EUROCONTROL

NET*ALERT* - the Safety Nets newsletter

August 2019 | N°25

WELCOME

Since October 2007, NET*ALERT* newsletters have reported on the latest developments and success stories from the world of safety nets. We have had many contributors in that time, from ANSPs to industry representatives, advisory bodies and colleagues in EUROCONTROL. Our thanks to them all! As NET*ALERT* looks to take a well-deserved break, this special issue recalls the main themes covered since the very first newsletter, and provides some useful reference material on the back page.

We start our journey with a few words to remind us of the need for safety nets and reflect on the achievements of the past 20 years. We move on to provide information on ground-based, airborne and airport safety nets, discussing their purpose and evolution, as well as some key elements to consider in their implementation and use. No recap would be complete without covering best practices to follow for the successful deployment of safety nets, and the impact the surveillance infrastructure can have on the day-to-day work of the controller. Our final article explores some of the challenges that safety nets are facing and what can be done to address them.

At the end of the newsletter you will find further reading references as well as a summary grid mapping the main topics explored in other NET*ALERT*s.

Last lines of defence - Safety nets success

Tony Licu

Tony Licu is the Head of Safety Unit within the Network Manager (NM) Directorate of EUROCONTROL. He is responsible for overseeing ground and airborne safety nets activities as well as the Safety Nets: Planning Implementation & eNhancements (SPIN) Sub-group. Here he reminds us where safety nets have come from and why they still matter.

As NETALERT looks to take a break, we review the progress achieved in implementing safety nets across Europe over the last two decades and compile a repository of information and useful links.

Q: What progress has been achieved in Europe with regards to safety nets over the last 20 years?

In 2004 and 2005, a set of EUROCONTROL surveys found different levels of maturity between European ANSPs regarding the adoption and use of ground-based safety nets. To address this, the SPIN Task Force was created in early 2005, initially assigned with developing standards and guidance material for STCA, MSAW, APM and APW. The Task Force was a true community effort, involving operational, technical and safety experts from numerous ANSPs, industry representatives, professional associations and EUROCONTROL.

These standards and guidance documents were successfully created and updated to accommodate the latest technological advances, like the use of Mode S downlink parameters. On top of that, SPIN identified other important topics to address, such as: best practices for STCA implementation and tuning, TCAS/STCA interaction issues, classification between safety nets and ATC tools and crucially, the need to carry on sharing best practices. Recognising these activities required sustained efforts, the Task Force became a Sub-group and the work continued.

In 2010 another survey was undertaken to measure progress and identify priorities. Workshops took place in control centres around Europe to spread the message about safety nets and to stay in touch with operational reality. Since its inception, SPIN has proved to be a very effective forum for developing a deep understanding of safety nets.

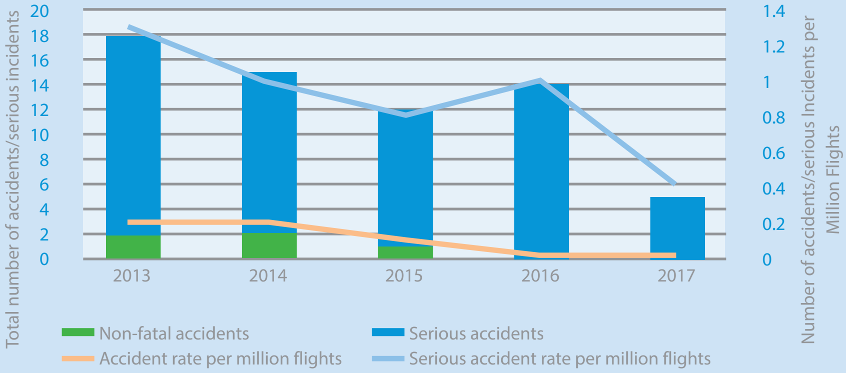
Last lines of defence – Safety nets success

continued

Safety nets improve ATM safety

Runway and airborne collisions are widely regarded as the highest risks in ATM. EASA's Annual safety review conducted in 2018[1] shows that accidents and incidents where ATM/ANS was a contributing factor have steadily declined, with no fatal accidents recorded in EASA Member States between 2013 and 2017. The rates of non-fatal and serious incidents linked to ATM/ANS is illustrated in the graph.

A spike in reported serious incidents took place in 2016. That year, EUROCONTROL's Safety Regulation Committee (SRC) identified 'TCAS Resolution Advisory (RA) not followed' as an emerging risk, evidencing the relationship between safety and proper safety net usage. Read the key findings of the NM's Operational Safety Study on the emerging risk in the SRC's Annual Safety Report 2017.



Q: Given the developments in ATM systems, are safety nets still relevant today?

Without a safety net alert, hazardous situations can remain undetected by the controller and pilots. Safety nets provide an extra safety margin and deliver a risk reduction of up to a factor of ten if implemented and operated appropriately. These days they form an integral part of the ATM system, so much so that they can sometimes be taken for granted. We know that as the operating environment evolves, safety nets need to be continuously improved to remain effective and this needs ongoing commitment from all levels of staff.

Q: What are the next big challenges … and how do we address them?

The next big challenges are how we adapt and improve safety nets to accommodate RPAS (drones) and how we ensure that, with the growing digitisation of ATM, cyber security is addressed. In addition, as automation changes the role of the controller and new safety net features are implemented, the controller will need increased support to ensure they continue to control aircraft safely and efficiently. These are big topics that will take some time to mature. There are however solutions and guidance documents available to help tackle some of these challenges and ensure that they do not continue to pose significant threats to ATM into the future. The remainder of this NET*ALERT* explores some of them.

[1]Chapter 7.2: Safety risk portfolio of the ATM/ANS domain, EASA Annual safety review 2018

Ground-based safety nets – Evolution not revolution

SPIN initiated significant improvements in ground-based safety nets over the past two decades. In this article we explore the evolution and current status of the four main ground-based safety nets. See the back page for signposting on further reading.

STCA (Short Term Conflict Alert)

STCA assists the controller in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima. It relies on radar data to predict the likely position of aircraft in the near future, typically alerting 90 to 120 seconds ahead of the closest point of approach.

STCA algorithms have evolved over the years to reduce nuisance alerts. The introduction of multi-hypothesis, which is about predicting the most likely trajectory of an aircraft but not ignoring the possibility of other trajectories being followed, allows the use of Cleared Flight Level (CFL) to reduce the number of alerts yet still gives some degree of level-bust protection. It enables the warning time to be optimised based on the most likely flight trajectory. However, implementing multi-hypothesis

A reminder of the difference between ATC tools and ground-based safety nets

ATC tools	Ground based safety nets
Designed and used to **increase the overall performance** of ATC (often by providing a capacity, efficiency and safety benefits).	Exclusively used to **increase safety** (by adding system safety defences; a single failure should never cause an incident).
Designed and proven to be dependable (as they are **intended or accepted to alter the way of working of the controller**).	Designed for maximum effectiveness during hazardous situations and proven to have no impact on normal operations (as they are **not intended or accepted to alter the way of working of the controller**).

Ground-based safety nets – Evolution not revolution

continued

Nuisance alerts

Nuisance alerts are alerts which are correctly generated according to the safety net rule set but are considered operationally inappropriate. A number of common types of nuisance alerts exist:

- Obnoxious alerts - those that are louder, brighter and/or longer than necessary.
- Alerts which are not representative of a real situation (e.g. due to surveillance errors).
- Alerts which only involve flights that are not of concern to ATC (e.g. military exercises, formation flights, mid-air refuelling).
- Alerts due to unknown RVSM status to which STCA applies an inappropriate vertical separation threshold.
- Alerts which may appear on the display too late to be useful or annunciate intermittently due to poor set-up/tuning.
- Alerts caused by aircraft converging rapidly (though still safely cleared).

is a very involved process which requires significant effort.

STCA tuning involves amending look-ahead times and alerting thresholds. Filtering also enables pre-defined types of operations to be disregarded. The evolution of STCA is well documented across NET*ALERT*s.

Possible improvements to STCA are under consideration across Europe. The TMA is a notoriously challenging environment for STCA to operate in as aircraft are closer to each other and do not necessarily follow published routes (e.g. due to vectoring). One solution is to reduce linear prediction parameters and to use standard turning prediction; ANSPs can implement prediction filters which 'know' traffic patterns and use the latest aircraft navigation abilities (such as RNP-AR).

The use of Downlinked Airborne Parameters (DAPs) is also still up for debate. DAPs can provide additional information to the controller or to the safety net algorithm. For example, in Maastricht Upper Area Control (MUAC) Center, when the Selected Flight Level DAP is outside the expected level band the aircraft is moving in, the STCA system will be triggered and will override the level the controller inserted.

MSAW (Minimum Safe Altitude Warning)

MSAW warns the controller about increased risk of controlled flight into terrain accidents (CFIT) by generating an alert of a potential or actual infringement of the required spacing to that airspace volume. Just as with STCA, MSAW can suffer from nuisance alerts. MSAW surfaces, which are polygons modelling the terrain around a particular airport or TMA, need to be shaped accurately to represent actual terrain. Certain types of operations can be filtered out and inhibition zones may also be set up. Multiple configurations for a given airport (processing areas, inhibition areas, glide slopes etc) can also be specified to account for different procedures and modes of operation. Generally, the desired configuration is activated by the shift supervisor.

The implementation of MSAW varies between ANSPs. Some providers have implemented enhanced features to support the controller in their decision making when responding to MSAW alerts. NAV CANADA for example displays terrain background contours, giving the controller an instant indication of the height of the relief in the area. Correlation with flight plans might also be available, where data such as arrival and departure information is used for more accurate alert calculation. For example, if a flight penetrates the inhibition volume of an airport, but its flight plan shows that it has not taken-off from or will not land at that airport, MSAW alerts for this aircraft will not be suppressed.

APM (Approach Path Monitor)

A typical APM system has an alerting threshold defined by a funnel shape; aircraft above or below the approach funnel produce an alert. This enables a more tailored polygon to be created, closely fitting the approach path.

Some ANSPs have deployed MSAW to alert for aircraft flying lower than a published approach path by defining a "staircase" of polygons. This aims to emulate APM, which warns the controller of an unsafe aircraft flight path during final approach. Although effective when tuned adequately, a dedicated APM performs better. It is also considered easier to set up and tune for the final approach segment than MSAW. It is consequently recommended to use APM, rather than tailoring MSAW for the final approach segment. MSAW and APM should not be seen in isolation; the boundary between the two systems should be tuned to achieve the best performance.

APW (Area Proximity Warning)

Area Proximity Warning warns the controller about the unauthorised penetration of protected airspace, hence indirectly preventing collision between aircraft. It aims to prevent pilots entering restricted areas or controlled airspace without clearances. APW is relatively easy to configure compared to other safety nets; for example, the airspace definitions needed in APW are much simpler than the terrain definitions needed in MSAW.

Airspace infringements are on the rise due to increasing airspace complexity and the introduction of new operations such as Flexible Use of Airspace (FUA). Sharing airspace flexibly is now seen as a major driver for unlocking additional capacity in European skies. APW can be linked to FUA to enable Free Route Airspace, allowing alerts to trigger only when a particular portion of airspace is active.

Level 3 documentation

EUROCONTROL's Level 3 documentation specifies minimum requirements and provides guidance for the definition, implementation, optimisation and operation of STCA, MSAW, APM and APW. Each document describes the safety net concept of operations and requirements (Part I), overall guidance for the various stages of the safety nets lifecycle (Part II), and a generic implementation example and detailed guidance for optimisation and testing of that safety net (Part III). Released in January 2017, it captures lessons learnt and recommendations on implementing safety nets, as well as the results from SESAR I.

Further reading:
EUROCONTROL Safety Nets Guide: https://www.skybrary.aero/bookshelf/books/2761.pdf

Airborne safety nets – Major change ahead

The development and implementation of Airborne Collision Avoidance System (ACAS) as a last line of defence against mid-air collisions has been well-documented. In this article we highlight some of the system's key developments and impacts on ATC.

Interactions between TCAS and STCA

A sometimes overlooked aspect of safety nets is the interaction between airborne and ground-based systems – in particular, the fact that TCAS may trigger before STCA. As pilots are expected to follow the TCAS Resolution Advisories (RAs), aircraft may deviate from the flight path expected by the controller. In some cases, pilots may not immediately report following a TCAS RA due to the workload associated with responding to the alert. However, hard and anecdotal evidence indicates that pilots sometimes do not comply with TCAS RAs. EUROCONTROL and IATA have developed Guidance Material on the assessment of pilot compliance to TCAS RAs using Flight Data Monitoring to raise awareness on this issue (see "Further reading" below). Some aircraft manufacturers have developed systems to support pilots. Airbus' AP/FD system is a guidance mode which allows the aircraft to automatically fly RAs if the autopilot is engaged. Another Airbus' solution - TCAP - decreases the aircraft vertical rate towards the selected altitude once a Traffic Advisory has been generated and the autopilot is engaged. This helps prevent the generation of RAs in the 1000-foot level-off geometries.

Terminology

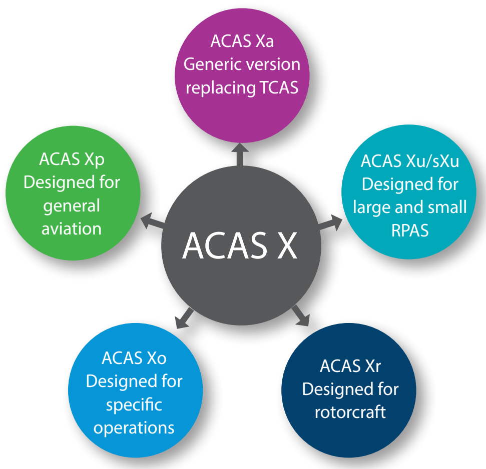
We tend to refer to ACAS when talking about the ICAO concept, whereas TCAS II (Traffic Collision Avoidance System) and ACAS X are specific implementations of ACAS. Although they are different systems, TCAS II and ACAS X are both designed to meet the same ICAO SARPS, but against their own specific minimum equipment standards (MOPS). It should be noted the SARPS for ACAS X are still in development.

ACAS X

ACAS X is a FAA-funded research and development program targeting a new approach to airborne collision avoidance. The approach takes advantage of recent advances in computational techniques to generate optimised RAs. Although primarily intended to provide improved alerting performance, it is also hoped that this approach will help reduce upgrade timescales and costs by being compatible with any surveillance source. This concept is called 'plug-and-play surveillance'.

The other key differences between TCAS II and the current concept for ACAS X is the collision avoidance logic. Instead of using a set of hard-coded rules, ACAS X alerting logic is based upon a numeric lookup table optimised with respect to a probabilistic model of the airspace and a set of safety and operational considerations.

ACAS X is expected to be adaptable to future operational concepts, to reduce collision risk and alert rate, and to extend collision avoidance protection to situations and user classes that currently do not benefit from TCAS (such as General Aviation). Five versions are in development:

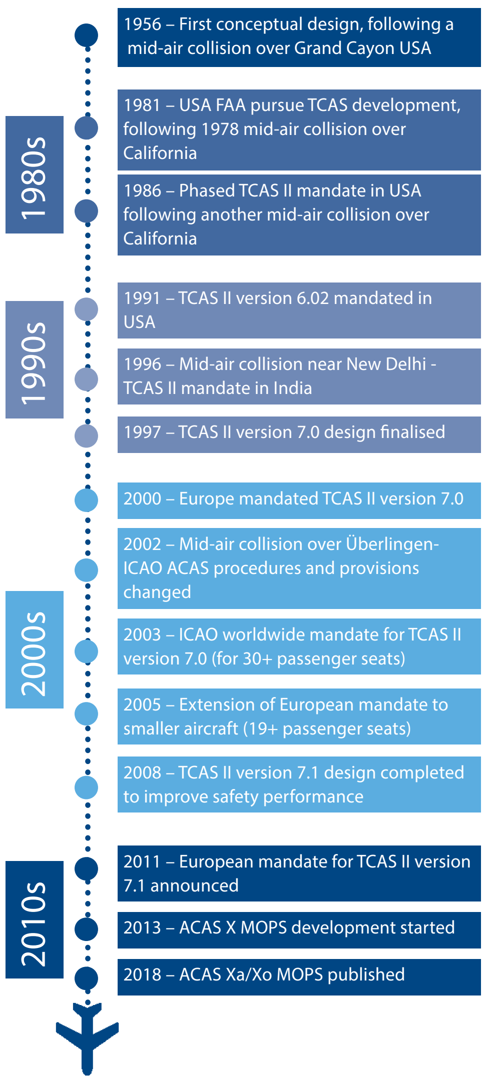


Encounter modelling

ACAS X relies on encounter modelling for its optimisation and tuning. Encounter modelling allows developers of safety nets to generate a large number of artificial, but realistic encounters, which are rarely observed in normal operations. The safety net can then be subjected to these encounters in exercises called fast-time simulations. They allow developers to predict how the safety net will perform in real operational scenarios, within a practical timeframe.

In Europe the CAFÉ (Collision Avoidance Fast time Evaluator) project is a simulation platform aiming to evaluate ACAS X's performance by simulating one trillion flight hours' worth of close encounter data. CAFÉ is building encounter models for each partner ANSP's airspace and then combining them into a single, unified, European model to run a set of validation exercises.

ACAS development and implementation timeline



Further reading:

ACAS Guide: https://www.skybrary.aero/bookshelf/books/106.pdf
Guidance Material on the assessment of pilot compliance to TCAS RAs: https://www.skybrary.aero/bookshelf/books/4507.PDF
Hindsight 6: APFD http://www.skybrary.aero/bookshelf/books/90.pdf
Hindsight 12: TCAP http://www.skybrary.aero/bookshelf/books/1417.pdf

Airport safety nets – Preventing runway incursions

Airport safety nets are increasingly valuable at busy aerodromes with complex movement areas. A whole host of systems exist to prevent incursions, but the main safety nets today are A-SMGCS and variations on runway safety lighting.

A-SMGCS

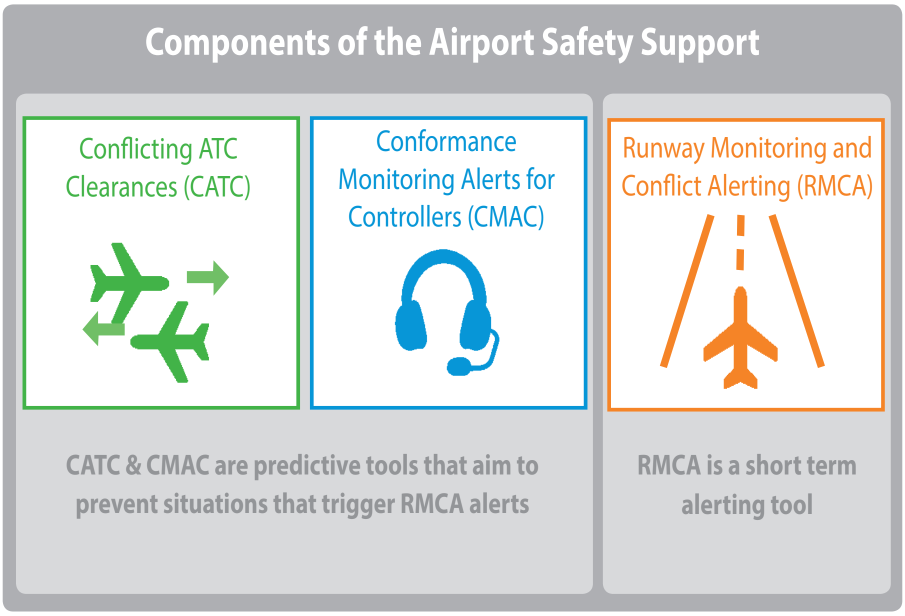
A-SMGCS (Advanced Surface Movement Guidance & Control System) is a modular system consisting of different functionalities to support the safe, orderly and expeditious movement of aircraft and vehicles on aerodromes, irrespective of traffic density, aerodrome layout, visibility conditions, or line-of-sight between the controller and aircraft/vehicles.

In March 2018, EUROCONTROL issued its first specification for A-SMGCS. Rather than using the ICAO 'Levels' categories, it adopts a complementary 'functional' categorisation approach. It incorporates the experience gained from the European implementation of A-SMGCS Surveillance and Runway Monitoring and Conflict Alerting (RMCA) Services and includes the new Services (Airport Safety Support, Routing and Guidance) that have been subject to validation in the SESAR programme.

Airport Safety Support Service

Perhaps the most relevant part of the A-SMGCS specification for NET*ALERT* readers is the Airport Safety Support Service. This contributes to airside operations as a safety improvement, enabling controllers to prevent hazards or incidents resulting from controller, flight crew or vehicle driver operational errors or deviations. It depends on the Surveillance Service in operation and supports the controller by: anticipating potential conflicts; detecting conflicts and incursions; and, detecting mobiles that are not following given clearances and providing alerts.

For the CATC and CMAC alerts to function correctly the system needs to know the controller's clearances. The controller must therefore be provided with an Electronic Clearance Input means e.g. Electronic Flight Strips (EFS). Some of the CMAC alerts work on the assumption that every mobile entering the Runway Protected Area or Restricted Area must have received a clearance from the controller.




Runway Status Lights (RWSL)

RWSL is a fully automatic, advisory safety system designed to reduce the number and severity of runway incursions while not interfering with airport operations. The concept was developed by Lincoln Laboratory in the US in response to FAA research that indicated the majority of runway incursions are attributed to pilot deviations. The lighting system visually warns pilots and vehicle drivers of potential conflicts with traffic already on the runway. RWSL has been implemented in several US airports. In Europe, the system is in use at Paris Charles De Gaulle and was trialled at Zurich in 2013. Zurich airport decided not to follow through with implementation, largely due to the lack of European standards at the time, and difficulties in tuning the system to take into account airport complexity.

Contribution of SESAR

It's worth noting that SESAR member ENAV has been testing dynamic virtual block control lights at Milan Malpensa as part of the Integrated Surface Management project. Initial results demonstrated the operational feasibility of the concept and controllers' tools, showing a positive impact on safety, resilience and predictability of surface operations.

Another SESAR solution in the pipeline is 'Enhanced Airport Safety Nets for Controllers' (PJ.03b-01/Release 2019), further details of which can be found in the link to the below.

Further reading:

EUROCONTROL Specification for A-SMGCS Services (No.171) – Version 1.0 - 1 March 2018: https://www.eurocontrol.int/publication/eurocontrol-specification-smgcs-services
SESAR testing of dynamic approach taxiway traffic lights – 20 Feb 2019 : https://www.sesarju.eu/news/sesar-tests-dynamic-approach-taxiway-traffic-lights
SESAR solution on 'Enhanced Airport Safety Nets for Controllers' (PJ.03b-01/Release 2019) : https://www.sesarju.eu/sesar-solutions/enhanced-airport-safety-nets-controllers
Description of RWSL: https://www.skybrary.aero/index.php/Runway_Status_Lights_(RWSL)

Safety net implementation – Consolidating good practices

What are the key principles for ANSPs to bear in mind when defining, developing, deploying and improving their safety nets? Here is a recap of what we've learnt over the years across editions of NETALERTs.

A well-defined framework

A research study sponsored by the EUROCONTROL Experimental Centre into MSAW implementations observed several different system development approaches across ANSPs, each with different degrees of success. ANSPs who were closely involved in the definition and implementation of their safety nets (e.g. through a combination of in-house R&D and co-development with a manufacturer) fared better than those who mainly relied on the manufacturer. ANSPs that demonstrated a proactive attitude towards safety nets and their continuous improvement, founded in a mature safety culture, ultimately implemented the most effective safety nets.

The pitfalls

The study identified three key areas where problems can occur:

1 **Viewing the implementation of safety nets as being solely about the execution of a plan.**

2 **Leaving implementation entirely to the manufacturer reflects the manufacturer' understanding of the local environment rather than that of the ANSP, and limits skills transfer.**

3 **Underestimating the complexity of safety nets and the amount of involvement required from the controller.**

Organisational clarity

Improving safety nets is a team effort, which involves balancing operational needs with safety considerations and engineering constraints. Safety nets require sustained commitment from the entire organisation, involving staff from the ops room all the way through to senior management.

A permanent and multidisciplinary team responsible for continuous monitoring and tuning of safety net is important. This team usually includes a safety net lead, who can interact with senior management and act as a focal point for expertise within the ANSP. In addition, specialised engineers are typically required, each responsible for one or a group of safety nets. The engineers have the skills to create and operate the equipment needed to monitor safety nets performance and parameterise them, such as test beds or analytical and replay tools. Controller input is also vital. A controller-centric perspective not only minimises the occurrence of nuisance alerts, but also helps to ensure safety nets acceptance in the ops room.

Clear procedures

Safety nets should be supported by a set of procedures explaining how they should be used and maintained. These also form the basis for training activities.

Operational procedures detail which types of flights the safety net takes into account to generate alerts, which volumes of airspace are covered, how alerts are displayed, what parameters are used to trigger alerts and expected warning times, as well as inhibition conditions. They should also explain how the controller is expected to react when an alert is generated.

Similarly, technical procedures, for example detailing the processes for periodic maintenance or the analysis of safety net performance, should be available. Here, procedures can be based on available standards and guidelines to ensure best engineering practices are implemented.

It is worth noting that both types of procedure interact with each other. Operational procedures are adapted based on the performance of the system while technical procedures rely on operational data to drive technical changes.

Focussed training

Training is essential to ensure controllers and engineers understand the role and behaviour of safety nets. It helps them define the purpose of safety nets in both operational and safety contexts, generate trust in the system, and deal with:

- The high-level principles of safety net performance (limitations and deficiencies – nuisance alerts in particular).
- Applying appropriate operational procedures dependent on the operational context.
- ATC contingency procedures, which may require role playing, workshops, or real-time simulations.
- Link with the Safety Management System and ability to debrief incidents and identify improvements.

Continuous improvement

No system is perfect all of the time, or indefinitely. To keep pace with operational changes like air traffic growth, airspace changes and practical experience, safety nets should be continuously improved. Here, the advice is to revisit the safety net lifecycle:

Safety Net Lifecycle

Ops room → Senior management		
	Training	Controller training
		Controller input on safety nets
	Operational expertise	Dedicated safety nets team
	Safety nets expertise	Specific safety nets expertise
	Collaboration	Collaboration with manufacturer
		Commitment to test practise
	Commitment	Commitment to continuous improvement in safety nets performance

Safety net implementation

– Consolidating good practices

continued

Typical improvements

With an adequate testing environment, it is possible to use offline recordings and replays, log files, simulations and test beds to evaluate performance and identify hotspots for nuisance alerts. Tuning can then take place to eliminate hot spots and improve performance. Controller surveys are another useful tool for identifying issues and improvements, as well as data monitoring tools such as Automatic Safety

Further reading:
Safety net Guide: https://www.skybrary.aero/bookshelf/books/2761.pdf

Safety net procurement

Before procuring, start by defining operational requirements:

Functional requirements

- Capabilities or features of the system e.g. prediction methods, use of CFL, RVSM requirements etc)
- System capacities (e.g. number of regions)
- Requirements on environment data (bothon-line and off-line, e.g. STCA parameters)
- HMI requirements (as far as is relevant for the system)
- Data recording requirements
- Futureproofing

Non-functional requirements

- Usability requirements (e.g. visibility of alerts, ease of Cleared Flight Level input)
- Quality attributes (e.g. reliability, maintainability, supportability, testability, safety standards and availability requirements)
- Constraining factors imposed externally (e.g. cost, legislation, policy)
- Interoperability/interface requirements (e.g. physical, process, support and information interfaces to other capabilities/systems)

Talk to other users and ask the perspective of the system supplier to provide you with a detailed description of the safety nets algorithms and system capabilities. Involve your own experts and engineers in testing and optimisation. Manufacturer user groups do exist, so get in touch with as many as you can!

Technological enablers – Enabling safety nets to perform efficiently

Safety nets performance is highly dependent on the quality of the inputs provided by the surveillance infrastructure and the reliability of transponders. In this article, we explore what happens when technological enablers fail.

Surveillance infrastructure

The surveillance infrastructure plays a crucial part in efficient safety nets. Traditionally, surveillance has comprised primary (PSR) and secondary (SSR) radars. SSR is an active surveillance system which relies on aircraft transponders.

Transponders provide information about the aircraft identification and barometric altitude to the ATC system on the ground and to TCAS on other aircraft. As well as being carried by commercial aircraft, they are also used by some helicopters, military aircraft, General Aviation, gliders and drones. Some airside ground vehicles are also equipped with transponders. Mode S transponder equipage is now mandatory for flights conducted as IFR/GAT in many European States and also for VFR flights in some designated airspace. Mode S transponders transmit additional parameters, referred to as Downlink Aircraft Parameters (DAPs), and in particular, Selected Vertical Intent (often referred to as Selected Flight Level).

An extra layer of surveillance to complement radars can be provided by Wide Area Multilateration (WAM) or Automatic Dependent Surveillance Broadcast (ADS-B). These can provide more up-to-date information compared to PSR or SSR. Aircraft turns and changes in speed are detected faster, meaning that alerts can be calculated earlier, providing the controller with more time to resolve conflicts. Both systems rely on transponders.

False alerts due to surveillance issues

Surveillance shortfalls are known to create false alerts, impacting the reliability of safety nets. Mode A/C replies in particular are more prone to interferences such as garbling. Garbling is when several transponders reply at the same time, making their transmission difficult to decode. Mode S ''selective interrogation' pattern is more resistant to garble.

Split tracks, which in some cases can be caused by garbling, are occurrences of two surveillance tracks for only one aircraft. Other issues include track swaps, false tracks and uncorrelated tracks. Gaps in coverage and differences in update rates (which are a minimum of 4 seconds for SSR, versus 1 second ADS-B/WAM) may also lead to incorrect information being displayed on the CWP.

Ground-based safety nets need the aircraft position, altitude and identification to operate effectively. For the controller, reductions in the reliability of safety nets can lead to loss of situational awareness, reliance on procedural control/voice reporting and a severely reduced ability to assess collision avoidance manoeuvres.

Future changes

Changes in surveillance systems are anticipated in the coming years. The increased use of ADS-B in low density and remote regions is expected to provide most benefits in oceanic airspace where no surveillance coverage is available currently. There is also an impetus to increase the number of

Technological enablers

– Enabling safety nets to perform efficiently

continued

The impact on the controller when transponders fail

Transponder failures can potentially make aircraft invisible to ATC. It also renders safety nets, including those in the cockpit, ineffective. A transponder can fail in several ways, each with different impacts.

Total failure

If no message was received, no aircraft identification and altitude would be displayed at the controller working position (CWP). The aircraft's position, however, will be available if a PSR feed is available. The controller may have to re-correlate the flight plan manually with the surveillance target.

Other transponder failures

Transponder failures are not always total:

- An intermittent Mode C failure results in transponder-based altitude information lost from the CWP for short periods of time. This could lead to delayed, incorrect or prematurely terminated safety nets alerts, as well as nuisance alerts due to the ATM system assuming the aircraft is at all altitudes.

- The Mode S 24-bit address, which is used to uniquely identify each aircraft, could be duplicated. This could cause systems that do not exclusively use Mode A to confuse two aircraft operating with the same address in proximity to one another (e.g. within the same sector or adjoining sectors). This can result in missed TCAS alerts as intruders with the same Mode S address(es) as own are ignored by TCAS II. TCAS will show TAs but no consistent RAs. Ground-based safety nets may miss alerts due to the track never being initiated or dropped.

- A corrupted Mode A would result in incorrect information received at the CWP; this is primarily due to an erroneous input into the transponder, or the processing and transmission of the Mode A code by the transponder. This may lead to false safety nets alerts (e.g. due to split tracks or if the corrupt code is one not permitted in a certain airspace volume) as well as missed alerts (e.g. if the corrupt code is on a list of codes that do not alert against each other or a protected volume of airspace).

The behaviour of ground-based safety nets when such failures occur will vary depending upon the local configuration of the ATM system. There is currently no single mitigation to deal with these different forms of transponder failures.

transponder-equipped aircraft, for example by using low power, low cost transponders (e.g. for gliders).

Discussions are now taking place with regards to extending the applicability of Mode S Enhanced Surveillance (EHS) to increase the opportunities for rationalisation of the surveillance infrastructure on the ground. Gradual improvements in surveillance quality will increase the reliability of safety nets.

Further reading:

EUROCONTROL Top 5 ATM Operational Safety Priorities: https://www.skybrary.aero/index.php/EUROCONTROL_TOP_5_Operational_Safety_Priorities

Operational Safety Study by Eurocontrol and Helios- Risk of operation without a transponder or with a dysfunctional one:
https://www.skybrary.aero/bookshelf/books/3305.pdf
https://skybrary.aero/bookshelf/books/2837.pdf

Challenges ahead – An evolving environment

Safety net development is continuously progressing. Constant adaptations are required to keep pace with technological advances and new operational needs. This article looks at three of the biggest challenges ahead and how they are being tackled around the world.

1. RPAS

The rapid growth in the small RPAS market combined with a diverse user group brings a unique challenge to the aviation industry. Reports of RPAS causing delays to airports and hazards to aircraft are increasing. Education is crucial in raising the awareness of users, particularly regarding no-fly zones close to airports. In the meantime, safety nets must evolve to manage this ever changing challenge to the industry.

ACAS Xu/sXu, the versions of ACAS X dedicated to RPAS, are under development and aim to protect conventional aircraft against RPAS hazards. Flight trials have taken place in the US to support the continuing evolution of the threat logic (ACAS Xu will feature horizontal and vertical avoidance manoeuvres) and surveillance modules, allowing for new surveillance sources. Standards for ACAS Xu are expected to be published in 2020. Further details on these two variants of ACAS X are given in the diagram overleaf.

2. Cyber-security

Your safety net is not behaving as usual. Could it be hacked? Cyber-crime has always existed but is becoming a growing threat within the world of aviation. Identifying how cyber-attacks could happen and their

Note: Sensors for detecting non-cooperative aircraft may be equipped on either large or small UAS

impacts on ATM operations is key to reducing the likelihood and effect of a future attack.

The connected and global nature of ATM operations means identifying all threat vectors is extremely difficult. This is particularly pertinent since cyber-attacks tend to occur through the weakest link in a chain. The complexity of ATM systems, and the relatively limited levels of monitoring mean that a hacker can remain undetected. As digitalisation of ATM increases, the threat of a cyber-attack increases too. The uptake in the use of Commercial-Off-The-Shelf hardware and software components enables cyber-criminals to re-use general IT skills rather than needing bespoke or specialist knowledge, making ATM systems more vulnerable.

Many types of cyber-attacks could occur, from maliciously generating many false safety nets alerts, inhibiting alerts to reduce controller awareness of potential incidents, or data breaches. Whilst not a direct safety issue, a data breach could severely affect the reputation of an ANSP, and potentially result in a loss of income. Perhaps the most damaging effect of a cyber-attack would be an extended service outage. Before an ANSP could return to full service it would need to demonstrate that the 'infection' has been completely removed. This may be extremely difficult or even impossible to prove. However the ANSP would have to achieve a high level of confidence prior to returning to normal operations, which could be very time consuming.

What would you and your organisation do if you suspected a cyber-attack?

Some good practices to consider:

- Define a strategy to monitor operations in order to detect unusual situations;
- Have clear contingency procedures to maintain safety and isolate the threat;
- Develop a resilience plan to facilitate a quick and efficient return to normal service;
- Learn from the circumstances and contributing factors to the attack to improve training, procedure and systems resilience.

3. Change to the role of the controller

The close involvement of ANSP staff from both an operational and engineering perspective is crucial for the successful implementation of safety nets. This is becoming ever more important with ATC tools adding new warnings on top of existing safety net alerts.
Multiple alerts at once increase cognitive workload and can cause or exacerbate the phenomenon of inattentional blindness. Applying industry recommendations on HMI design can reduce the chance of this happening. This is particularly important as the role of the controller changes in the coming years with increased levels of automation. HMI design should allow an efficient presentation of information based on a set of defined functional capabilities. Tools should also be implemented to monitor cognitive workload, inattentional blindness and fatigue.

The ATM system may be able to filter or prioritise between alerts, hence regulating the information presented to the controller. Once the alerts have been generated, a controller must make a quick decision on how to act. To aid this, semantic acoustic alerts can replace the standard 'beep' alerts with a voice indicating which safety net is alerting. The Irish Aviation Authority has been pioneering their use and has reported positive feedback.

NETALERTs – Where to look for more info

GROUND-BASED SAFETY NETS:

Issue 2 Optimising STCA for military ATC
- STCA success at Maastricht
- APW specification: getting closer!

Issue 4 Best approach – MSAW or APM?

Issue 6 Terrain alert – check your altitude immediately (including case study on MSAW deployment by DSNA)
- MSAW – preventing accidents (including three case studies in Orly, Dublin & Yerevan)
- APW in actions: NATS Controlled Airspace Infringement Tool (CAIT)
- Major milestone achieved – Final specifications and guidance material released (for MSAW, APM and APW)

Issue 8 Tuning and monitoring – STCA in Switzerland

Issue 10 Safety nets – how will they aDAPt to the future?
- MSAW implementation in Canada
- Georgia steps closer to MSAW optimisation

Issue 11 Focus on safety nets in Malta
- Safety nets survey 2010

Issue 12 Short Term Conflict Alert in the TMA
- Survey follow up – Why has MSAW 'switched off'?

Issue 13 ANS Czech Republic – PROPHET approaches
- Nuisance alerts – more than just a numbers game
- Safety nets implementation - lessons learnt from research on MSAW

Issue 14 Operating STCA at airports outside of major TMAs
- Use of Mode S parameters at MUAC

Issue 15 STCA – cycle time in the spotlight
- Multi-hypothesis – predicting STCA alerts in the vertical dimension

Issue 16 MSAW proves its worth at Lyon

Issue 19 Transponders in aviation

Issue 22 'Level 3' documentation - still ensuring the effectiveness of safety nets

AIRBORNE SAFETY NETS:

Issue 1 STCA: Tool or Safety Net

Issue 8 Tuning and monitoring – STCA in Switzerland
- RA Downlink, will it come to a screen near you?

Issue 13 STCA and TCAS, compatible safety nets?
- TCAS II upgrade on its way

Issue 17 ACAS X – the future of airborne collision avoidance

Issue 23 Close encounters – an introduction to encounter modelling
- ACAS X update

Issue 24 ACAS Xa – moving forwards Investigating TCAS RAs

AIRPORT SAFETY NETS:

Issue 15 Runway safety nets – last line of defence on the airport surface

Issue 18 A-SMGCS – implementation in Switzerland
- Emergency runway safety nets – Runway Status Lights (RWSL)
- Zurich airport – RWSL trialled
- Runway incursion at Luxembourg
- SESAR airport projects

BEST PRACTICE:

Issue 4 Revisions proposed for safety nets training

Issue 6 Major milestone achieved – final specifications and guidance material released

Issue 9 More questions than answers? (Relating to Just Culture)
- Safety Net – FAQs online (for role of simulations and test beds in safety net tuning & recommended training)

Issue 12 STCA in the TMA (for safety net procurement)
- Buying new safety nets? Read on…

Issue 16 The importance of responding promptly
- Developing a safety net capability – from Ops room to senior management

TECHNOLOGICAL ENABLERS:

Issue 9 Dealing with split tracks in STCA

Issue 10 Safety nets – how will they aDAPt to the future? (for what happens when a transponder fails)

Issue 14 HMI: a vital factor in STCA effectiveness
- Use of Mode S parameters at MUAC

Issue 19 Transponders in aviation
- No transponder – what now?
- Flying without a transponder – 10 minutes is all it can take
- Transponder failure is not always total

Issue 21 Surveillance infrastructure – the backbone for safety nets
- Wide Area Multilateration
- Over-interrogation draws a blank

CHALLENGES:

Issue 14 HMI: a vital factor in STCA effectiveness

Issue 16 The importance of responding promptly

Issue 20 RPAS – expert interview
- RPAS and safety nets – a race against time
- RPAS detect and avoid

Small RPAS – a unique challenge

Issue 23 ACAS X update

QUICK REFERENCE GRID

ISSUE	STCA	MSAW	APM	APW	ACAS and RA	Airport SNETs	Implementation good practices	Tuning	Surveillance	Human SNET interaction	RPAS
1	✔	✔			✔						
2	✔			✔							
3	✔										
4		✔	✔				✔				
5					✔		✔				
6		✔		✔			✔				
7	✔		✔								
8					✔			✔			
9	✔			✔			✔				
10		✔							✔		
11	✔	✔									
12	✔	✔					✔				
13	✔	✔			✔					✔	
14	✔						✔				
15	✔					✔					
16		✔			✔		✔				
17					✔			✔			✔
18						✔					
19									✔		
20											✔
21								✔	✔		
22	✔	✔	✔	✔						✔	
23					✔						✔
24					✔						

Current and previous NETALERT issues can be accessed at: https://www.skybrary.aero/index.php/NetAlert_Newsletter_-_EUROCONTROL

Contact

Contact us by email:
safety-nets@eurocontrol.int

EUROCONTROL

www.eurocontrol.int