# APPENDIX

**DRAFT**

# ICAO AIRBORNE SEPARATION ASSISTANCE SYSTEM (ASAS) CIRCULAR

**Draft prepared by the SCRSP ASAS SG**

**Version 2.0E**

**28 March 2003**

**TABLE OF CONTENTS**

1. Introduction . . . . . . . . . . A-4

Document objectives . . . . . . . . . . A-4
Background and context . . . . . . . . . . A-4

2. ASAS and ASAS applications . . . . . . . . . . A-6

Definition of ASAS . . . . . . . . . . A-6
Scope of ASAS . . . . . . . . . . A-6
ASAS applications . . . . . . . . . . A-7
ASAS applications template . . . . . . . . . . A-10
Responsibility for separation . . . . . . . . . . A-10
Airborne separation provision . . . . . . . . . . A-11

3. Criticality and safety issues . . . . . . . . . . A-12

Elements of ASAS safety assessment . . . . . . . . . . A-13
Comments on the ASAS safety objectives . . . . . . . . . . A-14
Specific ASAS safety issues . . . . . . . . . . A-15

4. ASAS functional characteristics . . . . . . . . . . A-17

Outline of ASAS functions . . . . . . . . . . A-17
Airborne surveillance and separation assurance processing . . . . . . . . . . A-17
Cockpit display of traffic information . . . . . . . . . . A-19
ASAS control panel . . . . . . . . . . A-20
ASAS design and integration issues . . . . . . . . . . A-20

5. ASAS data sources . . . . . . . . . . A-20

6. Interaction with ACAS . . . . . . . . . . A-21

The role of ACAS as an independent safety net . . . . . . . . . . A-21
ASAS conflict detection and resolution and ACAS . . . . . . . . . . A-22
Inhibition of ACAS during ASAS operations . . . . . . . . . . A-23
Shared use of CDTI by ASAS and ACAS . . . . . . . . . . A-23
ACAS hybrid surveillance . . . . . . . . . . A-24

7. ASAS performance requirements . . . . . . . . . . A-24

General . . . . . . . . . . A-24
Required surveillance performance for ASAS tracks . . . . . . . . . . A-24
Quality of data sources . . . . . . . . . . A-26

8. ASAS operational considerations . . . . . . . . . . A-26

Responsibilities during ASAS operations . . . . . . . . . . A-26
ASAS procedural and human factors issues . . . . . . . . . . A-27
ASAS and the ‘party line’ . . . . . . . . . . A-28
Training considerations . . . . . . . . . . A-28
ASAS transitional issues . . . . . . . . . . A-28

9. Projects and trials . . . . . . . . . . A-29

Introduction . . . . . . . . . . A-29
Outline of ASAS activities . . . . . . . . . . A-29
US activities . . . . . . . . . . A-29
European activities . . . . . . . . . . A-31
Coordination of R&D . . . . . . . . . . A-33
Standards and implementation . . . . . . . . . . A-33

10. Document terminology . . . . . . . . . . A-34

11. References . . . . . . . . . . A-35

**Attachments**

A — Documents required to standardize ASAS . . . . . . . . . . A-36
B — Template for assessing of ASAS applications . . . . . . . . . . A-37
C — Descriptions of ASAS applications . . . . . . . . . . A-41
D — Acronyms . . . . . . . . . . A-50

# 1. INTRODUCTION

## 1.1 Document objectives

1.1.1 This circular provides a high level overview of the airborne separation assistance system (ASAS) and its potential uses, and identifies the main operational and technical issues related to ASAS. Particular emphasis is given to the aircraft system considerations.

1.1.2 The main objective is to inform the aviation community about existing activities related to airborne situational awareness and airborne spacing and separation provision. It is considered of interest to publish information concerning these development activities as widely as possible, with a view to promoting a common understanding. It must be noted that the maturity of some applications is more advanced than others.

1.1.3 This circular describes ASAS, and its potential uses, with reference to the current air traffic management (ATM) system and to the transition as changes to the ATM system are introduced. Where appropriate, references are made to the corresponding elements of the future ATM operational concept [5].

1.1.4 The widespread operational implementation of ASAS would imply a new method of provision of some air traffic services, which might include a new distribution of responsibilities between the flight crews and the ATM service provider. Various safety and operational issues requiring further investigation are developed in this circular. The burden of proof will lie with those who would propose to change the current ATM system.

1.1.5 Implementation would also require acceptance from pilots, controllers and the aviation community. However, a decision to implement some operational uses, i.e. applications, of ASAS would not necessarily imply a commitment to implement other uses. For example, any use of ASAS to enhance flight crew's traffic situational awareness does not imply inevitable progression to implementing airborne self-separation.

1.1.6 This ASAS circular develops appropriate ideas and terminology to promote a common understanding of ASAS in the aviation community. Neither the publication of this ASAS Circular nor its contents implies or constitutes any commitment to implement ASAS, nor even a recommendation.

## 1.2 Background and context

1.2.1 The acronym 'ASAS' was coined in 1995, in reaction to pressures and desires to use the traffic display provided with an airborne collision avoidance system (ACAS) for purposes other than collision avoidance. [1] These pressures were evidence of the potential value of a flight deck system designed to give pilots a comprehensive and accurate picture of the surrounding air traffic. The SSR Improvements and Collision Voidance Systems Panel (SICASP) continued to develop the idea of ASAS until its next full meeting, SICASP/6 in 1997. [2] At that time, the main concern of SICASP was that ACAS was not intended for the ASAS function, and that the use of ACAS for anything other than collision avoidance could be counterproductive to ACAS.

1.2.2 Following SICASP/6, SICASP was tasked to develop and review proposals for operational and technical procedures for the use of ASAS; and to address ASAS criticality issues and their relationship with ACAS integrity. In 2000, the Surveillance and Conflict Resolution Systems Panel (SCRSP), the successor to SICASP, was given an expanded task on ASAS. This circular is the first step in the development of a manual for ASAS, which would cover these issues, and is in part fulfilment of the task laid on SICASP, which is now being discharged by SCRSP.

1.2.3 Following ADSP/4 in 1996, the Automatic Dependent Surveillance Panel (ADSP) had been tasked to develop an operational concept and operational requirements for the use of a system "to increase aircraft situational awareness and provide airborne separation assurance". Subsequently, the ADSP monitored the activities in several States developing the potential operational use of ASAS. At ADSP/5 in 1999, the Panel received and reported "information relevant to the use of a system to increase traffic situational awareness and provide airborne separation assurance." [3]

1.2.4 Under the auspices of Action Plan 1 of the FAA/EUROCONTROL Co-operative Research and Development Committee, a document [4] has been developed on the 'Principles of Operations for the Use of ASAS (PO-ASAS)'. The PO-ASAS, which is not an approved policy for ASAS applications, sought to focus the work necessary prior to the implementation of any ASAS application. The intended use of PO-ASAS was as guidelines by the research community, and other groups dealing with ASAS development. Thus, PO-ASAS has been taken into consideration when developing this ASAS Circular. In particular, the four categories of ASAS application identified in PO-ASAS are introduced in Section 2.

1.2.5 Trials and projects related to ASAS and its applications are in progress in various States and international organizations. These include fast time simulations, real time simulations, flight trials and limited local implementation. The first applications have been certified for operational use, and analyses similar to those required for certification have been carried out for some other potential applications. A brief résumé of these is provided in Section 9.

1.2.6 At its first meeting, in March 2002, the Air Traffic Management Concepts Panel (ATMCP) agreed an 'ATM Operational Concept Document'. [5] This outlined a vision for the potential evolution of ATM over the next three decades. This ASAS Circular is intended to support a range of elements described in the ATM operational concept. Indeed, the operational concept frequently refers explicitly to ideas and potential developments that are elaborated further in this circular. In the language of the operational concept, ASAS (as described in this circular) would support 'Information Management', 'Separation Provision' (which is part of 'Conflict Management') and 'Traffic Synchronization'. The operational concept states 'the pre-determined separator will be the airspace user, unless safety or ATM system design requires a separation provision service'. ASAS is the flight deck system that would enable this role in respect of separation from other traffic.

1.2.7 If ASAS were to be implemented, an international consensus through ICAO Standards would be required. International applicability of ASAS procedures, airborne separation minima, and any amendment to flight rules will require agreement and standardisation through ICAO. The ICAO documentation that would be expected to be required is listed at Attachment A.

## 2. ASAS AND ASAS APPLICATIONS

### 2.1 Definition of ASAS

2.1.1 In this circular, following discussions within SCRSP Working Group A (WGA) and elsewhere, ASAS is defined as:

> An aircraft system based on airborne surveillance that provides assistance to the flight crew supporting the separation of their aircraft from other aircraft.
>
> *Note.— It is recognized that separation from other hazards is also of importance, but these are beyond the scope of the assistance provided by an ASAS.*
>
> *Note.— The assistance provided to the flight crew by an ASAS may be limited to the provision of relevant flight concerning surrounding traffic. More automated decision support may also exist through an ASAS that provides advice to the flight crew to maintain instrument-based separation.*

And an ASAS application is defined as:

> A set of operational procedures for controllers and flight crews that makes use of an airborne separation assistance system to meet a defined operational goal.

### 2.2 Scope of ASAS

2.2.1 The range of ASAS applications that have been envisaged encompass those seeking to increase flight crews' situational awareness related to traffic, and those assisting the flight crew in maintaining the separation of aircraft. It is expected that ASAS applications could provide some significant operational advantages to both ATM service providers and airspace users alike. In addition, there could be some additional safety benefits due to improved situational awareness for the flight crew.

2.2.2 However, ASAS does not address the flight crews' complete situational awareness, which also includes weather, proximity to the ground, structure of the airspace (i.e. classes, restricted areas), aircraft state/control and many other aspects. Similarly, although 'separation' might often and usefully be considered to mean separation from all hazards (including the ground, or weather), in this circular 'separation' is from traffic. Failure to discuss separation from other hazards is not intended to imply that they are less than critical, nor that the support required to provide separation from other hazards would not be integrated with the support required to provide separation from traffic. It is merely that the discourse of this circular concerns separation from traffic, and the need to ensure freedom from the risk of collision between aircraft. Nevertheless, it is recognized that it will be necessary to consider separation provision from all hazards (not necessarily performed by the flight crew) before implementation of ASAS applications.

2.2.3 ASAS is often mentioned in the same context as automatic dependent surveillance — broadcast (ADS-B), but ASAS and ADS-B should not be confused. It is true that ASAS applications will require a surveillance capability, probably based on ADS-B, but not exclusively. For example, ASAS surveillance would probably use traffic information service — broadcast (TIS-B) where it is implemented[1]. In addition to airborne surveillance, some ASAS applications will require separation assistance capabilities.

2.2.4 ASAS cannot fulfil the ACAS function, which is to provide a collision avoidance safety net independent of the means of providing separation. [5] The relationship between ASAS and ACAS is discussed in Section 6.

2.2.5 ASAS encompasses applications related to traffic whether the aircraft is airborne or on the airport surface. When both own aircraft and other traffic are on the airport surface, ASAS is limited to situational awareness applications.

## 2.3 ASAS applications

2.3.1 Four broad categories of ASAS applications have been identified, for:

a) traffic situational awareness;

b) airborne spacing;

c) airborne separation; and

d) airborne self-separation (from all traffic).

***Traffic situational awareness applications***

2.3.2 Traffic situational awareness applications are aimed at enhancing the flight crews' knowledge of the surrounding traffic situation, both in the air and on the airport surface, and thus improving the flight crew's decision making process for the safe and efficient management of their flight. No significant changes in separation tasks are anticipated for these applications, and there would be no change in separation responsibility. However, it is possible that the mere fact of increased knowledge could entail some changes in procedures, for example in phraseology.

2.3.3 Three examples of ASAS traffic situational awareness applications are:

'Enhanced traffic situational awareness on the airport surface'

This ASAS application aims at increasing the traffic situational awareness of the flight crews operating an aircraft on the airport surface, for both taxi and runway operations, in all weather conditions. The objectives are to increase safety by a reduction of the potential for collisions on the airport surface, and secondarily, possibly, to better expedite the traffic flow, particularly in bad weather conditions. It would not alter the responsibility of the controller to manage traffic under his control.

[1] TIS-B can provide surveillance of traffic that is not equipped to broadcast ADS-B.

‘Enhanced traffic situational awareness during flight operations’

This ASAS application aims at increasing the traffic situational awareness of the flight crews during flight operations in all weather conditions and in all types of airspace (e.g. radar control, procedural control). Additional data would be provided to flight crews to supplement traffic information provided either by controllers or by other flight crews. The objectives are to improve safety of flight and to reduce the workload of air traffic control.

‘Enhanced visual acquisition for see-and-avoid for instrument flight rules (IFR) and visual flight rules (VFR)’

This ASAS application aims at improving IFR/VFR compatibility where separation is not provided by controllers between these two types of traffic. It would provide an aid to enhance visual acquisition of VFR traffic for flight crews, operating under either IFR or VFR, which could enable the ‘see-and-avoid’ principle to be applied more effectively.

These examples are described in greater detail in Attachment C.

***Airborne spacing applications***

2.3.4 In airborne spacing applications, separation provision would remain the controller’s responsibility and applicable separation minima would probably be unchanged. The controller would require the flight crew to perform new tasks so as to provide or, in some cases, maintain a given distance or time from designated aircraft, as specified in a new ATC instruction.

2.3.5 Controllers could use airborne spacing instructions to expedite and maintain the orderly flow of traffic, or to provide separation. For the former, the requirements on the delivery of the spacing could be relatively slack provided the spacing is well in excess of the separation minimum. If used for separation purposes, the requirements on the delivery of the spacing are likely to be more stringent.

2.3.6 An example of airborne spacing applications is ‘Enhanced sequencing and merging operations’, which would help to support traffic synchronization as described in [5]. The objective of this application is to redistribute tasks related to sequencing (e.g. in-trail following) and merging of traffic between the controllers and the flight crews. The controllers would use new instructions to direct the flight crews to undertake a new task, establishing and maintaining a specified spacing distance or time from a designated, preceding, aircraft. The flight crews would perform these new tasks using new aircraft functions. This example is described in greater detail in Attachment C.

2.3.7 The ability of the controller to issue instructions to the flight crew to apply a specified spacing from designated aircraft is expected to streamline the controller’s task, potentially leading to increased ATC capacity. The ability of the aircraft to maintain a specified spacing more accurately than at present could also lead to increased ATC capacity.

***Airborne separation applications***

2.3.8 In airborne separation applications, the controller would delegate separation responsibility and transfer the corresponding separation tasks to the flight crew, who would ensure that the applicable airborne separation minima are met. The separation responsibility delegated to the flight crew would be specified by a new clearance, which would be limited to designated aircraft, and in time and space. Except for this specific delegation, separation provision would remain the controller's responsibility.

2.3.9 To be safely and efficiently performed, these applications will require the definition of conditions of use, allowed limits of manoeuvring, applicable airborne separation minima, and contingency procedures.

2.3.10 It is not envisaged that the controller would monitor the separation delegated to the flight crew. The applicable airborne separation minima would be distinct from the separation minima that the controller would observe in the absence of delegation, and might be larger or smaller.

2.3.11 An example of airborne separation applications is an 'ASAS crossing clearance'. It is based on the controller delegating to the flight crew of a suitably equipped aircraft the task of separation provision with respect to designated crossing traffic. When the flight crew have received and accepted an ASAS crossing clearance, they would maintain airborne separation from designated traffic, in compliance with the applicable airborne separation minima and any manoeuvre restrictions that have been imposed (e.g. lateral only). The objectives are to increase the sector capacity through the reduction of controller's workload (fewer conflicts to resolve simultaneously) and to improve flight efficiency by optimisation of the specific conflict resolution. This application is described in greater detail in Attachment C.

2.3.12 The delegation of separation responsibility from the controller to flight crew could improve the flexibility and capacity of the ATC system, while preserving or enhancing safety. Increased ATC capacity might be achieved by streamlining the controllers' task through delegating the resolution of anticipated conflicts, and reducing the monitoring workload. The use of airborne separation standards, whose minima might be less than the separation minima applied by ATC, might improve efficiency, by reducing the number and extent of trajectory changes used to resolve conflicts.

***Airborne self-separation applications***

2.3.13 Airborne self-separation applications would require flight crews to separate their flight from all traffic, in accordance with the airborne separation minima and rules of flight applicable for the airspace occupied.

2.3.14 An example of airborne self-separation applications is 'Autonomous aircraft operations in dedicated airspace'. In dedicated portions of en-route airspace, to which access would be restricted to suitably equipped aircraft, aircraft are able to fly user-preferred three dimensional (3D) or 4D routings. The flight crew would be responsible for separation from other aircraft operating in the dedicated airspace, and there might be no tactical separation provision by an ATM service provider. This application is described in greater detail in Attachment C.

2.3.15 This is not the only mode of airborne self-separation that is currently anticipated. Alternative applications, in which access is not restricted and an ATM service provider has separation responsibility for some aircraft, could also be envisaged (for an example, see 9.3.10 concerning DAG-TM).

2.3.16 The expected benefits include better flight efficiency, through user-preferred routings and conflict resolutions. There may also be instances where self-separation could provide increased airspace capacity, but this is less obvious and is yet to be demonstrated.

## 2.4 ASAS applications template

2.4.1 To permit initial identification and assessment of the requirements for a proposed ASAS application, proposals should follow a standard template format, which addresses pre-determined areas. By this mechanism, the equipment functional and performance requirements, and the operational procedures including appropriate contingency measures, will be able to be assessed. This approach would enable operational and regulatory implications of a proposed application to be exposed and addressed. ICAO bodies are encouraged to use the template provided in Attachment B for the initial definition of applications.

2.4.2 RTCA has further developed this template to include other areas such as economic considerations and some certification aspects. [6] European projects have used a similar approach.

## 2.5 Responsibility for separation

2.5.1 Responsibility for providing separation between aircraft derives from the role of ATC defined in Annex 11 and Doc 4444. [7, 8] There are some ATC procedures in which the flight crew has, or is delegated, responsibility for separation based on their visual acquisition of other aircraft, but generally the controller is responsible for providing separation. In executing the responsibility for separation, the controller relies on the flight crew to follow his instructions and clearances. The use of ASAS could enable changes in the allocation of responsibility for separation between the ground and the air, which could be exploited by new instructions and clearances. Airborne spacing applications would not imply a change in separation responsibility, but airborne separation and self-separation applications would imply that the flight crew has some or total responsibility for separation, which would be enabled by ASAS.

2.5.2 The question of liability in the event of a loss of separation would be an issue for the authorities in the State in which it occurred, and it is outside the scope of this circular. However, both flight crews and controllers will require a clear understanding of their respective responsibilities and potential liability before they could undertake new procedures based on ASAS. The delegation or allocation of responsibility for separation could be the most complex aspect of introducing ASAS. In particular, there will be need for a mutually clear transfer of responsibility for separation, and it might be difficult to gain controllers' and flight crews' acceptance of this aspect of ASAS. This is discussed further in section 8.1.

2.5.3 The four categories of ASAS applications introduced in Section 2.2 each corresponds to a precise allocation of responsibility for separation between the ground and the air, stated in terms of current practices:

a) no change to current roles and responsibilities. In traffic situational awareness applications, present procedures would be enhanced through the flight crew's knowledge and understanding of the surrounding traffic situation.

*Note.— In the language of the ATM operational concept [5], traffic situational awareness applications help support 'information management' related to traffic.*

b) execution of new tasks without any delegation of responsibility. In airborne spacing applications, the controller would remain responsible for monitoring separation and taking corrective action, should it be necessary. This is not different in principle from the current situation, but the objective is to improve the efficiency of the controller's task.

*Note.— In the language of the ATM operational concept [5], airborne spacing applications are not examples of 'cooperative separation'.*

c) tactical delegation of responsibility. In airborne separation applications, the controller would delegate responsibility to the flight crew for maintaining airborne separation from designated aircraft only, the delegation being limited in time and space. The controller would retain responsibility for separation from all other aircraft.

*Note.— In the language of the ATM operational concept [5], airborne separation applications are instances of 'cooperative separation' between a service provider and an airspace user, with respect to designated traffic. The operational concept defines 'cooperative separation' as a temporary delegation.*

d) strategic allocation of responsibility. In airborne self-separation applications, separation responsibility from all known traffic would be allocated to the flight crew. The controller might retain responsibility for managing the overall volume of traffic, or expected traffic flows such that they are compatible with the capabilities of ASAS.

*Note.— In the language of the ATM operational concept [5], airborne self-separation applications would not be considered as a strategic delegation of separation responsibility, since the airspace user is defined as the pre-determined separator.*

There is no difference, in terms of separation responsibility, between a) and b). The more mature ASAS applications are these, which do not require changed responsibilities for separation.

## 2.6 **Airborne separation provision**

2.6.1 Airborne separation and self-separation applications will entail a significant change in the way separation is provided compared to current practices. For this reason, these applications are less mature than those in the other categories.

2.6.2 Separation provision includes many elements in addition to allocating responsibility for separation: the principles of collision avoidance contained in the 'Rules of the Air'; the measures associated with the flight rules; flight procedures; the provision of air traffic services and procedures; and the establishment of the separation standards. ASAS airborne separation and self-separation applications, which will require flight crew to have some responsibility for separation, will also require the development of specific procedures and standards for airborne separation minima. Specific rules may also be required for airborne self- separation applications.

2.6.3 The prerequisites for the implementation of airborne separation applications include:

a) **Procedures**[2]. The procedures are required to define, clearly, the allocation of separation tasks and the roles of both controllers and flight crew, depending on the type of airspace and rules of flight. In particular, the procedures must define the responsibility for initiating any manoeuvres necessary to correct a potential loss of separation. Also, for the event that technical failure or operational error compromises the procedure, appropriate contingency procedures must be developed. If there is a separation provision service, these contingencies should enable the safe re-establishment of ATC separation by the controller.

b) **Airborne separation minima**. The determination of airborne separation minima to be applied for airborne separation needs to take into account various factors, including the operational procedures, communication, navigation and surveillance capabilities, the flight performance capabilities of the aircraft and the capabilities of the crew. Flight crew executing airborne separation procedures would have to comply with established airborne separation minima. There is no necessary relationship between ATC separation minima and airborne separation minima. However, on an application-specific basis, the relationship between those separation minima will have to be considered when separation responsibility needs to be transferred back to ATC.

c) **Rules of the air.** In the case of airborne self-separation applications, new rules may need to be developed to address aircraft right of way during ASAS operations.

d) **Technology.** The appropriate ASAS technology to support these operational changes is essential. The facilities and functions required would depend on the details of each application, and on the procedures, minima and flight rules that are used.

2.6.4 Separation provision requires an appropriate means of communication. At present, the communication is usually by radiotelephony (RTF) between flight crews and controllers, and this, or potentially a replacement by controller-pilot data link communications (CPDLC), will be required for almost all ASAS applications. However, airborne separation and self-separation will often require direct communication between aircraft, particularly where coordination is required; this coordination between aircraft is expected often to be by an air-air crosslink, as opposed to broadcast.

---

[2] In this circular, the term ‘procedures’ has been used to include the actions carried out by controllers and flight crew as well as, for example, the methods used for the provision of separation from an ICAO perspective.

2.6.5 The need for explicit coordination of conflict avoidance manoeuvres between aircraft is not yet proven, and is disputed because several conflict resolution algorithms are self-organizing. However, the risk of inconsistent manoeuvres has to be extremely remote (sufficiently remote to ensure that the safety objectives discussed in Section 3.5 are met), and this might well require explicit coordination, even for self-organizing algorithms.

## 3. CRITICALITY AND SAFETY ISSUES

3.1 Although ASAS will operate between aircraft, it will also be part of ATM. Thus, safety objectives will need to be specified and allocated among the components of ATM, including its supporting communication navigation and surveillance (CNS) systems. As for any new equipment or procedures, the introduction of ASAS will require proof that it meets the safety objectives that have been allocated.

3.2 The operational use of ASAS will interact with its technical aspects, with consequences for safety and criticality. Therefore, the safety of each individual ASAS application must be assessed.

3.3 At present, the development, certification, and regulation of aircraft systems are conducted separately from those of ground systems. However, the air-to-ground interactions in ASAS applications transcend present regulatory institutions, and necessitate a coordinated process. Thus it is desirable that the safety assessment of ASAS applications consider the airborne components and the appropriate ground ATM components as a whole.

### 3.4 Elements of ASAS safety assessment

***Operational safety assessment***

3.4.1 The principal means of assessing ASAS applications should be based on an established process such as the operational safety assessment (OSA) defined by RTCA SC189/EUROCAE WG53[3] [9]. This process, with suitable adaptation, allows equipment distributed among multiple aircraft and ground stations, and the associated procedures, to be considered in the precise context of its intended use. OSA will need to be performed for each individual ASAS application. The process will produce requirements for ASAS equipment suitable for that application. Several of the key components of the process are the following:

a) the **operational services and environment definition** describes the application and where it is to be used. It should include the responsibilities of flight crews and ATC, the procedures and responsibilities, and the airspace and ATC characteristics;

b) the **operational hazard analysis** describes events and failure conditions that could produce operational hazards. The essence of this analysis is to determine the worst-case effect of each hazard, after accounting for mitigating factors that are present in the

[3] RTCA Special Committee 189 and the European Organisation for Civil Aviation Equipment Working Group 53. RTCA is not an acronym and refers to RTCA Inc.

equipment, procedures, and environment. The severity of each effect determines the maximum acceptable likelihood; and

c) the **allocation of safety objectives and requirements** assigns requirements to the various elements of CNS/ATM equipment and procedures so that the overall safety objective is met. This process relies upon the analysis of ASAS components so that the risks of various hazards may be made acceptable without undue burden on any component. For example, an equipment's development assurance level need not correspond to the highest hazard criticality in certain environments where other mitigating factors can be shown to reduce the hazard's severity or likelihood.

3.4.2 For those ASAS applications that would require safe airborne separation criteria to be established, the relationship between the use of the OSA methodology (to allocate safety objectives and requirements) and separation and collision risk assessment methods might have to be established. This would provide an overall framework for the establishment of airborne separation standards and associated air/ground safety requirements.

3.4.3 Indeed, one major issue when allocating the safety objectives and requirements for ASAS applications would probably consist of finding an acceptable combination of safety performance requirements assigned to the air/ground components and the separation criteria requirements.

***Specific assessment methods***

3.4.4 Many other means of analysis are used to support the OSA and subsequent validations of safety. The methods should be chosen to develop consensus that the systems are well understood and that hazard consequences and likelihoods meet the requirements derived from the OSA. Following are several of the available types of assessment methods:

a) **fault tree.** This is a graphical and analytical technique that expresses the elements contributing to a hazard, illustrates their logical relationship, and enables the calculation of the hazard likelihood. Analytical tools are available to incorporate statistical distributions;

b) **failure modes and effects analysis**. This method systematically evaluates potential failures of every function or component, producing a consequence of each;

c) **analytical models**. Certain hazards may be evaluated by modelling and analysis. This is the conventional method used for determining collision risk in some environments;

d) **fast-time simulation**. Computer simulation enables the evaluation of system performance over large numbers of traffic geometries, simulation of statistically distributed phenomena and rare events, and combinations of factors that are far too numerous to test by any other means;

e) **formal analysis**. This methodology can prove that a specification is complete and correct;

f) **human-in-the-loop simulation**. Applications may be evaluated in simulators of varying fidelity to demonstrate the feasibility and effectiveness of procedures, evaluate human-machine interactions, assess off-nominal conditions, and test contingency procedures; and

g) **flight trials**. Systems and applications may be evaluated in aircraft to sample the performance of all elements in full fidelity conditions.

3.4.5 The analyses listed above may contribute to, but do not replace, the ultimate evaluations required for equipment certification. That process considers additional factors, such as the integration of equipment in an aircraft.

## 3.5 Comments on the ASAS safety objectives

3.5.1 Aircraft operations should be based on the use of ASAS only when ASAS and the procedures agreed for its use provide the level of safety normally required for the operations in question. The ICAO standards and recommendations [10] suggest a target level of safety of $1.5\times10^{-8}$ collisions per flight hour. (More precisely, $5\times10^{-9}$ fatal accidents per flight hour per spatial dimension when determining the acceptability of future en-route systems that will be implemented after the year 2000.) This target relates to airspace standards and design, such as the determination of separation minima.

3.5.2 For equipment, the normal requirement for certification is to design ASAS, the system, so that the risk of catastrophic loss (e.g. collision) is no higher than $1\times10^{-9}$ per flight hour or per operation, based on reasonable, nominal use of the system. Operational procedures that use ASAS, ASAS applications, should then be approved only if the target level of safety of $1.5\times10^{-8}$ collisions per flight hour is achieved taking into account the full realistic range of possible flight crew and controller behaviours. The determination of separation minima should be part of the definition of the ASAS application, and thus part of the latter analysis.

3.5.3 It would not usually be sufficient merely to show that an ASAS application is safer than current practices, in lieu of addressing the safety objective. For those applications that, in any significant respect, are new, there is nothing to compare on a detailed basis.

3.5.4 When addressing the safety of an ASAS application, the contribution of ACAS must neither be included in determining the level of safety required for separation provision nor in demonstrating that such required level of safety is being met. However, ACAS, which provides additional protection beyond separation provision, forms part of ATM system safety management. [5] Therefore, the following points need to be taken into account:

a) the reduction in the risk of collision achieved by ACAS depends on context and therefore is not known for ASAS applications. It would need to be derived anew for ASAS applications. The calculations that have been made were for existing ATM practices and traffic patterns;

b) the mandate for ACAS was based on the premise that it provided a level of protection in addition to that provided by the primary means of separation, without regard to the absolute levels of safety with or without ACAS;

c) if ASAS is designed in a way that removes the independence of ACAS, then ACAS becomes less effective in reducing collision risk and the policy objective in mandating ACAS is subverted.

The role of ACAS as a safety net is discussed in Section 6.

### 3.6 Specific ASAS safety issues

3.6.1 This section discusses technical and operational safety issues that are specific to ASAS. This list is not exclusive, rather it is intended to be illustrative.

***Technical safety issues***

3.6.2 During any future transition to use of ASAS, when all aircraft might not be equipped with ADS-B, the ASAS cockpit display of traffic information (CDTI) might not receive surveillance data for all aircraft. In this circumstance, the ASAS could provide flight crew with a false sense of security since it would not necessarily display proximate traffic. Flight crew training must specifically address this point.

3.6.3 If the ASAS utilises surveillance data from different sources, the plan position accuracy of the displayed targets might not be mutually consistent. Therefore, flight crew interpretation of the data might not be appropriate. This situation could be avoided, potentially, by requiring a minimum level of data accuracy for any aircraft that is displayed, or by providing a clear indication of the inconsistency.

3.6.4 At this stage, it is an open question whether ADS-B data will have sufficient integrity to support all ASAS applications. Data from other sources, such as TIS-B, might be used to increase the integrity of the ASAS surveillance data, but in this case risks arising from any common failure modes with ground-based ATC must be addressed.

3.6.5 Any plans to base ATC surveillance on ADS-B alone, while ASAS is also based on ADS-B, would require proof that the simultaneous use of ADS-B for both functions does not degrade the safety of the ATM system. In this circumstance, as ADS-B navigation sources and ADS-B communications would be central to both airborne and ground based surveillance, a failure in ADS-B might lead to an increased risk of loss of separation through simultaneous loss of both surveillance systems.

3.6.6 The use of data from more than one source creates the risk that a single aircraft could be represented by more than one target symbol. This could present problems for correct interpretation of the ASAS display. This aspect is discussed at paragraph 4.2.

***Operational safety issues***

3.6.7 Under present ATC systems, instructions for separation and sequencing are centrally managed on a ‘first-come first- served basis’. These instructions are obligatory, except for due cause. Therefore, cooperation between aircraft for separation and traffic sequencing priority is naturally ensured. In order to avoid a potential reduction of the safety levels of the ATM system, even if all technical aspects are solved, the application of procedures should be monitored in self-separation applications. This would be to ensure appropriate adherence to flight rules and the applicable separation minima, for example in instances where commercial interest or other reasons could lead to situations where the application of the safety margins is not respected. However, it is not anticipated that this would be an appropriate function for an air traffic services (ATS) provider.

3.6.8 In airborne separation applications, which involve a tactical delegation of responsibility for separation, it will be necessary to ensure that there is a procedure that clearly defines the role of both ATC and the flight crew. This is required to avoid unsafe situations that could arise from misunderstanding or incorrect implementation of separation tasks.

3.6.9 An ASAS alerting system might be required to support airborne separation monitoring tasks performed by the flight crew. The efficacy of the ASAS alerts, and the priority with respect to alerts generated by other aircraft systems, would need to be addressed.

3.6.10 ASAS applications will involve new skills and tasks for the flight crew. Specific flight crew training must be provided to ensure correct interpretation and use of ASAS equipment. Equally importantly, the ATC ASAS training requirements must be addressed.

## 4. ASAS FUNCTIONAL CHARACTERISTICS

### 4.1 Outline of ASAS functions

4.1.1 An ASAS will interact with a specific on-board surveillance data transmission and reception (Tx/Rx) function, a communication system, and flight data system. A typical ASAS for commercial transport aircraft would include a surveillance data and separation assurance[4] processing system, a cockpit display and alerting system, and a control panel.

4.1.2 Figure 1 shows the main ASAS functions (inside the bold box), and their relation and potential exchanges of data with other systems. The diagram is not intended to prescribe architecture; it is purely conceptual. However, the functions inside the bold box are specifically ASAS functions, and those outside the bold box are not.

4.1.3 **Flight data system.** Provides flight and navigation data for the surveillance data Tx/Rx function (e.g. for ADS-B) and the ASAS.

4.1.4 **Surveillance data Tx/Rx function.** Receives surveillance data from all sources of surveillance, mainly broadcast data sources, and transmits own ship data.

4.1.5 **Communication system.** An addressed communication link might be required between ground systems and airborne systems, and between ASAS units of participating aircraft.

---

[4] The word ‘assurance’ has generally been avoided in this circular. It is retained in this context for the sake of consistency with the terminology of RTCA, who are developing standards for ASSAP — see Section 4.2.

## 4.2 Airborne surveillance and separation assurance processing

4.2.1 There is a requirement for an airborne surveillance and separation assurance processing (ASSAP) function. ASSAP processes the data received, forms tracks for other aircraft, presents the tracks to a cockpit display and makes any calculations required for particular applications, in particular to support the airborne separation process.

4.2.2 ASSAP is likely to perform several individual functions:

a) **Combination and processing of surveillance data**. This function processes surveillance reports from one or more sources, develops current estimates of position and velocity for each target aircraft, and makes these available to the CDTI function. This function includes several elements:

1) **Correlation.** Correlation is the determination of the aircraft to which a surveillance report is to be assigned.

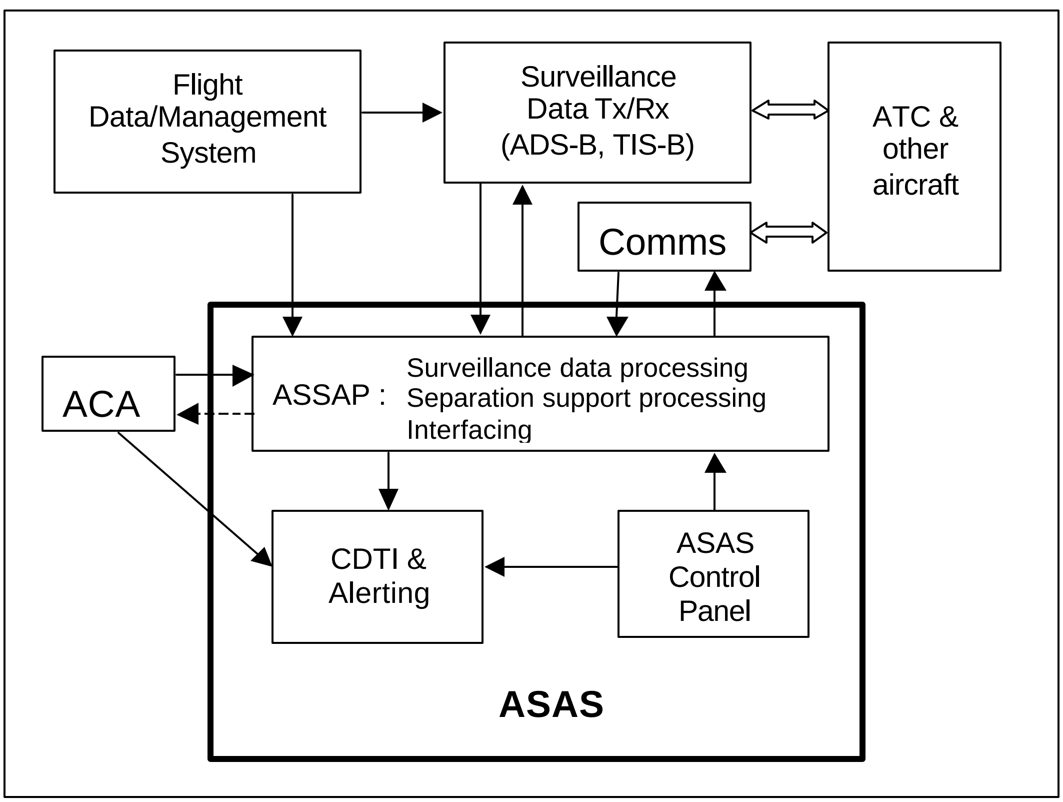


**Figure 1. Functional Diagram of ASAS and relation with other systems**

2) **Data fusion.** When multiple sources provide data for a target, a data fusion function must gather the reports, select or combine data from the various sources, possibly provide smoothing, and determine the appropriate quality measure to accompany the estimate. The estimated position, velocity, intent or other data (if any), quality measure, and the corresponding time are considered to form a 'track' for the target aircraft. The selection and use of one source of data in preference to others is here considered to be a simple form of fusion.

The consequence for ACAS functionality of using ACAS data in ASAS is discussed in Section 6.1. The use of the ASAS CDTI to display ACAS alerts and tracks is discussed in Section 6.4.

Own aircraft's navigation and intent data, while not strictly surveillance data, are used to develop information on targets relative to own aircraft.

b) **separation support processing.** This function performs processing of target data using criteria unique to the operational application, normally for supporting special display features or alerts pertaining to a target. It may not apply to traffic situational awareness applications of ASAS, for which the display of the target's track information on the CDTI may suffice.
The function needs an input to determine the application to be performed, and any particular parameters required for the application. It may include conflict detection and resolution (CD&R), and monitoring of the conflict resolution manoeuvre.

c) **External communication of conditions.** This function might be used to enable own ADS-B broadcasts, or if appropriate, crosslinks between aircraft, to announce any special conditions determined by on-board processing. Examples of such conditions could include: own aircraft's participation in an application; a coordination message between ASAS CD&R of the participating aircraft; or an alert condition declared by own ASSAP; and

d) **Internal communication of conditions.** This function might be used to notify other onboard functions of the status of an ASAS application. One example could be to indicate ASAS is conducting an application based on intentional close proximity to a target, and to identify that target. The possibility of suppressing ACAS alerts against specific targets during particular ASAS applications is discussed in Section 6.3.

### 4.3 Cockpit display of traffic information (CDTI)

4.3.1 The display is the interface between the data processing and the flight crew. The display could be substituted, or complemented, by an aural, textual, or graphical means of communicating information to the flight crew. Required display elements and their quality will depend on the intended operational use of the data.

4.3.2 The capabilities of the CDTI need to be consistent with those of ASSAP and the needs of the applications. Individual tracks will have to be selectable for some applications, so that additional information can be provided for those tracks.

4.3.3 The minimum information displayed by a CDTI could, for simple ASAS, be no more than the positions of proximate traffic. It is essential that the information required for any ASAS application is provided, but this can be regulated by not permitting applications that are not fully supported with the required information. Typical data to be presented on the CDTI might include:

a) the positions and velocities of proximate traffic;

b) the identity of proximate traffic, as flight I/D;

c) the altitude and altitude rate of proximate traffic;

d) the immediate intent of selected aircraft, e.g. that they are starting a turn or a climb;

e) flight plan information (trajectory change points) for selected aircraft; and

f) specific information for selected aircraft, e.g. range or rate of closure, when requested in support of a particular application.

### 4.4 ASAS control panel

4.4.1 The ASAS control panel is the interface between the flight crew, the display and the data processing. The ASAS control panel is likely to provide the ability to select a set of features based on the desired category of ASAS applications.

### 4.5 ASAS design and integration issues

4.5.1 The integration of ASAS in current cockpits could be complex. For example, depending upon the nature of the application, existing flight management systems (FMS) or auto-pilot functions might need to be modified.

4.5.2 Algorithms for conflict detection and resolution will have to meet various performance requirements. These include effectiveness, nuisance alert rate, and compatible resolution manoeuvres between aircraft. Manoeuvres recommended by ASAS CD&R need to be compatible between the two aircraft; the safest way to ensure compatibility between two aircraft is through explicit coordination, which might be best implemented through a two way air-air crosslink. (Compatibility with ACAS resolution advisories (RAs) is discussed in 6.2.2.) Dedicated algorithms might be necessary for some ASAS applications (e.g. merging of traffic or longitudinal station keeping).

4.5.3 ASAS and ACAS might share some hardware components. This is acceptable provided the probability of failure of the shared components is sufficiently low to ensure that the consequential common mode failure of ASAS and ACAS is sufficiently rare, bearing in mind that the joint failure of ASAS and

ACAS could lead to collision in some applications. The ACAS must remain the safety net in the event of navigation failure and separation failure.

## 5. ASAS DATA SOURCES

5.1 ASAS could utilize surveillance and navigation data from several sources. Other data, for example aircraft trajectory intent data, could also be used. It is therefore necessary to define the requirement, identify if the data is available and convey the information to the users.

5.2 ASAS will probably rely on ADS-B surveillance data. ADS-B is a function on an aircraft that periodically broadcasts its state vector (3D position and velocity) and other information. The position data is based on the aircraft's own navigation system. Many of the airborne applications envisaged for ASAS will also be applications of ADS-B technology.

5.3 The ADS-B navigation data does not have to be based on global navigation satellite systems (GNSS). Options could include inertial or DME (distance measuring equipment), but the requirements will be ASAS application dependent. Nevertheless, it is accepted that the majority of ADS-B units might well broadcast GNSS derived data, and that there is a widespread expectation that many ASAS applications will be based on the use of GNSS data.

5.4 It is recognized that the potential benefits brought by ASAS could be enhanced by the use of air-ground data-link (for example the proposed TIS-B service) and air-air crosslink to provide information on non-ADS-B equipped aircraft. The delay involved in obtaining information via the ground and the consequential problems of data correlation and synchronization will require investigation.

5.5 Depending on the ASAS applications, there may also be a requirement for exchange of flight information (e.g. ASAS capabilities, selected parameters or trajectory change points) between aircraft or the ground.

5.6 ACAS can provide surveillance information for traffic equipped with secondary surveillance radar (SSR) Mode A/C or Mode S transponders. This could be useful for ADS-B surveillance data validation, or if the traffic was not equipped with ADS-B capability. Issues related to the use of ACAS surveillance data are addressed at Section 6.

5.7 The surveillance data requirements will also be ASAS application dependent, but it is recognized that ASAS will benefit from the positive identification of other aircraft, for example flight I/D (call sign used in flight). In addition, aircraft trajectory intent information could be required for some ASAS applications. The availability and integrity requirements for intent data need to be assessed.

5.8 The potential need to coordinate resolution manoeuvres is discussed in paragraph 4.5.2. This coordination could be provided by ATC, or by RTF transmissions between aircraft, but in many cases air-air crosslink could be expected to support the necessary coordination for separation manoeuvres. The level of reliability required for the air-air crosslink coordination protocol needs to be assessed, but it is possible that ADS-B will prove inadequate for such purposes.

## 6. INTERACTION WITH ACAS

### 6.1 The role of ACAS as an independent safety net

6.1.1 ACAS is an airborne system based on SSR technology, which provides a last resort safety net function. Its purpose is to prevent collision when the primary means of separation provision has failed.

6.1.2 The reduction in the risk of collision that was predicted for ACAS was based on an assumption that it would operate independently of the primary means of separation. (The shared reliance on the aircraft pressure altitude measurement was taken into account when estimating the reduction in the risk of collision achieved by ACAS for current ATM practices.) Therefore it is essential to preserve the independence of ACAS, because the loss of this independence would undermine the reduction in collision risk achieved by ACAS. Further, it is contended that there is a general policy perception that ACAS operates independently of the current, ground-based, primary means of separation provision, and that this is why it adds value to the ATM system.

6.1.3 The most important elements contributing to the independence of ACAS are:

a) the range measurements made by ACAS: that it does not use the estimates of horizontal separation used by ground ATC; and

b) that it alerts automatically, not relying on the humans responsible for maintaining separation.

Secondary features are the ACAS collision avoidance algorithms, and the software that implements them; these have to be competent for the system to work, but the separateness of their existence contributes little numerically to the reduction in collision risk achieved by ACAS.

6.1.4 The following are examples of the ways in which the independence of ACAS might be lost, in the context of ASAS applications:

a) the use of ACAS data by aircraft surveillance and separation systems, for example the use of range data to modify ADS-B position data. The independence would be lost because a common mode of failure would be introduced: separation could be lost and a collision threat created because the data being used are in error;

b) the use by ACAS of data that are used for separation provision, e.g. the ADS-B position data expected to form the basis of ASAS applications. The argument is the same as in (a) above, and the distinction lies in the original primary purpose in obtaining the data;

c) the use of ACAS in operational procedures to maintain separation. There are two considerations here: that already given, which is that some fault in ACAS would lead to a loss of separation and a collision threat that, by construction, cannot be resolved by ACAS; and that such use of ACAS would presumably be intended to enable some reduction in separation between the aircraft concerned, thus increasing the risk of collision; and

d) the invoking of ACAS in the approval process. The independence is lost because the reduction in collision risk achieved by ACAS could no longer be considered to increase the safety of the procedure or system approved.

## 6.2 ASAS conflict detection and resolution, and ACAS

6.2.1 It is assumed that part of ASAS will be an airborne CD&R function that will alert the flight crew to a loss or potential loss of separation, and enable them to take corrective action. Idealistically, but somewhat unrealistically, ASAS CD&R would operate so effectively that ACAS alerts only when airborne separation has failed. It is likely that an interaction between ASAS CD&R and ACAS would be unavoidable.

6.2.2 It is necessary that the manoeuvres recommended by ASAS CD&R be compatible with ACAS RAs on the other aircraft. This could be achieved by some combination of the following:

a) making the ASAS manoeuvre precede the potential RA, which then does not occur;

b) making the ASAS manoeuvre complementary to the ACAS RA through design, for example a horizontal ASAS manoeuvre would be complementary to the vertical RAs issued by ACAS II;

c) explicitly coordinating the ASAS manoeuvre with the ACAS on the other aircraft - but ACAS is not designed to coordinate with ASAS CD&R[5]; and

d) ensuring that ASAS CD&R gives way to any ACAS RAs generated on own aircraft.

6.2.3 ACAS does not assure separation; ACAS resolution advisories can be generated in encounters whether or not there is a loss of current ATC separation. This should be expected to occur in ASAS applications; there could be occasions where there is a (nuisance) ACAS alert, but no alert from the ASAS CD&R. When designing ASAS application procedures, and establishing the airborne separation minima, the ACAS interaction should be borne in mind.

6.2.4 However, this does not indicate that ASAS CD&R could substitute, effectively, for the current ACAS. Practical problems would be raised by the introduction of an ASAS-based collision avoidance, which must be compatible and coordinate with the current ACAS. In addition, such a system would not be capable of providing independence from the primary separation system, unlike the active surveillance capability provided by the current ACAS.

---

[5] ACAS coordinates the RAs generated on two ACAS equipped aircraft by transmitting the RA sense, encoded as a Resolution Advisory Complement, on 1 030 MHz. Additionally, an 'RA report', which includes the nature of the RA and (if known) the address of the threat, is made available for replies (on 1 090 MHz) to specific Mode S interrogations. This RA report is also broadcast every 8s on 1 030 MHz. [11]

6.2.5 An alternative solution to reduce the problem of ACAS nuisance alerts could be to redesign the ACAS collision avoidance logic to utilise Mode S extended squitter data, or other suitable ADS-B data, or air-air crosslink data, provided provisions are made to protect the independence of ACAS.

## 6.3 Inhibition of ACAS during ASAS operations

6.3.1 It is anticipated that the level of nuisance ACAS alerts in some ASAS applications could be such that it will be necessary to disable some RAs, with the equivalent protection being provided in some other way. For example, the potential use of ASAS to enable simultaneous approaches to closely spaced parallel runways in instrument meteorological conditions (IMC) will certainly cause such nuisance alerts, but should not be prohibited due to that consideration alone if the procedure is demonstrated to be safe. If RAs are disabled in any particular application, ASAS will have to include a function to produce its own alert in the event of loss of the separation required during the application. However, these alerts would not be independent of ASAS and thus, alone, would not substitute for ACAS. However, if the state vector data used by ASAS are validated by comparison with the ACAS range measurements (and the bearing measurements, should they be of value), this validation against the independent range measurements could support substitution for ACAS.

6.3.2 ACAS range data might be used by ASAS to validate ADS-B position data for reasons in addition to those discussed in 6.3.1, such as to improve the integrity of the ASAS tracks in other demanding applications. Before a collision threat could result, a double failure would be required (the ADS-B data are wrong, and wrong ACAS range data validate the ADS-B data). However, it would be essential that action be taken should the ADS-B data not be validated. This would be likely to take the form of an abort of the ASAS procedure. No advantage can be claimed in terms of integrity added to the ADS-B data by the validation if such action is not taken.

## 6.4 Shared use of CDTI by ASAS and ACAS

6.4.1 The ACAS safety analyses, on which basis ICAO adopted the ACAS standards and recommended practices (SARPs), do not invoke the traffic display that is usually fitted with ACAS II equipments. The purpose of the ACAS traffic display is to aid visual acquisition of traffic on which a TA (and subsequently an RA) has been issued. Therefore, the ACAS traffic display can be shared with other functions. Conversely, a ‘general-purpose’ CDTI could be used for this purpose.

6.4.2 Where a CDTI is used as the ACAS traffic display, it must give priority to the display of ACAS alerts. The CDTI should not display two tracks for the same aircraft, for example the ASAS track and the ACAS track. It is acceptable for the ACAS alerts to be displayed on the ASAS track, for example by changing the shape and colour of the target symbol. The association of an ACAS and ASAS track is a matter of design, and should be included as an ASSAP function.

6.4.3 A displayed track based solely on ACAS must be clearly identifiable as such. ACAS tracks are displayed as an aid to visual acquisition for collision avoidance. Specifically, ACAS tracks must not be used as the basis for any manoeuvre.

6.4.4 It could happen that an ASAS track is displayed and appears to present a risk of imminent collision (not merely a conflict) when there is no corresponding ACAS track. The human factors issues arising from this, including whether or not specific text and symbology are required, need to be investigated.

### 6.5 ACAS hybrid surveillance

6.5.1 ACAS SARPs describe techniques that use the Mode S extended squitter and the air-air crosslink to improve the ACAS surveillance system. The purpose of this hybrid surveillance technique is to use ADS-B data to reduce the frequency of active interrogations by ACAS; it is a feature of ACAS and it is not provided for the support of ASAS. The hybrid surveillance technique maintains the independence of the ACAS collision avoidance function, as is explained below.

6.5.2 Using the hybrid surveillance technique, extended squitter, which is one implementation of ADS-B, would provide surveillance of most intruders, but ACAS will accept such surveillance only after it has used active interrogation to validate the extended squitter data. This validation will be repeated at regular intervals if the aircraft nears threat status. Furthermore, any intruder that is diagnosed by ACAS as potentially becoming a collision threat will be tracked using active interrogations and all ACAS advisories will be based on active interrogation data only. Thus the collision protection provided by ACAS would still be based on active interrogation.

## 7. PERFORMANCE REQUIREMENTS

### 7.1 General

7.1.1 This section provides general guidance for performance requirements related to ASAS applications. Specific requirements will have to be developed on an application-specific basis [9].

### 7.2 Required surveillance performance for ASAS tracks

7.2.1 The various ASAS applications would be based on the CDTI and, in some cases, on alerting or other support tools. The CDTI would display tracks for other aircraft formed by the airborne surveillance and separation assurance processing function (ASSAP, see Section 4.2). ASSAP would also generate the alerts, based on the tracks it forms. The required surveillance performance (RSP) thus relates to ASSAP, and the tracks formed by ASSAP, and different levels of RSP are likely to be required for different ASAS applications.

7.2.2 RSP must be chosen to satisfy two goals for every application:

a) to enable the intended function of the application to be successfully performed; and

b) to enable all hazards related to surveillance information to be maintained at acceptably low levels of risk (see Section 3).

7.2.3 The qualities of an ASSAP track that require specification include the following. These translate to corresponding requirements for each surveillance update (e.g. from ADS-B or TIS-B):

a) data elements, e.g. position, velocity, flight I/D;

b) accuracy, e.g. of position, velocity, vertical rate;

c) integrity (of the track);

*Note.— Integrity addresses undetected errors of such significance that hazardously misleading conclusions could be drawn. Sources of integrity failure include large errors resulting from failure conditions, or false tracks.*

d) update period of the track;

e) latency;

*Note.— Latency represents the age of a surveillance report when it is broadcast, with respect to the time it was measured.*

f) availability; and

g) continuity (of availability of the track).

7.2.4 One of the chief functions of ASSAP will be to assure that the RSP is met, by monitoring the quality of the data it uses to form its tracks (e.g. by monitoring the integrity of position data in ADS-B reports), and by carrying out its own checks.

7.2.5 Some ASAS applications might require a higher level of integrity than that reported by the source for ADS-B data; this would create a need to validate ADS-B data before they are used by ASAS. The fact that the position data conveyed by ADS-B are navigation data creates a common point of failure for navigation, or ATC based separation, and separation support provided by ASAS. Fortunately, these position data could be validated, either before they are transmitted (which would increase their integrity), or after receipt using a comparison with an independent means of measurement. One such approach could compare the ASSAP computed range to the measured range between the two aircraft. Use of ACAS range data in this manner is discussed in paragraph 6.3.2. Where there is independent ground surveillance (e.g. radar), another such approach could use a ground system's comparison of received ADS-B data. TIS-B could convey the validated data, or it could convey the ground surveillance measurement, allowing ASSAP to make the validation.

## 7.3 Quality of data sources

7.3.1 For some applications, the ASSAP tracks displayed on the CDTI will need to be current, i.e. have low latency and a sufficient update rate. This will constrain the update rates of the input data sources, in particular ADS-B and TIS-B, which, in turn, implies that ground based surveillance systems will need to match the requirements of those ASAS applications that depend on the support of TIS-B.

7.3.2 The performance of ASAS is likely to be determined by the performance of the surveillance source (e.g. ADS-B, TIS-B). In this context, required navigation performance (RNP) and required communication performance (RCP) are subsumed by RSP. The source must be capable of delivering the volume of data required, i.e. all the data elements for realistic aircraft numbers at the update rate discussed in 7.2.1, for aircraft within the maximum range for the various ASAS applications, with the required integrity. The availability of the ADS-B data could be improved by receiving ADS-B on more than one frequency.

7.3.3 Each surveillance source should announce its quality (c.f. 7.1.3) in a manner that enables an ASAS receiving the data to determine if the resulting ASSAP track quality for a target aircraft meets the minimum level required for a desired ASAS application.

## 8. OPERATIONAL CONSIDERATIONS

### 8.1 Responsibilities during ASAS operations

8.1.1 New, or modified, operational responsibilities will affect air traffic controllers and flight crews, and must be clearly defined. For those applications that would involve a delegation or allocation of separation responsibility to the flight crews, airspace authorities, ATM service providers, and aircraft operators will be responsible for modifying the existing legal requirements, regulations and procedures. This will require an agreed ATM operational concept that addresses the delegation of separation responsibility from the controller to the flight crew.

8.1.2 The tactical delegation of separation responsibility in airborne separation applications does not necessarily require substantial changes in the current ATM framework. The ATC system already involves the delegation of responsibility for separation based on visual acquisition in specific circumstances. (Note 1 of paragraph 5.9 of PANS-ATM) [7]

8.1.3 However, the strategic allocation of responsibility involved in airborne self-separation applications has more extensive implications. Even here, the role of ATC would still be essential in many circumstances, but more work is required to define this. It is envisaged that the role of the ATS provider might include:

a) to provide flight information services (e.g. meteorological data), and alerting service;

b) to provide strategic ATM functions such as flight plan de-confliction, traffic density and complexity management;

c) to provide a separation service in transition zones between airspace airborne self-separation and airspace with separation provision service;

d) possibly, to provide separation under contingency procedures if self-separation by the flight crew could not be sustained. The ATC requirement for information and surveillance data would need to be established; and

e) to provide other normal ATM functions which would not be provided by ASAS, for example terrain warnings.

8.1.4 In the event of any strategic allocation of separation responsibility to the airborne side, the appropriate regulatory authorities must have the means to verify the correct implementation of the applicable rules.

8.1.5 States should make their ATM service providers aware of the possibility of ASAS equipped aircraft flying in their airspace, even if ASAS applications are not implemented in their service area.

## 8.2 ASAS procedural and human factors issues

8.2.1 The ASAS procedures must precisely define the roles of flight crews and controllers and clearly implement any required delegation or allocation of responsibility. It will be essential to gain acceptance from pilots and controllers of their new roles and responsibilities before ASAS implementation.

8.2.2 The presence of ASAS on the flight deck could potentially influence the manner in which flight crews carry out existing tasks, as well as enabling new tasks. The combination of correctly designed procedures and displays should minimize disruptive effects such as inappropriate and unexpected manoeuvres, or superfluous questioning of the controller.

8.2.3 The possibility for controllers and flight crew to refer to third parties is an example of the need for correct procedures and useful displays. The identity information available to ASAS is likely to consist of the flight I/D. This maps directly onto, but is not the same as, the call-sign used by controllers for own aircraft when addressing flight crew. Many flight crew will often be familiar with the call-sign of other aircraft, and third party call-sign might be a natural means for controllers to identify the third party. However, it cannot be assumed that flight crew will recognise call-signs of all other aircraft. Further, the procedures used must guard against the risk that the third party will misunderstand an exchange as being directed at them.

8.2.4 For each ASAS application, contingency procedures will need to be defined. In applications where the flight crew has some responsibility for separation, it is not obvious that controllers will have a role in these contingencies. If controllers are involved, these procedures will need to accommodate the possibility that the airborne separation minima are likely to differ from those applied by the controller. Further, several aircraft might be involved in the same contingency.

8.2.5 ASAS procedures should not be contradictory to ACAS procedures. Further, contingency procedures must not be based on the fact that aircraft are fitted with ACAS; this is discussed in paragraph 3.5.4.

8.2.6 The controller should be provided with means to identify ASAS-capable aircraft and with tools to identify situations where delegation of separation tasks can take place.

8.2.7 For some ASAS applications there might be a need for the controller to be provided with downlinked ASAS information. This might include ASAS alerts or recommended separation manoeuvres.

8.2.8 ASAS applications will require implementation of new procedures and new rules to be applied both by flight crews and controllers. In order to maintain safety, it will be necessary to ensure that such new tasks are feasible and safe, taking into consideration the performance and workloads of both the controllers and flight crews in the environment (phase of flight, traffic density and complexity) in which the application would be used.

## 8.3 ASAS and the 'party line'

8.3.1 The improved traffic situational awareness that will be provided by ASAS, in particular by a CDTI, is not necessarily intended to substitute for traditional voice 'party line' information, although it might do so. The CDTI information will be of a different nature, and is more likely to enhance the understanding of the 'party line' than to replace it. Extensive CPDLC, for example, would lead to a loss of 'party line' information, but CPDLC is not an inevitable component of ASAS. ASAS is not intended specifically to compensate for the loss of 'party line', even though the CDTI might potentially help in this respect.

## 8.4 Training considerations

8.4.1 Pilots' and controllers' training will be essential for proper use of the ASAS procedures and displays. Appropriate training requirements will need to be defined, and course syllabuses developed, approved, and implemented.

8.4.2 In view of ASAS procedural and human factors issues discussed in Section 8.2, training aspects are critical and will have to be closely considered when:

a) implementing a new application;

b) extending a well-known application to a new operational environment; or

c) modifying the operational environment.

8.4.3 Training aspects will need to focus on new relations and responsibilities between flight crews of different aeroplanes performing ASAS applications, and between flight crews and controllers.

8.4.4 States will need to consider the appropriate provisions for the licensing of pilots for the various operational uses of ASAS equipment.

## 8.5 ASAS transitional issues

8.5.1 ASAS applications would require operational evaluation to validate technical performance, application viability and procedures. Results could encourage further equipage, by demonstrating potential benefits to ATM service providers and airspace users.

8.5.2 While there is a mixed population of non-equipped and suitably ADS-B-equipped aircraft, it will be necessary to consider which ASAS applications are feasible to implement. It could be possible to provide position information to equipped aircraft about non-equipped aircraft through implementation of ground functions such as TIS-B.

8.5.3 Reliable situation awareness requires full coverage, because flight crews might not allow for aircraft that are not shown on an apparently complete display. Nevertheless, some improved traffic situation awareness may occur even when the percentage of ASAS equipped aircraft is small, particularly in situations where two aircraft benefit from being able to track each other (e.g. paired approaches). The benefits to ASAS equipped aircraft would increase as the level of ADS-B equipage increases.

## 9. PROJECTS AND TRIALS

### 9.1 Introduction

9.1.1 This section highlights on-going activities that contribute to the development of ASAS applications and to their validation. This circular has been extensively informed by these activities.

9.1.2 The text in this section is valid at the time of writing, May 2003, and is necessarily dated.

### 9.2 Outline of ASAS activities

9.2.1 There has been considerable interest in ASAS like activities, including operational trials, since the mid 1990s in two regions of the globe. The scope of these activities ranges from research to the pre-operational implementation of ASAS applications. The four categories of ASAS applications have all been considered by various projects.

9.2.2 To increase the potential for an early implementation, particular attention is currently given by several States to airborne traffic situational awareness applications and airborne spacing applications. The idea is to develop an incremental approach towards the operational implementation of some ASAS applications and to provide some early benefits to airspace users. Airborne separation applications and airborne self-separation applications are also being investigated, mainly by research and development (R&D) centres in several States. Various perspectives are considered: concepts of use, operational and technical considerations, and algorithms for conflict detection and resolution.

### 9.3 US projects

***Overview***

9.3.1 In November 1998, FAA initiated the program now known as SafeFlight 21 (SF21) as a joint effort with Industry to demonstrate and validate the use of advanced surveillance technologies and procedures for enhancing safety, efficiency and capacity. Many of the enhancements under development utilise ADS-B, CDTI and TIS-B as enabling technologies to provide airborne and surface traffic situational awareness, as well as airborne spacing. Additional ASAS applications in the areas of airborne separation and airborne self-separation are under investigation by NASA, RTCA and other research organizations.

9.3.2 The operational trials and evaluations for ASAS applications in SF21 are conducted primarily in two regions. The first in the Ohio River Valley, primarily Louisville, Kentucky and Memphis, Tennessee, focuses on commercial air carriers in a busy hub environment with the cooperation and participation of members of the Cargo Airlines Association. The second region is in Alaska, with initial efforts centred at Bethel and Juneau under the aegis of the Capstone program within SF21. Trials in Alaska focus on the smaller classes of aircraft operating in a very limited surveillance and ATC environment. A similar effort under SF21 has been initiated in late 2002 to provide operational capabilities for general aviation aircraft in selected areas of the continental United States.

9.3.3 In addition to the development of operational uses, avionics, ground infrastructure and automation, and field tests, the SafeFlight 21 Office has been supporting the development of ASAS operational requirements, standards, safety analysis and applications in conjunction with RTCA Special Committee 186, as discussed in Section 9.5.

***SafeFlight 21 projects***

9.3.4 Operational Evaluation-1 was conducted in July 1999 in Wilmington, Ohio. Approximately 20 aircraft were fitted with a first generation ADS-B & CDTI suite. The aircraft demonstrated airborne 'see and avoid' and 'aid to visual acquisition' applications. Primary objectives included validation of operational uses and collection of human factors data. The results supported the next generation of avionics requirements and planning.

9.3.5 Operational Evaluation-2 was conducted in October 2000 in the Louisville airport vicinity. This activity continued the development of ASAS applications, refined the earlier human factors analysis and initiated trials with call sign procedures to enhance visual acquisition and pave the way for additional ASAS applications that involve ATC monitoring.

9.3.6 A follow-on evaluation effort at Louisville is planned for 2004 to test call sign procedure and enhanced visual approaches using ADS-B/CDTI avionics and the operational terminal automation system. If human-in-the-loop simulations demonstrate that they are technically and operationally feasible, 'CDTI Enhanced Flight Rules', a use of airborne separation under reduced visibility conditions, is also to be evaluated. About 100 Boeing 757/767 aircraft from a Cargo Airline will be equipped with 1 090 MHz ADS-B avionics.

9.3.7 During 2002, test and evaluation activities consisted of a series of trials, distributed in time and location, the first in Memphis in May. The tests included an airport surface moving map demonstration as a prerequisite to surface situational awareness, TIS-B initial trials to enhance ASAS operations and continued ASAS applications development and data gathering. A new generation of ADS-B and CDTI avionics was also tested. Concurrently, SF21 began developing and publishing electronically high quality airport surface maps for 60+ United States airports (more to follow) for use with CDTI.

9.3.8 The objective of the test & evaluation surveillance information system (TESIS) is to evaluate alternative air carrier based avionics for ASAS applications. Four avionics contractors developing prototype units with a set of core capabilities. Each vendor also selectively developed additional ASAS applications. Airborne and surface situation awareness, surface moving map, and hybrid surveillance on multi-functional display were evaluated in May 2002 at Memphis airport.

9.3.9 The phase-1 Capstone operational evaluation has been completed in the Anchorage-Bethel area. Approximately 150 aircraft were fitted with ADS-B/CDTI (universal access transceiver link only) to demonstrate and evaluate ASAS applications of see and avoid and aid to visual acquisition. Certified Capstone avionics also provided an advisory service to flight crews on terrain avoidance and flight information. Since January 2001, 'radar like' services for ATC in non-radar areas have been implemented operationally based on automation processing and display of ADS-B tracks. In addition, the data collected during this phase were used to define a next generation of avionics and ground equipment.

9.3.10 The phase-2 Capstone operational evaluation program in the Southeast region of Alaska began in the Juneau airport area in late 2002. Approximately 200 aircraft will be fitted with upgraded and certified ADS-B/CDTI avionics for visual acquisition, see and avoid and terrain avoidance in mountain-valley areas. Multilateration is being considered for use in the Juneau area for surface safety and for terminal approach surveillance through the mountainous areas.

9.3.11 A Capstone-like project has been initiated to extend broadcast services (ADS-B, TIS-B and FIS-B) to general aviation aircraft in the continental United States, including selected areas in East Coast and Southwestern United States. Primary ASAS applications are airborne situation awareness and enhanced visual acquisition. A cooperative agreement has been reached with Embry Riddle Aeronautical University to evaluate these two ASAS applications and broadcast services at Prescott, Arizona and Daytona Beach, Florida.

***NASA activities***

9.3.12 NASA is conducting ASAS research and development through the advanced air transportation technologies project (AATT). One part of AATT is the distributed air-ground traffic management (DAG-TM) research that is based on RTCA free flight principles. Research into trajectory negotiation, airborne spacing and airborne self-separation is ongoing under DAG-TM, including flight deck and ground based decision support tools, real-time and fast-time simulations, and flight trials. Research work under a prior project, terminal area productivity, included real-time simulation, flight trials and safety assessment modelling for closely-spaced parallel approaches, an airborne separation application.

## 9.4 **European projects**

9.4.1 In the more autonomous aircraft in future ATM system project (MA-AFAS), seven different ASAS applications from all four categories are being studied. The objectives are the definition of ASAS applications, the development of an avionics package, the performance of a cost benefit analysis and the performance of both real-time simulations and flight trials. The planned validation activities focus on the avionics package. They involve representative navigation facilities and surveillance functions, using real data-link communications.

9.4.2 The mediterranean free flight project (MFF) is investigating ASAS applications from all four categories, with a pre-implementation objective for some of them. Its geographical location encompasses Mediterranean airspace between the core European area and North Africa and the Near East. The project aims first at defining the operational concepts, the requirements and the procedures. It also aims at performing both fast-time and real-time simulations, conducting flight trials and achieving a safety case. Within MFF, the methodology defined by RTCA SC189 / EUROCAE WG53 is being used for the safety analyses.

9.4.3 In the NEAN Update Programme Phase I and II (NUP), various ASAS applications are developed by the NUP partners including airlines, ATM service providers, airport operators and an aircraft manufacturer. The applications are mainly traffic situational awareness and airborne spacing applications, with fewer airborne separation applications. The objectives are the definition of ASAS applications, their safety assessment, the development of airborne and ground equipment, and completing a pre-certification study and a cost benefit analysis and conducting real-time simulations and flight trials. Within NUP, the methodology defined by RTCA SC189/EUROCAE WG53 is used for the safety, performance and interoperability analyses. The applications are being validated using a common approach, integrated across the project. For some applications, the objectives are to perform an operational validation and to prepare for operational approval.

9.4.4 The gate-to-gate project is evaluating an integrated air-ground gate to gate operational concept that includes ASAS applications (including airborne sequencing and merging, and crossing) in departure, en-route and arrival flight phases. A layered planning approach with multi-sector planning will be used to reduce complexity en-route and in the terminal manoeuvring area (TMA) with a view to managing workload and capacity, and providing for a new distribution of tasks between controllers and pilots. The output of gate-to-gate will be exploited in large-scale live trials discussed in paragraph 9.4.8.

9.4.5 The CoSpace project, formerly called the evolutionary air-ground cooperative ATM concept study (EACAC), undertaken by the EUROCONTROL Experimental Centre, investigates the limited delegation of some separation tasks from the controller to the flight crew. The objectives of the human-in-the-loop experiments are to investigate the impact on practices and hence assess the operational acceptability and safety of new airborne spacing instructions. The validation of the concept was performed through real-time experiments from 1999 to 2002.

9.4.6 The main purpose of the cooperative actions of R&D in EUROCONTROL on ASAS (CARE/ASAS) is to support the validation of a strategic line of actions on progressive and delegation of separation responsibility to the flight deck. CARE/ASAS aims at, in particular, driving the establishment of a common view on ASAS applications. The action deals with the operational aspects, not with the supporting technologies. The CARE/ASAS action is composed of several activities including a validation framework for ASAS applications, the investigation of airborne separation minima and the selection of ASAS applications appropriate for the European traffic environment. CARE/ASAS started in 1999 and is an on-going activity.

9.4.7 The on-going cooperative ATS concept (COOPATS) developed by EUROCONTROL is based on two levels, which both encompass some ASAS applications. One of the five areas developed in level one is airborne traffic situational awareness. The two elements of level two are cooperative separation provision and autonomous flight operations. The initial work is focused on level one. At this stage, no validation activities are available or planned for these applications. Level one aims for implementation in steps up to 2008/2010 and level two aims at implementation in Europe between 2007 and 2015. COOPATS is currently being revised in the light of advances since it was first drafted.

9.4.8 Under the European Commission 6th Framework Programme for R&D, the cooperative ATM project will focus on live trials during 2005 - 2008 for a number of city pairs in an integrated air-ground concept based on information distribution for decision making, initial 4D services, CPDLC and ASAS Package 1 applications (see paragraph 9.6.3 below). Package 1 will form a major focal point of the project with airframe and avionics industry working towards certified equipment and procedures. It is expected that this will feed directly into a Trans European Network project that will involve a large-scale equipage of aircraft from European airlines to complete validation on a number of city pairs in core European airspace, also during 2005 - 2008. This approach is expected to provide clear benefits in terms of safety and business cases and a certified ground and air infrastructure ready to provide for a European role-out of ASAS package

1 services in a common operational concept from 2010, which baselines the first step to the '2020 Vision.' [13]

## 9.5 Coordination of R&D

9.5.1 The FAA and EUROCONTROL coordinate United States and European ATM R&D activities in a number of areas, including ASAS. Original contributions relating to ASAS include PO-ASAS, [4], which significantly influenced this circular, and 'Safety and ASAS Applications', in preparation.

## 9.6 Standards and implementation

9.6.1 The RTCA SC186 and EUROCAE WG51 have been developing standards for ADS-B, and the enabling technologies for ADS-B, for some years. SC186 is also developing standards for TIS-B, in cooperation with the EUROCONTROL ADS programme. Both SC186 and WG51 have identified that the standards for ADS-B should flow down from a definition of the use of ADS-B, and that airborne surveillance for ASAS applications is one of the main uses. The other main use of ADS-B is in ground-based surveillance for ATM, which is outside the scope of this circular.

9.6.2 RTCA SC186 is developing minimum aviation system performance standards for airborne surveillance applications (ASA MASPS). [14] The approach adopted has been to define a number of ASAS applications, which range from one that has already been approved for operations in the United States to others that have been selected because, hopefully, they define the possible future technical requirements. In the latter case, the motive is to identify technically demanding applications. EUROCAE WG51 is also committed to the development of ASA MASPS.

9.6.3 Airline operators have long been among those pressing for the development of ADS-B and ASAS: the United States Cargo Airline Association has worked closely with SF21, and SAS and Lufthansa have been partners in most of the European projects. In 2002, the Joint Users Requirements Group of the Association of European Airlines and the International Air Transport Association called for the early implementation of ADS-B, and included several ASAS applications as their objectives in so doing. [15] This motivated the definition of a package of applications of ADS-B for early development and implementation, under the aegis of CARE/ASAS. [16] The package, widely referred to as Package 1, contains five ground surveillance applications, and seven airborne surveillance (or ASAS) applications: four traffic situational awareness and three airborne spacing applications. By design, Package 1 does not encompass airborne responsibility for separation.

9.6.4 WG51 and SC186 have welcomed the definition of Package 1. For the former, it provides the operational requirement from which the ASA MASPS, and also ground surveillance applications MASPS, will flow. The intention of both SC186 and WG51 is to develop commonly agreed standards, and the two groups have agreed a schedule of applications that includes both the applications already under study in SC186 and Package 1.

## 10. DOCUMENT TERMINOLOGY

**Air-air crosslink.** The air-air crosslink is a technique for providing avionics (including ASAS and ACAS) access to the Comm-B registers contained in a Mode S transponder on another aircraft.

**ACAS.** An aircraft system based on SSR transponder signals which operates independently of ground-based equipment to provide guidance to the pilot on avoiding potential collisions with aircraft that are equipped with SSR transponders.

**Airborne collision avoidance.** An aircraft function that operates independently of ground based equipment to alert pilots to the risk of potential airborne collision with other aircraft and to generate avoidance advice.

**ADS-B.** A function on an aircraft or surface vehicle that broadcasts position, altitude, vector and other information for use by other aircraft, vehicles and by ground facilities.

**Airborne separation assistance system (ASAS).** An aircraft system based on airborne surveillance that provides assistance to the flight crew supporting the separation of their aircraft from other aircraft.

**ASAS application.** A set of operational procedures for controllers and flight crews that makes use of an Airborne Separation Assistance System to meet a defined operational goal.

**ASAS separation.** An airborne separation, to prescribed minima, either generic or specific to an ASAS application, which is applied by the flight crew between own aircraft and other aircraft, through reference to ASAS.

**Conflict.** Any situation involving two aircraft in which the applicable separation minima may, or are, compromised.

**Conflict detection.** The process of detecting or predicting a potential loss of separation. Unless the context indicates otherwise, this process is normally assumed to be automatic.

**Extended squitter.** The signal used for ADS-B on 1 090 MHz, using unsolicited transmissions of the Mode S long reply format that contain state vector and other ADS-B information.

**Procedures.** The term ‘procedures’ is used here to include the actions carried out by controllers and flight crew as well as, for example, the methods used for the provision of separation from an ICAO perspective.

**Separation.** Two aircraft are separated when their mutual displacement exceeds the separation minimum.

**Separation minima.** The minimum displacement between two aircraft that maintains the risk of collision to an acceptable level of safety.

**Spacing.** Any application of a distance or time between two aircraft at or above separation minima in order to maintain an orderly flow of traffic or provide separation. In this circular, the word ‘spacing’ is not used to refer to the distance between structures such as routes.

**TIS-B.** Traffic information service — broadcast: a service provided by ground stations, broadcasting information relating to aircraft based on surveillance carried out by ground systems, using ADS-B signals, formats and protocols, compatible with ADS-B receiving equipment.

## 11. REFERENCES

1. ‘Airborne Separation Assurance System: the ASAS Concept’, SICASP/WG2/489, Sydney, March 1995.

2. ‘The ASAS Concept’, SICASP/6-WP/44, Appendix A, Montreal, February 1997.

3. ‘Information relevant to the use of a system to increase traffic situational awareness and provide airborne separation assurance’, ADSP/5-WP/61, Appendix B, Montreal, October 1999.

4. ‘Principles of Operation for the Use of Airborne Separation Assurance Systems’, Version 7.1, FAA/EUROCONTROL Cooperative R&D, Action Plan 1, 19 June 2001.

5. ‘ATM Operational Concept Document’, ATMCP/1-WP/30, Appendix A to the report on Agenda Item 2, Montreal, March 2002.

6. ‘Development and Implementation Planning Guide for Automatic Dependent Surveillance — Broadcast (ADS-B) Applications’, RTCA/DO-249, RTCA, October 6 1999.

7. ‘Procedures for Air Navigation Services, Rules of the Air and Air Traffic Services’, Doc 4444-RAC/501, ICAO, 13th edition, July 1996.

8. ‘International Standards and Recommended Practices’, Air Traffic Services, Annex 11 to the Convention on International Civil Aviation, ICAO, 13th edition July 2001.

9. ‘Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications’, EUROCAE WG-53/RTCA SC-189, ED 78-A/DO-264, December 2000.

10. ‘Method for establishing ATS routes for use by RNAV-equipped aircraft’, Attachment B to Ref. 6 (Annex 11).

11. ‘International Standards and Recommended Practices, Aeronautical Telecommunications’, Annex 10 to the Convention on International Civil Aviation, Volume IV ‘Surveillance Radar and Collision Avoidance Systems’, ICAO, second edition July 1998.

12. ‘Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)’, RTCA/DO-242A, RTCA, 2002.

13. ‘European Aeronautics: a vision for 2020’, P Busquin et al, European Commission, 2001.

14. ‘Minimum Aviation System Performance Standards for Airborne Surveillance Applications (ASA)’, RTCA/DO-XXX, RTCA, to be published.

15. ‘JAFTI deliverables document’, version 1.3, AEA/IATA Joint Users Requirements Group, 14 June 2002.

16. ‘Description of a first package of GS/AS applications’, version 2.2, CARE/ASAS/EUROCONTROL/02-040, 30 September 2002.

**Attachment A**

## DOCUMENTS REQUIRED TO STANDARDIZE ASAS

The following new ICAO documents, or (mostly) amendments to existing documents, are expected to be required for the standardization of ASAS and ADS-B.

| DOCUMENT | PURPOSE |
|---|---|
| *Manual on Airborne Separation Assistance System (ASAS)* (Doc XXXX)<br>This would be a new document. | ASAS applications descriptions,<br>functional and performance description of the component systems, CDTI, ADS-B,<br>air-air crosslink, ASAS processor (ASSAP),<br>applications specific software (in particular CD&R) |
| *Manual of Air Traffic Services Data Link Applications* (Doc 9694) | Description of data link applications and services in support of ASAS applications |
| Annex 1 — *Personal Licensing* | Training related to the use of ASAS and ASAS applications |
| Annex 6 — *Operation of Aircraft* | Standards concerning the operation of aircraft during ASAS applications |
| Annex 8 — *Airworthiness of Aircraft* | Guidance on airworthiness for ASAS applications |
| Annex 2 — *Rules of the Air*<br>Annex 11 — *Air Traffic Services*<br>*PANS-ATM* (Doc 4444), *PANS-OPS* (Doc 8168) | Procedures for ASAS applications.<br>Guidance for airborne spacing procedures.<br>Guidance for airborne separation procedures.<br>Method, and values, for airborne separation minima. |
| *ATS Planning Manual* (Doc 9426) | Guidance on conditions governing the reduction of separation minima |
| *Manual on Airspace Planning and Determination of Separation Minima* (Doc 9689) | Guidance for airborne spacing.<br>Method, and values, for airborne separation minima |
| Annex 10 — *Aeronautical Telecommunications*, Volume IV | Standardization and guidance for flight deck display of traffic information |
| Annex 10 — *Aeronautical Telecommunications,* Volume IV | Standardization and guidance for airborne surveillance and separation assurance processing |
| Annex 10 — *Aeronautical Telecommunications* Volume IV | Standardization and guidance for conflict detection and resolution |
| Annex 2, Annex 6, Annex 10, Volumes III and V, and Annex 11 | Standardization of ADS-B and TIS-B |
| Annex 10 — *Aeronautical Telecommunications,* Volumes III, IV and V.<br>*Manual of SSR Systems* (Doc 9684) | Standardization and guidance for Mode S extended squitter |
| Annex 10 — *Aeronautical Telecommunications* Volumes III, IV, and V | Standardization and guidance for VDL Mode 4. |
| Annex 10 — *Aeronautical Telecommunications* Volumes III, IV, and V | Standardization and guidance for UAT.<br>These standards would be new. |

| | |
|---|---|
| Annex 10 — *Aeronautical Telecommunications* Volumes II | Communication procedures including those with PANS status |

## Attachment B

## TEMPLATE FOR ASSESSING ASAS APPLICATIONS

This template should be used for the initial definition and study of proposed ASAS applications. Its completion is intended to define the application and provide information for its technical analysis. It is not intended as a checklist of the actions and considerations that must be taken before an application can be implemented or approved, nor is it intended to help demonstrate that ASAS is the most suitable means of meeting operational requirements.

To permit identification and assessment of the implications of each proposed ASAS application, the proposal should address the following generic areas:

### 1. DEFINITION OF THE ASAS APPLICATION

a) **Operational purpose.** The proposal should contain a clear, accurately expressed, statement, which sets out its operational purpose.

b) **Type of airspace.** The airspace for which it is proposed, for example, for en-route, terminal, or oceanic airspace, and whether it is proposed for high or low density airspace.

c) **IFR/VFR applicability.** The applicability to IFR and VFR.

d) **Development of special flight rules.** The potential need for special flight rules (e.g. electronic flight rules (EFR)).

e) The applicability to a radar, or to a non-radar, environment.

*Note.— It would be advantageous to include an operational scenario illustrating the use of the proposed application.*

### 2. BENEFITS AND CONSTRAINTS

2.1 The benefits, and the level of those benefits, that are expected to be achieved from the ASAS procedure should be listed for the ATM user and the ATM provider. Similarly, the anticipated constraints should be exposed. For example, the application might be expected to increase ATM capacity and provide improved economic returns for an operator, but a constraining factor might be that all aircraft in the sector would require to be transmitting ADS-B data, or be capable of executing the application, before the application could be applied.

a) Benefits:

1) safety;

2) capacity, for example, airspace throughput;

3) operational efficiency, and flexibility;

4) environmental concerns.

b) Constraints:

1) the compatibility of the proposed application with aircraft not capable of executing the application;

2) need for 'exclusive-use airspace';

3) environmental concerns.

## 3. OPERATIONAL PROCEDURES

3.1 The proposal should provide information on the proposed operational procedures.

a) **Flight crew and controller actions.** A description of the operational procedure covering, where appropriate:

1) the flight crew and controller actions when initiating, authorizing, and terminating the procedure;

2) the criteria for flight crew acceptance of the procedure, for example, whether the flight crew can refuse the initiation of the procedure;

3) an assessment of the need to delegate the responsibility for separation from the controller to the flight crew, and indication of the procedure point at which the separation should be delegated, and the point at which it returns to the controller;

4) the proposed procedure to be applied when delegating separation responsibility from the controller to the flight crew;

5) the proposed procedure to be applied when returning separation responsibility from the flight crew to the controller;

6) the proposed procedure to be applied for transfer of control from one sector or unit to another.

b) **Proposed separation minimum.** The proposed ASAS separation between aircraft which is to be applied by the flight crew during the execution of the procedure.

c) **ASAS advisories and alerts.** The need for advisories or alerts to advise the flight crew of a potential loss of separation. The proposed flight crew response to those advisories/alerts.

d) **Proposed phraseology.** Proposed new, or new usage of current, RTF phraseology.

e) **The controller's responsibility to monitor.** If appropriate, the controller's responsibility for monitoring an application and re-establishing standard ATC separation in the event that the ASAS procedure is compromised.

f) **Contingency procedures.** In the event of an inability to maintain the ASAS procedure, for example due to received corrupted data provided by other aircraft, or ASAS failure, contingency measures must permit the effective and safe reapplication of standard separation by the controller (including use of redundant systems and capabilities).

g) **Emergency procedures.** The procedures to be followed in the event of an aircraft emergency.

## 4. SAFETY RATIONALE

4.1 An initial safety assessment, together with assessment of availability, continuity, and integrity requirements should be provided. At this stage, this need only be done at a high level, but it should demonstrate an acceptable intrinsic safety level of the application without the need for ACAS or any of its sub-systems. A comprehensive safety analysis of the application would be undertaken at a later stage in the standardization process. This would include:

a) failure mode analysis;

b) safety budget and allocation; and

c) collision risk modelling.

## 5. REQUIREMENTS FOR SURVEILLANCE AND AIRCRAFT STATE, OR ANY OTHER, DATA

5.1 The proposal should contain an assessment of the minimum surveillance and aircraft state, or any other, data requirements necessary for the proposed application. This would include:

a) data required;

b) update rate;

c) accuracy;

d) latency;

e) availability;

f) continuity; and

g) integrity.

## 6. REQUIREMENTS FOR DATA LINK

6.1 The proposal should include assessment of all the air-to-air, air-to-ground, ground-to-air, or broadcast data link requirements.

## 7. ASAS ALGORITHM REQUIREMENTS

## 8. FLIGHT CREW INTERFACE REQUIREMENTS

8.1 The proposal should identify the flight crew interface requirements needed for the application, together with its interaction with the flight crew interface of other systems. This should include an assessment of the following related areas:

a) **human factor aspects**, in particular, impact on pilot workload;

b) **display requirements**, for example, the minimum acceptable size and resolution of the cockpit display;

c) **aural indications**, for example, enunciation and aural 'attention-getter';

d) **alert priorities**, an assessment of aural or visual indications priority; and

e) **failure and mode selection indicators**, for example, mode or failure visual indicator 'flags' and aural 'attention-getter'.

## 9. CONTROLLER INTERFACE REQUIREMENTS

9.1 The proposal should identify the controller interface requirements needed for the application, together with its interaction with the existing control systems. This should include an assessment of the following related areas:

a) **human factor aspects**, in particular, impact on controller workload;

b) **display and data requirements**, for example, related to aircraft ASAS equipage and capability.

## Attachment C

## EXAMPLES OF ASAS APPLICATIONS

This attachment includes outline descriptions of potential ASAS applications derived from on-going ASAS projects and studies. The purpose is to provide insight into possible operational uses of ASAS, in terms of changes to current practices, without going into the details of specific operational procedures or specific functional or performance system descriptions. The ASAS applications described in this attachment are selected in order to illustrate the broad range of ASAS applications, independently from any implementation perspectives.

| | |
|---|---|
| **Name** | **Enhanced traffic situational awareness on the airport surface** |
| **ASAS application category** | Airborne traffic situational awareness |
| **ASAS application description** | This ASAS application aims at increasing the traffic situational awareness of the flight crews operating an aircraft on the airport surface, for both taxi and runway operations, in all weather conditions. The main objective is to increase safety by a reduction in the potential for collisions on the airport surface.<br><br>Flight crews would be provided with a cockpit display presenting surrounding traffic, including aircraft and vehicles. Information needs to include at least the position and identification of these traffic. They will be displayed on an airport surface map, which will improve navigation on the airport surface.<br><br>An additional benefit could be a better understanding of the movements of other traffic. With the improved navigation capabilities and the increased traffic situational awareness, the taxi speeds could potentially be increased, particularly in bad weather conditions.<br><br>This ASAS application is expected to apply to all types of suitably equipped aircraft, in sparsely or densely populated, controlled or non-controlled, airports. |
| **Roles and procedures for flight crews and controllers** | This ASAS application does not modify the roles of flight crews and controllers. The controller is still responsible for resolving conflicts between traffic and between aircraft and obstacles.<br><br>Procedures would be largely unaffected. However, traffic information needs to be revised to include identification (e.g. traffic type, callsign). |
| **Implementation considerations** | It is essential that all surrounding or relevant traffic are displayed to the flight crew. This implies either that all traffic (i.e. aircraft and vehicles) are equipped with ADS-B or that TIS-B is available.<br><br>The use of TIS-B in turn implies that ground surveillance of all traffic and vehicles is available, and that TIS-B data meets the required performances (e.g. update rate, latency).<br><br>The required airborne equipment includes an airborne surveillance function relying on |

ADS-B and TIS-B information, and a cockpit display of the surrounding traffic to flight crews. For greater efficiency of the ASAS application (and for improved navigation), this cockpit display should also include an airport surface map.

**Name** — **Enhanced traffic situational awareness during flight operations**

**ASAS application category** — Airborne traffic situational awareness

**ASAS application description** — This ASAS application aims at increasing the traffic situational awareness of flight crews during flight operations in all weather conditions. Flight crews would be provided with a traffic display, showing at least the position and identification of proximate traffic.

This ASAS application is expected to apply to all types of suitably equipped aircraft during all phases of flight in any type of airspace (e.g. controlled and non-controlled, radar and procedural control, TMA and en-route).

The main objectives are to increase safety of flight and efficiency of air traffic control. In procedural controlled airspace, flight crews would be able to detect potential conflicts, and alert the controller. In radar controlled airspace, flight crews would better understand the reasons for an ATC clearance, thus, perhaps, decreasing R/T exchanges, or encouraging more rapid compliance.

The display could be augmented by traffic advisories, alerting the flight crew to proximate traffic, but this is not an essential component of the application. The algorithms required to support such traffic advisories could well depend strongly on the airspace environment.

**Roles and procedures for flight crews and controllers** — This ASAS application does not modify the roles of flight crews or controllers. The controller is still responsible for managing traffic under his control so as to resolve conflicts. It should enhance some existing procedures, for example:

— the need for traffic information service (e.g. during radar separation or in a future environment with silent communications (CPDLC));

— traffic information broadcast by aircraft (TIBA).

The current traffic information procedure needs to be revised to include identification (e.g. traffic type, callsign). Otherwise, there should be almost no effect on existing procedures.

**Implementation considerations** — For reliable situation awareness, the display of traffic would need to be complete and relevant. This implies that:

— It is essential that all proximate traffic be detected by the airborne surveillance for full traffic awareness. Therefore, TIS-B should be provided, where feasible, unless all traffic are ADS-B equipped. If it is not (e.g. in oceanic airspace), the full benefit will be obtained only when all aircraft are ADS-B equipped.

— the cockpit display has to include a filtering function so as to only display relevant traffic to flight crews.

| | |
|---|---|
| **Name** | **Enhanced visual acquisition for see-and-avoid for IFR and VFR** |
| **ASAS application category** | Airborne traffic situational awareness |
| **ASAS application description** | This ASAS application aims at improving the IFR/VFR compatibility where separation is not provided by controllers between these two types of traffic. It would improve the efficacy of 'see-and-avoid' by prompting a visual search for aircraft that the flight crew might otherwise be unaware off, and by directing the search. Experience has shown that the efficacy of 'see-and-avoid' is limited by a number of factors, e.g. small size of VFR aircraft, high speed of IFR flights, limited view outside the cockpit, high flight crew workload in some phases of flight, visual misidentification of proximate traffic.<br><br>This ASAS application provides the flight crew with a display of proximate traffic. Information should include at least identification and position of the traffic. The display is likely to be augmented by traffic advisories, alerting the flight crew to proximate traffic and the need for a visual search.<br><br>The expected benefit is increased safety, attributable to more effective see-and-avoid. In addition, flight crew and controller workload could be reduced by the more timely and effective see-and-avoid action, and the reduced need for the controller to repeat traffic information. |
| **Roles and procedures for flight crews and controllers** | This ASAS application does not modify the roles of flight crews or controllers. The effect on procedures would be slight:<br><br>— If the flight crew of the IFR aircraft does not visually acquire the VFR traffic after a traffic information provided by the controller, he could use his traffic display to keep on looking for the VFR instead of asking for new traffic information.<br><br>— When he achieves visual contact, the traffic display should complement the visual information and lead to a more accurate assessment of the situation.<br><br>Subject to the pilot's duty to see-and-avoid, manoeuvres by the IFR aircraft to resolve conflicts would have to be coordinated with the controller. Manoeuvres based solely on the traffic display would not be authorised as part of this application. |
| **Implementation considerations** | The enhancement of see-and-avoid would be restricted to aircraft that are displayed. Further, failure to display some aircraft could lead to misidentification. Thus it is desirable that all aircraft be ADS-B equipped in remote areas, and that TIS-B be used where there is a ground surveillance service.<br><br>The required equipment for the IFR aircraft includes an airborne surveillance function relying on ADS-B and TIS-B information and a traffic display. |

| | |
|---|---|
| **Name** | **Enhanced sequencing and merging operations** |
| **ASAS application category** | Airborne spacing |
| **ASAS application description** | The aim of this ASAS application is to redistribute tasks related to sequencing (e.g. in-trail following) and merging of traffic from controllers to flight crews. Controllers would use new instructions directing the flight crews to establish and maintain a given time or distance from a designated aircraft. The flight crews will perform these new tasks using new aircraft functions (airborne surveillance, a traffic display, and spacing tools and advisories).<br><br>The main expected benefit is increased controller availability due to the streamlining of the controller's tasks. This could allow more aircraft to be accepted in a given sector or the size of sectors to be increased. It also hoped that these instructions would enable more regular spacing between aircraft, closer to the separation minima, and thus potentially an increase in capacity.<br><br>This ASAS application is designed for en-route airspace and TMAs in a radar environment. The applicable flight phases include cruise and descent from top of descent to the runway. |
| **Roles and procedures for flight crews and controllers** | The core roles and working methods of controllers and flight crews would remain unchanged. The controllers would remain responsible for separation, and would work to the present ATC separation minima.<br><br>The new set of spacing instructions would include:<br><br>— Instructions to merge behind a preceding aircraft and to establish a specified spacing time or distance from that aircraft. This could be done through the increase or the reduction of aircraft speed or through path stretching.<br><br>— Instructions to maintain a given spacing time or distance from a preceding aircraft. If the preceding aircraft is following a predefined trajectory (e.g. a STAR), the following aircraft would follow the same predefined trajectory while maintaining the spacing. If the preceding aircraft is not following a predefined trajectory (e.g. radar vectoring), the following aircraft will be diagnose the trajectory of the other aircraft and follow it.<br><br>These new instructions are going to require specific functions on board the aircraft. These include the provision of information to the flight crew (e.g. display of relevant traffic information, generation of advisories) and also automation functions (e.g. new auto-pilot or FMS functions). |

| | |
|---|---|
| **Name** | **Enhanced sequencing and merging operations** |
| **Implementation considerations** | To perform this ASAS application, only the aircraft involved in the procedure need to be fitted with equipment supporting airborne surveillance. However, to achieve meaningful capacity benefits, a significant proportion of aircraft will need to be equipped. The advantages for an operator that equipped for this application would be likely to be most marked at its hub airports.<br><br>During the transition to full ADS-B equipage, TIS-B could significantly improve the utility of this application. To be used this way, TIS-B must have the required performance parameters (e.g. update rate, latency) to support the spacing functions.<br><br>The benefits will be maximized if the spacing values used are close to ground radar separation minima. It is therefore essential to demonstrate that these new procedures are safe and that they do not compromise the provision of ground separation by ATC. Controllers are likely to need precise guidance on the spacing values that it would be reasonable (and considered reasonable) to use. |

| | |
|---|---|
| **Name** | **ASAS crossing clearance** |
| **ASAS application category** | Airborne separation |
| **ASAS application description** | The ASAS crossing clearance executes the delegation of the separation task from the controller to the flight crew of a suitably equipped aircraft to ensure safe separation from the aircraft designated by the controller under specific circumstances, limited in time, space and scope. The flight crew would maintain airborne separation the designated aircraft in compliance with applicable 'airborne separation minima' and any manoeuvre restrictions that have been imposed (e.g. lateral only).<br><br>It can be applied in several geometries (e.g. horizontal crossing, vertical crossing, lateral passing, etc), and separation would be maintained in the appropriate dimension (i.e. lateral, vertical or longitudinal).<br><br>The main objective is to reduce the number of conflicts that a controller has to resolve simultaneously, and allow flight crews to closely monitor the resolution, possibly using better information. This reduction of controller's workload could increase the sector capacity. In addition, the conflict resolution should be optimised because the airborne side has a more precise perception of the situation, and flight crew will be able to maximise flight efficiency. Additional increases in capacity and flight efficiency may also be achieved by the possible reduction of the applicable separation minima depending on the airspace.<br><br>This ASAS application can be used in various operational environments: radar or procedural airspace, en-route or TMA, fixed or free routes, possibly with a high traffic density. |
| **Roles and procedures for flight crews and controllers** | The roles of flight crews and controllers would be modified by this ASAS application. The controller would retain all separation responsibility except in respect of the execution of the clearance, where the flight crew is responsible for maintaining airborne separation with a designated aircraft within the boundaries defined by the clearance issued by the controller.<br><br>The controller would normally be the initiator of the clearance. When he detects a conflict, he could decide to delegate the separation task to the flight crew of a suitably equipped aircraft by issuing an ASAS crossing clearance. The flight crew also could request an ASAS crossing clearance, as they can today suggest a visual separation clearance in some States.<br><br>After accepting the clearance, the flight crew would adjust the horizontal trajectories, the vertical flight path or the speed of the aircraft according to the nature of the clearance in order to maintain airborne separation from the designated aircraft. For example, the clearance could be to 'pass below' (maintaining own vertical separation). The flight crew would be responsible for monitoring of the crossing until the clearance limit provided by the controller. |

| | |
|---|---|
| **Name** | **ASAS crossing clearance** |
| **Implementation considerations** | To perform this clearance, an aircraft needs to be fitted with new equipment. This includes airborne surveillance of surrounding traffic, and a system to assist the flight crew (i.e. determination that the clearance is feasible, display of relevant traffic information, conflict resolution assistance, and an indication that the designated aircraft has been crossed).<br><br>The designated aircraft does not need specific equipment. If it is not ADS-B equipped, TIS-B could enable the crossing, assuming that TIS-B data has the required performances (e.g. update rate, latency, integrity).<br><br>No change in ground systems is required. However, some new functions might help controllers use the ASAS application more efficiently (e.g. display of aircraft equipment, identification of possible ASAS crossing opportunities). |

| | |
|---|---|
| **Name** | **Autonomous aircraft operations in dedicated airspace** |
| **ASAS application category** | Airborne self-separation |
| **ASAS application description** | This ASAS application is envisaged in restricted portions of en-route airspace. Access to this airspace would be limited to suitably equipped aircraft. (Other ASAS applications involving a more active role for an ATM service provider might allow access by less capable aircraft. This application envisages that aircraft without a suitable ASAS are excluded from the dedicated airspace.)<br><br>In this airspace, suitably equipped aircraft would be able to fly user-preferred 3D or 4D routings. The flight crew would be responsible for separation from other aircraft operating in the same airspace, except, in some cases, in abnormal circumstances. The possibility that an ATM service provider, or the military, could provide a separation provision service in exceptional circumstances, e.g. emergencies, is not excluded, and would need to be addressed and defined.<br><br>For the safety of the application, it will be essential to address separation from all hazards. Other means than ASAS will have to address separation from hazards other than traffic.<br><br>The appropriate airborne separation minima will have to be determined. Transition zones would be required for aircraft entering and leaving this restricted airspace.<br><br>The expected benefits are mainly increased airspace capacity and better flight efficiency through direct routing and user-preferred conflict resolution. |
| **Roles and procedures for flight crews and controllers** | The roles and procedures for flight crews and controllers are radically modified.<br><br>In this restricted airspace, flight crews would be responsible for their separation from all other aircraft. This includes the detection and resolution of conflicts, including coordination with the other aircraft.<br><br>The controller will no longer be responsible for separation provision. Since one of the advantages of the application is to remove the need for separation provision by tactical ground controllers, it might not be possible to provide a separation provision service even in emergencies. However, provision of a service in such unusual circumstances is consistent with the concept, and is a matter that requires further consideration. An ATM service provider is likely to be responsible for overall flow control, and controllers could monitor the density of traffic and provide anticipatory information to flight crew. In the transition zones, flight crew of aircraft leaving the dedicated airspace would pass responsibility for separation to controllers, and controllers would pass separation responsibility to flight crew before they entered the dedicated airspace.<br><br>New rules are likely to be necessary to resolve conflicts. Two different methods could be envisaged: |

| | |
|---|---|
| **Name** | **Autonomous aircraft operations in dedicated airspace** |
| | — cooperative conflict resolution: the two aircraft in conflict both manoeuvre to resolve the conflict;<br>— priority rule based conflict resolution: only one of the two conflicting aircraft manoeuvres to resolve the conflict according to ‘rules of the air’. |
| **Implementation considerations** | As the roles and procedures are radically modified, there are some important new requirements for the airborne and ground systems.<br><br>Airborne functions to enable the flight crew to perform the task of self-separation would include:<br><br>— an airborne surveillance function providing a traffic display,<br>— a conflict detection function to identify potential infringements of the airborne separation minima from other aircraft or defined airspace volumes,<br>— ASAS alerts to inform/alert the flight crew when a conflict arises, and<br>— a conflict resolution function giving guidance to the flight crew,<br><br>A designated link (e.g. VHF frequency) would be devoted to aircraft to aircraft communication in support of conflict resolution. |

## Attachment D

## ACRONYMS

| | |
|---|---|
| AATT | advanced air transportation technologies project |
| ACAS | airborne collision avoidance system |
| ADS-B | automatic dependent surveillance — broadcast |
| ADSP | Automatic Dependent Surveillance Panel — now called the OPLINK Panel |
| ADSP/*n* | The *n*th meeting of ADSP |
| ASA | airborne surveillance applications |
| ASAS | airborne separation assistance system |
| ASSAP | airborne surveillance and separation assurance processing |
| ATC | air traffic control |
| ATM | air traffic management |
| ATMCP | Air Traffic Management Concept Panel |
| ATS | air traffic services |
| CARE/ASAS | cooperative actions of R&D in EUROCONTROL on ASAS |
| CD&R | conflict detection and resolution |
| CDTI | cockpit display of traffic information |
| CNS | communications, navigation and surveillance |
| COOPATS | cooperative ATS concept |
| CPDLC | controller-pilot data link communications |
| DAG-TM | distributed air-ground traffic management |
| DME | distance measuring equipment |
| EACAC | evolutionary air-ground cooperative ATM concept |
| EUROCAE | European Organization for Civil Aviation Equipment |
| EUROCONTROL | |
| FAA | Federal Aviation Administration (of the United States) |
| FMS | flight management system |
| GNSS | global navigation satellite system |

| | |
|---|---|
| ICAO | International Civil Aviation Organization |
| I/D | flight identity |
| IFR | instrument flight rules |
| IMC | instrument meteorological conditions |
| MA-AFAS | more autonomous aircraft in future ATM system |
| MASPS | minimum aviation system performance standards |
| MFF | mediterranean free flight |
| NASA | National Aeronautics and Space Administration (of the United States) |
| NEAN | North European ADS-B Network |
| NUP | NEAN Update Programme |
| OPLINKP | Operational Data Link Panel |
| OSA | operational safety assessment |
| PO-ASAS | principles of operations for the use of ASAS |
| RA | resolution advisory |
| R&D | research and development |
| RSP | required surveillance performance |
| RTCA | RTCA Inc. |
| RTF | radio telephony |
| SARPs | Standards And Recommended Practices |
| SCRSP | Surveillance and Conflict Resolution Systems Panel |
| SC186, SC189 | Special Committees of RTCA |
| SF21 | SafeFlight 21 |
| SICASP | SSR Improvements and Collision Avoidance Systems Panel |
| SICASP/n | The *n*th meeting of SICASP |
| SSR | secondary surveillance radar |
| TESIS | test & evaluation surveillance information system |
| TIS-B | traffic information service — broadcast |
| TMA | terminal manoeuvring area |
| Tx/Rx | transmission and reception |

| | |
|---|---|
| US | United States (of America) |
| VFR | visual flight rules |
| WGA | Working Group A of SCRSP |
| WG51, WG53 | Working Groups of EUROCAE |
| 3D, 4D | three, and four, dimensional |

— END —