciator message "TRAFFIC TRAFFIC TRAFFIC" will be heard as the symbol for the intruder aircraft changes from :
- (a) a solid diamond to a yellow circle
 - (b) a yellow circle to a red square
 - (c) an open diamond to a solid diamond
 - (d) a solid or open diamond to a red square
7. The aural message "TRAFFIC TRAFFIC" is heard. The crew should:
- a) determine from the TCAS display the relative bearing, relative height and range of the intruder and commence an appropriate manoeuvre without delay.
 - b) initiate a visual search for the intruder.
 - c) commence an immediate evasive manoeuvre, in the vertical plane only to avoid antenna shielding.
 - d) turn left or right as appropriate but delay vertical manoeuvres until a resolution advisory is generated.
8. The TCAS annunciator message "CLIMB-CLIMB NOW" will be heard instead of "CLIMB CLIMB CLIMB" when:
- a) a previously notified manoeuvre should now be commenced.
 - b) due to the urgency of the situation, a more rapid entry into a climb manoeuvre is required.
 - c) due to the intruding aircraft's manoeuvring, a more rapid rate of climb is required.
 - d) reversal of vertical speed is required for adequate separation.

9. In the event of a simultaneous GPWS warning and the entry of an intruder aircraft into the TCAS warning area:-
- the TCAS aural message will be inhibited.
 - both GPWS and TCAS aural messages will be inhibited.
 - GPWS and TCAS warnings will be heard and the correct response is at the discretion of the pilot.
 - the TCAS warning takes precedence over the GPWS warning
10. An intruder aircraft operating a transponder with Mode A only which is entering the warning area (20-30 seconds to the collision area) will appear as:-
- a red square symbol without relative altitude information.
 - a red square symbol with a vertical motion arrow but no relative altitude figures.
 - an amber circle symbol without relative altitude information
 - an amber circle symbol with a vertical motion arrow but no relative altitude figures.
11. Proximate traffic is displayed as a:
- yellow or amber solid circle
 - white or cyan open diamond
 - solid red square
 - white or cyan solid diamond
12. Which of the following are true statements with reference to a Traffic Advisory?
- It is a display indication recommending a manoeuvre to increase vertical separation relative to an intruding aircraft.
 - Traffic advisory airspace extends to a distance corresponding to about 40 – 45 seconds of the closing speed.
 - Traffic advisory airspace extends to 1200 feet above and below the aircraft.
- All are true
 - Only (i) and (ii) are true
 - Only (ii) is true
 - Only (i) and (iii) are true
13. Response to an RA _____
- should only be made when preceded by a TA
 - should be rapidly made after confirmation of the position of the intruder by visual sighting
 - should first be cleared by ATC if the aircraft is in controlled airspace
 - should be immediate.

14. On receiving a TA, flight crew should attempt to sight the potential threat. They should also _____
- a) be alert to the possibility of receiving a RA
 - b) commence an evasive manoeuvre without waiting for a RA
 - c) contact ATC to seek approval for any deviation from the clearance previously given.
 - d) try to establish radio contact with the intruder to coordinate any evasive manoeuvre.
15. For TCAS to generate a RA _____
- a) both intruder and subject aircraft must have height encoding altimeters with 1013.2 hPa set on the sub-scale.
 - b) the intruder aircraft must have active Mode C but not necessarily the subject aircraft.
 - c) the subject aircraft only must have an active altitude reporting transponder
 - d) both intruder and subject aircraft must have active Mode C transponders.
16. A nuisance RA _____
- a) may be the result of deficiencies in the equipment or data with which it is provided.
 - b) is most likely to occur at high altitude where many aircraft follow identical routes.
 - c) should always be treated as genuine.
 - d) should always be ignored.
17. If pilots simultaneously receive an instruction to manoeuvre from ATC and a RA which conflict::
- a) the ATC instruction should be followed as ATC will be aware of the position of the other aircraft
 - b) the advice given by ACAS should be followed
 - c) no action should be taken until clarification has been sought from ATC.
 - d) the intruder aircraft should be sighted before deciding which action to take.

18. The first RA received by an aircraft currently climbing advises the pilot to descend. This is an example of a _____
- a) preventive RA
 - b) corrective RA
 - c) negative RA
 - d) reversed sense RA
19. TCAS generates TAs and RAs. Which of the following statements is true?
- a) TAs are always followed by RAs
 - b) RAs are always preceded by TAs
 - c) RAs are always followed by TAs
 - d) a RA may not be preceded by a TA
20. An aircraft which is the subject of a RA is termed _____
- a) an intruder
 - b) a nuisance aircraft
 - c) a potential threat
 - d) an established threat.