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NETALERT - the Safety Nets newsletter **April 2016 | N°21**

Surveillance infrastructure - the backbone for safety nets

WELCOME

ATM professionals will know that safety nets rely on surveillance information, but how important is the quality of that information and how does it impact on safety net performance? These are some of the questions explored in this issue of NET*ALERT*.

We first look at the differences between traditional primary and secondary radar surveillance. While reflecting on the information needed by safety nets, we consider some of the options available for an ANSP looking to upgrade its surveillance infrastructure.

A popular choice is to install Wide Area Multilateration (WAM). We hear from two early WAM implementers, ANS of the Czech Republic and Austro Control, and get their feedback on the benefits and lessons learned.

Our surveillance ecosystem is changing and with this comes new challenges. In the closing article we describe the problem of transponder over-interrogation following an incident that took place over Central Europe in 2014.

Finally, a quick reminder about the upcoming Safety Forum 2016, taking place in Brussels on 7 and 8 of June. This year's edition focuses on active safety nets to see how their collective effects can support global safety improvements.

Surveillance is the backbone for safety nets. It provides vital information such as the position, height and identification of aircraft to determine if they will come into conflict with each other, infringe restricted areas or come too close to terrain or obstacles. Despite advances in safety nets and ATM system functionality in general, the type of surveillance used, and its overall quality, influences the effectiveness of safety nets. We explore this below and explain why it is important to provide the controller and safety nets with a high quality surveillance picture.

What is a typical surveillance infrastructure?

The surveillance information used every day by controllers has traditionally been provided by a combination of Primary Surveillance (PSR) and Secondary Surveillance Radars (SSR) – either Mode A/C or Mode S. PSR emit electromagnetic waves which are reflected on aircraft (as well as other objects). By measuring the time it takes for the emitted signal to bounce back to the radar, the position of that object can be determined. SSR additionally rely on transponders on-board aircraft to determine their identification (assigned Mode A code) and pressure altitude (Mode C). Mode S transponders also transmit additional parameters, referred to as Downlink Aircraft Parameters (DAPs), in particular Selected Vertical Intent (often referred to as Selected Flight Level).

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Surveillance requirements in Europe

How good should my surveillance infrastructure be? EUROCONTROL's "Specification for ATM Surveillance System Performance – Volume 1" (EUROCONTROL-SPEC-0147) specifies the requirements for cooperative (SSR) and non-cooperative (PSR) radar surveillance for application in the provision of Air Traffic Services.

The minimum surveillance requirements for 5NM and 3NM horizontal separation operations are given below.

	Performance requirements	5NM horizontal separation	3NM horizontal separation
Cooperative	Measurement interval	≤ 8 sec.	≤ 5 sec.
	Horizontal position error	≤ 500 m	≤ 300 m
	Pressure altitude error	≤ 200-300ft in 99.9% for stable flights ≤ 300ft in 98.5% for climbing / descending flights	≤ 200-300ft in 99.9% for stable flights ≤ 300ft in 98.5% for climbing / descending flights
Non-cooperative	Measurement interval	≤ 8 sec.	≤ 5 sec.
	Horizontal position error	≤ 500 m	≤ 300 m
	Pressure altitude error	N/A	N/A

The Specification also defines a number of requirements on the Quality of Service expected from the surveillance infrastructure including in terms of availability, continuity, integrity, time and coherence.

What information do surveillance systems provide to safety nets?

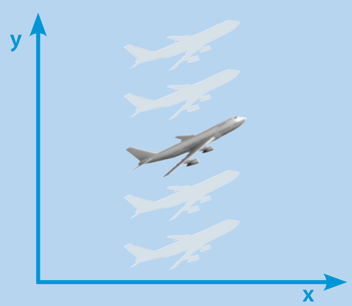
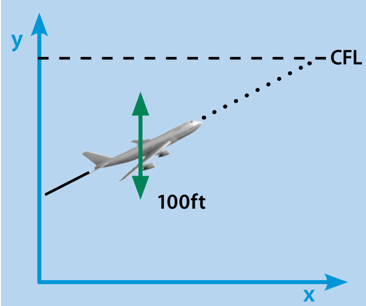
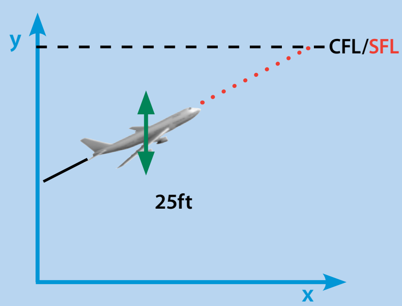
Ground-based safety nets such as Short Term Conflict Alert (STCA) or Minimum Safe Altitude Warning (MSAW) need the aircraft position, altitude and identification to operate effectively.

As summarised in the second column of the figure below, primary surveillance only provides the horizontal aircraft position. This greatly reduces the effectiveness of safety nets as each target is assumed to be at all flight levels. Using PSR as a sole surveillance source for safety nets is only viable in emergency situations, for example in case of transponder failure or indeed for an unequipped aircraft.

By comparison, the information provided by secondary surveillance is significantly more useful to safety nets. In addition to the aircraft position, the altitude of each target can be determined with varying resolutions: 100 ft for Mode A/C and 25 ft for Mode S. SSR also identifies each aircraft individually, allowing the aircraft callsign and other flight plan information to be displayed on the track label on the Controller Working Position (CWP).

Secondary surveillance information can also be combined with controller clearances and pilot inputs to improve alerting performance. Mode A/C data can be used in conjunction with the Cleared Flight Level (CFL) entered by the controller on the CWP. Additionally, the Selected Flight Level (SFL) DAP input by the flight crew can be downloaded via a Mode S transponder, hence providing the intent of the pilot. This information allows safety nets to account for the flight level an aircraft is intended to level off at. In turn this reduces the nuisance alerts that typically occur when safety nets only assume the aircraft will continue at its current rate of climb/descent (see **NET*ALERT* 15** for further information).

When combined with a finely tuned radar tracker, good quality surveillance data also allows safety nets to accurately determine if an aircraft is flying straight and level, climbing/descending and/or turning.

	PSR	SSR Mode A/C	SSR Mode S
Identification	No	Yes	Yes
Position / velocity	Yes	Yes	Yes
Height	No	Yes (100ft resolution)	Yes (25ft resolution)
Intent (ATC)	No	Yes (displayed CFL via CWP)	Yes (displayed CFL via CWP)
Intent (Pilot)	No	No	Yes (displayed SFL via DAPs)
Differences in vertical profile			

Surveillance infrastructure - the backbone for safety nets

continued

Mode A/C vs Mode S

Mode S offers several benefits over Mode A/C, which are particularly relevant for safety nets:

- Better granularity in the vertical plane: The 25ft altitude resolution brought by Mode S can offer the controller and safety nets a few extra seconds to detect vertical deviations compared with Mode A/C. Laterally, both radar types offer comparable characteristics with relatively accurate horizontal position and velocity.

- Less garbling: Mode A/C replies are more prone to interferences such as garbling (when several transponders reply at the same time, making their transmission difficult to decode). This can lead to split tracks being presented to the controller, which in turn can generate false alerts. Mode S' more robust 'selective interrogation' pattern is more resistant to garble.

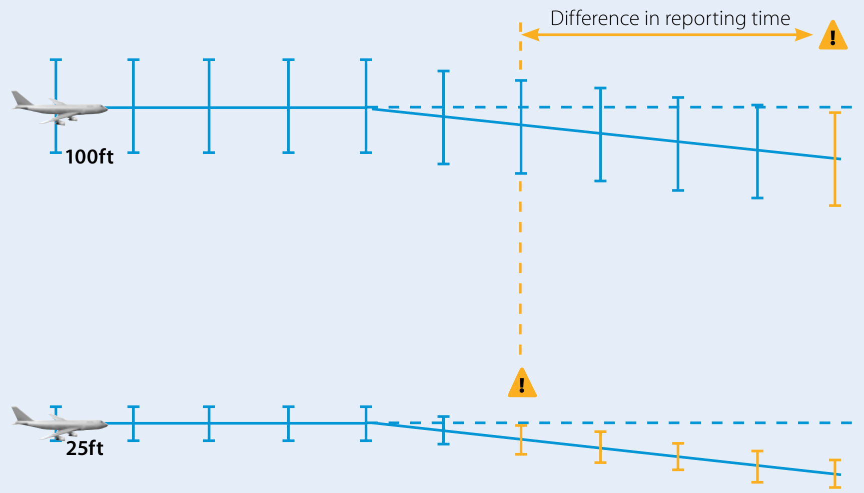
- Comparing controller instructions and pilot intents: Monitoring tools can be implemented to compare the issued cleared level to the flight level selected by the pilots in the cockpit (SFL). The controller will be alerted if there is a discrepancy and the SFL can be used by safety nets for optimal alerting.

A vital few seconds

Mode S' 25ft height resolution seems like a nice improvement over Mode A/C's 100ft. But what could it actually mean for the controller? Let's take an example.

An aircraft is flying level. Suddenly it starts deviating for an unknown reason, descending at 600ft/min. We assume that position updates are provided every 4 seconds (typical for approach/TMA radars).

In the worst case scenario, an aircraft equipped with a Mode A/C transponder will start reporting a change of altitude 7.5 seconds later than if it was equipped with a Mode S transponder. This may seem a relatively small difference but a lot can happen in that time.



Beyond radars

So, a surveillance infrastructure delivering accurate and reliable information is key to effective safety nets. Primary and secondary radars were developed several decades ago. They have benefited from significant improvements over the years but more recently other surveillance solutions have been adopted by Air Navigation Service Providers.

Wide Area Multilateration (WAM) and Automatic Dependent Surveillance-Broadcast (ADS-B) are often deployed as an extra layer of surveillance complementing radars. In some cases they can also be used to replace aging equipment. Both systems rely on transponders to determine aircraft position, WAM using ground stations while ADS-B relies on satellite positioning.

As detailed in the article on WAM on page 4, such systems provide additional benefits when compared to traditional radars in terms of performance and also cost. They directly improve the effectiveness of safety nets in two aspects:

- Coverage in areas not traditionally covered with PSR/SSR: Deploying WAM or ADS-B in mountainous or remote areas is generally easier and cheaper;

- Faster update rates: 1 second update rates can be achieved (compared to typically 4 seconds with SSR), depending on how the feed is integrated with other data in the surveillance tracker.

Current challenges

Today's surveillance infrastructure is highly reliant on aircraft transponders, with SSR, WAM and ADS-B all depending on this critical piece of equipment. This creates obvious issues in case of intermittent or total failure, aircraft not carrying such equipment (addressed in **NET*ALERT* 19**), or indeed in the case of over-interrogation, which is explored in the last article of this newsletter.

Conclusion

No matter whether the controller is working with a decade-old or state-of-the-art ATC system, without the right surveillance input, the full potential of the safety nets will not be realised. The seemingly marginal gains in safety net performance enabled by a high quality surveillance picture can make a real difference to day-to-day operations. In many cases it will increase controller trust in safety nets by reducing false and nuisance alerts. In some situations it can be what separates a controller intervention from a loss of separation and a serious incident.

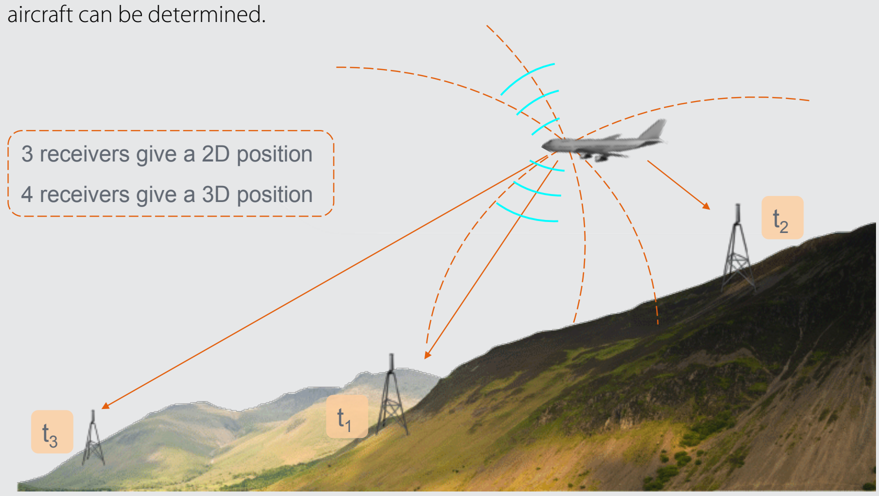
Wide Area Multilateration

Wide Area Multilateration (WAM) provides another source of surveillance data beyond primary and secondary radars. While safety nets are not the primary reason for its implementation there are some potential benefits. We catch up with two long-time WAM adopters, ANS of the Czech Republic and Austro Control, and explore the benefits and challenges of deploying this technology.

What is WAM?

WAM is a ground-based surveillance system which uses a network of distributed stations that listens to aircraft transponder replies. The corresponding interrogations generally originate from secondary radars, but can also be triggered by active multilateration stations (also referred to as WAM interrogators).

When an aircraft transponder emits a reply, it is received by several WAM stations. By calculating the time difference of arrival of the signal at each station, the position of the aircraft can be determined.



No additional avionics are required assuming the aircraft is equipped with either a Mode A/C, Mode S, ADS-B or IFF (Identification Friend or Foe – used by the Military) transponder.

The WAM data is then sent to a multi sensor tracker which combines all the surveillance information and outputs a composite picture displayed to the controller and fed to the safety nets. Surveillance data from WAM appears the same way as secondary surveillance data on the Controller Working Position.

What are the benefits of implementing WAM?

The advantages brought by WAM vary depending on the operating environment. ANS of the Czech Republic and Austro Control observed a number of improvements following the implementation of their new surveillance systems. WAM enables surveillance coverage to be extended to areas traditionally regarded as difficult to reach, such as mountainous or remote regions. Ground stations use standard equipment which can be installed and certified relatively easily, and the system's distributed architecture enables the WAM network to be quickly expanded by integrating new stations. Since WAM data is merged into the secondary surveillance feed, the controller sees the same surveillance symbol on their screen regardless of the surveillance source being used. There is therefore little impact on the controller, which in turns leads to a quick adoption in the ops room.

WAM can improve the quality of surveillance picture over traditional radar, especially with regards to update rates. Typically, 1 second update rates can be achieved compared to 4 seconds for SSR, although this does depend on how WAM data is integrated with other surveillance data in the tracking system.

WAM also adds another layer of surveillance. It can operate independently of primary and secondary radars by configuring its ground stations as active interrogators. As such, WAM can still provide surveillance data in case of PSR and SSR failures. Installing WAM can also lead to cost reductions, as explained further by Wolfgang Weidner from Austro Control: *"The overall goal of our WAM procurement is to significantly reduce the lifecycle cost for the provision of cooperative surveillance over the entire FIR while still maintaining required levels of reliability and performance. This is achieved by using WAM as a replacement for existing radars that provide the second layer of secondary surveillance but are approaching the end of their operational life".*

However, for the WAM installation to be successful, careful planning is required. Radek Prochazka from ANS of the Czech Republic comments: *"The ANSP should have clear expectations for their WAM system in terms of coverage and redundancy. It is essential to conduct a detailed coverage study at the beginning of the project as it drives the requirements in terms of equipment (and incidentally cost and safety). Considerations should be given to the monitoring and control systems too".*

How can WAM improve the effectiveness of SNETs?

There are also some potential benefits for safety nets. WAM's high update rate means that safety nets could potentially be fed with more up-to-date information compared to traditional surveillance systems. Aircraft turns and changes in speed are detected faster than when relying solely on PSR or SSR meaning that alerts can be calculated earlier, providing the controller with more time to resolve conflicts. In addition to the position and height of the aircraft, downlinked parameters such as selected altitude or ACAS RAs are also provided quicker.

The impact of WAM on safety nets will vary depending on the local installation, as mentioned above, particularly on how WAM and other surveillance sources are integrated

Wide Area Multilateration

continued

in the tracking system. As Wolfgang notes: *"We observed that in some cases safety nets alerts (such as STCA, MSAW, etc.) are triggered a little bit earlier due to the 1 second update rate of WAM. This effect becomes smaller in areas with double or triple SSR coverage."*

Are there specific challenges to consider when implementing WAM?

As with most new technology, deploying WAM can bring a number of challenges. Tuning can be effort-intensive depending on the operational environment within which the system is deployed. This calibration exercise is required to minimise unwanted surveillance errors such as track swaps, split tracks (when PSR/SSR sees one track, and WAM sees another track) and false tracks. From the perspective of safety nets, these can generate false alerts.

Additionally, comprehensive verification and validation activities might be required to ensure all aspects of the WAM installation are thoroughly assessed. In Austro Control's case, these activities included amongst others: simulations and offline data analysis, technical and operational validation as well as a number of on-site performance evaluations including availability, transponder occupancy and system load extrapolation under real conditions. In total, more than 100 hours of test flights with different and specially equipped aircraft were performed and analysed.

What advice would you give to a fellow ANSP thinking about implementing WAM?

About Austro Control's experience, Wolfgang comments: *"Integrating the WAM feed with the rest of the surveillance data chain should be planned at an early stage of the project to ensure that the requirements of the WAM system are fully adapted to the operational and technical environment. This might help minimise and sometimes even bypass some of the limitations of the ATM system. Also, the integration of WAM can sometimes coincide with a change of technology or protocol in other areas of the ATM system, for example surveillance data distribution, to enable or facilitate the usage of the WAM data. Close attention should be paid to such situations as it certainly adds complexity to the integration process."*

From ANS of the Czech Republic's perspective, Radek adds: *"Do not underestimate the effort required in tuning the WAM installation to reduce unwanted side-effects and minimise false alerts. System tuning is an on-going process, relying on specific activities such as radar quality assessment and air situation picture evaluation to continuously improve the tracker performance."*

WAM installations at ANS of the Czech Republic and Austro Control

ANS of the Czech Republic first implemented a WAM system at Ostrava in 2001. This installation was later complemented by two other deployments with overlapping coverage (centred on Prague and Brno) providing full WAM coverage countrywide.

Austro Control's first WAM system was implemented in 2003 to cover the airspace around Innsbruck which was not covered by SSRs. The Austrian WAM (AWAM) system is composed of nine independent horizontal and vertical "segments". The first AWAM segment was brought into operation in December 2013 and covers the Austrian FIR from FL285 and above. The second and third segments were deployed in March 2015 and covered the same area as the first AWAM segment but from FL125. The fourth segment focused on the Salzburg TMA and was implemented in December 2015. All AWAM segments will be operational by October 2016. Austro Control has recently launched further projects to expand the already successful AWAM system.

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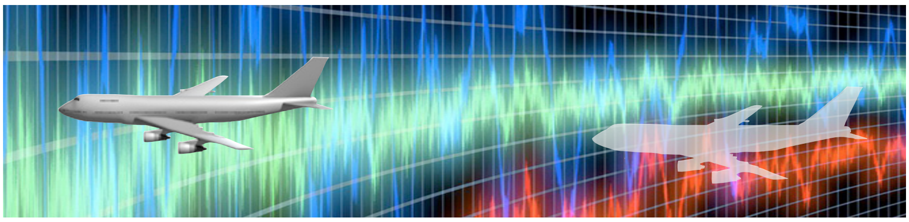
Austro Control

More on WAM:
http://www.skybrary.aero/index.php/Wide_Area_Multilateration

Over-interrogation draws a blank



ANSPs implement several layers of surveillance coverage to ensure critical information is always available, for example by deploying WAM in areas previously regarded as too challenging to reach. But are additional surveillance sensors or more frequent interrogation of aircraft always a good idea? Of course they are…. Or are they?

This article discusses events that took place over two days in 2014 over Central Europe, which led to a degradation or sudden disappearance of some aircraft tracks from controllers' screens. The incident illustrates the impact of our increasing reliance on aircraft transponders, the growing issue of over-interrogation and highlights some measures that could be adopted to ensure that surveillance remains sustainable for all ATM stakeholders.

Over-interrogation draws a blank

continued

The incident

On 5th and 10th of June 2014, some central European ANSPs experienced several occurrences of loss of surveillance data from their ATC displays for a sub-set of aircraft under their control. Not all surveillance data of aircraft flying in the affected sectors were lost, but controllers experienced both total and partial loss of surveillance tracks. While most occurrences only lasted a few minutes, some losses persisted for up to 20 minutes. The incident forced the implementation of traffic flow measures, reducing the airspace capacity and generating delays.

Over-interrogation in the spotlight

An investigation conducted by EASA, EUROCONTROL and ANSPs determined that the affected flights suffered from transponder over-interrogation on the 1030 MHz frequency. Transponders need a certain amount of time to reply to interrogations from surveillance systems such as secondary radars, WAM or indeed ACAS. If subjected to too many interrogations, some transponders shut down intermittently or totally to prevent the hardware from overheating.

EASA concluded that the incident was probably caused by a ground system being tested or configured in an unusual operational mode, which over-interrogated all transponders in the vicinity. This phenomenon affected two specific transponders types in particular, each with different failure modes.

Impact on the controller and safety nets

The total and partial loss of some surveillance tracks had a significant impact on controllers and the systems supporting them. For example, some safety nets (such as STCA and ACAS) were no longer available for the affected flights. Losses of flight plan correlation also contributed to a reduction of the safety margins and an increase in workload for the controllers.

Managing the demands on transponders

The EASA report highlights an eye opening fact: "in the affected area the normal level of interrogations on the 1030 MHz channel uses 80% of required transponder capabilities (considering as a basis the capabilities required by the Minimum Operational Performance Standards)". According to the said Standards, transponders should be able to produce 50 Mode S replies per second. This gives some perspective on how often the equipment is solicited.

Over-interrogation is a key issue, and it goes hand-in-hand with frequency spectrum management. An over-interrogation not only consumes 1030 MHz spectrum and transponder occupancy. It also results in excessive utilisation of the 1090 MHz spectrum as replies are emitted on that frequency band. Ground systems may struggle to extract the signal from this noisy environment, leading to a lowering of detection levels. To compensate for this reduction in performance, ANSPs may be tempted to increase the interrogation rate, hence contributing to this vicious circle. Also, interrogations do not respect national boundaries and can contribute to excessive use of radio spectrum many hundreds of miles away. It is therefore in the interest of the whole ATM community to use this valuable resource carefully.

These issues are reflected in the report recommendations. The safety improvements brought by the proliferation of surveillance applications need to be balanced against the increasing pressure they put on transponders. ANSPs and regulators should consider over-interrogation when deploying new surveillance systems, as this issue could have significant repercussions on controllers and safety nets.

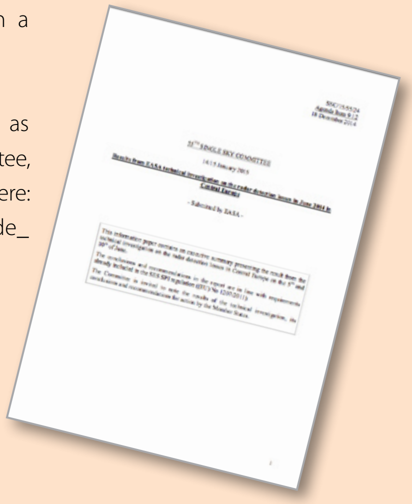
Recommendations

EASA made a number of recommendations to prevent similar incidents from occurring. They are summarised below.

Member States are responsible for the protection of the radio spectrum assigned to aviation, as identified in the SPI Implementing Rule (EU1207/2011 and amendments). As such, they should decrease the amount of interrogations in their airspace originating from ground systems. Additionally, mechanisms should be implemented to monitor and record the usage of the 1030/1090 MHz frequency band. This is to ensure that interrogations remain well within the transponders Minimum Operational Performance Standards.

Emphasis is given to Functional Airspace Blocks and cross-border co-operations, where efforts to minimise the amount of transponder interrogations should be coordinated. Finally, as with every safety occurrence, Member States should notify EASA and the European Commission in a timely manner.

The results of the EASA investigation, as presented at the 55th Single Sky Committee, are available by clicking on the document here: (http://www.skybrary.aero/index.php/Wide_Area_Multilateration)



2016 Safety Forum - Active Safety Nets

Invitation

You are cordially invited to join fellow aviation professionals at the **4th Annual Safety Forum** which takes place at EUROCONTROL's headquarters on the afternoon of 7 June and the morning of 8 June 2016. This edition of the Safety Forum explores Active Safety Nets to see how their collective effects can support global safety improvement.

Over 250 front line professionals and those who train and manage them will be able to hear presentations and view posters from the perspective of both the pilot and the controller on ground and airborne Safety Nets covering:

- **Airborne Collision**
- **Ground Collision**
- **Controlled Flight into Terrain (CFIT)**
- **Runway Excursion**

The aim is to improve understanding of Safety Nets and to identify realistic short-term safety improvement goals to increase their effectiveness, both generally and at system level. Ways to enhance the collective effect of Safety Nets which address the same risk will be of particular interest and the final deliverable will be a conference report documenting the findings and conclusions.

Attendance at the Safety Forum is free of charge and you will benefit from detailed, tailored safety knowledge and intelligence.

Click here to **REGISTER** now to reserve your place.
(http://www.eurocontrol.int/2016-safety-nets-forum-registration)

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