ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

Agenda Item 1: Introduction and assessment of a global air traffic management (ATM) operational concept
1.4 The role of airborne collision avoidance systems (ACAS) technologies :

HISTORICAL AND FUTURE ROLE OF THE AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS)

(Presented by the Secretariat)

1. INTRODUCTION

1.1 As one of its high priority initiatives, ICAO has addressed over many years the problem of mid-air collisions in order to build strategies to reduce the risk of these hazards in international civil aviation. As a result, the airborne collision avoidance system (ACAS) was identified as an effective means to accomplish this objective. In this paper, a brief history of the development of ICAO requirements and guidance on ACAS and its role in air traffic management (ATM) are presented.

1.2 ACAS is an aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide information to the pilot on potential conflicting aircraft that are equipped with SSR transponders. ACAS is designed to operate independently of ground-based equipment.

2. HISTORY

2.1 On 21 August 1987, the Federal Aviation Administration (FAA) issued a formal notice that it intended to require the installation and use of ACAS in the United States. The final requirement was for all aircraft carrying more than 30 passengers to be fitted with traffic alert and collision avoidance system II (TCAS II) by 30 December 1993. During 1988, there was a Limited Installation Program (LIP) evaluation of two prototype airborne collision avoidance systems.

2.2 In 1993, States were advised of certain safety objectives for ACAS II. ICAO recognized that ACAS cannot resolve all possible collisions and may cause some risk of collision. However, it concluded that the use of ACAS is expected to reduce significantly the risk of collision among Mode C and Mode S transponder equipped aircraft provided that equipage with transponders is sufficiently widespread. On this basis, the ACAS SARPs were developed, and ACAS carriage was mandated.

2.3 In November 1995, Annex 10 — *Aeronautical Telecommunications* was amended to include ACAS SARPs and guidance material. During 1993 to 1997, there was continuing work, by the

Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP) to refine the collision avoidance logic. There was also work on the surveillance protocols used by ACAS, designed to limit the effect of ACAS on the SSR environment, which had been found to exceed certain limits in the vicinity of major airports.

2.4 In November 1998, Annex 10 was amended to include specifications and logic reflecting the changes found desirable over the previous four years, in particular to standardize the new surveillance protocols and the performance of ACAS Version 7.

2.5 In November 1996, Annex 6 — *Operation of Aircraft* was amended to add the following requirements:

a) From 1 January 2003, all turbine-engined aeroplanes of a maximum take-off mass in excess of 15000 kg or authorized to carry more than 30 passengers shall be equipped with ACAS.

b) From 1 January 2005, all turbine-engined aeroplanes of 5700 kg or authorized to carry more than 19 passengers shall be equipped with ACAS.

3. ROLE OF ACAS

3.1 Paragraph 1.1 of the SICASP/5 report on the safety of ACAS states:

"The objective of ACAS is to provide advice to air crew in order to reduce the risk of collision. This is achieved through RAs, which recommend a manoeuvre, and through TAs, which are intended to prompt visual acquisition and to act as a precursor to the RA."

3.2 For ATM system safety management to be complete, both separation provision and collision avoidance must be separately effective. Separation provision must achieve its required level of safety without considering the beneficial effect of collision avoidance, and collision avoidance must be fully capable of operation when separation provision fails.

3.3 The requirement that collision avoidance (i.e. ACAS) is to be "additional and independent" to separation provision should not be taken to imply that the technological basis of the two functions must be entirely separate. It is accepted that some sharing of components will be inevitable. The obvious example of such sharing, which already occurs, is the shared use of pressure altitude.

3.4 The potential for the sharing of components between separation provision and collision avoidance has been the subject of active discussions between experts in Surveillance and Conflict Resolution Systems Panel (SCRSP) (formerly SICASP) and experts working on airborne surveillance applications in RTCA SC186. These discussions have made the following points.

a) There is a need to determine and evaluate various processes by which separation can be lost, followed by an examination of whether there would be an effective ACAS alert when each of these processes leads to a loss of separation.

b) Whenever a new "separation mode of separation provision" is developed, an analysis must be completed to determine how ACAS advisories will change with the introduction of the new mode.

c) Safety analyses are required to prove that the target level of safety is achieved during air traffic operations. ACAS must not be invoked as a mitigating factor that reduces the risk of collision following a loss of separation.

4. ROLE OF THE ACAS TRAFFIC DISPLAY

4.1 The traffic display is not a standardized component of ACAS. The SARPs require an indication of the approximate relative position of potential threat, and of certain other aircraft when there is a traffic advisory (TA) (Annex 10, 4.3.3.1, 4.3.3.2). This is to aid the reliable visual identification of the potential threat. However, there is no requirement for any particular manner of position indication, nor is there a requirement for an indication of any sort when there is no TA.

4.2 During the development of ACAS Version 7, it was necessary to revise the design of the surveillance in order to limit SSR interference caused by the system. During this process, special attention was paid to the quality of the traffic display. However, collision avoidance and the limitation of SSR interference remained more significant considerations.

4.3 ACAS, including the traffic display, provides valuable situational awareness for collision avoidance. However, the ACAS surveillance function is not designed to provide situational awareness for separation provision, nor more general situational awareness and, in practice, there are complaints about its inadequacy for this role.

4.4 There is good reason to improve the traffic display on the flight deck so that it supports situational awareness for separation provision. Automatic dependent surveillance — broadcast (ADS-B) data could be used in this context without impact on ACAS, and the ACAS SARPs already contain provisions relating to the reception and use of 1090 ADS-B (or extended squitter) for purposes other than collision avoidance, however using ACAS components. In this context, it is essential to have regard to recall the points made in paragraph 3.4 above.

5. ROLE OF OTHER COMPONENTS OF ACAS

5.1 ACAS has or uses several components, in addition to the traffic display, that are or could become part of the communications, navigation, and surveillance (CNS) infrastructure for ATM. Potentially, this could create common modes of failure between separation provision and collision avoidance. The essential considerations are discussed in section 3.

6. COORDINATION WITH THE CONTROLLER

6.1 The 1993 amendments to the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168) did not include discussion of the desirability of following the advice of an ACAS resolution advisory (RA) even if there is a conflicting instruction of an air traffic controller. However, the training objectives distributed as part of a State letter in 1997 included the training objectives that pilots "do not manoeuvre in a direction opposite to that indicated by the RA since the intruder may also

be responding to a coordinated RA." The ACAS implementation guidelines included a warning of a risk of counter-productive interaction between the advice of air traffic control (ATC) and the advice of ACAS. It is imperative that ATS authorities implement satisfactory training and procedures for controllers and pilots to minimize this risk. The PANS-ATM specifies that a controller shall not attempt to modify the aircraft flight path during an RA. However, prior to 2003 there was no ICAO provision stipulating that pilots shall follow ACAS RAs rather than conflicting ATC instructions.

6.2 On 31 January 2001 there was a near collision between two ACAS-equipped aircraft. On 1 July 2002 two ACAS-equipped aircraft collided. In both cases, the flight crew of one aircraft did not follow the ACAS RA, but followed the ATC instruction.

6.3 In May 2003, the PANS-OPS procedures regarding the use of ACAS indications were amended. These amendments require that pilots shall follow the advice of an RA even if there is a conflict between the RA and an ATC instruction (AN-Conf/11-WP/31 refers). They also reinforce the advice never to manoeuvre contrary to an RA, and encourage an early notification to air traffic control (ATC) that an RA is being followed.

6.4 Coordination between pilots and controllers during ACAS RAs, including the possibility of making RA events available to controllers automatically, remains under review.

7. POTENTIAL IMPROVEMENTS IN ACAS

7.1 The possibility of developing ACAS III, i.e. an ACAS that can generate horizontal collision avoidance advice, is not under active consideration.

7.2 ACAS generates many nuisance alerts, i.e. alerts when separation provision has not failed. Technical experts in SCRSP have considered the use of information not currently provided to ACAS to reduce the frequency of such alerts. However, it has been concluded that such data might itself be in error and that its use would create an unacceptable common failure mode between separation provision and collision avoidance. The possibility of using ADS-B data to improve the ACAS collision avoidance logic would be subject to the considerations discussed in section 3 above.

7.3 There is considerable scope to improve the traffic display. However, this would develop it as a component of airborne separation assistance system (AN-Conf/11-IP/5 refers) and should not be considered an improvement to ACAS. In this regard, the critical consideration is the effectiveness of the collision avoidance function and its independence from separation.

8. ACTION BY THE CONFERENCE

8.1 The Conference is invited to note this information, and use it for discussion.

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