



# AIRBORNE COLLISION AVOIDANCE SYSTEM - TCAS

## 1. Introduction

The TCAS or Traffic alert and Collision Avoidance System is a system designed to reduce the incidence of mid-air collisions with other aircraft.

The TCAS is independent of air traffic control and flight navigation instruments.

## 2. ICAO regulation

### 2.1. Definition and rules

Airborne collision avoidance system or ACAS is an aircraft system based on secondary surveillance radar (SSR) transponder signals which operate independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders.

The International Civil Aviation Organization prescribes that an Airborne Collision Avoidance System (ACAS) must be installed and operational for all aircraft heavier than 5700 Kg and all aircraft authorized to transport more than 19 passengers.

### 2.2. Types of ACAS

- **ACAS I** gives Traffic Advisories (TAs) but does not recommend any manoeuvres. The only implementation of the ACAS I concept is TCAS I. These equipments are limited to interoperability and interference issues with ACAS II.
- **ACAS II** gives Traffic Advisories (TAs) and Resolution Advisories (RAs) in the vertical sense (direction). The only implementations of the ACAS II concept are TCAS II Version 7.0 and Version 7.1.
- **ACAS III** gives TAs and RAs in vertical and/or horizontal directions. ICAO SARPs for ACAS III have not been developed. Currently, there are no plans to proceed with such a development

Not all TCAS systems can be considered as accepted ACAS.

TCAS I is mandated in the United States for certain smaller aircraft.

TCAS II Versions 7.0 and 7.1 are mandated in Europe and elsewhere

Collision avoidance systems can be passive, like for example the **PCAS** or **Portable Collision Avoidance System** which only monitors the surrounding aircraft without emitting any signal. This portable system is often used within General Aviation.

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## 2.3. ACAS II as a standard

Currently, the only commercially available implementations of ICAO standard for ACAS II (Airborne Collision Avoidance System) are TCAS II versions 7.0 and version 7.1 (Traffic alert and Collision Avoidance System).

ACAS II is an aircraft system based on Secondary Surveillance Radar (SSR) transponder signals. ACAS II interrogates the Mode C and Mode S transponders of nearby aircraft ('intruders') and from the replies tracks their altitude and range and issues alerts to the pilots, as appropriate. ACAS II works independently of the aircraft navigation, flight management systems, and Air Traffic Control (ATC) ground systems.

Non-transponding aircraft are not detected.

## 3. TCAS instrument onboard

The TCAS system can be implemented as:

- a dedicated instrument
- a combined instrument with the vertical speed indicator
- a combined instrument with the Navigation Display or the Electronic Horizontal Situation Indicator



### 3.1. Different modes

TCAS can be currently operated in the following modes:

- **Standby:** TCAS does not issue any interrogations and the transponder only replies to discrete interrogations. This mode is used on the ground, outside of the runway.
- **Transponder:** the transponder replies to all appropriate ground and TCAS interrogations and TCAS remains in stand-by. This is a passive mode which is the minimum mandatory mode to be set by any airborne aircraft (typically in General Aviation)
- **Traffic Advisory (TA):** TCAS issues the appropriate interrogations and perform all tracking functions. However, TCAS will only provide traffic advisories (TA) and the resolution advisories (RA) are inhibited
- **Automatic (TA/RA):** TCAS provides traffic advisories (TA) and resolution advisories (RA) when appropriate. This mode is mandatory for all Commercial Aviation aircrafts.

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## 4. Technical description

The TCAS II is a system that:

- Monitors the airspace around the aircraft and communicates with all traffic equipped with a corresponding active transponder
- Queries all surrounding aircraft on the frequency 1030 MHz and each aircraft transponder replies on the frequency 1090MHz
- Warns pilots of the presence of other transponder-equipped aircraft which may present a threat of mid-air collision (MAC)

TCAS is only able to interact with aircraft that have a correctly operating mode C or mode S transponder.

### 4.1. Definition

TCAS II equipment provides two types of advisories to pilots: Resolution Advisories (RAs) and Traffic Advisories (TAs).

These are defined as follows:

- Resolution advisory (RA) is an indication given to the flight crew recommending:
  - a manoeuvre intended to provide separation from all threats, or
  - a manoeuvre restriction intended to maintain existing separation.
- Traffic advisory (TA) is an indication given to the flight crew that a certain intruder is a potential threat.

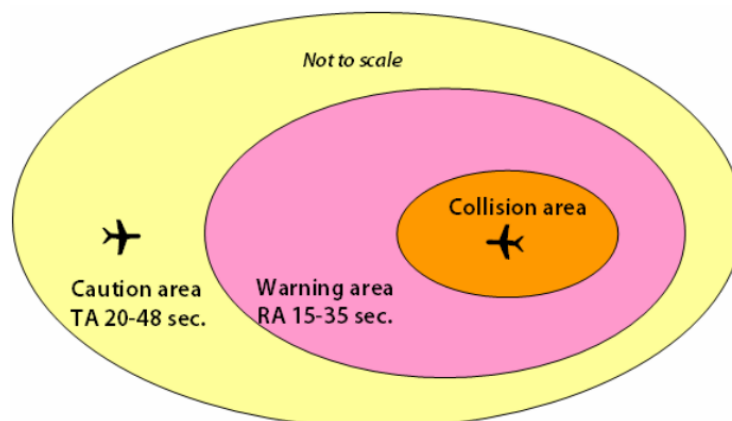
### 4.2. Protection volume

A protected volume of airspace surrounds each ACAS II equipped aircraft.

The size of the protected volume depends on :

- the altitude of the aircraft involved in the encounter.
- the speed of the aircraft involved in the encounter.
- the heading of the aircraft involved in the encounter.

The TCAS system builds a three dimensional map (Protection Volume) of the airspace around the aircraft. The map range depends on the TCAS configuration.



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### 4.3. TCAS symbols

The map is filled with all intruder aircraft depending on:

- their distance (deduced from the interrogation and response round trip time)
- their altitude (as reported by the interrogated aircraft)
- their bearing (by the directional antenna from the response)

Traffic is represented by small geometrical symbols with associated numbers indicating the vertical separation with respect to your airplane, expressed in hundreds of feet.

For example:

- -012 = 1200 feet below
- 121 = 12100 feet above
- -02↓ = 200 feet below and descending
- +07 = 700 feet above
- -01↑ = 100 feet below and climbing



Symbol of your aircraft



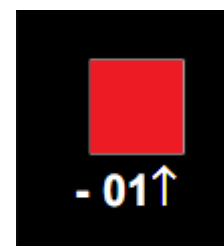
Symbol of non-threat traffic of unknown altitude  
(empty diamond with white or blue borders)  
Separation > 1200 ft or distance > 6 NM



Symbol of a non-threat proximity traffic  
(full white or blue diamond)  
Separation < 1200 ft or distance < 6 NM



Symbol of a Traffic Advisory - TA alert  
(full orange or amber circle)



Symbol of a Resolution Advisory -RA alert  
(full red square)

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## 4.4. Advisories

Finally, by extrapolating the current range and altitude difference to anticipated future values, the system determines whether a potential collision threat exists.

TCAS is also an active system since it reports to the pilot the position of all aircraft inside the protected volume and warns the pilot about any risk of conflict.

Following the identification of potential collisions, the TCAS automatically negotiates a mutual avoidance manoeuvre (currently, manoeuvres are restricted to changes in altitude and modification of climb/sink rates) between the two (or more) conflicting aircraft. These avoidance manoeuvres are communicated to the pilot by a cockpit display and by synthesized voice instructions.

### 4.4.1. Traffic Advisory (TA)

In the case of a potential collision, a sounding alert is emitted by the “Traffic Advisory” (TA). This system warns the pilot about every intruder aircraft by a “traffic, traffic” vocal announcement. It does not provide any avoidance manoeuvre suggestion.

TAs are nominally generated 20–48 seconds prior to the predicted Closest Point of Approach which would be 10–13 seconds earlier than any RA, although shorter generation times are possible in some geometries – indeed, in certain cases an RA can occur without a preceding TA. The majority of TAs will not be followed by an RA because often the separation between the aircraft does not drop below the alert threshold for an RA. On average, only 1 in 10 TAs will be followed by an RA.

When a TA is issued, the pilot is meant to initiate a visual search for the traffic causing the TA. If the traffic is visually identified, the pilot has to maintain visual separation.

He is also supposed to avoid any horizontal manoeuvre based on the solely information shown on the traffic display. On the contrary, slight adjustments in vertical speed while climbing or descending, or slight adjustments in airspeed while still complying with the ATC clearance are acceptable.

TA alerts shall not be used by the pilot to separate himself with other pilots especially in controlled area.

### 4.4.2. Resolution Advisory (RA)

Whenever the conflict situation gets worst after a TA alert and the collision seems impending, an audio message and a visual alert are generated by the « Resolution Advisory » (RA). This alert indicates the concerned airplane and suggests an avoidance action to be immediately executed by the pilot.

The system is conceived in such a way that the TCAS of the other airplane suggests another action.

For example when the TCAS provides a climb advisory to one airplane, the TCAS of the other aircraft suggests a descent suggestion, which gives an increased separation between the two aircraft.

Although the system may sometimes cause false alerts, pilots are instructed to strictly consider all TCAS messages as real alerts which require an immediate action. In the case of a difference between the TCAS RA and ATC instructions, the TCAS RA has always priority.

As soon as the alert disappears, the system announces « clear of conflict ».

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### 4.4.3. List of TCAS advisories

The list of TCAS advisories is presented below:

Type	Audio	Meaning	Required action
TA	Traffic, traffic	Intruder is close both horizontally and vertically	Attempt visual contact and be prepared to manoeuvre if an RA occurs
RA	Climb, climb	Intruder will pass below	Begin climbing at 1500–2000 ft/min
RA	Descend, descend	Intruder will pass above	Begin descending at 1500–2000 ft/min
RA	Increase climb	Intruder will pass just below	Climb at 2500 – 3000 ft/min
RA	Increase descent	Intruder will pass just above.	Descend at 2500 – 3000 ft/min
RA	Adjust vertical speed, adjust	Intruder is probably well above or below	Descend or climb at a slower rate
RA	Climb, climb now	Intruder that was passing above will now pass below	Change from a descent to a climb
RA	Descend, descend now	Intruder that was passing below will now pass above	Change from a climb to a descent
RA	Maintain vertical speed, maintain	Intruder will be avoided if vertical rate is maintained	Maintain current vertical rate
RA	Adjust vertical speed, adjust	Intruder is considerably away or the initial RA is weakening	Begin to level off
RA	Monitor vertical speed	Intruder is ahead in level flight, above or below	Remain in level flight
RA	Crossing	Passing through the intruder's level. Usually added to any other RA.	Proceed according to the associated RA
RA	Level off, level off	Intruder is no longer a threat while maintaining this level	Maintain current level (no climb, no descent)
CC	Clear of conflict	Intruder is no longer a threat	Return promptly to previous ATC clearance

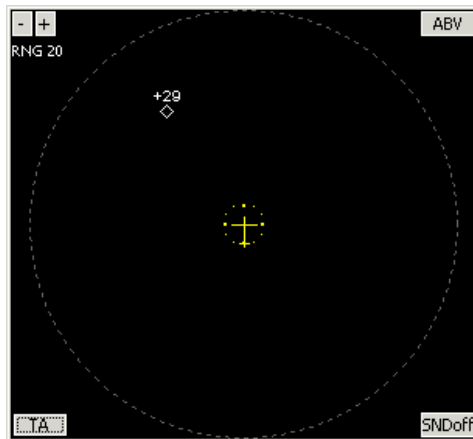
## 5. TCAS in IVAO

The TCAS is a function available in IvAp 1.6 & 2.0 and x-IvAp 0.3 version or above.

This means that it is always available regardless the aircraft model you choose, even for airplanes which are not equipped in real life. It is up to you to make use of it or not depending on the aircraft you fly with and on the degree of realism you wish to reach.

On IVAO, the TCAS function is useful when ATC is not present in order to prevent collision.

### 5.1. TCAS representation



IvAp for FS9/FSX



x-IvAp for X-plane

### 5.2. Use of TCAS

The symbol of your aircraft is placed in the middle of a circle in the TCAS window

The radius of this circle can be increased or decreased by clicking on « + » or « - ». The range possible values are **3, 5, 10, 15, 20** or **40** NM.

The TCAS activation button is placed on the left bottom corner of the window. The different modes are:

- **OFF**: (inactive TCAS) with « TCAS OFF »
- **TA**: « Traffic Advisory » mode
- **TA/RA**: « Traffic Advisory/Resolution Advisory » mode

For the time being, IvAp is not able to handle the TCAS II functions, namely RAs, since avoidance manoeuvres cannot yet be coordinated between two aircraft (this function is foreseen for a later release). IvAp TCAS is a ACAS I system only.

The display mode can be changed with the button placed on the right top corner:

- **NORM**: the traffic at +/- 2700 ft is displayed
- **ALL**: all traffic within the TCAS range is displayed
- **ABV**: the traffic within the interval (-2700, +9000) ft is displayed
- **BLW**: the traffic within the interval (-9000, +2700) ft is displayed

Finally, the TCAS sound can be deactivated or activated by the right bottom button.

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### 5.2.1. TCAS Caution

A TCAS “Caution” is issued whenever an airplane is at  $\pm 1600$  ft and/or at 7 NM from your position. The intruder aircraft is displayed in yellow.

### 5.2.2. TCAS Alert

A TCAS “Alert” is issued whenever an airplane is at  $\pm 900$  ft and/or at 3 NM from your position. The intruder aircraft is displayed in red.

When a TCAS alert is issued, the reaction time allowed to you is very short.  
You must execute all possible manoeuvres to avoid the collision and inform the ATC when available.

In the case of a high load traffic situation, it is extremely important to inform the ATC as soon as possible in order to avoid conflicts with other aircraft.

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