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EUROCONTROL

NET*ALERT* - the Safety Nets newsletter

WELCOME

There is no doubt that safety nets have proven their worth in ATC systems, but how can we make sure that they perform as expected? What methodology is being used? What is the aviation community doing to maximise their usefulness? These are some of the questions explored in this issue of NET*ALERT*.

We first look at encounter modelling, the methodology underlying most safety net testing done today. We reflect on the benefits it can bring and consider why it is being used increasingly often.

ACAS X, a new airborne collision avoidance system, is expected to be the next leap in airborne safety net technology. We give a quick update on the recent developments for each variant. We also hear from Chris Shaw, who manages the CAFÉ project, to understand the latest work EUROCONTROL is doing to validate its performance in Europe.

Next, we hear from Robert Guttman, the Chairman of T-SNUG. This group is a partnership between Thales and ANSP users of the TopSky ATM system to share experiences on the development and implementation of safety nets.

Finally, we bid farewell to a well-known contributor to the world of safety nets. Ben Bakker retired in July 2017, after over two decades working at EUROCONTROL.

Close encounters of a different kind – an introduction to encounter modelling

What would happen if Traffic Alert and Collision Avoidance System (TCAS) II was no longer fit for purpose? Well, we may be closer to this than you might think thanks to the changing ATM environment, and especially the exponential uptake of drones. ACAS X is being developed to improve on TCAS performance – but how can we ensure that it (or any other future safety net) will be effective? This is where encounter modelling comes in. Here we explain what it is and why it is gathering increasing momentum now.

What is encounter modelling?

Encounter modelling is an umbrella term for being able to model interactions (called encounters) between two or more aircraft in a realistic manner. Importantly for Air Traffic Management, it 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 reliably predict how the safety nets will perform in real operational scenarios, within a practical timeframe. Undertaking a similar exercise that relies on real radar data alone would be near impossible. Since only a handful of high-risk encounters may be recorded in a given year (if any), it would take several years to collect enough data.

CONTENTS

Close encounters of a different kind – an introduction to encounter modelling

Why is it important?

To continue to deliver safety benefits, safety nets must always be developed and adapted to the changing environment in which they operate. Today, this means addressing the growing popularity of unmanned aircraft systems (UAS) for commercial and recreational use, and developments brought by Single European Sky ATM Research (SESAR), such as trajectory-based operations and new separation modes. In the future, the increased adoption of new surveillance technologies by General Aviation users is likely to fuel the deployment of new safety nets.

Encounter modelling is accelerating the development of the next generation of safety nets by providing developers with the ability to rigorously test, measure and refine performance metrics such as the reduction in collision risk and the number and timing of alerts.

Why now?

Although the potential for encounter modelling to optimise safety nets performance has been well understood since the 1980s, its use has become more prevalent in the last 10 years. The main reason for this recent upsurge in activity comes from improvements in mathematical modelling techniques that are applied to encounter modelling.

These techniques (such as Bayesian networks) allow developers to capture encounter characteristics that are affected by one another. For example, airspace class and the altitude at which the aircraft is flying are interdependent. Not only do the 'rules of the air' differ in each class (thus affecting how the safety net might perform when tested), safety nets are also required to perform differently at different altitudes (e.g. TCAS does not issue resolution advisories for encounters occurring below 1000ft above ground level). Such complex relationships can now be modelled more accurately.

Recent advances in mathematical techniques have cleared the path for encounter modelling to become a standard technique in the field of safety net performance testing and optimisation.

A brief history of encounter modelling

1984
First encounter model developed to test TCAS II performance in the US operational environment

1998
ICAO publishes the results of its study on performance of ACAS II, which used encounter modelling methodology

2001
EUROCONTROL's ACASA (ACAS Analysis) project adapts the ICAO safety encounter model for use in support of the European ACAS mandate

2007
First European ATM encounter model developed as part of the I-AM-SAFE project

2010
EUROCONTROL's PASS (Performance and Safety aspects of STCA) project applies encounter modelling to evaluate the performance of STCA

2016
EUROCONTROL's CAFÉ (Collision Avoidance Fast-Time Evaluator) project begins, aiming to test the performance of ACAS X using the most advanced European encounter model to date
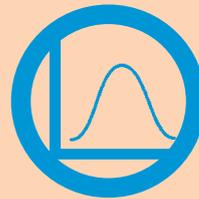
How does encounter modelling work?

Real radar data is the starting point. Recent data is used to ensure realistic traffic scenarios can be tested. It is filtered to **identify encounters** with the potential to trigger collision avoidance.

The **physical characteristics of encounters** (flight path geometries, aircraft speeds) **are extracted** from the data.

These characteristics are used to generate **millions of artificial, but realistic, encounter scenarios** between aircraft.

These artificial encounters are used in **fast-time simulations** to test and compare the performance of different safety nets.

An update on – ACAS X

ACAS X is expected to become the next generation airborne safety net, gradually replacing TCAS. Adapted to multiple operational scenarios, it relies on encounter modelling for its optimisation and tuning. Following the introduction to ACAS X provided in NETALERT 17 (June 2013), here we give an update on the latest developments for each variant.

Variant	Overview	Latest updates	Maturity
ACAS Xa	Generic variant of ACAS X that makes active interrogations to establish the range of intruders. It is the successor to TCAS II.	EUROCAE Working Group 75, in conjunction with RTCA Special Committee 147, are developing Minimum Operational Performance Standards (MOPS) for ACAS Xa. The final period of comment and consultation started in March 2018, with publication planned for the end of the year. Separately, EUROCONTROL will soon begin a European safety and operational acceptability study. Provided that it receives regulatory approval, ACAS Xa is expected to enter operations in 2020.	(green)
ACAS Xu	Designed for UAS.	ACAS Xu falls under the remit of the same standardisation groups as ACAS Xa. In Europe, the validation work is performed as part of SESAR PJ11 CAPITO. To date there have been flight trials in the US to support the continuing evolution of the threat logic (ACAS Xu will feature horizontal avoidance manoeuvres) and surveillance modules. The modelling that underpins this is used to inform the CAFÉ project and vice versa, as part of an iterative development cycle. Standards for ACAS Xu will be published in 2020.	(orange)
ACAS Xp	Intended for General Aviation, it relies solely on passive ADS-B to track intruders and does not make active interrogations.	Work has begun on integrating General Aviation performance into an encounter model. However, the current focus is to ensure that the models for ACAS Xa and ACAS Xu are sufficiently mature before progressing ACAS Xp further.	(red)
ACAS Xo	Designed for operations for which ACAS Xa is unsuitable and may generate an unacceptable number of nuisance alerts (e.g. procedures with reduced separation, such as closely spaced parallel approaches).	Work on ACAS Xo is being carried out in conjunction with ACAS Xa. It is specified in a joint standard with ACAS Xa.	(orange)

Maturity Level 🟩 - high 🟧 - medium 🟥 - low

No ordinary CAFÉ – a Europe-wide collaboration to test safety nets

Encounter modelling is becoming the primary technique to assess the performance of safety nets and enable their optimisation. In this article, Chris Shaw, Project Manager for EUROCONTROL's CAFÉ project, talks to us about the latest work being done in this field.

Q: What is CAFÉ?

A: CAFÉ stands for Collision Avoidance Fast-time Evaluator. Currently under development[1], it is a simulation platform designed to test the next generation airborne collision avoidance system, called ACAS X. Its goal is to evaluate ACAS X's performance by simulating approximately one trillion flight hours' worth of close encounter data. The impact on safety is assessed by comparing the simulated number of Near Mid-Air Collisions using ACAS X and the current TCAS II system, as well as comparing a number of other performance metrics including alert timing and separation at closest point of approach.

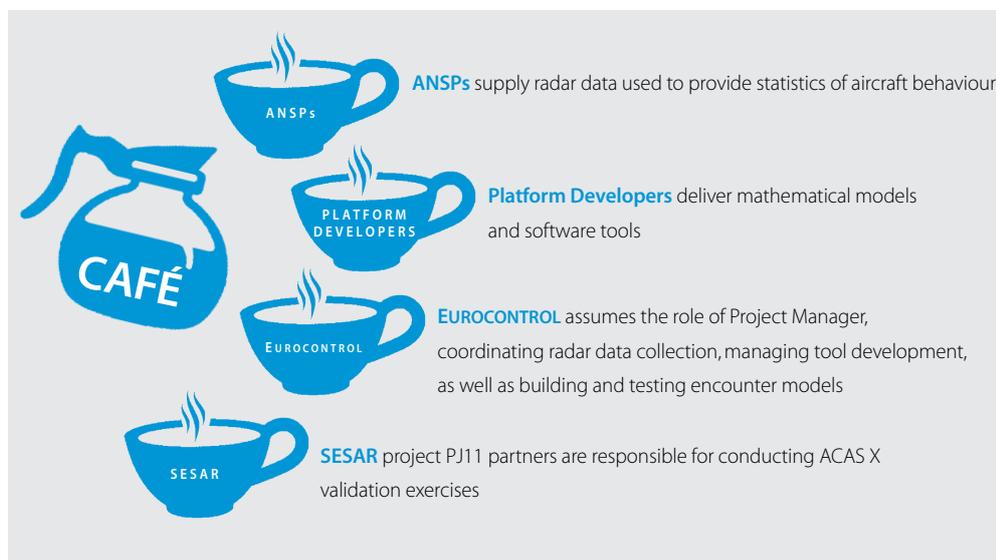> 🔍 **1,000,000,000,000 (One trillion hours!) of close encounter data**

Q: What is the project's aim?

A: Building on the foundations of the last European encounter model developed some 10 years ago, as well as more recent US models, CAFÉ aims to update and improve European models of how aircraft behave in very close encounters. It will achieve this through combining radar data from several European Air Navigation Service Providers (ANSPs) and state-of-the-art modelling techniques (Bayesian networks, see "Close encounters of a different kind", page 2). This should result in an encounter model that is representative of the European ATM environment, which is known to have different characteristics from the US, where ACAS X was being developed originally. In turn, this will enable ACAS X to be appropriately validated.

[1]CAFÉ developers are QinetiQ, Egis Avia, and Polytechnic University of Catalonia.

Q: Who is involved?

A: The project began in April 2016 and involves over 20 ATM stakeholders across Europe.

Q: How will simulation results be used?

A: For now, the output will be used to check that ACAS Xa will work safely and effectively in European airspaces. This is to ensure that controllers and pilots alike will have the confidence that ACAS Xa will perform as required when called upon in an increasingly complex ATM environment. In the future, further studies will aim to do the same for other variants of ACAS X, or any other collision avoidance systems that are developed.

> 🔍 **Validation of ACAS X in European airspace**

Q: What are the next steps?

A: The immediate future for CAFÉ is to build encounter models for each partner ANSP's airspace, combine them into a single, unified, European model and run a set of validation exercises. Multiple avenues will be explored after this. The project has ambitions to extend the scope of the model to include UAS behaviour by the end of 2018 and separation assurance aspects of Detect And Avoid (DAA) for ACAS Xu in 2019. Eventually, modelling interactions between different variants of ACAS X will be one of the main areas of interest for CAFÉ.

> 🔍 **Detect And Avoid for ACAS Xu in 2019**

Q: What are the key challenges?

A: The main difficulty in modelling UAS behaviour is the limited availability of real radar data. This is important as encounter sets that are evaluated in simulation should statistically represent all relevant airspaces and all subclasses of encounters considered important for safety or operational suitability. The model is being extended to incorporate expected UAS behaviour such as flying from point-to-point or loitering patterns typical of reconnaissance. The feasibility of extending CAFÉ to separation assurance aspects of DAA is currently being assessed, with findings due to be reported in the summer.

ANSPs supply radar data used to provide statistics of aircraft behaviour

Platform Developers deliver mathematical models and software tools

EUROCONTROL assumes the role of Project Manager, coordinating radar data collection, managing tool development, as well as building and testing encounter models

SESAR project PJ11 partners are responsible for conducting ACAS X validation exercises

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Chris Shaw

Chris is an ATM researcher with EUROCONTROL. His experience is in performance assessment of new concepts, and includes secondments to NASA on airborne separation assurance and QinetiQ on 4D trajectory-based flight management. Before EUROCONTROL, Chris worked for Smiths Aerospace producing avionics for airliners and helicopters.

Cosying up to T-SNUG – a new group for TopSky safety nets

January 2017 saw the founding of a new group aiming to support the development and implementation of safety nets for Thales' TopSky ATM system. In this article, Robert Guttman, T-SNUG Chairman, summarises the participants' views on the group's purpose, its achievements and plans for the future.

Q: What is T-SNUG?
A: The TopSky Safety Nets User Group (T-SNUG) is a product-specific forum for users of the TopSky Safety Nets (T-SN) suite. It supports a harmonised approach to the development of T-SN, recognising that most European ANSPs have comparable operational requirements and therefore need safety nets offering similar features.

T-SNUG is a collaboration between several ANSPs and Thales as the manufacturer. It is chaired by one of its ANSP members. Each meeting is usually hosted by an ANSP, supported by the manufacturer bringing technical expertise and to update the group on ongoing developments.

Q: Why is the group needed?
A: Generally, system manufacturers have to tailor their safety nets to the bespoke needs of each of their customers, resulting in having to maintain and test various software branches. New features need to be ported from one software branch to another, increasing the possibility for mistakes and costs.

This situation typically arises from the fact that customers may have non-harmonised or contradicting requirements. T-SNUG aims to prevent this from happening.

> **T-SNUG member says:**
> *"In the past the most recent customer had their features implemented in the latest version of T-SN. Other customers would potentially dislike some of these features, creating additional re-integration effort for them as well as the manufacturer."*

Q: What benefits do you expect T-SNUG to bring?
A: T-SNUG facilitates a harmonised approach
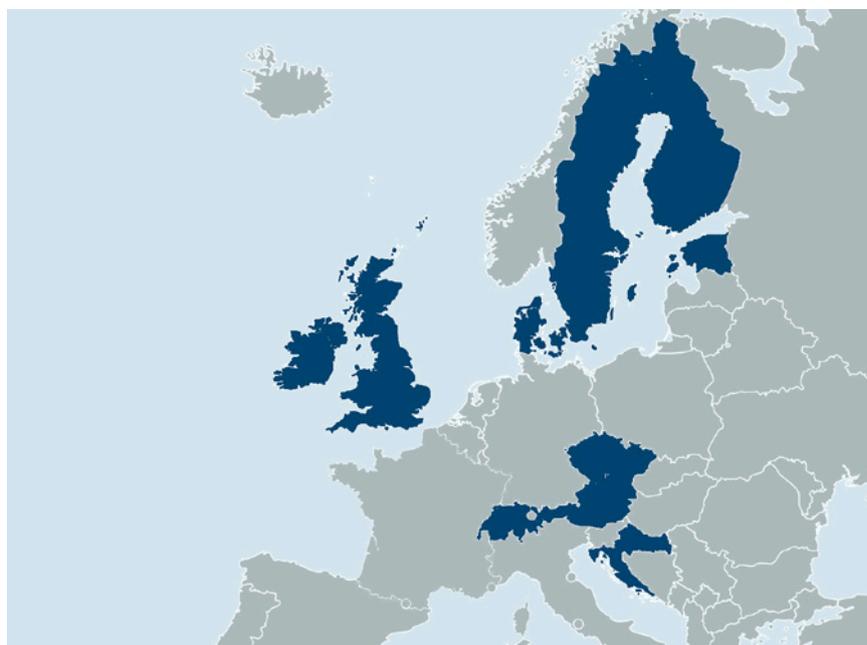
Map of all the T-SNUG ANSP members

to the product development of T-SN. Any user request for implementation of "contradicting requirements" will be identified and discussed within the group to resolve the issue, normally by making certain features customisable.

A harmonised approach enables users to benefit from each other's developments. At the same time the manufacturer only has to maintain one main software branch. Stakeholders can therefore focus on the development of new features rather than spending time resolving implementation issues.

> **T-SNUG member says:**
> *"Some users may be looking for a similar feature. By combining the effort and developing a customizable solution, users collaborate to make T-SN a better product."*

Q: Which stakeholders are involved?
A: To date, the stakeholders that have participated in T-SNUG are:

- ANS Czech Republic
- COOPANS (Austro Control, Croatia Control, Irish Aviation Authority, LFV, NAVIAIR)
- EANS
- EUROCONTROL (ASTERIX Management)
- Finavia
- NATS
- QinetiQ
- Skyguide
- Thales

Meetings happen face-to-face every 9 months. New participants are welcome.

> **T-SNUG member says:**
> *"I like the idea that others are using the same safety net as I, and they are finding bugs and having them corrected before I even can see them."*

Q: What progress has been made?
A: The group has so far contributed towards these safety net developments:

- Enhancement of ASTERIX CAT004. Following discussions at recent T-SNUG meetings, EUROCONTROL published an update the ASTERIX CAT004 standard in August 2017. This will enable T-SNUG partners and the wider aviation community to implement new safety net functions as well as extensions to existing functions.

- Enhancement to Short Term Conflict Alert (STCA) to use Verified Cleared Flight Level (VCFL). This allows STCA users that had avoided using the CFL due to the risk of erroneous CFL input to introduce a vertical limit for climbing/

Cosying up to T-SNUG – a new group for TopSky safety nets
continued

descending targets; this functionality is only used when the downlinked selected altitude (Final State Selected Altitude) matches the CFL.

Q: What are the next steps?
A: There are 3 key objectives in T-SNUG's immediate future:

1. Share experiences of using safety nets and discuss enhancements of existing functions.
2. Discuss ongoing safety nets development projects and future activities, to identify possible synergies between stakeholders.
3. Work towards the standardisation of interfaces.

Participants from left to right: Adam Brown (LFV, Sweden), Goran Ilic (CCL, Croatia), Peter Stadelmeyer, Robert Guttman (ACG, Austria), Jesper Smed Holmgard, Eric Gaardsted (NAVIAIR, Denmark), Alex Engel (EUROCONTROL) Jean-Philippe Shepherd (skyguide), Eric Landel (THALES, TopSky Safety Nets Component Manager), Radek Prochazka (ANS CZ), Olivier Seguin (THALES, Business Development), Rod Howell (Qinetiq), Angus McDougall (NATS, UK)

Ben Bakker – retires

At the end of July 2017, we bid farewell to EUROCONTROL Safety Nets expert and SPIN secretary Ben Bakker, who left to enjoy a well-earned retirement. Ben became involved in safety nets activities shortly after the 2002 Überlingen accident when swift action was needed to improve European network safety. He was instrumental in setting up the SPIN Task Force (subsequently sub-group) and remained secretary to the group right up to his retirement.

Ben's enthusiasm and dedication to improving European network safety resulted in the production and subsequent updates of key deliverables including EUROCONTROL Specifications and Guidance material for four ground-based safety nets.

A talented engineer, Ben also supported ANSPs in the implementation, tuning and effective operations of ground-based safety nets. Today's safety nets across Europe, from Scotland to Georgia and from Portugal to Poland, have been influenced by his pragmatism and expertise. Despite having an enormous influence on the safety of air traffic in Europe, he preferred to stay out of the limelight, quietly advancing his work, helping and mentoring his colleagues. We all wish him many trouble-free and sunny days on his retirement.

Contact

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ENSURING THE EFFECTIVENESS OF SAFETY NETS