# Module N° B0-102: Baseline Ground-based Safety Nets

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| **Summary** | This module provides a baseline set of ground-based safety nets assisting the Air Traffic Controller and generating, in a timely manner, alerts of an increased risk to flight safety (collision, unauthorised airspace penetration and controlled flight into terrain). | |
| **Main Performance Impact** | **KPA-10 Safety** | |
| **Operating Environment/Phases of Flight** | All airborne flight phases | |
| **Applicability Considerations** | Benefits increase whilst traffic density and complexity increase. Not all ground-based safety nets are relevant for each environment.<br>Deployment of this module should be accelerated. | |
| **Global Concept Component(s)** | CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational awareness<br>GPI-16 Decision support and alerting systems | |
| **Main Dependencies** | None | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Not applicable** |
| | Avionics Availability | **Ready now** |
| | Ground Systems Availability | **Ready now** |
| | Procedures Available | **Ready now** |
| | Operations Approvals | **Ready now** |

## 1. Narrative

### *1.1 General*

This module aims to implement a baseline set of ground-based safety nets. Ground-based safety nets are intended to assist the Air Traffic Controller (ATCO) in generating, in a timely manner, alerts of an increased risk to flight safety (collision, unauthorised airspace penetration and controlled flight into terrain), which may include resolution advice.

#### 1.1.1 Baseline

#### 1.1.2 Change brought by the module

Ground-based safety nets are functionalities of ATM systems that have the sole purpose of monitoring the environment of operations, during airborne phases of flight, in order to provide timely alerts of an increased risk to flight safety. Ground-based safety nets make an essential contribution to safety and remain required as long as the operational concept remains human-centred.

Ground-based safety nets have been in use since the 1980s. Provisions for ground-based safety nets were introduced in PANS-ATM (Doc 4444) in the early 2000s. In the mean time Ground Systems Suppliers have made ground-based safety nets part of their off-the-shelf product lines.

This module corresponds to a baseline version of the safety nets as already implemented or being implemented in many areas.

### *1.2 Element 1: Short Term Conflict Alert (STCA)*

This element is intended to assist the controller, in an effective manner, in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima. STCA must alert when the separation provision layer has been compromised but must also provide sufficient warning time to allow for corrective action, i.e. ideally avoiding that an Airborne Collision Avoidance System (ACAS) resolution advisory will be generated when the geometry of the situation permits this. In some environments this necessitates the use of separation minima in STCA that are significantly lower than the separation minima used in the separation provision layer. STCA is only effective when each alert causes the controller to immediately assess the situation and if necessary take appropriate action.

Compatibility between ACAS and STCA has to be ensured through the procedures

### *1.3 Element 2: Area Proximity Warning (APW)*

This element is intended to warn the controller, in an effective manner, about unauthorised penetration of an airspace volume by generating, in a timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume. APW can be used to protect static, fixed airspace volumes (e.g. danger areas) but increasingly also dynamic, modular airspace volumes to enable flexible use of airspace.

### *1.4 Element 3: Minimum Safe Altitude Warning (MSAW)*

This element is intended to warn the controller, in an effective manner, about increased risk of controlled flight into terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles. MSAW is only effective when each alert causes the controller to immediately assess the situation and if necessary take appropriate action.

### *1.5 Element 4: Approach Path Monitor (APM)*

This element, generally associated with MSAW, is intended to warn the controller, in an effective manner, about increased risk of controlled flight into terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles during final approach. APM is only effective when each alert causes the controller to immediately assess the situation and if necessary take appropriate action.

## 2. Intended Performance Operational Improvement/Metric to determine success

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|---|---|
| *Safety* | Significant reduction of the number of major incidents. |

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|---|---|
| *CBA* | The business case for this element is entirely made around safety and the application of ALARP (As Low As Reasonably Practicable) in risk management. |

## 3. Necessary Procedures (Air & Ground)

The relevant PANS-ATM (Doc 4444) provisions exist.

## 4. Necessary System Capability

### *4.1 Avionics*

Aircraft should support cooperative surveillance using existing technology such as Mode C/S transponder or ADS-B Out.

### *4.2 Ground Systems*

Units providing surveillance services must be equipped with the ground-based safety nets that are appropriate and optimised for their environment.

In addition they must regularly analyse the data and circumstances pertaining to each alert in order to identify and correct any shortcomings pertaining to ground-based safety nets, airspace design and ATC procedures.

## 5. Human Performance

### *5.1 Human Factors Considerations*

The generated alerts should normally be appropriate and timely, and the controller should understand under which circumstances interactions can occur with normal control practices or airborne safety nets.

The two main issues from human performance are related to nuisance alerts which should be kept to a minimum and warning time for a genuine alert which should be high enough to support the completion of the procedure.

The use of ground-based safety nets will depend on the controller's trust. Trust is a result of many factors such as reliability and transparency. Neither mistrust nor complacency is desirable; training and experience is needed to develop trust at the appropriate level.

### *5.2 Training and Qualification Requirements*

Controllers must receive specific ground-based safety nets training and be assessed as competent for the use of the relevant ground-based safety nets and recovery techniques.

### *5.3 Others*

Nil

## 6. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Nil

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

Worldwide, most units that provide surveillance services and that are using recent surveillance systems are already equipped with ground-based safety nets that are in principle fit for purpose. However, in many cases there is a lack of expertise, lack of tools or conflicting priorities for limited resources that cause these ground-based safety nets not being effective.

### *7.2 Planned or Ongoing Trials*

No general validation required.

## 8. Reference Documents

### *8.1 Standards*

- EUROCONTROL Specifications for STCA, APW, MSAW and APM, available at http://www.eurocontrol.int/safety-nets

### *8.2 Procedures*

- PANS-ATM (Doc 4444), section 15.7.2 and 15.7.4

### *8.3 Guidance Material*

- EUROCONTROL Guidance Material for STCA, APW, MSAW and APM, available at http://www.eurocontrol.int/safety-nets

# Module N° B1-102: Increased Effectiveness of Ground-based Safety Nets

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| **Summary** | This module provides improvements to the effectiveness of the ground-based safety nets assisting the Air Traffic Controller and generating, in a timely manner, alerts of an increased risk to flight safety (collision, unauthorised airspace penetration and controlled flight into terrain). | |
| **Main Performance Impact** | **KPA-10 Safety** | |
| **Operating Environment/Phases of Flight** | All airborne flight phases | |
| **Applicability Considerations** | Benefits increase whilst traffic density and complexity increase. Not all ground-based safety nets are relevant for each environment. | |
| **Global Concept Component(s)** | CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational awareness<br>GPI-16 Decision support and alerting systems | |
| **Main Dependencies** | Successor of B0-102 | |
| **Global Readiness Checklist** | | **Status** (ready now or estimated date) |
| | Standards Readiness | **Not applicable** |
| | Avionics Availability | **Ready now** |
| | Ground Systems Availability | **Est. 2014** |
| | Procedures Available | **Est. 2014** |
| | Operations Approvals | **Est. 2014** |

## 1. Narrative

### *1.1 General*

This module aims to significantly increase the effectiveness of ground-based safety nets.

#### 1.1.1 Baseline

The baseline is provided by module B0-102. However, it may be possible to implement as a single package the baseline and the improvements brought by this module.

Ground-based safety nets need to be optimised for the environment in which they have to operate. However, many Air Navigation Service Providers (ANSPs) are not sufficiently able to successfully complete the optimisation process due to lack of expertise, lack of tools or conflicting priorities for limited resources. This can lead to sub-optimal performance, desensitised controllers missing time-critical alerts or even the inhibition of ground-based safety nets in airspace where the number of alerts is excessive.

#### 1.1.2 Change brought by the module

This module addresses the root cause of optimisation problems faced by ANSPs, i.e. lack of a formal legal basis for sufficiently detailed specifications and guidance material for ground-based safety nets. Establishing such a formal legal basis will facilitate:

- Exploitation of proven good practices that will form the foundation

- Improved industrial products and support offerings that better meet the needs
- Avoidance of investments that can not be fully capitalised and cost savings thanks to sharing of good practices
- Significantly increased reach and effectiveness of ground-based safety nets

### *1.2 Element 1: Short Term Conflict Alert (STCA)*

This element provides for the optimisation of SCTA by keeping the number of nuisance and false alerts to an effective minimum. Dependent on airspace complexity this process includes tuning the values of a large number of parameters. Moreover, new operational concepts and procedures necessitate further optimisation of STCA through refined conflict detection algorithms and use of downlinked aircraft parameters.

### *1.3 Element 2: Area Proximity Warning (APW)*

This element provides for the optimisation of APW algorithms and processes.

### *1.4 Element 3: Minimum Safe Altitude Warning (MSAW)*

This element provides for the optimisation of MSAW by keeping the number of nuisance and false alerts kept an effective minimum which requires the use of an accurate terrain and obstacle model.

### *1.5 Element 4: Approach Path Monitor (APM)*

This element provides for the optimisation of APM by keeping the number of nuisance and false alerts to an effective minimum which requires the use of an accurate approach path model.

## 2. Intended Performance Operational Improvement/Metric to determine success

| | |
|---|---|
| *Safety* | Significant reduction of the number of major incidents. |

| | |
|---|---|
| *CBA* | The business case for this element is entirely made around safety and the application of ALARP (As Low As Reasonably Practicable) in risk management. |

## 3. Necessary Procedures (Air & Ground)

The relevant PANS-ATM (Doc 4444) provisions need to be reviewed and complemented.

## 4. Necessary System Capability

### *4.1 Avionics*

Aircraft should support cooperative surveillance using existing technology such as Mode C/S transponder or ADS-B Out. Consideration should be extended to include all air vehicles (manned and unmanned) that will be operating within or close to the confines of controlled airspace.

### *4.2 Ground Systems*

Units providing surveillance services must be equipped with the ground-based safety nets that are appropriate for their environment.

In addition they must regularly analyse the data and circumstances pertaining to each alert in order to identify and correct any shortcomings pertaining to ground-based safety nets, airspace design and ATC procedures.

## 5. Human Performance

### *5.1 Human Factors Considerations*

The generated alerts should normally be appropriate and timely, and the controller should understand under which circumstances interactions can occur with normal control practices or airborne safety nets.

The two main issues from human performance are related to nuisance alerts which should be kept to a minimum and warning time for a genuine alert which should be high enough to support the completion of the procedure.

The use of ground-based safety nets will depend on the controller's trust. Trust is a result of many factors such as reliability and transparency. Neither mistrust nor complacency is desirable; training and experience is needed to develop trust at the appropriate level.

### *5.2 Training and Qualification Requirements*

Controllers must receive specific ground-based safety nets training and be assessed as competent for the use of the relevant ground-based safety nets and recovery techniques.

### *5.3 Others*

Nil

## 6. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Nil

## 7. Implementation and Demonstration Activities

### *7.1 Current Use*

Nil..

### *7.2 Planned or Ongoing Trials*

- EUROPE: The SESAR programme is developing enhancements to ground-based safety nets such as multi-hypothesis algorithms and use of downlinked aircraft parameters. Ongoing trials of enhanced functionalities commenced in 2011

## 8. Reference Documents

### *8.1 Standards*

- EUROCONTROL Specifications for STCA, APW, MSAW and APM, available at http://www.eurocontrol.int/safety-nets (to be complemented)

### *8.2 Procedures*

- PANS-ATM (Doc 4444), section 15.7.2 and 15.7.4 (to be reviewed and complemented)

### *8.3 Guidance Material*

- EUROCONTROL Guidance Material for STCA, APW, MSAW and APM, available at http://www.eurocontrol.int/safety-nets (to be complemented)
- ICAO Manual for Ground-based Safety Nets (to be developed)

# MODULE N° B0-84: INITIAL CAPABILITY FOR GROUND-BASED COOPERATIVE SURVEILLANCE

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| **Summary** | Ground surveillance supported by ADS-B OUT and/or wide area multilateration systems will improve safety, especially search and rescue and capacity through separation reductions. This capability will be expressed in various ATM services, e.g. traffic information, search and rescue and separation provision | |
| **Main Performance Impact** | KPA- 02 Capacity, KPA-03 Efficiency, KPA-09 Predictability KPA-10 Safety | |
| **Operating Environment/Phases of Flight** | All airborne flight phases in continental or subsets of oceanic airspace and on aerodrome surfaces | |
| **Applicability Considerations** | This capability is characterized by being dependent and cooperative. The overall performance is affected by ADS-B out performance and equipage. | |
| **Global Concept Component(s)** | CM – Conflict Management | |
| **Global Plan Initiatives (GPI)** | GPI-9 Situational awareness<br>GPI-16 Decision support and alerting systems | |
| **Main Dependencies** | | |
| **Global Readiness Checklist** | | Status (ready now or estimated date) |
| | Standards Readiness | Ready now |
| | Avionics Availability | Ready now |
| | Ground Systems Availability | Ready now |
| | Procedures Available | Ready now |
| | Operations Approvals | Ready now |

## 9. Narrative

### *9.1 General*

The surveillance service delivered to users may be based on a mix of three main types of surveillance as defined in ICAO Doc 9924:

- Independent Non-Cooperative Surveillance: The aircraft position is derived from measurement not using the cooperation of the remote aircraft.
- Independent Cooperative Surveillance: The position is derived from measurements performed by a local surveillance subsystem using aircraft transmissions. Aircraft-derived information (e.g. pressure altitude, aircraft identity) can be provided from those transmissions.
- Dependent Cooperative Surveillance: The position is derived on board the aircraft and is provided to the local surveillance subsystem along with possible additional data (e.g. aircraft identity, pressure altitude).

The module describes the cooperative surveillance services.

### 9.1.1 Baseline

Currently, air to ground aircraft position and surveillance is accomplished through the use of primary and secondary radar surveillance. The Primary surveillance radar derives aircraft position based on radar echo returns. The secondary radar is used to transmit and receive aircraft data for barometric altitude, identification code. However, current primary and secondary radars are comparatively expensive and acceptable radar sites are often difficult to obtain. Additionally, radar surveillance performance decreases as distance increases from the radar increasing minimum aircraft separation in En Route airspace versus the terminal airspace.

### 9.1.2 Change brought by the module

ADS-B is recognized as one of the important enablers of several of the ATM operational concept components including traffic synchronization and conflict management (ANConf.11/Rec1/7, 2003). The transmission of ADS-B information (ADS-B out) is already used for surveillance in some non-radar and radar areas (Block 0)

ADS-B is an advanced surveillance technology that allows avionics to broadcast an aircraft's identification, position, altitude, velocity, and other information. The broadcasted aircraft position is more accurate than with conventional Secondary Surveillance Radar (SSR) because it is normally derived from the Global Position System (GPS) and transmitted at least once per second. The inherent accuracy and high update rate will provide service providers and users improvements in safety, capacity, and efficiency. Note: ADS-B is dependent upon having a source of required positional accuracy (such as GNSS today).

Operationally, the lower costs of ADS-B infrastructure in comparison to conventional radars will increase capacity by enabling expansion of surveillance coverage and use of radar-like separation procedures into remote or non-radar areas. In addition to lower costs, ADS-B ground infrastructure can also be sited in locations that are difficult for radar installations. For example, in the Gulf of Mexico, ADS-B Receiver stations are installed on oil platforms to provide radar-like services using ADS-B as the surveillance source. Compared to non-radar services, flights are flying more direct routes, and service providers are able to handle more traffic in each sector.

Furthermore performance of surveillance in radar areas and terminal areas is also improved by ADS-B due to improved accuracy, update rate, improved safety nets and improved coverage at a lower cost than radar.

Use of ADS-B also improves the Search and Rescue support provided by the surveillance network. In non-radar areas, such as the Gulf of Mexico, ADS-B's positional accuracy and update rate enhances the ability for Search and Rescue teams to pinpoint the location.

The enhanced surveillance services provided by ADS-B will enable advanced applications such as Interval Management (B1-85) and ATSA-VSA (B0-100). Interval management enables service providers to use Continuous Descent Approaches (CDA) during increased levels of demand using ADS-B information to improve trajectory prediction accuracy and facilitate efficient spacing control. Furthermore, enhanced positional and speed vector accuracy will improve metering calculations improving efficiency (e.g., in the use of AMAN, B0-15).

Additionally, ADS-B can be an enabler for sharing of surveillance data across FIR boundaries and significantly improves the performance of predictive tools using aircraft derived velocity vector and vertical rate data. It also downlinks other useful ATC relevant data similar to Mode S DAPS.

ADS-B-OUT SARPS (ICAO Annex 10, Volume IV and Doc 9871) and MOPS (RTCA-DO260-B/ Eurocae ED102-A) are available. ANConf/11 recommended ADS-B on 1090MHz for international use and this is happening. Equipage rate is growing together with Mode S, ACAS and ADS-B Out mandates. A distinguishing feature of ADS-B out surveillance technology, is that it is a key enabler for ADS-B IN applications as well. It is pointed out that ADS-B OUT version 2 also provides for ACAS RA DOWNLINK information in support of monitoring activities currently only possible in SSR Mode S coverage.

These systems are ground based and are related to continental airspace or oceanic airspace supported by ADS-B receivers on islands. ADS-B data

Multilateration technique is a new technique providing independent cooperative surveillance. Its deployment is made easier by the use of Airborne Mode S equipment capability with the spontaneous transmission of messages (Squitters). In this case the signal transmitted by aircraft is received by a network of receivers located at different places. The use of the different times of arrival at the different receivers allows an independent determination of the position of the source of signals. This technique can be passive and use the existing transmissions made by the aircraft or be active and trigger replies in the manner of Mode S SSR interrogations. Surveillance of conventional Mode A/C transponders requires that they be interrogated.

Multilateration systems have been initially deployed on main airports to make the surveillance of aircraft on the surface. The technique is now used to provide surveillance over wide area (Wide Area Multilateration system - WAM).

## 10. Intended Performance Operational Improvement/Metric to determine success

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| *Safety* | Reduction of the number of major incidents. Support to Search and Rescue |
| *Capacity* | Typical separation minima are 3 NM or 5 NM enabling a significant increase in traffic density compared to procedural minima.<br><br>Improved coverage, capacity, velocity vector performance and accuracy can improve ATC performance in both radar and non radar environments. Terminal area surveillance performance improvements are achieved through high accuracy, better velocity vector and improved coverage. |
| *CBA* | - either comparison between procedural minima and 5NM separation minima would allow an increase of traffic density in a given airspace<br><br>-or comparison between installing/renewing SSR Mode S stations using Mode S transponders and installing ADS-B OUT (and /or Multilateration systems). |

## 11. Necessary Procedures (Air & Ground)

The relevant PANS-ATM (Doc 4444) provisions are available.

## 12. Necessary System Capability

### *12.1 Avionics*

Aircraft must be equipped with ADS-B OUT. Accuracy and integrity are reported from the avionics. Users of the data decide on the required accuracy and integrity for the application

### *12.2 Ground Systems*

Units providing surveillance services must be equipped with the ground-based safety nets that are appropriate for their environment.

Units may provide ADS-B surveillance in environments where there is full or partial avionics equipage depending on the capabilities and procedures of the ATC system.

ATC Systems must also be able to separation services between ADS-B-to-ADS-B and ADS-B-to-radar and fused targets.

# 13. Human Performance

## *13.1 Human Factors Considerations*

The air traffic controller has a direct representation of the traffic situation, and reduces the task of controllers or radio operators to collate position reports.

## *13.2 Training and Qualification Requirements*

Controllers must receive specific training for separation provision, information service and search and rescue based on the ADS-B and WAM systems in use.

## *13.3 Others*

Nil

# 14. Regulatory/standardisation needs and Approval Plan (Air & Ground)

Nil

# 15. Implementation and Demonstration Activities

## *15.1 Current Use*

ASMGCS systems using multilateration technology are operational at many locations worldwide.

**Australia -** ADS-B is operational throughout the Australian continent for delivery of 5 NM separation services in radar and non-radar areas, in continental and oceanic airspace. ADS-B data sharing between Indonesia and Australia is fully operational allowing safety nets and situational awareness at the boundary. WAM is operational in Sydney Australia supporting 3 NM TMA separation and PRM operations. WAM is operational in Tasmania, Australia supporting enroute separation.

**United States –** ADS-B surveillance coverage for continental United States will be completed in 2013.

## *15.2 Planned or Ongoing Trials*

Currently in use at this time.

# 16. Reference Documents

## *16.1 Standards*

- ICAO ANNEX 10 Volume IV + ICAO DOC9871 technical specifications
- RTCA MOPS DO260 and DO260A EUROCAE ED102 and ED102A.

## *16.2 Procedures*

- PANS-ATM (Doc 4444)

## *16.3 Guidance Material*

- ICAO Aeronautical surveillance Manual (DOC9924)
- ICAO Aeronautical surveillance Manual (DOC9924)
- ICAO Assessment of ADS-B and Multilateration Surveillance to Support Air Traffic Services and Guidelines for Implementation (Circular 326)
- ICAO Asia Pacific : ADS-B IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT

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