OPS 5

Airborne Collision Avoidance Systems

1. Introduction

1.1. Airborne collision avoidance systems are designed to improve safety by acting as a "last resort" method of preventing mid-air collisions. This is achieved by recommending pilots to manoeuvre in the vertical plane when a risk of collision is detected.

1.2. The concept for an airborne collision avoidance system, which is independent from ATS systems, emerged in 1955. In the early 1980s ICAO started work on the development of standards for an "Airborne Collision Avoidance System" (ACAS). The definition is found in ICAO Annex 10.[1]

1.3. The US FAA made a decision in 1981 to develop and introduce a collision avoidance system capable of recommending evasive manoeuvres in the vertical plane to cockpit crew. This system is called "Traffic Alert and Collision Avoidance System" (TCAS).

1.4. Within Europe, the mandatory carriage and operation of an airborne collision avoidance system is required by defined civil aircraft. European States have enacted legislation which, for flight within their airspace, mandates the carriage of ACAS II for larger aircraft from January 2000, and this requirement is extended to aircraft weighing more than 5700 kg, or having more than 19 passengers seats from 1 January 2005. In line with this, the JAA included ACAS equipment provisions in JAR-OPS 1 regulations.[2]

1.5. Today "TCAS II v.7.0" offers the same functionality as ICAO has specified for ACAS II and in practice, the terms "TCAS" and "ACAS" are used interchangeably. For simplicity, the term "ACAS" will be used to mean "ACAS II" throughout this document.

[1] ICAO Annex 10 Volume IV – Surveillance Radar and Collision Avoidance Systems – Chapter 4 Paragraph 4.1.
[2] JAR-OPS 1.668 – Airborne Collision Avoidance System.

2. ACAS Indications

2.1. ACAS issues two types of warning of potential collision:

(a) A traffic advisory (TA) is issued 20 to 48 seconds before the closest point of approach (CPA) to warn the pilots that an RA may follow and to assist in a visual search for the traffic;

(b) A resolution advisory (RA) is issued 15 to 35 second before CPA which provides the pilots with indication of appropriate vertical manoeuvres, or vertical manoeuvre restrictions, to ensure the safe vertical separation of the ACAS aircraft. However, it should be noted that the vertical separation provided by ACAS is independent of ATC separation standards. This is because ACAS does not seek to ensure separation, which is the role of ATC, but as a last resort, seeks to avoid collision.

3. Operation of ACAS

3.1. The value of ACAS as an accident prevention aid has been amply demonstrated; however, unless sound operating procedures are followed by all pilots, the value of ACAS may be seriously eroded or even negated.

3.2. JAR-OPS[3] requires that when an RA is received, the PF "shall ensure that corrective action is initiated immediately to establish safe separation unless the intruder has been visually identified and has been determined not to be a threat".

3.3. JAA TGL11[4] contains performance-based training objectives for ACAS II pilot training. This includes detailed instructions on the proper reaction to receipt of an ACAS RA or TA.

[3] JAR-OPS 1.398 – Use of Airborne Collision Avoidance System (ACAS).
[4] JAA Administrative & Guidance Material Section Four: Operations, Part Three: Temporary Guidance: Leaflets (JAR-OPS) Leaflet No. 11: Guidance For Operators On Training Programmes For The Use Of Airborne Collision Avoidance Systems (ACAS)

3.4. With regard to pilot response to RAs, TGL11 specifies that:

(a) For corrective RAs, the response must be initiated in the proper direction within 5 seconds of the RA being displayed, and the change in vertical speed must be accomplished with an acceleration of approximately ¼g;

(b) For modified RAs, the response must be initiated within 2½ seconds of being displayed; and,

– For Increase Rate RAs, or for RA reversal, the change in vertical speed must be accomplished with an acceleration of approximately ⅓ g;

– For RAs that weaken or strengthen, the change in vertical speed must be accomplished with an acceleration of approximately ¼g.

3.5. JAA regulations are currently under review in the light of recent (November 2003) changes to the Flight Procedures for Operation of ACAS Equipment established by ICAO[5]. These concern the (new) requirement that in the event of conflict between ATC instructions and ACAS, pilots must follow ACAS.

3.6. Until the publication of revised JARs, operators of ACAS equipped aircraft must review their operating procedures in accordance with the ICAO procedures[5] to ensure that pilots are provided with clear rules stating precisely how they should respond in given circumstances. This guidance should be incorporated in all initial, conversion and recurrent training.

3.7. In essence, these rules are quite straightforward:

(a) Do not take any avoiding action on the sole basis of a TA;

(b) On receipt of an RA:

– respond immediately by following the RA as indicated, unless doing so would jeopardise the safety of the aeroplane;

– follow the RA even if there is a conflict between the RA and an air traffic control (ATC) instruction to manoeuvre;

– do not manoeuvre in the opposite sense to an RA;

– do not manoeuvre laterally;

– as soon as possible, as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current air traffic control instruction or clearance;

– promptly comply with any modified RAs;

– limit the alterations of the flight path to the minimum extent necessary to comply with the RAs;

– promptly return to the terms of the ATC instruction or clearance when the conflict is resolved; and,

– notify ATC when returning to the current clearance.

3.8. Further explanation may be necessary to ensure that pilots understand the danger of not following the SOP:

(a) Stall warning, windshear, and Ground Proximity Warning System alerts have precedence over ACAS;

(b) Visually acquired traffic may not be the traffic causing an RA, or it may not be the only traffic to which ACAS is responding. Visual perception of an encounter, particularly the action being taken by the traffic, may be misleading, especially at night. Therefore, the pilot should continue to follow the RA even when he/she believes he has identified the intruder visually;

(c) In the case of an ACAS-ACAS co-ordinated encounter between different aircraft, the RAs complement each other in order to reduce the potential for collision. Manoeuvres, or lack of manoeuvres, that result in vertical rates opposite to the sense of an RA could result in a collision with the threat aircraft;

(d) Separation at CPA is based on the assumption that both pilots follow the indicated manoeuvre; if one pilot does not do so, separation may be less than if that aircraft was not ACAS equipped;

(e) Unless informed by the pilot, ATC does not know when ACAS issues RAs. It is possible for ATC to issue instructions that are unknowingly contrary to ACAS RA indications. Therefore, it is important that ATC be notified when an ATC instruction is not being followed because it conflicts with an RA;

[5] ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures Part VIII Chapter 3 Amendment 12.

(f) ACAS equipment updates the position and calculates the trajectory of the threat aircraft once per second; in contrast, the update rate of ATC radar is only once per 4 seconds, or less. Therefore ACAS knowledge of the vertical situation is at least 4 times greater than ATC.

3.9. SOPs should stress that in the event of a level bust that involves an actual risk of collision, the ACAS is the only means to resolve the situation effectively. **It is therefore imperative that pilots follow the RA.**

3.10. ATM procedures in regard to ACAS equipped aircraft and the phraseology to be used for the notification of manoeuvres in response to an RA are contained in the PANS-ATM.[6]

4. ACAS and RVSM

4.1. Interim assessments by the ACAS Programme, since the implementation of RVSM, have not indicated any evidence to suggest that ACAS is generating any major problems within RVSM airspace. The improved height keeping performance of RVSM approved flights is beneficial to ACAS performance.

4.2. Within RVSM airspace, unless there are differing instructions within National AIPs, aircraft should climb/descend in accordance with normal flight profiles except when approaching the cleared flight level.

4.3. ICAO is developing guidance material in order to prevent unnecessary RAs associated with high vertical rates. The guidance will advise pilots that when traffic information is provided by ATC the rate of climb or descent should be less than 1500 ft per min when approaching 1000 ft above or below the cleared flight level.

5. Training

5.1. ACAS should be included in ab-initio and continuation training for civil and military pilots and for ATC controllers.

5.2. JAA TGL11[4] contains valuable guidance on the development of training programmes. However, the current version of this document (October 1998) is under review in the light of the revision to ICAO Pans-OPS (see paragraph 3.3. above).

6. Summary

6.1. ACAS is a last resort system, which operates with very short time thresholds before a potential near mid-air collision. It assesses the situation every second, based on accurate surveillance in range and altitude. For maximum efficiency, when both aircraft are operating ACAS in RA mode, ACAS co-ordinates the RAs. ACAS is extremely effective.

6.2. Pilots must follow all RAs even when there is:

(a) ***an opposite avoiding instruction by the controller*.** If the RA is not followed, it can adversely affect safety when the other aircraft responds to a co-ordinated RA;

(b) ***conflict at maximum operating altitude.*** If a climb RA is generated commence a climb, do not descend opposite to the RA. Maximum altitude usually permits a 200 ft min capability. Otherwise, if the aircraft is performance limited the ACAS is usually programmed not to give the relevant warning. Operators should check with equipment manufacturers and brief crews accordingly;

(c) ***traffic information from the controller.*** The slower update rate of the radar display, even with radar data processing system (RDPS) multi-radar data, means that the vertical situation seen by the controller may be inaccurate, particularly when aircraft are rapidly climbing or descending;

(d) ***visual acquisition.*** The wrong aircraft could be identified and the situation may be wrongly assessed.

6.3. It is recognised that workload is often high during an ACAS RA encounter, nonetheless pilots must notify ATC as soon as possible using the standard phraseology (e.g. "[callsign] TCAS CLIMB").

6.4. This information will help the controller in his/her task: "When a controller is informed that a pilot is following an RA, the controller shall not attempt to modify the aircraft flight path until the pilot reports returning to the clearance. He/she shall provide traffic information as appropriate".

6.5. For maximum safety benefit from ACAS, follow RAs promptly and accurately.

7. Examples

7.1. The examples and information[7] that follow illustrate the operation of ACAS as well as the potential dangers of non-compliance with sound standard operating procedures.

7.2. Examples 1-7 illustrate actual operational encounters. Examples 8 & 9 illustrate the performance of ACAS in common scenarios.

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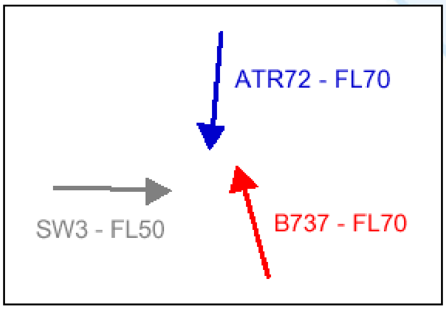
[6] ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM) Chapters 15 and 12 respectively

[7] These examples include material taken from two EUROCONTROL Safety Letters: "ACAS II bulletin – Follow the RA!", and, "Reducing Level Bust".

Example 1: ATC Avoiding Instruction Opposite to RA



Two aircraft level at FL70 are being radar vectored by the approach controller:

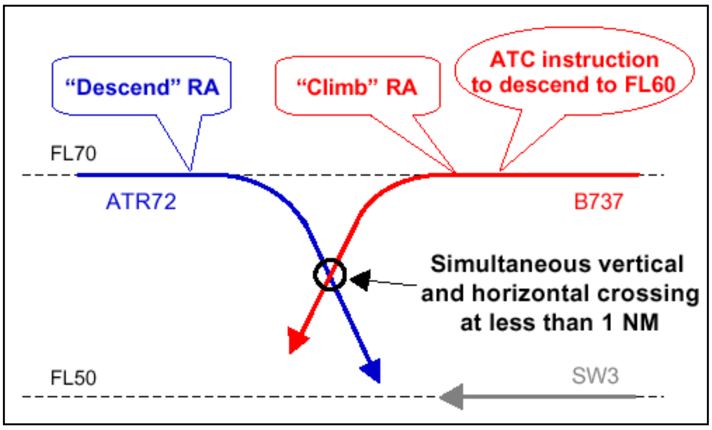
- an ATR72 is heading 185°;
- a B737 is on opposite track heading 345°.

A third aircraft (SW3) level at FL50 is heading east.

All aircraft are in IMC.

Because the controller is occupied with the resolution of another conflict, the B737 is instructed, late, to descend to FL60 when the aircraft are slightly less than 5 NM head on.

Both aircraft are at the same level and converging quickly. The ACAS of each aircraft triggers a co-ordinated RA a few seconds later:



- the ATR72 pilot receives a "Descend" RA that he follows;
- the B737 pilot receives a "Climb" RA that he does not follow. He continues to comply with the ATC instruction.

The ATR72 pilot immediately informs the controller that he has a "Descend" RA using the standard phraseology. However just after, the controller repeats to the B737 the instruction to descend to FL60 for avoiding action.

The B737 pilot, who has reported afterwards that he '*had to avoid ACAS alert*', descends through FL60. This opposite reaction to his "Climb" RA induces an "Increase Descent" RA on-board the ATR72, which leads the pilot to deviate much more than initially required by ACAS. This large vertical deviation induces a new ACAS conflict with the SW3 level at FL50.

If the B737 pilot had responded correctly to his "Climb" RA, the vertical separation between the ATR72 and the B737 would have been 600 ft (i.e. 300 ft vertical deviation for each).

The Air Traffic Controller and ACAS as a "last resort safety net"

When a loss of separation is likely to occur or has occurred, the controller has to:

- *detect the conflict using the available tools (e.g. radar display, Short Term Conflict Alert [STCA]);*
- *assess the situation;*
- *develop a solution in a very short period of time;*
- *communicate this solution to the aircrew as quickly and clearly as possible.*

The detection of the conflict may bae delayed due to tasks with other aircraft under his/her control. Communications with conflicting aircraft may also be delayed due to RTF congestion or misunderstandings between the controller and the pilots.

ACAS automatically detects any risk of collision for the mode C equipped aircraft. When a risk of collision is detected, it calculates the necessary vertical avoidance manoeuvre and communicates the solution directly to the flight crew via the RA display and an aural message attention-getter. It does this in less than one second.

Whenever both aircraft are operating ACAS in TA/RA mode, ACAS co-ordinates the RAs.

In 1996 a near-collision occurred in the holding pattern near a major international airport. The controller was alerted to the loss of separation by the STCA but was obliged to ask each aircraft in turn for its altitude before avoiding instructions could be issued. Both aircraft were in cloud and neither crew saw the other. Neither aircraft was fitted with ACAS. Subsequent analysis revealed that the aircraft came within 100 ft vertically and around ½ a mile horizontally of each other.

Example 2: ATC Avoiding Instruction Opposite to RA

A B737 is level at FL280 flying a north-west route. An A321 is climbing cleared to FL270 and flying a southbound route. Due to a misunderstanding with the controller, the A321 pilot busts his altitude and continues to climb to FL290.

The controller detects the altitude bust and takes corrective actions. He instructs the A321 to descend immediately to FL270 (it is displayed on the radar at FL274) and the B737 to climb to FL290. The B737 pilot initiates the climb manoeuvre but the A321 pilot continues to climb instead of descending back to FL270.

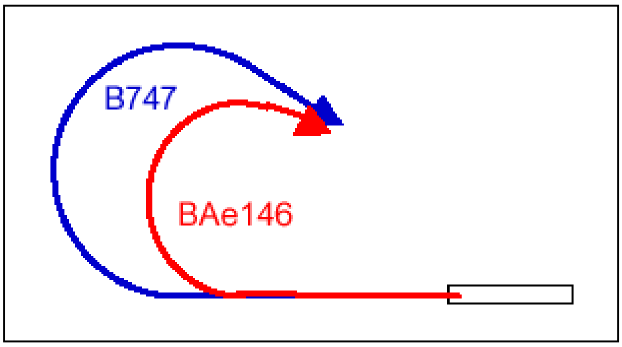
A few seconds later, the ACAS of each aircraft triggers a co-ordinated RA: a “Climb” RA for the A321 (it is now 300 ft above the B737) and a “Descend” RA for the B737.

The B737 pilot follows his RA and starts to descend. However, the A321 pilot eventually complies with the ATC instruction, stops the climb and starts to descend despite his “Climb” RA. In addition, the A321 pilot reported that he preferred to avoid the B737 visually

As a result, both aircraft passed less than 2 NM apart, with only 100 ft vertical separation.

If the A321 pilot had followed the ACAS RA, this dangerous situation would have been avoided.

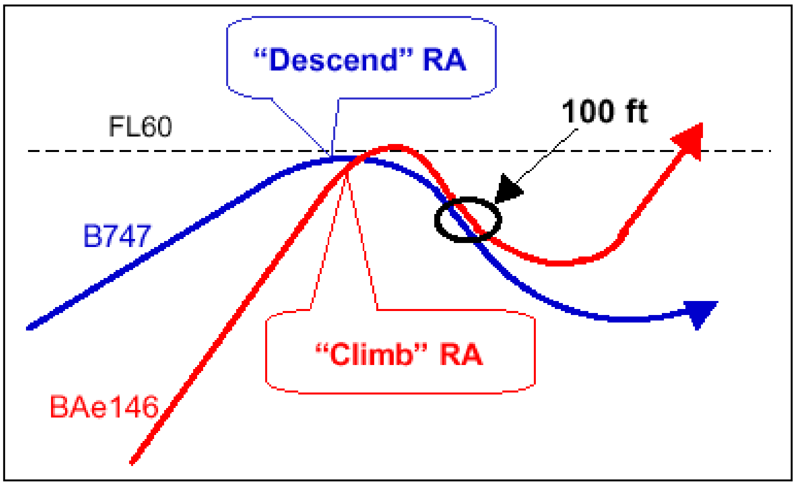
Example 3: Erroneous traffic information and incorrect visual perception



Two aircraft are departing from the same airport, on the westerly runway. The first one is a long-haul B747, which is turning right to heading 150°. The second one is a short-haul BAe146, which is turning to the east, after a steep initial climb. Both aircraft are cleared to FL190.

Due to the good climb performance of the BAe146, the controller gives it an early right turn. This clearance induces a conflict between the BAe146 and the B747.

The controller detects the conflict and provides the B747 with traffic information about the BAe146. The pilot replies “we are passing *6000 feet*”. Then, the controller instructs the BAe146 to “stop climb flight *level 60”*, advising the pilot that a B747 is “1000 ft above climbing”. However, two elements have not been taken into account:



- the pressure is high (QNH 1032), so that the 6000 ft altitude is actually FL54, and FL60 is 6600 ft altitude;
- both aircraft are ACAS equipped so that the ACAS of each aircraft triggers a co-ordinated RA.

The B747 pilot receives a “Descend” RA that he follows: he stops his climb and starts to descend.

The BAe146 pilot has the B747 in visual contact. However, due to the actual B747 flight configuration, the descent manoeuvre is difficult to detect visually (positive pitch). As he is also misled by the erroneous traffic information, he decides to descend visually to avoid the B747 despite his “Climb” RA.

As the B747 is also descending in response to his “Descend” RA, the aircraft continue to get closer.

Because the BAe146 pilot did not follow his “Climb” RA, the B747 deviated by 1200 ft. **However, despite this large vertical deviation, the B747 pilot reported that the two aircraft passed *“very, very, very close”* (i.e. 100 ft and 0.5 NM).**

If the BAe146 pilot had followed the ACAS RA, this dangerous situation would have been avoided.

Example 4: Insufficient Visual Avoiding Manoeuvre

A B747 and a DC10 flying on converging tracks are both cleared to FL370 by mistake. When the controller detects the conflict, he tries to instruct the DC10 to descend to FL350 but uses a mixed callsign.

The B747 pilot wrongly takes the clearance and initiates a descent. At the same time, his ACAS issues a "Climb" RA. However, the pilot decides not to follow the RA because he has the visual acquisition on the DC10 (at the time of the incident, his airline standard operating procedures stated that manoeuvres based on visual acquisition took precedence over RAs) and he continues to descend.

The DC10 pilot who has also the B747 in sight, receives a co-ordinated "Descend" RA that he follows. At the last moment, he stops his descent when he perceives the B747 to be at the same altitude and descending.

At the very last second, the B747 pilot performs a sudden and violent escape manoeuvre, injuring a number of passengers and flight attendants.

***As a result, the B747 passes just beneath the DC10 (by 10 metres reported), with no lateral separation*.**

ACAS Altitude data is better than ATCs

The ATC radar displays are usually provided with data by a Radar Data Processing System (RDPS), whose inputs come from Secondary Surveillance Radars (SSR) with:

- *an update rate of several seconds (from 4 to 10s)*
- *altitude data in 100 ft increments*

Sudden vertical manoeuvres may not be displayed immediately. For instance, the altitudes displayed for a manoeuvring aircraft may lag by as much as 500 ft. In addition, the displayed vertical tendency may be erroneous in some cases.

ACAS interrogates all surrounding transponders every second, making the update 4 to 10 times quicker than SSRs. Mode S equipped aircraft provide ACAS with 25 ft increments making it 4 times more accurate.

Therefore, for aircraft in close proximity, the ACAS knowledge of the vertical situation is much better than the ATC one. It can be considered to be at least 4 times more accurate, and 4 times more up-to-date.

Visual Acquisition - Limitations

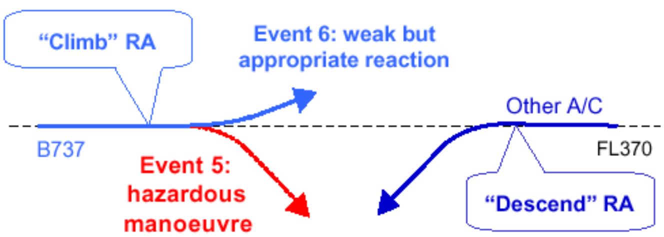
- *The visual assessment of traffic can be misleading. At high altitude, it is difficult to assess the range and heading of traffic as well as its relative height. At low altitude, the heavy aircraft attitude at low speed makes it difficult to assess whether it is climbing or descending.*
- *Visual acquisition does not provide any information about the intent of other traffic.*
- *The traffic in visual contact may not be the threat that triggers the RA. A visual manoeuvre relative to the wrong visual traffic may degrade the situation against the real threat.*

Examples 5 & 6: "Climb" RA at the Maximum Certified Flight Level

Two events involving a B737 level at FL370 (i.e. the maximum certified flight level for this specific aircraft type) have been identified where the pilot reaction to the "Climb" RA has been different. In both these events, the B737 was flying towards another aircraft level at the same altitude due to an ATC mistake and the ACAS generated a "Climb" RA.

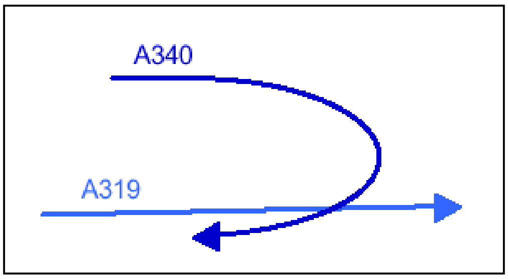
Example 5: the B737 pilot decided not to climb in response to the RA as the aircraft was flying at the maximum certified flight level. However, as he wanted to react to the ACAS alert, he then decided to descend. He did not take into account that the other aircraft would receive a co-ordinated "Descend" RA. As a result, the B737 pilot descended towards the other aircraft, which was correctly descending in accordance with its own RA.

Example 6: the B737 pilot climbed in response to his RA, but as one could expect, he was not able to comply with the normal 1500 fpm vertical rate requested by the RA. He climbed only about 100 ft. However, even this slight climb was beneficial as the other aircraft received a co-ordinated "Descend" RA, which was correctly followed by the pilot. The vertical separation achieved was the vertical deviation of the descending aircraft PLUS the 100 ft achieved by the B737.



In conclusion, DO NOT react contrary to an RA: if there is some doubt of the ability to respond to a "Climb" RA, at least remain level, do not descend.

Example 7: Correct Response to RAs by Both Pilots



An A340 and an A319, which are departing from two different airports, are in contact with different controllers but in the same airspace.

The A340, in contact with the departure controller, is cleared to climb to FL150 with an initial heading 090°. The A340 climbs slowly and is planned to climb above the A319.

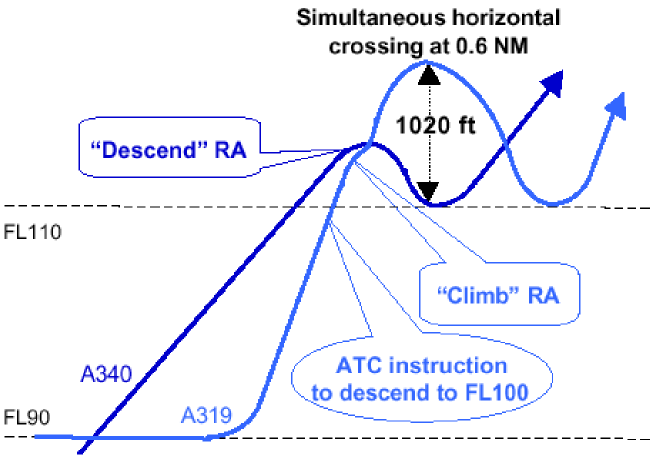
The A319, which is level at FL90 and also heading east, is already in contact with the en-route centre.

When passing through FL100, the A340 is turned to the right by the departure controller. At the same time, the A319 is cleared by mistake by the en-route controller to climb to FL210, which induces a conflict with the A340. The en-route controller detects the conflict and instructs the A319 to stop climb at FL100. The A319 pilot replies that he has already passed FL100 and that he is descending back to FL100.

However, because of the simultaneous horizontal and vertical convergence, the ACAS of each aircraft triggers a co-ordinated RA:

- the A340 receives a "Descend" RA that he follows correctly despite the clearance to climb to FL150
- the A319 receives a "Climb" RA that he also follows correctly even though he has already started his manoeuvre to descend back to FL100

In this event, the correct responses to the RAs by both pilots provide more than the ACAS vertical separation objective.

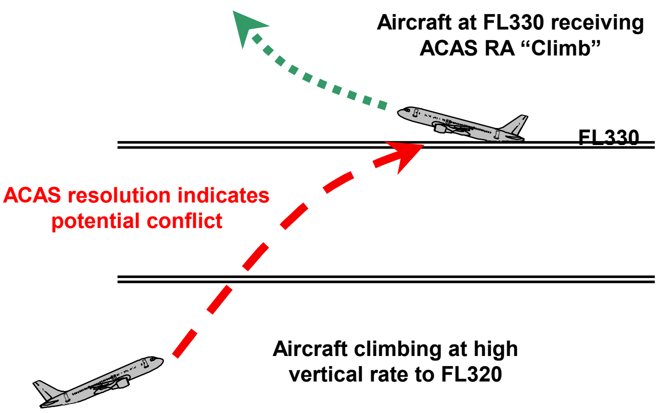


Example 8: ACAS Bump-up.

Induced Deviation from Clearance

An ACAS RA can be issued where an aircraft is climbing, or descending, **with a high vertical rate** to a cleared level that is 1000 ft from an adjacent aircraft. An RA issued in the adjacent aircraft could cause the aircraft to deviate from its cleared flight level. This is sometimes referred to as an "operationally unnecessary" or "nuisance" RA, but it is entirely justified. If the aircraft that is climbing or descending does not successfully level off at its cleared flight level the risk of collision is very real.

There have been many recent altitude busts, where aircraft failed to level off at their cleared flight level. So it is important that pilots follow the RA.



Logic modifications mean that the majority of RAs issued in these situations do not now require a move off level by the level aircraft, or a reversed vertical rate by the climbing/descending aircraft. However, ***occurrences of RAs can be minimised if pilots adjust their rate of climb/descent to 1500 ft per min. when they are approaching an altitude 1000 ft above, or below, their cleared level.***

At a number of airports, departure routes (SIDs) climb under holding stacks or arrival routes. Where possible, Terminal Areas are designed to avoid the types of interaction between departing and arriving traffic that make level bust incidents more hazardous.

Example 9: Knock-on Effects

Concerns are often expressed that RAs could induce conflicts with other aircraft. This is particularly the case where aircraft are "packed" close to each other, for example, in a holding pattern serving a major airport.

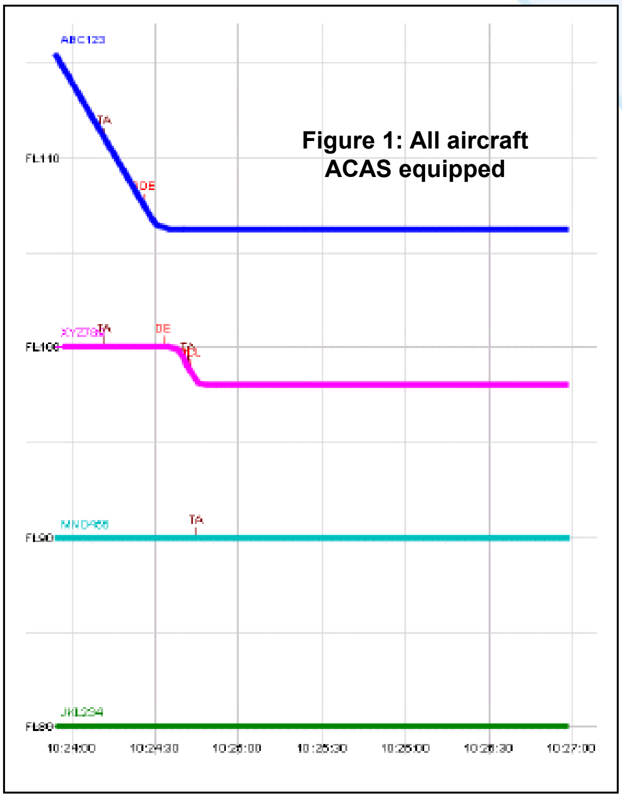
The following worst-case scenario demonstrates that in such a situation, the safest procedure is for all aircraft to follow the RA.

Three aircraft are in a holding pattern at FL80, FL90 and FL100, coincidentally all exactly one above the other.

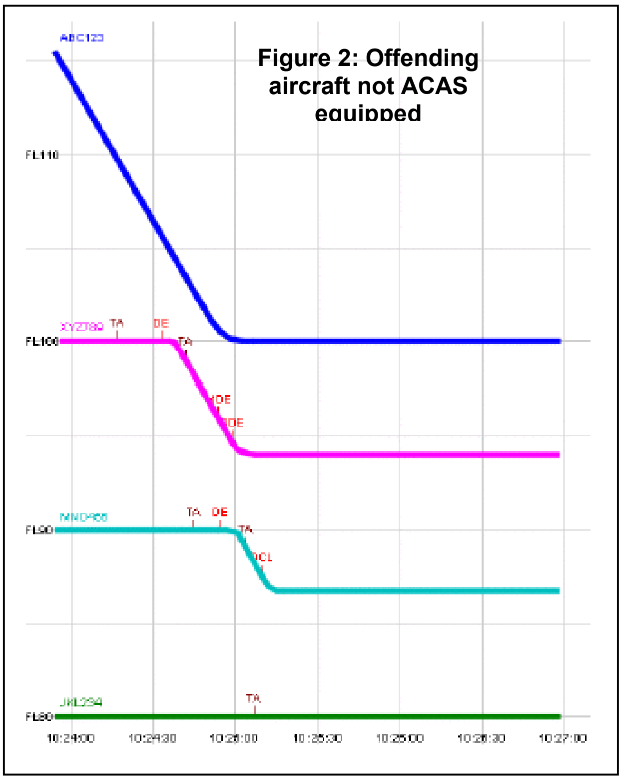
A fourth aircraft (blue line) busts FL110, and mistakenly enters the hold descending to FL100, on top of the aircraft (red line) already occupying that level.

All four aircraft are ACAS equipped (Figure 1).

- The joining aircraft receives a TA as he passes FL112;
- He receives an RA requiring a level-off as he passes FL107;
- The aircraft already at FL100 receives an RA and descends 200ft;
- The aircraft at FL90 receives a TA only.



In this case, separation between the joining aircraft and that at FL100 is lost, but the ACAS safety net prevents a potential mid-air, or near mid-air collision. Only the joining aircraft commits a level bust.



ACAS can still resolve the situation when the offending aircraft is not ACAS equipped and continues its descent to FL100 (Figure 2).

- Aircraft at FL100 (red line) receives an RA and descends 600 ft;
- This induces an RA in the aircraft below (green line) which descends 300 ft;
- The aircraft at FL80 receives a TA only.

In this case, separation is seriously reduced, but a collision risk will not arise provided all aircraft followed the instructions given by their ACAS equipment promptly and accurately.

In the absence of ACAS, a controller, however skilled, would find it extremely difficult to resolve the conflict before a dangerous situation developed (see the information at the foot of Page 3).

This emphasises the point that in the event of a level bust that involves an actual risk of collision, the ACAS is the only means to resolve the situation effectively.

It is therefore imperative that pilots follow the RA.

8. Resources

Other Level Bust Briefing Notes

8.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 1 – Standard Operating Procedures;

OPS 3 – Standard Calls;

OPS 4 – Aircraft Technical Equipment.

Access to Resources

8.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory References

8.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 10 Volume IV – Surveillance Radar and Collision Avoidance Systems;

ICAO Doc 4444: PANS-ATM, Chapters 12 and 15;

ICAO Doc 8168: PANS-OPS, Volume I – Flight Procedures, Part VIII Chapter 3;

ICAO Doc 7030 Section 16: Use of ACAS;

JAR-OPS 1.398 – Use of Airborne Collision Avoidance System (ACAS);

JAR-OPS 1.652 – Flight and Navigational Equipment & Associated Equipment;

JAR-OPS 1.668 – Airborne Collision Avoidance System.

Training Material & Incident Reports

EUROCONTROL Safety Letter – Airborne Collision Avoidance Systems (ACAS);

EUROCONTROL ACAS II Bulletin: "Follow the RA!";

EUROCONTROL – ACAS Training for Operations in RVSM Environment;

EUROCONTROL – Replay Interface of TCAS Advisories (RITA) – a dynamic graphical tool showing TCAS occurrences;

JAR-OPS TGL-11 – Guidance for Operators on Training Programmes for the use of ACAS;

Report by the Norwegian Air Accident Investigation Bureau into an Airprox between an Airbus A310 and a Boeing 737 at Oslo in February 2002;

UK CAA Flight Operations Department Communication 2/03 – Airprox report 105/02 – TCAS Incident – Level Bust.

Other References

UK CAA ATSIN 15/02 – ACAS Interface with Air Traffic Control;

UK CAA CAP 710 – "On the Level" and associated recommendations;

UK CAA Flight Operations Department Communication 27/03 – ACAS: Action to be Taken Following a Resolution Advisory (RA).

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.