LEAFLET NO. 11 Rev 1 **GUIDANCE FOR OPERATORS ON TRAINING PROGRAMMES FOR THE USE OF AIRBORNE COLLISION AVOIDANCE SYSTEMS (ACAS)**

Note: The material contained in this Leaflet has been issued in accordance with Chapter 10 of Administrative & Guidance Material Section Four: Operations, Part Two: Procedures (JAR-OPS).

1 Introduction

1.1 During the implementation of the airborne collision avoidance system (ACAS), several operational issues were identified which had been attributed to deficiencies in flight crew training programmes. As a result, the issue of flight crew training has been discussed within the International Civil Aviation Organisation (ICAO) which has developed guidelines for operators to use when designing training programmes.

1.2 This Leaflet contains performance-based training objectives for ACAS II flight crew training. Information contained in this paper that relates 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 traffic advisories (TAs); and response to resolution advisories (RAs).

1.3 The information given is valid for TCAS II Version 6.04A as well as for Version 7 (ACAS II): where differences do arise, these are identified.

2 Scope

2.1 The training objectives are further divided into the areas of: academic training; manoeuvre training; initial evaluation and recurrent qualification. Under each of these four areas, the training material has been separated into those items which are considered essential training items and those which are considered desirable. In each area, objectives and acceptable performance criteria are defined.

2.2 No attempt is made to define how the training programme should be implemented. Instead, objectives are established that define the knowledge a flight crew member operating ACAS is expected to possess and the performance expected from a flight crew member who has completed ACAS training. However, the guidelines do indicate those areas in which the flight crew member receiving the training should 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

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 flight crew member should demonstrate an understanding of ACAS operation and the criteria used for issuing TAs and RAs. This training should address the following topics:

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a. System Operation

- Objective: Demonstrate knowledge of how ACAS functions.

- Criteria: The flight crew member must demonstrate an understanding of the following functions:

(i) Surveillance:

- ACAS interrogates other transponder-equipped aircraft within a nominal range of 14 nm; and,

- 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 14NM. However, this information is not used for collision avoidance purposes.

(ii) Collision Avoidance:

- 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;

- RAs can be issued only against aircraft that are reporting altitude and in the vertical plane only;

- RAs issued against an ACAS-equipped intruder are co-ordinated to ensure complementary RAs are issued; and

- 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 if own aircraft were not ACAS equipped.

b. Advisory Thresholds

- Objective: To demonstrate knowledge of the criteria for issuing TAs and RAs.

- Criteria: The flight crew member should 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:

(i) 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;

(ii) Thresholds for issuing a TA or RA vary with altitude. The thresholds are larger at higher altitudes;

(iii) A TA occurs from 15 to 48 seconds and an RA from 15 to 35 seconds before the projected CPA; and

(iv) 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 that the flight crew member is aware of the limitations of ACAS.

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- Criteria: The flight crew member should demonstrate a knowledge and understanding of the ACAS limitations including:

(i) ACAS will neither track nor display non-transponder equipped aircraft, nor aircraft not responding to ACAS Mode C interrogations; and

(ii) ACAS will automatically fail if the input from the aircraft's barometric altimeter, radio altimeter or transponder is lost.

Note 1: 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 flight crews are aware of what types of failures will result in an ACAS failure.

Note 2: ACAS may react in an improper manner when false altitude information is provide to own ACAS or transmitted by another aircraft. Individual operators should ensure that their flight crews are aware of what type of unsafe condition can arise. Flight crews should ensure that when they are advised that their own aircraft is transmitting false altitude reports, an alternative altitude reporting source is selected, or altitude reporting is switched off.

(iii) Some aeroplanes within 380 ft above ground level (agl) (nominal value) are deemed to be 'on ground' and will not be displayed. If ACAS is able to determine an aircraft below this altitude is airborne, it will be displayed;

(iv) ACAS may not display all proximate transponder-equipped aircraft in areas of high density traffic;

(v) The bearing displayed by ACAS is not sufficiently accurate to support the initiation of horizontal manoeuvres based solely on the traffic display;

(vi) 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

(vii) 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 that the flight crew member is aware of the conditions under which certain functions of ACAS are inhibited.

- Criteria: The flight crew member should demonstrate a knowledge and understanding of the various ACAS inhibits including:

(i) "Increase Descent" RAs are inhibited below 1,450 ft agl;

(ii) "Descend" RAs are inhibited below 1,100 ft agl;

(iii) All RAs are inhibited below 1,000 ft agl;

(iv) All TA aural annunciations are inhibited below 500 ft agl (1000ft Version 6.04A); and

(v) 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 aeroplane's certified ceiling.

Note: In some aircraft types, "Climb" or "Increase Climb" RAs are never inhibited.

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3.1.2.2 Operating Procedures

The pilot should 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 that the pilot can properly operate all ACAS and display controls.

- Criteria: Demonstrate the proper use of controls including:

(i) Aircraft configuration required to initiate a Self Test;

(ii) Steps required to initiate a Self Test;

(iii) Recognising when the Self Test was successful, and when it was unsuccessful. When the Self Test is unsuccessful, recognising the reason for the failure, and, if possible, correcting the problem;

(iv) 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;

(v) Recognition that the configuration of the display does not affect the ACAS surveillance volume;

(vi) Selection of lower ranges when an advisory is issued to increase display resolution;

(vii) Proper configuration to display the appropriate ACAS information without eliminating the display of other needed information.

(viii) 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; and

(ix) 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.

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

b. Display Interpretation

- Objective: To verify that a flight crew member understands the meaning of all information that can be displayed by ACAS.

- Criteria: The flight crew member should demonstrate the ability to properly interpret information displayed by ACAS including:

(i) Other traffic, i.e. traffic within the selected display range that is not proximate traffic, or causing a TA or RA to be issued;

(ii) Proximate traffic, i.e. traffic that is within 6 NM and ±1,200 ft;

(iii) Non-altitude reporting traffic;

(iv) No bearing TAs and RAs;

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(v) Off-scale TAs and RAs. The selected range should be changed to ensure that all available information on the intruder is displayed;

(vi) Traffic advisories. The minimum available display range which allows the traffic to be displayed should be selected to provide the maximum display resolution;

(vii) 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;

(viii) Resolution advisories (RA display). Flight crew members 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. Flight crew members 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 2,500 ft/min, an Increase Rate RA cannot be properly displayed;

(ix) If appropriate, awareness that navigation displays oriented on "Track-Up" may require a flight crew member 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 flight crew member understands the appropriate times to select the TA only mode of operation and the limitations associated with using this mode.

- Criteria: The flight crew member should demonstrate the following:

(i) Knowledge of the operator's guidance for the use of TA only;

(ii) Reasons for using this mode. 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 for any reason TA Only is not selected, and an RA is received in these situations, the response should comply with the operator's approved procedures.

(iii) All TA aural annunciations are inhibited below 500 ft agl (1,000 ft agl for Version 6.04A). 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 that the flight crew member understands how ACAS advisories will be handled.

- Criteria: The flight crew member should demonstrate knowledge of the crew procedures that will be used in responding to TAs and RAs including:

(i) Task sharing between pilot flying and pilot not flying;

(ii) Expected call-outs, and

(iii) Communications with ATC.

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e. Phraseology Requirements

- Objective: To verify that the flight crew member is aware of the requirements for reporting RAs to the controller.

- Criteria: The pilot should demonstrate the following:

(i) The use of the phraseology contained in the Procedures for Air Navigation Services - Rules of the Air and Air Traffic Services (PANS-RACATM Doc 4444); and,

(ii) Understanding that verbal reports should be made promptly to the appropriate air traffic control unit:

(A) Whenever any manoeuvre has caused the aeroplane to deviate from an air traffic clearance;

(B) When, subsequent to a manoeuvre that has caused the aeroplane to deviate from an air traffic clearance, the aeroplane has returned to a flight path that complies with the clearance;

(C) When air traffic issue instructions that, if followed, would cause the crew to manoeuvre the aircraft contrary to an RA with which they are complying.

f. Reporting Requirements-

- Objective: To verify that the flight crew member is aware of the requirements for reporting RAs to the Operator.

- Criteria: The flight crew member should demonstrate the following:

(i) Where information can be obtained regarding the need for making written reports to various States when an RA is issued. Various States have different reporting requirements and the material available to the flight crew member should be tailored to the airline's operating environment. For JAR OPS 1 operators, this responsibility is satisfied by the flight crew member reporting to the operator according to JAR OPS 1.420

3.1.3 Non-essential Items

a. Advisory thresholds

- Objective: To demonstrate knowledge of the criteria for issuing TAs and RAs.

- Criteria: The flight crew member should 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:

(i) The minimum and maximum altitudes below/above which TAs will not be issued;

(ii) 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 at high altitude;

(iii) 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

(iv) RA fixed range thresholds vary between 0.2 and 1.1 NM.

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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 an ACAS display and controls similar in appearance and operation to those in the aeroplane. If a flight simulator is utilised, 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 flight crew member 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 consequences of failure to respond correctly should be demonstrated by reference to actual incidents such as those publicised in Eurocontrol ACAS II 'safety flash' Bulletins

a. TA Responses

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

- Criteria: The pilot should demonstrate the following:

(i) Proper division of responsibilities between the pilot flying and pilot not flying. Pilot flying should fly the aeroplane using any type specific procedures and be prepared to respond to any RA that might follow. For aircraft without an RA pitch display, pilot flying should consider the likely magnitude of an appropriate pitch change (see Note 1 to 3.2.3 b below). Pilot not flying should provide updates on the traffic location shown on the ACAS display, using this information to help visually acquire the intruder;

(ii) Proper interpretation of the displayed information. Flight crew members 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);

(iii) Other available information is used to assist in visual acquisition. It includes ATC "party-line" information, traffic flow in use, etc.;

(iv) 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, except that if own aircraft is approaching its cleared level at a high vertical rate with a TA present, vertical rate should be reduced to less than 1500 ft/min; and

(v) When visual acquisition is attained, and as long as no RA is received, normal 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 at night, or without a definite horizon are understood.

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b. RA Responses

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

- Criteria: The pilot should demonstrate the following:

(i) Proper response to the RA even if it is in conflict with an ATC instruction and even if the pilot believes that there is no threat present

(ii) Proper task sharing between the pilot flying and pilot not flying. Pilot flying should be responding to a corrective RA with appropriate control inputs. The pilot not flying should monitor the response to the RA and should provide updates on the traffic location, by checking the traffic display. Proper CRM should be used;

(iii) Proper interpretation of the displayed information. The pilot recognises the intruder causing the RA to be issued (red square on display). Pilot responds appropriately;

(iv) 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 1/4g;

(v) Recognition of the initially displayed RA being modified. Response to the modified RA is properly accomplished:

- For Increase Rate RAs, the vertical speed change is started within 2 1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/3g;

- For RA reversals, the vertical speed reversal is started within 2 1/2 seconds of the RA being displayed. The change in vertical speed is accomplished with an acceleration of approximately 1/3g;

- For RA weakenings, the vertical speed is modified to initiate a return towards the original clearance;

Note: An acceleration of approximately 1/4 g will be achieved if the change in pitch attitude corresponding to a change in vertical speed of 1500 ft/min is accomplished in approximately 5 seconds, and of 1/3 g if the change is accomplished in approximately 3 seconds. The change in pitch attitude required to establish a rate of climb or descent of 1500 ft/min from level flight will be approximately 6 degrees when the True Air Speed is 150 kts, 4 degrees at 250 kts, and 2 degrees at 500 kts. (These angles are derived from the formula: 1000 divided by TAS.)

(vi) Recognition of altitude crossing encounters and the proper response to these RAs;

(vii) For preventive RAs, the vertical speed needle or pitch attitude indication, remains outside the red area on the RA display;

(viii) For Maintain Rate RAs, the vertical speed is not reduced. flight crew members should recognise that a Maintain Rate RA may result in crossing through the intruder's altitude;

(ix) When the RA weakens, or when the green 'fly to' indicator changes position, 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;

(x) The controller is informed of the RA as soon as time and workload permit using the standard phraseology;

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(xi) 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 RA (a "Adjust Vertical Speed" RA

(Version 7) ("Reduce Climb" or "Reduce Descent", Version 6.04A), it should be done; the horizontal (turn) element of an ATC instruction should be followed; and

(xii) A knowledge of the ACAS multi-aircraft logic and its limitations, and that ACAS can optimise 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;

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-threat 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.

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 flight crew members 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.

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