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

Work Package 3

ASAS application maturity assessment

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1. Introduction

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 initial, and thereafter annual, assessment of the progress and necessary steps in the development of ASAS applications.

2. What is the ASAS-TN?

ASAS-TN2 is a three-year project that is primarily a communication activity. ASAS-TN2 is sponsored by the European Commission (Directorate General Research).

ASAS-TN2 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.

The work of the ASAS-TN2 is threefold:

- Five workshops and a final seminar
- Web-based documentation; and
- Annual reporting of the status and maturity of ASAS application development.

The Workshops and discussion forums provide information on the ASAS-TN2 WP3 application maturity reporting work.

The ASAS-TN2 is managed by a consortium led by EUROCONTROL that includes BAE Systems, ENAV, LFV, NLR, Thales ATM and Thales Avionics.

In addition to the above organisations, the 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 Controller’s Associations), IFALPA (International Federation of Air Line Pilot’s Associations) and ECA (European Cockpit Association)).

3. 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.

As well as organising workshops to exchange information on ADS-B/ASAS related activities, the ASAS-TN2 tasks also include specifically 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

More specifically, it will produce a yearly assessment of the advancements of ADS-B/ASAS towards implementation in a very concise and graphical format.

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 called clusters of applications were defined for analysis:

- ADS-B surveillance (ground and airborne)
- Situational awareness
- Spacing
- Separation
- Self-separation

Each application within each cluster was assessed 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 are listed in Appendix A of this document. The list is not in any way exhaustive and will be updated during the course of ASAS-TN2.

This assessment includes a report on the current status of ADS-B equipage of aircraft flying in European airspace.

4. ADS-B equipage status in European airspace

4.1. Core Europe 1090 Extended Squitter

The following statistics were taken from the Airborne Monitoring Project ADS-B Monthly Report, January 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 based on information collected in the 3 month period from November 2005 to January 2006 by: France (Charles de Gaulle), Germany (Dusseldorf), The Netherlands (Schipol, Woensdrecht), The United Kingdom (Clee-Hill), Czech Republic (Pisek) and Switzerland (Geneva) consolidated by EUROCONTROL.

Number of recorded flights: 360,213
Recording duration: 2,406 hours
Percentage of **Mode-S equipped flights**: **95.78%**
ADS-B Extended Squitter capability as percentage of Mode-S equipped: **39.81%**

Note: The ADS-B messages are not certified for operational use. Of the 39.81% ADS-B Extended Squitter capability, a detailed statistical analysis of data collected from Switzerland, Czech Republic and France, indicates that about half of those were broadcasting a position.

The EUROCONTROL CASCADE Programme in partnership with stakeholders (AIRBUS, DSNA, THALES ATM and Alticode) has launched the CRISTAL Toulouse project which addresses the certification roadmap and needs of ADS-B 1090 ES. This will be used as a basis for the preparation of certification material by the relevant organisations during 2006 and the availability of certified ADS-B avionics.

4.2. Regional VDL/4 ADS-B

The following statistics are based on information collected by LFV in the 10-month period from May 2005 to March 2006 in Östgöta TMA, Kiruna TMA, Stockholm-Arlanda TMA and Arlanda surface movements, Sweden.

The total recorded duration of VDL Mode 4 equipped flights is approximately 1500 hours of flight time. The surface vehicles at Arlanda airport generate in excess of 300 hours of surface movements recorded each day, giving an estimated total of 100 000 hours of recorded movements during the 10-month period.

Analysis of the application clusters

5. ADS-B surveillance

5.1. Cluster overview

This cluster contains the following applications:

- Airport surface surveillance (ADS-B-APT)
- Air Traffic Control (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)

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.

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

- North European ADS-B Update Programme (NUP-1)
- NUP-2
- 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.

In the USA, Safe Flight 21 (SF21) is 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.

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.

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 France, Italy, Malta, Greece and Cyprus.

In the USA, ADS-B-RAD is investigated by Safe Flight 21. The recent interest of the FAA to proceed with nationwide ADS-B implementation will most probably accelerate the investigation, validation and certification process for this application.

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 applicable to 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.

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).

In the USA, the application was operational in January 2001 for 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. The US Federal Aviation Authority (FAA) has recently expressed interest in a possible nationwide ADS-B implementation.

In Australia, Air Services 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.

ICAO OPLINK and SASP panels are currently developing separation standards based on ADS-B and updating the PANS/ATM document (doc. 4444) to consider the impact of ADS-B on procedures and phraseology.

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.

ADS-B ADD has been addressed by European R&D projects such as: NUP 2, DADI 2, MEDUP, 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 (e.g. CRISTAL Sweden).

5.2. Maturity assessment

5.2.1. Operational concepts

Application	Maturity level	Notes
ADS-B-APT	2	The OSED is being drafted by RFG
ADS-B-RAD	2	The OSED is being drafted by RFG
ADS-B-NRA	3	This application was one of the two fast-tracks applications considered by RFG. Therefore the OSED, SPR (Safety Performance Requirements) and Inter-operability (Interop) documents are close to completion by the RFG and approval process RTCA/EUROCAE (European Organisation for Civil Aviation Equipment), target date June 2006. Australia participates in this RFG activity and brings 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.

5.2.2. Benefits and constraints

Application	Maturity level	Notes
ADS-B-APT	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.
ADS-B-RAD	2	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.
ADS-B-NRA	3	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 contemplated. 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).
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.

5.2.3. 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) is in progress at the RFG.
ADS-B-ADD	1	Will be analysed by RFG

5.2.4. 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	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

5.2.5. 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	

5.2.6. 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.

5.2.7. 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.

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 considered to be relatively 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.

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

5.3. 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. At that time the 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 NIC, NAC, SIL, etc.) Australia is implementing with DO-260, Europe and USA may require 260A.

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 and ADS-B APT (especially A-SMGCS).

When surveillance relies only on ADS-B (i.e. on GPS (Global Positioning System)) additional information such as RAIM (Receiver Autonomous Integrity Monitoring) availability might be required to be displayed as well

5.4. Current implementation and plans

A near term step is to certify on-board ADS-B equipment for use. This should preferably be done on current ADS-B equipment (DO-260) as any modification would imply costs for airlines and consequently significantly slow down ADS-B implementation.

6. Airborne traffic situational awareness

6.1. Cluster overview

This application cluster contains the following ASAS airborne surveillance applications:

- 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)

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 three 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 three sub-applications are:

- Enhanced flight operations related to other traffic: the addition of an appropriate on-board display of nearby traffic improves flight operations related to other aircraft by assisting the flight crew in building an enhanced traffic situational awareness.
- 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 first application contributes to improving both safety and efficiency of flight in controlled airspace, whereas the objective of the two last applications is safety.

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).

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

The ATSA-SURF 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..

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).

In-trail procedure in non-radar oceanic airspace (ATSA-ITP)
The ATSA-ITP 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. ATSA-ITP trials are planned as part of the FAA Global Air Transport Interoperability (GATI) program.

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

Enhanced Visual Separation on Approach (ATSA-VSA)
The ATSA-VSA 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.

6.2. Maturity assessment

6.2.1. Operational concepts

Application	Maturity level	Notes
ATSA-AIRB	2	RFG has developed draft OSED. The concepts are quite stable.
ATSA-SURF	1.5	RFG has developed draft OSED.
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.

6.2.2. 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	Benefits are identified. NASA studies identify benefits. Procedure needs to be refined. ICAO assessment is necessary at some point.
ATSA-VSA	2.5	Benefits are identified Basic assessments have been made (UPS use in Louisville) but no modelling. Remaining issues of aircraft identification.

6.2.3. 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	Draft OHA document
ATSA-VSA	3	Draft OHA and ASOR documents. UPS CDTI certified for a very similar application.

6.2.4. 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	Procedures are defined in OSED. Procedure validation is ongoing
ATSA-VSA	2	Procedures are defined in OSED. Procedure validation is ongoing

6.2.5. 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

6.2.6. Transition issues

Application	Maturity level	Notes
ATSA-AIRB	3	Rely on current procedures. Mixed fleet equipage is probably acceptable.
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.

6.2.7. 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
- ATSA-ITP - Concept, procedures and systems/HMI well advanced. Ongoing safety assessment. Work needed on benefits and transition.

6.3. 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 ADS-B-in equipped. All the applications require the same basic ADS-B-in equipage corresponding to ATSA-AIRB, though integrity 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. However, pair wise operations are likely to require means to check that appropriate integrity is available; this might require an upgrade of avionics to DO-260A to provide appropriate NIC/NAC/SIL information.

The decision to equip aircraft for ADS-B-in with ATSA 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.

6.4. 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.

NUP II+: Preoperational live trials at Arlanda are planned for 2006. The services included in the trials will be RWY incursion, routing and clearance deviation detection service. The system at Arlanda is now approved for vehicles and aircraft, Equipage of approximately 20 F50 and B737 are ongoing. Further RJ100 aircraft and vehicles will be included in these pre operational trials.

EUROCONTROL's CASCADE programme is co-ordinating activities, including local implementations, for ATSA-AIRB, ATSA-SURF, ATSA-VSA and possibly ATSA-ITP.

7. ASAS spacing applications

7.1. Cluster overview

This application cluster contains the following ASAS application(s):

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

Enhanced 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.

Key projects addressing the application: MFF, MA-AFAS, NUP I, CoSpace, FALBALA, DAG-TM, G2G, UPS Merging and Spacing.

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.

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 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.

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

7.2. Maturity assessment

7.2.1. 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.

7.2.2. Benefits and constraints

Application	Maturity level	Notes
ASPA-S&M	2.5	Consolidated results on benefits and detailed report on constraints have been produced.
ASPA-C&P	1	Negative initial results. Need for further development. Depends on whether the application moves to separation cluster.

7.2.3. Safety assessment

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

7.2.4. Procedures and human factors

Application	Maturity level	Notes
ASPA-S&M	3	Training need completely addressed and task analysis assessment validated.
ASPA-C&P	1	Re-definition of responsibilities required.

7.2.5. Systems, HMI and technology

Application	Maturity level	Notes
ASPA-S&M	2	Some systems and HMI validation work. Target identification work required.
ASPA-C&P	1	A review of systems supporting this application is required.

7.2.6. Transition issues

Application	Maturity level	Notes
ASPA-S&M	2	Some assessment on technical and operational transition issues.
ASPA-C&P	1	Further investigation required.

7.2.7. Summary

ASPA-S&M - Some good results have been achieved.
ASPA-C&P – A lot of activity has taken place, but results were not completely satisfactory. It may be necessary to move the application to ASEP- C&P.

7.3. 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 and NUP have been also successfully tested. There are many issues with ASAS spacing, for example the need for a clear benefits case and issues relating to differing local implementations, that need to be addressed. Work is required in producing guidance material regarding the necessary airspace re-design issues.

7.4. 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).

8. ASAS separation cluster

8.1. Cluster overview

This application cluster contains the following ASAS applications:

- Lateral Crossing and Passing (ASEP-LC&P)
- Vertical Crossing and Passing (ASEP-VC&P)
- In-Trail Follow (ASEP-ITF)
- In-Trail Procedure (ASEP-ITP)

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.

ASSTAR is currently defining a “Lateral Crossing” procedure allowing a aircraft (the “clearance” aircraft) to cross or pass a “target” aircraft using ASAS. Responsibility for separation is ceded 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.

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.

The ASEP-VC&P application is not subject of considerable work at present within the ASAS community.

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.

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:

1. A Following Climb.
2. A Following Descent.
3. A Leading Climb.
4. A Leading Descent.
5. A Combined Leading-Following Climb.
6. A Combined Leading-Following Descent.

8.2. Maturity Assessment

8.2.1. 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-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-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.

8.2.2. Benefits and Constraints

Application	Maturity Level	Notes
ASEP-LC&P	1	Will be studied during ASSTAR.
ASEP-VC&P	1	Some perceived benefits, generally based on assumptions, but no definite conclusions yet.
ASEP-ITF	1.5	Will be 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-ITP	1	Will be studied during ASSTAR, although benefits will likely be similar (if not marginally better) than ATSA-ITP.

8.2.3. Safety Assessment

Application	Maturity Level	Notes
ASEP-LC&P	1	Will be studied during ASSTAR.
ASEP-VC&P	1	No specific analysis has been carried out yet.
ASEP-ITF	1	Will be studied during ASSTAR.
ASEP-ITP	1	Will be studied during ASSTAR.

8.2.4. Procedures and Human Factors

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

8.2.5. 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-ITF	2	Based on the similarities to ASPA-S&M.
ASEP-ITP	1.5	Work has been carried out by NLR for similar types of operation.

8.2.6. 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-ITF	1	Transition issues not investigated yet.
ASEP-ITP	1	Transition issues not investigated yet.

8.3. 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 will undertake 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. The next steps are via the RFG.

Acceptance of the ASEP applications will also depend on the outcome of cost benefit analyses and safety cases, which have yet to be carried out. 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 ATC domain will address these issues in the near-term future.

8.4. Current Implementation and Plans

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

9. Airborne self-separation cluster

9.1. Cluster overview

This application cluster contains the following ASAS applications:

- 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)

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 1 shows the possible location of FFAS with respect to Managed Airspace (MAS).

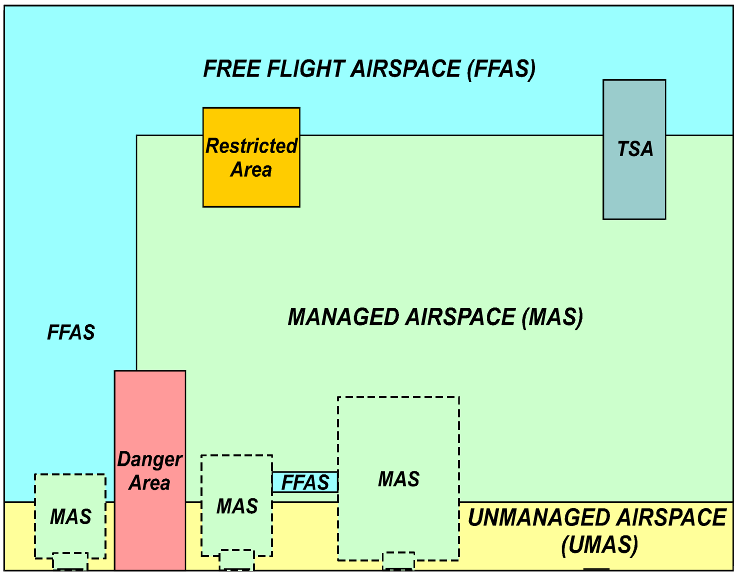


Figure 1: Possible locations of FFAS and MAS.

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

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

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

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 Free Flight Track within the oceanic Organised Track System (OTS), segregated from the non-equipped aircraft. The crew is not able to choose their trajectory freely in the horizontal direction. The altitude and speed can however be freely chosen. This concept is expected to be a first implementation towards SSEP-FFAS. The ASSTAR project is planning to test this concept in fast-time and human-in-the-loop simulations, as well as by means of an extensive safety analysis.

9.2. Maturity assessment

9.2.1. 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

9.2.2. Benefits and constraints

Application	Maturity level	Notes
SSEP-FFAS	2	fast-time simulations conducted, MFF
SSEP-MAS	2	qualitative assessment of benefits conducted, Langley
SSEP-FFT	1	initial benefit review conducted, ASSTAR

9.2.3. Safety assessment

Application	Maturity level	Notes
SSEP-FFAS	2	safety cases conducted (OSED, OHA, ASOR), MFF, NLR/NASA Free Flight
SSEP-MAS	1	no safety case conducted yet, Langley
SSEP-FFT	1	no safety case conducted yet, ASSTAR

9.2.4. Procedures and human factors

Application	Maturity level	Notes
SSEP-FFAS	1.5	flight tested in MFF
SSEP-MAS	1.5	human-in-the-loop simulations conducted, Langley
SSEP-FFT	2	initial procedures described and based on the similarities to SSEP-FFAS, ASSTAR

9.2.5. Systems, HMI and technology

Application	Maturity level	Notes
SSEP-FFAS	2	flight tested, MFF
SSEP-MAS	2	human-in-the-loop simulations conducted, Langley
SSEP-FFT	2	based on the similarities to SSEP-FFAS, ASSTAR

9.2.6. 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	basic concept described, ASSTAR

9.2.7. 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 producing 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 will be tested in simulations in the next years within the ASSTAR project

9.3. Critical path and blocking issues

The main 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 should be further studied, especially the safety case and benefits analysis.

Another blocking issue may be the willingness of flight crews and operators to accept the new liabilities arising from the adoption of this family of applications

9.4. Current implementation and plans

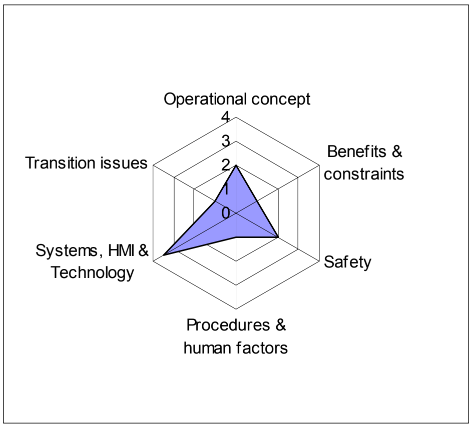
See section 9.3. The next steps are currently underway by means of the ASSTAR project. Further benefit analysis would support the introduction of SSEP. The airlines are invited to participate in this benefit analysis, as this is typically airline specific. Initial “back-of-the-envelope” calculations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

10. Applications maturity summary

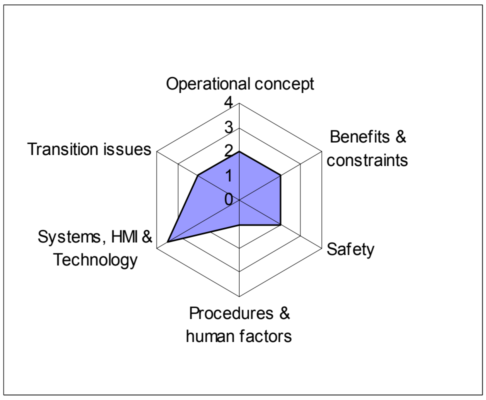
The following diagrams try to give an indication of the overall level of maturity of each application with respect to the six criteria selected for the assessment. The size of the shaded area does not necessarily reflect the readiness for deployment because all axes may not carry equal weight

10.1. ADS-B surveillance

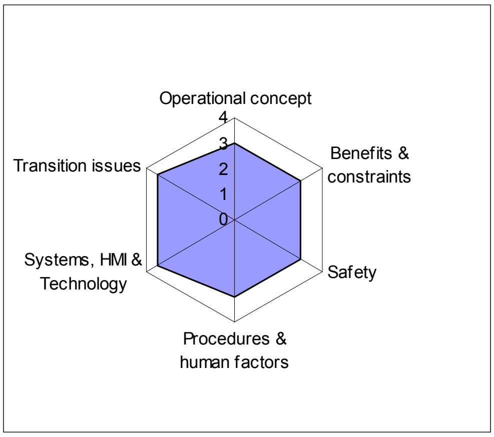
Airport surface surveillance (ADS-B-APT)



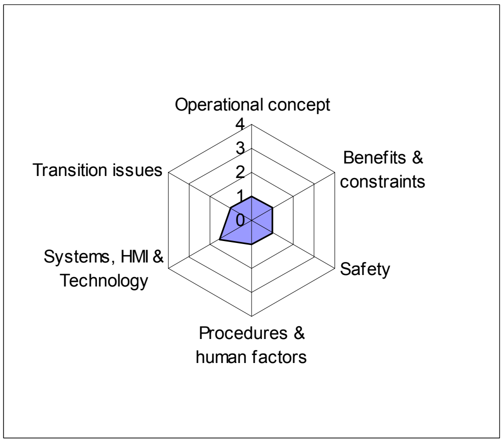
ATC surveillance in radar airspace (ADS-B-RAD)



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

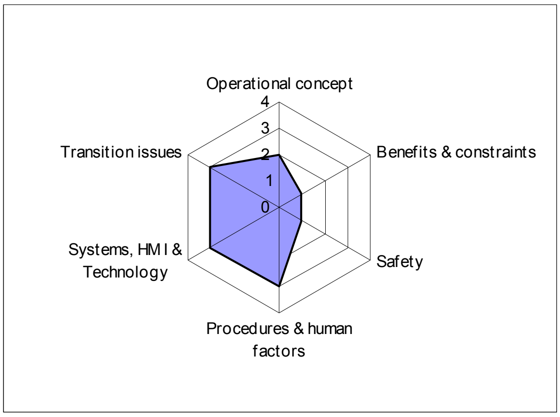


Aircraft derived data for ground tools (ADS-B-ADD)

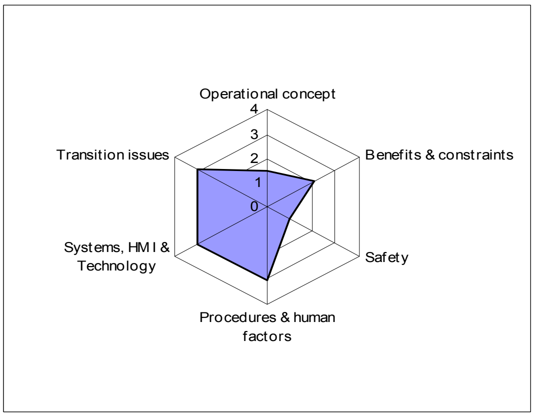


10.2. Airborne traffic situational awareness

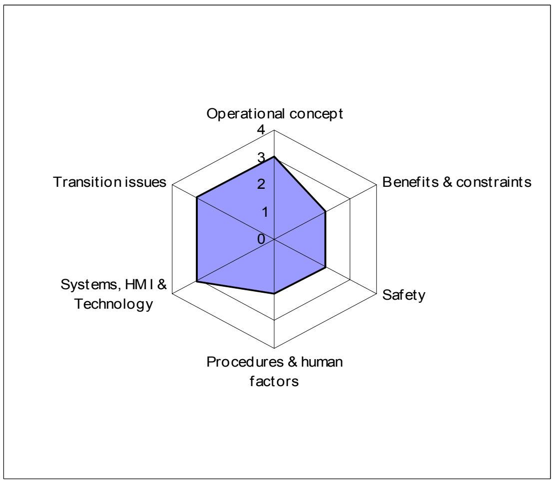
Enhanced traffic situational awareness during flight operations (ATSA-AIRB)



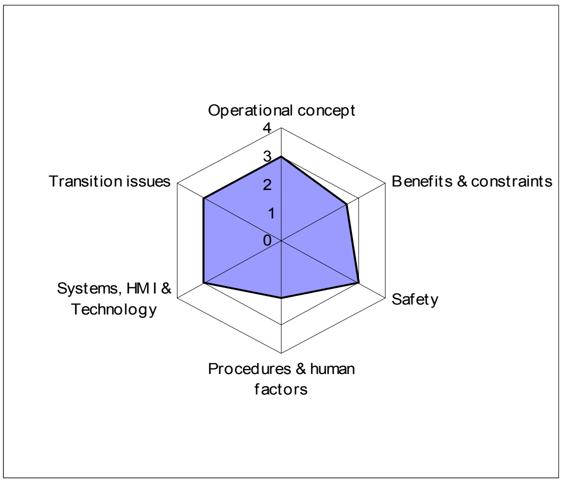
Enhanced traffic situational awareness on the airport surface (ATSA-SURF)



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

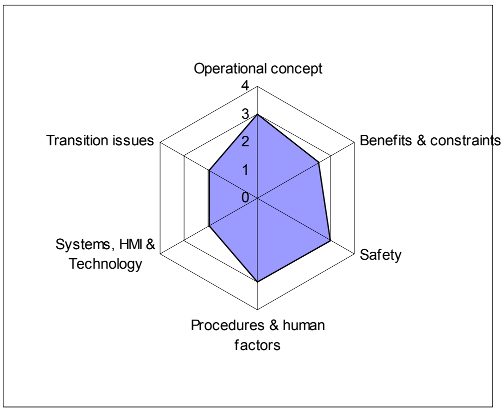


Enhanced visual separation on approach (ATSA-VSA)

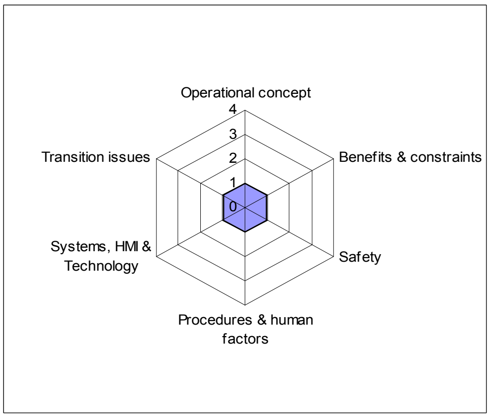


10.3. ASAS spacing

Enhanced sequencing and merging (ASPA-S&M)

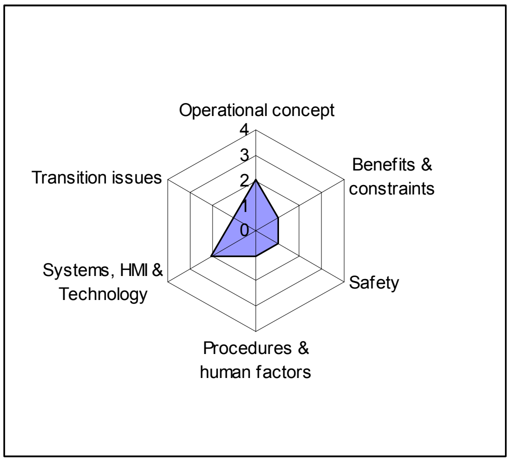


Enhanced crossing and passing (ASPA-C&P)

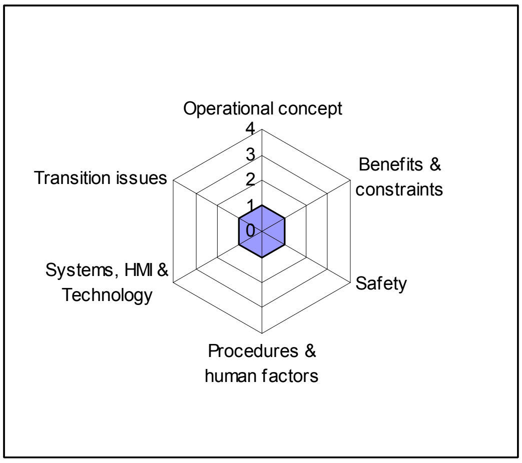


10.4. ASAS separation

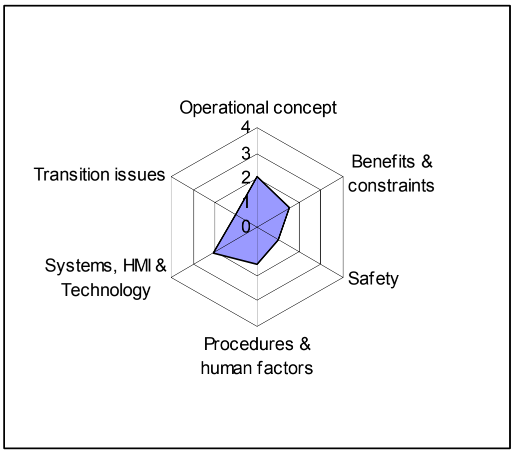
Lateral crossing and passing
(ASEP-LC&P)



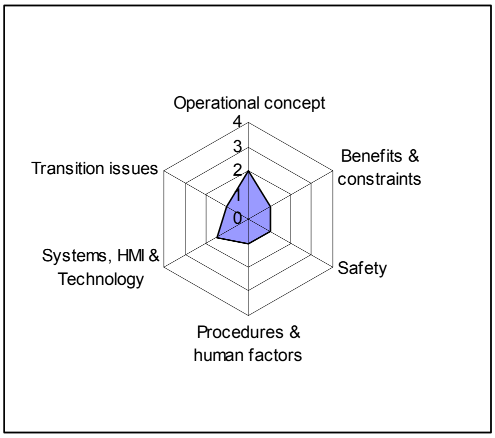
Vertical crossing and passing
(ASEP-VC&P)



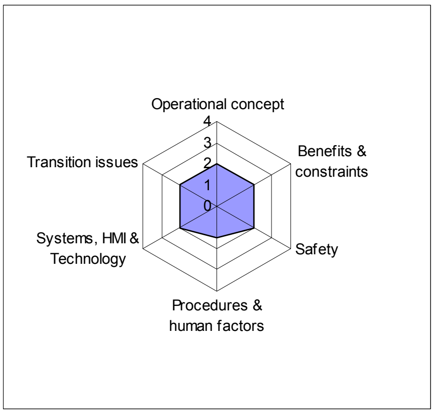
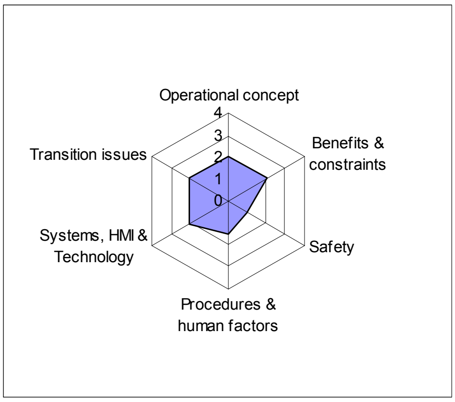
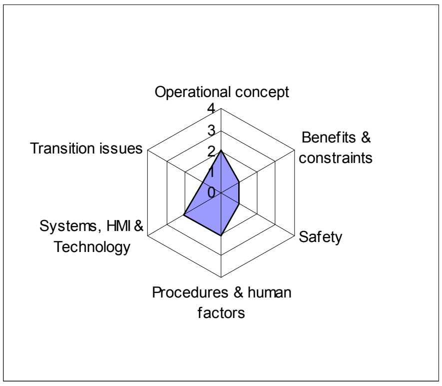
In-trail follow
(ASEP-ITF)



In-trail procedure
(ASEP-ITP)



10.5. ASAS 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)	
	

11. Appendix A – ASAS related projects used for this review

3FMS (http://www.cordis.lu/)
AATT/DAG-TM (http://www.asc.nasa.gov/aatt/dag.html)
ASSTAR (website under development)
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/)
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)
G2G (http://www.g2g.isdefe.es/)
ICAO standards development (e.g.ASAS SG)
INTENT (www.intentproject.org)
ISAWARE II (http://www.isaware.org/home.htm)
MA-AFAS (www.ma-afas.com)
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.eurocontrol.int/eec/public/standard_page/SSP_seap.html)