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30 August 2002

Subject: ACAS PROVISIONS AND
OPERATIONAL PROCEDURES

Action required: TO ENSURE THAT
NATIONAL AVIATION DOCUMENTATION
AND THAT OF AIRCRAFT OPERATORS
HIGHLIGHT THE CRITICAL IMPORTANCE
OF FOLLOWING AN ACAS RESOLUTION
ADVISORY AND NOT MANOEUVRING
OPPOSITE TO THE SENSE OF A
RESOLUTION ADVISORY, EVEN IF ATC
ISSUES CONFLICTING INSTRUCTIONS

Sir/Madam,

1. I have the honour to draw your attention to the current ICAO provisions concerning the Airborne Collision Avoidance System (ACAS) and, in this regard, to request your urgent action to review your national aviation documentation and that of aircraft operators under your authority. This issue came to light following the publication of an accident investigation report dated 12 July 2002, concerning a near mid-air collision over Japan on 31 January 2001. This accident involved two wide-bodied aircraft equipped with ACAS II and resulted in injuries to passengers and crew. Furthermore, it is noted that there is an on-going accident investigation of a mid-air collision over Germany on 1 July 2002 involving two aircraft equipped with ACAS II.

2. States may note that ACAS provides a proven, independent safety net to prevent mid-air collisions. Operational monitoring programmes have highlighted, in numerous actual events, the significant ACAS II contribution to improved flight safety. However, its ability to fulfil that role is dependent on the correct performance of the necessary operational procedures by flight crews and air traffic control.

3. In this connection, I would like to invite your attention to a list of the ICAO documentation containing International Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS) and guidance material related to ACAS operations, provided in Attachment A. Please note that Annex 2 — *Rules of the Air*, Chapter 3 — *Avoidance of Collisions* recognizes the important role of ACAS to assist the pilot-in-command in choosing the best course of action to avoid a collision. Annex 2, paragraph 3.2.2. states that “..... nothing in these rules shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert a collision”.

4. In addition, I wish to direct your attention to guidance material in Annex 10 — *Aeronautical Telecommunications*, Volume IV — *Surveillance Radar and Collision Avoidance Systems*, Attachment A, paragraph 3.5.8.10.3, which states “Contrary pilot response. Manoeuvres opposite to the sense of an RA may result in a reduction in vertical separation with the threat aircraft and therefore must be avoided. This is particularly true in the case of an ACAS-ACAS coordinated encounter”. The reason for this statement is that if both aircraft are equipped with ACAS II, the RAs are coordinated so as to complement each other in order to reduce the potential for collision.

5. Moreover, the *Procedures for Air Navigation Services – Air Traffic Management* (PANS-ATM, Doc 4444), paragraph 15.6.3.2, requires that “**When a pilot reports a manoeuvre induced by an ACAS resolution advisory (RA), the controller shall not attempt to modify the aircraft flight path until the pilot reports returning to the terms of the current air traffic control instruction or clearance but shall provide traffic information as appropriate.**”

6. Furthermore, performance-based training objectives for pilot training on ACAS (as contained in Attachment E to State letter AN 7/1.3.72-97/77 dated 8 August 1997 and reproduced as Attachment B to this letter) state in sub-paragraph 3.2.3 b) 12) that “**if pilots simultaneously receive instructions to manoeuvre from ATC and an RA which are in conflict, the pilot should follow the RA**”. The reason for this statement is that ATC may not be aware of an RA, and may issue instructions that are contrary to the RA.

7. It is noted that a number of States have introduced procedures prompting flight crews to immediately follow the RA when it occurs. These procedures also take into account guidance mentioned in paragraph 4 above. Attachment C to this letter lists some examples of national aviation documentation that reflect such procedures.

8. For ACAS to function as intended, it is essential that flight crews follow the procedures contained in their aircraft operating manuals concerning responses to RAs. States are requested to review their national aviation documentation on the operation of ACAS to take due account of the ICAO provisions referenced in paragraphs 4 and 5, and the procedures successfully applied in some States as referenced in paragraph 7. In particular, States are requested to ensure that operators under their regulatory oversight:

- a) incorporate appropriate procedures in their operations manuals regarding flight crew responses to ACAS RAs, as required by Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport – Aeroplanes*, paragraph 4.2.2.1;
- b) implement initial and recurrent flight crew training in these procedures, in accordance with Annex 6, Part I, paragraph 9.3, taking into account the training objectives reproduced in Attachment B hereto; and

- c) require flight crews to demonstrate proficiency in responding to ACAS RAs, as described in paragraph 3.2.3 of Attachment B to this letter, during proficiency checks conducted in accordance with Annex 6, Part I, paragraph 9.4.4.

9. You may also wish to note that the accident investigation report concerning the near mid-air collision accident over Japan recommended that ICAO should strengthen statements in ICAO documentation concerning the danger of manoeuvring in the opposite sense to an RA, and the importance of following the RA when it conflicts with an ATC instruction. The recommendations from Japan and the related ICAO provisions will be reviewed by the Air Navigation Commission during its 161st Session, commencing on 7 October 2002.

Accept, Sir/Madam, the assurances of my highest consideration.

R.C. Costa Pereira
Secretary General

Enclosures:

- A — References to the carriage and operation of ACAS in ICAO documents
- B — Airborne Collision Avoidance System (ACAS) performance-based training objectives
- C — Examples of national aviation documentation concerning ACAS procedures

**REFERENCES TO THE CARRIAGE AND OPERATION OF ACAS
IN ICAO DOCUMENTATION**

1. Annex 2 — *Rules of the Air*, Chapter 3, paragraph 3.2.2, Right-of-way.
2. Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*:
 - a) paragraph 4.2.2.1 regarding provision, for the use and guidance of operations personnel concerned, of an operations manual in accordance with Appendix 2;
 - b) paragraph 6.18, Aeroplanes required to be equipped with an airborne collision avoidance system (ACAS II);
 - c) paragraph 6.19, Aeroplanes required to be equipped with a pressure-altitude reporting transponder;
 - d) paragraph 9.3, Flight crew member training programmes;
 - e) paragraph 9.4.4, Pilot proficiency checks.
3. Annex 11 — *Air Traffic Services*, Chapter 2, paragraph 2.25, Establishment of requirements for carriage and operation of pressure-altitude reporting transponders.
4. *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), Chapter 15, *Procedures Related to Emergencies, Communication Failure, and Contingencies*, Section 15.6.3, Procedures in regard to aircraft equipped with airborne collision avoidance systems (ACAS) paragraph 15.6.3.2.
5. *Procedures for Air Navigation Services — Aircraft Operations*, Volume I — *Flight Procedures* (PANS-OPS, Doc 8168), Part VIII, *Secondary Surveillance Radar (SSR) Transponder Operating Procedures*, Chapter 3, Operation of ACAS equipment.
6. Annex 10 — *Aeronautical Telecommunications*, Volume IV — *Surveillance Radar and Collision Avoidance Systems*, Attachment A, paragraph 3.5.8.10.3, Contrary pilot response.
7. State letter AN 7/1.3.72-97/77, dated 8 August 1997, Attachment E, Proposed ACAS performance - based training objectives, page E-11, sub-paragraph 3.2.3 b) 12), which provides guidance in relation to pilot action when ATC instructions to manoeuvre conflict with an ACAS resolution advisory (reproduced at page B-10 of this letter).
8. *Regional Supplementary Procedures* (Doc 7030), AFI, Part 1, Chapter 14; EUR, Part 1, Chapter 20; MID/ASIA Part 1, Chapter 8; NAT, Part 1, Chapter 15; and PAC, Part 1, Chapter 8 — Use of Airborne Collision Avoidance Systems (ACAS).

**AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS)
PERFORMANCE-BASED TRAINING OBJECTIVES
(Previously circulated as Attachment E to State Letter AN 7/1.3.72-97/77)**

Note. — The technical specifications contained in this document were those in effect in 1997. Since then some modifications have been made to ACAS algorithms to accommodate reduced vertical separation minima (RVSM), and to minimize unnecessary alerts. However, none of these changes modify the requirements for pilot responses. Nevertheless, these and other issues will be reviewed by the Air Navigation Commission commencing in the 161st Session.

1. BACKGROUND

1.1 During the implementation of the airborne collision avoidance system (ACAS), ACAS II and the operational evaluations conducted by States, several operational issues were identified which had been attributed to deficiencies in pilot training programmes. These deficiencies were identified early in the evaluations conducted by the Federal Aviation Administration (FAA), the Japanese Civil Aviation Bureau (JCAB) and the European Organisation for the Safety of Air Navigation (EUROCONTROL). As a result, the issue of pilot training has been discussed during previous working group meetings. These discussions resulted in a decision to present a working paper at SICASP/5 which contained training guidelines for both pilots and controllers. It was agreed that it would be distributed to States by the International Civil Aviation Organization (ICAO) as part of the ACAS implementation guidelines.

1.2 The training guidelines identified those areas in which a pilot is expected to have knowledge prior to operating ACAS II. The SICASP/5 paper identified areas of ACAS performance and operation that should be covered during both initial and recurrent training. However, it only identified topics that should be addressed; it did not specify the exact contents of the training programme nor the performance a trainee should demonstrate during the training.

2. SCOPE

2.1 This document presents an initial set of performance-based training objectives for ACAS II pilot training. The information contained in this paper related to traffic advisories (TAs) is also applicable to ACAS I and ACAS III users. The training objectives cover five areas: theory of operation; pre-flight operations; general in-flight operations; response to TAs; and response to resolution advisories (RAs).

2.2 The training objectives are further divided into the areas of: ACAS academic training; ACAS manoeuvre training; ACAS initial evaluation; and ACAS recurrent qualification. Under each of these four areas, the training material has been divided into those items which are considered an essential training item and those which are considered desirable. Those items which are deemed to be essential should be made a requirement for each ACAS operator. In each area, a list of objectives and acceptable performance criteria is defined.

2.3 In developing this material, no attempt was made to define how the training programme should be implemented. Instead, objectives were established that define the knowledge a pilot operating ACAS is expected to possess and the performance expected from a pilot who has completed ACAS training. However, the training guidelines do indicate those areas in which the pilot receiving the training must demonstrate his/her understanding, or performance, using a real-time, interactive training device, i.e. a simulator or a computer-based training (CBT) aid. When appropriate, notes are included within the performance criteria which amplify or clarify the material addressed by the training objective.

3. PERFORMANCE-BASED TRAINING OBJECTIVES

3.1 ACAS academic training

3.1.1 This training is typically conducted in a classroom environment. The knowledge demonstrations specified in this section may be completed through the successful completion of written tests or providing the correct responses to non-real-time CBT questions.

3.1.2 **Essential items**

3.1.2.1 **Theory of operation.** The pilot must demonstrate an understanding of ACAS operation and the criteria used for issuing TAs and RAs. This training should address the following topics:

a) **System operation**

Objective: Demonstrate knowledge of how ACAS functions.

Criteria: The pilot must demonstrate an understanding of the following functions:

1) Surveillance:

- i) ACAS interrogates other transponder-equipped aircraft within a nominal range of 14 NM; and
- ii) ACAS surveillance range can be reduced in geographic areas with a large number of ground interrogators and/or ACAS II-equipped aircraft.

Note.— If the operator's ACAS implementation provides for the use of the Mode S extended squitter, the normal surveillance range may be increased beyond the nominal 14 NM. However, this information is not used for collision avoidance purposes.

2) Collision avoidance:

- i) TAs can be issued against any transponder-equipped aircraft which responds to the ICAO Mode C interrogations, even if the aircraft does not have altitude reporting capability;
- ii) RAs can be issued only against aircraft that are reporting altitude and in the vertical plane only;
- iii) RAs issued against an ACAS-equipped intruder are co-ordinated to ensure complementary RAs are issued; and
- iv) Failure to respond to an RA deprives own aircraft of the collision protection provided by own ACAS. Additionally, in ACAS-ACAS encounters, it also restricts the choices available to the other aircraft's ACAS and

thus renders the other aircraft's ACAS less effective than were own aircraft not ACAS equipped.

b) Advisory thresholds

Objective: Demonstrate knowledge of the criteria for issuing TAs and RAs.

Criteria: The pilot must be able to demonstrate an understanding of the methodology used by ACAS to issue TAs and RAs and the general criteria for the issuance of these advisories to include:

- 1) ACAS advisories are based on time to closest point of approach (CPA) rather than distance. The time must be short and vertical separation must be small, or projected to be small, before an advisory can be issued. The separation standards provided by air traffic services are different from the miss distances against which ACAS issues alerts;
- 2) thresholds for issuing a TA or RA vary with altitude. The thresholds are larger at higher altitudes;
- 3) a TA occurs from 15 to 48 seconds and an RA from 15 to 35 seconds before the projected CPA; and
- 4) RAs are chosen to provide the desired vertical miss distance at CPA. As a result, RAs can instruct a climb or descent through the intruder aircraft's altitude;

c) ACAS limitations

Objective: To verify the pilot is aware of the limitations of ACAS.

Criteria: The pilot must demonstrate a knowledge and understanding of the ACAS limitations including:

- 1) ACAS will neither track nor display non-transponder equipped aircraft, nor aircraft not responding to ACAS Mode C interrogations; and
- 2) ACAS will automatically fail if the input from the aircraft's barometric altimeter, radio altimeter or transponder is lost.

Note.—In some installations, the loss of information from other on-board systems such as an inertial reference system (IRS) or attitude heading reference system (AHRS) may result in an ACAS failure. Individual operators should ensure their pilots are aware of what types of failures will result in an ACAS failure.

- 3) some aircraft within 380 ft above ground level (AGL) (nominal value) will not be displayed. If ACAS is able to determine an aircraft below this altitude is airborne, it will be displayed;
- 4) ACAS may not display all proximate transponder-equipped aircraft in areas of high density traffic;
- 5) because of design limitations, the bearing displayed by ACAS is not sufficiently accurate to support the initiation of horizontal manoeuvres based solely on the traffic display;
- 6) because of design limitations, ACAS will neither track nor display intruders with a vertical speed in excess of 10 000 ft/min. In addition, the design implementation may result in some short-term errors in the tracked vertical speed of an intruder during periods of high vertical acceleration by the intruder; and

- 7) ground proximity warning systems/ground collision avoidance systems (GPWS/GCAS) warnings and windshear warnings take precedence over ACAS advisories. When either a GPWS/GCAS or windshear warning is active, ACAS aural annunciations will be inhibited, and ACAS will automatically switch to the TA only mode of operation;

d) **ACAS inhibits**

Objective: To verify the pilot is aware of the conditions under which certain functions of ACAS are inhibited.

Criteria: The pilot must demonstrate a knowledge and understanding of the various ACAS inhibits including:

- 1) increase descent RAs are inhibited below 1 450 (\pm 100) ft AGL;
- 2) descend RAs are inhibited below 1 100 (\pm 100) ft AGL;
- 3) all RAs are inhibited below 1 000 (\pm 100) ft;
- 4) all ACAS aural annunciations are inhibited below 500 (\pm 100) ft AGL. This includes the aural annunciation for TAs; and
- 5) altitude and configuration under which climb and increase climb RAs are inhibited. ACAS can still issue climb and increase climb RAs when operating at the aircraft's certified ceiling.

Note.—In some aircraft types, climb or increase climb RAs are never inhibited.

3.1.2.2 **Operating procedures.** The pilot must demonstrate the knowledge required to operate the ACAS avionics and interpret the information presented by ACAS. This training should address the following topics:

a) **Use of controls**

Objective: To verify the pilot can properly operate all ACAS and display controls.

Criteria: Demonstrate the proper use of controls including:

- 1) aircraft configuration required to initiate a Self Test;
- 2) steps required to initiate a Self Test;
- 3) recognizing when the Self Test was successful and when it was unsuccessful. When the Self Test is unsuccessful, recognizing the reason for the failure, and, if possible, correcting the problem;
- 4) recommended usage of range selection. Low ranges are used in the terminal area, and the higher display ranges are used in the en-route environment and in the transition between the terminal and en-route environment;
- 5) if available, recommended usage of the Above/Below mode selector. Above mode should be used during climb and the Below mode should be used during descent;
- 6) recognition that the configuration of the display does not affect the ACAS surveillance volume;
- 7) selection of lower ranges when an advisory is issued to increase display resolution;

- 8) if available, proper selection of the display of absolute or relative altitude and the limitations of using this display if a barometric correction is not provided to ACAS; and
- 9) proper configuration to display the appropriate ACAS information without eliminating the display of other needed information.

Note.— The wide variety of display implementations make it difficult to establish more definitive criteria. When the training programme is developed, this general criteria should be expanded to cover specific details for an operator's specific display implementation;

b) Display interpretation

Objective: To verify a pilot understands the meaning of all information that can be displayed by ACAS.

Criteria: The pilot must demonstrate the ability to properly interpret information displayed by ACAS including:

- 1) other traffic, i.e. traffic within the selected display range that is not proximate traffic, or causing a TA or RA to be issued;
- 2) proximate traffic, i.e. traffic that is within 6 NM and $\pm 1\ 200$ ft;
- 3) non-altitude reporting traffic;
- 4) no bearing TAs and RAs;

- 5) off-scale TAs and RAs. The selected range should be changed to ensure that all available information on the intruder is displayed;
- 6) traffic advisories. The minimum available display range which allows the traffic to be displayed should be selected to provide the maximum display resolution;
- 7) resolution advisories (traffic display). The minimum available display range of the traffic display which allows the traffic to be displayed should be selected to provide the maximum display resolution;
- 8) resolution advisories (RA display). Pilots should demonstrate knowledge of the meaning of the red and green areas or the meaning of pitch or flight path angle cues displayed on the RA display. For displays using red and green areas, demonstrate knowledge of when the green areas will and will not be displayed. Pilots should also demonstrate an understanding of the RA display limitations, i.e. if a vertical speed tape is used and the range of the tape is less than 2500 ft/min, an Increase Rate RA cannot be properly displayed;
- 9) if appropriate, awareness that navigation displays oriented on “Track-Up” may require a pilot to make a mental adjustment for drift angle when assessing the bearing of proximate traffic.

Note.— The wide variety of display implementations will require the tailoring of some criteria. When the training programme is developed, these criteria should be expanded to cover details for an operator’s specific display implementation;

c) Use of the TA only mode

Objective: To verify that a pilot understands the appropriate times to select the TA only

mode of operation and the limitations associated with using this mode.

Criteria: The pilot must demonstrate the following:

- 1) knowledge of the operator's guidance for the use of TA only;
- 2) reasons for using this mode and situations in which its use may be desirable. If TA only is not selected when an airport is conducting simultaneous operations from parallel runways separated by less than 1 200 ft, and to some intersecting runways, RAs can be expected. If an RA is received in these situations, the response should comply with the operator's approved procedures; and
- 3) the TA aural annunciation is inhibited below 500 ft (f 100 ft) AGL. As a result, TAs issued below 500 ft AGL may not be noticed unless the TA display is included in the routine instrument scan;

d) Crew co-ordination

Objective: To verify the pilot adequately briefs other crew members on how ACAS advisories will be handled.

Criteria: The pilot must demonstrate their preflight briefing addresses the procedures that will be used in responding to TAs and RAs including:

- 1) division of duties between pilot flying and pilot not flying;
- 2) expected call-outs;
- 3) communications with ATC; and

- 4) conditions under which an RA may not be followed and who will make this decision.

Note 1.— Different operators have different procedures for conducting preflight briefings and for responding to ACAS advisories. These factors should be taken into consideration when implementing the training programme

Note 2.— The operator must specify the conditions under which an RA need not be followed, reflecting advice published by the State Civil Aviation Authority. This should not be an item left to the discretion of a crew.

Note 3.— This portion of the training may be combined with other training such as crew resource management (CRM); and

e) Reporting requirements

Objective: To verify the pilot is aware of the requirements for reporting RAs to the controller and other authorities.

Criteria: The pilot must demonstrate the following:

- 1) the use of the phraseology contained in the *Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services* (PANS-RAC, Doc 4444)¹; and
- 2) where information can be obtained regarding the need for making written reports to various States when an RA is issued. Various States have

¹ Now *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444).

different reporting requirements and the material available to the pilot should be tailored to the airline's operating environment.

3.1.3

Non-essential item

a) **Advisory thresholds**

Objective: Demonstrate knowledge of the criteria for issuing TAs and RAs.

Criteria: The pilot must be able to demonstrate an understanding of the methodology used by ACAS to issue TAs and RAs and the general criteria for the issuance of these advisories to include:

- 1) the TA altitude threshold is 850 ft below FL 300 and 1 200 ft above FL 300;

Note.— The threshold above FL 300 may be modified at a later date to accommodate a reduced vertical separation environment;

- 2) when the vertical separation at CPA is projected to be less than the ACAS-desired separation, a corrective RA which requires a change to the existing vertical speed will be issued. This separation varies from 300 ft at low altitude to a maximum of 700 ft above FL 300;
- 3) when the vertical separation at CPA is projected to be just outside the ACAS-desired separation, a preventive RA which does not require a change to the existing vertical speed will be issued. This separation varies from 600 to 800 ft; and
- 4) RA fixed range thresholds vary between 0.2 and 1.1 NM.

3.2 ACAS manoeuvre training

3.2.1 The pilot's ability to use ACAS displayed information to properly respond to TAs and RAs should be carried out in a flight simulator equipped with a ACAS display and controls similar in appearance and operation to those in the aircraft. If a simulator is utilized, the crew resource management (CRM) should be practised during this training.

3.2.2 Alternatively, the required demonstrations can be carried out by means of an inter-active CBT with an ACAS display and controls similar in appearance and operation to those in the aircraft. This inter-active CBT should depict scenarios in which real-time responses must be made. The pilot should be informed whether or not the responses made were correct. If the response was incorrect or inappropriate, the CBT should show what the correct response should be.

3.2.3 The scenarios included in the manoeuvre training should include: corrective RAs; initial preventive RAs; maintain rate RAs; altitude crossing RAs; increase rate RAs; RA reversals; weakening RAs; and multi-aircraft encounters. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and manoeuvring opposite to the direction called for by the displayed RA as follows:

a) **TA responses**

Objective: To verify the pilot properly interprets and responds to TAs.

Criteria: The pilot must demonstrate the following:

- 1) proper division of responsibilities between the pilot flying and pilot not flying. Pilot flying should continue to fly the airplane and be prepared to respond to any RA that might follow. Pilot not flying should provide updates on the traffic location shown on the ACAS display, using this information to help visually acquire the intruder;
- 2) proper interpretation of the displayed information. Both pilots confirm that the aircraft they have visually acquired is that which has caused the TA

to be issued. Use should be made of all information shown on the display, note being taken of the bearing and range of the intruder (amber circle), whether it is above or below (data tag), and its vertical speed direction (trend arrow);

- 3) other available information is used to assist in visual acquisition. It includes ATC “party-line” information, traffic flow in use, etc.;
- 4) because of the limitations described in 3.1.2.1 c), the pilot flying should not manoeuvre the aircraft based solely on the information shown on the ACAS display. No attempt should be made to adjust the current flight path in anticipation of what an RA would advise; and
- 5) when visual acquisition is attained, right of way rules are used to maintain or attain safe separation. No unnecessary manoeuvres are initiated. The limitations of making manoeuvres based solely on visual acquisition, especially at high altitude or without a definite horizon are understood.

b) RA responses

Objective: To verify the pilot properly interprets and responds to RAs.

Criteria: The pilot must demonstrate the following:

- 1) proper division of responsibilities between the pilot flying and pilot not flying. Pilot flying should be responding to the RA with positive control inputs, when required, while the pilot not flying is providing updates on the traffic location, checking the traffic display and monitoring the response to the RA. Proper CRM should be used;
- 2) proper interpretation of the displayed information. The pilot recognizes the intruder causing the RA

to be issued (red square on display). Pilot responds appropriately;

- 3) for corrective RAs, the response is initiated in the proper direction within 5 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/4 g;
- 4) recognition of the initially displayed RA being modified. Response to the modified RA is properly accomplished:
 - i) for Increase Rate RAs, the vertical speed is increased within 2-1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/3 g;
 - ii) for RA reversals, the vertical speed is reversed within 2-1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/3 g;
 - iii) for RA weakenings, the vertical speed is modified to initiate a return towards the original clearance within 2-1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/4 g; and
 - iv) for RAs which strengthen, the vertical speed is modified to comply with the revised RA within 2-1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/4 g;
- 5) recognition of altitude crossing encounters and the proper response to these RAs;
- 6) for preventive RAs, the vertical speed needle remains outside the red area on the RA display;

- 7) for Maintain Rate RAs, the vertical speed is not reduced. Pilots should recognize that a Maintain Rate RA may result in crossing through the intruder's altitude;
- 8) if a decision is made to not follow an RA, no changes in the existing vertical speed are made in a direction opposite to the sense of the displayed RA. Pilots should be aware that if the intruder is also ACAS equipped, the decision to not follow an RA may result in a decrease in separation at CPA because of the intruder's RA response and a decision not to follow an RA also renders the other aircraft's ACAS less effective than were own aircraft not ACAS-equipped;
- 9) when the RA weakens, the pilot initiates a return towards the original clearance, and when "Clear of Conflict" is annunciated, the pilot completes the return to the original clearance;
- 10) the controller is informed of the RA as soon as time and workload permit using the standard phraseology;
- 11) when possible, an ATC clearance is complied with while responding to an RA. For example, if the aircraft can level at the assigned altitude while responding to a Reduce Climb or Reduce Descent RA, it should be done;
- 12) if pilots simultaneously receive instructions to manoeuvre from ATC and an RA which are in conflict, the pilot should follow the RA;
- 13) a knowledge of the ACAS multi-aircraft logic and its limitations, and that ACAS can optimize separations from two aircraft by climbing or descending towards one of them. For example, ACAS only considers intruders which it considers to be a threat when selecting an RA. As such, it is possible for ACAS to issue an RA against one intruder which results in a manoeuvre towards another intruder which is not classified as a threat.

If the second intruder becomes a threat, the RA will be modified to provide separation from that intruder; and

- 14) the consequences of both responding to, and not responding to, an RA.

3.3 ACAS initial evaluation

3.3.1 The pilot understanding of the academic training items should be assessed by means of a written test or inter-active CBT that records correct and incorrect responses to phrased questions.

3.3.2 The pilot understanding of the manoeuvre training items should be assessed in a flight simulator equipped with a ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly, and the results assessed by a qualified instructor, inspector, or check airman. The range of scenarios should include: corrective RAs; initial preventive RAs; maintain rate RAs; altitude crossing RAs; increase rate RAs; RA reversals; weakening RAs; and multi-aircraft encounters. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and maneuvering opposite to the direction called for by the displayed RA.

3.3.3 Alternatively, exposure to these scenarios can be conducted by means of an inter-active CBT with a ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly. This inter-active CBT should depict scenarios in which real-time responses must be made and a record made of whether or not each response was correct.

3.4 ACAS recurrent training

3.4.1 ACAS recurrent training ensures that pilots maintain the appropriate ACAS knowledge and skills. ACAS recurrent training should be integrated into and/or conducted in conjunction with other established recurrent training programmes. An essential item of recurrent training is the discussion of any significant issues and operational concerns that have been identified by the operator. Recurrent training should also address changes to ACAS logic, parameters or procedures and to any unique ACAS characteristics of which pilots should be made aware.

3.4.2 It is recommended that an operator's recurrent training programmes using flight simulators include encounters with conflicting traffic when these simulators are equipped with ACAS. The full range of likely scenarios might be spread over a two-year period. If a flight simulator, as described above, is not available, use should be made of an inter-active CBT that is capable of presenting scenarios to which pilot responses must be made in real time.

**EXAMPLES OF NATIONAL AVIATION DOCUMENTATION
CONCERNING ACAS OPERATIONAL PROCEDURES**

Eurocontrol

Training brochure — *ACAS II Operations in the European RVSM Environment*, 3 August 2001.

Available on line at <http://www.eur-rvsm.com/library.htm>, e-mail enquiries to acas@eurocontrol.int

Joint Aviation Authorities (JAA)

JAR-OPS Temporary Guidance Leaflet No. 11 — *Guidance for Operators on Training Programmes for the use of Airborne Collision Avoidance Systems (ACAS)*, 1 June 1998. Available in print only.

JAA Publication catalogue
<http://www.jaa.nl/catalogue/catalogue.html#para6>

United Kingdom

Aeronautical Information Circular (AIC) 54/1999 — *Airborne Collision Avoidance System (ACAS) — Legal Aspects and Interface with Air Traffic Control*. Available on line at:

http://www.ais.org.uk/Uk_aip/AIP/pdf/aic/4P194.PDF

Civil Aviation Publication (CAP) 579 — *Airborne Collision Avoidance Systems (ACAS)*, 1 March 1994. Available on line at <http://www.caa.co.uk> and in print from:

Documedia Solutions Ltd
37 Windsor Street
Cheltenham, Gloucestershire GL52 2DG
United Kingdom

Tel 44 (0) 870 887 1410
Fax 44 (0) 870 887 1411

United States

Federal Aviation Administration Advisory Circular (AC) 120-55B — *Air Carrier Operational Approval and Use of TCAS II*, 22 October 2001. Available in print only. Order by mail from:

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