Airborne Separation Assistance System Thematic Network 2
(ASAS-TN2)

Work Package 3

ASAS application maturity assessment

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Change history

Version	Date	Sections/Pages Affected	Reasons for change
1.0	27th March 2006	All	Initial publication
1.1	19th December 2006	Text added to all main sections except Airborne separation. Maturity levels changed for: ATSA VSA ASPA S&M SSEP MAS SSEP FFT New section added "Summary of changes from March 2006 to February 2007"	Draft annual update (2007) preparation. Initial changes from ASAS-TN2 authors

1.2	8th January 2007	Updated following sections: ASAS spacing cluster ASAS separation cluster Applications maturity summary (new ASEP-S&M diagram) Summary of changes from March 2006 to February 2007 (including adding ASEP S&M to histogram)	Draft annual update (2007) preparation. Changes from ASAS-TN2 authors and NASA Langley
1.3	22nd January 2007	Refinements to all chapters of document Added chapter 4.3 ADS-B equipage status for Hong Kong, China	Draft annual update (2007) preparation - Changes arising from group ASAS-TN2 review held 18th January 2007
2.0	9th March 2007	Refinements to structure and contents of all chapters of document. Addition of summary and conclusion.	Annual update (2007) external release - Changes arising from ASAS-TN2 plus external reviewers from: NASA Langley, AENA (Spain), Rockwell Collins (Netherlands), QinetiQ (UK), Airbus (France), Air Services Australia, Boeing (Seattle), Thales ATM (France), and MITRE (US).

Summary

The global maturity of eighteen applications based on Automatic Dependent Surveillance Broadcast (ADS-B), has been assessed by the European Commission sponsored Airborne Separation Assistance System (ASAS) Thematic Network 2 project. A group of twelve European operational and technical ASAS specialists from industry, service providers and research (BAE Systems (UK), ENAV (Italy), LFV (Sweden), NLR (The Netherlands), Thales ATM (France), Thales Avionics (France) and EUROCONTROL) judged maturity based on a set of commonly agreed metrics and their experience in the field.

For each application, maturity scores in the range 0 to 4 were assigned for each of the following metric types: (i) Operational concepts, (ii) Benefits and constraints, (iii) Safety, (iv) Procedures and human factors, (v) Systems, HMI and technology and (vi) Transition issues. The maturity assessment was reviewed externally by at least nine selected peers in Europe, USA and Australia. The assessment has been conducted twice, once in 2006 and again in 2007.

Results indicate that one of the most mature applications is ‘ATC surveillance in non-radar areas’ with scores in the range 3 to 4 for all aspects of maturity rated. The airborne traffic situational awareness applications ‘In-trail procedure in non-radar oceanic airspace’ and ‘Enhanced visual separation on approach’, and the Airborne spacing application ‘Sequencing and merging’ also seem to have made progress with scores in the range 2.5 to 3.5. The applications judged to be relatively immature are ‘Aircraft derived data for ground tools’ (ADS-B surveillance category), ‘Enhanced crossing and passing’ (Airborne spacing category) and ‘Vertical crossing and passing’ (Airborne spacing category) with scores between 1 and 2 for all aspects of maturity. The low score of ‘Enhanced crossing and passing’ (Airborne spacing category) can be explained by it being superseded by the related application ‘Lateral crossing and passing’ in the Airborne separation category.

Over the year from March 2006 to February 2007 the maturity scores of fifteen out of seventeen applications increased and one decreased. ‘In-trail procedure’ (Airborne separation category) had increased scores in four out of the six maturity metrics. ‘ATC surveillance in radar airspace’ (ADS-B surveillance category), ‘In-trail procedure in non-radar oceanic airspace’ (Airborne traffic situational awareness category), ‘Sequencing and merging’ (Airborne spacing category) and ‘Lateral crossing and passing’ (Airborne separation category) all had increases in three out of the six maturity metrics. The decrease in maturity score of ‘Enhanced traffic situational awareness during flight operations’ (Air traffic situational awareness category) was due to results from the US/European ADS-B applications requirements focus group identifying safety issues related to mixed fleet equipage. A new application was also added to the assessment ‘Sequencing and merging’ (Airborne separation category) as an extension of the existing ‘Sequencing and merging’ application in the Airborne spacing category.

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1. Introduction

1.1. Purpose and scope

This report provides an assessment of the global maturity of Airborne Separation Assistance System (ASAS) applications. The purpose of this part of the ASAS Thematic Network 2 (ASAS-TN2) is to provide an annual assessment of the progress and necessary steps in the development of ASAS applications. This report is the first annual update of the initial report version 1.0 issued on 27th March 2006.

1.2. ASAS-Thematic Network

ASAS-TN2 is a three-year project that is primarily a communication activity. ASAS-TN2 is sponsored by the European Commission (Directorate General Research). It is a stand-alone project, following on from the work of its predecessor project ASAS-TN1. The scope has now increased to address applications beyond ADS-B (Automatic Dependent Surveillance Broadcast) Package 1. ASAS-TN1 arose out of the ASAS work within the programme of Co-Operative Actions of Research & Development (R&D) in EUROCONTROL (CARE-ASAS). It is organised within the work programme for Competitive and Sustainable Growth of the European Community, Key action 4, New Perspectives in Aeronautics, Target Platform 4, “More Autonomous Aircraft in the Future Air Traffic Management System”.

The main objective of the ASAS Thematic Network is to accelerate the implementation of ASAS applications in European airspace taking into account global applicability in order to increase airspace efficiency, capacity and safety.

More specifically the ASAS-TN2 tasks include the following:

- Reviewing R&D work on ASAS/ADS-B applications including validation/safety/human factors work – in particular work performed in ASAS-related projects;
- Reviewing the development of operational standards;
- Reviewing the development of technical standards;
- Reviewing of the achievement of early implementations; and
- Developing guidelines and recommendations to accelerate implementation of ASAS/ADS-B applications

The deliverables of the ASAS-TN2 are threefold:

- Host five ASAS workshops and a final seminar
- Provide web-based related documentation including ASAS-TN2 reports; and
- Reporting annually on the status and maturity of ASAS application development.

This report concerns the third bullet above. It is the second report of three aiming to summarise, in a concise and graphical format, the advancements of ADS-B/ASAS applications towards implementation

ASAS-TN2 is managed by a consortium led by EUROCONTROL that includes BAE Systems (UK), ENAV (Italy), LFV (Sweden), NLR (Netherlands), Thales ATM and Thales Avionics (France).

In addition to the above organisations, ASAS-TN2 involves a very wide range of organisations (e.g. ATM stakeholders, universities) including pilot and controller professional associations (ATCEUC (Air Traffic Controllers European Union’s Coordination), IFATCA (International Federation of Air Traffic Controllers’ Associations), IFALPA (International Federation of Air Line Pilots’ Associations) and ECA (European Cockpit Association)).

1.3. ADS-B

1.3.1. ADS-B definition

An Automatic Dependent Surveillance – Broadcast (ADS-B) transmitter allows an aircraft to broadcast its identification, position, velocity and intent information over a range of the order of 100 nautical miles. Aircraft equipped with an ADS-B receiver can then process and present this surrounding traffic information to pilots on a cockpit display of traffic information (CDTI). This gives rise to a set of potential new applications based on what is referred to as an airborne separation assistance system (ASAS). ADS-B receivers on the ground can also be used to enhance the traffic information available to air traffic controllers.

1.3.2. ADS-B equipage status

1.3.2.1. Core Europe 1090 Extended Squitter

The following statistics were taken from the Airborne Monitoring Project ADS-B Monthly Report, October 2006 of the EUROCONTROL CASCADE project (Co-operative Air Traffic Services through Surveillance and Communication Applications Deployed in the European Civil Aviation Conference area).

The results are generally based on information collected by: France (Charles de Gaulle), Germany (Dusseldorf), The Netherlands (Schipol, Woensdrecht), The United Kingdom (Pease-Pottage), Belgium (Bertem/St. Huber) Czech Republic (Pisek) and Switzerland (Geneva) consolidated by EUROCONTROL.

Number of recorded flights: 535,640
Recording duration: 2,891 hours
Percentage of flights that are Mode-S equipped: 95.3%
ADS-B Extended Squitter capability as percentage of Mode-S equipped: 57.3% (compared with 39.8% in January 2006)

Note: The ADS-B transponder are not certified for operational use. A detailed statistical analysis of data collected (from France, Switzerland and UK) indicates that about two thirds of ADS-B capable transponders were broadcasting a position:

Extended Squitter data statistics (Com-B Data Selector 1.7)	Jan 2006 % of flights	Oct 2006 % of flights	Trend over 10 months
ES Airborne position set to 1 (bds 0.5)	53.5	66.5	+24%
ES Ground position set to 1 (bds 0.6)	38.4	59.0	+54%
ES Status set to 1 (bds 0.7)	54.8	69.3	+27%
ES type and id set to 1 (bds 0.8)	65.0	74.2	+14%
ES Airborne velocity set to 1	56.0	69.9	+25%
ES Even driven set to 1	0	0	0%

Table 1 Statistics for Extended Squitter capable flights in Europe

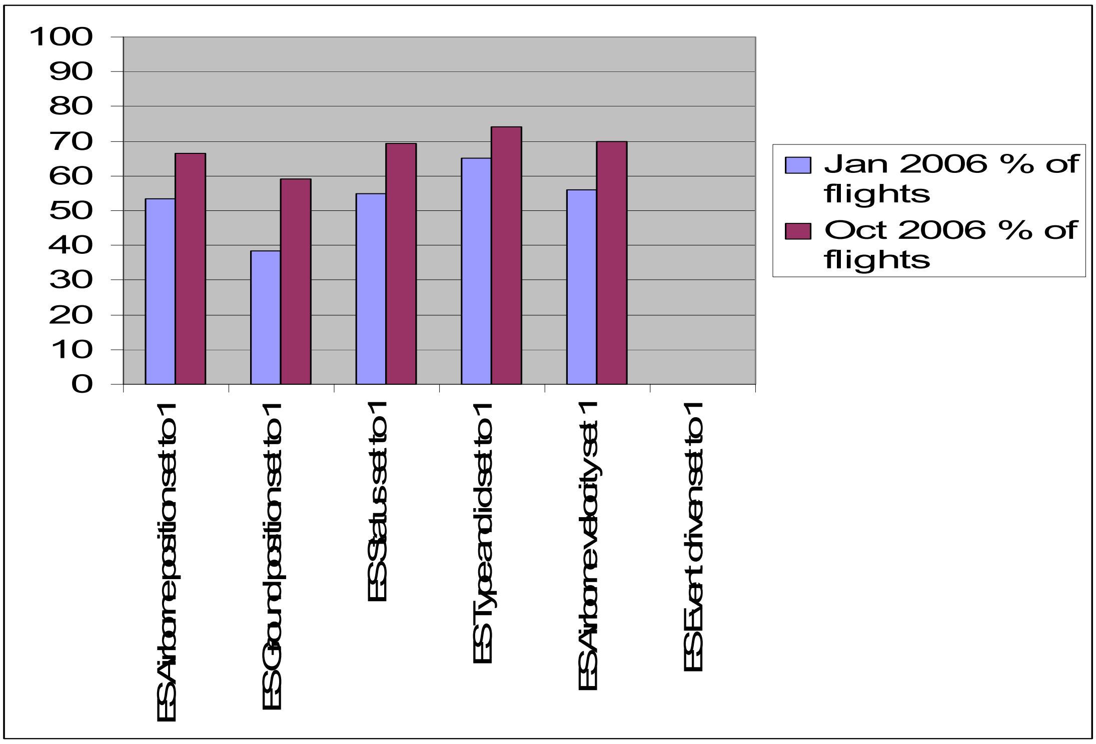


Figure 1 Statistics for Extended Squitter capable flights

Figure 2 shows the evolution of 1090 ES equipage in Europe.

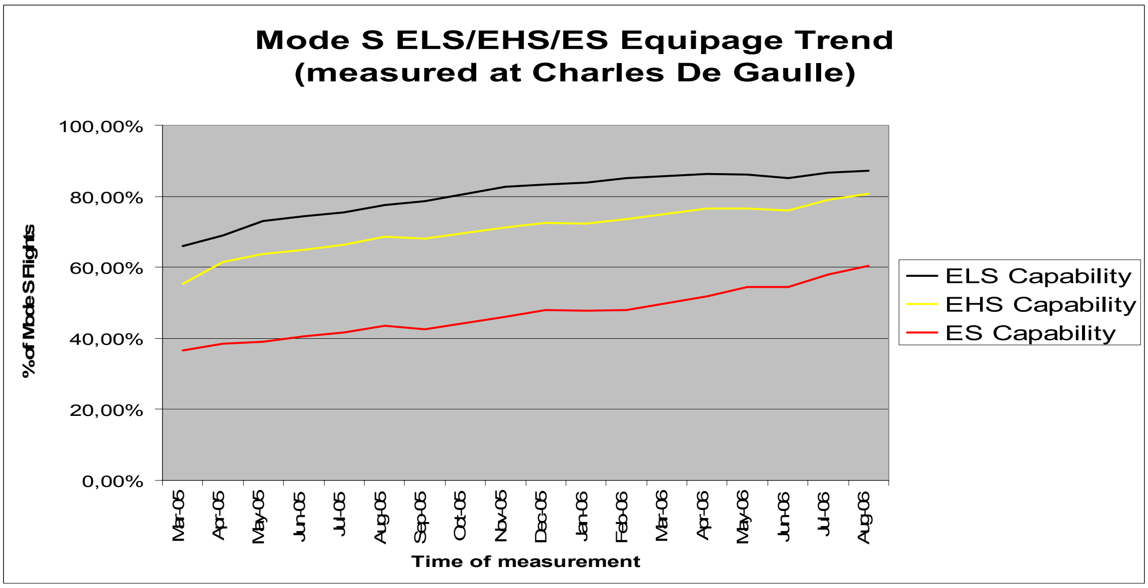


Figure 2 Mode S Equipage trend measured at Paris Charles de Gaulle

Regarding the Figure Of Merit (FOM), the trend is that more than 60% of the analysed ADS-B reports (from the stations at Bretigny and Toulouse) have FOM>4. The rest of the reports mostly indicate FOM=0.

The EUROCONTROL CASCADE Programme in partnership with stakeholders (AIRBUS, DSNA, THALES ATM and Alticode) has performed the CRISTAL Toulouse project which assessed statistically the quality of ADS-B 1090 ES and defined the certification roadmap.

This will be used as a basis for the continuing monitoring/analysis work, the preparation of certification material by the relevant organisations during 2006-2007 and the availability of certified ADS-B avionics.

1.3.2.2. Regional European VDL/4 ADS-B

The following statistics are based on information collected by LFV (Sweden) in the 18-month period from May 2005 to November 2006.

LFV is recording data from the newly deployed ADS-B network with ground stations in Malmö, Arlanda and Umeå. These stations are the three first in a series of 12 stations that will provide nation wide ADS-B coverage.

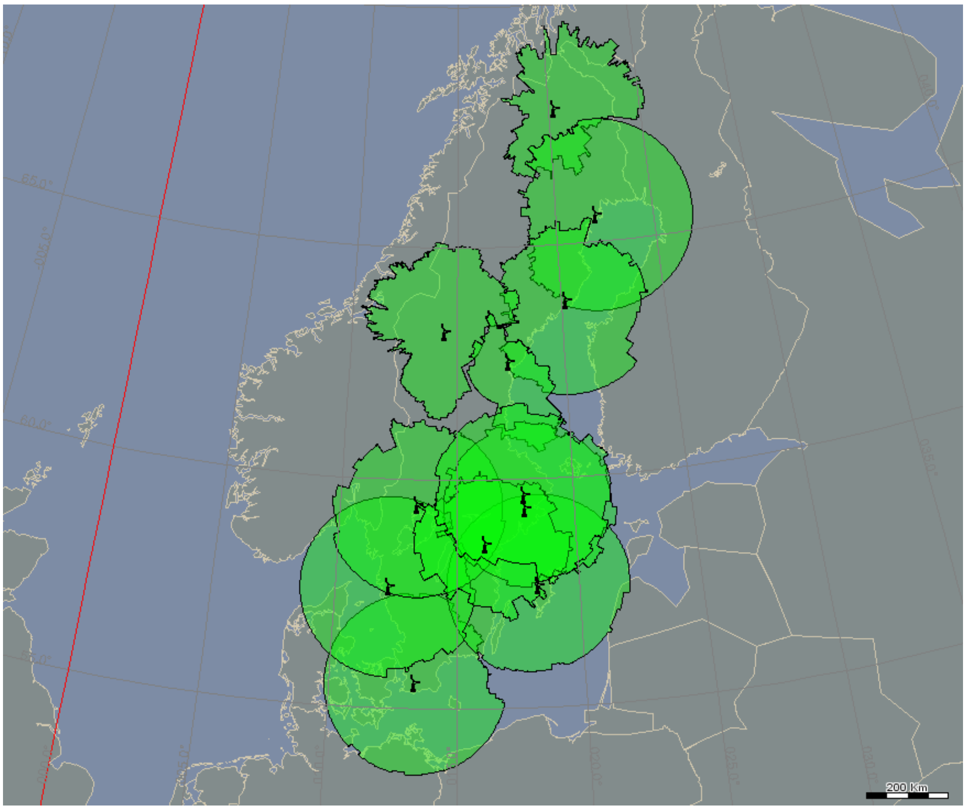


Figure 3 Estimated coverage at 10,000 ft above Mean Sea Level for the Swedish ADS-B network when all 12 ground stations are deployed (Analysis done using EUROCONTROL CAPT tool)

The current installation gives en-route coverage over the Swedish airspace from Malmö to Umeå, where the local commuters, Malmö Aviation and Skyways operate.

The total recorded duration of VDL Mode 4 equipped flights is approximately 3,000 hours of flight time (GA and commercial operators). The surface vehicles at Arlanda airport generate in excess of 300 hours of surface movements recorded each day.

1.3.2.3. Hong Kong, China

Since November 2004, Hong Kong Civil Aviation Department has collected statistics on ADS-B equipage of the aircraft flying close to Hong Kong International Airport. The following statistics were presented to the 5th ICAO meeting of ADS-B study and implementation task force in New Delhi, India, 5-7th April 2006.

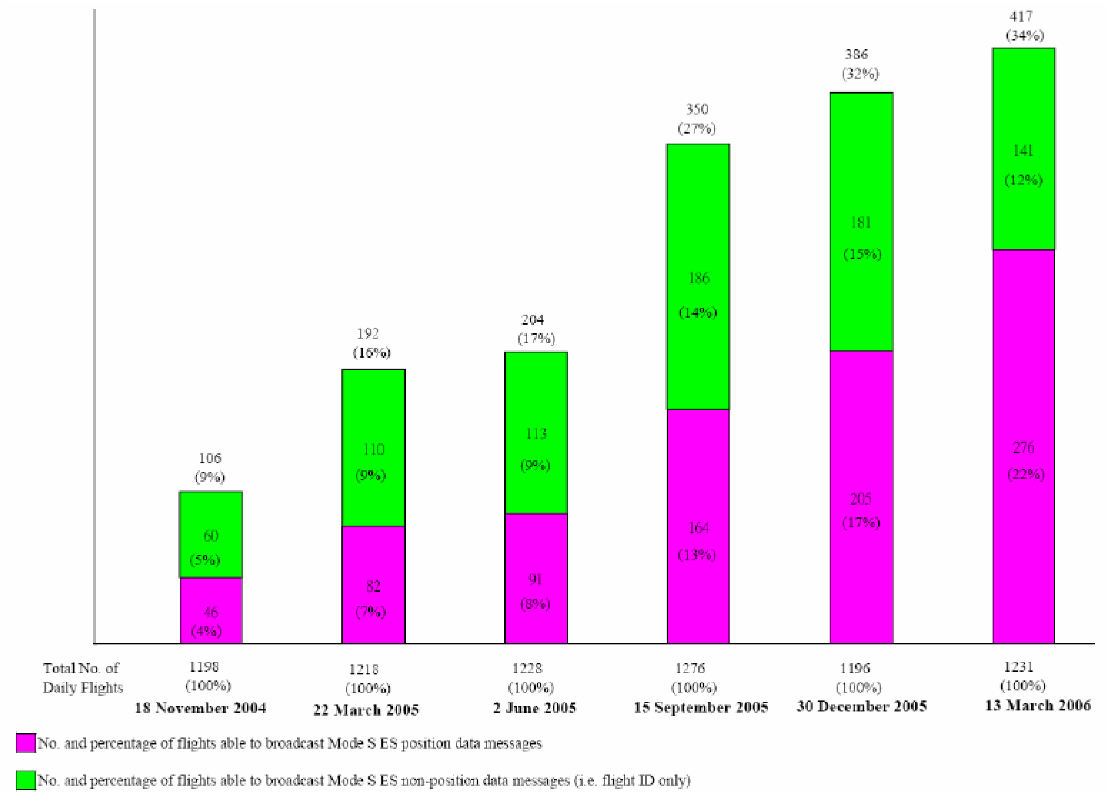


Figure 4 Quarterly survey of Mode S extended squitter (ES) equipage, Hong Kong, China

2. Applications of ADS-B

Eighteen ADS-B applications were selected for this maturity assessment. They are grouped in five categories depending on whether they can be characterised as ADS-B surveillance or by the four ASAS categories: Airborne traffic situational awareness, Airborne spacing, Airborne separation and Airborne self-separation. The applications per category are described as follows:

2.1. ADS-B surveillance

2.1.1. Airport surface surveillance (ADS-B-APT)

This application will provide a new source of surveillance information for a safer and more efficient ground movement management at airports. Equipped ground vehicles can also be displayed.

2.1.2. ATC surveillance in radar airspace (ADS-B-RAD)

The ADS-B-RAD application will apply to en-route and terminal phases of flight in airspace classes (A to E) where radar surveillance currently exists (note that non-radar area cases are covered by ADS-B-NRA).

An example is the case of surveillance in areas where single radar coverage presently exists; ADS-B surveillance could be considered as enhancing the quality (i.e. accuracy, integrity, availability, etc.) of surveillance information and may also be used as back up in case of radar failures. Another example is where multi-radar presently exists but a radar is to be de-commissioned in future and the radar replacement costs are not justified.

2.1.3. ATC surveillance in non-radar areas (ADS-B-NRA)

The ADS-B-NRA application will provide enhanced air traffic services in areas where radar surveillance currently does not exist.

Examples of use of this application are remote areas (including offshore, oilrig and small island environments), which, due to the level of traffic, location or the cost of the equipment, could not justify the installation of radar. This application may also be useful in areas where there are gaps in the radar coverage, (e.g. due to obstacles, mountainous terrain, shadowing etc). as well as areas where existing radar is to be de-commissioned and the replacement costs are not justified.

2.1.4. Aircraft derived data for ground tools (ADS-B-ADD)

This application will provide additional aircraft derived data through ADS-B to be used by the ATC ground system for developing or enhancing ATC tools like displays, MTCD (Medium Term Conflict Detection), AMAN (Arrival Manager), DMAN (Departure Manager) and ground based safety nets. Collaborative Decision Making (CDM) applications will also share the benefits. It should be noted that this application does not encompass the ground tools themselves; it only provides additional input data for these tools.

2.2. Airborne traffic situational awareness

2.2.1. Enhanced traffic situational awareness during flight operations (ATSA-AIRB)

ATSA-AIRB is the basic application. It provides flight crews with information about nearby traffic including at least the aircraft identifier and its position. This display supplements verbal traffic information provided either by controllers or other flight crews, as well as normal out-the-window visual scans.

ATSA-AIRB can be used in all visual conditions and therefore is relevant to both Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC) operations. It is also applicable to all flight rules, i.e. Instrument Flight Rules (IFR) and Visual Flight Rules (VFR), and to all types of aircraft.

The objectives of this application are to improve the flight safety and efficiency in all airspace.

This Airborne surveillance application contains two sub-applications, which aim at enhancing some current procedures. They are defined by the operational goal and the airspace involved with the associated services provided by ATS. The two sub-applications are:

- Enhanced visual acquisition for see-and-avoid: in airspace where separation service is not provided by ATC, it aims at making the visual acquisition task easier and more reliable by the addition of an appropriate on-board traffic display.
- Enhanced TIBA (Traffic Information Broadcast by Aircraft): in airspace where TIBA is applied it improves the current TIBA procedure by the addition of an appropriate on-board display of surrounding traffic to provide surveillance additional to listening to the TIBA VHF frequency.

The objective of the first application is to improve efficiency of flight in controlled airspace. The objective of the second application is safety.

2.2.2. Enhanced traffic situational awareness on the airport surface (ATSA-SURF)

This application provides the flight crews with information on the surface traffic that supplements out-the-window observations and see-and-be-seen procedures. The goal is to reduce the potential for conflicts, errors and collisions (e.g. runway incursion) by providing enhanced situational awareness to the flight crew operating an aircraft on or near the airport surface.

2.2.3. In-trail procedure in non-radar oceanic airspace (ATSA-ITP)

This application permits a “climb-through” or “descend-through” manoeuvre to pass a “blocking” aircraft, using a distance-based longitudinal separation minimum with the blocking aircraft during the ITP manoeuvre. This distance-based longitudinal separation minimum is less than the standard separation minimum applied in oceanic airspace. The goal is to enable aircraft that desire flight level changes in oceanic and remote airspace to achieve these changes on a more frequent basis, thus improving flight efficiency and safety.

2.2.4. Enhanced visual separation on approach (ATSA-VSA)

This application helps crews to achieve the visual acquisition of the preceding aircraft and then to maintain visual separation from this aircraft. The goal is to allow an increased use of visual separation on approach in order to provide an optimum flow of traffic.

2.3. Airborne spacing

2.3.1. Sequencing and merging operations (ASPA-S&M)

The objective 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 will utilise a new set of instructions allowing them, for example, to instruct the flight crews to establish and to maintain a given time or distance in trail from a designated aircraft. The flight crews will perform these new tasks using a suitable human-machine interface. One anticipated benefit is increased capacity through better adherence to the ATC-requested spacing.

2.3.2. Enhanced crossing and passing operations (ASPA-C&P)

The objective is to provide the controller with a new set of procedures to solve conflicts directing, for example, the flight crews to cross or pass a designated traffic aircraft while maintaining a given spacing value. The flight crews will perform these new tasks using a human-machine interface. The main expected benefit is increased efficiency through the reorganisation and the streamlining of tasks.

2.4. Airborne separation

2.4.1. Lateral crossing and passing (ASEP-LC&P)

ASSTAR is currently defining a “Lateral Crossing” procedure allowing an aircraft (the “clearance” aircraft) to cross or pass a “target” aircraft using ASAS. Responsibility for separation is delegated to flight crew of the clearance aircraft, although ATC remain responsible for separation of the clearance aircraft from all other aircraft. This responsibility is limited in time, space and scope for the duration of the Lateral Crossing procedure. Except in these limited specific circumstances where the flight crew takes responsibility for separation, ATC retains all other separation responsibility.

2.4.2. Vertical crossing and passing (ASEP-VC&P)

The ASEP-VC&P application will consist of scenarios such as Pass Above or Pass Below, in which a trailing aircraft will be able to climb or descend two or more flight levels relative to a blocking aircraft such that during the vertical manoeuvre, the aircraft do not approach closer than some specified horizontal distance, until the vertical separation is recovered. There also exists RVSM to non-RVSM transition scenarios which will support flight level transitions in the presence of opposing traffic when flying from RVSM to non-RVSM airspace.

2.4.3. In-trail procedure (ASEP-ITP)

ASEP-ITP is the In Trail Procedure defined as an Airborne Separation application, as opposed to an Airborne Traffic Situational Awareness application as currently being defined by the RFG. ASEP-ITP is currently subject of work in the ASSTAR project.

The ASEP-ITP application is designed for use en-route in an Oceanic environment. The main objective is to increase efficiency. This will be achieved by allowing climbs or descents with temporarily reduced longitudinal separation minima. For ASEP-ITP, a limited transfer of separation responsibility between the controllers and aircrews is assumed (i.e. the duration of the ITP climb or descent). The flight crew has to monitor and maintain spacing to specific aircraft during the manoeuvre.

The ITP criteria for ASEP-ITP will most likely differ from the ITP criteria for ATSA-ITP to enable a further reduction in longitudinal separation minima during the ASEP-ITP manoeuvre.

Within ASSTAR, there are six ITP climb or descent manoeuvres, as follows:

- A Following Climb.
- A Following Descent.
- A Leading Climb.
- A Leading Descent.
- A Combined Leading-Following Climb.
- A Combined Leading-Following Descent.

2.4.4. In-trail follow (ASEP-ITF)

The ASEP-ITF application is currently being studied in ASSTAR which uses the MFF Operational Concept as the basis for defining the ASEP-ITF application.

The application is designed for use en-route in an Oceanic environment. The objective is to reduce controller workload and to increase capacity and flight efficiency. This will be achieved by redistributing tasks and separation responsibility related to the in-trail following of traffic between the controllers and the aircrews.

Both oceanic and domestic controllers will be provided with new ATC procedures directing, for example, the aircrews to establish at the oceanic entry point and to maintain a given time or distance from a designated aircraft. The aircrews will perform these new tasks using new aircraft functions (e.g. airborne surveillance, display of traffic information, spacing functions). Within the context of ASSTAR, the use of ASEP-ITF procedures will replace most of the controller's use of the sliding Mach technique to separate traffic in the NAT Organised Track System, or more general in NAT airspace for traffic flying the same route.

2.4.5. Sequencing and merging operations (ASEP-S&M)

The application is designed to delegate the tasks related to sequencing (e.g. in-trail following in approach) and merging of traffic from the controllers to the flight crews. The controllers will utilise a new set of instructions allowing them, to delegate the responsibility for maintaining separation from a designated target (lead aircraft) to the flight crew for a limited duration and under specific conditions. The flight crews will perform these new tasks using a suitable human-machine interface. The expected benefits are increased flight predictability, airspace throughput and the enabling of more efficient flight profiles.

2.5. Airborne self-separation

2.5.1. Self-separation in segregated free flight airspace (SSEP-FFAS)

The "Airborne Self Separation" concept, also referred to as "Free Flight", is where aircrews are allowed to select their trajectory freely in real-time, at the cost of acquiring responsibility for conflict management. EUROCONTROL defines Free Flight as the flight through 'Free Flight Airspace' (FFAS) (see ATM2000+ Strategy), where, suitably equipped aircraft are able to fly user-preferred routings and responsibility for separation assurance from other aircraft operating in the same airspace will rest with the aircrew. Figure 5 shows the possible location of FFAS with respect to Managed Airspace (MAS).

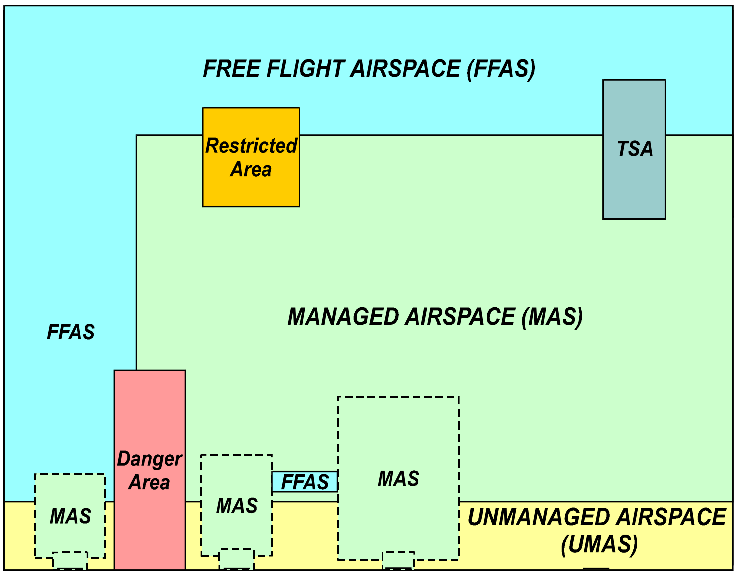


Figure 5 Possible locations of FFAS and MAS.

2.5.2. Self-separation in managed airspace (SSEP-MAS)

The SSEP-MAS concept is slightly different from the definition as provided by EUROCONTROL. In the SSEP-MAS concept, equipped aircraft are allowed to freely choose their trajectory in Managed Airspace, provided that they avoid the non-equipped aircraft in MAS which are conventionally controlled by ATC.

2.5.3. Self-separation in an organised track system (SSEP-FFT)

The SSEP-FFT concept is a variation of the SSEP-FFAS concept, although more restricted. The concept assumes equipped aircraft to be flying on a designated track within the oceanic Organised Track System (OTS), segregated from the non-equipped aircraft. The crew is able to choose their trajectory freely, albeit with some limitations in the horizontal direction. This concept is expected to be a first implementation towards SSEP-FFAS.

3. Method

3.1. Approach

The approach to the ASAS-TN2 ASAS application maturity work is based on a simple assessment and scoring system to report the maturity of ASAS applications, in order to produce a lightweight and accessible summary of the level of maturity of ASAS applications in a few pages.

The maturity was judged by a team of experts consisting of representatives from the ASAS-TN2 consortium and selected external peer reviewers from NASA Langley (USA), AENA (Spain), Rockwell Collins (Netherlands), QinetiQ (UK), Airbus (France), Air Services Australia, Boeing (Seattle, USA), EUROCAE (Paris), Helios (UK), EUROCAE (Europe) and MITRE (USA).

Within the scope of the project it was considered that we could not address each ASAS application individually and that an analysis at the level of the ASAS packages was at too high a level. Indeed, the content of ADS-B packages 2 and 3 at the time of writing is still under definition. Therefore intermediate groupings were defined for analysis corresponding to whether the applications were a type of ADS-B surveillance or an ASAS category:

- ADS-B surveillance (ground and airborne)
- Airborne traffic situational awareness
- Airborne spacing
- Airborne separation
- Airborne self-separation

3.2. Metrics

Each application within each group was assessed by a team of experts for maturity from several aspects:

- Operational concepts
- Benefits & constraints
- Safety assessment
- Procedures and human factors
- Systems, HMI & technology
- Transition issues

Each maturity level is scored as follows:-

Operational concept:

1 - Problem statement, identify solutions, concept generation (concept of operations)
2 - Preliminary Operational Concept Description (R&D Operational Service and Environment Description (OSED))
3 - Draft OSED in development (e.g. feedback from R&D OSEDs, trials and experiments, initial Requirements Focus Group (RFG) OSED) – in review and close to approval by appropriate internationally recognised body.
4 - Consolidated OSED (demonstrating integration in ATM system, feedback from Operational Safety Assessment (OSA) – some validation activity) - Published

Benefits & constraints:

1 - Benefits expectations & constraints survey
2 - Qualitative assessment of benefits
3 - Quantitative assessment of benefits (e.g. by means of fast-time simulations)
4 - Confirmation of benefits by means of large-scale data collection (real-time simulations, flight trials, etc.)

Safety assessment:

1 - Safety expectations
2 - Identification of hazards & risks, leading to Operational Hazard Analysis (OHA).
3 - Stable OSA. Allocation of safety objectives to the aircraft/aircraft operators and (Air Navigation Service Providers) ANSP. Standardisation activities.
4 - Approval for operations.

Procedures and human factors:

{There are two elements to address, air and ground. The score will reflect the lowest level of maturity - appropriately weighted}

1 - Role of actors, philosophy of automation defined

2 - Functional model of information presentation and operator interaction enabling high-level assessment of Human Factor (HF) risks and human performance
3 - Task analysis, derivation of cognitive model, investigate human factors risks and human performance, training needs analysis
4 - Mitigate risks in human performance and HF and validate task analysis and cognitive model. Identify training needs.

Systems, HMI & technology:
{There are two elements to address, air and ground. The score will reflect the lowest level of maturity - appropriately weighted}

1 - Functional design
2 - R&D, mock-up/part-task evaluation with humans-in-the-loop
3 - Industry-led system simulations, including human-in-the-loop simulations for Human Machine Interface (HMI). Shadow-mode/flight trials.
4 - Manufacturer(s) commit to full system development

Transition issues (All benefit dependant; Benefits high – just do it! Benefits proven low – forget it?):

1 - Issues identified
2 - Options identified (mixed equipage/airspace)
3 - Impact assessed
4 - A solution has been shown feasible and agreed upon

The evidence for scoring will be based on the projects, programmes and activities to be reviewed listed in the references section of this document. The list is not in any way exhaustive and will be updated during the course of ASAS-TN2.

This version of the document marks in brackets any differences in maturity scores since the previous version last year.

4. Results

4.1. ADS-B surveillance

4.1.1. Overview

4.1.1.1. Airport surface surveillance (ADS-B-APT)

This application is or has been addressed by European R&D projects such as:

- North European ADS-B Update Programme (NUP-1)
- NUP-2
- NUP II+
- EMMA and EMMA 2 (European Airport Movement Management by A-SMGCS)

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE programme. This includes the standardisation work (e.g. RFG) as well as validation trials (named CRISTAL) throughout Europe. A draft OSED has been developed by RFG addressing A-SMGCS level 1 and “ADS-B only” environments. Progress on this application will benefit from the ADS-B out monitoring and validation trials initiated in the context of CRISTAL. In NUP II+ project operational tests will be executed in 2007 at Stockholm-Arlanda airport, Sweden. Those tests will contain Routing service and Runway Incursion detection service. In Routing service ground control will send a graphical and text message of the cleared and expected taxiroute to aircraft via ADS-B datalink, taxiroute will be displayed on an EFB on board. If deviating from the cleared route an alarm will be triggered in cockpit as well as in ATC. No voice communication is needed only “accept” via datalink. Mobiles equipped with ADS-B out/in and a CDTI/EFB on board will also be able to display all surrounding traffic via TIS-B transmissions. Four B737NG and two vehicles will be fully equipped during these trails. Runway Incursion detection is also included in those trials and every participant has an alarm detection system of their own with different algorithms.

In the USA, Safe Flight 21 (SF21) has been addressing ADS-B APT. However, it must be emphasized that SF21 started earlier than RFG and that the scope of the applications considered within SF21 might not exactly match those developed by RFG and reviewed in this document. In addition, the US FAA has launched a country wide ADS-B implementation program that is going to include various applications, including surveillance on airports. There is no indication today whether the application considered by the FAA for this program matches the one addressed by RFG.

Australia has contracted Sensis to provide three ASMGCS systems with ADS-B capability at Sydney, Brisbane and Melbourne. The ADS-B data received will be used in the tower and in the TCU.

4.1.1.2. ATC surveillance in radar airspace (ADS-B-RAD)

ADS-B RAD is or has been addressed by European R&D projects such as:

- NUP-1
- NUP-2
- MEDUP (Mediterranean Update Programme)
- SEAP (Large Scale European ADS Pre-implementation Programme)

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes the standardisation work (e.g.

RFG) as well as validation trials (named CRISTAL) throughout Europe (e.g. CRISTAL Mediterranean, Netherlands, Sweden, UK).

In particular, the CRISTAL MED (Co-opeRative ValidatIon of Surveillance Techniques and AppLications of Package I Mediterranean) project (started in late 2005) addresses the use of this application in Portugal, France, Italy, Malta, Greece, Cyprus (and possibly Spain as well).

RFG standardisation of ADS-B-RAD will benefit from the work done on ADS-B-NRA and from the validation of ADS-B-out undertaken in CASCADE / CRISTAL trials. ADS-B-RAD is one of the three applications that will get RFG focus now that work on ADS-B-NRA / ED126 has been completed.

In the USA, ADS-B-RAD is investigated by Safe Flight 21. The recent decision by the FAA to proceed with nationwide ADS-B implementation will most probably accelerate the investigation, validation and certification process for this application. However today, there is no indication whether the application considered by the FAA for this program matches the one addressed by RFG.

Australia ordered 20 additional ADS-B ground stations in Decmber 2006 of which 11 will be installed at existing enroute radar stations to support a RAD service.

4.1.1.3. ATC surveillance in non-radar areas (ADS-B-NRA)

This application has been addressed by several European R&D projects: NUP-1, NUP-2, MEDUP, and SEAP.

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes the standardisation work (RFG) as well as validation trials (named CRISTAL) throughout Europe (e.g. CRISTAL Austria, Ireland, Mediterranean, Netherlands, Sweden).

CASCADE/CRISTAL is running an extensive "ADS-B out" validation programme across 12 European countries to monitor ADS-B out 1090 MHz Extended Squitter signals broadcast by aircraft. The programme develops statistics on the percentage of aircraft equipped and actually broadcasting ADS-B, but also analyses in more detail whether the aircraft broadcast the correct set of data with the right accuracy and quality indicators. This work benefits all ADS-B enabled applications.

Three ground stations are being installed on the island of La Reunion in the Indian ocean by DSNA (France). Operations are expected in 2008.

ADS-B-NRA OSED, SPR and INTEROP material developed by the RFG was accepted by the EUROCAE/RTCA Working Group at the end of September 2006, and final ED-126/D0-303 version was submitted to the EUROCAE Council Meeting & RTCA PMC for adoption in December 2006. This is the basis for the relevant certification material being prepared for publication by EASA in 2007 (Notice of Proposed Amendment-NPA and Acceptable Means of Compliance-AMC).

In this context, CASCADE has launched the ADS-B Pioneer Airlines project, which aims at the airworthiness approval of 1090 ES equipped aircraft for ADS-B NRA, using the ED-126 EASA certification material. 10 airlines will participate for a total of about 200 aircraft. A second wave of pioneer airlines is expected to be launched in 2007.

In the USA, the application was operational in January 2001 as part of the Capstone programme, in Alaska. However, due to the very specific nature of the Capstone program, it is not sure to what extent the content of the application is in line with the European definition, as described in the OSED.

In Australia, Airservices Australia has decided to deploy a network of ADS-B ground stations providing nationwide coverage in the Upper Airspace. Daily operation of ADS-B-NRA is expected to start in 2007. Five of the stations are operational and data is presented to controllers today. In the scope of this program, the Australian regulator (CASA) has approved 5NM separation between two aircraft equipped with approved ADS-B avionics. Over 300 airframes have been approved for use in this program including many international carriers.

SASP and OPLINKP developed changes to PANS/AT (doc. 4444) intended to accommodate the use of ADS-B for the controller's surveillance display. The wording supports delivery of ADS-B based 5 nautical mile separation services.

4.1.1.4. Aircraft derived data for ground tools (ADS-B-ADD)

ADS-B ADD has been addressed by European R&D projects such as: NUP 2, DADI 2, MEDUP, ADD Safety Now project due to start by ENAV

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes the standardisation work (RFG) as well as validation trials (e.g. CRISTAL Sweden).

4.1.2. Maturity assessment

Differences in maturity scores since previous year are marked in brackets.

4.1.2.1. Operational concepts

Application	Maturity level	Notes
ADS-B-APT	2	The OSED is being drafted by RFG
ADS-B-RAD	2.5 (+0.5)	The OSED is being drafted by RFG. This is one of the three applications the RFG plans to focus its work on in 2007.
ADS-B-NRA	4 (+1)	This application was one of the two fast-tracks applications considered by RFG. The OSED, SPR (Safety Performance Requirements) and Inter-operability (Interop) documents were completed by RFG in the second half of 2006 and submitted to RTCA/EUROCAE (European Organisation for Civil Aviation Equipment) for approval which was expected in December 2006. Australia participated in this RFG activity and brought significant inputs.
ADS-B-ADD	1	The operational concept for this application is not at a mature stage. Currently the only inputs provided are from NUP-2.

4.1.2.2. Benefits and constraints

Application	Maturity level	Notes
ADS-B-APT	2 (+1)	Expected benefits include the improvement of the surveillance of movements on the airport surface. ADS-B allows to complement Surface Movement Radar at a low cost, extending effective coverage to areas previously affected by shadows, obstacles, …etc and facilitating track labelling and correlation to flight call-signs. It also allows tracking and identifying airport vehicles. ACSS working on benefits assessment.
ADS-B-RAD	2.5 (+0.5)	Benefits are expected through the improvement of the radar coverage in terms of continuity. In some cases, when a target is far from the radar, the ADS-B position could be considered instead, which will improve the global assessment of the air situation. If ADS-B is approved to be equivalent to radar surveillance, then multiple radar coverage could be simplified, with the consequence of reducing the cost of the ground infrastructure. FAA have done business case. Improved velocity vector information will benefit automated alerts.
ADS-B-NRA	3.5 (+0.5)	Expected benefits range from safety improvements through efficiency, cost saving for airlines through the provision of reduced separations compared to procedural control. 5NM radar-like separation is currently operational 24 hours per day / 7 days per week in Australia. Other benefits also include support to Search and Rescue. Constraints are that ATC centres must be upgraded to address the application. Maximum benefits will be accrued only when a significant number of aircraft are equipped, although some benefits can be provided to early participants (e.g. User Preferred Routes). Australia progressing towards implementation.
ADS-B-ADD	1	The expected benefits are improved and new ground tools performance, in term of efficiency and accuracy e.g. for trajectory prediction or safety nets.

4.1.2.3. Safety assessment

Application	Maturity level	Notes
ADS-B-APT	2	Safety analysis underway at RFG
ADS-B-RAD	2	Safety analysis underway at RFG
ADS-B-NRA	3	This application is a fast track in RFG, and some states are willing to implement it in the short / medium term. An initial ASOR (Allocation of Safety Objectives and Requirements) /PSSA (Preliminary System Safety Assessment) was conducted by the RFG. (Publication ED126/D0303)
ADS-B-ADD	1	Will be analysed by RFG

4.1.2.4. *Procedures and human factors*

Application	Maturity level	Notes
ADS-B-APT	1	Initial assessment carried out in the scope of OSED development
ADS-B-RAD	1.5 (+0.5)	Initial assessment carried out in the scope of OSED development
ADS-B-NRA	3	An in-depth analysis of human factor risks and human performance was carried out in Australia in preparation for operations foreseen in the short term
ADS-B-ADD	1	Initial assessment carried out in the scope of OSED development

4.1.2.5. *Systems, HMI and technology*

Application	Maturity level	Notes
ADS-B-APT	3.5	Technology available for airports; the impact of ADS-B on the HMI will be to be capable of displaying an appropriate symbol so the controller knows what source of positional data is being used
ADS-B-RAD	3.5	Ground and airborne systems available; the impact of ADS-B on the HMI will be to be capable of displaying an appropriate symbol so the controller knows what source of positional data is being used
ADS-B-NRA	3.5	Ground and airborne systems available; the impact of ADS-B on the HMI will be to be capable of displaying an appropriate symbol so the controller knows what source of positional data is being used.
ADS-B-ADD	1.5	

4.1.2.6. *Transition issues*

Application	Maturity level	Notes
ADS-B-APT	1	Tracking of ground vehicles might be based on ADS-B, providing full benefits as soon as ground vehicles at a given airport are equipped.
ADS-B-RAD	2	Transition issues not investigated yet.
ADS-B-NRA	3.5	Reduced separation can be provided between two equipped aircraft. User Preferred Routes could be cleared to ADS-B equipped aircraft.
ADS-B-ADD	1	Transition issues not investigated yet.

4.1.2.7. *Summary*

ADS-B-APT provides the potential to improve ground surveillance on the airport surface, providing an additional highly accurate sensor source to manage ground movements with or without an A-SMGCS. There may be some issues with GPS performance in airport environments. In most cases, ADS-B is used as an additional source of surveillance data for A-SMGCS systems. Some systems are already ADS-B-APT capable typically multilateration based systems that can also receive ADS-B.

ADS-B-RAD provides the potential to improve ATC service particularly in areas where single radar coverage is available or to become a cost-effective replacement for some of the secondary radars. The challenge here is the demonstration and validation of the separation service when a layer of radar surveillance is replaced by ADS-B (Safety Case). The FAA's decision to go for nationwide deployment of ADS-B will most probably accelerate the process.

ADS-B-NRA is mature. Initial applications of ADS-B-NRA have been tested through pre-operational trials in Australia, Alaska and Europe and a full-scale deployment is well underway in Australia. The main challenge in ADS-B-NRA is the demonstration and validation of the separation service using radar-like minima (e.g. 5nm) with the target architecture (Safety Case). Ensuring consistent ADS-B-out equipage is also a transition issue to be overcome (see related issue of DO260/DO260A in next section).

ADS-B-ADD remains less mature than the other GS applications and requires further analysis of the corresponding ADD parameters and of their performance requirements – important issue.

4.1.3. Critical path and blocking issues

The critical path for ground surveillance applications is mainly to ensure adequate and consistent aircraft equipage for the ADS-B-out function. Due to the European mandate on Enhanced Surveillance (EHS), Mode S transponders have been upgraded to address this new function. Avionics manufacturers agreed with the main airframe manufacturers (Airbus, Boeing) to include the 1090 Extended Squitter (ES) function as part of the upgrade. Since early 2003 the fleet capable of transmitting ADS-B reports on 1090 ES is steadily growing.

However, the ADS-B out function has been certified only on a non-interference basis i.e. the transponder is allowed to broadcast ADS-B messages but the ADS-B messages are currently not certified to any level of performance. There are avionics issues relating to the DO-260 vs 260A standards (especially with regard to integrity and accuracy quality indicators such as NIC, NAC, SIL, etc.). Both DO-260 and DO-260A are acceptable for NRA (ED126/DO303). Boeing and Airbus both participate in the CASCADE trials with DO-260 equipped aircraft. There is currently a NPA (Notice of Proposed Amendment) under development (target date end 2007).

Another issue is to deal with mixed fleet equipage and transition to full equipage. Solutions may vary depending on the particular application considered and local solutions may exist where traffic is dominated by a small number of operators.

Constraints are related to the upgrade of the ATC system to receive and process ADS-B reports for ADS-B NRA, ADS-B RAD and ADS-B APT (especially A-SMGCS). Note that NRA is more mature than APT.

4.1.4. Current implementation and plans

Australia is implementing with DO-260 (plans to accept 260A as well), Europe and USA may require 260A. FAA RFT for service requires the GS to be able to process DO260.

A near term step is to certify on-board ADS-B equipment for use. However there is still uncertainty as to whether 260 or 260A or both will be adopted as the preferred standard(s). EASA are expected to clarify the position by the end of 2007. It is desirable that all applications should (if possible) be compatible with both standards to ensure inter-operability

4.2. Airborne traffic situational awareness

4.2.1. Overview

4.2.1.1. Enhanced traffic situational awareness during flight operations (ATSA-AIRB)

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes the standardisation work (RFG) as well as validation trials (e.g. CRISTAL Sweden, CRISTAL ATSAW).

4.2.1.2. Enhanced traffic situational awareness on the airport surface (ATSA-SURF)

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes the standardisation work (RFG) as well as validation trials (e.g. CRISTAL Sweden, CRISTAL ATSAW).

4.2.1.3. In-trail procedure in non-radar oceanic airspace (ATSA-ITP)

ATSA-ITP trials are planned by EUROCONTROL CASCADE (CRISTAL ITP involves NATS, ISAVIA, Airbus, Alticode). Air Services Australia is preparing ATSA-ITP trials and support for NASA.

ICAO APANPIRG/ADS-B task force is currently investigating the potential use of ATSA-ITP in the Asia-Pacific region.

4.2.1.4. Enhanced visual separation on approach (ATSA-VSA)

This application has been investigated in the US during the Ohio Valley ADS-B trials and for Frankfurt during the FALBALA (First Assessment of the operational Limitations, Benefits & Applicability for a List of package I AS applications) project.

4.2.2. Maturity assessment

4.2.2.1. Operational concepts

Application	Maturity level	Notes
ATSA-AIRB	2	RFG has developed draft OSED. The concepts are quite stable.
ATSA-SURF	2 (+0.5)	RFG has developed draft OSED. No major issues identified.
ATSA-ITP	3	RFG has developed draft OSED. The concepts are quite stable. Feedback from preliminary results of the OSA process.
ATSA-VSA	3	RFG has developed draft OSED. The concepts are quite stable. Feedback from preliminary results of the OSA process.

4.2.2.2. Benefits and constraints

Application	Maturity level	Notes
ATSA-AIRB	1	Benefits are identified but not assessed nor modelled.
ATSA-SURF	2	Benefits are identified not assessed but deemed sufficient for a first implementation (ACSS is currently developing Safe Route for UPS)

ATSA-ITP	2.5 (+0.5)	Benefits are identified. NASA studies identify benefits. Procedure needs to be refined. ICAO assessment is necessary at some point. Airbus identified benefits but communication of results pending agreement from NAT IMG.
ATSA-VSA	2.5	Benefits are identified. Basic assessments have been made (UPS use in Louisville) but no modelling. Issues of aircraft identification remain.

4.2.2.3. Safety assessment

Application	Maturity level	Notes
ATSA-AIRB	1	No OHA document by RFG (on-going)
ATSA-SURF	1	No OHA document by RFG
ATSA-ITP	2.5 (+0.5)	OSA on-going. ICAO Separation and Safety Panel (SASP) officially decided to consider ATSA-ITP and Mathematics sub-group (MSG) currently conducting safety analysis.
ATSA-VSA	3	OSA on-going. UPS CDTI certified for a very similar application.

4.2.2.4. Procedures and human factors

Application	Maturity level	Notes
ATSA-AIRB	3	Procedures are defined in OSED. Procedure validation is ongoing but it is straightforward: do not manoeuvre with CDTI as sole source of information.
ATSA-SURF	3	Procedures are defined in OSED. Procedure validation is ongoing but it is straightforward: do not manoeuvre with CDTI as sole source of information.
ATSA-ITP	2.5 (+0.5)	Procedures are defined in OSED. Procedure validation is ongoing at ICAO SASP using the ITP collision risk model developed by NASA. RFG emphasising work in this area.
ATSA-VSA	3 (+1)	Procedures are defined in OSED. No change in current procedures.

4.2.2.5. Systems, HMI and technology

Application	Maturity level	Notes
ATSA-AIRB	3	Real time simulations have been performed (for the airborne part). Already used by UPS
ATSA-SURF	3	Real time simulations have been performed
ATSA-ITP	3	Real time simulations have been performed (for the airborne part).
ATSA-VSA	3	Real time simulations have been performed (for the airborne part). Already Used by UPS

4.2.2.6. Transition issues

Application	Maturity level	Notes
ATSA-AIRB	2 (-1)	Rely on current procedures. RFG results identified safety issues related to mixed fleet equipage.

ATSA-SURF	3	Rely on current procedures. Mixed fleet equipage is probably acceptable.
ATSA-ITP	3	Derived from current procedures. Mixed fleet equipage is acceptable.
ATSA-VSA	3	Rely on current procedures. Mixed fleet equipage is acceptable.

4.2.2.7. Summary

ATSA-AIRB -Concept, procedures and systems/HMI well advanced
Work needed on safety, benefits and transition.

ATSA-SURF - Concept, procedures and systems/HMI well advanced
Work needed on safety, benefits and transition.

ATSA-VSA - Concept, procedures and systems/HMI well advanced. Ongoing safety assessment. Work needed on benefits and transition. RFG focus.

ATSA-ITP - Concept, procedures, systems/HMI and benefits well advanced. Ongoing safety assessment. Work needed on transition. RFG focus.

4.2.3. Critical path and blocking issues

The definition and validation effort has to continue.
Modifications of some ICAO documents will be necessary: for most applications phraseology has to be slightly modified; ITP and TIBA will require changes of Annex 11 or Doc 4444; ITP separation has to be evaluated by the Separation and Airspace Safety Panel (SASP). The approval authorities will have to be involved.

In pair wise operations:

The manoeuvring aircraft has to be ATSAW equipped. All the applications require the same basic ADS-B-in equipage corresponding to ATSA-AIRB, though performance requirements may vary between applications.

The other aircraft has to be ADS-B-out capable. This will become more frequent because a growing part of the worldwide fleet will be ADS-B-out equipped. Note however that DO-260 and DO-260A are only ‘pipes’. An important issue is the navigation source and whether the transponder ADS-B out function is qualified. For ATSAW applications, correlation with Mode-S active interrogations might provide sufficient integrity.

The decision to equip aircraft for ATSAW capability relies on the identification of operational and economic benefits that would trigger the decision of airframe manufacturers or avionics manufacturers to offer the modification

No blocking issue has been identified mainly because the different ATSA applications aim at improving existing procedures. Studies may be required regarding the impact of ATSA on the ground ATC.

4.2.4. Current implementation and plans

An important milestone will be the decision from an airframe manufacturer to offer ATSA applications combined with the decision of ANSPs to approve ATSA operations in their airspace.

LFV conducted a live trial at Arlanda during the 4th quarter of 2006 to assess flight crew benefits of ATSA-SURF, the trial targeted one flight crew on the calibration aircraft and the results provides valuable inputs to the large scale trial planned for the first half of 2007 in NUPII+ (4 B737NG equipped with ADS-B in and dual CDTI installations). The results from this first trial provided valuable results concerning CDTI placement and flight deck procedures. During the trials initial verification of a runway incursion detection algorithm where conducted with promising results, this functionality will be further investigated in upcoming trials 2007.

EUROCONTROL's CASCADE programme is co-ordinating activities, including local implementations, for ATSA-AIRB, ATSA-SURF, ATSA-VSA (the CRISTAL ATSAW validation project has been launched in 2006) and possibly ATSA-ITP.

Target date for certification of ATSAW on Airbus aircraft is 2009. Validations on simulator and flight test aircraft are planned in 2007 under the umbrella of Eurocontrol CASCADE CRISTAL validation.

4.3. Airborne spacing

4.3.1. Overview

4.3.1.1. Sequencing and merging operations (ASPA-S&M)

Key projects addressing the application: MFF, MA-AFAS, NUP I, NUP II, CoSpace, FALBALA, DAG-TM, G2G, FlySafe, UPS Merging and Spacing, EFAS (UK), SEAP.

In Europe, the work towards implementation of this application is co-ordinated by the EUROCONTROL CASCADE Programme. This includes amongst others an intensive involvement in the standardisation work (RFG) as well as validation work (CRISTAL Paris).

4.3.1.2. Enhanced crossing and passing operations (ASPA-C&P)

Key projects addressing the application: MA-AFAS, MFF, G2G.

4.3.2. Maturity assessment

4.3.2.1. Operational concepts

Application	Maturity level	Notes
ASPA-S&M	3	Consolidated OSED delivered on S&M operational concepts.
ASPA-C&P	1	Operational concept to be refined/reviewed in further activities.

4.3.2.2. Benefits and constraints

Application	Maturity level	Notes
ASPA-S&M	2.5	Results on benefits and detailed report on constraints have been produced.
ASPA-C&P	1	Negative initial results. Further development depends on whether the application moves to Airborne separation category.

4.3.2.3. Safety assessment

Application	Maturity level	Notes
ASPA-S&M	3	ASOR and preliminary safety assessment performed.
ASPA-C&P	1	Negative initial results.

4.3.2.4. Procedures and human factors

Application	Maturity level	Notes
ASPA-S&M	3.5 (+0.5)	Training need completely addressed and task analysis assessment validated. Third party identification procedure still needs development.
ASPA-C&P	1	Re-definition of responsibilities required.

4.3.2.5. Systems, HMI and technology

Application	Maturity level	Notes
ASPA-S&M	2.5 (+0.5)	NASA has done significant testing at Langley and Ames with human-in-the-loop including flight demonstrations. ACSS is currently doing flight trials for their SafeRoute tool which is what UPS will be using for Merging and Spacing
ASPA-C&P	1	A review of systems supporting this application is required.

4.3.2.6. Transition issues

Application	Maturity level	Notes
ASPA-S&M	2.5 (+0.5)	Some assessment on technical and operational transition issues. Change of airspace and controller/pilot acceptance are the key issues.
ASPA-C&P	1	Further investigation required.

4.3.2.7. Summary

ASPA-S&M - A lot of activity has taken place. Some good results have been achieved. Europe and US at a similar level of maturity but with different set of issues identified.
ASPA-C&P –Some activities have taken place, but results were not completely satisfactory. Research results indicate this application should be re-classified as ASEP- C&P.

4.3.3. Critical path and blocking issues

In ASAS spacing several important results have been achieved. ASAS spacing applications have been successfully demonstrated and the operational procedures designed ad-hoc for projects like MFF, Cospace, NUP and G2G have been also successfully tested. There are many pending issues with ASAS spacing that need to be addressed, for example target identification, the need for a clear benefits case and issues relating to differing local implementations. Work is required in producing guidance material regarding the necessary airspace re-design issues.

4.3.4. Current implementation and plans

The example of UPS's "Merging and Sequencing", while not exactly the same as ASPA S&M, is a good example of the level of benefits that can be achieved by such an application in a high equipage environment.

Future ASAS spacing work should quantify the benefits in terms of capacity and should address the inter-relationships with other TMA concepts (e.g. Continuous Descent Approaches and RNAV).

UPS trials are tailored for a specific (US) environment and concept of operations; Europe needs to assess the application in its own real-life ATM context to draw the appropriate conclusions on implementation issues as well as operational applicability/usability

Europe is missing an operational trial of S&M operation. Based on the UPS and MFF examples, we know it's achievable from a technical perspective.
RNAV is an environment characteristic which needs to be accounted for.

4.4. Airborne separation

4.4.1. Overview

4.4.1.1. Lateral crossing and passing (ASEP-LC&P)

The ASEP-LC&P application is principally being studied in ASSTAR. It was also investigated during the MA-AFAS and MFF programmes.

EUROCONTROL's ADAS(Advanced Data-link and Airborne Surveillance Applications) activity is integrating data-link requirements into ASEP LC&P starting from the kernel procedure designed by RFG and ASSTAR.

4.4.1.2. Vertical crossing and passing (ASEP-VC&P)

Though, the ASEP-VC&P application is not subject of considerable work at present within the ASAS community, it has been identified by EUROCONTROL's ADAS, during the work on ASAS Concept of Use, as being potentially beneficial in the departure phase. As such it'll form part of the ASEP C&P OSED produced by ADAS.

4.4.1.3. In-trail procedure (ASEP-ITP)

Within ASSTAR, there are six ITP climb or descent manoeuvres, as follows:

- A Following Climb.
- A Following Descent.
- A Leading Climb.
- A Leading Descent.
- A Combined Leading-Following Climb.
- A Combined Leading-Following Descent.

4.4.1.4. In-trail follow (ASEP-ITF)

The ASEP-ITF application is currently being studied in ASSTAR which uses the MFF Operational Concept as the basis for defining the ASEP-ITF application.

Within the context of ASSTAR, the use of ASEP-ITF procedures will replace most of the controller's use of the sliding Mach technique to separate traffic in the NAT Organised Track System, or more general in NAT airspace for traffic flying the same route.

4.4.1.5. Sequencing and merging operations (ASEP-S&M)

The ASEP-S&M application is currently studied by EUROCONTROL-ADAS.

4.4.2. Maturity assessment

4.4.2.1. Operational concepts

Application	Maturity level	Notes
ASEP-LC&P	2	Overall, the concept is quite clearly defined and is being further developed in ASSTAR. Also demonstrated in MA-AFAS and MFF.
ASEP-VC&P	1	The VC&P application has yet to be explicitly looked at.
ASEP-ITP	2	This application is well defined from work carried out on package 1 ATSA-ITP, and is also being studied in detail in ASSTAR.

ASEP-ITF	2	Currently being studied in ASSTAR which uses the MFF Operational Concept as the basis for defining the ASEP-ITF application. Application also very similar to ASPA-S&M.
ASEP-S&M	1.5 (0)	The concept is in advanced definition phase. The concept uses all the lessons learnt from ASPA-S&M (CoSpace, G2G, MFF, etc)

4.4.2.2. Benefits and constraints

Application	Maturity level	Notes
ASEP-LC&P	2 (1)	Currently being studied during ASSTAR.
ASEP-VC&P	1	Some perceived benefits, generally based on assumptions, but no definite conclusions yet.
ASEP-ITP	2 (1)	Currently being studied during ASSTAR, although benefits will likely be similar (if not marginally better) than ATSA-ITP.
ASEP-ITF	2 (1.5)	Currently being studied during ASSTAR. Expected benefits include reduced controller workload, increased capacity, and more efficient flight operations. NASA Glenn Research Center prepared Benefits Assessment of Reduced Separations in North Atlantic Organized Track System which is similar to ASEP-ITF application.
ASEP-S&M	1.5 (0)	Will be studied by ADAS. Expected benefits include reduced controller workload, improved predictability, increased runway throughput and more efficient flight operations

4.4.2.3. Safety assessment

Application	Maturity level	Notes
ASEP-LC&P	1.5 (1)	Currently being studied during ASSTAR.
ASEP-VC&P	1	No specific analysis has been carried out yet.
ASEP-ITP	1.5 (1)	Currently being studied during ASSTAR.
ASEP-ITF	1.5 (1)	Currently being studied during ASSTAR.
ASEP-S&M	1 (0)	Will be studied by ADAS

4.4.2.4. Procedures and human factors

Application	Maturity level	Notes
ASEP-LC&P	1.5 (1)	Currently being studied during ASSTAR.
ASEP-VC&P	1	No assessment carried out yet.
ASEP-ITP	1.5 (1)	Currently being studied during ASSTAR.
ASEP-ITF	1.5	The ASEP-ITF application is analogous to ASPA-ITF which is already well defined, the difference is ASEP-ITF is defined for non-radar environments. Currently being further studied during ASSTAR.
ASEP-S&M	1 (0)	Will be studied by ADAS

4.4.2.5. Systems, HMI and technology

Application	Maturity level	Notes
ASEP-LC&P	2	Work on this aspect has been carried out during MA-AFAS. NLR have also done some work.
ASEP-VC&P	1	NLR have performed some initial work in this area.
ASEP-ITP	2 (+0.5)	Work has been carried out by NLR for similar types of operation.

ASEP-ITF	2	Based on the similarities to ASPA-S&M.
ASEP-S&M	1 (0)	Will be studied by ADAS

4.4.2.6. Transition issues

Application	Maturity level	Notes
ASEP-LC&P	1	Transition issues not investigated yet.
ASEP-VC&P	1	Transition issues not investigated yet.
ASEP-ITP	1	Transition issues not investigated yet.
ASEP-ITF	1	Transition issues not investigated yet.
ASEP-S&M	1 (0)	Will be studied by ADAS

4.4.3. Critical path and blocking issues

Final harmonized versions of operational concepts are maturing (from the initial work of the MFF and NUP II projects) in the ASSTAR project, and these will require validation. In this regard, ASSTAR is undertaking a number of real and fast time simulations. It has been identified that the amount of communications within the ASEP procedures needs to be reduced. It is anticipated that reducing the message exchanges will make the procedure faster. ADAS Datalink User Group will be looking at developing application OSED for ASEP S&M and ASEP C&P that will include the analysis of use of data-link and (potentially) intent information

Acceptance of the ASEP applications will also depend on the outcome of cost benefit analyses and safety cases, which have yet to be completed. The safety case in particular will drive some of the operational requirements as well as the cost.

The critical path and blocking issues of ASEP applications relate to the transfer of responsibility, criticality of equipment, airborne separation etc. The EUROCONTROL SSATS domain addresses these issues in the near-term future through ADAS.

4.4.4. Current implementation and plans

The ASSTAR project is developing ASEP operational concepts and is also performing safety and cost benefit analyses. Airlines in particular have been invited to participate, which is seen as essential to evolution.

EUROCONTROL'S ADAS activity is responsible for coordinating the development within Eurocontrol of Package 2 applications. The work is done building on CASCADE and RFG work on Package 1 applications and standards developed for initial ADS-B applications.

4.5. Airborne self-separation

4.5.1. Overview

4.5.1.1. Self-separation in segregated free flight airspace (SSEP-FFAS)

The SSEP-FFAS concept, which is in line with the EUROCONTROL definition, has been studied extensively in the following projects:

- NLR/NASA Free Flight project
- 3FMS project
- FREER project
- INTENT project
- MFF project
- Hybridge project

Fast-time simulations, human-in-the-loop simulations and flight trials have been conducted, together with extensive safety case analysis.

4.5.1.2. Self-separation in managed airspace (SSEP-MAS)

This concept has been studied extensively by NASA Langley in fast-time and human-in-the-loop simulations.

4.5.1.3. Self-separation in an organised track system (SSEP-FFT)

The ASSTAR project is testing this concept in fast-time and human-in-the-loop simulations, as well as by means of an extensive safety analysis.

NASA has developed the expanded concept ‘dynamic multi-track airways (DMA)’, assessed feasibility, modeled aspects of it in fast-time simulation, and prototyped the airborne passing tools.

4.5.2. Maturity assessment

4.5.2.1. Operational concept

Application	Maturity level	Notes
SSEP-FFAS	2	flight tested, MFF
SSEP-MAS	2	human-in-the-loop simulations conducted, Langley
SSEP-FFT	2	basic concept described, ASSTAR & DMA

4.5.2.2. Benefits and constraints

Application	Maturity level	Notes
SSEP-FFAS	2	fast-time simulations conducted, MFF
SSEP-MAS	2	quantitative assessment of single-year benefits conducted and life-cycle benefit/costs from detailed capacity/demand and controller workload models, Langley
SSEP-FFT	1	initial benefit review conducted, ASSTAR preliminary benefits assessment, DMA

4.5.2.3. Safety assessment

Application	Maturity level	Notes
SSEP-FFAS	2	safety cases conducted (OSED, OHA, ASOR), MFF, NLR/NASA Free Flight. quantitative risk assessment conducted, HYBRIDGE
SSEP-MAS	1.5 (+0.5)	hazards/risks identified, safety design established, and validation simulations underway, Langley
SSEP-FFT	1	hazards/risk identified, OHA in progress, ASSTAR no safety case conducted yet, DMA

4.5.2.4. Procedures and human factors

Application	Maturity level	Notes
SSEP-FFAS	2 (+0.5)	flight tested in MFF
SSEP-MAS	2 (+0.5)	integrated air-ground human-in-the-loop simulations conducted, Ames-Langley
SSEP-FFT	2	initial procedures described and based on the similarities to SSEP-FFAS, initial human-in-the-loop simulations underway ASSTAR

4.5.2.5. Systems, HMI and technology

Application	Maturity level	Notes
SSEP-FFAS	2	flight tested, MFF
SSEP-MAS	2	Integrated human-in-the-loop simulations conducted, Ames-Langley
SSEP-FFT	2	based on the similarities to SSEP-FFAS, ASSTAR prototype airborne system for passing developed but not formally evaluated, DMA

4.5.2.6. Transition issues

Application	Maturity level	Notes
SSEP-FFAS	2	human-in-the-loop simulations conducted, MFF
SSEP-MAS	2	human-in-the-loop simulations conducted, Langley
SSEP-FFT	1.5 (+0.5)	transition issues identified and options posed, ASSTAR, DMA

4.5.2.7. Summary

SSEP-FFAS - After extensive human-in-the-loop simulations, in July 2005, the MFF flight trials have been completed. These flight trials have shown that the SSEP-FFAS concept is feasible in a real-life environment. Further, the safety case of SSEP-FFAS in MFF has been completed using OSED, OHA and ASOR.

SSEP-MAS - The SSEP-MAS concept has not been tested yet flight trials, but human-in-the-loop simulations have shown that the concept is feasible
SSEP-FFT - The SSEP-FFT is still under development and human-in-the-loop and batch simulations are in progress within the ASSTAR project

4.5.3. Critical path and blocking issues

The main near-term benefits of the SSEP concept in general are expected in Oceanic environment. Since SSEP-FFAS and SSEP-MAS can obviously not be introduced immediately, a transition path towards these concepts is required. The SSEP-FFT is part of this transition path, and needs to be studied in detail, both in simulations and the safety case. In case of positive results, the SSEP-FFT concept is ready to be flight tested over segregated Oceanic airspace. If these trials are also positive, the next step towards implementation can be made. If the SSEP-FFT is implemented, the next steps are to transition towards SSEP-FFAS. The SSEP-MAS concept is not feasible in oceanic environment, since there is no TIS-B available by which the equipped aircraft can "see" the non-equipped aircraft. SSEP-MAS is applicable in RADAR airspace, and the work to prove the safety of distributed systems should be continued

Other issues related to near-term implementation is the lead time needed to certify the technology, and the formal acceptance of new liabilities arising from the adoption of this family of applications.

4.5.4. Current implementation and plans

See section 9.3. The next steps are currently underway by means of the ASSTAR project. Further benefit analysis would support the introduction of SSEP. The airlines are invited to participate in this benefit analysis, as this is typically airline specific. Initial "back-of-the-envelope" calculations results are very positive and support the quick return on investment requirements by the airlines.

NASA's research plans are in the following areas:
(1) traffic complexity management research through development of new decision-support functions
(2) performance-based analysis of self-separation through batch simulation
(3) safety design validation through batch simulation
(4) consideration of self-separation aircraft by Tactical Flow Management
(5) further benefits analyses
Quantitative risk assessment of self-separation applications as performed in the HYBRIDGE project will be further progressed within the iFLY project.

4.6. Summary of annual changes (2006-7)

4.6.1. ADS-B equipage status

4.6.1.1. Europe:

Percentage of Mode-S equipped flights down slightly from 95.8% to 95.3%
ADS-B Extended Squitter capability as percentage of Mode-S equipped increased from 39.8% to 57.3%.

4.6.1.2. China:

From 30th December 2005 to 13th March 2006 percentage of daily flights near Hong Kong international airport broadcasting ADS-B Modes S extended squitter grew from 32% to 34%.

4.6.2. ADS-B surveillance

4.6.2.1. Airport surface surveillance (ADS-B-APT)

NUPII+ was added to the list of European R&D projects addressing this application

A draft OSED has been developed by RFG addressing A-SMGCS level 1 and "ADS-B only" environments. Progress on this application will benefit from the ADS-B out monitoring and validation trials initiated in the context of CRISTAL. In NUP II+ project operational tests will be executed in 2007 at Stockholm-Arlanda airport, Sweden. Those tests will contain Routing service and Runway Incursion detection service. In Routing service ground control will send a graphical and text message of the cleared and expected taxiroute to aircraft via ADS-B datalink, taxiroute will be displayed on an EFB on board. If deviating from the cleared route an alarm will be triggered in cockpit as well as in ATC. No voice communication is needed only "accept" via datalink. Mobiles equipped with ADS-B out/in and a CDTI/EFB on board will also be able to display all surrounding traffic via TIS-B transmissions. Four B737NG and two vehicles will be fully equipped during these trails. Runway Incursion detection is also included in those trials and every participant has an alarm detection system of their own with different algorithms.

The US FAA has launched a country wide ADS-B implementation program that is going to include various applications, including surveillance on airports. There is no indication today whether the application considered by the FAA for this program matches the one addressed by RFG.

Australia has contracted Sensis to provide three ASMGCS systems with ADS-B capability at Sydney, Brisbane and Melbourne. The ADS-B data received will be used in the tower and in the TCU.

4.6.2.2. ATC surveillance in radar airspace (ADS-B-RAD)

Portugal and possibly Spain were added to the CRISTAL MED list of countries.

RFG standardisation of ADS-B-RAD will benefit from the work done on ADS-B-NRA and from the validation of ADS-B-out undertaken in CASCADE / CRISTAL trials. ADS-B-RAD is one of the three applications that will get RFG focus now that work on ADS-B-NRA / ED126 has been completed.

There is no indication whether the application considered by the FAA for Safe Flight 21 matches the one addressed by RFG.

Australia ordered 20 additional ADS-B ground stations in Decmber 2006 of which 11 will be installed at existing enroute radar stations to support a RAD service.

FAA have done business case. Improved velocity vector information will benefit automated alerts.

4.6.2.3. ATC surveillance in non-radar areas (ADS-B-NRA)

CASCADE/CRISTAL is running an extensive “ADS-B out” validation programme across 12 European countries to monitor ADS-B out 1090 MHz Extended Squitter signals broadcast by aircraft. The programme develops statistics on the percentage of aircraft equipped and actually broadcasting ADS-B, but also analyses in more detail whether the aircraft broadcast the correct set of data with the right accuracy and quality indicators. This work benefits all ADS-B enabled applications.

Three ground stations are being installed on the island of La Reunion in the Indian ocean by DSNA (France). Operations are expected in 2008.

ADS-B-NRA OSED, SPR and INTEROP material developed by the RFG was accepted by the EUROCAE/RTCA Working Group at the end of September 2006, and final ED-126/D0-303 version was submitted to the EUROCAE Council Meeting & RTCA PMC for adoption in December 2006. This is the basis for the relevant certification material being prepared for publication by EASA in 2007 (Notice of Proposed Amendment-NPA and Acceptable Means of Compliance-AMC).

In this context, CASCADE has launched the ADS-B Pioneer Airlines project, which aims at the airworthiness approval of 1090 ES equipped aircraft for ADS-B NRA, using the ED-126 EASA certification material. 10 airlines will participate for a total of about 200 aircraft. A second wave of pioneer airlines is expected to be launched in 2007.

In Australia, Airservices Australia has decided to deploy a network of ADS-B ground stations providing nationwide coverage in the Upper Airspace. Daily operation of ADS-B-NRA is expected to start in 2007. Five of the stations are operational and data is presented to controllers today. In the scope of this program, the Australian regulator (CASA) has approved 5NM separation between two aircraft equipped with approved ADS-B avionics. Over 300 airframes have been approved for use in this program including many international carriers.

SASP and OPLINKP developed changes to PANS/AT (doc. 4444) intended to accommodate the use of ADS-B for the controller’s surveillance display. The wording supports delivery of ADS-B based 5 nautical mile separation services.

4.6.2.4. Aircraft derived data for ground tools (ADS-B-ADD)

The ADD Safety Now project due to start by ENAV was added to the list of European R&D projects addressing this application.

4.6.2.5. Changes to maturity scores:

- ADS-B-APT
    - Benefits and constraints increased from 2 to 3
- ADS-B-RAD
    - Operational concept increased from 2 to 2.5,
    - Benefits and constraints increased from 2 to 2.5
    - Procedures and human factors increased from 1 to 1.5
- ADS-B-NRA
    - Operational concept increased from 3 to 4
- ADS-B-ADD

- No change

4.6.2.6. Critical path and blocking issues

There are avionics issues relating to the DO-260 vs 260A standards (especially with regard to integrity and accuracy quality indicators such as NIC, NAC, SIL, etc.). Both DO-260 and DO-260A are acceptable for NRA (ED126/DO303). Boeing and Airbus both participate in the CASCADE trials with DO-260 equipped aircraft. There is currently a NPA (Notice of Proposed Amendment) under development (target date end 2007).

4.6.2.7. Current implementation and plans

Australia is implementing with DO-260 (plans to accept 260A as well), Europe and USA may require 260A. FAA RFT for service requires the GS to be able to process DO260.

A near term step is to certify on-board ADS-B equipment for use. However there is still uncertainty as to whether 260 or 260A or both will be adopted as the preferred standard(s). EASA are expected to clarify the position by the end of 2007. It is desirable that all applications should (if possible) be compatible with both standards to ensure inter-operability

4.6.3. Airborne traffic situational awareness

4.6.3.1. Enhanced traffic situational awareness during flight operations (ATSA-AIRB)

CRISTAL ATSAW was added to the list of projects investigating this application by the CASCADE programme.

RFG results identified safety issues related to mixed fleet equipage.

4.6.3.2. Enhanced traffic situational awareness on the airport surface (ATSA-SURF)

CRISTAL ATSAW was added to the list of projects investigating this application by the CASCADE programme.

4.6.3.3. In-trail procedure in non-radar oceanic airspace (ATSA-ITP)

ATSA-ITP trials are planned by EUROCONTROL CASCADE (CRISTAL ITP involves NATS, ISAVIA, Airbus, Alticode). Air Services Australia is preparing ATSA-ITP trials and support for NASA.

Airbus identified benefits but communication of results pending agreement from NAT IMG.

OSA on-going. ICAO Separation and Safety Panel (SASP) officially decided to consider ATSA-ITP and Mathematics sub-group (MSG) currently conducting safety analysis.

Procedure validation is ongoing at ICAO SASP using the ITP collision risk model developed by NASA. RFG emphasising work in this area.

4.6.3.4. Enhanced visual separation on approach (ATSA-VSA)

No change in current procedures.

4.6.3.5. Changes to maturity scores:

- ATSA-AIRB
  - Transition issues maturity level decreased from 3 to 2
- ATSA-SURF
  - Operational concept maturity level increased from 1.5 to 2

- ATSA-ITP
    - Benefits & constraints increased from 2 to 2.5
    - Safety increased from 2 to 2.5
    - Procedures and human factors increased from 2 to 2.5
- ATSA-VSA
    - Procedures and human factors maturity level increased from 2 to 3.

4.6.3.6. Current implementation and plans

LFV conducted a live trial at Arlanda during the 4th quarter of 2006 to assess flight crew benefits of ATSA-SURF, the trial targeted one flight crew on the calibration aircraft and the results provides valuable inputs to the large scale trial planned for the first half of 2007 in NUPII+ (4 B737NG equipped with ADS-B in and dual CDTI installations). The results from this first trial provided valuable results concerning CDTI placement and flight deck procedures. During the trials initial verification of a runway incursion detection algorithm where conducted with promising results, this functionality will be further investigated in upcoming trials 2007.

Target date for certification of ATSAW on Airbus aircraft is 2009. Validations on simulator and flight test aircraft are planned in 2007 under the umbrella of Eurocontrol CASCADE CRISTAL validation.

4.6.4. Airborne spacing

4.6.4.1. Sequencing and merging operations (ASPA-S&M)

NUP II, CoSpace FlySafe, EFAS (UK), SEAP were added to the list of projects addressing this application.

CRISTAL Paris was added to the validation work being carried out by the Eurocontrol CASCADE programme.

Third party identification procedure still needs development.

NASA has done significant testing at Langley and Ames with human-in-the-loop including flight demonstrations. ACSS is currently doing flight trials for their SafeRoute tool which is what UPS will be using for Merging and Spacing.

Change of airspace and controller/pilot acceptance are the key issues.

4.6.4.2. Enhanced crossing and passing operations (ASPA-C&P)

G2G was added to the list of projects addressing this application.

4.6.4.3. Changes to maturity scores

- ASPA-S&M
    - Procedures & human factors increased from 3 to 3.5
    - Systems, HMI & technology increased from 2 to 2.5
    - Transition issues increased from 2 to 2.5
- ASPA-C&P
    - Systems, HMI & Technology increased from 1 to 2
    - Transition issues increased from 1 to 2

4.6.4.4. Summary

ASPA-S&M - Europe and US at a similar level of maturity but with different set of issues identified.

ASPA-C&P – Research results indicate this application should be re-classified as ASEP-C&P.

4.6.4.5. Current implementation and plans

UPS trials are tailored for a specific (US) environment and concept of operations; Europe needs to assess the application in its own real-life ATM context to draw the appropriate conclusions on implementation issues as well as operational applicability/usability.

Europe is missing an operational trial of S&M operation. Based on the UPS and MFF examples, we know it's achievable from a technical perspective.
RNAV is an environment characteristic which needs to be accounted for.

4.6.5. Airborne separation

4.6.5.1. Lateral crossing and passing (ASEP-LC&P)

EUROCONTROL's ADAS(Advanced Data-link and Airborne Surveillance Applications) activity is integrating data-link requirements into ASEP LC&P starting from the kernel procedure designed by RFG and ASSTAR.

4.6.5.2. Vertical crossing and passing (ASEP-VC&P)

Though, the ASEP-VC&P application is not subject of considerable work at present within the ASAS community, it has been identified by EUROCONTROL's ADAS, during the work on ASAS Concept of Use, as being potentially beneficial in the departure phase. As such it'll form part of the ASEP C&P OSED produced by ADAS.

4.6.5.3. In-trail procedure (ASEP-ITP)

Currently being studied during ASSTAR, although benefits will likely be similar (if not marginally better) than ATSA-ITP.)

4.6.5.4. In-trail follow (ASEP-ITF)

The ASEP-ITF application is analogous to ASPA-ITF which is already well defined, the difference is ASEP-ITF is defined for non-radar environments. Currently being further studied during ASSTAR.

Expected benefits include reduced controller workload, increased capacity, and more efficient flight operations. NASA Glenn Research Center prepared Benefits Assessment of Reduced Separations in North Atlantic Organized Track System which is similar to ASEP-ITF application.

4.6.5.5. Sequencing and merging operations (ASEP-S&M)

The ASEP-S&M application is currently studied by EUROCONTROL-ADAS.

The concept is in advanced definition phase. The concept uses all the lessons learnt from ASPA-S&M (CoSpace, G2G, MFF, etc).

Expected benefits include reduced controller workload, improved predictability, increased runway throughput and more efficient flight operations.

4.6.5.6. Changes in maturity scores

- ASEP-LC&P
    - Benefits & constraints increased from 1 to 2
    - Safety increased from 1 to 1.5
    - Procedures & human factors increased from 1 to 1.5

- ASEP-VC&P
    - No change
- ASEP-ITP
    - Benefits & constraints increased from 1 to 2
    - Safety increased from 1 to 1.5
    - Procedures & human factors increased from 1 to 1.5
    - Systems, HMI & technology increased from 1.5 to 2
- ASEP-ITF
    - Benefits & constraints increased from 1.5 to 2
    - Safety increased from 1 to 1.5
- ASEP-S&M
    - New application

4.6.5.7. Critical path and blocking issues

ADAS Datalink User Group will be looking at developing application OSED for ASEP S&M and ASEP C&P that will include the analysis of use of data-link and (potentially) intent information

The critical path and blocking issues of ASEP applications relate to the transfer of responsibility, criticality of equipment, airborne separation etc. The EUROCONTROL SSATS domain addresses these issues in the near-term future through ADAS.

4.6.5.8. Current implementation and plans

EUROCONTROL'S ADAS activity is responsible for coordinating the development within Eurocontrol of Package 2 applications. The work is done building on CASCADE and RFG work on Package 1 applications and standards developed for initial ADS-B applications.

4.6.6. Airborne self-separation

4.6.6.1. Self-separation in segregated free flight airspace (SSEP-FFAS)

The Hybridge project was added to the list of projects addressing this application.
Flight tested, MFF.
Quantitative risk assessment conducted, HYBRIDGE

4.6.6.2. Self-separation in managed airspace (SSEP-MAS)

Quantitative assessment of single-year benefits conducted and life-cycle benefit/costs from detailed capacity/demand and controller workload models, Langley

Hazards/risks identified, safety design established, and validation simulations underway, Langley

4.6.6.3. Self-separation in an organised track system (SSEP-FFT)

NASA has developed the expanded concept 'dynamic multi-track airways (DMA)', assessed feasibility, modelled aspects of it in fast-time simulation, and prototyped the airborne passing tools. Preliminary benefits assessment performed of DMA.

Transition issues identified and options posed, ASSTAR, DMA

4.6.6.4. Changes to maturity scores

- SSEP-FFAS
    - Procedures & human factors increased from 1.5 to 2
- SSEP-MAS
    - Safety increased from 1 to 1.5

    - Procedures & human factors increased from 1.5 to 2
- SSEP-FFT
    - Safety increased from 1 to 1.5
    - Transition issues from 1 to 1.5

4.6.6.5. Critical path and blocking issues

Issues related to near-term implementation is the lead time needed to certify the technology, and the formal acceptance of new liabilities arising from the adoption of this family of applications.

4.6.6.6. Current implementation and plans

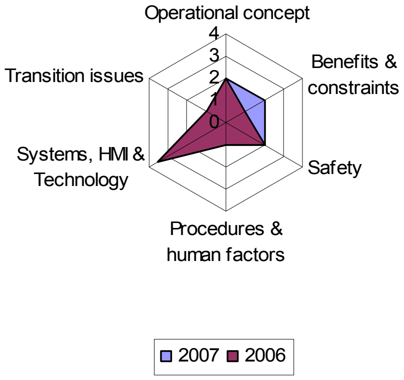
The next steps are currently underway by means of the ASSTAR project. Further benefit analysis would support the introduction of SSEP. The airlines are invited to participate in this benefit analysis, as this is typically airline specific. Initial "back-of-the-envelope" calculations results are very positive and support the quick return on investment requirements by the airlines.

4.7. Graphical summary

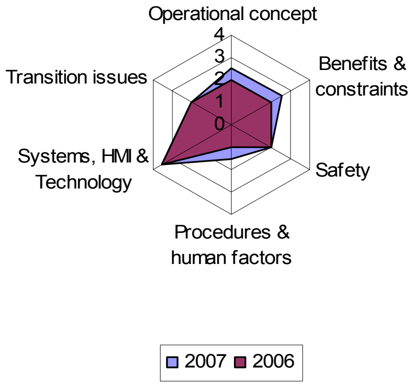
The following diagrams try to give an indication of the overall level of maturity of each application with respect to the six criteria selected for the assessment. The size of the shaded area does not necessarily reflect the readiness for deployment because all axes may not carry equal weight. The values for consecutive years 2006 and 2007 are shown on the same axes for comparison.

4.7.1. ADS-B surveillance

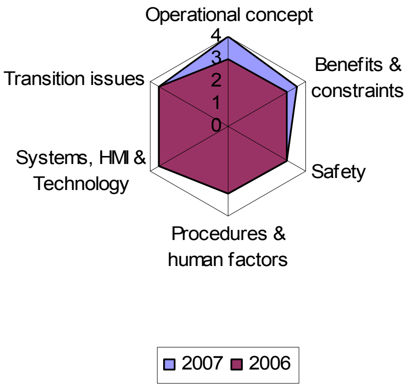
Airport surface surveillance (ADS-B-APT)



ATC surveillance in radar airspace (ADS-B-RAD)



ATC surveillance in non-radar areas (ADS-B-NRA)



Aircraft derived data for ground tools (ADS-B-ADD)

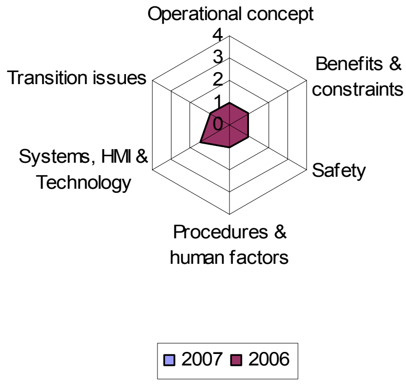
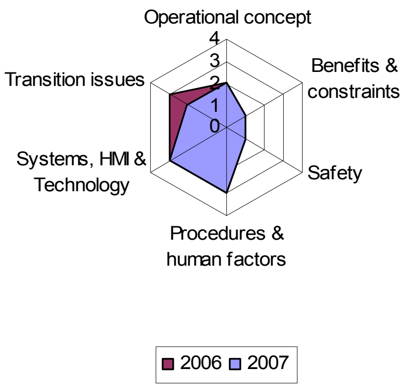


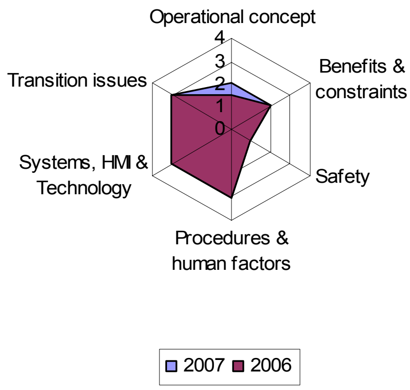
Figure 6: ADS-B surveillance applications maturity summary

4.7.2. Airborne traffic situational awareness

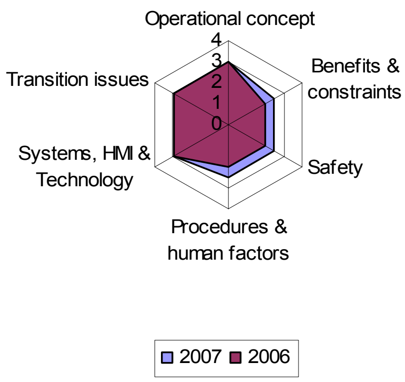
Enhanced traffic situational awareness during flight operations (ATSA-AIRB)



Enhanced traffic situational awareness on the airport surface (ATSA-SURF)



In-trail procedure in non-radar oceanic airspace (ATSA-ITP)



Enhanced visual separation on approach (ATSA-VSA)

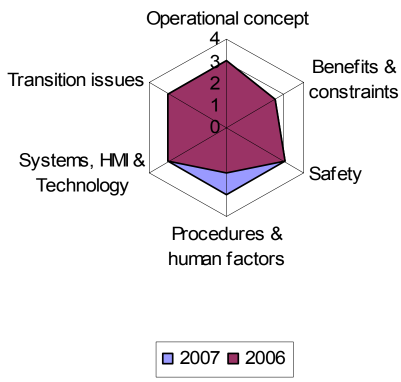


Figure 7: Airborne traffic situational awareness applications maturity summary

4.7.3. Airborne spacing

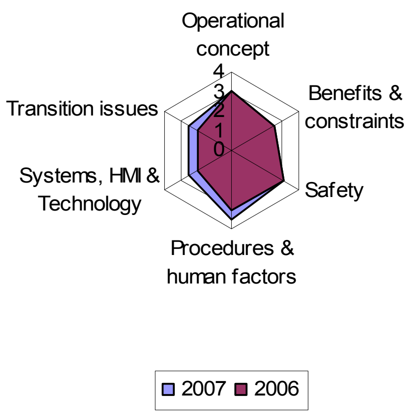
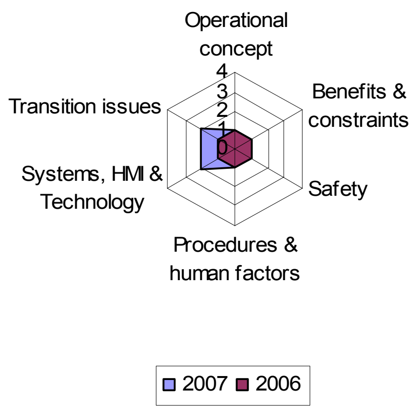
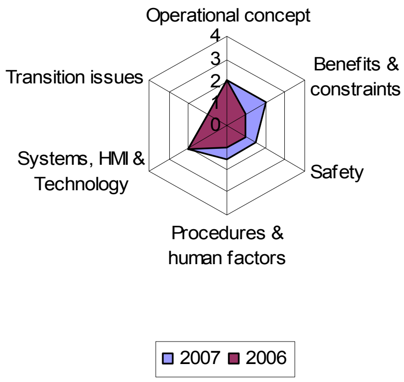
Sequencing and merging (ASPA-S&M)	Enhanced crossing and passing (ASPA-C&P)
	

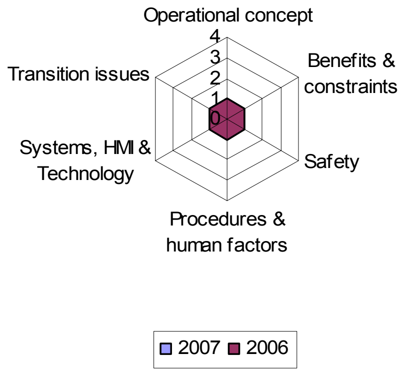
Figure 8: Airborne spacing applications maturity summary

4.7.4. Airborne separation

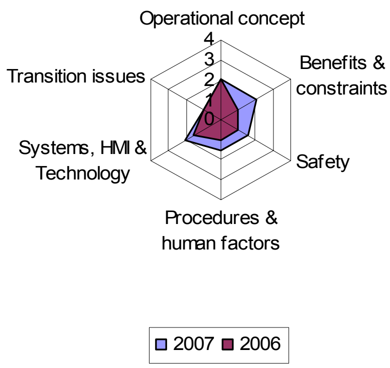
Lateral crossing and passing
(ASEP-LC&P)



Vertical crossing and passing
(ASEP-VC&P)



In-trail procedure
(ASEP-ITP)



In-trail follow
(ASEP-ITF)

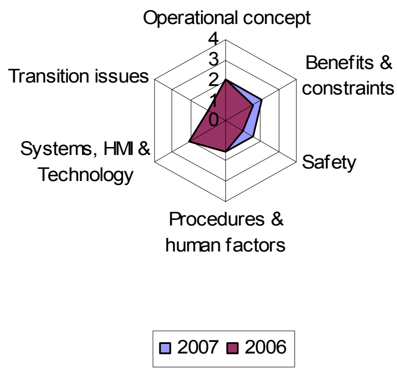


Figure 9: Airborne separation applications maturity summary

Sequencing and Merging
(ASEP-S&M)

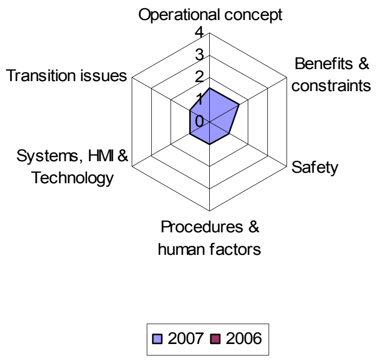
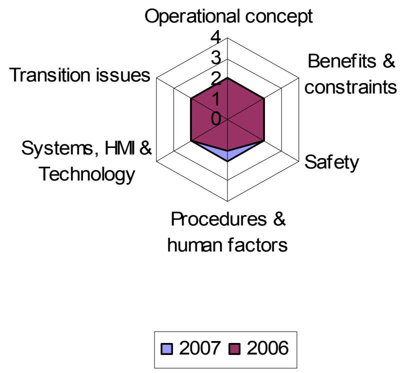


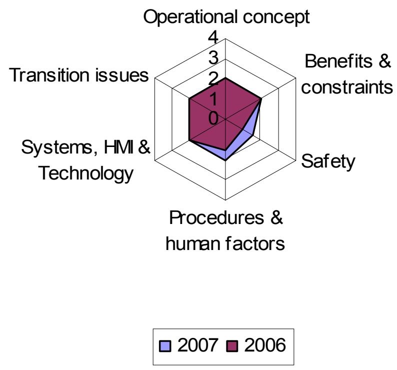
Figure 10 Airborne separation applications maturity summary (2)

4.7.5. Airborne self-separation

Self-separation in segregated free flight airspace (SSEP-FFAS)



Self-separation in managed airspace (SSEP-MAS)



Self-separation in an organised track system (SSEP-FFT)

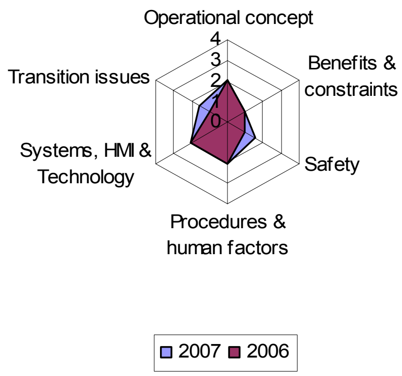


Figure 11 Airborne self-separation applications maturity summary

5. Conclusion

This assessment indicates that one of the most mature applications is ‘ATC surveillance in non-radar areas’ with scores in the range 3 to 4 for all aspects of maturity rated. The airborne traffic situational awareness applications ‘In-trail procedure in non-radar oceanic airspace’ and ‘Enhanced visual separation on approach’, and the Airborne spacing application ‘Sequencing and merging’ also seem to have made progress with scores in the range 2.5 to 3.5. The applications judged to be relatively immature are ‘Aircraft derived data for ground tools’ (ADS-B surveillance category), ‘Enhanced crossing and passing’ (Airborne spacing category) and ‘Vertical crossing and passing’ (Airborne spacing category) with scores between 1 and 2 for all aspects of maturity. The low score of ‘Enhanced crossing and passing’ (Airborne spacing category) can be explained by it being superseded by the related application ‘Lateral crossing and passing’ in the Airborne separation category.

Over the year from March 2006 to February 2007 the maturity scores of fifteen out of seventeen applications increased and one decreased. ‘In-trail procedure’ (Airborne separation category) had increased scores in four out of the six maturity metrics. ‘ATC surveillance in radar airspace’ (ADS-B surveillance category), ‘In-trail procedure in non-radar oceanic airspace’ (Airborne traffic situational awareness category), ‘Sequencing and merging’ (Airborne spacing category) and ‘Lateral crossing and passing’ (Airborne separation category) all had increases in three out of the six maturity metrics. The decrease in maturity score of ‘Enhanced traffic situational awareness during flight operations’ (Air traffic situational awareness category) was due to results from the US/European ADS-B applications requirements focus group identifying safety issues related to mixed fleet equipage. A new application was also added to the assessment ‘Sequencing and merging’ (Airborne separation category) as an extension of the existing ‘Sequencing and merging’ application in the Airborne spacing category.

An update to this assessment is planned for 2008.

6. References

ASAS related projects used for this review
3FMS (http://www.cordis.lu/)
AATT/DAG-TM (http://www.asc.nasa.gov/aatt/dag.html)
ADAS (website under development)
ASSTAR (www.asstar.org/index.111206.php)
Australian UAP (Upper Airspace Program)
(http://www.airservicesaustralia.com/pilotcentre/projects/adsb/adsbuap.asp)
CARE/ASAS (www.eurocontrol.int/care-asas/public/subsite_homepage/homepage.html)
CASCADE Stream 1&2/Cristals
(http://www.eurocontrol.int/cascade/public/subsite_homepage/homepage.html)
C-ATM (http://www.c-atm.com/)
COSPACE (http://www.eurocontrol.int/eec/public/standard_page/SSP_cospace.html)
DADI II (http://icadc.cordis.lu/)
EASA regulation development (http://www.easa.eu.int/home/)
EFAS Environmentally Friendly Airport System
EMERALD (http://www.cordis.lu/transport/src/emerald.htm)
EMERTA (http://www.cordis.lu/transport/src/48320.htm)
EMMA (http://www.dlr.de/emma)
FAA Safe Flight 21 (www.faa.gov/safeflight21) including Capstone (Alaska) and Gulf of Mexico
FALBALA (http://www.eurocontrol.int/care-asas/public/subsite_homepage/homepage.html)
FlySAFE (http://www.eu-flysafe.org/)
FREER (www.eurocontrol.int/eec/public/standard_page/SSP_cospace)
http://www.g2g.isdefe.es/
HYBRIDGE (hosted.nlr.nl/public/hosted-sites/hybridge)G2G (http://www.g2g.isdefe.es/)
ICAO standards development (e.g.ASAS SG)
iFly Sefety, Complexity and Responsibility based design and validation of highly automated Air Traffic Management
INTENT (www.intentproject.org)
ISAWARE II (http://www.isaware.org/home.htm)
MA-AFAS (www.ma-afas.com)
DMA Dynamic Multi-track Airways
MEDUP (http://www.adsmedup.it/)
MFF (www.medff.it)
NASA Glenn Research Center
(http://acast.grc.nasa.gov/resources/documents/Benefits_Assessment_Red_Sep_NAtlantic_OTS_Final_Report_2005Oct3.pdf
NASA Langley/Ames (www.asc.nasa.gov/aatt/dag)
NLR/NASA Free Flight (hosted.nlr.nl/public/hosted-sites/freeflight)
NUP - OPERATIONAL ENVIRONMENT DEFINITION (OED) Pilot Delegated In-Trail Procedure (ITP) in Non- Radar Oceanic Airspace, REY_NUP_WP8_OED_1, 07/01/01
NUP - OPERATIONAL ENVIRONMENT DEFINITION (OED) Delegated Airborne Separation Approach and Climb-Out Stockholm-Arlanda, SAS_NUP_WP2_OED2DAS, 01/03/30.
NUP - OPERATIONAL ENVIRONMENT DEFINITION (OED) Delegated Airborne Separation Cluster Control (DAS-CC) En-Route Maastricht UAC, MAAS_NUP_WP2_OED5, 2000/08/30.
NUP2, NUP2+ (www.nup.nu)
RFG (http://www.eurocontrol.int/cascade/public/subsite_homepage/homepage.html)
RTCA SC 186 (www.rtca.org)
SEAP (http://www.ads-seap.com)