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Communications, Navigation and Surveillance

At the heart of the future ATM system

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Contents

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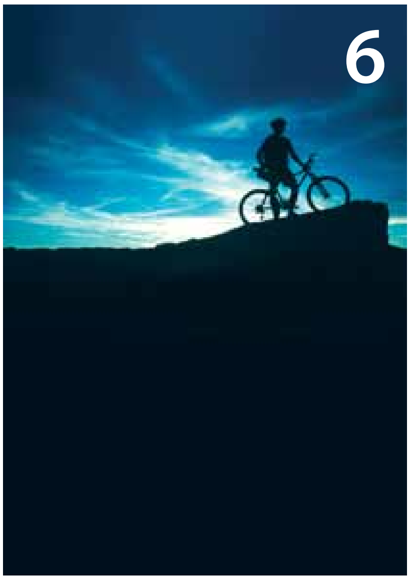

EDITORIAL

FOCUS

72

91

102

INTERVIEW

VIEWPOINT

CALENDAR

28


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Dear readers,

It is a great pleasure to introduce our Winter 2010 Skyway magazine which draws upon the expertise of not only EUROCONTROL, but also some of our key stakeholders – the European Commission, ESA, ICAO, the SESAR Joint Undertaking and, of course, industry partners. The focus for this issue is on a very technical subject which lies at the very heart of the future ATM system, communications, navigation and surveillance (CNS). As our first article points out, CNS is as vital to the aviation industry as a bicycle is to a cyclist.

Future operations, based on the SESAR three core principles of time, trajectory and performance, will transition aviation into a new frontier where efficiency, cost-effectiveness, safety and capacity are all enhanced. However, this vision can only be achieved through improved and interoperable CNS systems arrived at through common standards and specifications applied throughout Europe and eventually worldwide. This is a huge task involving all players within the aviation community and beyond.

EUROCONTROL, sitting as it does at the centre of this community in Europe, will naturally play a pivotal role in helping to set validated standards and ensure they are implemented in a harmonious fashion. Furthermore, our status as a founding member of the SESAR Joint Undertaking will enable the Agency to ensure full consistency and continuity between the numerous technological developments arising from the programme, particularly with regard to CNS systems.

To prepare ourselves for this role, the Agency has recently emerged from a radical and fundamental reorganisation – one that enables us to focus our efforts on helping to implement the Single European Sky. We have separated our regulatory support tasks from our service provision and created an organisation based on three main directorates – Single Sky, Network Management and SESAR & Research. In September, the EUROCONTROL Performance Review Commission was designated as the Performance Review Body, and, with the setting of the applicable performance targets, we are now ready to enter the first reference period which will run from 2012 to 2014. Next year will see EUROCONTROL refine and strengthen our ability to manage network operational activities as a means to help deliver the performance targets.

In commending this edition of Skyway to all our readers I would like to wish everyone the very best for 2011 – a year which promises to be very challenging but nonetheless interesting.

David McMillan,
Director General

Chers lecteurs,

J'ai le grand plaisir de vous présenter le numéro de l'hiver 2010 de notre magazine Skyway, qui fait fond sur l'expertise non seulement d'EUROCONTROL, mais aussi de certains de nos partenaires clés – la Commission européenne, l'ASE, l'OACI, l'Entreprise commune SESAR – et, bien sûr, de nos partenaires de l'industrie. Ce numéro porte plus particulièrement sur un sujet très technique qui se trouve au cœur du futur système ATM : les systèmes de communication, navigation et surveillance (CNS). Comme le souligne notre premier article, les CNS sont aussi indispensables au secteur aéronautique que le vélo au cycliste.

Les opérations futures, fondées sur les trois principes essentiels de SESAR que sont le temps, la trajectoire et la performance, feront passer le transport aérien dans une nouvelle dimension, où l'efficience, l'efficacité économique, la sécurité et la capacité seront renforcées. Cette vision ne se concrétisera toutefois que si des systèmes CNS améliorés et interopérables sont mis en place sur la base de normes et spécifications d'application commune dans toute l'Europe et, à terme, dans le monde entier. Il s'agit là d'un chantier gigantesque, faisant intervenir tous les acteurs de la communauté aéronautique et au-delà.

Forte de son positionnement au centre de cette communauté en Europe, EUROCONTROL jouera tout naturellement un rôle pivot en contribuant à la fixation de normes validées et en veillant à ce que celles-ci soient mises en œuvre de manière harmonieuse. En outre, notre statut de membre fondateur de l'Entreprise commune SESAR permettra à l'Agence d'assurer une cohérence et une continuité parfaites entre les nombreux développements technologiques découlant du programme, notamment en ce qui concerne les systèmes CNS.

Afin de nous préparer à ce rôle, l'Agence a récemment fait l'objet d'une réorganisation radicale et fondamentale, qui nous permet aujourd'hui de centrer nos efforts sur la participation à la mise en œuvre du Ciel unique européen. Nous avons dissocié les tâches d'appui à la réglementation et les fonctions de prestation de services et institué une organisation reposant sur trois directions clés : "Ciel unique", "Gestion du réseau" et "SESAR et Recherche". D'autres pièces du puzzle sont également en cours de mise en place. En septembre, EUROCONTROL a été désignée comme organe d'évaluation des performances du SES et, avec la fixation des cibles de performance à atteindre, nous sommes désormais prêts à entamer la première période de référence, qui s'étendra de 2012 à 2014. L'année prochaine, EUROCONTROL affinera et renforcera son aptitude à gérer les activités opérationnelles de réseau de manière à contribuer à la réalisation des objectifs de performance.

Je profite de la présentation de ce numéro de Skyway pour vous adresser à toutes et à tous mes meilleurs vœux pour 2011, une année qui promet d'être riche en défis, certes, mais néanmoins intéressante.

David McMillan
Directeur général

Communications, navigation and surveillance (CNS) is to air traffic management (ATM) what a bicycle is to a cyclist. In short: ATM cannot exist without the enabling technologies of communication, navigation and surveillance – commonly referred to as CNS.

Why CNS?

The articles which follow consider CNS within the ATM theatre precisely because of this inter-dependence between CNS and ATM and because of EUROCONTROL's unique role in European CNS/ATM. That said, CNS also makes contributions well beyond ATM, e.g. mobile telecommunications and the radars used to trap speeding motorists.

But although CNS rolls off the tongue as a single word, can CNS really be said to be a single entity? And if not, should it be? And why, some might ask, is EUROCONTROL involved in CNS? Should it be part of the work programme of an intergovernmental organisation such as ours? Or should it be left exclusively to industry? **Franca Pavličević, Head of the Navigation and CNS Research Unit, Jacky Pouzet, Head of the Communications and Frequency Coordination Unit, and Jean-Marc Duflot, Head of the Surveillance Services Unit, at EUROCONTROL, report.**

CNS – UNITED WE STAND

Historically – and even to the present day, to some extent – COM, NAV and SUR have not operated as an integrated whole – partly for safety reasons. C-N-S 'separation' ensured, for example, that if the SUR failed, aircraft were still capable of COM and NAV. But as SUR technology evolved, with ATC increasingly reliant upon multi-sensor trackers rather than on individual surveillance sensors, CNS started its migration from single systems to systems of systems.

In the future, CNS applications will need to become greater than the sum of their respective parts. To achieve this, there is a need to change these quite distinctive COM, NAV and SUR mentalities. Realities are changing fast. And so must independent C-N-S thinking – because as swords are drawn in the battle for spectrum, on-board avionics (a combination of "aviation" and "electronics") are becoming more integrated, as are CNS applications. What this means is that C-N-S has to mutate into CNS. SESAR has recognised this by creating some technical work packages across CNS boundaries.

SPECTRUM

Once, not so long ago, the individual entities of COM, NAV and SUR were comfortable in the knowledge that each had enough spectrum to meet their individual requirements. That this secure position might not be sustainable was a possibility that gradually came to light. C-N-S undoubtedly experienced a slight shiver each time a new technology appeared on the market with its own demand for spectrum. The draught became colder with the advent of mobile communication technologies on which society is now hooked – our personal GSMs.

Today, it is glaringly evident that new commercial technologies, many of which have nothing to do with aviation, are putting enormous pressure on the once 'invincible' CNS bands in the frequency spectrum. Our sheltered position is a thing of the past. Not only have newcomers stormed the fortress, but even the invisible walls between C-N and S spectrum have crumbled, with ATM communications systems being reassigned to operate in spectrum previously reserved for navigation and surveillance purposes.

As more applications evolve and pressures increase from commercial and emerging aviation markets (e.g. unmanned aerial vehicles), the battles for spectrum will become more intense. These pressures will force us to expand services with a fixed spectrum e.g. with SUR and NAV using COM links. This is evident each time there is a World Radio Conference (every four years) held under the auspices of the International Telecommunication Union (ITU). These realities are triggering new developments which can – and must – envisage CNS regrouping in the quest for common spectrum solutions to meet aviation challenges.

AVIONICS

Airborne technological changes are also drawing CNS closer together as the human machine interface (HMI) in cockpit avionics becomes increasingly integrated with shared CNS information incorporated into multi-functional control and display units (MCDU). Nowadays, pilots can monitor NAV data (flight planned route) with superimposed SUR ACAS data on one EFIS display (electronic flight instrument system) and toggle between COM channel and NAV function selections on a single control device. This was unthinkable a few decades ago. But needs must – and technology has a habit of finding solutions. What this means is that engineers are increasingly obliged to consider all three components of CNS when seeking to provide a technological solution to an operational requirement. As such, trade-offs have to be considered between C-N-S: is a particular solution really restricted only to NAV? Or could SUR provide part of the solution? This interplay is already common when deciding on the spacing between ATS routes. Whilst route spacing is primarily determined by aircraft navigation performance, radar surveillance allows routes to be brought closer together. Result: more capacity.

Whilst route spacing is primarily determined by aircraft navigation performance, radar surveillance allows routes to be brought closer together. Result: more capacity.

CNS APPLICATIONS

Similarly, satellite technologies are doing their part to span the gaps between different CNS applications. In this, ADS-B (automatic dependent surveillance – broadcast) is a prime example with its different applications. Here, GPS (the US global positioning system) provides position information for both the SUR and NAV elements of ADS-B. This GPS common-point is both a strength and a weakness (in the event of GPS outage, NAV and SUR are lost – so mitigations are needed). But the 'marriage' isn't limited to NAV and SUR: data needs to be transferred between different parties – and this is COM.

CNS IN EUROCONTROL

The answer is simple: EUROCONTROL's unique strength is being impartial, with no vested national or commercial interest in any CNS technology, as is EUROCONTROL's coupled CNS-

Why CNS? (cont'd)

ATM pan-European expertise which allows it to target the pan-European ATM network in the quest for cost-effective CNS solutions.

EUROCONTROL does not build CNS equipment; it makes no claim on any part of the CNS commercial market. As a pan-European agency with CNS-ATM at its core, EUROCONTROL is in an ideal position to capture pan-European ATM requirements with a view to benefiting the entire European network – and ultimately our final customers, the airspace users. Industrial enterprise cannot play this role in business, where having an edge over one's competitor counts for everything. Whereas industry looks to differentiate products with quick time to market, ATM needs harmonised systems to enable efficient and safe operations. As a non-profit intergovernmental organisation, EUROCONTROL acts as arbiter. It facilitates consultation with a wide-range of partners including ANSPs, regulators, industry, airspace users (civil and military) and avionics manufacturers with one aim in mind: the efficiency of the pan-European ATM network.

Through its consultation arrangements, EUROCONTROL's CNS domains 'translate' pan-European network requirements into the language of CNS technology which ultimately culminate in the development of technical standards. These standards also benefit from analyses fed in from studies funded by the Agency or from data sourced in various Agency CNS tools. Because global interoperability is a must, consultation includes international organisations such as ICAO and technical multi-national bodies such as EUROCAE (the European Organisation for Civil Aviation Equipment) and RTCA (Radio Technical Commission for Aeronautics).

What EUROCONTROL provides to all CNS stakeholders is a neutral platform where robust dialogue and debate can take place when setting international standards

It is for exactly these reasons that the Agency is ideally placed to develop technological requirements and standards for future CNS.

So in short, what EUROCONTROL provides to all CNS stakeholders is a neutral platform where robust dialogue and debate can take place when setting international standards with a view to ensuring cost-effective solutions for the pan-European ATM network.

INTO THE FUTURE

It's just over 100 years since aviation, as we know it, really took off. It has not been that much longer since the streets of Vienna, Paris or Amsterdam were first lit by electric lamps. Yet how much of what we have now was imaginable to those living in the Victorian era? Was it not our grand-parents who were more than a little suspicious of a steam iron? Could teenagers in 1900 have been capable of imagining that their descendants would one day carry a pocket telephone? Probably not. If only because it is difficult, if not impossible for most of us to imagine what's in store over the 100-year horizon. What will the next generations invent? One can only imagine...

In European ATM, this nettle has been grasped by EUROCONTROL and the European Commission in the Single European Sky ATM Research Project (SESAR). Looking to the future, 20-30 years downstream, SESAR has provided a vision, a target, a great arrow in the sky pointing European CNS-ATM in a particular direction. This direction envisages a transition from airspace to performance-based operations through the three steps viz. time-based operations, trajectory-based operations and performance-based operations.

To these ends, great volumes of operational and technical investigative work will be undertaken in a partnership between European industry, ANSPs and EUROCONTROL over the next few years. Unsurprisingly, CNS is very much at the core of the SESAR technical work packages, particularly in Work Packages 9 and 15, which look at integrated avionics and CNS infrastructure respectively.

Will CNS still be around in 100 years? Probably – but it is unlikely to bear much resemblance to what we know today. Some suggest that people will be out of the loop by then; computers will talk to computers (COM)… and aircraft will find their own way (NAV) … and sense-and-avoid (SUR) will be the natural order of business.

But it's likely that aircraft will still be flying – which means that ATM will still exist, and CNS too. As will the bicycle. Probably.

Moving aviation towards a 21st-century communications system

COMMU

Jacky Pouzet, Head of the Communications and Frequency Coordination Unit at EUROCONTROL, explains what the aviation community needs to do in order to create a global and interoperable 21st-century communications system for both civil and military, manned and unmanned aircraft.

A KEY ATM ENABLER

The need to communicate with pilots to ensure that flights take place in a safe manner dates back to the very early stages of aviation. Up to the end of the last millennium, voice communication was a key tool for managing air traffic and passing information and instructions between air traffic controllers and pilots.

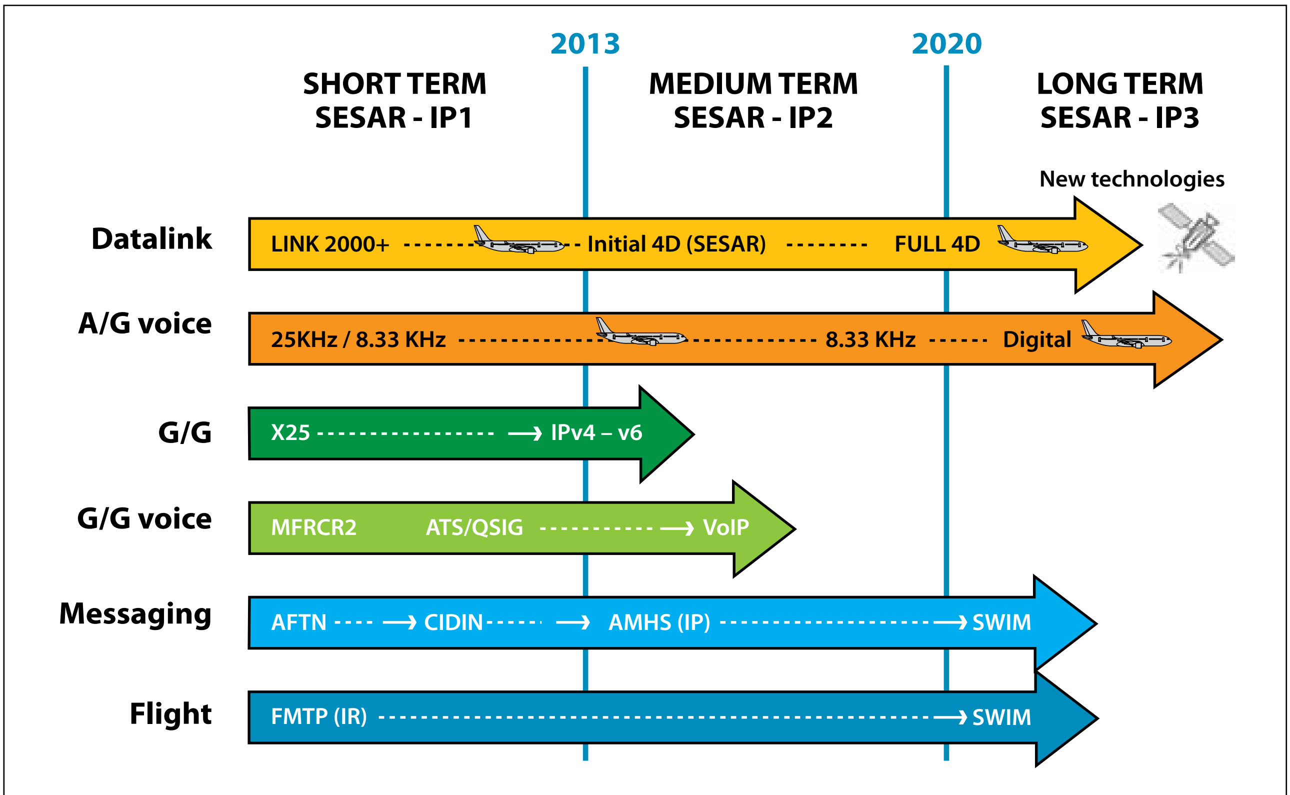
THE NEED FOR CHANGES

However, as traffic has increased beyond expectations, this form of communication has now reached operational limits in some of the more busy areas. To solve this problem, the aviation community has developed and started to implement digital data communication to support and, probably at later stage, replace the voice as the principal means of communication. Not surprisingly, such a paradigm shift requires operational changes, and also creates technical and institutional challenges related to the safe implementation of a harmonised and coherent system which can operate in parallel with the existing infrastructure and ensure a smooth transition at local, regional and global levels.

ONGOING CHANGES

EUROCONTROL, in conjunction with all of its aviation partners, is supporting the move towards the future communication infrastructure, primarily in the context of SESAR. This new communications infrastructure requires changes as illustrated in the following picture. The main elements of these changes are described in more detail in subsequent articles.

NICATION

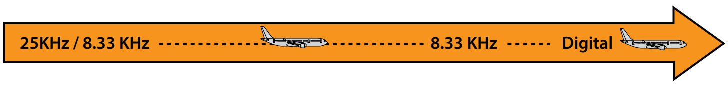


Communications infrastructure roadmap

Moving aviation towards a 21st-century communications system (cont'd)

SELECTING THE APPROPRIATE TECHNOLOGIES

The main change which will bring about increases in safety and capacity is enhanced airborne and ground system coordination. The target, as described in the SESAR concept of operation, is to move to full 4D trajectory management in an incremental step-by-step way. This will be achieved through LINK 2000+, initial 4D and full 4D implementation. Full 4D will require root-and-branch adaptations to operations and technology in order to bring the appropriate air-ground link capacity in all the different airspace areas – airport, TMA, en-route, polar and oceanic. Not surprisingly, in view of SESAR, the selection and development of the required technology is taking place in Europe. However, this critical work is being closely coordinated with the US Federal Aviation Authority (FAA) and ICAO (International Civil Aviation Organization). Furthermore, these new technologies will have to support both air traffic management (ATM) and aeronautical operational control (AOC) communications, both of which also require more capacity. Other articles on datalink, future communications infrastructure and AeroMACS cover this process in more depth.



Today, voice is still the main link between airborne and ground ATM systems. In the face of increasing capacity demand, more communication channels need to be found as the VHF-COM band has reached its limits and has become congested. To bring additional capacity in that band, 8.33 kHz channelisation and efficient frequency management are required. Potential digital voice will come later, if required.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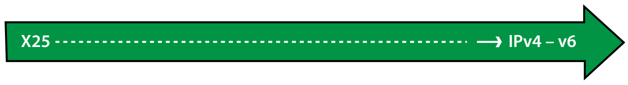
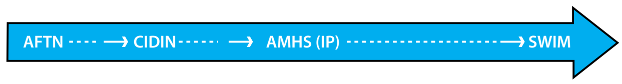
MODERNISING GROUND/GROUND COMMUNICATION



Current ATM ground/ground communication (voice and data) is dependent on legacy technologies that need to be updated to meet future capacity. The migration from X25 to Internet protocol (IP) has started with the pan-European network service (PENS), while voice communication will migrate onto voice over Internet protocol technology (VoIP). IP and VoIP are now ICAO standards and will allow more flexible and cost-efficient communications. Industry has followed these lines with products that are (or will soon be) readily available off the shelf.



Ground messaging and flight plan (FPL) exchanges have also been standardised for global harmonisation with modern technologies, and the current AMHS (ATM messaging) and FMTP (flight message transfer protocol) processes are covered by this standardisation. The next challenge will be interconnection of the messaging between all the stakeholders (mainly airlines, airport and military systems) in order to exchange 4D trajectory data rapidly. In the future, all these applications will have to be embedded in SWIM (system-wide information management).

ENSURING A SMOOTH MIGRATION

Implementing new concepts and technologies in aviation takes time, particularly if it requires retrofitting equipment as a mandatory activity. The most complex challenge which all the actors will have to confront is implementing the new technologies and systems so that they are able to operate with legacy systems. This will have to be done through a smooth transition, and a typical example of such a challenge will be the successful migration towards SWIM.

THE NEED FOR GLOBAL STANDARD DEVELOPMENTS

Obviously, changes to a new ATM system on such a major scale cannot be made in isolation. Coordination at global level is therefore of paramount importance. Consequently, ICAO will have a key role to play in developing clear and concise standards for these new communication systems. Recent experience in IP standardisation, for instance, has shown that the overall standardisation time can be contained and even reduced by reusing industrial standards.

INCREASED CIVIL-MILITARY COORDINATION

So far, the civil and military communities have developed technologies on their own. This cannot continue, and in the future there will be a need for both sectors to coordinate their development activities in order to ensure global operation with a minimum of disparity together with global harmonisation across all the airspace. Moreover, the unmanned aerial vehicle (UAV) community will also have to coordinate their activities.

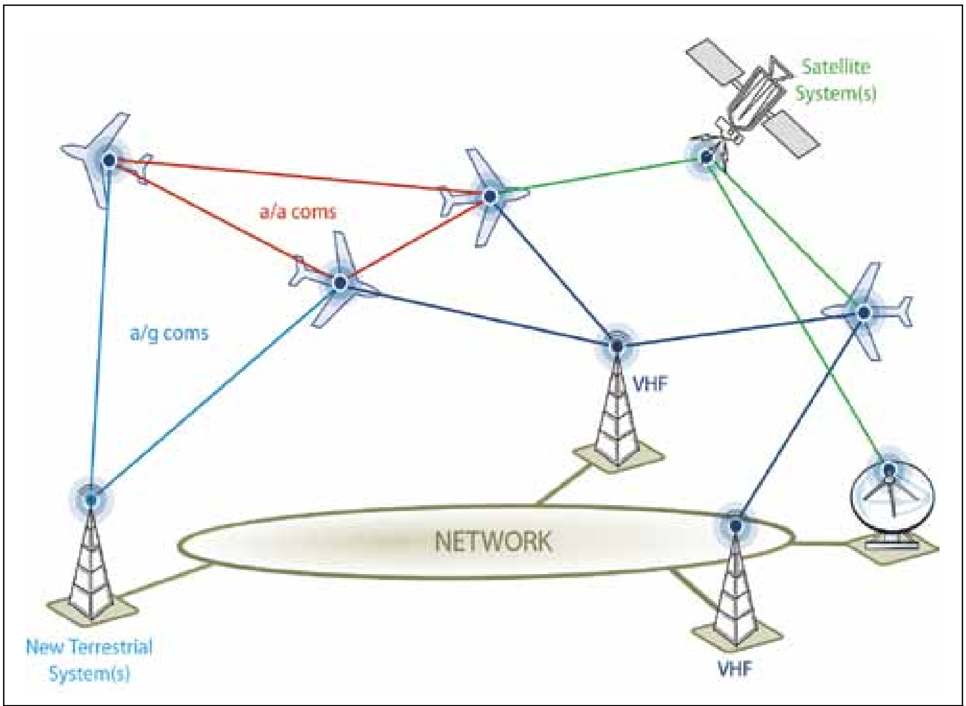
RATIONALISATION OF CNS TECHNICAL SYSTEMS

CNS (communications, navigation and surveillance) technical systems all share a common resource: the frequency spectrum. In addition, technology is evolving, and hard-coded CNS systems are gradually being replaced by software-based systems, opening new areas for development. The technology of the software defined radio (SDR) is now offering the potential for integrating several CNS systems in the same piece of radio equipment. These technologies are opening up new paths which need to be exploited in the context of SESAR, with the objective of defining the number of "boxes" required on board the aircraft and on the ground in order to perform CNS functions.

CHALLENGES

As future ATM concepts will be based on key enablers such as communications, it is important to modernise the COM technologies used in aviation in order to meet future challenges.

Key projects such as LINK 2000+, PENS, FMTP, ATM messaging and 8.33 which are already in progress will have to be completed. However, they will need to incorporate developments to meet the new ATM application demands, and this will in turn require wider secured communication systems interconnection to all the ATM actors across the air navigation service provider, airline and airport domains. These independent systems will have to converge to become a global standardised interoperable system. EUROCONTROL will be working together with its partners to make this happen. ■



Future communications infrastructure

Datalink

Martin Adnams, the LINK 2000+ Programme Manager at EUROCONTROL, reports on the progress of the implementation of the first generation of datalink, which is set to become an operational reality across Europe within five years. This implementation will provide a firm foundation for the longer-term SESAR plans to extend automation, services and technology.

Data communications have been an integral part of modern life for both business and leisure purposes for many years. However, it is only now that the airborne air traffic management (ATM) systems and ground systems are starting to connect. The need for this connection, known as datalink, is identified in every major ATM strategy and initiative, including SESAR and NEXTGEN, as the keystone of future ATM improvements.

The need for datalink is not in question – studies have shown that currently, up to one in three voice communications are misunderstood, and that controllers spend up to 50% of their time talking to pilots. The first step in datalink is to connect pilots and controllers to support routine communications; this will increase safety and efficiency in the short term and lead to new ways of working in the future.

DATALINK ROADMAP

The basic roadmap for the implementation of datalink in Europe is shown below. It is being fully coordinated between European organisations, the FAA and ICAO, and will be based on global standards.

The datalink roadmap recognises the SESAR target concept as the end goal and identifies a practical strategy for getting there by achieving the benefits of implementation packages. In order to achieve the final goal, the roadmap contains three steps corresponding to the SESAR implementation packages (IPs) identified in D4, the Deployment Sequence, and D5, the SESAR Master Plan.

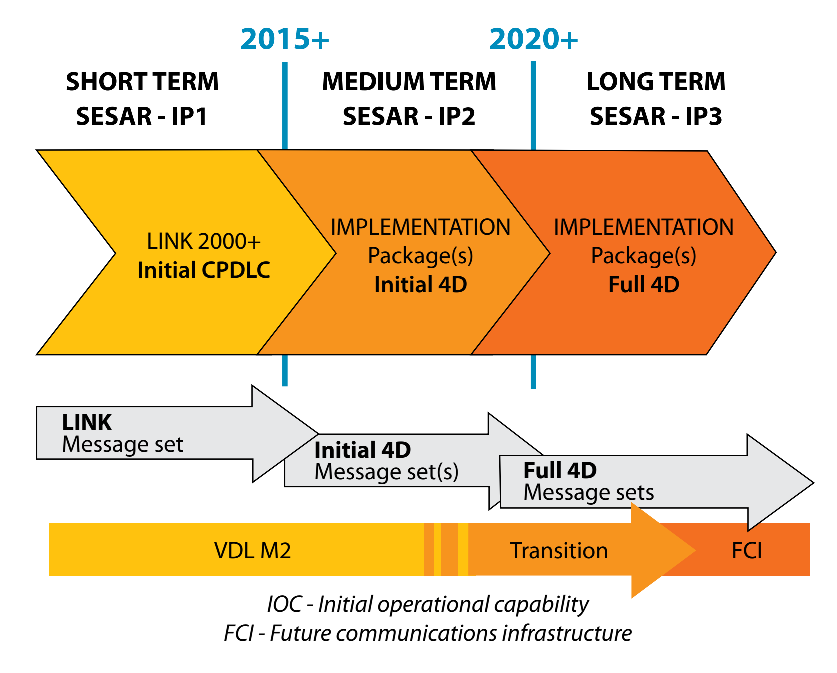


Figure 1 – Datalink roadmap

CPDLC as a key enabler for the next generation of datalink planned in IP2 and IP3

DATALINK IN IP1

The first datalink step will take place within SESAR IP1 and consists of the implementation of the initial controller pilot datalink communications (CPDLC), which is being coordinated by the LINK 2000+ programme. The Internet working solution for CPDLC messages is the ICAO aeronautical telecommunications network (ATN) and the air-ground physical link will be VDL Mode 2, which is the technology of choice of the airline industry for airline operational communications.

Implementation of CPDLC is recognised by SESAR as a key enabler for the next generation of datalink planned in IP2 and IP3. So it is essential that it is implemented in time.

The European Commission published EC Regulation No. 29/2009, the Datalink Services Implementing Rule, on 16 January 2009, making implementation a legal obligation for both air and ground (see below).

DATALINK IN IP2

The second datalink step supports trajectory management for the first time (initial 4D) as identified by the SESAR Master Plan and implements additional airport services (taxi and terminal information). It will take place within SESAR IP2 and aims to deliver quick-wins and benefits whilst facilitating the transition towards the SESAR target concept.

Initial 4D does not change the operating paradigm in the communications area, maintaining voice for "time critical" (e.g. tactical) controller/pilot exchanges and using datalink to automate routine and complex exchanges. It does not require a new datalink technology and will build on infrastructure currently being deployed. No implementation decision on datalink services in IP2 has as yet been taken; research, development and validation are underway.

DATALINK IN IP3

The third roadmap step will introduce the full SESAR concept where datalink is the prime means of communication, including the complete management of business trajectories. The precise definition of all the datalink services required for this third step will only be possible when a comprehensive validation programme is executed in the context of the SESAR Joint Undertaking (SJU). Studies show that these future concepts will require new datalink messages and a new datalink technology to meet "time-critical" performance requirements and the need for a much higher bandwidth. No implementation decision on datalink services and supporting technology in IP3 has as yet been taken.

IP3 will also see the deployment of the future communications infrastructure (FCI), which was hitherto coordinated under Action Plan 17 with the FAA for initial deployment after 2020.

For more information please see the future communications infrastructure article in this issue of Skyway on page 19.

Datalink (cont'd)

DATALINK NOW: THE LINK 2000+ PROGRAMME

The LINK 2000+ Programme packages a first set of en-route CPDLC services into a beneficial and affordable set for implementation. The R&D has been carried out, the standards are stable, the safety case is mature and the business case provides the justification. The Maastricht Upper Area Control Centre (UAC) has been operational with CPDLC since 2003; it is unique in Europe in its capability to lead the field testing ATM improvements.

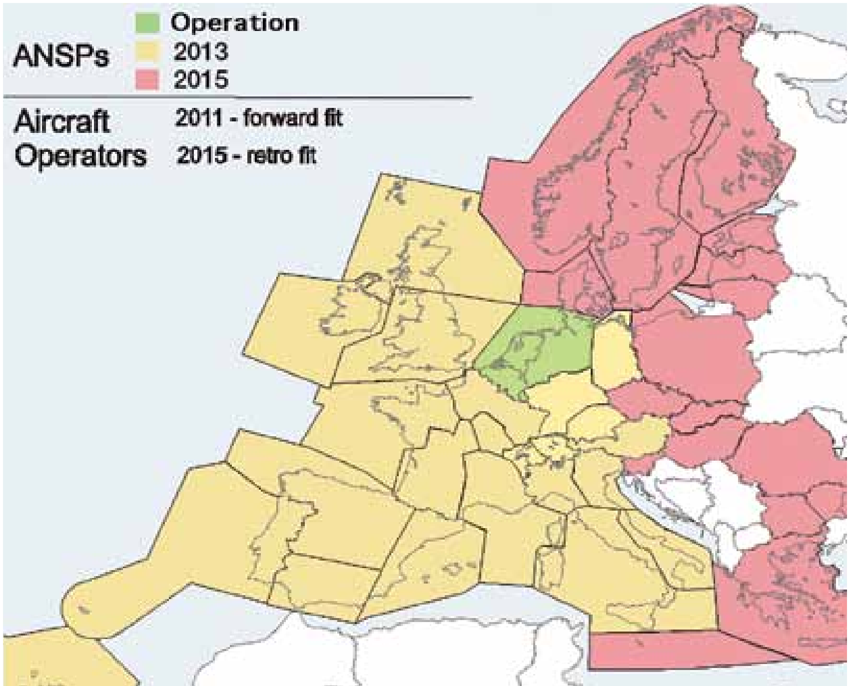


Figure 2 – LINK overview

Observations on the flight deck and on the ground show that as many as 1 in every 3 voice communications between pilots and controllers needs to be repeated or is misunderstood. CPDLC provides clear, unambiguous information directly to the cockpit – it helps to solve this problem.

All pilots and controllers exposed to CPDLC understand the advantages immediately: fewer misunderstandings (increased safety), reduced workload (increased efficiency).

The increased safety and efficiency provides extra capacity in the ATM system. LINK 2000+ implements three basic services automating the routine tasks that currently take up to 50% of controllers' time:

- ATC communications management – to handle repetitive frequency changes (transfer of communications);
- ATC clearances – to provide standard clearances (e.g. climb to flight level 350);
- ATC microphone check – to enable communication in the case of blocked voice frequencies.

These services do not replace voice as the primary means of communication; both media will always be available, providing a definite safety improvement. In the case of non-standard communications or emergencies, "revert to voice" is the procedure.

REGULATION & STANDARDS

The Single European Sky Data Link Services Implementing Rule (DLS IR) was published as EC Regulation No. 29/2009 on 16 January 2009 and made implementation of the LINK 2000+ services mandatory in the air and on the ground by the following dates:

- **1 Jan 2011** – After this date all new aircraft operating above FL 285 must be delivered with a compliant system.
- **7 Feb 2013** – By this date all LINK Region air navigation service providers (ANSPs) must have implemented an operational compliant system (see the yellow region in Fig. 2).
- **7 Feb 2015** – By this date all aircraft operating above FL 285 must have been retrofitted with a compliant system.
- **7 Feb 2015** – By this date all EU Region ANSPs must have implemented an operational compliant system (see the pink region in Fig. 2).

The regulation refers to existing ICAO and RTCA/EUROCAE standards, all of which are bound together as a single reference point in a EUROCONTROL Specification available on the programme website: www.eurocontrol.int/link2000.

IMPLEMENTATION STRATEGY

The biggest challenge following final system operational validation in 2000 has been to convince aircraft operators and ANSPs to synchronise investment in order to deploy for mutual benefit. Whilst regulation was always the end goal, the implementation strategy was to encourage early equipage and early benefits by means of financial stimulus. A three-step strategy was adopted.

1. **PIONEER PHASE**
   Objective: 100+ aircraft equipped. The EUROCONTROL budget was used to part fund airborne equipage for final operational validation of CPDLC and ATN/VDL M2 with Maastricht UAC. The phase is drawing to a close with more than 400 aircraft equipped.

2. **INCENTIVES PHASE**
   Objective: accelerate airborne equipage to achieve early benefits. After five years' research into funding schemes EUROCONTROL successfully obtained a grant of €19.3 million from the European Commission (TENT-EA) to partially fund the upgrade. The application was made on behalf of the airline associations and will result in more than 700 aircraft being equipped in 2011-12.

3. **MANDATORY IMPLEMENTATION PHASE**
   Objective: more than 75% of flights in LINK airspace operating CPDLC with European ANSPs in upper airspace (green and yellow on the previous map – Fig. 2) by 2015 in compliance with the Data Link Services Implementing Rule.

STAKEHOLDER SUPPORT & TESTING

After the Pioneer phase and the development of the regulatory material the main focus of the LINK 2000+ team at EUROCONTROL is to support stakeholders (airspace users, avionics and airframe manufacturers, communications service providers and ANSPs). The support falls into 2 categories:

1 in every 3 voice communications between pilots and controllers needs to be repeated or is misunderstood. CPDLC helps to solve this problem.

- **Testing:** the LINK2000+ test facility at the EUROCONTROL Experimental Centre (EEC) in Brétigny has a comprehensive set of CPDLC/ATN and VDL Mode 2 tools to test interoperability. Avionics can be tested locally in the laboratory as well as by remote connection to manufacturers' sites. Flight tests against EEC test tools are conducted via the VDL M2 network. ANSP implementations can also be tested by connecting to EEC.

- **Technical support:** the LINK Integration Team (LIT) and Operational Focus Group (OFG) provide technical and operational support to new implementers. Expert support is given in the areas of safety, operations and technical infrastructure. Guidance documents have been produced for all stakeholder sectors, including aircrew, controllers, systems integrators and manufacturers. System monitoring and investigation tools have been developed for use at CPDLC operational level, internetworking (ATN) level and for VDL M2.

Moving aviation towards a 21st-century communications system (cont'd)

DATALINK THE NEXT STEP

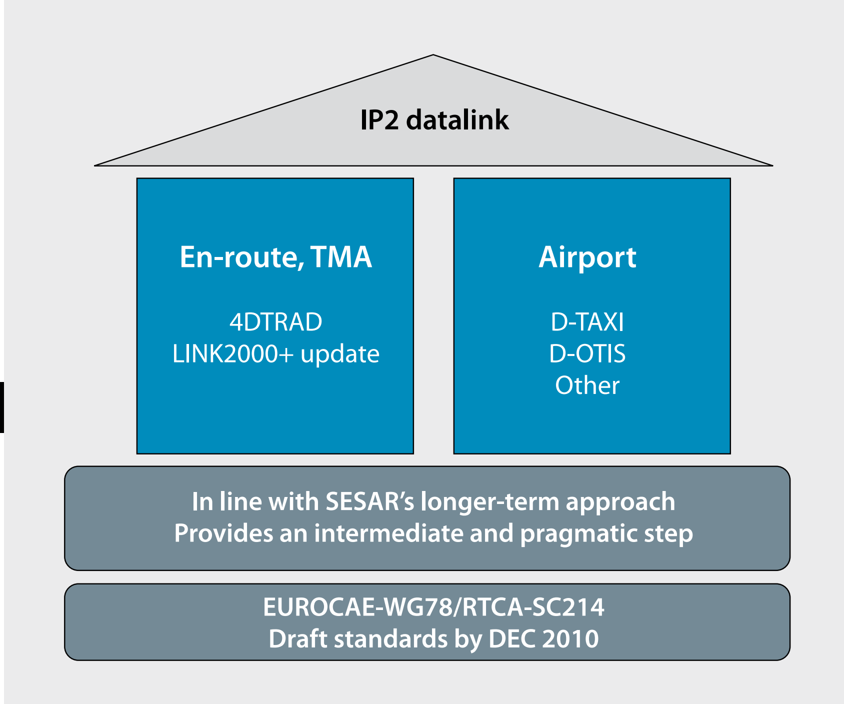


Figure 3 – New datalink services for IP2

The next step in the datalink roadmap (Fig. 1) is a move towards trajectory management, commonly referred to as Initial 4D in SESAR Implementation Package 2 (IP2). IP2 will also include new datalink services for en-route, TMA and airports by extending the LINK 2000+ services. For example, it will also include new airport services for the ground movement phase of flight and new terminal information services.

It is essential to ensure that through standards and products, full backwards compatibility with LINK 2000+ is maintained and that the infrastructure laid down by the Programme is reused. The new services will operate over the ATN/VDL M2 infrastructure but new air-ground technologies will be incorporated as they are implemented on a wider scale (see the following article on future communications infrastructure).

NEW DATALINK SERVICES FOR IP2

4DTRAD
4DTRAD implements the initial 4D concept. The 4DTRAD service enables/supports the negotiation and synchronisation process for flight data between ground and air. The 4D trajectory (i.e. the 3D trajectory with time constraints) is downlinked from the aircraft, negotiated if necessary, coordinated/notified between all relevant interested downstream and/or flow management units.

D-TAXI
The D-TAXI service provides datalink support to the ground movement phase of flight. It provides pre-departure information and taxi routeing for departing and arriving flights.

D-OTIS
The datalink operational terminal information service (D-OTIS) provides flight crews with compiled meteorological and operational flight information for aerodromes. It includes ATIS[1], NOTAM VOLMET[2] and in-flight real-time NOTAM updates relating to the departure, approach and landing phases of flight.

Other services are also being considered for continental Europe; for example, the D-RVR service provides flight crews with up-to-date runway visual range (RVR) information relating to an airport's runway(s).

STANDARDS

The EUROCAE-WG78/RTCA-SC214 Joint Committee develops the operational service descriptions, safety/performance requirements and interoperability standards for the air traffic services (ATS) supported by data communications to be implemented in Europe during the IP2 timeframe and in the US in a similar timeframe, in the context of the FAA Datacom/NextGen Programme.

1- Automatic terminal information service
2- Notice to airmen, routine voice broadcasts of MET information for aircraft in flight

VALIDATION & IMPLEMENTATION

The draft standards will be validated over the next few years in both SJU and NEXTGEN. Initial 4D flight trials involving AIRBUS, Maastricht UAC, NORACON and European airports are planned for 2012. A decision on the phased implementation of these new services will be taken based on the results of the SJU validation in coordination with FAA NEXTGEN and ICAO global planning. This may lead to an update of the existing Datalink Services Implementing Rule or a new rule.

CONCLUSION

In cooperation with the European Commission and the European Aviation Safety Agency (EASA), the LINK 2000+ Programme is actively supporting stakeholders in the implementation of the first package of datalink services designed for high-density en-route airspace. The value of these services is recognised in European legislation, which sets dates for full European operation. The experience gained and infrastructure implemented will provide a springboard for the next generation of datalink services currently under study by the SJU.

There can be no Single European Sky without datalink.

Future aeronautical communications

Nikos Fistas, Future Communications Infrastructure Focal Point at EUROCONTROL, looks at future aeronautical communications and the likely future datalink environment beyond 2020, highlighting the challenges of selecting technologies which will meet evolving, global, future requirements.

Future aeronautical communications (cont'd)

BACKGROUND

The origin of the EUROCONTROL-sponsored investigations concerning future aeronautical communications can be traced back to ICAO's 11th Air Navigation Conference (AN-Conf/11) in 2003. In its conclusions, AN-Conf/11 agreed that the aeronautical mobile communication infrastructure had to evolve in order to accommodate new functionalities and to provide the adequate capacity and quality of service required to support evolving air traffic management (ATM) requirements within the framework of the global ATM operational concept. Accordingly, the conference developed recommendations addressing the need for an evolutionary approach while ensuring the global interoperability of air/ground (a/g) communications, and requesting the investigation of the technology alternatives for future a/g communications and the standardisation of those selected.

The conference discussions stressed the requirement to maximise the use of systems already implemented, and highlighted the particular attention to be given to the careful utilisation of the (limited) available spectrum as well as to the appropriate consideration of transition aspects. AN-Conf/11 emphasised the need for international cooperation, particularly for air/ground communications.

In line with the conference recommendations, EUROCONTROL and the US Federal Aviation Administration (FAA) decided to establish a dedicated working arrangement (Action Plan 17 of the EUROCONTROL-FAA Memorandum of Cooperation) to carry out this work. Action Plan 17 (AP17) has been very closely coordinated with ICAO's Aeronautical Communications Panel (ACP) to facilitate global harmonisation. AP17 was a joint activity between FAA/NASA and EUROCONTROL. In Europe, France, Germany, Spain, Sweden and the UK have also been actively supporting and contributing to the European investigations. The AP17 work was concluded in 2007 and the outcome was used to plan the future activities in the context of the SESAR and NextGEN projects.

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In Europe, the future communications infrastructure (FCI) work is now carried out in the context of the SESAR Programme, which will oversee the development of the required new generation of technological systems, components and operational procedures to support the future concepts as defined in the SESAR ATM Master Plan and Work Programme.

A key outcome of the AP17 activities was that there is no single technology which meets all expected future requirements across all operational flight domains. In addition to the importance of maximising the use of the existing infrastructure, the need to introduce technologies driven by clear operational requirements linked to tangible benefits, led to the conclusion that the FCI should be a "system of systems", integrating existing and new technological components. FCI should secure seamless continuation of operations supporting the current and future requirements, to safeguard investments in infrastructure and equipage, and to facilitate the required transitions.

In summary, the FCI work is built on the following assumptions:

- In the future operating concept, data becomes the primary mode of communications (voice will remain available for emergency communications).
- In the event of failure of data communications, voice is unlikely to be able to sustain operations at the same capacity level. Consequently, different datalinks may be needed in order to maintain capacity of operations.
- The future (2020+) system needs to support ATS (air traffic services) and AOC (airline operational communications) end-to-end communications, including ground/ground, air/ground and air/air.

The AP17 activities focused on air/ground data communications and analysed many candidate technolo-

FUTURE COMMUNICATIONS INFRASTRUCTURE

gies. The technology investigations led to the following three proposals for new wireless data communications system developments:

1. a ground-based, high-capacity, airport surface datalink system, referred to as the aeronautical mobile airport communications system (AeroMACS);
2. a ground-based datalink system for continental airspace in general, referred to as the L-band digital aeronautical communications system (LDACS);
3. a satellite-based datalink system for the oceanic, remote (deserted) and continental environments (in the latter case complementing the terrestrial systems).

While for AeroMACS (the aeronautical mobile airport communications system), a specific existing standard has already been identified, for the other two technology developments, AP17 recommended further activities, to finalise the technical investigations and the selection and standardisation of the proposed systems.

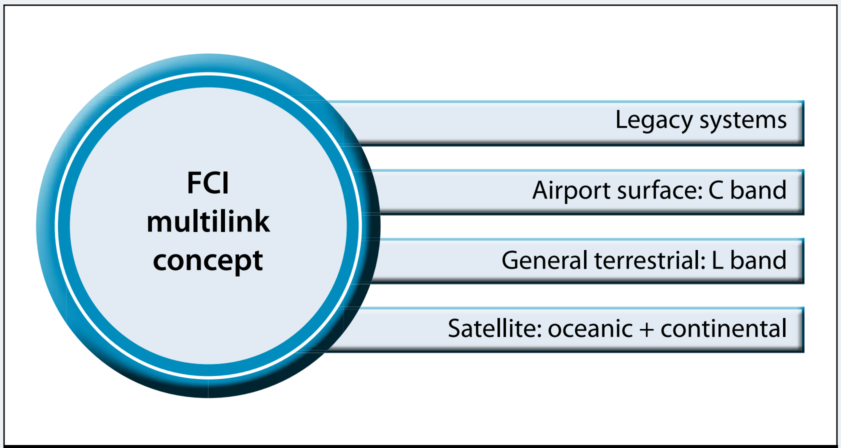
It is important to note that a significant constraint in the technology investigations for aviation is the spectrum to be used. Communications supporting ATM exchanges fall into the category of "safety of life" communications, and as a result they have a special protection status in order to avoid interference. However, this protection is applicable only to specific bands, and effectively there are three such bands: the VHF band, the L band and the C band. In Europe, the VHF band is a very congested band, and there is no room for additional systems to operate. The VHF band was therefore not considered for use by any of the new systems, leaving the other two bands as the only candidates.

Airport surface system: AeroMACS

AeroMACS is intended to support on-the-ground communication exchanges, particularly at busy airports. Whilst the aim is to support both ATS and AOC applications, it is expected that the AOC applications may be the driving element in the initial system implementations in Europe. In addition, especially in the US, the same standard is also being considered to support other aviation applications on the airport surface.

Considering the expected significant volumes of information to be carried and the short distances to be covered while the aircraft is on the ground, the aeronautical C band (5 GHz) has been selected, and an appropriate allocation for AM(R)S (aeronautical mobile route service allocation) was obtained by the International Telecommunication Union (ITU) in 2007. AeroMACS will be based on the IEEE 802.16 WiMAX mobile communications standard, in order to benefit from commercial general telecom developments and minimise the required development resources.

In SESAR, there are two projects (P15.2.7 and P9.16) supporting the development of the AeroMACS system. These two projects aim to define and validate an international global aviation standard. The two projects will carry out analysis, simulations and testing, involving purpose-built system prototypes. Project 15.2.7 addresses the overall system aspects and focuses on the ground system component, whilst project P9.16 focuses on the aircraft system aspects and airborne integration. The AeroMACS development is also being actively pursued in the US (a separate article on page 91 describes in detail the relevant US activities).



Legacy systems and new datalinks

FUTURE COMMUNICATIONS INFRASTRUCTURE (cont'd)

Standardisation of AeroMACS is currently taking place in two closely cooperating groups in the European Organisation for Civil Aviation Equipment, EUROCAE, (WG82) and the US Radio Technical Commission for Aeronautics, RTCA, (SC223). These two groups are working on the development of the aviation-specific profile of the WIMAX standard to describe AeroMACS, and in the future the groups will also address the development of additional material (MOPS[1] and MASPS[2]). While EUROCAE and RTCA will cover the technical details of the proposed system, ICAO is also expected to be involved in the standardisation process, with high-level documents such as SARPs[3].

Terrestrial a/g system: LDACS

LDACS is a ground-based system using line-of-sight communications to support air/ground communication, in particular for en-route and TMA communications in continental airspace. The system is targeting operations in the L- band (1 GHz). This band is heavily utilised by navigation and surveillance aviation systems. However, considering the need to communicate over significant distances, the L-band was identified as the best compromise candidate band, primarily because of its acceptable propagation characteristics. A co-primary AM(R)S allocation was obtained from the ITU in 2007, which means that LDACS should not interfere with the other primary users of the band (navigation and surveillance systems).

The spectrum compatibility analysis is critical for LDACS and has to work in both directions: first not to hinder the operation of existing systems, but also to be able to operate in the presence of existing systems.

The AP17 investigations did not identify a commercially utilised system meeting all requirements, so they proposed to define a system based on features of some existing systems and reuse of previous developments. Following a trade-off analysis, two options for the LDACS were identified. The first option (LDACS1) represents the state of the art in the commercial developments employing modern modulation techniques, and may lead to utilisation/adaptation of commercial products and standards. The second option (LDACS2) capitalises on experience from current aviation systems and standards such as VDL3[4], VDL4[5] and UAT[6].

The two LDACS options need further analysis, especially in terms of the spectral compatibility, before one of them is finally selected.

In SESAR, project P15.2.4 (Future Mobile Datalink system definition) is tasked with investigating the proposed LDACS options, selecting the most appropriate one, and developing the required standards. The full project activities will be starting in the second quarter of 2011. The key tasks for the LDACS investigations are to define the interference environment and the criteria for the spectrum compatibility analysis. For these investigations, there will be development of prototypes and test beds to perform the required testing in a representative environment in order to validate the previous theoretical investigations and analysis carried out.

To ensure worldwide interoperability, the selected LDACS system will require global standards, which means that the decision for the LDACS system needs to be taken in the ICAO framework. Consequently, coordination with all other interested regions, such as the US, is very important.

New satellite communication system

Satellite communications are very well placed to cover the large oceanic and remote airspaces. Currently, there are two ICAO standards for satellite communications, the INMARSAT3 and IRIDIUM systems. However, the performance requirements in the current ICAO satellite standards (AMS(R)S SARPs) are insufficient to cover the quality of service (QoS) requirements of the applications supporting the future operating concept. There is therefore a need to update the satellite SARPs to include more stringent performance requirements, to select a new technology and to develop the required standards to meet the updated requirements.

The need to select a new technology does not constitute an undesirable proliferation of technologies, as by the 2020+ timeframe all current aviation satellite systems will be reaching the end of their lifetime and new systems will have to be reconsidered in order to continue supporting the oceanic areas.

1- Minimum operational performance standards
2- Minimum aviation system performance specifications
3- Standards and recommended practices
4-5- VHF digital link - mode 3/4
6- Universal access transceiver

Furthermore, in order to support the new operating concepts, it is anticipated that multiple datalinks will be required to meet availability and other QoS requirements. It is therefore proposed that the satellite system should also be used in continental airspace jointly with the terrestrial-based systems to make it easier to meet the application requirements.

In Europe, the European Space Agency (ESA) has established the Iris project to spearhead the development of the future aviation satellite system. The Iris programme is described in a separate article in this edition of Skyway (see page 88).

The Iris programme is complemented by the SESAR P15.2.6 project (future satellite communication system). The SESAR project focuses on support for validation and standardisation, and will drive the development of the required global ICAO standards. The international aspect of satellite system standardisation will be dealt with in a dedicated group, the EUROCONTROL NEXUS group, with contributions from all interested parties in Europe and other interested parties such as Japan.

Airborne integration

The proposed new system developments need to be seen to be coupled with a new approach in order to address the future airborne integration questions. The proposed FCI will only be feasible if a "flexible" airborne architecture is made possible by new technological developments such as use of software radios and multiband antennas.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CONCLUSION

While significant work and achievements have already been accomplished, a lot of work remains to be done. Developing new technology solutions for aviation is a very lengthy and expensive process. There are many different factors which need to be properly aligned in order to bring about the successful implementation of a new system. Above all, any new system needs to be justified by new operational procedures and applications meeting future requirements.

New systems in aviation carry significant new costs for installation, and also additional costs for operation and maintenance, and they have to be offset by clear and measurable benefits. The proposed datalinks in the future communications infrastructure are not the drivers of the developments but are the enablers of the required new concepts. However, in recognition of the long timescales required to introduce new systems in aviation, work needs to start many years in advance. The challenge in aviation is to select systems to be widely implemented at least a decade later, but which will remain capable of meeting evolving requirements.

Timely availability of mature global standards will be critical in decision-taking and system implementation.

In the technology development process, international coordination is one of the prerequisites of success. It is critical to work with all interested parties from all regions. Timely availability of mature global standards will be critical in decision-taking and system implementation.

EUROCONTROL is committed to working closely with ICAO and other interested parties to ensure that the appropriate systems are available to support the emerging concepts and operational requirements of the full 4D-trajectory-based operations. ■

Stay tuned!
8.33 kHz below FL195

Europe is getting ready for a decision on the final phase of the deployment of 8.33 kHz radios. Their mandatory use in all European airspace by 2018 would solve the long-standing European frequency shortage problem. **José Roca, 8.33 Programme Manager at EUROCONTROL, explains.**

THE FREQUENCY CONGESTION CHALLENGE

For more than ten years, it has been impossible to readily satisfy all the requests for new aviation communications frequencies in the central European region. In spite of the implementation of 8.33 kHz channel spacing above flight level (FL) 195 and improvements in the frequency assignment process, forecasts indicate that the situation is going to get worse in the near future and extend to more European countries.

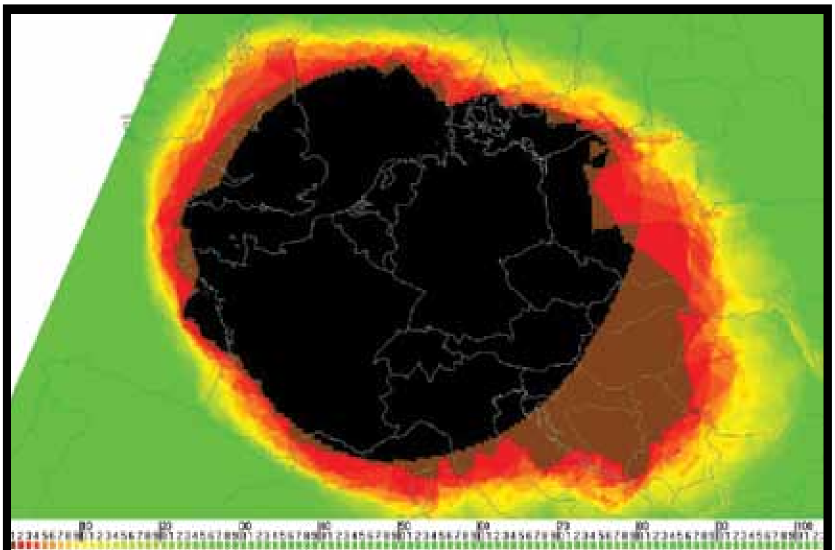
WHY DO WE NEED MORE FREQUENCIES?

Voice communications channels are essential for air traffic control. They are required to deploy operational improvements such as:

- the creation and modification of ATC sectors to better match air traffic flows;
- the creation and modification of services such as approach control, tower control, flight information, etc.

Aviation frequencies are also used to deploy datalink communications systems such as the VHF datalink (VDL) that will be used in combination with voice communications to increase the safety and effectiveness of ATC communications.

The operational improvements enabled by aviation frequencies deliver significant benefits such as reduced flight delays and increased airspace capacity that will be required to effectively accommodate the forecast growth of air traffic in the coming years.

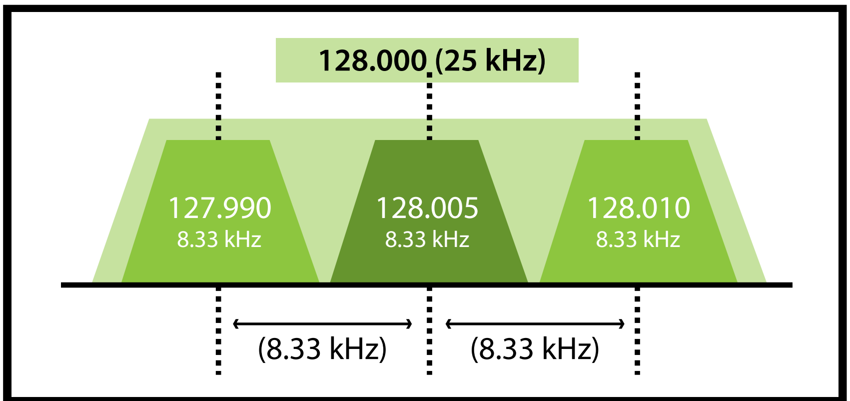


FREQUENCY CONGESTION AREA
The black region over the centre of Europe is the area where no area control centre (ACC) frequencies are available. Brown indicates the area where one frequency is available and red indicates where two to four frequencies are available. Source: FUA Study (http://www.eurocontrol.int/corporate/public/event/081010_frequency_usage_analysis_project.html)

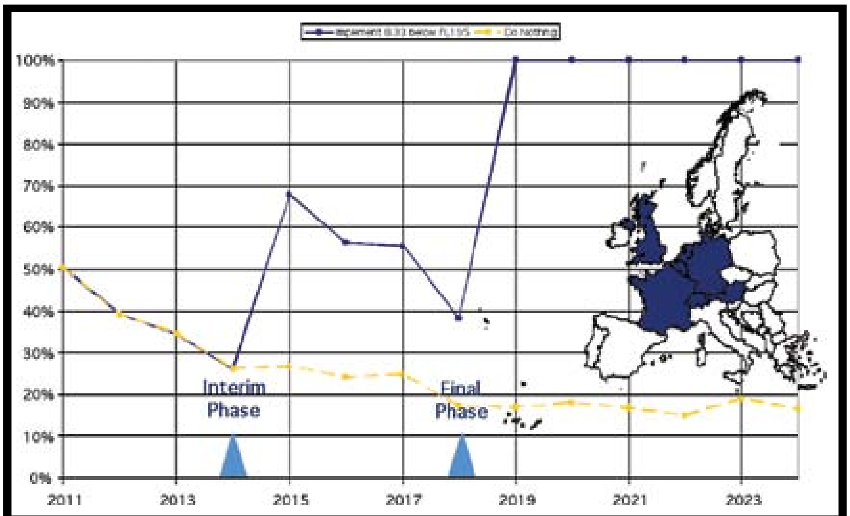
WHAT CAN BE DONE TO FIND MORE FREQUENCIES?

A range of potential solutions to the frequency shortage problem has been analysed. These included optimising frequency usage and making use of new technologies.

The optimisation of frequency usage will deliver significant benefits but



8.33 kHz channel spacing consists of the reduction in the width of the communication channels from 25 kHz to 8.33 kHz (i.e. one third). This allows for the creation of three communication channels where before there was only one. However, the two additional communication channels are not always usable due to adjacent 25 kHz assignments and ground site technical constraints.



Percentage of frequency requirements satisfied (core area, ACC and APP services)

it will not be able to meet all the demand expected for new frequencies in the near future.

The new technologies being developed by SESAR are not expected to change significantly the usage of air traffic control voice communications before 2030. Therefore the only realistic, validated option for solving the medium to long-term frequency congestion problem is to continue with the reduction of channel spacing to 8.33 kHz.

The radio channel spacing has already been reduced on four occasions since the 1950s to increase the number of channels: from 200 kHz to 100 kHz in the 1950s, to 50 kHz in the 1960s, to 25 kHz in 1972 and finally the reduction to 8.33 kHz, begun in 1999. 8.33 kHz has been mandatory in European airspace above FL 195 since 2007.

THE VOICE CHANNEL SPACING REGULATION

In 2005 the European Commission issued a mandate to EUROCONTROL for the development of a draft implementing rule on air-ground voice channel spacing, to provide a regulatory framework for the European deployment of the 8.33 kHz technology.

It was decided to address the scope of the mandate in two stages. The first stage, the deployment of 8.33 kHz channel spacing in the airspace above FL 195, was completed with the adoption and publication of Commission Regulation (EC) No 1265/2007 in October 2007.

The second stage, the extension of 8.33 kHz channel spacing to the airspace below FL195, is now being finalised and it is expected to be adopted and published in 2011.

THE PROPOSED EXTENSION OF 8.33 KHZ CHANNEL SPACING BELOW FL 195

The proposed approach to extend 8.33 kHz below FL195 comprises three phases:

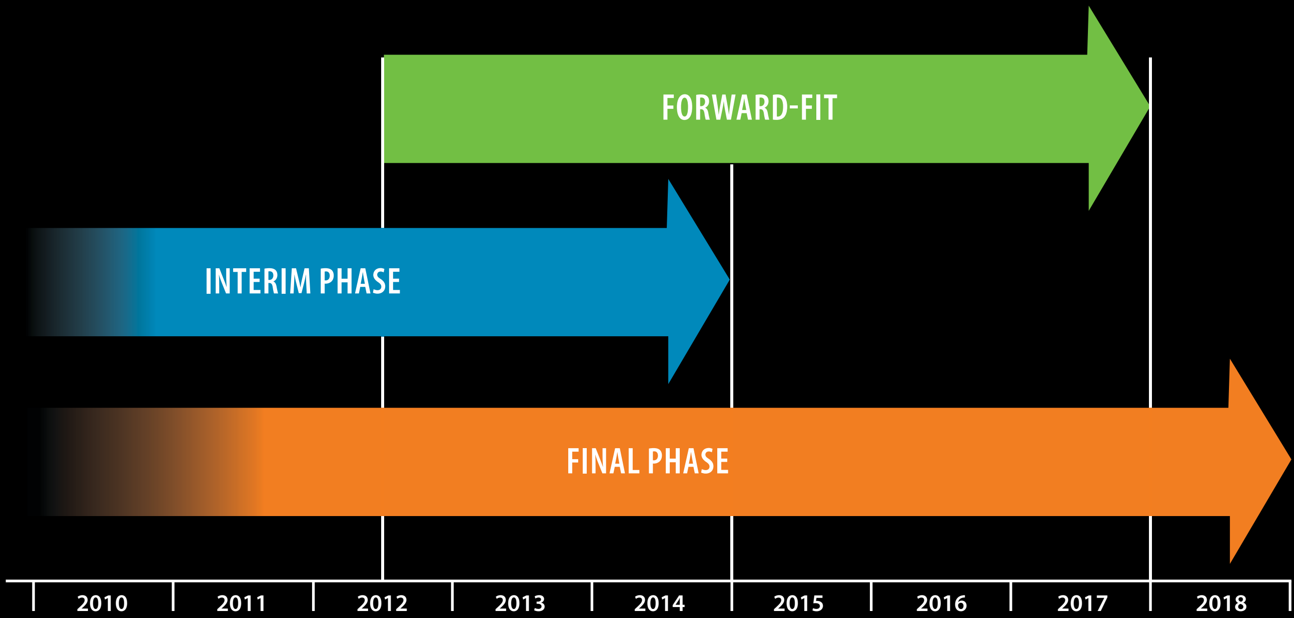
1- The requirement for all new radios to be 8.33 capable (forward-fit phase)
2- An interim phase by 2014, which targets instrument flight rules (IFR) traffic in sectors where a significant number of aircraft are already equipped with 8.33 radios (interim phase)
3- Europe-wide implementation by 2018 (final phase)

A full formal consultation is expected to take place early 2011, leading to an update of the already published implementing rule before the end of the year.

WILL 8.33 KHZ BELOW FL 195 SOLVE ALL FREQUENCY SHORTAGE PROBLEMS?

The simulations of the future frequency availability once 8.33 is implemented below FL195 show that the interim phase would temporarily reduce frequency congestion, but only the final phase would be able to meet all of the forecast demand for at least a decade. And this result applies also to the central European States, where the congestion is the highest, and to the services that require the most demanding frequency assignments (i.e. area control centre (ACC) and approach (APP) services).

Proposed phases for 8.33 kHz below FL195



FORWARD-FIT

One year after the publication of the Implementing Rule

- All aircraft and ground radios put into service must be 8.33 kHz-capable.
- All aircraft and ground radios put onto the market must be 8.33 kHz-capable.
- If a new radio is installed in an aircraft, even if it operates in airspace where radio carriage is not required, this radio should be 8.33 kHz-capable

Until 1 January 2014
Radios which are not 8.33 kHz-capable may be replaced by the same model/part number.

Until 1 January 2018
Radios which are not 8.33 kHz-capable and are not impacted by the Interim Phase may be replaced by the same model/part number.

The forward-fit phase does not require carriage of radios in airspace where there is currently no requirement to carry a radio.

INTERIM PHASE

By 1 January 2014
Aircraft operating under instrument flight rules (IFR) as general air traffic (GAT), in airspace classes A, B or C of the participating States*, mainly situated in the core area of Europe, must be equipped with 8.33 kHz-capable radios.

By 31 December 2014
The participating States must have implemented a number of new 8.33 conversions equivalent to 25% of the total 25 kHz area control centre (ACC) assignments for which conversion is feasible (COM2 table of December 2010 used as baseline)

By 31 December 2014
Frequencies used for operations control (OPC) must be converted to 8.33 kHz channel spacing.

** The list of participating States will be included in the updated Implementing Rule*

FINAL PHASE

By 1 January 2018
All radios operating in the ICAO EUR region should have the 8.33 kHz channel spacing capability. ANSP ground radios are exempted.

By 31 December 2018
All Member States and air navigation service providers must ensure that all frequency assignments in the aeronautical mobile communications service band are converted to 8.33 kHz channel spacing, except for cases where the conversion is not feasible.

The above provisions will be applicable only to radios intended for operation in the aeronautical mobile communications service band (i.e. 117.975 to 137 MHz). Radios operating exclusively in frequencies which will remain within the 25 kHz channel spacing (i.e. the emergency frequency and VHF data link frequencies and some operations control frequencies) will be exempt. Transitional arrangements and an exemption policy for State aircraft will be defined.

Improving the use of the aviation radio spectrum

The deployment of 8.33 kHz radios will provide many new voice frequencies after 2018. Until then, improvements to the frequency management process will be required to meet demand for frequencies. **José Roca, Frequency Coordination Focal Point at EUROCONTROL,** tells us how this will be done.

MANIF is used here to assess the impact of assigning 128.835 to Paris/Reims

WHAT IS FREQUENCY MANAGEMENT?

Today's aviation relies entirely on radio frequencies. Pilots and controllers talk using radio frequencies; radar controllers can see where the traffic is thanks to radio frequencies; aircraft determine their position using navigation systems that use radio frequencies; collision avoidance systems exchange positions on radio frequencies.

All these frequencies have to be assigned to users and protected against interference to ensure the safety of air traffic in an increasingly congested radio frequencies environment.

For over 20 years EUROCONTROL has been committed to ensuring the safe and efficient use of the European aviation frequencies. In addition to managing programmes to increase the availability of suitable frequencies, such as the 8.33 kHz channel spacing, EUROCONTROL monitors the frequency usage situation and plays a very active role in frequency management.

Frequency management is the process that ensures that the appropriate radio frequency channels are assigned to radio stations.

INSTITUTIONAL FRAMEWORK

The radio frequency spectrum is divided into frequency bands allocated to the various users by the International Telecommunication Union (ITU), a United Nations agency. Several frequency bands have been allocated to aviation, and their use in Europe is coordinated by the ICAO Frequency Management Group (FMG).

EUROCONTROL supports the frequency coordination activities and develops software tools to improve the efficiency of the process. SAFIRE and MANIF are the two most important tools in this area.

WHAT IS SAFIRE?

SAFIRE (the spectrum and frequency information resource) is a web-based centralised database that contains the frequency assignments for the entire ICAO EUR region. This database provides:

- a coordination tool for all new EUR region frequency requirements;
- an accurate description of current frequency assignments which supports frequency usage analyses.

In 2008 the EU High-level Radio Spectrum Policy Group issued a formal opinion recognising SAFIRE as an example of frequency management best practice.

WHAT IS MANIF?

MANIF provides assistance to States in finding appropriate frequency candidates for new radio stations.

It takes all the existing frequency assignments from SAFIRE and looks for a new frequency that meets the specific requirements provided by the user. The tool also displays graphically possible incompatibilities with existing neighbouring assignments.

WHAT ARE THE BENEFITS?

These tools provided automated impartial mechanisms to significantly improve the efficiency of the frequency management process at a time when Europe was suffering from a very serious lack of available frequencies.

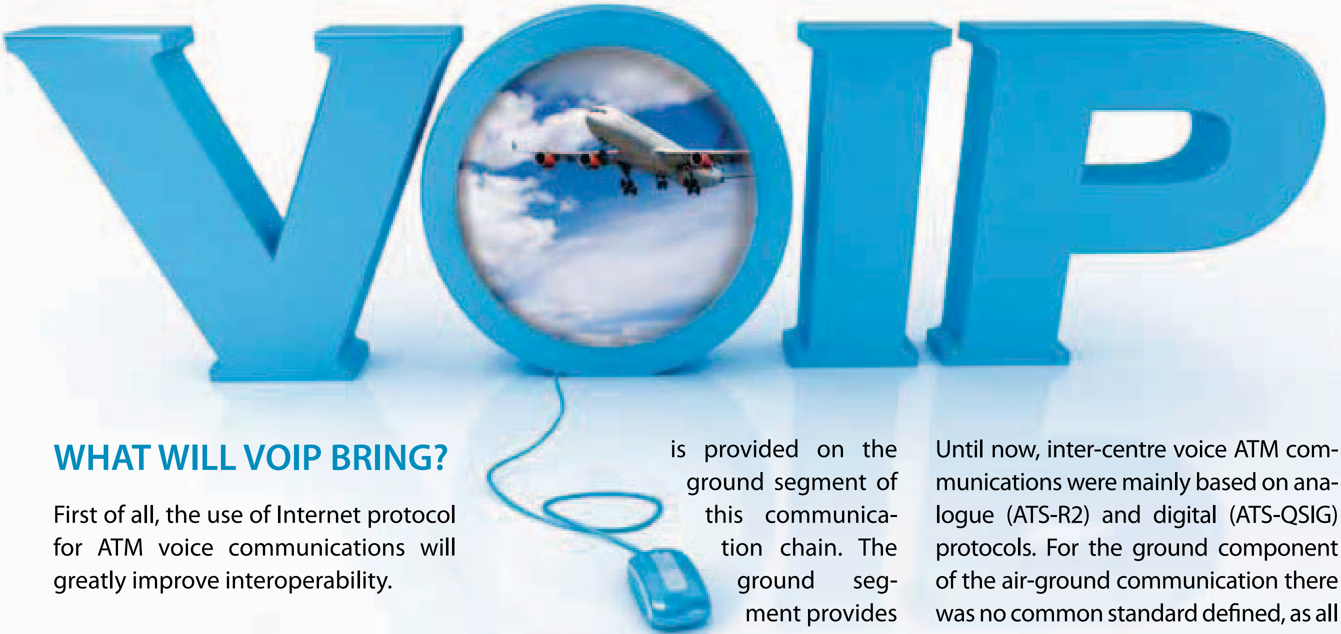
The 8.33 KHz channel spacing will deliver many available frequencies, but unless they are managed properly Europe could again be facing frequency shortages in the future. EUROCONTROL remains committed to ensuring that Europe has the frequency management tools and processes to support the safety and growth of European aviation. ■

VoIP: upcoming

Internet technology for voice communication

Operational use of voice over Internet protocol (VoIP) in air traffic management (ATM) is not new. One European air navigation service provider, the Romanian Air Traffic Services Administration (ROMATSA), adopted the Internet technology for all ATM ground voice communications at the very beginning of the twenty-first century. Another, DSNA (Direction générale de l'aviation civile), will soon follow. EUROCONTROL is planning to start the deployment across Europe in 2013 and to finalise it by 2020.

On the other side of the Atlantic, the FAA has identified VoIP as a key technology in developing NextGen. **Liviu Popescu, Voice Communications Expert at EUROCONTROL, and Dieter Thigpen, Voice Communications Manager at the US Federal Aviation Administration (FAA), report.**



WHAT WILL VOIP BRING?

First of all, the use of Internet protocol for ATM voice communications will greatly improve interoperability.

Voice ATM communications are mainly used for coordination by planning air traffic controllers located in adjacent air traffic service (ATS) units and also for ATS control between the executive air traffic controllers and pilots. In the latter case, the use of VoIP technology is provided on the ground segment of this communication chain. The ground segment provides the connection between the voice communication switch located in the air traffic control (ATC) centre and the ground radio station – most of the time situated in a very remote location.

Until now, inter-centre voice ATM communications were mainly based on analogue (ATS-R2) and digital (ATS-QSIG) protocols. For the ground component of the air-ground communication there was no common standard defined, as all communications between ATC centres and ground radio stations were point-to-point and no network was needed.

The Single European Sky package II (SES II), enforced by the European Parliament and the European Council on

The migration of the European ATM voice services to VoIP is expected to be finalised by December 2018 for inter-centre telephony and by December 2020 for the ground segment of air-ground communications.

4 December 2009, requires a more efficient operational concept based on functional airspace blocks (FABs). Within an FAB, there is a need to effectively deliver capacity to airspace volumes when required. To do this, airspace and sector structures must have the ability to adapt to predicted traffic flows and workload without delay or restriction. Furthermore, adjacent units must know the sector configuration of all the surrounding FAB partners. Dynamic sectorisation is required to support this new concept.

To achieve dynamic sectorisation, new flexible technical solutions are needed for which interoperability is an essential ingredient. The VoIP in ATM standard is the ideal solution to provide interoperability, particularly for the air-ground component where a ground radio station will be shared by several adjacent ATC centres belonging to different air navigation service providers (ANSPs).

Furthermore, a number of European telecommunication service providers (TELCOs) are planning to phase out, or are already phasing out, analogue and digital 64k circuits. These circuits are currently providing the supporting infrastructure on which the ATM voice services are based. This situation in the TELCO market is affecting both civil and military ANSPs. A replacement of current analogue and digital ATM voice services with a common standard is therefore urgently needed at the European level. VoIP in ATM is able to provide the right replacement at the right time.

PLANNED DEPLOYMENT
How close are we?

EUROCAE WG-67, with cooperation from EUROCONTROL, European industry, and ANSPs, developed the first VoIP in ATM standard. The standard was issued in February 2009 as a set of documents (ED136-138) defining the operational voice concept, the interoperability solutions and the network-associated requirements. Dedicated European Telecommunications Standards Institute (ETSI) plug-testing events, opportunity for companies to test their prototypes against a standard with their partners and competitors, and bilateral pre-operational validation by DSNA and DFS (Deutsche Flugsicherung GmbH) have yielded a high confidence level of the standard. Consequently, a new version called ED137A was released in September 2010 after a review which included integration of requirements from the US Federal Aviation Administration (FAA). A draft EUROCONTROL European Single Sky Implementation (ESSIP) objective for VoIP in ATM was developed for the European Civil Aviation Conference (ECAC) States. The deployment is planned to be initiated in January 2013 for both inter-centre telephony and the ground segment of the air-ground voice communications. The migration of the European ATM voice services to VoIP is expected to be finalised by December 2018 for inter-centre telephony and by December 2020 for the ground segment of air-ground communications.

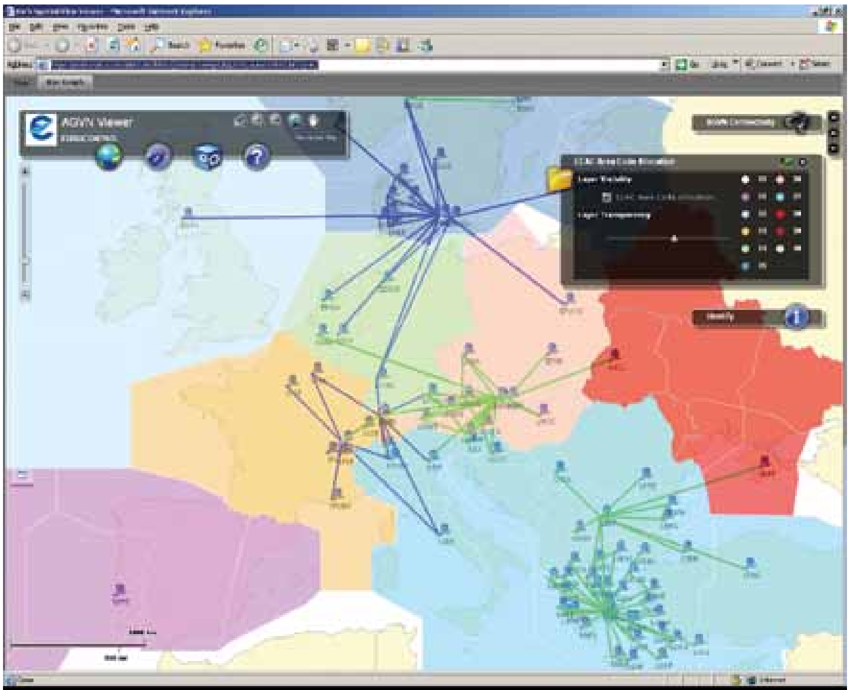
To support the European-wide ATM voice communications transition towards VoIP, EUROCONTROL launched the VoIP Implementation and Transition Expert Group (VOTE) in February 2010. VOTE has the generic mission to address VoIP in ATM implementation and transition-related issues on a case-by-case basis; and to identify solutions and deliver recommendations to interested parties (e.g. ANSPs, industry, TELCOs and standardisation bodies). VOTE activities are proving to be essential in facilitating the future deployment of VoIP in ATM. Active schedules and determination of the VOTE subgroups are paving the way towards a Europe-wide VoIP implementation in ATM.

In September 2009, EUROCONTROL launched the ATM Ground Voice Network (AGVN) web-based database which defines all current operational ▶▶

VoIP: upcoming Internet technology for voice communication (cont'd)

roles at the controller working position level. The AGVN database is a key element in the evolution to a European-wide network environment. It is the repository of current ATM voice systems numbering plan and will contain future VoIP addressing information as the transition progresses. This online tool has already proved to be an essential enabler for the FAB's ATM voice services implementation.

EUROCONTROL has recently initiated the development of the VoIP in ATM test suite, an essential element to facilitate timely multi-vendor VoIP implementations. Within the SESAR Project 15.2.10, EUROCONTROL is working with the other partners to validate and verify VoIP in ATM over the pan-European network service (PENS). Wide area network (WAN) VoIP validation over PENS is planned for 2012.



AGVN online application on the EUROCONTROL extranet

The global dimension

The ICAO Aeronautical Communication Panel WG I, responsible for the development of the ICAO Aeronautical Telecommunication Network over the Internet Protocol Suite (IPS) standards, will include VoIP requirements in the ATN/IPS Manual DOC 9896 Edition 2 by making a reference to the September 2010 edition of the EUROCAE ED137A standard.

On the other side of the Atlantic, the FAA has identified VoIP as a key technology in developing the US Next Generation Air Transportation System (NextGen). NextGen is an umbrella term for the ongoing, wide-ranging transformation of the US national airspace system.

The FAA has identified national airspace system (NAS) voice system (NVS) as one of five transformational NextGen programmes. VoIP technology is anticipated to play a key role in NVS implementation. NVS will replace current voice switches with a network-based infrastructure that will evolve into a more flexible voice communications system that supports dynamic resectorisation, resource reallocation and airspace redesign. Currently, the FAA is in the process of incorporating references to ICAO ATM VoIP documents into the NVS Specification.

In support of NVS early definition of requirements, capabilities and implementation, the FAA William J. Hughes Technical Center was recently directed to develop a VoIP integration test bed. This test bed will be used to evaluate VoIP technology integrated with current voice communications systems. In addition, in May 2011, the FAA is planning an interoperability VoIP in ATM event which is open to all vendors who are interested in working together to achieve interoperability of their products as defined by the approved EUROCAE WG-67 standards and related FAA addendums. Furthermore, the FAA is an active member of EUROCONTROL VOTE and EUROCAE WG-67.

EUROCONTROL and the FAA are planning a set of activities in support of the transition to VoIP in ATM services. Such activities will investigate the possibility of sharing VoIP test specifications and the use of test beds and test tools to facilitate global interoperability of ATM voice services and the set-up of field trials. The activities will examine the transition and validation aspects of VoIP in ATM for both inter-centre telephony and the ground segment of air-ground communications within the framework of the FAA Telecommunications Infrastructure (FTI) and the NVS programmes on the US side; and the SESAR projects (P15.2.10) and VOTE on the European side.

These joint activities will contribute towards the validation of the relevant ICAO standards.

CONCLUSION

VoIP in ATM is a mature standard able to respond to SES II challenges and become a building block of future European FABs. The time is right to initiate the transition from legacy ATM voice services that will soon no longer be supported by the European TELCOs. A dedicated group was created by EUROCONTROL to secure the European-wide transition towards VoIP services in ATM.

The EUROCAE VoIP standard will soon be referenced in ICAO ATN/IPS Manual, DOC 9896. The global standardisation of VoIP protocols for ATM systems is a key step in the evolution towards an integrated, modern and highly capable worldwide air traffic control system. The FAA has identified VoIP as a key technology in enabling NextGen. SESAR P15.2.10 partners are working on the validation and verification of VoIP in ATM over PENS.

Cooperation between the FAA and EUROCONTROL is paving the way for early adoption of VoIP in ATM services to thereby realise their potential benefits to meet the challenges of air travel in the twenty-first century. Joint EUROCONTROL–FAA activities will contribute to the validation of the relevant ICAO standards. Initial operational capability in Europe is expected by January 2013. ■

Evolution of air traffic service messaging

Yuksel Eyuboglu, AMC Project Manager at EUROCONTROL, sketches the evolution of air traffic service messaging towards SWIM, system-wide information management.

The major part of data message interchange in the aeronautical fixed service (AFS) is performed by the aeronautical fixed telecommunications network (AFTN), an international network spanning the whole globe. Today, most ground-based information with respect to national and international aviation operations is exchanged via ICAO-administered AFTN. Several hundred nodes located in virtually every country of the world exchange messages containing flight plans, NOTAMs and meteorological data on various types and speeds of links using "store-and-forward" procedures.

The common ICAO data interchange network (CIDIN) was introduced in the 1980s to improve the transport layer of the AFTN which dates back to the 1950s. While AFTN application format and procedures remain unchanged, the data transport within the network using CIDIN takes advantage of techniques with higher capacity and better quality of service, such as X.25 and ISO OSI layering for CIDIN protocols. In Europe and neighbouring countries most international nodes which were deployed after 1990 have both AFTN and CIDIN capabilities.

Due to the outdated technology and limited capabilities of AFTN/CIDIN, the ATS message handling system (AMHS) was the next system introduced by ICAO for ground-ground messaging in the early 2000s. AMHS will replace the character-oriented AFTN protocol with a modern message handling system based on international standards such as ISO/IEC 10021 and ITU-T X.400. The AMHS uses IP or ATN as a transport network and can carry bit-oriented data required by modern ground-ground aeronautical data applications. The deployment of the AMHS has begun in all ICAO regions, and it is expected that with the introduction of PENS (pan-European network service) more European air navigation service providers will utilise the new protocol in the coming years.

The ATS Messaging Management Centre (AMC), developed and implemented by EUROCONTROL on behalf of ICAO, has been providing off-line network management service since 2007 to the European segment of global AFTN/CIDIN/AMHS network.

ATS MESSAGING AND SWIM

SWIM (system-wide information management) is currently being defined in the context of SESAR, as part of two work packages:

- WP8 Information Management, relating to the SWIM/ATM information model and services, and;
- WP14 SWIM Technical Architecture, relating to the system and protocol architecture.

A "big bang" implementation of SWIM, replacing ATS messaging as a whole and in one single operation, is not realistic. A managed transition will have to take place as part of this evolution to communication architecture based on SWIM. Some of the main technical topics expected to be addressed during that period are highlighted in the following paragraphs.

Regarding geographical coverage, the systems in Europe communicating via SWIM will also need to communicate directly or indirectly with systems in other regions which are not "SWIM-capable", but which may still be exchanging messages/data using ATS messaging. Inter-working will be required between the European SWIM environment and the ATS messaging environment in other regions.

The major part of data message interchange in the aeronautical fixed service (AFS) is performed by the aeronautical fixed telecommunications network (AFTN), an international network spanning the whole globe.

Since ATS messaging is generic by nature and can be used to exchange any kind of message, service continuity for the exchange of other messages, including distress messages, urgency messages and administrative and service messages, needs to be ensured during the transition period.

Transition approaches for communication systems often include conversion gateways, encapsulation techniques and dual/multiple stack implementations. One of the main tasks in the period is expected to be the identification, development and implementation of such transitional systems.

As regards the communication models, the major differences between ATS messaging (store/forward) and SWIM (publish/subscribe) need to be analysed by taking into consideration the operational and technical role of the existing COM centres and their staff.

It is obvious that there is a certain degree of overlap between ATS messaging on the one hand and SWIM on the other. Managing such a complex transition period is expected to be one of the main challenges facing the deployment of SWIM in Europe.

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Navigation: an ongoing skill?

NAVIGA

Franca Pavličević, Head of the Navigation and CNS Research Unit, and Charlie Eliot, Navigation Instructor, at EUROCONTROL, explain the role of navigation in air traffic management, the evolution of navigation applications and infrastructure over the years and the importance of global coordination in supporting any future ATM development.

Climb into a car today and you are likely to find a GPS navigation system. Plan to drive any distance and you'll probably just type the address or postcode into the unit and press 'navigate'. How much thinking is required? Do you ever ask yourself how this box knows where it is and how trustworthy it really is? Do you think about looking at a map? Do you blindly place your trust in the little black box? Some people do: a few drivers have ended up in rivers or have had their lorries trapped on roads too narrow to proceed or turn round just because they followed their GPS navigator.

Are we, in the aviation community, ready to believe in the signal from space that can provide accuracy inconceivable to the fathers of navigation such as Eratosthenes, Hadley and Harrison? On top of this, can we believe the data in the navigation system that defines the route we need to fly that will allow us to use the satellite data to fly our aircraft automatically along complex routes between mountains and down to points just a few hundred feet above the runway a few seconds before landing? What would Lindbergh and Earhart have said to the commercial pilots of today who now fly strategic lateral offsets (SLOPS) on oceanic routes to avoid sitting in the slip stream of aircraft the level above because the lateral navigation accuracy is so high? Such are some of the significant navigational advances we have made.

In this series of articles we discuss navigation in the context of ATM with particular emphasis on the work undertaken by EUROCONTROL to support our customers, the airspace users and service providers, and coordinate with industrial partners and international bodies such as ICAO.

TION

These articles address performance-based navigation, precision landing and navigation infrastructure.

THE KEYS TO NAVIGATION – POSITIONING AND GUIDANCE

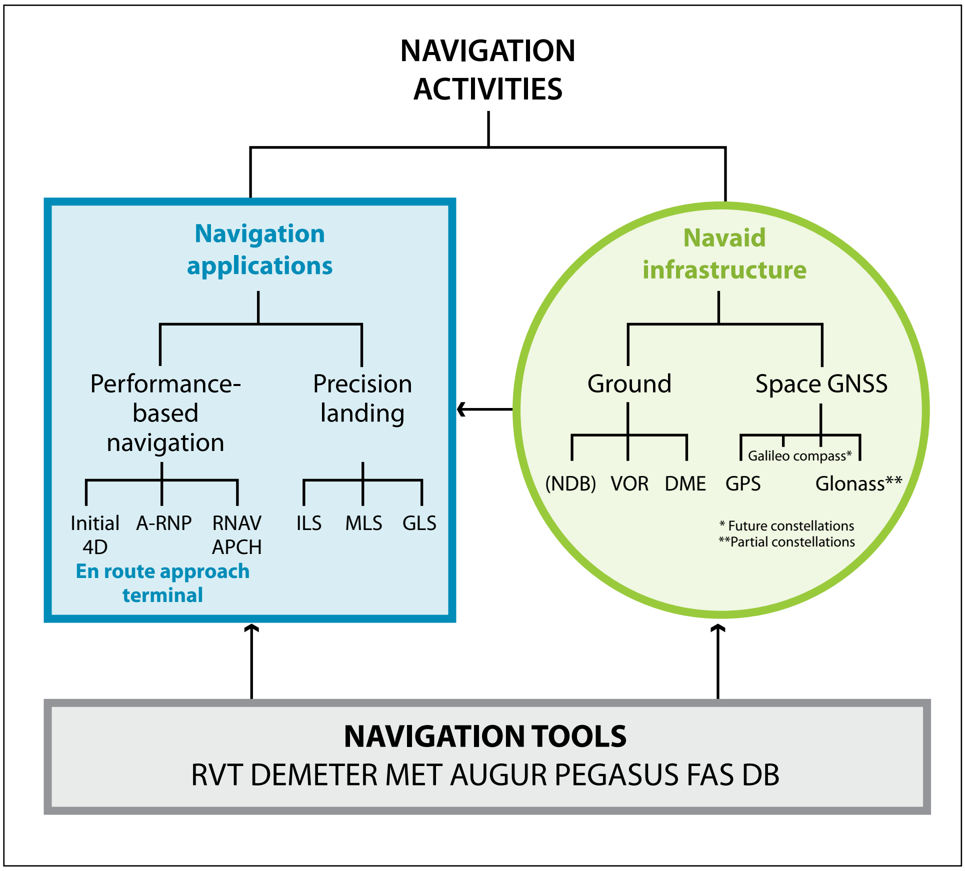
Humans have always wanted to travel. The Phoenicians were great travellers as were the Romans – and so, judging by the ever-increasing volumes of traffic, are modern societies. Whatever mode of transport used to get around, the ability to navigate from point A to point B and back is essential. This does not necessarily mean that complicated instruments are needed for navigation – when walking we see where we are and follow the path ahead. Navigating an aircraft or ship over a voyage of thousands of miles requires something more precise. Whatever means are used to navigate we need to know our position, the route we have to follow to get to out destination and we need to be able to steer or guide ourselves (or the vehicle we are travelling in) along the chosen route.

Establishing the position of a place is taken for granted today, but this was not always the case. Until quite recently, countries had their own reference 'grids' used to publish the 'official' position of aeronautical locations within a State – and most national grids or local coordinate systems were different. This meant that one point on the earth could end up with multiple different 'published' locations. To overcome such a potentially dangerous situation a global reference model was introduced called the World Geodetic System 1984 (WGS84). This model is the basis of positioning data used by GPS that could be used by everyone.

This uniformity of position data is critical in a world where navigation relies increasingly on coordinate data rather than by reference to an outside visual reference or to a radio beam to a ground navigation aid. Without a doubt, high quality aeronautical data is a key enabler for navigation.

Positioning a location on the earth is one part of the challenge, but knowing an aircraft's position in real time is also crucial if it is to get from A to B. Today, commercial air transport relies on instruments for position determination which means that position is determined from various navigation aids (navaids). On board, aircraft avionics are able to calculate the aircraft's position from the information received from the navaids. Some navaids provide much more accurate signals than others and in that, GPS reigns supreme. ▸▸

Navigation: an ongoing skill? (cont'd)



NAVIGATION APPLICATIONS

Whilst positioning, route definition and steering are fundamental to navigation, it is how we use it in the air traffic management (ATM) system that determines the value of the navigation system to aviation. Navigation applications are essentially used to maximise the capacity of airspace by facilitating flows of traffic between airports and maximising safe, efficient access to airports. Navigation applications differ depending on the flight phase, with approach and landing applications often demanding higher accuracy and integrity of operation from those applied for en-route and terminal operations.

Airport access and landing also depends on navigation with an approach system of some form providing guidance towards the runway and the capacity of the landing system to guide the aircraft to touchdown.

Steering or **guiding** an aircraft from A to B is the other great challenge of navigation. How accurately can an aircraft maintain its path depends upon the navigation systems. Today, many aircraft have highly sophisticated integrated modular avionics accepting position information from a variety of sources to calculate the steering signals and auto-pilots that ensure the aircraft follows the desired track. These navigation avionics systems take the form of area navigation (RNAV) equipment or flight management systems that combine RNAV capabilty with a performance management capabilty.

Despite impressive sophistication in navigation capability, there remains much to be done. Increasing precision of navigation together with enhanced functionality extend the applications possible. For navigation applications that cover performance-based navigation (PBN) and precision landing, the emphasis is on navigating through different phases of flight and providing the quality of service needed to operate the aircraft in all phases of flight. But lateral and vertical navigation (3D) is not the end point of navigation capabilty. Adding time to 3D navigation (4D) airborne navigation capabilty will provide new capabilities and very impressive performance was demonstrated by the Programme of Harmonised ATM Research in EUROCONTROL (PHARE) in the late 1980 early 1990s. Now SESAR looks to be the next step in validating the capability of the ATM system to use this level of navigation performance, thus enabling more efficient flight operation.

In general terms it can be said that separation between flows of traffic (including the spacing between ATS routes) is determined primarily, but not exclusively, by aircraft navigation performance. Similarly, how close procedures can be placed to obstacles is also dependent on an aircraft's navigation performance.

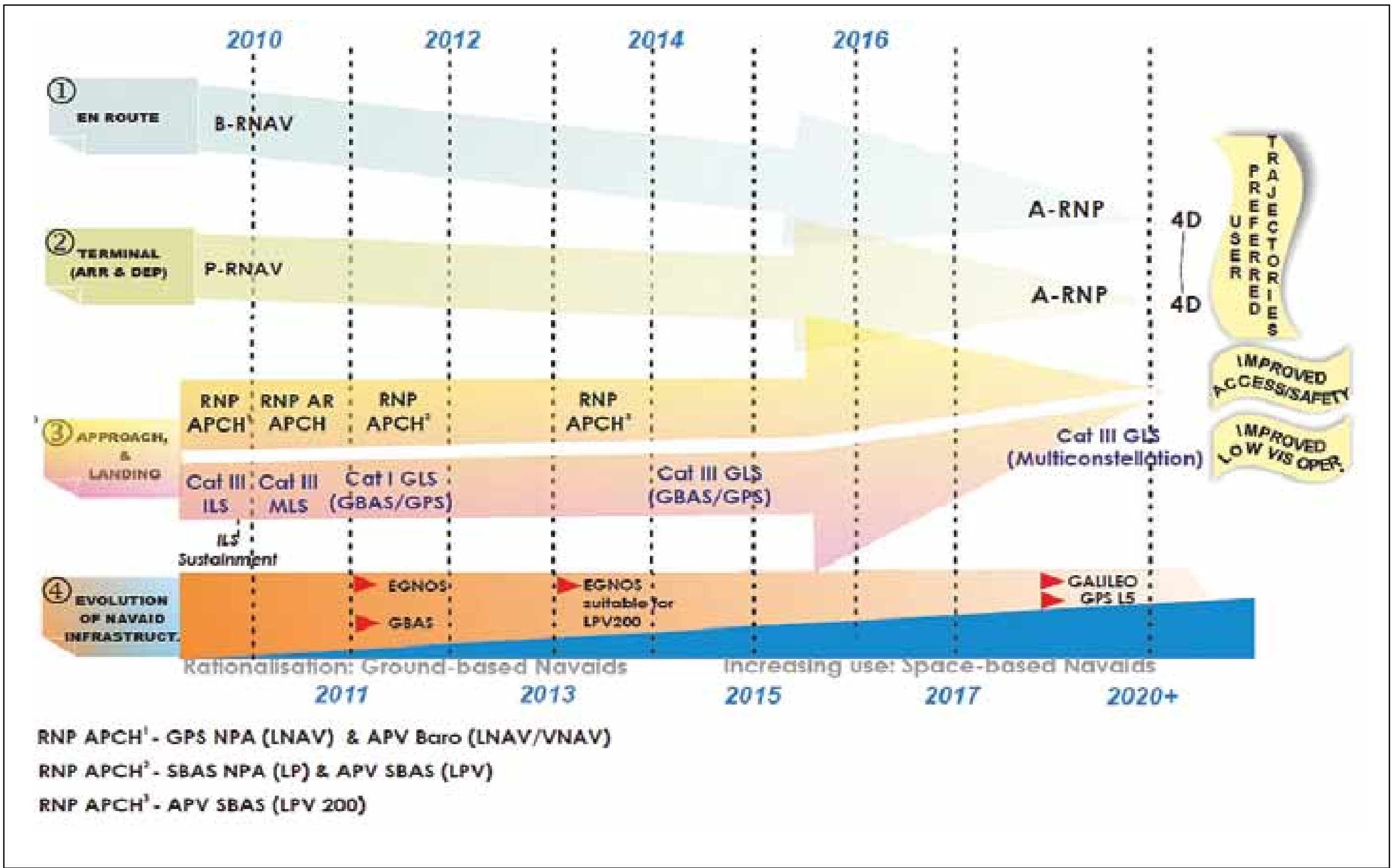
Airport access and landing also depends on navigation with an approach system of some form providing guidance towards the runway and the capacity of the landing system to guide the aircraft to touchdown. Precision approach and landing has traditionally been associated with instrument landing system (ILS), but increasing use is being made of satellite technologies for landing (generally referred to as GLS) which will allow for landings with minima comparable to that of ILS. Where there is no precision approach system, instrument approaches have been conducted using a non-precision approach. With the advent of GNSS, RNAV approaches have become realisable and with the use of space-based augmentation with barometric altimetry, these procedures can be flown in a manner very similar to precision approach, enhancing safety and improving access.

THE NAVAID INFRASTRUCTURE AND NAVIGATION TOOLS

Navigation applications cannot be realised without a navaid infrastructure. The traditional ground-based infrastructure consists of navigation aids such as non directional beacon (NDB), very high frequency omni-directional ranging systems (VOR) and distance measuring equipment (DME), which have been with us for 50 years or more. Today's infrastructure also includes a satellite-based infrastructure. Presently, only one such constellation, global positioning system (GPS) is fully operational, though in the future, the European constellation of Galileo will be added and the Russian Glonass will be operational at the end of 2010. The generic name for any satellite constellation used for positioning is global navigation satellite system (GNSS).

GNSS provides the user community with a navigation capability which is significantly more accurate than any ground-based navigation sensor and has the potential to support global operations through all phases of flight and ground movement unlike the terrestrial aids which are limited by line of sight. So when can we rationalise these potentially obsolescent ground-based systems? The answer is only when globally we are able to accept the safety implications associated with reliance for navigation being placed upon signals from a satellite source radiating a radio signal at the power close to that of a domestic light bulb. The expectation is that the first ground aids to go would be the NDB and VOR as these provide, at best, limited value to RNAV operations. DME, and possibly also the military's tactical air navigation (TACAN) will remain as a back-up, together with autonomous onboard navigation functions (e.g. inertial navigation systems) to enable continued operations if the GNSS signal is lost. Any such rationalisation will need to be coordinated at a European level to ensure a draw-down does not affect overall system performance; today the computers on aircraft take no account of State boundaries and will use any and all navigation signals in view. The benefit to operators of no longer having to carry legacy equipment will only be realised if there is global agreement on transition to GNSS and the requirements for back-up. These ECAC-wide and global coordination tasks are important roles of the Navigation Team.

Supporting tools which assist ECAC harmonisation and standardisation are of the utmost importance in meeting both application and infrastructure needs. Several navigation tools are used in support of the navigation applications or the navaid infrastructure. The tools include AUGUR, an online operational tool made available 24/7 (www.ecacnav.com), providing assessment of availability of GNSS for en-route and approach operations. An RNAV validation tool (RVT) is available, supporting the assessment of RNAV procedures, DEMETER is available to determine coverage of DMEs and PEGASUS provides performance assessment to support both precision landing (GBAS) and approach developments.



Navigation roadmap

THE NAVIGATION ROADMAP

In terms of both airspace and navigation, a major change is envisaged from the navigation requirements for today's fixed ATS route structure and those for 4D business trajectories identified as key requirements in the SESAR ATM Concept for 2020+. The development in navigation capability needed to realise the SESAR concept is the final objective of EUROCONTROL's navigation activities.

Fully consistent with SESAR's ATM Master Plan, the future ECAC Navigation environment is set out in the Navigation Roadmap. This roadmap reflects ICAO's PBN Strategy as agreed at the 36th ICAO General Assembly in September 2007 and updated at the 37th Assembly in September 2010. It describes navigation applications and how these are supported in terms of required performance, equipment functionality and enabling infrastructure. In identifying the navaid infrastructure, the strategy takes due account of the ICAO Global CNS Concept and the EUROCONTROL GNSS Policy.

This roadmap is summarised in the figure above. For en-route and terminal operations, it shows the move towards advanced RNP from today's basic and precision RNAV environment leading ultimately to the SESAR 4D business trajectories. For approach, it shows the move from non-precision approach to area-navigation-based approaches using the PBN specification for RNP APCH. For landing, it shows the maintenance of a category III (blind landing) capabilty of ILS and MLS but augmented by GNSS landing system (GLS) initially at Cat I with a 200 ft decision height but ultimately leading to a full Cat III GLS. The roadmap also identifies the move from today's infrastructure to one where, with multiple constellations available, increased reliance will be placed upon GNSS.

CONCLUSION

Until the mandate for the carriage of B-RNAV equipment in 1998, ECAC navigation had been based for over 50 years on a route structure predicated on VOR and NDB. The RNAV mandate provided a 30-40% increase in ECAC en-route capacity. However, with this came a challenge. Navigating using VOR or NDB resulted in navigation applications that were stable for these 50 years, but each generation of RNAV (B-RNAV, P-RNAV, A-RNP, 4D, etc.) offers new capabilities which enable new navigation applications to support ATM system developments. Ensuring there is a development path that provides coherent avionics (RNAV/FMS) and ATM developments requires global coordination in which the Navigation Team is playing a vital role.

PBN: optimising airspace and improving airport access

Roland Rawlings, Navigation Applications Expert, and Rick Farnworth, RNAV Approaches Expert, at EUROCONTROL, outline the benefits of performance-based navigation in the several phases of flight.

BACKGROUND

Although performance-based navigation (PBN) is 'new' as a term, its gestation has been long. One could say that it started the first time pilots used instrument navigation, i.e. the first time they used on-board instruments to read signals from the ground.

Instrument navigation originally made use of ground-based fixed navigation aids – initially the non-directional beacon (NDB) followed later by the VHF omni-directional ranging system (VOR) and distance-measuring equipment (DME). The route structure of continental airspace was defined as tracks leading to and from these ground navigation aids. Where additional routes were required, new navigation aids had to be installed.

From the 1960s and 1970s, area navigation (RNAV) systems began to appear on board aircraft. Such systems used signals from several navigation aids to compute a position and allowed the aircraft to navigate along any route independent from the location of the ground navigation aids. This separation of the route structure from the location of navigation aids allowed new routes to be implemented without new aids having to be installed.

However, in order to take advantage of such capabilities, a significant proportion of the aircraft flying in the airspace had to be capable of flying along such RNAV routes. Handling a mixed fleet of aircraft where some can and some cannot fly RNAV has proved unworkable. In Europe, the ATS route structure remained firmly linked to the ground navigation aids until the ECAC made the carriage of basic-RNAV equipment mandatory in 1998, more than twenty years after aircraft with this capability had started to become available. It was only at this time that a sufficient population of aircraft were equipped to make this requirement achievable. A requirement for more sophisticated RNAV capabilities would have called for a significant retrofit of aircraft, which would have been too costly for aircraft operators.

PBN: optimising airspace and improving airport access (cont'd)

Airspace requirements tended to be defined around the capabilities of the aircraft and often around specific systems. This approach has led to different performance and functional requirements being applied regionally. To overcome the proliferation of RNAV applications, ICAO developed the concept of required navigation performance (RNP), which standardised the navigation accuracy requirements for particular types of route. Nevertheless, many different specifications of navigation capability emerged, because navigation accuracy turned out to be just one of a number of requirements which needed to be standardised for RNAV operations. The variety of solutions was accompanied by significant confusion across the globe regarding concepts, terminology and definitions. It became evident that unless this problem was addressed, it would only get worse and hinder improvements in airspace capacity and efficiency.

ICAO established the Required Navigation Performance and Special Operational Requirements Study Group (RNPSORSG) to act as the focal point for addressing several questions related to required navigation performance. The group reviewed the ICAO RNP concept and its impact thoroughly. It developed an agreed understanding of what is now the PBN concept and the relationship between RNP and RNAV system functionality and applications. The aim was to harmonise existing implementations, establish a basis for the harmonisation of future operations and limit the number of global navigation specifications in use.

PERFORMANCE-BASED NAVIGATION

The ICAO PBN Manual contains navigation specifications for various navigation applications covering the various phases of flight. These specifications define the RNAV system performance requirements in terms of accuracy, integrity and continuity, and a series of functional requirements which are needed for aircraft to operate within a particular airspace concept. PBN seeks to initiate a shift from sensor-based specifications to a set of requirements which are performance-based and not tied to a particular set of navigation systems and on-board architectures. There may be several technologies available which could meet a navigation specification, and operators are free to choose which one suits them best.

RNAV approach procedures using GNSS provide a safer operation to those runways which are not equipped with precision-approach systems.

The PBN concept recognises that the driver is not just the navigation capability on board the aircraft but that it also depends on the CNS infrastructure and in particular the airspace concept being applied. It also takes account of the fact that RNAV systems have developed over a 40-year period, and as a result there are a large variety of on-board implementations. Identifying navigation requirements, rather than the means to meet the requirements, allows the use of all RNAV systems which meet these requirements, irrespective of the means by which they are met.

A navigation specification is a set of aircraft and aircrew requirements needed to support a navigation application within a defined airspace concept. The PBN concept assumes that future navigation will rely more and more on a robust RNAV capability, leading to higher system integrity requirements, in particular as the aim is to remove VOR and NDB navigation aids which today can be used to cross-check the performance of the RNAV system. To provide such integrity, there needs to be a flag which indicates when the performance requirements required in the airspace are not met. Some navigation specifications have a requirement for on-board performance monitoring and alerting. These are referred to as RNP specifications. Those specifications not having such requirements are referred to as RNAV specifications.

EN ROUTE AND TERMINAL

The first edition of the PBN Manual has harmonised the current situation, and the navigation specifications have been derived from existing standards. During the development of the manual, it was identified that for continental operations expected in the ECAC area, parts of North America and potentially elsewhere, there was a need for improved functionality. An advanced RNP (A-RNP) placeholder was entered in the manual, but no specification was available. Through the ICAO PBNSG (the successor to the RNPSORSG), work is underway to develop the A-RNP specification. This will be the first attempt at deriving the navigation specification from an airspace concept. Inevitably, it will have to be a carefully crafted balance, taking into account the target implementation timescales (2017-20), the needs of the global ATM community and the ability to meet cost-benefit criteria. An important aspect of this work is the fact that there is a conscious effort to develop a specification which, for continental navigation, can provide a

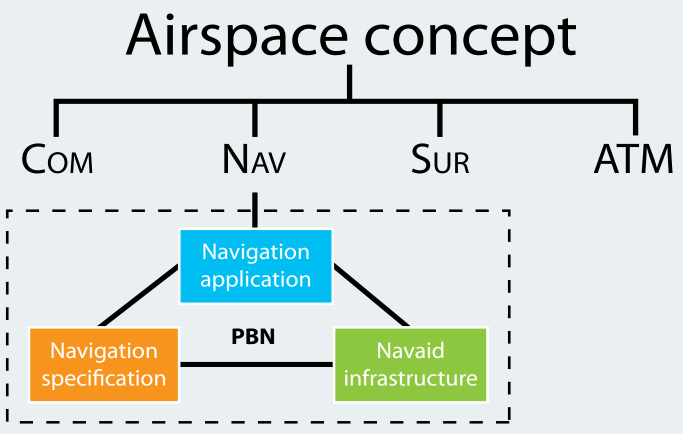


Figure 1: PBN in context

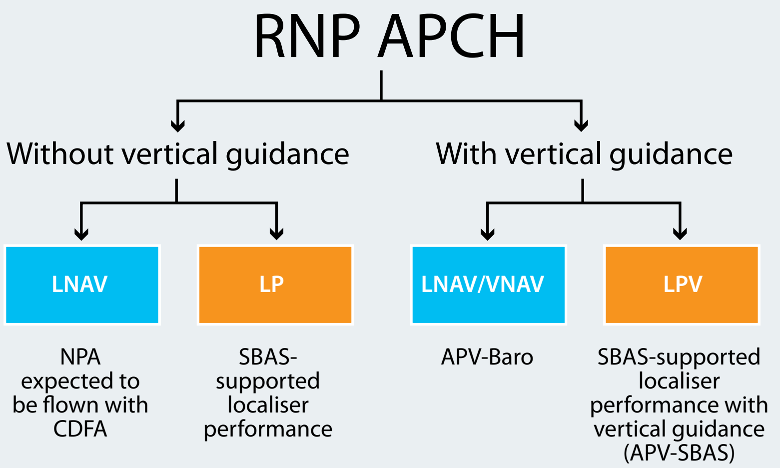


Figure 2 : RNP approach types as described in the ICAO PBN Manual (Doc 9613)

Note: LNAV = lateral navigation; LP = localiser precision; VNAV = vertical navigation; LPV = localiser precision with vertical guidance; CDFA = continuous descent final approach; SBAS = satellite-based augmentation (EGNOS, in Europe); APV = approach with vertical guidance.

capability for operation in all phases of flight, and can, through the application of GNSS, be applicable globally. This offers airframe manufacturers the potential to offer a single navigation capability, specified globally, with obvious economies to the operators in avoiding multiple equipage requirements with accompanying certification and operational approval costs.

PBN AND APPROACHES

In the approach area, benefits can be achieved more quickly. It is not necessary to have a large proportion of the fleet equipped before a procedure can be implemented. RNAV approach procedures using GNSS provide a safer operation to those runways which are not equipped with precision-approach systems. They also provide more reliable access by allowing lower approach minima. The provision of vertical guidance on an RNAV approach improves safety even further. RNAV approach procedures with vertical guidance are referred to as APV procedures. The vertical navigation capability is made possible either by the integration of barometric vertical data or through the use of a satellite-based augmentation system (SBAS). In the case of SBAS procedures, the minima can be as low as 200 ft, which is equivalent to that achieved using ILS Category I.

The terminology used to describe RNAV approaches has evolved over time and become rather confusing. In the development of the PBN Manual, ICAO agreed on a naming convention, putting RNAV approach specifications into the PBN Manual. They fall under the heading of RNP APCH. There are four flavours of RNP APCH, as illustrated in Figure 2 and they are flown to different minima lines published on the approach chart.

The chart title for all these approach types will be RNAV (GNSS) with the runway heading. For example RNAV (GNSS) RWY 26. There may be several minima lines on the same chart. As indicated in the chart title, GNSS is necessary in order for such procedures to be performed.

It is recognised throughout the community that the introduction of RNAV approaches with vertical guidance provides safety benefits. The 36th ICAO Assembly, held in September 2007, agreed a resolution encouraging States to implement approach procedures with vertical guidance at all runway ends.

This resolution was reiterated at the ICAO's 37th Assembly in 2010. Either APV type of approach (APV-Baro or APV-SBAS) can be implemented in compliance with this recommendation. EUROCONTROL has established the RNAV Approach Task Force (RATF) to co-ordinate the activities necessary for the implementation of RNAV approaches in the ECAC area and to monitor implementation status.

THE WAY FORWARD

PBN is clearly the way forward for RNAV and RNP. If it is to succeed, it requires a strong partnership between ANSPs, airspace users, regulators and others. This partnership has already started at ICAO level (global and regional), and as more PBN implementations are sought, it will cascade to the operational level and improve safety, efficiency, capacity and access, and help mitigate the environmental impact. ■

Precision landing

Improving safe access in low visibility

Sylvie Grand-Perret and Andreas Lipp, precision landing specialists at EUROCONTROL, outline the potential of GLS, the GNSS (global navigation satellite system) landing system based on GBAS (ground-based augmentation system), to provide improved operational and cost efficiency.

INTRODUCTION

At the same time that radio navigation was being introduced to support en-route operations by night and in limited weather conditions, the need for an effective landing system was also being identified. Initially approaches were assisted by lights at the aerodrome, but these were insufficient in poor visibility. Therefore, in the 1920s a specialised radio navigation system started to be developed for the final phase of flight and in 1929 an instrument landing system (ILS) was first demonstrated. After over 70 years of successful operations, during which its capability was gradually improved to a point where blind landings and automatic runway roll-out were possible, this approach and landing system is now under pressure and a cost-effective replacement is being sought.

ILS DEVELOPMENT

ILS was designed to provide lateral and vertical guidance relative to an ideal approach path. Early ILS development required the pilot to take over visually before committing to land. This became known as the 'decision height' (DH) and is the point at which the pilot must visually acquire the runway or the specific precision approach lighting, or must initiate a go around. Initially ILS was able to support a guided approach down to a DH of 200 feet/60 metres.

Developments in autopilot and flight display design, improved ground system accuracy and service continuity together with the development of approach lighting made lower decision heights possible. In 1964 the first automatic landing was demonstrated and in 1972 the first blind landing was performed. As a basis for identifying system capability, ICAO introduced a series of categories to indicate the minimum approach height which could be achieved with each system's performance. These categories are:

	Decision height (DH)
CAT I	≥ 200'/60m
CAT II	≥ 100'/30m
CAT III	< 100'/30m down to no DH

Each category is associated with a runway visual range which is the actual visibility on the runway.

CAT III systems have significantly increased flight safety and improved airport access in the most difficult weather conditions. However, CAT II/III operations require increased separation between arriving aircraft to prevent interference with the radio signal generated by the previous aircraft.

ILS LIMITATIONS

ILS signals can suffer from interference from static and mobile sources in the transmission area. The growth in air travel since the 1970s has seen a significant increase in airport aircraft movements and considerable construction around many airports. Protection of the signal is becoming increasingly difficult. Furthermore, ILS uses radio frequencies close to the FM radio stations and the growth of these commercial enterprises is putting pressure on the aviation industry.

OPTIONS FOR CHANGE

The 1970s microwave landing system (MLS) was considered a robust alternative to ILS. MLS overcame several ILS limitations by using a completely different radio frequency which resolved problems of signal distortion. MLS was standardised in 1978 but failed to become widely deployed due to a lack of airport and civil airspace user commitment. Furthermore, an emerging GPS (global positioning system) technology became the primary focus and interest in MLS waned. As a result, while London Heathrow has an operating MLS capable of providing guidance to Cat III, no other MLS implementations are planned.

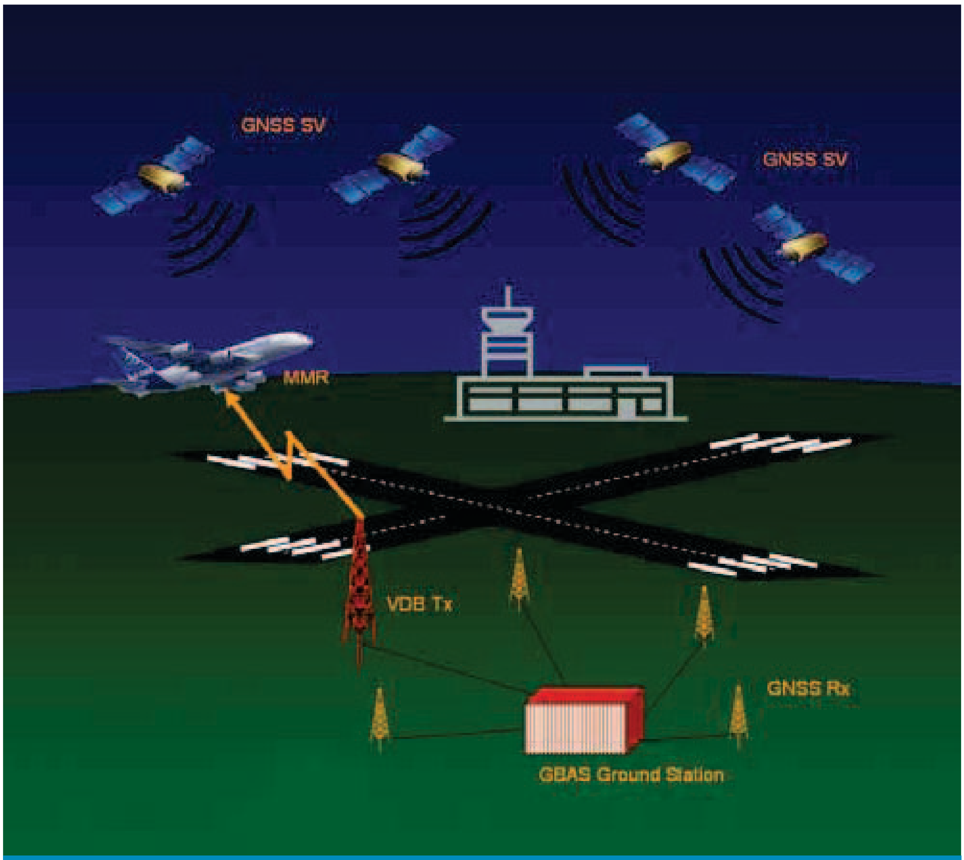
GNSS LANDING SYSTEM (GLS)

In the early 1990s, another alternative to ILS was identified. This GLS precision approach and landing system uses a ground-based augmentation system (GBAS) which enhances the capability of the GNSS satellite constellation. It will initially use just GPS but ultimately augmentation of multi-constellation GNSS will be provided.

GBAS offers greater flexibility by supporting GLS operations on multiple runways, with a single system offering lower implementation and operating costs. The switch to GBAS is in line with ICAO's strategy of satellite navigation for all phases of flight.

The GBAS system consists of three elements depicted in Figure 1:

- the satellite constellation;
- the ground station, consisting of receiving antennae, a processing unit, an approach database and a datalink transmitter;
- the aircraft, fitted with a GBAS receiver possibly through a multi-mode receiver (MMR).



GEO – Geostationary orbit
GPS – Global positioning system
MMR – Multi-mode receiver
VDB – VHF data broadcasting

Figure 1: Ground-based augmentation system (GBAS)

WHY THE TRANSITION FROM ILS TO GLS?

ILS and MLS have high operating costs and have to be deployed at each end of the runway. ILS also has significant operational limitations, notably on airport throughput, in low-visibility conditions. A move from ILS to GLS would:

- improve airport capacity in low-visibility conditions by providing additional landing slots;
- reduce installation costs – potentially only one GBAS system is required per airport;
- reduce maintenance costs;
- allow alternate approach paths and displaced thresholds;
- support cost-efficient use in complex runway situations;
- eliminate interference from aerodrome movements;
- support curved and segmented approaches.

In addition, the use of the GPS, Galileo and, potentially, the other GNSS constellations would result in the same navigation signal being used for all phases of flight, with resultant savings in aircraft equipment costs.

This transition needs to be managed and, based on the MLS migration experience, a phased approach is proposed. This will initially develop and implement GLS CAT I as an ILS look-alike using GPS alone and then build on the experience gained.

Improved flight efficiency and airport operation flexibility and capacity will be provided when GLS CAT III is achieved. Initially, a number of limitations are expected due to reliance on GPS only. Full benefit will be delivered once Galileo and other GNSS constellations become available.

Precision landing
Improving safe access in low visibility (cont'd)

GBAS CHALLENGES

Development and implementation of GBAS is not an easy task as there are some fundamental issues which need to be addressed to ensure correct deployment:

- Some European States are concerned about depending on current satellite navigation capabilities during low-visibility operations, especially with the possible risk of interference stemming from sources such as solar flare activity.
- The cost of new on-board equipment and the associated retrofit costs.
- Identifying and developing the appropriate redundancy measures for system outages.
- While ILS performance and limitations are well known and ILS system prices (onboard and ground equipment) are relatively low, GBAS systems are currently at a low rate of production and therefore more expensive.
- The need to maintain ILS carriage at least to support ILS operations before a worldwide transition is achieved and potentially in the long term to sustain operations during periods of high solar activity.
- Confirmation that GLS using GBAS can be made safe and secure for all operations, down to CAT III.

CURRENT GBAS DEVELOPMENT SITUATION

The aviation industry has embraced GBAS because of the numerous advantages that have been identified, and GBAS equipment suitable for supporting Cat I operations is starting to be deployed. Early trials have demonstrated that GBAS equipment designed for CAT I operation may provide a better level of service and could support GLS operations up to CAT II. Global development standards for the validation of GBAS CAT III were agreed in early 2010. The first operational CAT III systems are expected in the period 2013 to 2015. The systems currently under development are designed to allow full interoperability of GLS CAT I-certified aircraft. Ground systems are designed to be upgradeable to meet service provider performance requirements as they evolve. Within Europe it is widely accepted that GLS benefits will only be fully achieved with CAT II/III capability.

The first operational CAT III systems are expected in the period 2013 to 2015.

GBAS CAT I DEPLOYMENT

GBAS ground stations are being installed at a rate of about 10 per year. Figure 2 shows the current GBAS ground station worldwide deployment.

Boeing and Airbus have certified their GLS CAT I operation for a large part of their fleet; for some aircraft GLS is standard fit. Both manufacturers are actively working on GLS CAT III certification criteria and airworthiness demonstration for 2013. The worldwide fleet GLS equipage forecast is depicted in Figure 3.

Since 2008, QANTAS has been using GLS in regular operations and they

Figure 2: GBAS ground system implementation (www.flygls.net)

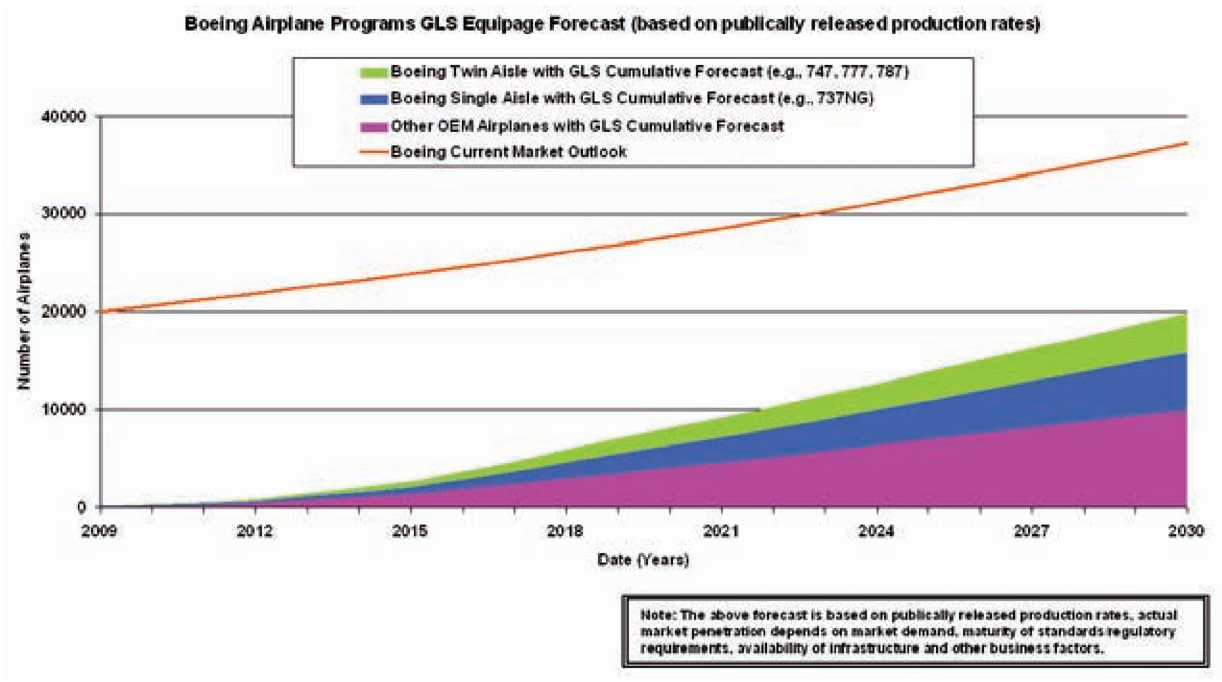


Figure 3: Boeing forecast for GLS aircraft equipage (Courtesy Boeing)

were joined by airberlin in 2009 (read relative article on page 86). Other airlines such as Lufthansa, ANA, Emirates and Continental have also invested in GLS.

Although GLS CAT III is the final expectation for major airlines, CAT I is able to provide benefits in locations which do not currently permit an ILS installation, e.g. where land is not available for ILS installation or where terrain features around the potential site for the ILS antenna would cause an unacceptable distortion of the ILS path.

EUROCONTROL'S CONTRIBUTION TO GLS

EUROCONTROL contributes to GLS and in particular GBAS by representing the European perspective at global level within ICAO and at industry fora. Within SESAR, EUROCONTROL is working on all packages relating to GBAS. EUROCONTROL supports the development of international standards. In addition it provides a manufacturer-independent data evaluation toolset called PEGASUS allowing unbiased assessment of products from competing manufacturers. EUROCONTROL has also looked at how to move from ILS to GLS based on economic and operational assessments and has studied the safety and security aspects of the GLS transition.

Since 2008, QANTAS has been using GLS in regular operations and they were joined by airberlin in 2009.

CONCLUSION

ILS is under growing pressure today. In low visibility, ILS limitations significantly affect airport capacity. GLS has the potential to provide a greater level of efficiency and to be more cost-effective.

For Europe, GLS CAT I is not considered sufficient and CAT II/III capability is required. Initial institutional concerns regarding the exclusive use of GPS will be mitigated by the appearance of GBAS systems providing augmentation of GLONASS (Russian) and GALILEO (European) signals, which will enable a multi-constellation, multi-frequency GLS precision approach and landing. This final goal has the potential to overcome all the current ILS limitations by providing guaranteed access for operators to airports equipped with GLS CAT III regardless of visibility. ■

LINKS

1. **GBAS implementation website: http://www.flygls.net**
2. **EUROCONTROL GBAS activities:**
   http://www.eurocontrol.int/eec/public/standard_page/ETN_2010_2_GBAS.html
   http://www.ecacnav.com/RNAV_Applications/GBAS

Looking to the skies … but keeping our feet on the ground

Providers of navigation services take great care to operate an infrastructure that sends reliable "signals in space" to aircraft's electronic navigation systems. These positioning and timing signals are an often unseen enabler of efficient traffic flows. Navigation infrastructure is undergoing a transition from ground-based to space-based signals. To ensure that these services can expand their operational benefits while maintaining their excellent safety record, EUROCONTROL contributes to these developments on many levels. In some cases, its contribution comes through tools, as outlined in the second part of the article. However, the tools may also serve the applications discussed in previous articles.

Gerhard Berz, Charlie Eliot, Francisco Salabert, and Valeriu Vitan, responsible for Navigation Infrastructure, at EUROCONTROL, explain.

BACKGROUND

To enable regular scheduled air services to operate uninterrupted by weather, navigation aids were developed. Non-directional beacons (NDBs) were introduced in the 1930s and provided an indication of the station's location. The subsequent VHF omni-directional range (VOR) permitted aircraft to fly a course to and from the facility, allowing the pilot to correct for crosswind. Later, distance-measuring equipment (DME) was co-located with the VOR to give distance to the station. VOR/DME has been the backbone of route networks for many decades. The instrument landing system (ILS) enabled safe approaches to the runway in poor weather. Early oceanic and remote area long-range navigation provided aviation with greater challenges, as terrestrial navaids require radio line-of-sight. Traditional navigation skills with a clock, heading and speed supported by astronavigation (not simple on a fast-moving aircraft subject to wind) were significantly assisted by Omega, and currently, inertial navigation systems. However, the solution was never ideal. With the advent of the global navigation satellite system (GNSS), these challenges have become a thing of the past. Aviation soon realised that this trans-oceanic necessity could also improve continental operations by removing the operational constraints of a route network tied to VOR and NDB locations. Consequently, GNSS has become a key enabling infrastructure for PBN (performance-based navigation) and will ultimately support the SESAR operational concept of 4D trajectory navigation.

EVOLVING NAVIGATION INFRASTRUCTURE

Today, GPS is the only GNSS constellation that is fully operational. This evolving satellite technology is providing accurate positioning and timing services that are progressively being used not only for navigation, but also for communication and surveillance applications. One key advantage is that these signals are available globally without suffering radio horizon limitations. However, no satellite constellation (the US GPS, Russia's GLONASS and the future European Galileo) has been specifically designed to meet aviation safety requirements. Therefore, augmentation systems have been developed to meet this need, providing integrity, improved accuracy and continuity. These augmentation systems either reside on the aircraft, known as aircraft-based augmentation (ABAS), or are based on specifically deployed infrastructure. The European geostationary navigation overlay service (EGNOS) provides continent-wide augmentation (SBAS) and ground-based augmentation supports precision approach (GBAS).

The impact of GNSS failures upon ATM is significantly more critical than the impact of a failure of individual terrestrial navaids because of the size of the airspace that could be affected. To enable a progressive reliance on GNSS, aviation is assessing its vulnerabilities to implement appropriate mitigations. The mitigations can come through anything from receiver technology to operational measures, and will be greatly enhanced by new GNSS developments such as Galileo and EGNOS, the latter to become operationally usable by early 2011. The final goal is a multi-frequency primary navigation service provided by Galileo, GPS and possibly GLONASS, with ground-based back-up provided by DME and ILS. These conventional navaids will be needed for some time, depending on how far GNSS mitigations can be developed. Other conventional navaids, NDB and VOR, with a limited utility in a PBN environment, will be gradually reduced in number.

GPS is the only GNSS constellation that is fully operational. This evolving satellite technology is providing accurate positioning and timing services that are progressively being used not only for navigation, but also for communication and surveillance applications.

The main vulnerabilities of GNSS are propagation disturbances and interference. A portion of the upper atmosphere, the ionosphere, which stretches from a height of about 50 km to more than 1000 km, is subject to irregularities caused by solar eruptions. These impact GNSS signals as they travel through the ionosphere and can cause receivers to produce incorrect measurements. Both interference and ionosphere disturbances can be significantly mitigated by the availability of GNSS signals on multiple frequencies, which is under development.

EUROCONTROL is studying both the effects of interference and ionosphere disturbances, the latter especially with the forthcoming height of the 11-year solar cycle in 2012/2013. The results of these and other studies provide guidance to GNSS satellite system providers, augmentation service providers, receiver manufacturers and the associated standardisation process to ensure that GNSS developments result in a cost-effective and robust service that provides maximum benefit to the ATM community. Providing such guidance is a very multilateral process: from partnerships with the European Commission and the European Space Agency, contributions to the ICAO Navigation Systems Panels as well as industry forums, information needs to be shared, awareness raised, and efforts coordinated.

While supporting GNSS evolution and implementation, EUROCONTROL is also involved in a variety of projects to optimise conventional infrastructure. Especially the deployment of new facilities to support PBN needs to be considered judiciously. This is due to cost but more importantly because of spectrum issues. The L-band from 960 to 1215 MHz contains established navigation and surveillance systems (DME, SSR) while a variety of new CNS services (GNSS, ADS-B and

Looking to the skies … but keeping our feet on the ground (cont'd)

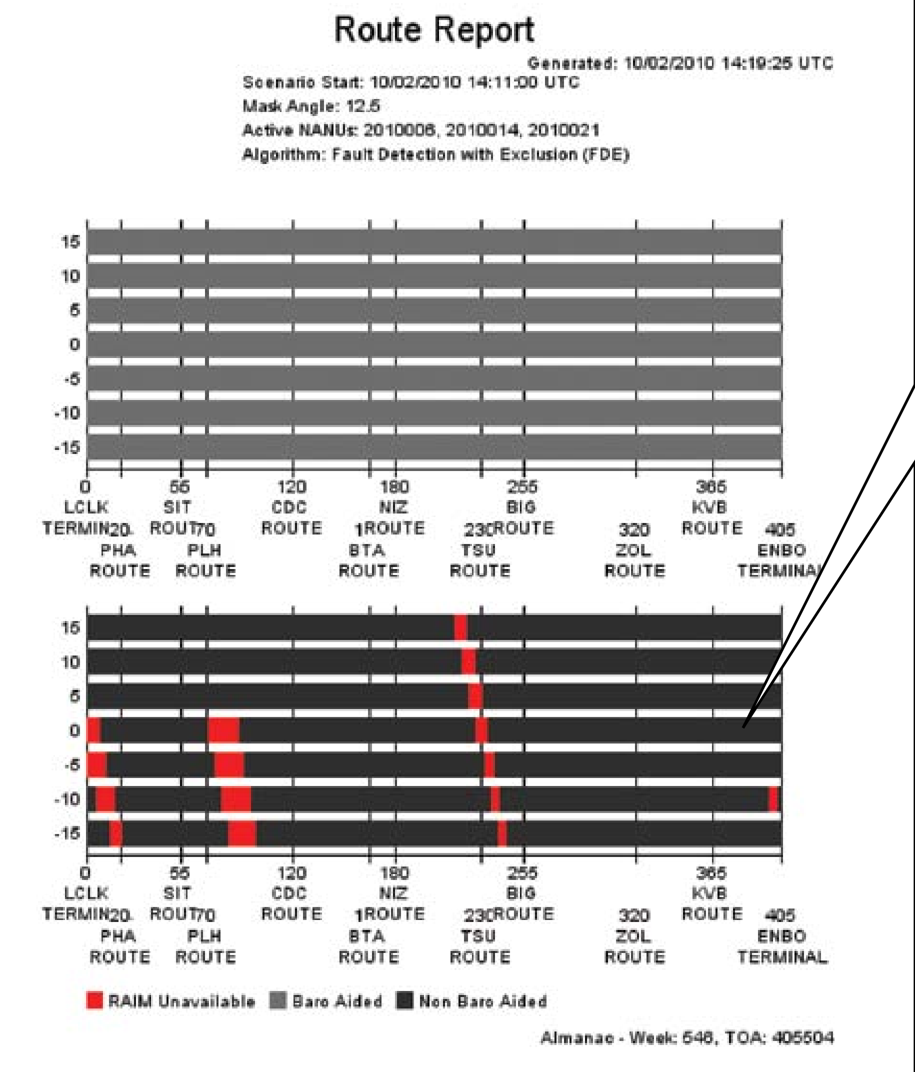
others) are also trying to find a home. Infrastructure activities contribute cross-discipline expertise to ensure that new services can be implemented safely. Especially the planning of DME evolution will require a new level of cross-border cooperation in the coming years, because DME/DME positioning is an established GNSS back-up while new CNS services are needed just as much for the trajectory-based operations of SESAR. A significant activity of recent months has been the upgrade of the DEMETER tool, described below, and associated validation efforts to investigate what level of coverage prediction accuracy can be achieved with a specific level of terrain data quality and resolution. Such efforts are crucial for realistic evolution planning that succeeds in striking a good balance between infrastructure cost and operational safety and efficiency.

While working arrangements are changing to lead and contribute in various SESAR projects, infrastructure efforts at EUROCONTROL continue to support service providers and users in ensuring that navigation systems remain an "invisible success story" thanks to interoperable and continual service. In addition, EUROCONTROL supports the ATM community by providing a set of tools which have been developed to enhance operations.

EUROCONTROL'S NAVIGATION TOOLS

Support to States

EUROCONTROL supports both the standardisation and implementation process. Once standards have been written, there is still a lot of work to help ensure harmonised implementation across Europe. Harmonisation is important because it contributes to safety, establishes best practice and creates economies of scale. This is especially true when it comes to support tools. Independent developments



AUGUR route assessment

would be inefficient and increase the cost of implementation. Many of the tools focus on data quality – especially with the move from station-based navigation to coordinate-based navigation, getting coordinates right becomes a matter of avoiding operational hazards all the way up to controlled flight into terrain (CFIT). Making such tools available on a free basis ensures that they are available to all European partners working on implementation, regardless of their individual budget situation. The development of these tools is always the result of close coordination between implementing organisations.

AUGUR: Pre-flight planning for GNSS operations

Part of a pilot's duty is to check whether required navigation facilities will be available en-route and at the destination airport. This becomes a little more complicated if the navigation aid is orbiting in space. AUGUR estimates GNSS performance and takes into account scheduled maintenance actions on satellites. This way, operators can find out whether GNSS will be available along their planned route. AUGUR is becoming part of a NOTAM system for ABAS and SBAS operations.

DEMETER: Conventional infrastructure assessment and optimisation

With performance-based navigation (PBN) moving routes away from navigation facilities to where they are operationally needed, an assessment needs to be made if the current facilities provide sufficient coverage to enable RNAV (area navigation) based on DME/DME (distance measuring equipment) positioning.

DEMETER is a tool that models facility coverage using a terrain database and assesses how RNAV functions

GNSS/RAIM predicted to be not available along filed flight plan, including a time window of +/- 15 min.

can be supported. Specific features help determine where navigation aids can be rationalised (VOR, VHF omni-directional radio range) and where new facilities may be needed (DME). DEMETER has just undergone a significant upgrade.

RVT:
Helping procedure designers "speak FMS"

The prototype RNAV validation tool (RVT) conducts a variety of rule and coding checks to help ensure that published procedures will be flyable by the large variety of aircraft in use today. A 3D view coupled with a trajectory simulator can display the expected distribution of tracks. Although not a final validation tool, it means that any silly mistakes do not have to be made in an expensive simulator or operational environment.

FAS DB (Final approach segment data block):
Hitting the runway

GNSS approach procedures use an algorithm called cyclic redundancy check (CRC) to ensure that whatever data is provided by an air navigation service provider (ANSP) is correctly translated into the avionics guidance functions in the aircraft. The FAS DB tool packs the 3D final approach track into a specific data record and calculates the CRC. The CRC function is then used at each point in the data chain to check that no data has changed.

MET (Minima estimation tool):
Chasing the cost benefit

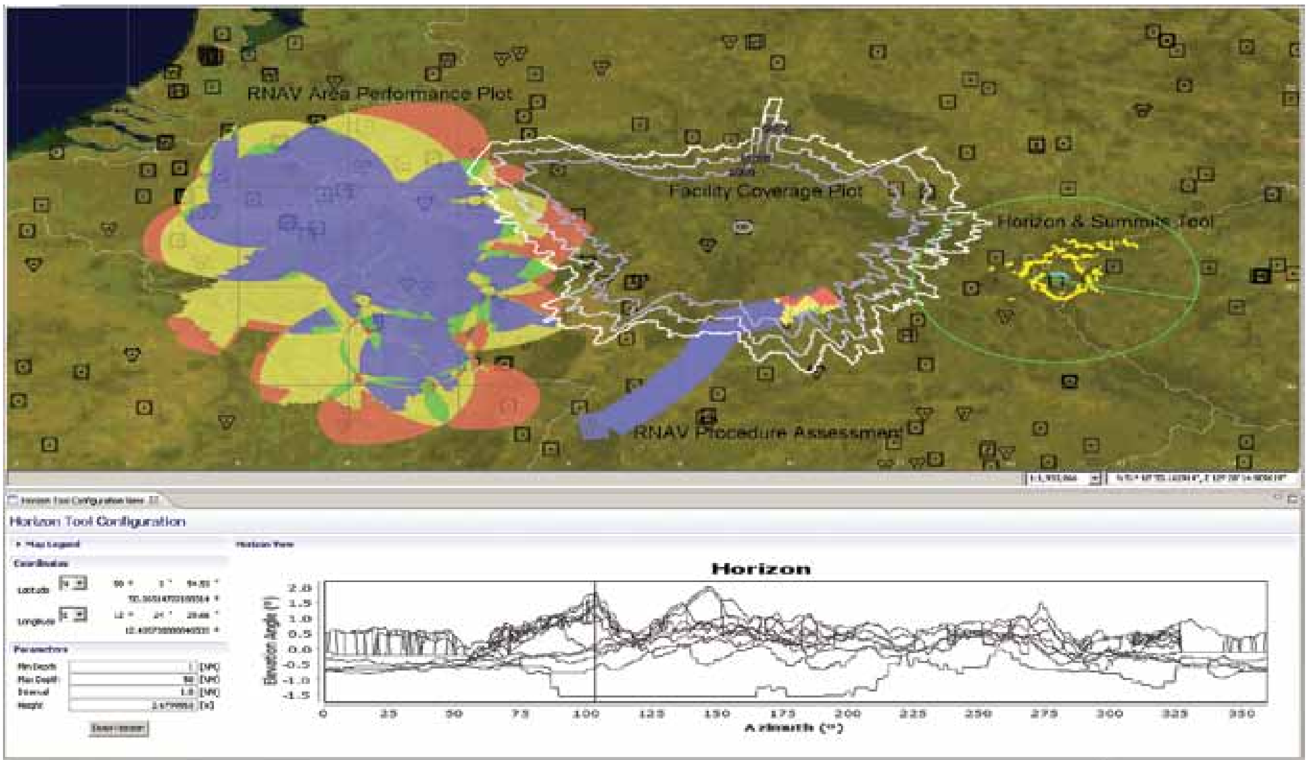
Before committing resources to a full GNSS approach procedure design, stakeholders need to know what the expected descent minima will be. The MET estimates the likely height of these minima.

PEGASUS:
Implementing SBAS and GBAS

PEGASUS processes data to analyse required navigation performance in terms of GNSS accuracy, integrity, continuity and availability, both pre- and post-implementation. This is part of ensuring the ANSP commitment to provide a signal in space that meets ICAO standards, both for SBAS (space-based augmentation system) and GBAS (ground-based augmentation system). When installing GBAS at an airport, PEGASUS supports site and operational approvals for Cat I precision approach. Shortly, an update of this toolset will provide GBAS Cat II/III approach functionality.

All of these tools are available to stakeholders free of charge.

Further information and download instructions can be found at: http://www.ecacnav.com/Tools



DEMETER facility coverage and RNAV redundancy assessment

The changing face of surveillance

SURVEI

John Law, Head of the Surveillance and Code Coordination Unit at EUROCONTROL, describes how the entire surveillance infrastructure and environment are changing, presents the measures already established to promote this change, and argues that careful management is necessary to retain the necessary levels of safety, performance and interoperability.

The objective of the surveillance infrastructure is to provide the required functionality and performance to enable a safe, efficient and cost-effective service.

Not too long ago, the surveillance infrastructure was composed of monopulse (secondary surveillance radar (SSR), SSR Mode-S and primary surveillance radars (PSRs). Recently, however, technological developments such as automatic dependent surveillance – broadcast (ADS-B) and wide-area multilateration (WAM) have reached maturity for operational deployment.

In parallel, new performance targets and associated operational requirements are emerging from Single European Sky and SESAR initiatives. These factors will drive changes to the existing surveillance infrastructure. This evolution needs to be managed, for it will also be influenced by an extensive range of other factors such as global interoperability, civil-military coordination, the introduction of functional airspace blocks (FABs), and changes to the composition of the aircraft fleet with the introduction of very light jets and unmanned aircraft. Furthermore, cost and radio frequency spectrum efficiency considerations will lead to a rationalisation of the current infrastructure, in which legacy systems will be phased out as soon as practicable and new, more efficient technologies will be introduced.

Surveillance systems are a key enabler of the SESAR future operational concept. They are expected to be "leaner" and more efficient in the future – combining a layer of ADS-B with a layer of surveillance (provided either by SSR, SSR Mode S or WAM). Primary radar coverage will also be available, where required, possibly in the form of multistatic PSR (MSPSR). In addition to ground-based

surveillance, ADS-B will also enable the development of new airborne surveillance operational services including air traffic situational awareness (ATSAW), spacing, separation and self-separation.

To achieve these changes, the avionics carried on board an aircraft must become a fully integrated element of the surveillance infrastructure. The scope of surveillance systems will extend to embrace an increasingly diverse range of avionic components – such as GPS systems, traffic computers and cockpit display systems, as well as the transponders.

PARTNERSHIP FOR CHANGE

The Surveillance and Code Coordination Unit is establishing partnerships with a growing number of stakeholders to further the common objective of building the new surveillance infrastructure. These stakeholders include air navigation service providers, aircraft operators (civil and military, commercial and general aviation), avionic manufacturers, regulatory authorities (national authorities and the European Aviation Safety Agency (EASA)) and the European Commission. These each bring unique contributions which reflect their specific expertise and perspective. Collectively we are cultivating a pan-European network approach.

It is recognised that achieving this enhanced surveillance infrastructure will require significant effort, resources and commitment. The transition to the future will be challenging. Such challenges can only be addressed by all parties working in concert. There is a need for an independent/impartial expert organisation to coordinate, harmonise and pilot the process. The EUROCONTROL Agency is committed to this task.

A PROGRAMME APPROACH: FOCUSED ON DEPLOYMENT

The development, validation and deployment of a new surveillance technique is a process of major importance.

Achieving success requires vision, clarity of purpose and concrete objectives in terms of how this can be accomplished on a pan-European basis. Through close partnership with the stakeholders and the application of multi-disciplinary expertise across the entire life cycle, the Agency has demonstrated, over many years, its ability to deliver successful pan-European programmes. Examples such as the recent Mode S/ACAS Programme and the current CASCADE (ADS-B and WAM) and Aircraft Identification (ACID) Programmes serve to illustrate this.

The changing face of surveillance (cont'd)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Pierre Depape, ATSAW Multi-Programme Manager at Airbus, recently stated that *"Airbus has worked closely with the CASCADE Programme to support the validation of the ADS-B technology. The approach adopted by the programme built a unique know-how or "savoir-faire" for supporting the introduction of new technologies. The validation activities certainly accelerated the introduction of ADS-B from R&D to deployment. A solid confidence in many fields has been established between Airbus, the CASCADE team and other partners through this programme orientated approach".*

It is anticipated that such a programme approach, coordinated with the various stakeholders, will be an efficient way of supporting the operational introduction of the extensive range of deliverables coming from SESAR. (Read article on page 56 for more details.)

GLOBAL INTEROPERABILITY

A fundamental requirement for surveillance systems is global interoperability.

A surveillance system is composed of many components including avionics, ground stations and multi-sensor trackers, with interfaces to the ATM and sensor systems, etc. Therefore a systematic approach is needed to ensure that the functionality and performance delivered by each constituent part contributes effectively to the overall system requirements. Standardisation at international level is the means of achieving this, and EUROCONTROL has a principal role in this process.

Examples of existing operational and technical standards to which EUROCONTROL has contributed include ICAO documentation (ASP, SASP, etc.), SPR/INTEROP and MOPS for ADS-B applications and systems by EUROCAE/RTCA, acceptable means of compliance (AMCs) or certification specifications (CS) by EASA, and the EUROCONTROL ASTERIX data format.

EUROCONTROL is ideally placed to support standardisation activities. It integrates operational matters and technical constraints, interfaces avionics and ATC systems, and provides a focal point for the views of stakeholders such as ANSPs, regulators, aircraft operators, standardisation authorities and industry; it ensures that the pieces in the "surveillance jig-saw" all fit seamlessly together. (Read article on interoperability on page 58 for more details.)

Prior to deployment and wide-scale roll-out, a system validation has to be conducted. A considerable effort is being made to ensure that surveillance systems (ground and airborne) are performing correctly and are appropriately verified and validated for their operational use. The comprehensive suite of validation tools and platforms, the CRISTAL projects in partnership with the ANSPs, and the Pioneer Aircraft Projects for "ADS-B out" and more recently also for "ADS-B in" were all significant investments by EUROCONTROL and its stakeholders – these are investments that have been seen to have brought dividends and that have also accelerated the deployment of ADS-B.

VALIDATION THROUGH TRIALS

The approach adopted in order to validate a new surveillance technique is selected on the basis of an extensive range of factors. The validation activities of the CASCADE Programme have been established to address the performance and functioning of ADS-B systems and applications, primarily through simulations and trials. The focus here is on the extensive range of trial activities conducted to verify and validate the actual performance that an end-to-end ADS-B system achieves.

A four-pronged approach to validation through trials is being adopted through:

- dedicated "CRISTAL" trials;
- the Pioneer Airline Project;
- the use of the ADS-B validation test bed (AVT – which is the reference platform for ADS-B validation work in Europe);
- the ADS-B Monitoring Programme.

These provide impartial, independent testing designed to validate the enabling infrastructure as well as the operations.

The CRISTAL (cooperative validation of surveillance techniques and applications) trial projects have one clear objective: to perform trials in partnership with stakeholders in defined portions of local airspace in Europe ("pocket areas") where the surveillance service can be improved and where ADS-B implementation is envisaged.

The CRISTAL ADS-B out project, which covers the validation of a range of ADS-B applications, was recently launched by CASCADE in partnership with ANSPs. With its clear emphasis on the ground deployment of operationally compliant systems, it is a cornerstone of the validation activities. Currently, ANSPs from Norway, Bulgaria, Cyprus, Germany, Iceland, Denmark, Sweden and Greece have installed and set to work ADS-B systems at designated sites.

An additional project addressing the validation of ADS-B/WAM in the airspace of the London Terminal Control Area, which is one of the most complex and highest-density airspaces in the world, has recently been established.

In parallel to the ground-implementation-related projects previously presented, two pioneer airline projects have been launched:

- The project aiming at airworthiness approval for ADS-B in non-radar airspace (NRA) was successfully completed and involved 18 airlines, more than 500 aircraft and 14 different aircraft types.
- The ATSAW (Air Traffic Situational Awareness) Pioneer project is to assist airspace users in equipping aircraft with certified ATSAW equipment and participating in trial operations, later transitioning to regular operations. The project kicked off at the end of 2009. Three airlines have been selected so far and more operators are expected to join shortly.

The particular needs of the general aviation (GA) community regarding ADS-B were addressed by a tailored project (CRISTAL GA), now successfully completed.

The outcome of the trials and activities previously described provides the basis for the validation or proof of performance of ADS-B, a surveillance technique that will form a cornerstone of future European surveillance.

The partnerships with the stakeholders established through the CRISTAL trials, pioneer projects and monitoring project can be seen to have accelerated the progress from validation to deployment and generated wide stakeholder involvement. The approach to validation ensures cost-efficient use of the scarce EUROCONTROL and stakeholder resources. These projects are focused on the real operational needs, with open sharing of the knowledge, the core data and the results. It offers a multitude of best practices which are a solid foundation for similar activities in the future.

MONITORING AVIONIC PERFORMANCE

In 2003, as part of the Mode S Programme, a dedicated project was established to focus on the correct operation of transponders, the detection of anomalies and the monitoring of the radio frequency (RF) environment in which transponders operate. Since this project was established, it has developed an impressive reputation in terms of the support it offers to industry in the identification of anomalous behaviour in avionics, transponders and ground-based elements of the surveillance infrastructure. The scope of the project is being extended with the addition of ADS-B monitoring work assessing ADS-B equipage and quality (accuracy, latency, continuity, etc). More than 1,200 ADS-B-equipped aircraft are currently monitored, and many billions of ADS-B reports have been analysed so far. The service provided is seen by many in the aviation community as a key contributor to the performance assessment of the ATM infrastructure. (Read the article on safeguarding the performance of the surveillance system on page 60.)

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The changing face
of surveillance (cont'd)

RULE-MAKING

EUROCONTROL provides impartial advice and expert support to the stakeholders in areas such as the definition of strategies, the development of technical specifications, the writing of procurement documents and the development of safety cases. In this context, the Surveillance and Code Coordination Unit has provided the technical expertise to draft implementing rules (IRs) for surveillance performance and interoperability (SPI), for the use of aircraft identification (ACID) and for Mode S interrogator code allocation (MSI). Indeed, with regard to the last example, ICAO has also designated EUROCONTROL as the body responsible for the allocation of Mode S interrogator codes for the European Region and North Africa.

The key objective for the forthcoming SPI IR is to establish performance requirements for surveillance. In addition to a range of additional requirements for ANSPs, the draft SPI IR that EUROCONTROL submitted to the European Commission also requires that all aircraft operating IFR/GAT in Europe be compliant with Mode S elementary surveillance. Additionally, aircraft with a minimum take-off mass greater than 5,700 kg and/or with a maximum cruising true air speed greater than 250 kts are subject to additional requirements. Aircraft exceeding either of these thresholds are required to be compliant with Mode S enhanced surveillance and, through the carriage and operation of an extended squitter transponder, with all "ADS-B out" requirements in support of ground and airborne surveillance applications.

To achieve this, the SPI IR will necessitate a transponder upgrade to ED102A/DO260B and direct GNSS receiver-transponder wiring. In achieving this requirement the SPI IR also ensures that airborne installations are "future proof", i.e. able to support all surveillance techniques currently used or planned for use.

The mandate dates currently proposed in the draft SPI IR are January 2015 for forward fit and December 2017 for retrofit, with specific provisions anticipated for State aircraft.

The Single European Sky second package includes a revision of the basic EASA regulation, which further extends EASA's responsibilities to air traffic management/air navigation services safety. In close cooperation, EUROCONTROL is providing detailed technical expertise to support EASA in drafting certification documentation, such as acceptable means of compliance/certification specifications, rule-making material and other technical documents.

THE FUTURE

As is the case for the whole of the ATM infrastructure, surveillance is in a period of fundamental change. It must continue to adapt and improve in order to meet the increasing demands being placed upon it.

The activities conducted in recent years have established a solid foundation which allows the European surveillance infrastructure to meet future needs and upon which SESAR can build. These foundations are been actively reinforced through programmes such as CASCADE (ADS-B[1] and WAM[2]) and also through the development of legislative instruments such as the implementing rules published by the European Commission.

1- Automatic dependent surveillance - broadcast
2- Wide area multilateration

SURVEILLANCE IN SESAR

As one of the founding members of SESAR, EUROCONTROL is contributing to a number of important projects and is committed to their successful delivery. In the field of surveillance, the Agency is supporting the following processes:

- deployment and integration of new high-potential technological enhancements, such as ADS-B;
- cost and spectrum rationalisation.

ADS-B is one of the key enablers of SESAR, supporting what are known as the new separation modes, i.e. spacing, separation and self-separation. These are the future ADS-B applications, beyond those cur-

rently addressed by the CASCADE Programme. EUROCONTROL will contribute to operational projects addressing the definition of these future applications. Moreover, the Agency is leading the work of specifying and supporting the validation of the surveillance ground system enhancements for the future ADS-B applications, in partnership with industry and ANSPs. It is also contributing to the prototyping of enhancements to the ADS-B ground station, the surveillance data processing and distribution systems, and the relevant interfaces.

Another key project to which EUROCONTROL's surveillance experts are contributing is addressing the rationalisation of the surveillance system from the cost and spectrum viewpoints. Rationalisation is a broad topic and reflects the objective of improving the efficiency of resources from the ATM network perspective. It thus requires a strategic approach, driven by performance/operational objectives and reflected in specific criteria or indicators. It is in this strategic context that opportunities have to be assessed. For example, the operational deployment of WAM/ADS-B systems can replace classical SSR radars and enable, in a cost- and spectrum-efficient manner, the vision of a dual surveillance layer consisting of ADS-B and an independent surveillance technique (such as Mode S or WAM).

EUROCONTROL is also working on a project investigating the future airborne collision avoidance system (ACAS) functionality – building on its considerable experience in ACAS development and operational deployment.

In all these projects, the focus is on the key objective of smooth evolution and the exploitation of the synergies between the short-term work of implementation programmes and the medium and long-term R&D activities.

Another key project to which EUROCONTROL's surveillance experts are contributing is addressing the rationalisation of the surveillance system from the cost and spectrum viewpoints.

CONCLUSION

It is recognised that achieving the enhanced surveillance capability needed for the Single European Sky in a globally harmonised way will require leadership, resources and commitment. The transition to the future will be challenging. Such challenges can only be addressed by all parties working in concert and through the adoption of a network approach.

Largely thanks to positive partnerships with all its stakeholders, the EUROCONTROL Surveillance and Code Coordination Unit has been successful in understanding their needs and helping to deliver collective successes. Those successes have been achieved by developing and implementing new technologies which enable tangible operational benefits and provide a sound foundation for the future. ■

Cascade

Benefits of a programme approach

The success of a programme approach has a number of key prerequisites, as demonstrated by CASCADE, the Programme for Cooperative ATS through Surveillance Applications deployed in ECAC. **Christos Rekkas, CASCADE Deputy Programme Manager at EUROCONTROL, tells us more.**

From the outset there was a clear vision and the focus was on deployment. When the CASCADE Programme was established in 2004 it inherited from its predecessor, the ADS Programme, a number of important projects (for example, the first CRISTAL projects) and effective industry partnerships (such as the Requirements Focus Group – RFG). It was also able to take over a solid baseline from the research and development (R&D) work conducted over a number of years into how use could be made of ADS-B (automatic dependent surveillance – broadcast) or of the "applications" of ADS-B.

CASCADE built on this legacy with the added advantage of a clear mandate: to achieve operational deployment. Those applications which the R&D activities could demonstrate were sufficiently mature for implementation in the short term (by around 2010) formed the first milestone of this process. These had undergone a thorough assessment in terms of:

- technical feasibility
- operational acceptability
- cost-benefit analysis
- stakeholder support (including, but not limited to, initial implementation objectives)

This process established the initial scope of the Programme. The scoping process is regularly reviewed, taking into account ongoing developments and the most up-to-date information. For example, recently, taking into account the synergies between WAM (wide area multilateration) and ADS-B, the Programme extended its scope to include WAM.

A key for CASCADE's success is its partnership with the stakeholders. This was built not only by the traditional means, i.e. working arrangements allowing stakeholders to monitor and contribute to the steering of the Programme's activities, but was also extended to other, rather innovative, forms of best practice.

Such best practice includes the safety case teams with the ANSPs, the RFG (including EUROCONTROL organisation experts, EUROCAE, RTCA, FAA, Australia, Japan, etc.), the CRISTAL Projects (more than 15 ANSPs involved) and the Pioneer Airline Projects (more than 20 airlines and 500 aircraft). It also includes a close and similarly very successful cooperation in support of the European Commission in the area of regulation, with the European Aviation Safety Agency (EASA) in the area of certification , ICAO, etc.

Another important asset for CASCADE is its multidisciplinary expertise. As opposed to a traditional "functional" approach (e.g. surveillance programmes, communication programmes, operational programmes), CASCADE gathers together expertise from all relevant areas, i.e. operational, technical (mainly surveillance but also navigation, communication, etc.), safety, economics, regulatory domains, etc.

This helped to ensure an open "network" approach, taking all aspects dynamically into account, at every step of the process. This is particularly evident in the standardisation work where the ADS-B application description and the definition of the relevant safety, performance and interoperability requirements was the product of multifunctional groups including controllers, pilots, engineers, safety experts and regulators. The same also applies to the validation work, using teams with a diverse portfolio of expertise covering such areas as verification and operational validation.

A key for CASCADE's success is its partnership with the stakeholders.

Mark Watson, Head of CNS/ATM, Oceanic and Safety Research, at National Air Traffic Services (NATS) UK, summarised the benefits that such an approach had brought when he stated *"Engaging with the expertise within the CASCADE programme, whilst also drawing upon NATS' own experts, accelerated the technology assessment in a real and meaningful operational environment and this has helped us to understand the opportunities that ADS-B and wide area multilateration could present to our business".* He continued, *"NATS has also benefited from the wider work of the CASCADE programme and other groups such as the Requirements Focus Group and the Multilateration Task Force. In keeping with the spirit of the CASCADE programme and the CRISTAL funding, the results of the CRISTAL UK projects have then been provided back to these forums as local validation of these technologies. Such an approach is beneficial to the wider ATM community".*

This structured and top-down/bottom-up approach established a solid framework for the production of the Programme deliverables and global interoperability. Adaptations of the methodologies were adopted in a flexible way to improve efficiency. The safety assessment from a generic level to a local level for a number of interested ANSPs is a typical example. Such generic deliverables provide, in a cost-efficient manner, the framework for ANSPs to pick up, build upon and expedite the introduction of new surveillance techniques such as ADS-B into their surveillance infrastructure.

A comprehensive validation platform and toolset (such as the ADS-B validation test bed) was also built in coordination with the stakeholders. Through an efficient allocation of centralised and local activities and by sharing the results obtained, it proved possible to achieve good results and cost-efficiency in the monitoring, verification and validation trials.

Providing stakeholders such as the ANSPs, airspace users, industry and regulators with local and focused support to where the operational needs were identified, catalysed the progress and accelerated implementation.

"ADS-B out" and WAM (ground surveillance techniques) and "ADS-B in"/ATSAW (air traffic situational awareness on board an aircraft) are now being operationally deployed throughout Europe and worldwide! ■

Interoperability

An essential component of surveillance

Eric Potier, Senior Surveillance Expert at EUROCONTROL, outlines the complexity of ensuring global surveillance interoperability and describes the Organisation's contribution to the attainment of this objective.

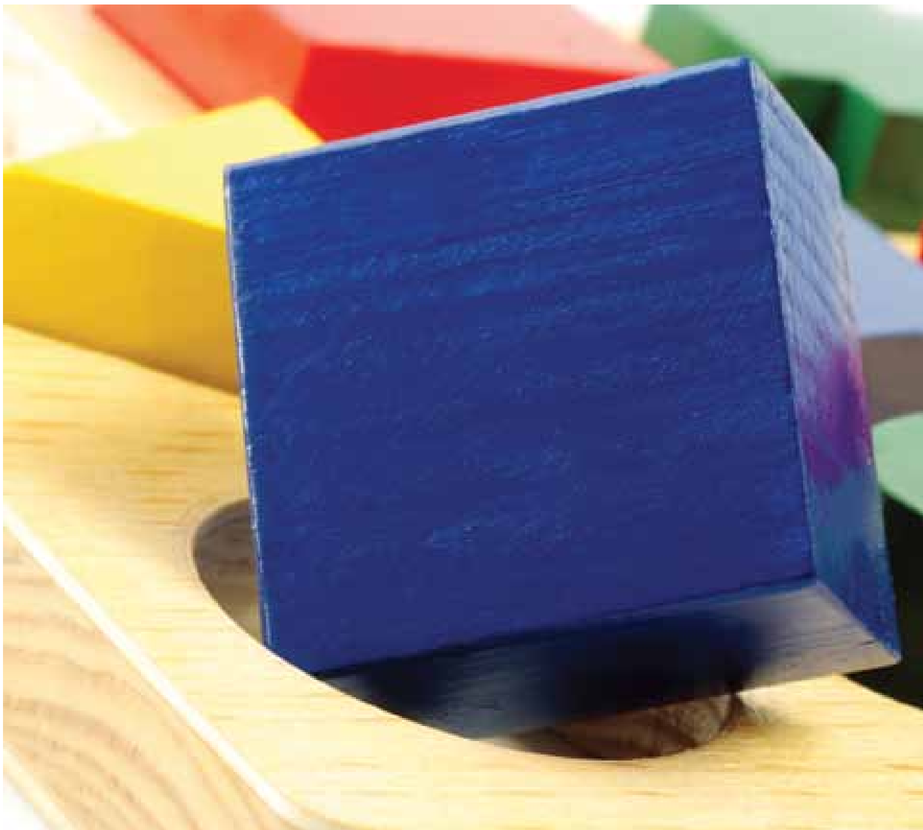
Imagining a system as complex as the surveillance chain, built from components specified, designed, built and tested in isolation, in all different parts of the world and dependant upon shared usage of a 1030/1090MHz frequency band is enough to give any engineer nightmares. Each constituent part of such a complex endeavour must be carefully specified to perform a defined set of tasks to an acceptable level of performance in a safe and globally interoperable manner.

There are a significant number of constituent parts within a surveillance chain. They are the point of interface between the aircraft and air traffic control, and the information exchanged is used for a variety of purposes, and by a variety of tools. Ensuring the surveillance chain components are fit for purpose, for the applications or operations to be performed today and in the future, is a key requirement to ensuring that ATM functions as it should.

An increasing number of surveillance system functionalities are installed in the aircrafts' avionics. The growing complexity of avionics and on-board interfaces means that the required expertise for a surveillance engineer is no longer limited to the ground system but must now cover a wider range of component parts. Stakeholders such as aircraft operators, ANSPs, regulators, States and industry must either maintain a global understanding of the entire system or delegate that role. Many ANSPs and States no longer choose to maintain their own team of system experts but rely on EUROCONTROL to represent their interests and those of Europe.

For surveillance, global interoperability with the aircraft is achieved by a global standard agreed by States and documented in ICAO Annex 10 and associated documents. This is further refined in equipment specifications developed in industry forums like EUROCAE (European Organisation for Civil Aviation Equipment) and RTCA (Radio Technical Commission for Aeronautics).

These fora are interconnected, and it is necessary to participate to all of them to be able to efficiently contribute to the process. European industries, ANSPs and regulators are often poorly



There are a significant number of constituent parts within a surveillance chain. They are the point of interface between the aircraft and air traffic control, and the information exchanged is used for a variety of purposes, and by a variety of tools.

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represented in these fora. Consequently, there is a need for a system engineer to represent European interests and ensure that surveillance systems which operate, or will operate, in Europe remain interoperable and are able to deliver the current and future European operational concepts. The EUROCONTROL Agency fulfils this role.

The deployment of new surveillance techniques based on the broadcast of the aircraft position by ADS-B allows new surveillance applications to be deployed. For each of these applications, the role of EUROCONTROL is to define the operational services provided, the operational environment and to determine which performance, interoperability and safety requirements are necessary.

For ADS-B applications this is managed under an international Requirement Focus Group (RFG). EUROCONTROL's surveillance experts actively contribute to this international surveillance standard to ensure that the correct interoperability, performance and safety requirements are specified.

Interoperability is also necessary between the ground surveillance subsystems. EUROCONTROL ensures this interoperability through the definition of a specific data exchange format known as ASTERIX. Such common formats allow easier interconnection of systems from various ANSPs and vendors. The ASTERIX format is fast becoming the worldwide reference for the exchange of surveillance data.

EUROCONTROL is one of the rare actors with all of this expertise and therefore able to actively steer global surveillance interoperability standards in these different fora. This expertise is essential not only to create and maintain the interoperability necessary for a pan-European surveillance network but is equally importantly for global interoperability. ■

Safeguarding the performance of the surveillance system

The 1030/1090 MHz radio frequency (RF) spectrum is at the heart of the modern surveillance infrastructure. However, unless carefully managed, dependence upon this increasingly utilised common resource places all air traffic management at risk. **Andrew Desmond-Kennedy and Eric Potier, Senior Surveillance Experts at EUROCONTROL, explain.**

While modern surveillance techniques are more RF efficient, many older systems remain in operation and these are contributing to a congested RF environment in which transponders and ground stations are struggling to cope.

Although detailed simulations have been made of the RF environment that transponders are operating in, they are recognised as having limitations. Therefore, to obtain an accurate view of the actual status, EUROCONTROL has developed a unique set of test and data analysis equipment which is carried on board an Airbus Beluga aircraft as it conducts its normal range of flights through the increasingly dense RF fog above Europe. (See map).

Periodically the captured data is downloaded from the aircraft and scrutinised by surveillance experts to determine a true image of the RF environment. Such information is key to developing safe and cost-effective strategies that stakeholders can implement to mitigate RF congestion. The information is also being used to provide evidence in support of the proposals being made to adapt the surveillance aspect of airborne collision avoidance systems (ACAS).

A dedicated project was established in 2003 to identify anomalous behaviour in transponder-related operations. The assessments are made by using a specially developed software tool set to analyse surveillance data pertaining to 'targets of opportunity' recorded at a number of ground stations across Europe.

An aircraft's transponder performance is comprehensively monitored by analysing data provided by ANSPs across Europe. If anomalous behaviour is identified, the issue is investigated in more detail and, if necessary, the aircraft operator or transponder manufacturers are informed of the circumstances. The project members perform the role of focal point between ANSPs, aircraft operators, EASA and regulatory authorities. Issues are managed through to resolution by working in concert with additional parties such as EASA and the regulatory authorities.

The service provided is becoming increasingly important as transponder designs become more complex. EASA recognises the valuable contribution these activities play. Kevin Hallworth, an Avionics Expert at EASA, described the relationship in the following terms: *'EASA and EUROCONTROL work together to identify transponder issues and provide rectification through discussions with the equipment suppliers and aircraft operators. EASA airworthiness directives (ADs) are also issued where an unsafe condition is identified…'*

EUROCONTROL's expertise is often requested to provide an independent and impartial view for investigating possible air-ground interoperability issues.

To conduct the investigative aspect of the task, a unique laboratory test bed has been developed that fully tests the capabilities and operations of any transponder. Using this test bed it is pos-

Route of the Beluga aircraft

sible to resolve transponder anomalies without recourse to expensive flight trials.

EUROCONTROL's expertise is often requested to provide an independent and impartial view for investigating possible air-ground interoperability issues. This independence, together with a good system view, is key to supporting regulatory authorities in establishing rules, acceptable means of compliance and in determining the impact of a failure on the system and whether regulatory actions are necessary. This expertise is also used to provide independent verification of the interoperability of new developments, for example for the analysis of new military modes.

The Mode S and ADS-B Monitoring Project is split into the following activities:

- Verifying correct transponder operation with respect to Mode S protocols using data obtained from Mode S groundstations located in France, the Netherlands, the UK, the Czech Republic, Belgium and Switzerland.
- Monitoring and comparing the actual ADS-B transponder equipage against the capability declared in the Mode S and ADS-B reports.
- Monitoring ADS-B data quality both whilst the aircraft is airborne, or on the ground, using recorded data provided by sensors located in Germany, France, Greece, the Netherlands and the UK.
- Supporting partners such as aircraft operators, avionic manufacturers and EASA to develop solutions that ensure the timely resolution of identified anomalies

In recent times the increasing numbers of wind turbines and wind farms that are deployed throughout Europe have begun to impact upon the operation of surveillance sensors. To tackle this, a set of guidelines have been produced for use by ANSPs and wind energy bodies to assess and mitigate any detrimental impact that may occur.

The Surveillance and Code Coordination Unit can also provide expertise to assess and optimise the performance of surveillance systems and in the use of the SASS-C[1] tool set. Further details regarding SASS-C and the other tools developed within EUROCONTROL to support surveillance activities can be found in the article on page 62.

The performance of the system can thus be ensured by providing a comprehensive means to investigate and test both airborne and ground-based components of the ATM surveillance infrastructure. ■

1- Surveillance analysis support system for ATC centre

Integrating surveillance systems

EUROCONTROL's surveillance products & services

Air traffic management (ATM) needs reliable and accurate surveillance data. Loss of surveillance data in one part of the airspace can cause a major reduction in air traffic control (ATC) capacity, with a knock-on effect across the entire network. The optimum use of all available sensor data in an interoperable manner throughout the entire area is therefore a key element for overall ATM network safety and efficiency. In the field of surveillance, interoperability is supported by the application of common performance standards as well as the harmonisation and possible further integration of surveillance data processing means. **Jean-Marc Duflot, Head of the Surveillance Services Unit at EUROCONTROL, tells us more.**

SURVEILLANCE DATA PROCESSING CHAIN

A number of processing steps are required in order to transform the data produced by the surveillance sensors detecting aircraft (the plots) into the representation of aircraft trajectories (the tracks), which can be exploited by the air traffic controller. In this context, EUROCONTROL has developed and supported for many years three complementary elements of a complete surveillance data processing chain. This comprises surveillance data distribution in the form of RMCDE (surveillance message conversion and distribution equipment), surveillance data processing system in the form of ARTAS (ATM surveillance tracker and server) and surveillance infrastructure analysis in the form of SASS-C (surveillance analysis support system for ATC centre).

Launched in the early 90s, the three software projects and related services were developed at the request of Member States, recognising EUROCONTROL's central role in Europe-wide technical coordination and its expertise in the field of communication and surveillance. The common development and provision of centralised maintenance and support services were, and still are, in general justified by the resulting economy of scale for the Member States and efficiency in terms of systems harmonisation and possible further integration.

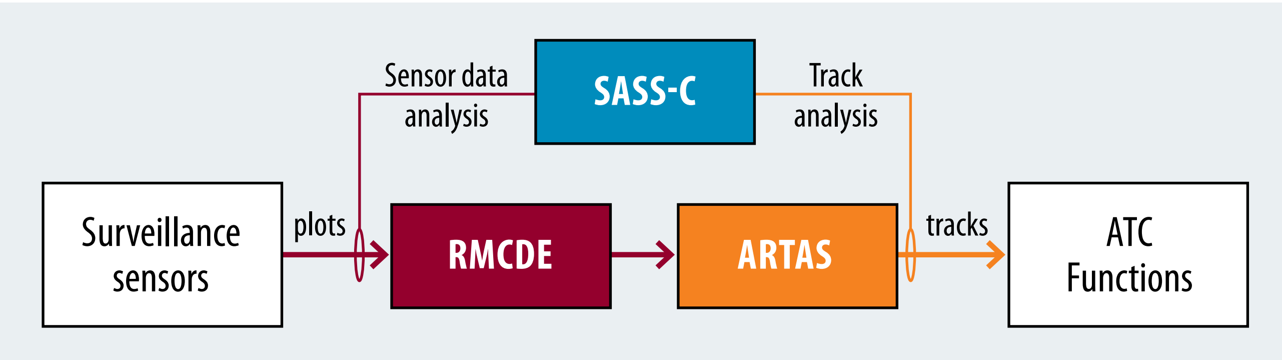
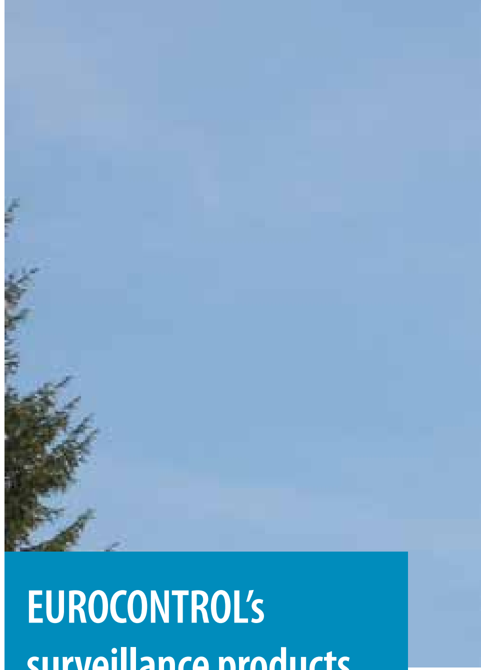


Figure 1: The EUROCONTROL surveillance products in an operational environment

The three products are designed to operate within any surveillance environment, although maximum benefit is reached when using them as shown in Figure 1: ARTAS produces the tracks required by the ATC functions (controller display, safety nets, flight plan data processing, etc.) by processing plots received via the RMCDE from a surveillance sensor configuration (radars, ADS, WAM, etc.). The quality of the data generated by both the surveillance sensors and ARTAS is monitored by SASS-C. Interoperability within the surveillance chain is supported by ASTERIX (All-purpose, structured EUROCONTROL surveillance information exchange), the European and de facto worldwide standard for surveillance data exchange.

SURVEILLANCE DATA DISTRIBUTION

RMCDE was designed as the node of an intelligent logical network for the distribution of surveillance data in order to make optimum use of communication resources and facilitate the sharing of available surveillance information. In addition to data filtering and flow control mechanisms, RMCDE converts many specific surveillance data formats into the ASTERIX standard, as needed to ensure interoperability across the surveillance data distribution network.



Integrating surveillance systems
EUROCONTROL's surveillance products & services (cont'd)

EUROCONTROL's surveillance products and services constitute a sound example of European cooperation.

SURVEILLANCE DATA PROCESSING

ARTAS was designed as an advanced solution for the harmonisation and integration of high-quality surveillance in Europe. The prime objective of ARTAS is to produce an accurate picture of the air traffic situation so as to enable the safe application of lowest uniform separation minima throughout the entire European airspace, in particular during ATC centre transfers.

What differentiates ARTAS from any other tracker system is the overall concept of a distributed system, consisting of an assembly of identical units which can all coordinate together and act as one region-wide integrated surveillance system. The various surveillance sensors are connected to a Regional Surveillance WAN (wide area network) and the units are also connected to this network. Each ARTAS unit processes surveillance data received on the network and acts as a server through the surveillance data distribution (SDD) systems, providing continuous aircraft track data to the ATC units and other user systems (e.g. military, air defence systems, flow management units) which are connected to the network.

SURVEILLANCE INFRASTRUCTURE ANALYSIS

SASS-C is a reference toolbox for assessing the performance of surveillance infrastructure. It is typically used for monitoring compliance with nominal performance, in particular as defined in the EUROCONTROL surveillance standard for en-route and major TMA. SASS-C is used in support to ATC operations and also to the acceptance of newly installed surveillance systems.

The main purpose of SASS-C is to assess various performance criteria by comparing input data against reference trajectories built directly from the dataset to be analysed. The advantage of the method is that the evaluation can be done from opportunity traffic, which is a cheap way to perform evaluations.

The quality of EUROCONTROL's surveillance products and services is now widely recognised and adopted inside as well as outside ECAC, with a growing number of users. ARTAS is one of the most advanced surveillance data processing system in the world, SASS-C is a reference for surveillance data evaluation and RMCDE/ASTERIX is a key solution for enabling surveillance data exchange.

Operational focus

Beyond the contribution to surveillance-related operational improvements, the ongoing deployment of the surveillance products is a direct enabler to defragmentation in line with the Single European Sky's objectives. The introduction in Europe of common surveillance data processing techniques and performance, by applying standardised format for data exchange, is a concrete contribution to ATM network interoperability.

A case in point is that ARTAS is currently used in 15 countries, including one county outside ECAC, and is undergoing tests in other countries prior to operational use. In a few years, more than 80% of the continent's traffic should be controlled through the ARTAS surveillance picture. RMCDE has been implemented in 18 European countries. SASS-C has been distributed to ANSPs and surveillance systems manufacturers in 50 countries worldwide.

In addition to the operational development of the products, EUROCONTROL provides maintenance and support services to the product users. RMCDE is supported by the RIT service (RADNET/RMCDE Implementation Team), ARTAS by the CAMOS service (Centralised ARTAS Maintenance and Operational Support) and SASS-C by the SACSO service (SASS-C Support Office). These services are managed by Agency staff, supported by contracts with industry for software maintenance and improvement.

Innovation

Surveillance products are in constant evolution, requiring innovation and adaptability while keeping in mind the safety and quality requirements of operational systems. In line with the Surveillance Strategy for ECAC, the products have always been prepared for the timely introduction of new surveillance technologies such as Mode-S, ADS and WAM with a view to improving ATC functions. Similarly, they are prepared for future developments, including the processing of airport surveillance sensors reports, with the potential of building a continuous, gate-to-gate surveillance layer.

The ARTAS project included the development and validation of advanced tracking techniques as well as the in-

novative concept of a distributed surveillance system. Fairly visionary when the project started, these techniques and this concept are still advanced today. The already available ARTAS server functions will facilitate the implementation of cooperative ATM functions defined in SESAR and in the context of the FABs.

The RMCDE has reached end-of-life and needs to be replaced, considering increased surveillance data communication requirements. A new generation of SDD system called SDDS (surveillance data distribution system) is under development, using state-of-the-art technologies with the objective of ensuring a higher level of flexibility by providing a platform that can be used for new technologies such as ADS-B (automatic dependent surveillance – broadcast) position report server and ADS-C (automatic dependent surveillance – contract) capabilities, while lowering the total cost of ownership.

SASS-C is also undergoing a major change in preparation for the future, in particular to accompany the emerging Community specification on surveillance performance. The system has been completely redesigned to implement new evaluation techniques while it is re-engineered to improve user friendliness, flexibility for developments and openness.

On the methodological side, investigations are ongoing on how product innovation could be even further stimulated for the benefit of the whole community. Models based on open source and collaborative innovation principles are being considered as an interesting way forward. Moreover, the current SPS (standard positioning service) developments are also showcases of how ES-ARR6-compliant development can be achieved without significantly higher costs compared to conventional development.

European cooperation

EUROCONTROL's surveillance products and services constitute a sound example of European cooperation. From the outset, the development of the products has involved the concerted efforts of European surveillance experts including researchers and developers in industry and surveillance experts in national authorities and within the Agency.

The evolution of the three products is steered by their respective user groups, taking into account the requirements stemming from both the product users and the surveillance strategy. EUROCONTROL is taking care of the complete lifecycle management, outsourcing to industry and research institutes are dealing with certain parts, such as software development

A new business model

As part of the reorganisation of EUROCONTROL, the management of the surveillance products and services is undergoing a significant change in business model, with the introduction of the user-must-pay principle. In substance, specific services managed by the Agency will no longer be funded from the common Member States' contributions, but directly financed by the users themselves i.e. mainly the ANSPs.

In this context, new governance arrangements are being defined for surveillance services, giving the users much more control over activities. The governance should decide inter alia the evolution of the products, the financial arrangements within the user community, the industrial strategy with respect to each product and also the Agency's future involvement.

Further integration

Commenced in the early 90s, the common development of the surveillance products and the provision of centralised maintenance and support services has enabled economies of scale for the Member States and has contributed effectively to system harmonisation. The overall success of this approach is demonstrated by the ever-increasing number of systems deployed and the wide recognition of their technical value.

The further integration of surveillance systems is an essential step towards the defragmentation of Europe's ATM infrastructure and is very much in line with SESAR concepts and the implementation of functional airspace blocks.

With high-level stakeholder commitment, EUROCONTROL's surveillance products constitute an exemplary success story over almost two decades of European cooperation. ■

The civil-military dimension in CNS interoperability

Experts from EUROCONTROL's Directorate of Civil-Military ATM Coordination (DCMAC) present their views on the interoperability issues surrounding the coordination of military aviation with civil air traffic management.

CIVIL-MILITARY INTEROPERABILITY R&D IN SESAR

Eric Billard and Jorge Pereira, DCMAC

The SESAR target concept is heavily dependent on the interoperability of civil-military ATM/CNS[1] systems as the preferred approach to enable military operations within the highly automated SESAR network-centric structures.

The SESAR Programme includes a number of specific joint civil-military research and development (R&D) projects to determine the feasibility of integrating modern military aircraft into the future 4D trajectory environment. Primarily, this will be done on the basis of re-utilising available military avionics (military data links, mission computers, military transponders, navigation enablers and so on) to the maximum extent possible, implementing ground-based interfaces and promoting performance-based approaches as the basis for equivalent compliance.

The extensive re-use of existing military capabilities is expected to minimise the need for retrofitting equipment and will enable SESAR solutions to become standardised and industrialised for the benefit of modern aircraft in line with military procurement cycles and budget limitations. However, it is clear that transitional measures will still be needed to accommodate some legacy aircraft in order to allow them to fulfil their military missions.

In parallel, the interoperability and security challenges which need to be met to raise the connectivity levels between the SESAR system-wide information management (SWIM) infrastructure and military ATM and other systems will also be the subject of significant R&D efforts.

EUROCONTROL plays a fundamental role in all military-related SESAR CNS thread activities, providing a more global operational view, sound military technical knowledge and links with national military organisations at expert level.

1- Communications, navigation and surveillance (CNS) enablers supporting air traffic management (ATM) functions and services

CIVIL-MILITARY COMMUNICATIONS INTEROPERABILITY

Jorge Pereira, DCMAC

Ground communications

The aeronautical ground communications drive towards Internet protocol (IP) distributed networking technologies offers a unique opportunity to enhance the interoperability between the European ATM infrastructure, military ATM and other systems. Aspects that require close attention include:

- interface and security requirements for the interconnection between relevant military systems and the emerging pan-European IP communications backbone;
- potential synergies between military messaging systems and aeronautical message handling systems (AMHS);
- the advent of voice over IP.

Interoperability R&D efforts will be essential in determining how military requirements can be safeguarded for the availability of a common picture as well as the adequate sharing of flight data, aeronautical information, radar data and airspace management information.

This will constitute a decisive move towards military integration in future network-centric SWIM structures and a fundamental end-to-end merger with the air-ground segment.

Air-ground voice communications

Air-ground voice communications are expected to rely on analogue very high frequency (VHF) 8.33 kHz channel-spacing technology at least until 2030/35. Consequently, military organisations are making a huge effort to equip their fleets with 8.33 kHz-capable radios (several hundreds of aircraft are planned for retrofit between 2010 and 2014) but transition arrangements, including ultra-high frequency (UHF) provision, and exemptions will still be required to respond to the procurement, technical and life-cycle constraints impacting large military fleets.

8.33 kHz expansion is therefore a perfect demonstration of the need for strong business cases and innovative approaches for the "obsolescence management" of military legacy fleets.

Air-ground data communications

The gradual introduction of air-ground datalink communications, in the context of ATM, raises another significant challenge to military organisations. The military have been advised to introduce CPDLC[2] capability to new transport-type State aircraft in compliance with existing regulations and specifications. It is likely that additional measures will be required since, in the longer term, datalink is expected to become a vital enabler for advanced ATM concepts.

Equipage with duplicated civil/military datalink configurations will not be possible for military aircraft due to airborne integration constraints. That said, military fighter aircraft could benefit from the implementation of ground interfaces to exchange information received from tactical datalinks as a means of complying with ATM requirements. This kind of solution may avoid costly retrofits.

For longer-term data communications developments, the preferred approach is to promote technology convergence between civil and military ATM/CNS enablers. This requires a closer look at on-board flexible architectures, including software-defined avionics.

Additionally, a decisive aspect, related to this issue, is the spectrum supportability of future systems, which needs to be closely coordinated with military stakeholders. ■

2- Controller-pilot datalink communications

CIVIL-MILITARY DATA PROCESSING INTEROPERABILITY

Marc De Cat, DCMAC

OAT harmonisation in Europe

In order to facilitate the transit of OAT[3] flights through the future operational environment of a Single European Sky, military aviation organisations will adapt to trajectory-based operations. To enable this, the automated sharing of aeronautical information in the SWIM[4] environment in support of such things as advanced flexible use of airspace (AFUA), mission trajectory operations, demand and capacity balancing and digital NOTAM (notice to airmen) is a necessity.

To support enhanced automated processing of data and sharing of information, data harmonisation has to be extended to OAT flight plan data and other military aeronautical data.

- The inclusion of OAT flight plan data in an integrated civil-military ATM system will be prepared by SESAR. Work packages 7 (Network Operation) and 13 (Network Information Management Systems) will address the identification and processing of the OAT flight data. In due course, a project will have to be launched to implement these SESAR results.

- The Harmonisation of Military Aeronautical Information (HMAI) in Europe through the European Aeronautical Database (EAD) Project will harmonise military aeronautical information publications (AIPs) and align them with civil ICAO SARPS (Standards and Recommended Practices) and prepare EAD to better accommodate military-specific data through an adaptation of AIXM (aeronautical information exchange model) and the EAD static data set (SDO). Migration of military organisations to the EAD will improve the availability, completeness and harmonisation of aeronautical information.

The previously-mentioned approach will lead to a 'de facto' standardisation of military aeronautical information in Europe. It ensures a compatible, interoperable and consistent military-military and civil-military exchange of flight information and supports automated processing by military and civil systems. Aeronautical data quality requirements, therefore, should also be applied by the military.

Although military experience with net centricity could be of benefit for SESAR/SWIM developments, military organisations themselves should be prepared to become a partner in SWIM following SOA[5] and EA[6] approaches. Interoperability with military Command and Control (C2) systems will be given special attention in the SWIM context.

EUROCONTROL will have a key role to play in enhancing the awareness of the military community, contributing to SESAR R&D and providing guidance to military and other stakeholders in areas such as common data models, common information requirements, interoperability and supervision in order to facilitate successful implementation.

3- Operational air traffic
4- System-wide information management
5- Service-oriented architecture
6- Enterprise Architecture

CIVIL-MILITARY NAVIGATION INTEROPERABILITY

Pascal Barret, DCMAC

The need for enhanced civil-military interoperability in the navigation domain is of the utmost importance – especially when flights are conducted in mixed-mode environments in controlled airspace. Although military operational requirements with regard to positioning, navigation and timing have already been met, the increasing influence of civil navigation requirements needs to be taken into account when State aircraft fly under General Air Traffic (GAT) rules.

The main aspect impacting civil-military navigation interoperability will be a transition from equipment-based certification to an alternative process based mostly on equivalent required navigation performance values.

In this sense, close cooperation between civil and military organisations responsible for the provision of navigation services is a clear objective in the following domains:

- consideration of the performance-based navigation (PBN) concept, which is crucial for advanced navigation to pave the way for military performance-based solutions;
- demonstration that military navigation systems such as TACAN, GPS PPS[7], Galileo PRS[8], MMR[9] and JPALS[10] can be declared as equivalent to civil navigation requirements;
- consideration of military datalink capabilities of the most advanced military aircraft to take advantage of its relative navigation capabilities[11];
- RVSM[12] solutions for fighter aircraft in Europe which have to be investigated on the basis of a performance approach rather than on an equipage requirement perspective;
- 4D navigation, which is a fundmental notion for SESAR, to be considered also for military airframes, taking into account their specific equipage with mission management systems and dedicated databases;
- military involvement in navigation infrastructure rationalisation efforts.

Transition arrangements and exemptions will have to be defined and agreed in order to cope with lower-capability military airframes. For that reason, all innovative approaches must be weighted, including lost-cost solutions, with regard to the considerable expense of military aircraft retrofit.

In this light, and based on the ongoing work scheduled and performed in the SESAR Programme, EUROCONTROL has a clear and key role in providing guidance to military stakeholders and in taking into account the specific nature of their needs in order to achieve a seamless civil and military approach in the navigation domain when preparing for 2020+. ■

7- Precise positioning service
8- Public regulated service
9- Multi-mode receiver
10- Joint precision approach and landing systems
11- Some military datalinks support a navigation function
12- Reduced vertical separation minima

CIVIL-MILITARY SURVEILLANCE INTEROPERABILITY

Thomas Oster, DCMAC

Need for independent non-cooperative surveillance

From the technical point of view, military ATC surveillance systems are not so different from civil ATC surveillance systems. For example, a military ATC primary surveillance radar (PSR) is technically similar to a civil ATC PSR. The difference lies in their operational use.

In some States in the core area of Europe, during peacetime operations, it is mandatory for military controllers to rely on PSR data. Secondary surveillance radar (SSR) data can be used as an additional means of identification. In such cases, controlling an aircraft with SSR data alone does not satisfy national military regulations. Non-cooperative aircraft must always be detected for safety and security reasons.

As a consequence, PSR is of paramount importance for military ATC operations and not only for Air Defence (AD) operations for which security is the major consideration.

In addition, military ATC PSR needs to be able to detect and track aircraft flying at lower altitudes with much higher manoeuvring capabilities (climb-/descent-/turn-rates) than civil airliners. This explains why the impact on military PSR (ATC and AD) caused by wind turbines is much more significant than on the civil infrastructure. This fact has caused some misunderstandings with proponents of the renewable energy sector.

Military ATC and Air Defence will continue to use independent non-cooperative surveillance systems (PSR being the only one available today) in order to meet the safety and security tasks identified by their own national governments. Naturally, any new technology with the same capability could offer an alternative to such expensive and spectrum-inefficient military PSR systems.

Some years ago, EUROCONTROL commissioned a study on alternative solutions for independent non-cooperative surveillance. The result was the proposal to further develop multi-static primary surveillance radar (MSPSR), which is a distributed ground-based system that could be considered as a combination of PSR and multilateration. Due to its multi-static design, this technology has the potential to be much more resistant to interference caused by wind turbines. In addition, it could also potentially provide precision approach radar (PAR)-like services, which might reduce the cost of replacing very expensive primary radar systems.

Another means of minimising costs in this domain is the rationalisation of the surveillance infrastructure, which will be analysed in depth as part of SESAR. This rationalisation should also consider military surveillance infrastructure, since sharing surveillance data between civil and military air navigation service providers could contribute to optimised coverage and a reduction in the number of sensors.

However, the main surveillance enablers in the short and medium term will continue to be PSR for TMAs (terminal manoeuvring areas) and SSR for TMAs and en-route. Due to ATM security and safety requirements, the importance of PSR as an independent and non-cooperative surveillance technology is being raised, including for en-route applications.

Mode S is being implemented progressively to cope with the lack of identification codes and radio frequency pollution. Military adherence is significant, with plans to equip a considerable part of their fleets with Mode S-capable transponders.

The development and implementation of advanced surveillance techniques such as ADS-B and wide area multilateration (WAM) is also progressing. The feasibility of fitting ADS-B in/out in military aircraft still requires R&D studies to be conducted within SESAR.

To support the implementation of surveillance enablers, a draft Surveillance Performance and Interoperability Implementing Rule (SPI IR) was prepared by EUROCONTROL under a mandate from the European Commission and is now due for discussion within the Single European Sky Committee.

At the end of this regulatory process, it is expected that the SPI IR will include provisions on airborne equipage such as Mode S elementary and enhanced surveillance, use of surveillance identifier (SI) capability, extended squitter and ADS-B out. The detailed equipage requirements will depend on the type of aircraft and will be subject to various timeframes, but some of them will also be applicable to State aircraft.

CIVIL-MILITARY INTEROPERABILITY ASPECTS – STANDARDISATION AND CERTIFICATION

Dominique Colin, DCMAC

Standardisation and certification are essential to ensuring that military aircraft are interoperable within the future Single European Sky (SES). Moreover, improved interoperability between military and civil systems will benefit the whole aviation community.

Most civil regulations do not directly apply to military aircraft but as they fly in civil-regulated airspace, a whole set of derogations and exemptions has to be approved on a national basis. This approach is not entirely satisfactory because it makes ATM more complex and multiplies the systems in service.

SES offers the opportunity to radically change the relationship between civil and military users and service providers in order to obtain the full benefits of the operational improvements that will be implemented in the framework of SES.

This opportunity raises new challenges in the domains of regulation and standardisation. The SES regulatory framework includes essential requirements (ER) and implementing rules (IR). The ERs are high-level requirements, generally refined by IRs. This framework governs the future SES and even if it does not directly apply to military aircraft, it defines services or rules that have a clear impact on military aviation.

However, CNS systems are fully integrated within military aircraft weapon systems, which makes any change in the weapon systems very costly. Furthermore, military procurement cycles are long. Consequently, if civil-military interoperability is set as a goal, military involvement in the rule-making process is essential. As a civil-military organisation, EUROCONTROL has an essential role to play in this domain, facilitating consultation with national military authorities.

The military should therefore also be more involved in regulation drafting in order to address military specifics as early as possible in the interoperability process.

In addition, the military have a problem in "proving" that they are compliant with civil regulations even though their system performance is sometimes superior to civil requirements. Civil regulation often focuses on system architecture or equipage as a mandate requirement, and this approach sometimes makes it impossible for military systems to comply with the civil requirements.

At the ICAO Global Air Traffic Management Forum on Civil/Military Cooperation in Montreal in October 2009, the military said that they "preferred performance requirements over equipage requirements." It was concluded that "civil and military requirements can be met provided a will and mutual understanding exists between both communities." For the military, this implies that the ATM dimension is added to the airworthiness requirements that are already under development and are "as civil as possible".

The civil community should, no doubt, open the door to wider cooperation with the military authorities beyond the current strategic level, as technical regulatory issues also need to be resolved. EUROCONTROL is, after all, promoting a performance-based approach to facilitate military system certification against civil regulatory mandates.

Standardisation efforts are key to future civil-military interoperability. A civil-military standard will facilitate certification of military systems and thus the smooth integration of military aircraft in the civil-regulated airspace. Technical standards need to be considered in the future ATM operational environment. This means that the military community must engage in standardisation working groups to ensure further civil-military interoperability. The European Defence Agency (EDA) can help EUROCONTROL in organising the military engagement in standardisation activities by reaching the appropriate military experts.

As EUROCONTROL is engaged in SESAR Project C3 (Maintain Standardisation and Regulatory Roadmaps), the Agency will have a key role to play in providing guidance to the military to enable them to implement these roadmaps and to help them secure the right level of influence, which they are entitled to as an essential stakeholder in the SES. This will without doubt benefit the entire aviation community. ■

Speaking to Nancy Graham

Director Air Navigation Bureau, ICAO

Nancy Graham is the Director of the Air Navigation Bureau of the International Civil Aviation Organization (ICAO), the United Nations specialised agency whose mandate is to establish and revise international standards for safe, secure and sustainable development of civil aviation. In her current position, which she took up in April 2007, Ms Graham oversees much of the work undertaken in the development of ICAO's technical Standards and Recommended Practices (SARPs), which are critical to the safety of the international air transport infrastructure.

What are ICAO's priorities in the field of communications, navigation and surveillance (CNS)?

ICAO has three CNS programmes which have been given high-priority status by the Council of ICAO and are based on the ICAO concept of operations. Specifically, these:

- outline the State infrastructure and aircraft equipage elements necessary for a seamless sky in tomorrow's aviation system, on the basis of operational needs;
- ensure adequate frequency spectrum allocation to support existing and planned operational capabilities for civil aviation;
- maintain and develop performance-based standards, recommended practices and guidance material for current and emerging technologies in CNS.

Each of these initiatives has a range of supporting projects delivered by the voluntary workforce (e.g. panels, study groups and task forces organised through the Air Navigation Bureau) provided to ICAO by Contracting States and international organisations.

Global interoperability is essential in order to support CNS. How will ICAO contribute in the future to the coordination of regional authorities?

ICAO has a four-step plan to deliver global interoperability, and each step brings regional authorities into the development and decision-making elements of ICAO's programme.

Step one was to bring the standard-making bodies together to form a Standards Organisation Round Table. EUROCAE, EUROCONTROL, the SESAR Joint Undertaking, EASA and the European Commission are all members of this Round Table, and actively participate in establishing the working agreements with standards organisations on which work programmes have priority.

Step two is to define global system upgrades for interoperability purposes that are independent of when and where specific ATM improvement progammes are introduced.

Step three requires access to the right

information. As part of this, ICAO will be hosting a Integrated Systems Symposium which will give our industry a critical voice in deliberations, and again our European partners will be playing a significant role in reviewing the individual Regional Plans (NextGen and SESAR in this case), developing the gap analysis, and, in the near future, agreeing on common areas for block upgrades, which will need to include the operational improvement intended, the technology required (on the ground and in the air), the procedures for all of the components (operational and technological), the regulatory approval plan, and the business case and/or mandate plan (if required) to achieve results in terms of infrastructure standards and requirements.

I am transitioning all of our CNS requirements from a model founded on technology-based capability to one predicated on outcome-based performance needs.

Finally, step four will be to deliver a new Global Air Navigation Plan at the 12th Air Navigation Conference in November 2012, presenting three specific planning elements for tomorrow's aviation system:

- a series of operational improvements (block upgrades) and identification of the work programmes and implementation efforts required for their implementation;
- an Avionics Roadmap oriented around the block upgrades eventually agreed upon, and an ATC Communication Plan;
- an electronic regional Air Navigation Planning facility providing transparent, real-time regional planning capability.

How should organisations such as EUROCONTROL and the FAA contribute to the ensuring of global interoperability?

There are three areas of engagement in which the contribution of organisations such as EUROCONTROL and the FAA is essential to the desired global interoperability outcomes.

These areas are information, expertise and funding. Information is required so that global developments are synchronised with regional developments, particularly where those regional developments are leading world practices.

Expertise in the form of panel membership, standard-making body support and the meeting of engagements in terms of hardware and procedures design; and expertise for educational purposes, for workshops and symposia through which we can bring some of the identified best practices to the rest of our global system at a reasonable cost.

The last area is financial support. ICAO does not receive sufficient budget from Contracting States to resource all of the projects which are needed to achieve all of our global interoperability targets. The 37th General Assembly has just approved a Voluntary Safety (SAFE) Fund, through which donors can provide resources in terms of funding or expertise tied to a particular project, and we see this as an ideal mechanism allowing EUROCONTROL and the FAA to ring-fence funding for projects which are of particular relevance to their needs but which also have an application in terms of global interoperability.

How is ICAO's approach to CNS evolving? How do you see the future CNS infrastructure evolving?

There has been a strategic change in ICAO's approach since the start of my tenure here at the Air Navigation Bureau. I am transitioning all of our CNS requirements from a model founded on technology-based capability to one predicated on outcome-based performance needs. It will take time and we are concentrating on future needs for the moment, but, following the 12th Air Navigation Conference, I will be looking to reverse-engineer all of our current Annex 10 Standards to fit the new model.

This is driven by my belief that future CNS infrastructure needs are evolving from a technological capability model to an operational requirement model catering for the huge variety of operations in our global system. We don't want to be the roadblock obstructing any proposed international civil operation bringing safety and/or efficiency benefits.

As ICAO moves forward with a performance-based approach, it will be looking to the standard-making bodies to agree on technical specifications and standards allowing systems to be designed, implemented and maintained in compliance with the stated level of air navigation system performance.

What will be the main challenges ahead?

In terms of CNS infrastructure, we have a number of significant challenges to meet over the next couple of years.

Our immediate concern is to obtain agreement on the first of the block upgrades which will support the aviation community for the future, and to ensure that there is a business case to support them. The early block upgrades are probably ready to identify themselves, and in many cases there is plenty of evidence to support the business case for industry.

As we look further ahead into the various ATM improvement programmes, however, the individual elements which should be brought together to form block upgrades are less clear, and in some cases we are still missing the results of operational trials, which we need in order to substantiate the packages.

Agreement on an ATC Communication Plan for the future will also present us with a real challenge. Both the navigation and the surveillance elements have largely been identified, and a global consensus is achievable, but we still have much work ahead of us to reach agreement on an ATC Communication Plan, so this will be one of the primary work efforts leading up to the 12th Air Navigation Conference.

Finally, the frequency spectrum ranges which we keep protected for aviation safety purposes are under continuous threat from more lucrative uses. ICAO has a policy and a plan leading up to WRC-12, and we have already begun working on strategies for ICAO's position leading up to WRC-15. There is a need to find spectrum for remotely piloted aircraft and future innovations, to make more efficient use of the spectrum we currently have allocated to us, and to have a strategic plan for the release of spectrum as we phase out some of the older technology.

What are likely to be the most important aspects of the 12th Air Navigation Conference in 2012, and what are ICAO's expectations?

First, to provide some background, ICAO has been working to create the mechanisms to achieve an integrated global ATM system through the implementation of air navigation systems in a progressive, cost-effective and cooperative manner. As the formulation of performance-based regional, sub-regional, national, industry and user plans for air navigation systems gains maturity, ICAO continues to address the challenge of the integration, interoperability and harmonisation of the systems leading to the concept of One Sky. The notion of the One Sky concept would be conceived globally, the plans would be developed regionally and the infrastructure would be implemented locally.

The One Sky initiative, while enabling ATM to cope with future air transport demand, would also support the restructuring of airspace and the provision of air navigation facilities and services on the basis of traffic flows rather than national borders, the increase of overall capacity and efficiency, and the improvement of safety, while also contributing positively to the environment. The One Sky high-level global architecture should enable the digital environment, integrate aerodromes (gate-to-gate strategies), facilitate trajectory-based ATM and support performance-based CNS systems.

Finally, the Conference will provide an opportunity to work together within and outside ICAO towards the establishment of a strategy for air navigation planning and implementation, based on the work accomplished over the past twenty years, during the two-year build-up to the conference and during the follow-up.

It would provide the venue and impetus to set priorities, coalesce around major themes, obtain agreement from the global aviation community on a 10-year agenda for air navigation planning and implementation, organise and rationalise work programmes before and after the Conference and drive them towards finalisation, provide a stimulus to air navigation activity and implementation, and give States the legal framework for funding and developing work programmes and more.

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Single European Sky regulatory framework

Eduardo Morere Molinero from the European Commission's Air Transport Directorate explains how the Single European Sky regulatory framework is being used to develop CNS Mandates, Implementing Rules and Community Specifications.

"The purpose of the Single European Sky (SES) regulatory framework is really quite simple. It is to lay down the necessary legal tools to reduce the fragmentation of air traffic management (ATM) and to increase the capacity of European airspace, in order to enhance its efficiency, safety and cost-effectiveness," explains Eduardo Morere Molinero.

The framework is built around four European Union (EU) Regulations dealing with the creation of the Single European Sky itself, the provision of air navigation services, the organisation and use of airspace, and the interoperability of the European ATM network. These four Regulations make up what is now referred to as the first SES legislative package, which was adopted by the European Parliament and the Council of the EU in March 2004. As far as CNS (communications, navigation and surveillance) is concerned, the last Regulation, known as the "Interoperability Regulation", is the one on which Mr Morere Molinero is most focused.

Having established this regulatory framework, the European Commission (EC) was subsequently tasked with developing a process for implementing the Single European Sky. This process follows a similar route to other EU policies in that it is based on three main practical tools – Mandates, Implementing Rules (IRs) and Community Specifications.

According to Morere Molinero, "A Mandate is a request from the EC asking another organisation, such as EUROCONTROL, for example, to draft an Implementing Rule. As such, it is the starting point for each of the separate elements that make up the whole concept." The Implementing Rules are in practice EC Regulations. They are legally binding instruments adopted by the EC. Once published in the Official Journal of the EU, they become law and give mandatory provisions which are directly applicable to the EU Member States.

The third tool, the Community Specification, is not mandatory, but, as Morere Molinero points out, "If you follow them, you are in conformity with the legislation." There is a slight nuance here, since the normal way of demonstrating conformity within the EU is through the European Standards (EN Standards) system, but, because of the specific characteristics of the SES, the Community Specifications route has been adopted. In principle, it achieves the same objectives.

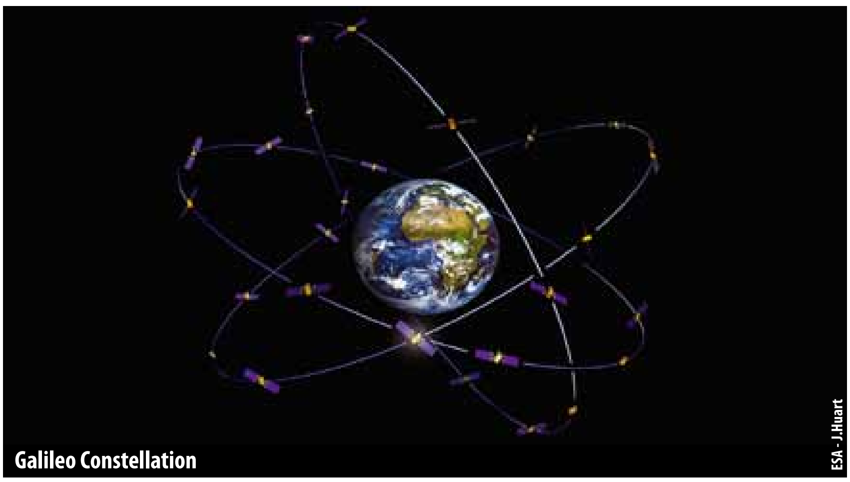
MAIN ACTORS

A policy as large and fundamentally radical as the SES naturally involves a huge number of organisations and bodies. It starts with the EC, which has the two vital functions of drafting the Mandates to initiate the process and then adopting the Implementing Rule to finalise it. Once the Mandate has been drafted, it is delivered to a relevant organisation for the IR to be developed. In the case of the Single European Sky, this means EUROCONTROL. Under the present system for the Interoperability Regulation, EUROCONTROL has two main roles

to play. Its main role is to draft the IRs through a mandated system of consultation. However, EUROCONTROL also shares a second role with the European Standards Organisations (ESOs), that of drawing up Community Specifications. If these Specifications are accepted by the Single Sky Committee (SSC), or mandated, a reference to them is published in the Official Journal of the EU and they are formally recognised as a means of compliance.

As already mentioned, a number of Community Specifications are also developed by the ESOs – CEN (the European Committee for Standardization), Cenelec (the European Committee for Electrotechnical Standardization) and ETSI (the European Telecommunications Standards Institute). In the case of the SES, however, only ETSI and CEN are tasked with this role. In order to ensure that civil aviation expertise is taken into account when drafting the specifications, the SES Regulations stipulate that the ESOs must cooperate with EUROCAE, the European Organisation for Civil Aviation Equipment. "This," says Morere Molinero, "is very important, and that is why it is explicitly mentioned in the SES Regulations."

As far as the IRs which have already been adopted are concerned, the European Aviation Safety Agency (EASA) has been involved only in activities relating to the airworthiness of airborne equipment. However, as Morere Molinero points out, "At the end of 2009, the Council and the European Parliament decided to extend EASA's competence to ATM and airports." Therefore, in the future, EASA will be competent to participate in the process of preparing legislation for the safety of ATM, thus extending its remit into the realm of ground equipment. EASA will also play a large role in the certification of pan-European systems such as EGNOS and, in the opinion of Morere Molinero, "EASA may have a role to play in the certification of the navigation signal of Europe's Galileo satellite constellation."



Galileo Constellation

ESA - J.Huart

CONSENSUS DECISION-MAKING

With so many different stakeholders directly affected by the SES regulatory framework, it is essential, according to Morere Molinero, that the project moves forward on the basis of consensus and stakeholder buy-in. There is too much at stake to travel down a lengthy route in pursuit of a certain objective only to find that serious objections are raised at a critical point, putting a particular project at risk. With this very much in mind, the SES regulatory framework has built in two major vehicles for obtaining the necessary consensus before a Mandate is drafted or an IR developed – the Single Sky Committee and the Industry Consultation Body (ICB).

The ICB has a legal basis, having been created by the SES basic regulation. It includes all those with a vested interest in this policy, from air navigation service providers and airlines to the equipment manufacturers and, naturally, the trade unions which represent the associated industries and service providers. Up to now, the EC has consulted the ICB on all the SES Mandates which have been awarded. In fact, Morere Molinero insists that the first thing the EC asks before handing over a Mandate is, "What does the ICB think?" This, he says, gives the EC the confidence of knowing that any particular Mandate already has the support of the aviation community as a whole.

Once the EC has consulted the ICB, the next step is to go to the Single Sky Committee (SSC). This Committee is unique in terms of EU policies in that it has two representatives from each of the 27 EU Member States – one civil and one military. Moreover, there are a number of European States that have been invited onto the Committee as observers, able to attend all of the meetings but without voting rights. The SSC is the body that gives its formal opinion, through a majority vote, before a Mandate is issued or an IR or Community Specification adopted.

Morere Molinero is confident that the EC, EUROCONTROL, the ESOs, EUROCAE, EASA, the ICB and the Single Sky Committee have all reached a working basis for the drafting of the necessary regulations

However, there is yet another consultative process in play after a Mandate has been issued, and that is EUROCONTROL's own ENPRM (EUROCONTROL Notice of Proposed Rule-Making) procedure, which consists of consultation at two levels. The first level seeks opinions on the regulatory approach to be taken, and then the second consultative process covers the creation of the draft text itself.

ACHIEVEMENTS TO DATE

At the time of going to print, seven "Interoperability" IRs and seven Community Specifications have been adopted. Significantly, four of the seven IRs are specifically for CNS. They include the Flight Message Transfer Protocol (FMTP) (633/2007), air-ground voice channel spacing (1265/2007), datalink services (29/2009) and Mode S interrogator codes (262/2009). "This shows we have a working system and that we can agree and adopt regulations," says Morere Molinero.

There are two more CNS IRs in the pipeline, covering surveillance performance and aircraft identification. There is also the possibility that there will be a new regulation on Performance-Based Navigation (PBN). This has been proposed by EUROCONTROL and has already entered consultation with the ICB's "Interoperability" subgroup, which has indicated its qualified support. Morere Molinero is not sure what the outcome will be, but says that if the ICB does think that a PBN regulation is required, this will be put in front of the SSC.

MAIN CHALLENGES

For Eduardo Morere Molinero, the main challenge in terms of the regulatory framework, particularly with CNS in mind, is how to deal with the future systems that emerge from the SESAR Joint Undertaking and the ATM Master Plan, endorsed by the Council in March 2009. For example, Morere Molinero asks, concerning the definition of future ATM systems, "Once we know what the future systems are, will we need regulation or not?" The answer to this question will inevitably become apparent later on, but, for the meantime, Morere Molinero is confident that the EC, EUROCONTROL, the ESOs, EUROCAE, EASA, the ICB and the Single Sky Committee have all reached a working basis for the drafting of the necessary regulations. To what extent they will be needed in the future remains to be seen, but they have been proven to work and are there if they are needed.

CNS technology in SESAR

Deploying new CNS technologies that reduce cost and provide the improved capabilities for new concepts is at the very core of the SESAR programme. The future CNS infrastructure will need to be more capable, and importantly, more flexible than ever in order to ensure that technical constraints do not limit the development of advanced procedures and applications. **David Bowen, Head of ATM Systems at the SESAR Joint Undertaking, explains the role of CNS technology in the SESAR ATM concept.**

It could be easy for a casual observer to believe that the SESAR programme does not provide adequately for the development of CNS systems and technologies.

It is true that a fundamental principle in the SESAR approach is that all technology developments should deliver a capability which is directly derived from operational requirements and support the delivery of a performance benefit to the overall system. In the past, many people believed that we in the CNS community were guilty of developing technical systems first, and then wondering which problems they could solve.

This does not however lead to the sidelining of CNS developments in SESAR. On the contrary, the CNS infrastructure SESAR is targeting will need to be more capable, and importantly, more flexible than ever in order to ensure that technical constraints do not limit the development of advanced procedures and applications. CNS activities constitute a significant level of investment within the SESAR programme.

It is important to recognise the iterative nature of this process. While technical constraints must of course set limits for some of the conceptual thinking, we must also allow the 'did you know we could do this' kind of feedback to those with the job of envisaging the future concept.

Deploying new CNS technologies that reduce cost and provide the improved capabilities for new concepts is therefore at the very core of the SESAR programme. It is equally important to take into account legacy CNS systems as the approach evolves, while new developments are based on developments from other domains or contain commercial off-the-shelf (COTS) components, in order to move away from bespoke CNS solutions for ATM.

COMMUNICATIONS

The future SESAR ATM concept demands datalink services supporting features such as 4D trajectory management, ASAS separation, automation and SWIM. A reliable and efficient communication infrastructure will have to serve all airspace users in all types of airspace and

CNS technology
in SESAR (cont'd)

phases of flight, providing the appropriate quality of service needed by the most demanding applications. The mobile part of this infrastructure will be based on a multi-link approach, composed of three different subnetworks:

- A ground-based line of sight datalink as the main system in continental airspace and supporting air/ground services and possibly air/air services, offering a high quality of service which will be necessary in the high-density areas; two systems are under consideration (LDACS 1and 2) with the objective of selecting one for implementation. Both operate in the L band and are based on modern and efficient protocols.
- A satellite-based system providing the required capacity and quality of service to serve oceanic airspace whilst complementing ground-based continental datalink as a way of improving the total availability. The system is being defined in close cooperation with the European Space Agency. The type of satellite constellation to be used (dedicated or commercial) is still under consideration.
- A system dedicated to airport operations, based on standards similar to WiFi, providing a broadband capacity to support the exchanges of a significant amount of information such as the uploading of databases or maps in the aircraft.

In addition, and to allow in the medium term interoperability with military operations, a gateway is being defined to interconnect the ATM system and the military Link 16 system.

NAVIGATION

Navigation system developments in SESAR are predominantly focussed on the evolution of GNSS[1]-based navigation technologies which will be developed to fulfil navigation performance supporting RNP[2]-based operations as defined and validated in the operational projects of the programme.

The SESAR work programme integrates operational projects, which define new PBN[3] procedures and concepts, with the technical projects, which develop the navigation tools and systems according to operational needs, which are validated by the operational projects.

For the underlying navigation sensor and system developments SESAR projects aim to define the medium and long-term GNSS baseline, including the expected configuration of constellations, signals and augmentation systems (SBAS[4] and ABAS[5]) and complemented by classical navaids. This will drive the further developments within the programme covering EGNOS[6] evolution from GPS L1 to multi-constellation/signals (GPSL1/L5 + Galileo E1/E5 over e.g. GEOs). Space-based components will also form part of the overall system providing this capability and the scope of the SESAR projects is intended to complement the ESA European GNSS Evolution Programme.

For approach operations, while instrument landing system (ILS) Cat II/III is expected to remain the main precision approach and landing system for major airports, in the medium term an increased use of GBAS[7] to support precision approach operations is expected. Prototyping and validation of GBAS Cat II/III will be progressed (based on GAST D and the GPS L1 SARPs) in a first step while GBAS ground-station supporting multi-frequencies will be defined and validated to meet the Cat II/III requirements. The airborne architecture of the initial GBAS CAT II/IIII airborne system will also be defined.

The rationalisation of the ground navaid infrastructure in support of the GNSS-based systems must ensure we have a cost-effective, fit for purpose terrestrial back-up capability.

SURVEILLANCE

While the evolving role of the surveillance capability is less obvious than the PBN 'revolution' in navigation and the system-wide connectivity driving communication developments, surveillance nevertheless continues to be an essential enabler to ATM modernisation.

Increasing traffic densities, pressures on the utilisation of the RF spectrum, new modes of separation, including ASAS[8] applications in the cockpit and improved safety nets are placing greater demands on surveillance systems.

These needs stimulate the use of new surveillance techniques including ADS-B[9] and wide area multilateration

1 - GNSS: global navigation satellite system
2 - RNP: required navigation performance
3 - PBN: performance-based navigation
4 - SBAS: satellite-based augmentation system
5 - ABAS: aircraft-based augmentation system
6 - EGNOS: European geostationary navigation overlay service
7 - GBAS: ground-based augmentation system
8 - ASAS: airborne separation assistance/assurance system
9 - ADS-B: automatic dependent surveillance - broadcast
10 - SSR: secondary surveillance radar
11 - ACAS: airborne collision avoidance system

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The added-value of SESAR and its complexity comes from interlinking operational and technical projects

(WAM) which can deliver improved performance in terms of accuracy, update rate and coverage and are also potentially more efficient from an RF perspective than traditional SSR[10]. Advanced multi-sensor surveillance data fusion can also maximise the use of common airborne components, depending on specific ground system requirements and operational needs.

SESAR will develop an ADS-B ground-station to include the integration of WAM capability. On the airborne side the ability of 1090MHz ADS-B to continue to work in the ever-more congested 1090MHz band is being investigated while the longer-term consideration of a potential new ADS-B system is also planned. Other options in the future could include satellite-based solutions and the evolution of the non-cooperative surveillance infrastructure.

The intelligent combination of these different surveillance techniques and the improved sharing of surveillance data will allow a rationalisation of the surveillance infrastructure (especially in terms of multiple overlapping SSR as we have today) which should lower costs and reduce the impact on the 1030/1090 spectrum, extending its useful life as traffic increases.

ACAS[11] evolution will also take account of new separation modes and the coordination of airborne and ground-based safety nets also drives the development and validation of the ground system capability to receive ACAS alerts to be made available to the ground systems.

The ongoing development of weather and wake vortex detection capabilities at aerodromes is another key thread within the SESAR surveillance projects to reduce the impact of adverse weather conditions on the ability of an airport to maintain capacity.

CONCLUSION

The added-value of SESAR and its complexity comes from interlinking operational and technical projects. Hence, our developments are no longer made in isolation; they are integrated in a consistent operational concept and architecture.

The performance focus of SESAR is certainly the most important cultural change in ATM R&D. This, applied to CNS, will mean trade-offs between technical performance, real users' requirements and cost. We expect to move away from ATM-specific solutions, in particular in communications, in order to benefit from state-of-the-art technologies.

CNS should become a much more integrated part of the overall European ATM system enabling performance-based operations through the capabilities provided.

Underlying much of these evolutions will be a long-term development of the future datalink technologies with a multi-link approach to the mobile capability as well as a ground-ground communication infrastructure enabling SWIM between all stakeholders.

More use of satellite-based navigation capabilities leads to less reliance on ground infrastructure and therefore greater flexibility for airspace users and the definition of performance-driven trajectory-based operations delivering direct benefits to the user in terms of cost and environmental impact.

Ultimately the way we think about CNS will change and the stand-alone nature of CNS that many of us have grown up with will evolve. This does not mean however that these capabilities will be less important in the future system. All of the conceptual steps forward envisaged in the European ATM Master Plan ultimately rely on an ever more adept CNS capability made available to all the users whenever it is needed. ■

Thales

Modernising Europe's ATM systems

As a member of the SESAR Joint Undertaking, Thales is fully committed to the modernisation of European ATM systems by coordinating and concentrating all relevant research and development efforts across Europe.

Centre for Advanced Studies in ATM (CASIA) – Thales Australia

Thales is a global technology leader in the defence and security and aerospace and transport markets With its 22,500 engineers and researchers, Thales has a unique capability to design, develop and deploy equipment, systems and services that meet the most complex security requirements. Thales has an exceptional international footprint, with operations around the world working with customers as local partners.

www.thalesgroup.com

Thales has been selected to co-lead the three work packages dedicated to the development of the new generation of ATC systems, the system-wide information management system, which will be the backbone of the European ATM network, as well as the development of communication, navigation and surveillance technologies. It will significantly contribute to the work packages dedicated to aircraft avionics systems and airport systems. The Group will also bring its expertise to the work packages dedicated to the definition and validation of the concepts of operations and operational procedures, and will actively participate in the definition of the overall "system-of-systems" architecture.

In this respect, Thales ATM Lab will be a key enabler in SESAR, supporting fast and agile prototyping and assessment of innovative technologies and concepts.

ATM LAB

In April 2009 Thales set up the ATM Lab in order to reinforce the research collaboration between universities, public research laboratories and a leading industry player. This "Lab" stands for "Land of freedom", "Anticipation" and "Be innovative". For its creator, Areski Hadjaz, the ATM Lab is above all a new way, both flexible and dynamic, of encouraging and supporting innovation, with the help of research and technology, operations, marketing and communications departments.

More concretely, the ATM Lab is an incubator for ideas, an environment designed to help ideas become reality, and has four key objectives:

- to formulate innovative ATM solutions;
- to anticipate market evolution and future ATM needs by offering quick-win solutions, by improving the efficiency of the ATC system and by rapidly constructing prototypes;
- to demonstrate the validity of new concepts;
- to foster technical and technological break-through in order to introduce key differentiators to our customers.

THALES

Deliberately short, the incubation period is intensive: a maximum of six months to formalise and hone an idea, develop a solution and improve a prototype which may or may not allow the concept to be approved.

The Thales ATM Lab team focuses on three main themes currently covering more than 15 projects, and has already generated numerous patent applications:

Green ATM

Challenge: What can be done to contribute to the reduction of aviation's environmental impact?

For instance, the green indicators project (fuel consumption, emission and noise models) – to provide air traffic controllers with the means to assess the environmental impact.

Flight optimisation

Challenge: How can we increase capacity without decreasing safety?

For instance, the flight efficiency project – propose to air traffic control the optimum trajectory (minimising the overflight duration), whilst taking into account several constraints including flight separation, restricted area avoidance, controller workload, and aircraft performance.

Future controller working position

Challenge: How can we combine new man-machine interaction tools with operational needs?

For instance, the ART project (Augmented Reality Tower) – implementation of an enriched display in control towers, which in turn increases safety in low-visibility conditions.

PENS

The first European air navigation service provider communications network

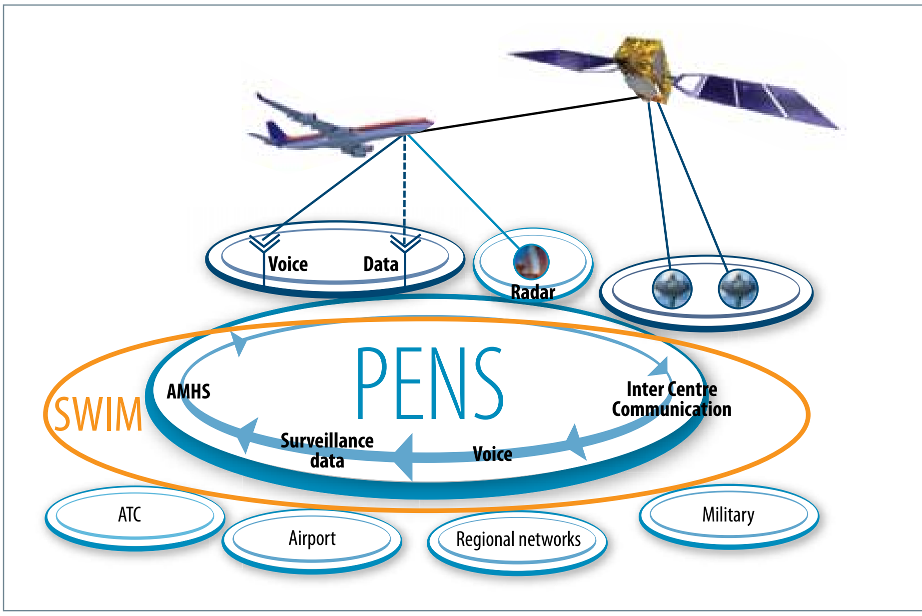
Rafael de Reyna Zaballa, Head of International Cooperation at Aena, outlines how PENS, the pan-European network service, is a key element in the future technical infrastructure of ATM, and discusses the advantages of being a PENS user.

WHAT IS PENS?

The pan-European network service (PENS) is an international ground/ground communications infrastructure jointly implemented by EUROCONTROL and the European air navigation service providers (ANSPs) in order to meet existing and future air traffic management (ATM) communication requirements, current needs for inter-ANSP information exchange and the needs within the SESAR programme for system-wide information management (SWIM), all of which need to be aligned with the Single European Sky Regulations and industry/ICAO standards.

PENS aims to provide a common Internet-protocol (IP)-based, managed network service across the European region to cover data and voice communications. It will enable its users to exchange critical and common aeronautical information in a seamless and integrated manner, providing a highly cost-effective common infrastructure for the deployment of emerging ATM applications, which will significantly reduce the costly fragmented network services implemented under the umbrella of the outdated X.25 protocol, still in widespread use in some ANSPs.

PENS will not only cover the ANSPs' aeronautical information, but also the current IP network services of EUROCONTROL, the Central Flow Management Unit (CFMU) information, and data of the European aeronautical information services database (EAD), offering cost-saving benefits by gathering together in a single network the locations (many of which are shared) where both CFMU and EAD services are distributed.



PENS involves the establishment of multilateral stakeholder communications for CDM (collaborative decision-making) and SWIM applications, bringing benefits for the entire air transport industry.

PENS GOVERNANCE

A PENS governance body is an organisation the sole remit of which is to contribute to the governance of the PENS. There will be two main PENS governance bodies, the PEN Service Steering Group (PSSG) and the PENS User Group (PUG).

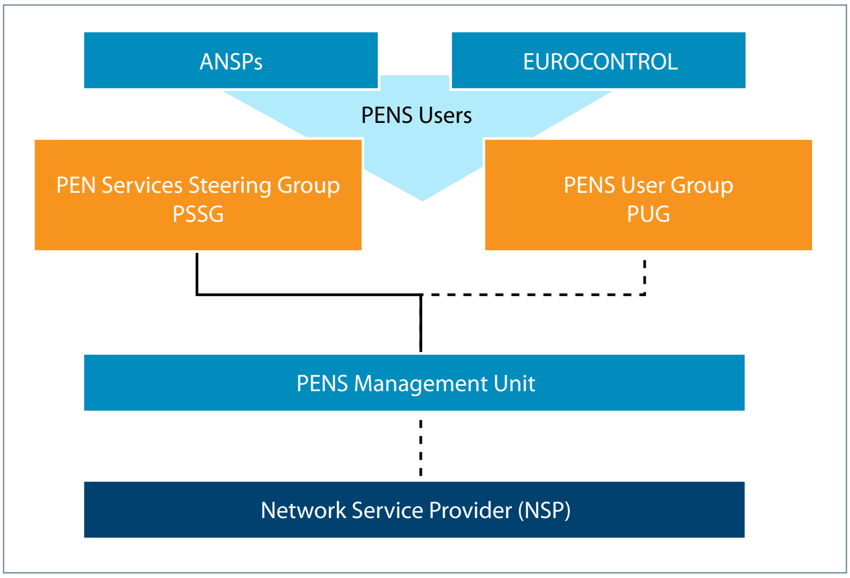
The PENS Management Unit (PMU) is a body within the EUROCONTROL Agency in charge of the day-to-day management of PENS. All technical and contract management matters are carried out by the PMU.

The PSSG is a committee representing PENS ANSP users and the EUROCONTROL Agency which will set policy and standards and review the performance of PENS. It will also provide direction and guidance to the PMU in relation to service and business planning, and financial, contractual and procurement matters, subject to the code of conduct and security.

The PUG is a committee consisting of members from the user community who may carry out specific detailed reviews of performance, user needs, policy and standards.

The PUG advises the PSSG of its findings and may execute specific tasks on behalf of the PSSG. It may draw the attention of the PSSG to deficiencies or emerging opportunities.

The PENS service is operated and managed by the network service provider (NSP), which is currently SITA. The PMU is the unit responsible for monitoring and supervising NSP performance on behalf of the PENS user organisations.



BENEFITS OF PENS

EUROCONTROL and its Member States' ANSPs evaluated the feasibility of establishing a single pan-European network service which would:

- be delivered and managed by a communications service provider;
- deliver cost savings vis-à-vis continuing with individual dedicated IP networks, as a result of common CFMU, EAD and/or ANSP backbone sites;
- provide the platform for the exchange of AMHS messages and surveillance data between ANSPs;
- support ANSPs in complying with the Single European Sky flight data exchange implementing rule;
- provide a platform to evaluate the performance and benefits of ATC voice communications over IP;
- provide SESAR with a platform for the evaluation and validation of SWIM and other work packages.

PENS PHILOSOPHY

The PENS philosophy is based on the concept of sharing. All PENS users located at the same site can in fact share the same infrastructure in a secure way, providing substantial economies of scale, as the number of lines is optimised.

PENS provides a secure and robust infrastructure for exchanging information between the users connected to it, since the pan-European network

WHO IS ALREADY A PENS USER?

Since the signature of the contract on 28 October 2009 between EUROCONTROL and SITA for the provision of PENS, the following organisations have become PENS users:

- EUROCONTROL for CFMU and EAD services
- Aena, Spain
- NAVIAIR, Denmark
- LFV, Sweden
- LPS, Slovakia
- Finavia, Finland
- Avinor, Norway
- NAV, Portugal
- Hungarocontrol, Hungary
- ENAV, Italy
- Croatia control
- Slovenia control
- NATS, United Kingdom
- DFS, Germany
- DSNA, France
- skyguide, Switzerland
- Austrocontrol, Austria

offers fully redundant connectivity with no single point of failure.

EVOLUTION

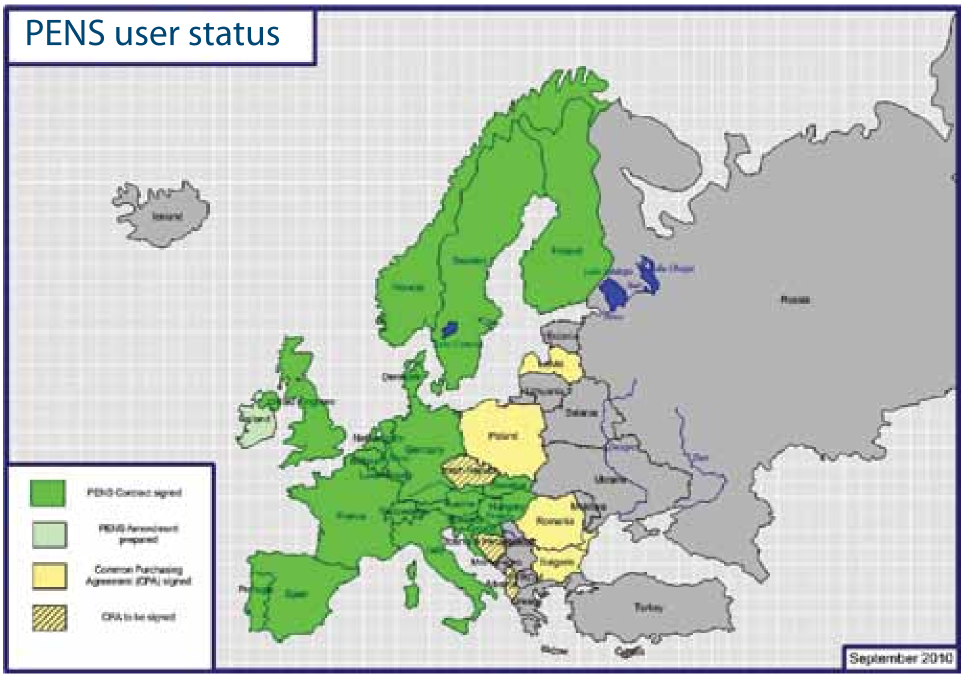
PENS may potentially become the overall communications backbone for the whole ATM world.

The PENS project was initiated jointly by EUROCONTROL, certain ANSPs (Aena in Spain, NAVIAIR in Denmark and LFV in Sweden) and SITA on 28 October 2009. Since then, the number of PENS users has been increasing constantly and a high growth rate is expected in the future.

Negotiations are planned in order to open up the PENS community to airlines, airports, the military, future aeronautical applications (RIMS, MCC, SATCOM), and other ANSPs which currently do not belong to PENS, as well as other ATM partners with similar communications needs.

EUROCONTROL and the ANSPs are working together tirelessly on the PENS project, improving it in order to turn it into one of the key elements in the future technical infrastructure of ATM in Europe, as David McMillan, Director General of EUROCONTROL, said.

EUROCONTROL and the ANSPs are working on PENS development and implementation in order inter alia to draw in new users, offer new services and new strategic developments, make the extension of service provision to new customers and the opportunity to obtaining new incomes much easier, since this would mean a profitable benefit for all users of PENS. PENS mean significant cost savings and the optimisation for the ATM community in Europe.



HOW TO BECOME A PENS USER

An organisation interested in becoming a PENS user has to declare its intention and interest by signing the Common Procurement Agreement (CPA), which allows EUROCONTROL to act on behalf of each signatory in the selection of the NSP, the negotiation and signature of the PENS contract and the subsequent management of the contractual relationship with the NSP.

The signature of the CPA does not turn the organisation into a PENS user. After signing the CPA, it has to submit its application to the PSSG. If it is accepted, the PSSG informs the PMU who has to negotiate an amendment to the PENS contract in order to expand the service to the candidate PENS user, who previously will have signed a letter of consent allowing EUROCONTROL to act on its behalf. After that, the candidate officially becomes a PENS user.

Each PENS user has to pay a charge for the service required in accordance with the PSSG document "Charging for the PENS".

airberlin: the GBAS European Pioneer Airline

Marc Altenscheid, Chief Boeing Fleet airberlin, reveals how airberlin is the first European airline to benefit from the flexibility, efficiency and safety improvements which satellite navigation technology can provide to operations.

airberlin, the second-largest German airline with around 28 million passengers, operates a very modern fleet of aircraft. On average its planes are just five years old. By constantly renewing its fleet and focusing on technical innovation, airberlin has been able to reduce its specific fuel consumption: in 2008 average specific fuel consumption at airberlin was 3.70 litres per 100 passenger kilometres, while in 2009 this was reduced by another 1.6%, to 3.64 litres. This is one of the lowest figures achieved by airlines.

The blended winglets of the 737 fleet, which airberlin introduced before any other airline, have since become a trademark of airberlin's Boeings. airberlin has also taken on a pioneering role in other innovative projects. airberlin leads the field in the development and implementation of the "electronic flight bag" (an electronic display system used by pilots) and the "paperless cockpit". The airline's declared aim is to dispense with using paper altogether for its flying operations by 2012.

Flights carried out with area navigation technology and the ground-based augmentation system (GBAS) landing system (GLS) represent one of the largest current projects undertaken by airberlin, as the innovative potential is enormous. In comparison with the conventional instrument landing system (ILS), satellite technology offers much greater flexibility during the approach. In addition to offering better time schedule stability and improved cost efficiency, this will also allow further reductions in noise and pollution to be achieved.

NEW FLEXIBILITY THANKS TO PERFORMANCE-BASED NAVIGATION

Performance-based navigation (PBN) and the GBAS landing system allow waypoints to be individually determined in three-dimensional space. In contrast to ILS, which specifies a straight-line approach to the runway, this delivers a more flexible way of skirting densely populated areas – an interesting aspect in terms of reducing aircraft noise for people living near an airport.

Satellite navigation also represents a new option for airports which, due to their geographical location, have not yet been able to operate an instrument landing system. The GBAS ground station allows up to 49 approaches to be coordinated simultaneously. If this technology is upgraded to CAT III standard in the future, it will also mark an end to aircraft being unable to land in low visibility conditions at airports without ILS. If satellite technology were to replace ILS as standard, this equipment would also make possible a major step towards improved schedule stability for airberlin, which lands not only at large international airports, but also at many smaller airports. Flights to holiday islands in Greece or destinations in mountainous regions, such as the Alps, are still subject to visual flight rules (VFR) as a prerequisite for landing. Without the right conditions, pilots frequently have no option but to divert to an alternative airport. It is obvious that such innovations are of great significance as far as passenger convenience is concerned, let alone the cost-saving potential for airlines.

However, satellite navigation technology also means a series of simplifications for central airports equipped with ILS as standard. There will be no need to alter the separation of aircraft in low visibility on account of sensitive areas as is required with ILS, and aircraft would no longer be compelled to fly a holding pattern because of the differently staggered approaches, as restrictions no longer have to be imposed on an airport's capacity once a GBAS ground station is in place. The complex ILS antenna system and the associated high maintenance could also be dispensed with if satellite-based navigation technology were to replace ILS in the future.

EXPERIENCE WITH GLS FLIGHTS: PILOTS ARE ENTHUSIASTIC

At present only a few airports have the technology to permit GLS approaches. In Germany these are Bremen airport and the research airport of DLR (German Aerospace Centre) in Braunschweig-Wolfsburg. airberlin carried out GLS validation flights for DLR at the latter airport during 2009 and 2010. At European level, only Malaga airport in Spain has a GBAS station.

airberlin is the only airline worldwide that has been approved by the LBA (German Federal Aviation Office) to use GLS in normal flight operations. While the airline is allowed to fly GLS approaches as routine at Bremen in North Germany, it is only permitted to monitor the GLS signal at Malaga for the time being. However, pilots are already confirming the aeronautical benefits of satellite navigation. In comparison with ILS, the vertical profile is much more stable, especially in mountainous terrain. Furthermore, there is no difference between GLS and ILS in terms of operating the aircraft. Consequently pilots do not require complex simulator training and can familiarise themselves with the system using a computer-based training method.

It is currently not possible to retrofit the aircraft with the new technology, as manufacturers are not offering this option for the GBAS landing system (GLS) at present. At airberlin all new Boeing 737-700s and -800s delivered since June 2007 have been fitted with this new equipment. Due to the airline's flight modernisation policy, which aims to operate a fleet equipped with the newest available technology, the entire Boeing 737 fleet will carry such equipment by 2013. The new deliveries will gradually replace the older models. About one third of the airline's Boeing aircraft is already equipped with GLS.

airberlin is the only airline worldwide that has been approved by the LBA (German Federal Aviation Office) to use GLS in normal flight operations.

GLS AS AN ALTERNATIVE TO ILS

The GBAS landing system represents a future-oriented alternative to ILS. To ensure that this happens, all those involved will endeavour to develop this technology to CAT III standard, so that the full benefits can be reaped. airberlin could provide a major contribution if the GBAS ground station were to be installed at the airline's hubs. The benefits for Frankfurt are clearly evident. But the other airports of major interest to airberlin include those of Berlin, Düsseldorf, Nuremberg and Munich in Germany, and airberlin's hub at Palma de Mallorca at an international level. By using GLS for routine flight operations, the airline would then be able to gather empirical data even more rapidly.

The new satellite navigation technology has quickly established itself at airberlin. It took just two years from the initial talks with EUROCONTROL to the approval of GLS approaches for normal operations. After the first meetings relating to GBAS/GLS had taken place with the German air navigation service provider (DFS) in 2007, airberlin was given permission in 2008 to fly GBAS trial approaches in Bremen and Malaga – and the first trials were immediately carried out in July and August of that year. In July 2009 the German Aerospace Centre (DLR) put a Thales GBAS ground station into operation at its research airport in Braunschweig. airberlin then carried out validation flights with one of its Boeing 737-700s. The breakthrough for normal flight operations came in November 2009, when airberlin was the first airline to be approved for GLS CAT I approaches. Since then GLS has been used alongside ILS on flights to Bremen.

In conjunction with DLR, DFS and Fraport AG, airberlin recently used GLS to try out new noise abatement measures. Approaches to the airport of Frankfurt am Main were simulated at the research airport in Braunschweig-Wolfsburg to measure the extent to which aircraft noise could be reduced by adopting more flexible landing approaches. Consequently the tests involved both curved-line and steeper approaches while measurements were taken on the ground. Further tests and validation flights are due to follow.

airberlin is the first European airline to benefit from the flexibility, efficiency and safety improvements which GBAS/GLS operations can provide. ■

Iris Programme

Satellite communications on board aircraft are not new. Passengers have been able to call home or book a hotel while in the air for some time now, but what about safety-critical communications between the pilot and the air traffic controller? To a large extent, these are still passed through a limited voice communication channel. However, for the future operating concepts, there are requirements for new air-to-ground data links for aircraft communications by 2020. **Nathalie Ricard, Iris Programme Manager at the European Space Agency, reports.**

The European Space Agency (ESA), with the support of SESAR, EUROCONTROL, the European space industry, air navigation service providers and national space agencies, is implementing the Iris Programme in order to design, develop and validate a new satellite communication system for air-to-ground safety communications which will fulfil the requirements of the SESAR Programme.

WHY SATELLITES?

Satellites are an ideal solution to support air traffic management (ATM). They not only deploy communication capacity over vast areas rapidly, including oceanic and remote regions, but also tailor the capacity to meet regional requirements in high-density areas. By allowing communication seamlessly across continental, oceanic and remote air routes with a single terminal, satellites offer a unique opportunity for safety improvements and the provision of additional services to pilots and crews. This is especially important on oceanic routes, as the limitations associated with HF radio communications allow only the most basic forms of communication between aircraft and the ground.

In continental airspace, the new satellite communication system for ATM will be used together with a new terrestrial-based air-ground datalink system. The purpose of using these two independent technologies is to ensure that the service will be constantly available, using at least one of the links, since data communication exchanges will become critical to maintaining efficient operations. Because the service will need to be constantly available in high-density continental airspace, the technology needs to be resilient. It is a safety system which is fundamental for the future of ATM.

The implementation of the new satellite communication system requires two parallel developments:

1. The development of technical specifications for a new satellite communication standard. This standard will have to be adopted at worldwide level, because airlines are truly global in operation. This requires standardisation and coordination with international stakeholders such as ICAO.
2. The design of a modular satellite system which will allow various world regions to deploy their own infrastructure, and the development of the European satellite infrastructure, which will enable the provision of this service in Europe.

The key will be to guarantee that a unique communication standard is openly available for all regions, so that the new aircraft avionic terminals are interoperable and communications can occur seamlessly and transparently when aircraft travel from one regional system to the next.

The satellite-based system is envisaged to be part of, interface with, and be fully interoperable with the other elements of the new telecommunication infrastructure of the European ATM system, notably the other communication links based on terrestrial networks developed in SESAR.

WHAT IS A SATELLITE COMMUNICATION SYSTEM?

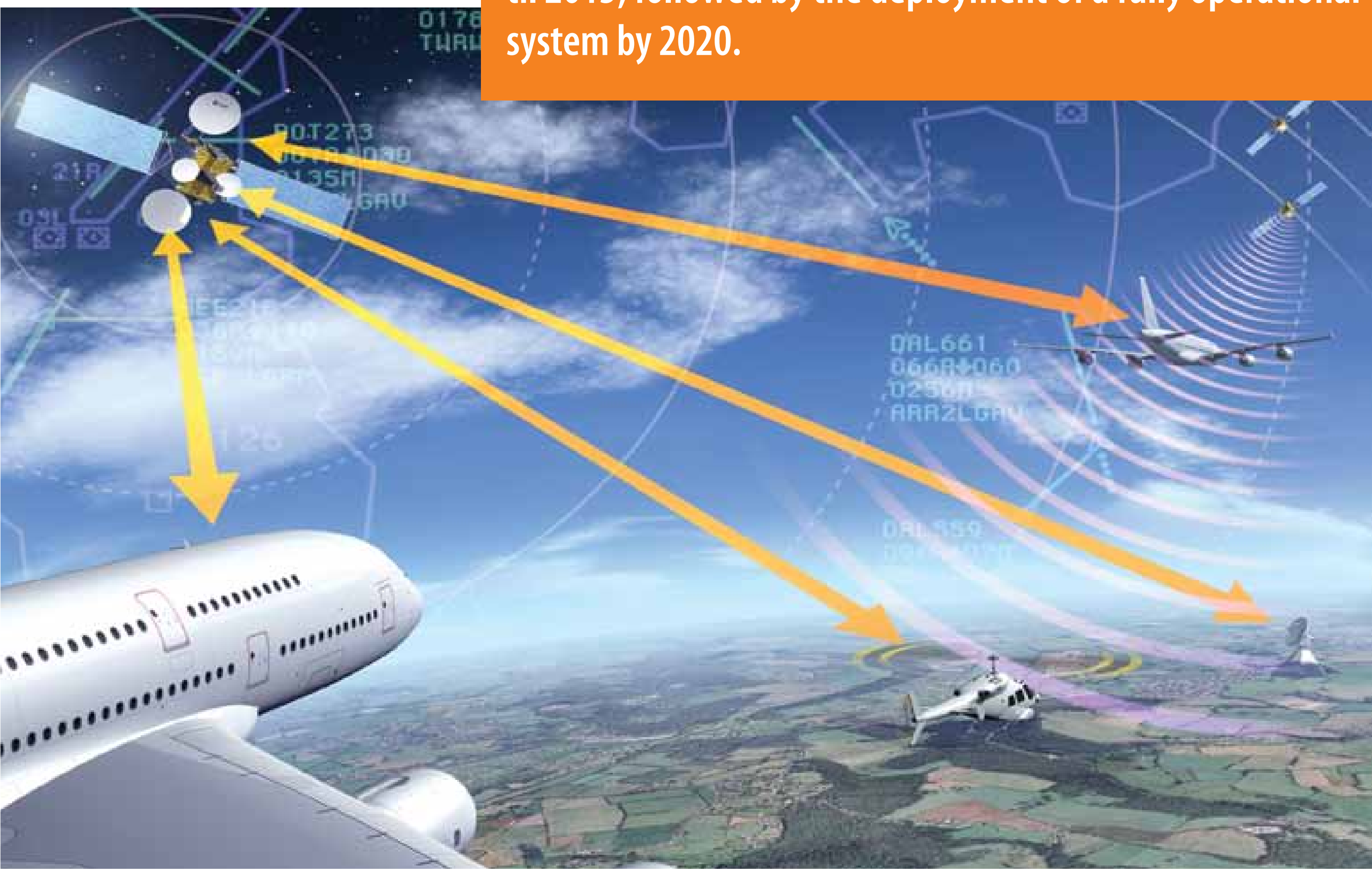
Design of the satellite system started in 2009, after two years of feasibility analyses. The Iris Programme has been built on many years of close collaboration between ESA and EUROCONTROL involving preparatory work since the late 1990s, which raised awareness of the benefits which satellite communication technology can bring to ATM.

Most of the technical challenges of the Iris Programme revolve around designing appropriate communication protocols which not only guarantee the integrity of the information exchanged whilst simultaneously serving all aircraft but also meet the delay and reliability requirements for the system. The design also needs to be sufficiently flexible to accommodate new types of messages which may need to be introduced in the future.

The system relies on a spacecraft located in geostationary orbit. The design and sizing of the satellite payload will follow the design of other elements of the system. Capacity requirements are based on the number of simultaneous users and the transmission rate from user terminals towards the satellite.

The actual validation of the end-to-end system requires the implementation of an infrastructure as close as possible to the system to be deployed operationally. This validation infrastructure will be developed and procured by ESA, with support from the future owner of the operational system. Validation will be carried out by 2015, synchronised in

Iris is financed by ESA Member States and the system is being developed by European industry under ESA contracts. The total development phase for Iris will run until 2015, followed by the deployment of a fully operational system by 2020.



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Iris programme (cont'd)

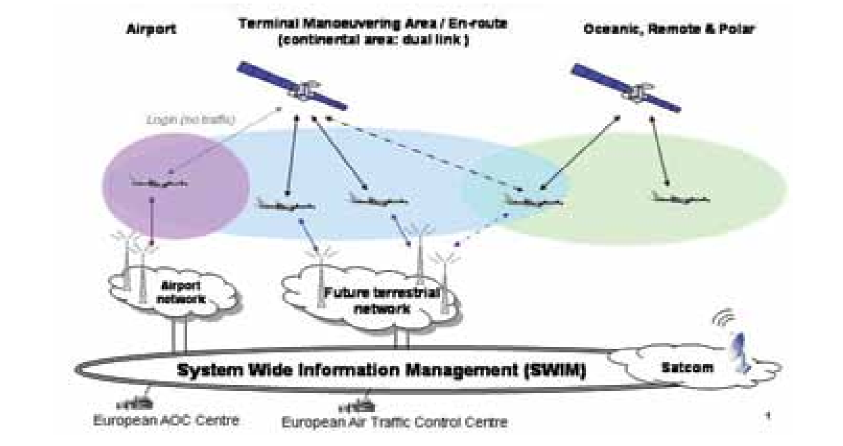
time with Implementation Package 3 of the SESAR Development Phase.

As there might be a need to have several service providers of satellite communications, the system has been designed with the capability to fragment the resources among several competitors. However, as the service model has yet to be defined, the design has to cater for every option. There may be a single entity offering the satellite communication service, or there may alternatively be competitive providers. Each service provider may decide to install their own ground station(s) anywhere within the service coverage area. Considering the current high level of fragmentation of European ATM provision with small geographical sectors, and the evolution towards the implementation of functional airspace blocks (FAB) within European airspace, one of the options assumes a similar model for service provision, with an independent service provider per FAB. Cost estimates for both the centralised and the distributed options will be provided to the SESAR Joint Undertaking (SJU) to support aviation's cost-benefit analyses.

Once validated, the globally interoperable satellite communication system infrastructure will be deployed over time in various world regions depending on their respective needs. It will be procured by different organisations and will be modular in design. Europe will deploy only a regional infrastructure, to ensure seamless transition from areas of high-density traffic to oceanic and remote areas.

USER TERMINALS

Design of aircraft user terminals (aeronautical earth stations) is focusing on ensuring low-cost, small and light-weight satellite data units. Similar design constraints are also applicable for the required antennas (which need to be small). The location for mounting the antenna on the aircraft fuselage and the location of indoor unit(s) on board different aircraft types are also being addressed with a view to minimising the cost of installing or retrofitting equipment and to ensure continuous availability of the communication link even when the aircraft is banking.



Satellite communications services in SESAR continental and oceanic airspace

IRIS PROGRAMME STRUCTURE

The Iris Programme has been structured to match the SESAR programme schedule and milestones, and is in line with the calendar of development and deployment of the European ATM system infrastructure.

From a technical perspective, the role of the European Space Agency covers the design of the new communication system, the design and development of the satellite system and the procurement and deployment of the infrastructure required for technical validation.

From an institutional perspective, ESA is supporting the SJU and the European Commission in facilitating the definition of the service model by carrying out preparatory activities with satellite operators and satellite service providers and by analysing options for consideration within the business case. ESA is also facilitating the definition of the safety case by involving the European Aviation Safety Agency in a supervisory role from the inception of the technical design.

The Iris Programme is a collaborative endeavour between aviation stakeholders and the space industry. It is a new type of initiative for the European Space Agency in which the space component is a tool in a much bigger system. Iris is financed by ESA Member States and the system is being developed by European industry under ESA contracts. The total development phase for Iris will run until 2015, followed by the deployment of a fully operational system by 2020.

SAFER AIR TRAVEL THROUGH IMPROVED COMMUNICATIONS

Iris is a major programme of coordinated activities focused on addressing a global problem. ESA, with the support of SESAR and EUROCONTROL, the European space industry, air navigation service providers and national space agencies are collaborating to develop a new satellite communication system which will contribute to making air travel in Europe safer, more efficient, environmentally sound and cost-effective.

AeroMACS: Aeronautical Mobile Airport Communications System

Future wireless communications infrastructure for the airport surface

Brent Phillips (Federal Aviation Administration), James Budinger (NASA Glenn Research Center) and Ward Hall (ITT Corporation) jointly present the AeroMACS designed to support airport surface operations, especially in high-density areas, through the development of common technology in support of both NextGen and SESAR requirements.

The current validation work, to be carried out both in the US and in Europe, should lead to the development of the system in the latter half of 2013.

AeroMACS: Aeronautical Mobile Airport Communications System

Future wireless communications infrastructure for the airport surface (cont'd)

BACKGROUND

At the International Civil Aviation Organization's (ICAO's) 11th Air Navigation Conference, held in Montreal, Canada, in 2003, it was determined that Europe and the United States were on diverging paths in terms of technologies identified to support their future air traffic services voice and data communications requirements. Following the meeting, EUROCONTROL and the FAA management came together and agreed to work together in order to ensure future global harmonisation and interoperability. The result of this agreement was the initiation of the Future Communications Study (FCS) under Action Plan 17 of the Joint EUROCONTROL/FAA and NASA Memorandum of Cooperation.

During the first phase of the FCS, over 60 wireless communications technologies were assessed by NASA Glenn Research Center and ITT Corporation in the US and QinitiQ Group PLC in Europe for their ability to support the future US NextGen and European SESAR requirements. It was quickly determined that no single technology supported all data communications requirements in all domains of operation. As a result, a short list of common recommendations for candidate technologies, as presented in Figure 1, was proposed in the C-Band for airport surface communications, in L-Band for terrestrial en route communications, and in satellite bands for oceanic and remote communications. These recommendations were endorsed by the FAA and EUROCONTROL, and by the international community through the ICAO Aeronautical Communications Panel. This paper set out the status of the research and development activities for the common technology proposed by the FAA and EUROCONTROL to support airport surface operations, especially in high-density areas. This system is referred to as the Aeronautical Mobile Airport Communications System (AeroMACS).

A NEW COMMUNICATIONS SYSTEM FOR A NEW SPECTRUM ALLOCATION

The proposed AeroMACS system is based on the Worldwide Interoperability for Microwave Access (WiMAX) Forum™ profile of the existing Institute of Electrical and Electronic Engineers (IEEE) standard 802.16-2009 and provides a new class of broadband wireless data communications capabilities on the airport surface for the safety and regularity of flight services.

The AeroMACS system is planned to operate in the 5091-5150 MHz band. This new frequency band is ideal for airport surface wireless networks with short range (~10 km or less sector coverage) and high aggregate data throughput (up to 10s of Mb/s). The World Radiocommunications Conference, held in November 2007 (WRC-07), approved the addition of an Aeronautical Mobile Route Service [AM(R)S] allocation within the 5091-5150 MHz band to the ITU-R International Table of Frequency Allocations. The AM(R)S designation provides protected spectrum for safety and regularity of flight applications. This enables ICAO to develop international standards for the development of mobile airport surface wireless communications networks. The WRC-07 allocation limits communications with aircraft to only when wheels are in contact with the airport surface.

A properly designed, secure airport surface communications system like AeroMACS will reliably interconnect pilots, aircraft and surface equipment with air traffic controllers, airline and airport operators and stakeholders, with new and legacy data sources and applications.

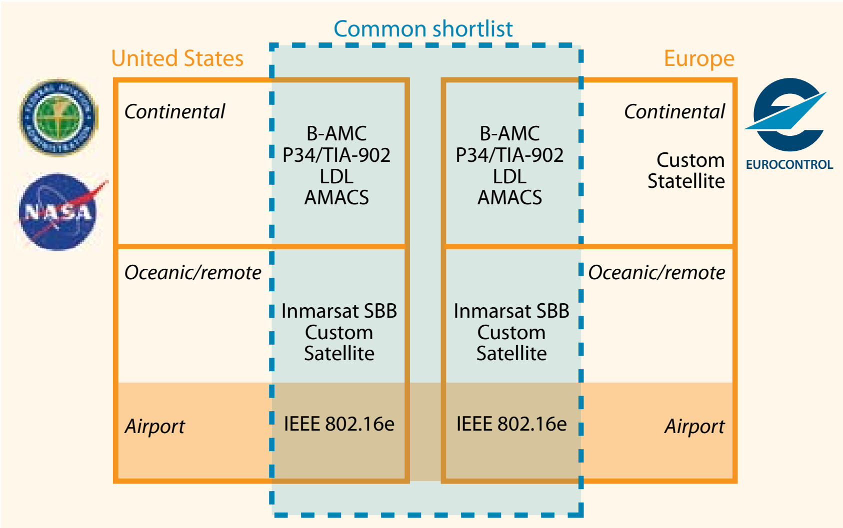


Figure 1 – Common list of technologies recommended by the US and Europe under the Future Communications Study.

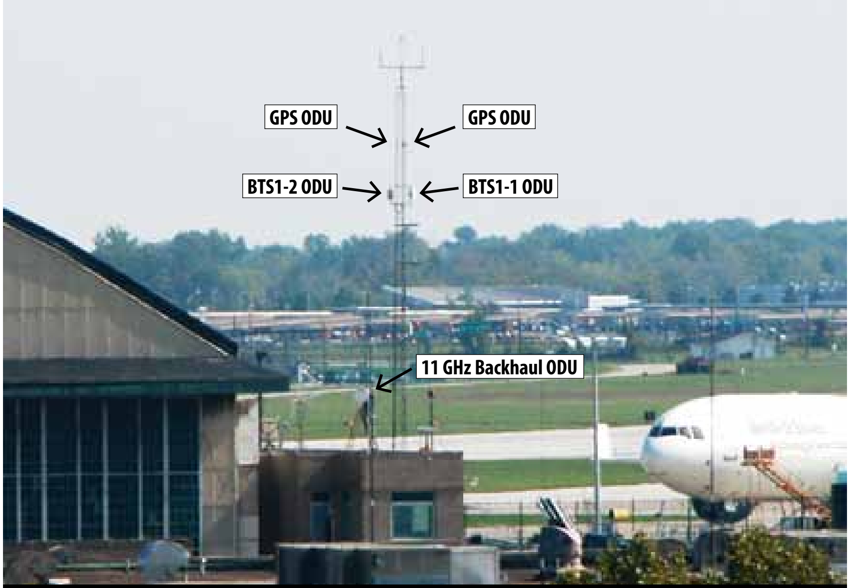


Figure 2 – AeroMACS base station on NASA Glenn property, with two base transceiver stations.

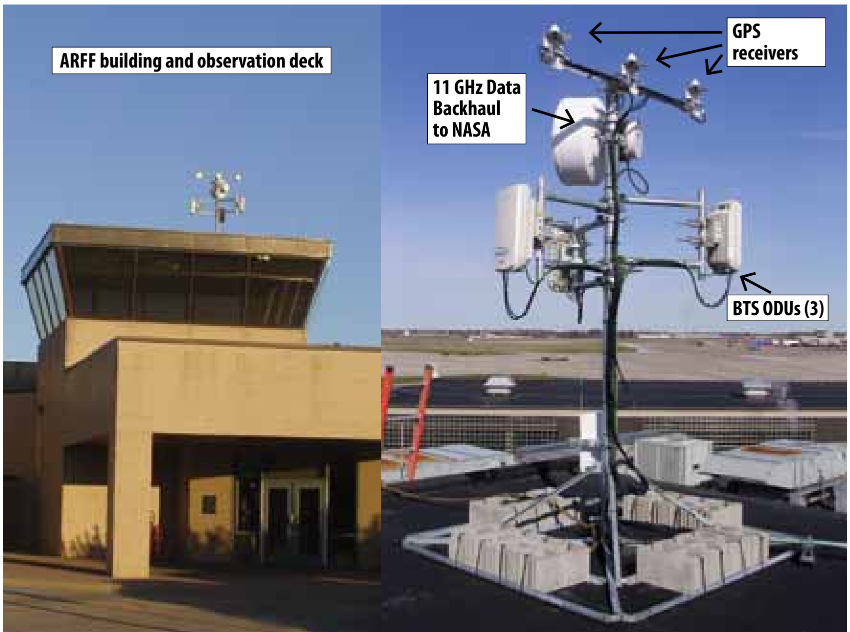


Figure 3 – AeroMACS base station on the Cleveland Hopkins International Airport aircraft rescue and fire-fighting (ARFF) building, with three base transceiver stations and a microwave link to the AeroMACS control facility on NASA Glenn property.

The FAA interpretation of the WRC-07 allocation allows for the inclusion of fixed airport assets within the mobile wireless communications network to the extent that those fixed services directly affect the safety and regularity of flight. Examples of such fixed assets include communications, navigation, and surveillance (CNS) equipment which produce data used for the control of aircraft and other vehicle movements on the surface. The FAA is considering a near-term implementation of AeroMACS to support immediate needs for the distribution of data from fixed assets on the airport surface.

Owing to the wireless nature of this technology and the propagation characteristics in this band, the AeroMACS system can enable a wide variety of rapidly deployed airport improvements in efficiency and capacity as surface movement control and surface operations applications expand over the next few years. A properly designed, secure airport surface communications system like AeroMACS will reliably interconnect pilots, aircraft and surface equipment with air traffic controllers, airline and airport operators and stakeholders, with new and legacy data sources and applications.

US AeroMACS PROTOTYPE

The FAA's AeroMACS research is identified in the FAA's 2009 and 2010 "NextGen Implementation Plans" and is being sponsored by the NextGen Integration and Implementation Office under an existing Project Level Agreement (PLA) with the Systems Engineering and Safety Office. The FAA has contracted NASA Glenn and ITT for support services under this effort. Through the PLA, the development of concepts of use, requirements, and architecture for a new C-Band airport surface wireless communications system has been completed. In addition, with the support of NASA Glenn and ITT, the development of an AeroMACS prototype was completed in late 2009 for validation of airport surface operational concepts and verification of communications performance requirements. The AeroMACS prototype is deployed within NASA-CLE CNS Test Bed located at NASA Glenn and the adjacent Cleveland Hopkins International Airport (CLE).

The AeroMACS prototype is designed to implement the proposed AeroMACS features required to support modern secure broadband wireless data communications at operational airports across the National Airspace System (NAS). The AeroMACS prototype network is implemented with two base stations (BSs) each with multiple base transceiver stations (BTSs), one on Glenn property and the other on CLE airport property as shown in Figures 2 and 3.

These BS outdoor units (ODUs) are linked to core servers located

AeroMACS: Aeronautical Mobile Airport Communications System
Future wireless communications infrastructure for the airport surface (cont'd)

Figure 4 – NASA Glenn's Aeronautical Research Vehicle (ARV) equipped to perform AeroMACS mobility testing and demonstrations.


Figure 5 – ARV internal equipment racks, showing AeroMACS SS test equipment and mobile weather and video demonstrations on laptop computers.

on Glenn property by line-of-sight (LOS) microwave data backhaul radios operating in a different licensed spectrum band. Fixed-location subscriber stations (SSs) are located at two positions on Glenn property and six positions on airport property. The first mobile AeroMACS SS has been implemented with Glenn's Aeronautical Research Vehicle (ARV) shown in Figures 4 and 5 to allow experiments and demonstrations at lower cost than using an AeroMACS equipped aircraft. The ARV mobile SS uses dual antennas mounted in a multiple input multiple-output (MIMO) 2 x 1 (two receive and one transmit) configuration on the roof.

AeroMACS TESTING, EXPERIMENTS AND DEMONSTRATIONS

Several fixed performance experiments and a set of initial mobility tests have been conducted successfully. Initial tests have explored the unique propagation conditions at C-Band frequencies of an airport surface environment and the effects of AeroMACS profile parameter settings. Data throughput and packet integrity are measured for 5 and 10 MHz channel bandwidths, stationary and mobile SS (subscriber station), line-of-sight (LOS) and non-LOS (N-LOS) propagation links, and the presence of adjacent channel activity. Mobility performance has been measured during hand-off transition between BTS coverage sectors and between BSs, with vehicles speeds of at least 50 knots on runways, and 25 knots on taxi and ramp areas. The transmit power required to maintain a minimum level of link performance has been determined for stationary and mobile SSs, single SS antenna and MIMO antenna diversity, and under LOS, near-LOS, and N-LOS link conditions. The first candidate FAA service demonstration involved characterising the link performance when transferring data from Sensis Corporation multilateration (MLAT) surveillance sensors distributed across the airport surface. An example of one of those sites is shown in Figure 6. Additional tests are being considered for security vulnerability and interference assessment.

AeroMACS STANDARDS DEVELOPMENT PROCESS

In July 2009, the US RTCA Program Management Committee approved the development of Special Committee (SC-223) to carry out the development of an airport surface wireless communications standard. The principal products of this special committee are a draft AeroMACS profile delivered by December 2010, and a Minimum Operational Performance Standard (MOPS) document to be delivered by December 2011.

In parallel within Europe, EUROCAE2 Working Group 82 (WG-82) is chartered to develop an AeroMACS profile. In the formation of their respective terms of references, both groups agreed to work collaboratively towards the development of a single common profile document. A common AeroMACS standard will allow properly equipped aircraft to receive compatible AeroMACS services at properly equipped airports in both the US and Europe. In addition to representatives from each group participating in one another's meetings, a joint meeting of the two groups was held in August 2010 at NASA Glenn in Cleveland Ohio as a means of working out existing problems and completing a draft version of the AeroMACS profile.

A common AeroMACS standard will allow properly equipped aircraft to receive compatible AeroMACS services at properly equipped airports in both the US and Europe.

During the development of the AeroMACS profile document, system profile parameter values are being selected within the WiMAX™ standard to maximise the use of commercial-off-the-shelf (COTS) hardware and software. In addition, parameter options are included that give the AeroMACS designer flexibility to accommodate the specific applications and environment which will be unique to each airport. Design considerations, including spectrum allocation, interference, security and channelisation, are just a few parameters which have been included in the design process. Channelisation is particularly important, because it ensures that the communications system is properly structured and configured to meet a large set of requirements and potentially multiple service providers. Practical limits on total radiated emissions from all airports in the NAS are being established so that the threshold of interference into existing mobile-satellite service (MSS) feeder uplinks is not exceeded.

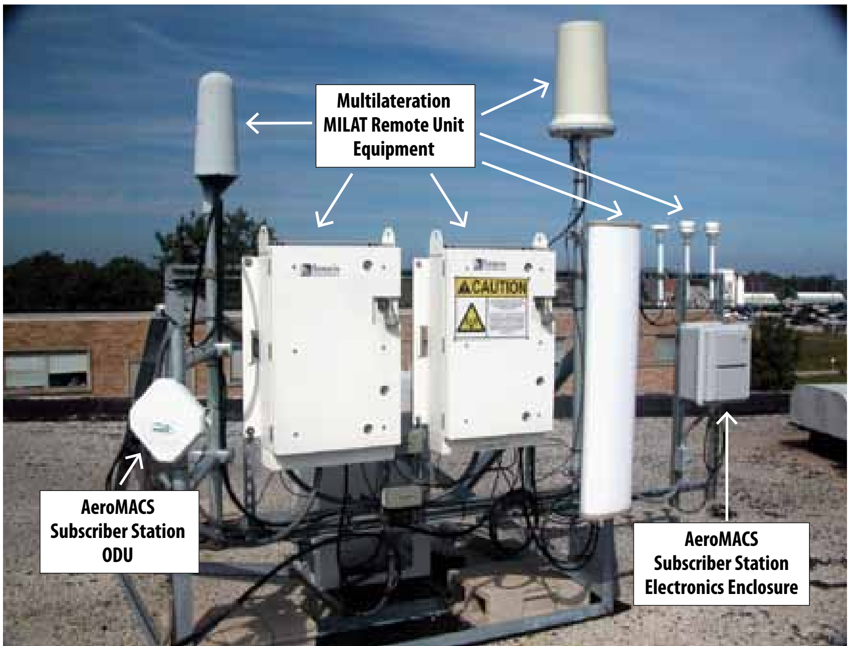


Figure 6 – A multilateration (MLAT) surveillance site equipped with an AeroMACS subscriber station and associated test equipment in the NASA-CLE CNS Test Bed in Cleveland Ohio.

NEXT STEPS IN EUROPE AND THE US

System prototyping and validation against the draft AeroMACS profile will take place in Europe over the next 8-12 months under a recently awarded SESAR contract. Any necessary changes to the profile based on the validation testing will then be incorporated into a final version of the document. This document will then be submitted to ICAO via the Aeronautical Communications Panel for international standardisation.

The FAA sponsors the research associated with the AeroMACS prototype and standard development. This work is currently represented in the FAA's communications infrastructure roadmaps for the NAS Enterprise Architecture. The communications infrastructure roadmap indicates that development of an operational AeroMACS could begin in the latter half of 2013.

Aeronautical fixed service

Supporting the exchange of flight information

Constantina Andrikopoulou, Chairman of the ICAO Aeronautical Fixed Service Group (AFSG), sheds light on the purpose of aeronautical fixed services and how this ground (fixed) segment of aeronautical communications supports air traffic management. She also outlines the roles and responsibilities of the main stakeholders in this field and provides some insight into future developments.

WHAT IS AFS?

The exact nature and purpose of the aeronautical fixed service (AFS) is not perfectly clear to the aviation community, even though it is a vital element of air navigation.

The formal definition provided in the ICAO Annex 10 which states that the AFS comprises "communication services between specified fixed points provided primarily for the safety of air navigation and for the regular, efficient and economical operation of air services" does not make the matter any clearer.

Upon careful examination of the Standards and Recommended Practices (SARPs) in Annex 10, the elusive AFS may be broken down into well-defined, distinct components, which enable the exchange of information considered necessary for the support of a flight during its execution, and also in the pre- and post-flight phases.

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In technical terms, the AFS implements a number of ground-based aeronautical communication applications by means of a coordinated organisation of interconnected systems, circuits and networks that exchange information on the basis of well-defined protocols, interfaces and procedures.

Further consideration of the SARPs in other Annexes leads to specific requirements being placed on the AFS by air navigation services, search and rescue services and airport and aircraft operators.

In operational terms, the distinct AFS components accommodate:

- voice communications between air traffic service (ATS) units;
- exchange of flight transfer data between air traffic control systems;
- transport of messages such as flight plans, notices to airmen and meteorological forecasts and reports;
- dissemination of meteorological data such as meteorological charts; and
- delivery of distress calls and urgent messages.

In technical terms, the AFS implements a number of ground-based aeronautical communication applications by means of a coordinated organisation of interconnected systems, circuits and networks that exchange information on the basis of well-defined protocols, interfaces and procedures.

The SARPs ask for the minimum requirements to ensure global interoperability of the AFS. However, they also provide various options, so that ICAO regions may have some degree of implementation flexibility.

EUROCONTROL has made a significant contribution to the formulation of the AFS SARPs, through its consistent participation in the ICAO standardisation activities. This contribution is expected to continue as relevant SESAR recommendations find their way in the SARPs.

THE AFS IN EUROPE

Regional planning and implementation is performed through the ICAO Planning and Implementation Regional Groups (PIRGs) and is reflected in the regional Air Navigation Plans (ANPs) and the regional Supplementary Procedures (SUPPs).

The PIRG of the European Region (EUR) is the EANPG[1]. This has established subordinate contributory bodies to undertake tasks related to various domains of air navigation.

The Aeronautical Fixed Service Group (AFSG) is the contributory body responsible for the AFS domain.

The official role of the AFSG is to:

- ensure the continuous and coherent development of the relevant sections of the EUR ANP, the SUPPs and other relevant regional documents, taking into account the evolving operational requirements in EUR and the need for harmonisation with the adjacent regions;
- monitor and coordinate implementation of the relevant SARPs and regional procedures, facilities and services by the EUR states and ensure harmonisation;
- identify any deficiencies in AFS-related matters in the region and ensure the development and implementation of action plans to resolve them;
- foster implementation by facilitating the exchange of expertise and transfer of knowledge and experience;
- provide input to the work of other bodies as appropriate.

1- European Air Navigation Planning Group

Aeronautical fixed service
Supporting the exchange of flight information (cont'd)

REGIONAL COOPERATION

The planning role of the AFSG applies to all the distinct components of the AFS. It is mainly exercised through the introduction of enablers in the EUR ANP for future AFS systems and concepts considered appropriate for regional implementation.

EUROCONTROL supports the planning role of the AFSG by contributing to the formulation of the regional documents and through the development of regional databases, where implementation planning and connectivity information is maintained and used as input to the EUR ANP.

The implementing role of AFSG is prevalent in the deployment and operation of the AFTN/CIDIN/AMHS[2] network. By means of the regional documents, the AFSG has introduced technical specifications, testing principles, operational procedures and network management practices that have achieved global acceptance.

EUROCONTROL supports the AFSG in this role by providing highly specialised expertise on complex technical subjects such as the development of the EUR AMHS Profile and the concept of operations for Directory Services. However, the major contribution of the Agency in this domain has to be the ATS Messaging Management Centre (AMC), which performs off-line management of the network. The service provided by the AMC is of such high quality that states not only from EUR but all ICAO regions readily subscribe. The AMC has been designated by ICAO as the means to globally coordinate the allocation and management of AMHS addresses. It becomes evident that the upcoming broad implementation of AMHS will render the AMC a global necessity with significant potential in future areas such as directory services, security services and online management.

The implementing role of AFSG in the deployment and operation of ATS Voice and OLDI/FMTP[3] is traditionally limited to monitoring. At an international level, these applications are typically established and managed on a bilateral basis, which may evolve to multilateral in the case of functional airspace blocks. Currently, the relevant technical specifications and procedures (based on the SARPs) are maintained and coordinated under the umbrella of EUROCONTROL.

EUROCONTROL is also one of the driving partners of the ambitious pan-European network service (PENS) initiative, which will facilitate testing and deployment of current and future AFS applications. For AMHS in particular, PENS is expected to meet the requirements for end-to-end connectivity in an efficient and cost-effective manner. In this direction, the formality of opening PENS to all air navigation service providers (ANSPs) in EUR should be addressed soon.

It is clear that the evolution of the AFS in Europe relies on the solid, functional and collaborative relationship established amongst ICAO, EUROCONTROL and ANSPs over the years. This relationship will play a pivotal role in the successful transition to the future SESAR/SWIM[4] environment.

2- **Aeronautical fixed telecommunication network/ Common ICAO data interchange network/ ATS message handling system**
3- **Online data interchange/flight message transfer protocol**
4- **System-wide information management**

E-operations and connected aircraft

How the new generation of aircraft integrates with the digital world

Frédéric Saugnac, Head of e-Operations and FSA-NG[1] Architect at Airbus, reveals how Internet-based communication systems are introducing a new age of the 'connected aircraft'.

The Internet, digital documentation and communication technologies are changing the aircraft operational environment for the benefit of airline operations, both in flight and on the ground. However, the paperless cockpit, introduced via the electronic flight bag (EFB), is not a new phenomenon. During the previous decade, airlines have been adopting EFB largely through laptops installed in the cockpit, which have to be stowed away during take-off and landing. There is no doubt that laptop EFBs (known as Class 1 systems) bring major advantages for digital documentation and lighten the paper load in the cockpit and are therefore a very efficient starting point to the digital world. However, over the same period, airlines have also been gradually adopting aircraft-installed EFBs (so-called Class 2 or Class 3 systems) as a route for attaining a more manageable return on investment. Now, thanks to increased communications capabilities and decreased costs, the introduction of the EFB as an aircraft-installed solution can be achieved with a much more promising and efficient business case, thus bringing greater functionality from cockpit to cabin and through to the maintenance cycle.

1- FlySmart with Airbus New Generation

E-operations and connected aircraft

How the new generation of aircraft integrate with the digital world (cont'd)

The key function is to implement reliable and secure communications between the aircraft and the airline network. The new generation of Airbus aircraft, like the A380 and A350, is approaching the digital world and connectivity with great enthusiasm. With the A380, Airbus proposed a first step of "digital aircraft" through the on-board information system (OIS). This enhanced airline operations by integrating EFB and electronic maintenance within an aircraft network and introduced 'wireless' connectivity at the gate. Moreover, thanks to Airbus-SITA solutions such as OnAir or equivalent systems, A380 passengers can also enjoy in-flight connectivity.

The incoming Airbus A350 will go a step beyond this: from paperless cockpit to "connected aircraft and e-operations". The first challenge is to understand how the new generation of aircraft, such as the A350, will be operated in the digital world of Internet connectivity over the coming decades. Another challenge is how to couple aircraft technologies and lifecycle them with IT technologies

Replacing paper with digital data, hardware with software and allowing permanent ground-board Internet connectivity is helping pave the way towards easier and faster aircraft operations. The concept of "IT is boarding" is opening up more and more possibilities for optimising fleet operations by moving to e-operations.

A new generation of aircraft with IT ground-board integrated solutions allows airlines to keep aircraft directly and securely connected to their networks. By creating a link between applications on board the aircraft and applications on the ground, faster and smoother updating of aircraft data and logs can be achieved. Initially, the EFB's priority is to simplify and improve cockpit crew operations by replacing paper with digital documentation and then decreasing weight and simplifying documentation management by update procedures and removing the reliance on frequent print-outs. Thanks to on-board networks, EFB facilities can be now extended to the pilots' flight "dossiers", which they commonly bring on board with them, as well as to cabin crews or maintenance operations. As an example, the majority of time-consuming and frequently occurring maintenance tasks, which typically force ground staff to go back and forth from the aircraft, can now be completed from a desk. Another major gain for operators is the ability to enable the cockpit crew to undertake all departure and arrival procedures directly from the cockpit. However, this can only be done if there is sufficient confidence in the communication systems.

Reshaping operations with e-processes brings much-needed confidence in communication systems and 'stay connected' is a maxim for new-generation aircraft. For the A350, Airbus is developing a centralised communication manager, which offers the airlines a combination of devices enabling Internet protocol communications. The A350 can be wirelessly connected to public systems like cellular or wireless/wifi networks while waiting at the gate. With the A350 operations environment in mind, Airbus is anticipating that operators will need high bandwidth at their main base to allow maximum volumes of data to be transferred with aircraft at the gate. Secured wifi networks provide a convenient solution. For the future, WIMAX and AeroWIMAX, as developed within the SESAR programme, will be easily implemented as part of the system. With a rate of 50Mb/s or more, most of the maintenance tasks can be carried out during aircraft stops. Furthermore, as aircraft travel all around the world, cellular protocols like UMTS offer easy

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global access, allowing airlines to keep aircraft connected to their networks. In the future, similar bandwidth rates, promised in the forthcoming 4G/LTE standards, will also be able to support e-operations requirements. Not only that, the combination of wifi and cellular devices is an "eco-efficient" answer for the mobility solution. Ultimately, aircraft on the ground will act as a mobile part of the airline IT network. In fact, it becomes easy to think how much EFBs can improve and ease cockpit workloads if pilots are connected to the airline network.

In-flight connectivity also offers a large spectrum of improvements. With the A380, Airbus is introducing and validating the new Inmarsat SBB (swift broadband) satcom service to support EFB and crew communications during flight. SBB offers a step change for crews as it securely connects aircraft in flight directly to the airline network with an Internet-like communication utility. It therefore becomes possible to send and receive pictures or updates of complex data like weather charts. In this way, numerous new and not previously envisaged services can become a reality. In-flight connectivity promises not only to change passenger entertainment, but also offer new services and facilities to the crew. Just as ACARS (aircraft communications addressing and reporting system) introduced a revolution for in-flight communications, EFBs with IP communication will bring about a major change to the way crews operate in the future.

In conclusion, the new generation of aircraft, such as the A380 and A350, is entering the world of the Internet.

Currently, it is well known that a large part of traditional ACARS communications is carried out while aircraft are at the airport. It is very likely that new IP communication devices such as wifi/Aerowacs or cellular devices will drive the migration of some AOC communications from ACARS to IP. Nevertheless, it is predicted that ACARS will remain an essential communication device for the next decade or so, as ACARS delivers specific advantages and remains a fast and efficient way of communicating.

One of the main challenges of the 'connected aircraft' business is to deliver all the benefits expected by operators as well as easier end-user operations for those working with the variety of communications solutions described above. Nothing is impossible, but making such a complex spectrum of innovations easy to use will require a lot of work from everybody involved. On the airline side, tangible efficiency gains are primarily made by gathering all the messages at the right place at the right time. This will involve IT effort and problem-solving in order to converge and integrate all these different means of communication – including the merging of ACARS with IP communications on the ground. For the on-board EFB, pilots and commercial crews must have easy access to communication equipment, such as "iPhone-like" devices, to ensure they are able to concentrate on their own priorities. This will force application developers to focus on the role of the aircraft crew and make communication access transparent. Standardisation, as achieved through ARINC (Aeronautical Radio Incorporated) and/or EUROCONTROL, is key. From the point of view of the aircraft, communication systems and equipment must be able to follow technology evolutions, which generally advance faster than avionics computers. They need also to bring the right level of data security.

In conclusion, the new generation of aircraft, such as the A380 and A350, is entering the world of the Internet. Likewise, legacy aircraft such as the A330/340 and A320 will also make the transition, thanks to EFB upgrades and retrofits. Undoubtedly, a large amount of work remains to be done in order to make the transition from current operations to "e-operations", but the necessary equipment and expertise exists to achieve that vision.

Amsterdam RAI, 8-10 March 2011

EUROCONTROL will once again be an active player at the ATC Global 2011 Exhibition & Conference

Meet the experts on **our stand** in Hall 10 and get the latest news on some of the key ATM issues by attending one of our briefings:

Symposium "Working to deliver network performance"
In association with EUROCONTROL, the EUROPEAN COMMISSION, ACI EUROPE, CANSO & IATA

Where: Workshop Theatre, Hall 9
When: Thursday 10 March 2011, morning

The recently agreed Single European Sky performance targets will be a very challenging service delivery factor for all ATM partners in the short and long term. It is only by working in partnership that these targets can be met.

Can these targets be achieved? Will one target influence the achievement of another? Are we in control of all of the factors influencing the requisite performance? These are some of the questions which will be addressed by high-level speakers from air navigation service providers, airports, airlines, EUROCONTROL and the European Commission at the Performance Symposium.

Workshop "MET, serving ATM"
In association with EUROCONTROL

Where: Workshop Theatre, Hall 9
When: Tuesday 8 March 2011, morning

All elements are key in ensuring that meteorology plays its role in the future ATM system within the SWIM construct. The solutions presented will showcase the fact that sharing information on meteorology and ash and fusing this with relevant ATM information is a valuable tool for decision makers at network management and local level.

Workshop "ADS-B deployment"
In association with EUROCONTROL

Where: Workshop Theatre, Hall 9
When: Wednesday 9 March 2011, afternoon

ADS-B for both ground and airborne surveillance is now a reality! Deployment and pioneering activities are ongoing worldwide. The Workshop will provide an overview of the deployment programmes in Europe, the US and other areas. It will review both the pioneer implementations (by ANSPs and aircraft operators) and the regulations (adopted or in preparation) mandating carriage of ADS-B equipment. Finally the Workshop will demonstrate that a solid foundation for the future surveillance system is being built, which will ensure the expected benefits for safety, capacity, efficiency, fuel savings and reduced emissions.

2011 events

Check out where EUROCONTROL will be:

EUROPEAN AVIATION SAFETY SEMINAR
1-3 March 2011 – Istanbul, Turkey

In association with the Flight Safety Foundation, the European Regions Airline Association and EUROCONTROL, the European Aviation Safety Seminar (EASS) focuses on safety challenges of interest to the European industry.

David McMillan, Director General of EUROCONTROL, will deliver the keynote speech.

www.flightsafety.org

ATC GLOBAL 2011
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Seminar "Giving to the customer: free route airspace implementation at Maastricht UAC"

Where: Seminar Theatre, Hall 9
When: 8 March 2011, 12:30 - 12:50

Seminar "The aerospace performance factor – a way forward in demystifying ATM safety indicators"

Where: Seminar Theatre, Hall 9
When: 8 March 2011, 16:00 - 16:20

EUROCONTROL and FAA Joint Seminar "Risk analysis tool – a major breakthrough for the harmonisation of safety occurrence assessment in Europe and the US"

Where: Seminar Theatre, Hall 9
When: 9 March 2011, 12:00 - 12:20

AERODAYS
30 March -1 April 2011 – Madrid, Spain

EUROCONTROL will be at the Sixth Community Aeronautics Days which will bring together aeronautics stakeholders, ministries, agencies and R&D centres from all over Europe and overseas to network, present their latest research results and discuss common future R&D projects.

www.aerodays2011.org

AERO FRIEDRICHSHAFEN
14-17 April 2011 – Friedrichshafen, Germany

The Global Show for General Aviation: EUROCONTROL will be there with a stand.

www.aero-expo.com

LE SALON DU BOURGET
20-26 June 2011 – Paris Le Bourget

EUROCONTROL will have a stand at the International Paris Air Show 2011– Paris Le Bourget – which for over a century has been the premier and largest worldwide event dedicated to the aviation and space industry.

http://www.paris-air-show.com/

To keep up to date on our presence at key international events, visit www.eurocontrol.int,
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