research BULLETIN
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Corporate Research – a selection of our latest achievements

A key objective of our research activities is that they should lead to the exploitation of results. We follow an innovation process that takes the form of several distinct stages. Concept development leads to the creation of research demonstrators and product prototypes and the most promising approaches are subsequently taken up by product development. Most of our results are achieved in cooperation with highly academic and skilled research partners who, in the main, are from universities and specialist research institutions. The Frequentis Corporate Research team also acts as the translator of successful ideas taking them from one business field into others.

Some of the research topics on our agenda need a considerable degree of perseverance before we can gauge market response and ultimately commence commercial delivery. They include extremely advanced technology for air-ground voice and data transfer and information management. Iterative and incremental improvements to early approaches can lead to several generations of projects that, subsequently, may take more than a decade to finally achieve success in commercial markets. The long timespans underline the fact that our research activities need to follow an exploitation process. Our organisational focus – now with the addition of a central department for New Business Development – is directed towards streamlining our research pipeline and working on innovative solutions to meet operational challenges in the most economically promising business areas. In this annual compilation of research activities, we share insights into various research topics. These include: Drones – 'Converging UTM and ATM for a Safe and Unified Airspace', 'SESAR Horizon 2020 Virtual Centre', and 'Software Defined Networking in IPv6 Satellite Networks'. Other articles provide an overview of activities relating to 'Engage KTN 2019' – the SESAR Knowledge Transfer Network that promotes and facilitates the development of Air Traffic Management research in Europe. In future years, we expect to invest increasing efforts into specialisms currently pushing a number of our markets including Blockchain and Artificial Intelligence. We hope you enjoy reading – our experts will be more than happy to exchange views and elaborate further.

Christoph Aschauer, Director New Business Development Georg Trausmuth, Head of Corporate Research

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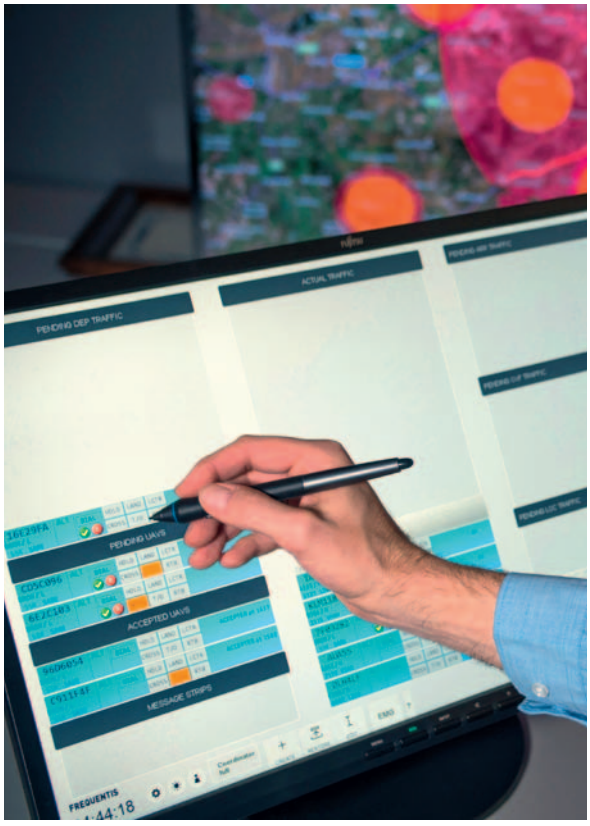
Converging UTM and ATM for safe and unified airspace

Author: Jan Ziegler

From the evidence available today, we can foresee that as UAVs (Unmanned Aerial Vehicles) continue to evolve, they will further challenge aviation systems and before long need to be accommodated into all classes of airspace.

UAVs routinely operate at much lower altitudes than manned aviation. New use cases like runway inspections, ILS calibrations, and air taxis flying to and from airports, will lead to large numbers of UAVs operating within, or in the vicinity of, controlled airspace. This creates a new challenge for ANSPs (Air Navigation Service Providers) to ensure separation of UASs (Unmanned Aerial Systems) from both manned and other unmanned aircraft in non-segregated airspace and has the potential to impact on the safety and efficiency of ATM.



A key factor in safely integrating unmanned technology in non-segregated airspace is the interoperability of UTM (Unmanned Traffic Management) and ATM (Air Traffic Management) systems for both the planning and execution phase of the intended UAV operation. Any UTM service interface must be designed to be compatible with the existing ATM data requirements so changes to the ATM service must be minimal. Additional considerations are cost and the incorporation of appropriate cyber security necessary to ensure the ongoing integrity of the ATM service.

Frequentis and Altitude Angel (UK), an aviation technology company creating global-scale solutions that enable the safe integration and use of fully autonomous drones into global airspace, have worked together to validate full interoperability between UTM and ATM Systems by demonstrating the safe use of UAVs within the busy, complex, and dynamic airfield environment of an international airport.

The widely-deployed CADAS information management system and AIDA-NG aeronautical message handling system, developed by Frequentis Comsoft [1] , enabled both the Guardian UTM and the ATM tower infrastructure to connect using safe and secure ATM technologies and aviation standards. The ATM-grade data was visualised in the Frequentis smartSTRIPS system deployed in the tower to enable Air Traffic Controllers to manage the control zone as one unified airspace for manned and unmanned air traffic.

Frequentis follows the approach of converging from ATM towards UTM thereby avoiding isolated UTM solutions with proprietary formats that can result in operational changes and a requirement for additional and costly training.

During the course of 2019 Frequentis will continue to underline its pioneering role in paving the way towards a safe ATM-UTM integration. It will do so by repurposing further ATM components for Communications, Navigation, Surveillance (CNS), and Aeronautical Information Service (AIS) applications in the UTM domain to ensure the safe integration of unmanned aviation in a unified airspace. The next real-life demonstration is planned for mid-2019 within the framework of the SESAR U-space programme in Estonia and Finland.

[1] Frequentis Comsoft GmbH became an integrated member of the Frequentis Group in 2016, complementing the solution spectrum and covering the complete surveillance chain. Today the company's expertise covers a vast proportion of the modern ATM industry, including market-leading AMHS solution AIDA-NG and innovative surveillance and communication solutions such as ADS-B and Multi lateration sensors. Frequentis Comsoft's high quality portfolio and skilled team, coupled with the Frequentis Group's extensive expertise, will continue to develop innovative solutions for the ATM Market, consistent with international standards.

SESAR Horizon 2020 Virtual Centre

Author: Michael Poiger

Europe's Air Traffic Management (ATM) is a highly-fragmented network composed of country-based systems and processes. In accordance with the virtualisation ambitions captured within the European ATM Master Plan and alongside its various SESAR partners, Frequentis is working on analysing and specifying the resulting operational needs (SESAR PJ15-09) and related possible technical concepts (SESAR PJ16-03).

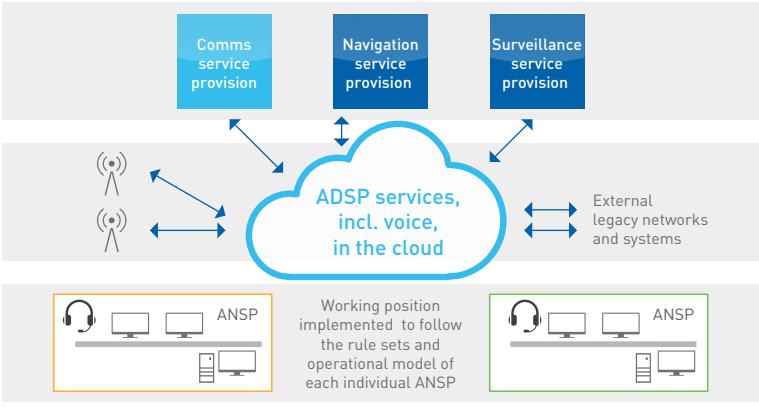
Its focus is directed towards supporting the following benefits:

- Increased flexibility provided by workload balancing
- Better cost efficiency based on rationalisation and standardisation in ATM infrastructure and processes
- Increased agility and cost efficiency to implement and commission new ATM functionalities throughout European Air Navigation Service Providers
- Increased capability to organise contingency plans, using interchangeable standard services
- Harmonised ATM functionalities and seamless cross-border and cross-ATSUs (Air Traffic Service Units) transitions for airspace users that will result in an increased capacity

The key to successfully introducing new operational methods and technical solutions is the understanding of the communication paths within the borders of control rooms and beyond. Special focus is placed on the identification of the interaction points and exchange of the necessary information between the different stakeholders, supporting the different process steps within virtual control rooms. Frequentis is supporting the SESAR partners to generate a joint view on future virtual centre operational procedures and objectives through Frequentis Information Stream Design, highlighting the important communication paths and necessary content.

Additionally, Frequentis is continuously working on the technical concept of virtual centre, mapping the operational needs (rationalisation of infrastructure, delegation of airspace, contingency) on suitable infrastructure and supportive services (e.g. voice communication, flight plan, surveillance).

First validations within 2018 successfully showed the feasibility of the virtual centre concept. One of the key components to achieve the coordination was the Frequentis Voice Communication Service based on the open and service-oriented Frequentis MosaiX framework. The next steps necessary to increase the maturity of the defined operational and technical concepts are the additional validations planned within the framework of the SESAR 2020 PJ16.03 Virtual Centre project that will take place in mid-2019.



Engage KTN 2019 activities

Authors: Graham Tanner, Eduard Gringinger

www.engagektn.com

Engage, the SESAR Knowledge Transfer Network, promotes and facilitates the development of Air Traffic Management research in Europe. It is managed by a consortium [1] of academia and industry and has the support of and receives funding from the SESAR Joint Undertaking [2]. The focus for Engage is to inspire new researchers and help align exploratory and industrial research through a wide range of activities and financial support actions.

Many of the initiatives developed in the first year of the network will begin to bear fruit in 2019. Early in the year, a series of PhD and post-graduate thesis students will investigate innovative research ideas and address the long-term evolution of the European ATM system. These will be closely followed by the first wave of focused projects where specific activities will be conducted to further mature exploratory research into applications and operational contexts.

A number of Engage events are planned, including four workshops to be organised and held in different European locations. They will be linked to the network's thematic challenges and consider new ideas from the research community that have not already been included within the scope of an existing SESAR project. A summer school will be hosted in Belgrade and EUROCONTROL will offer two 'GEN-INTRO' training courses for PhD students and researchers. Additionally, support will be given to help organise the 9th SESAR Innovation Days conference.

An on-line 'knowledge hub' – a single European point of entry for ATM knowledge – will also be launched. This will offer researchers an accessible meta-source of research data, whilst helping us to define an ATM roadmap for future industry needs not currently being addressed. It will also provide an opportunity to facilitate contact with other researchers in order to combine disciplines and share ideas.

Many thanks to Graham Tanner, Senior Research Fellow at the University of Westminster and co-author of this article, for his valuable contribution.

[1] Engage consortium: University of Westminster (coordinator), EUROCONTROL, European Aviation Safety Agency, Frequentis, Innaxis, Delft University of Technology, University of Belgrade, and University of Trieste.

[2] Funding from SESAR JU under the EU's Horizon 2020 research and innovation programme under grant agreement No 783287.

Semantic Container – ATM Information Cubes

Author: Eduard Gringinger

project-best.eu

When transmitted in a 'traditional' format, the sea of information shared in pilot briefings can have the effect of 'drowning' them. We believe that rather than providing them with large volumes of unfocused Air Traffic Management (ATM) information, pilots require only the information that relates to their specific intended flight.

As a result, we have introduced the concept of ATM information 'cubes'. Our proposition is that a conceptual framework (Semantic Container) with both merge and abstraction operations for the combination and summarisation of the necessary information, is organised into what we envisage as ATM information 'cubes'.

A merge operation is designed to combine ATM information from individual cells of the cube. An abstraction operation summarises the data items within a cell, replacing individual items by more abstract data with summary information. The result is a management summary of relevant information.

Consider, for example, the semantic containers positioned on the left in the diagram. These hold the relevant DNOTAMs (Digital Notices to Airmen) for different segments in a Flight Information Region (FIR), their levels of importance and flight phases.

- The first container holds the relevant DNOTAMs for the EDDU-01 segment of the EDDU FIR, classified as reports of an Operational Restriction for the Cruise flight phase.
- The second container holds the relevant DNOTAMs for the EDDU-02 segment, classified as Flight Critical for the Descent flight phase.
- Data from these individual containers are then merged into a container with DNOTAMs that comprises the Essential Briefing Package for the EDDU FIR when the flight is in an en-route phase.

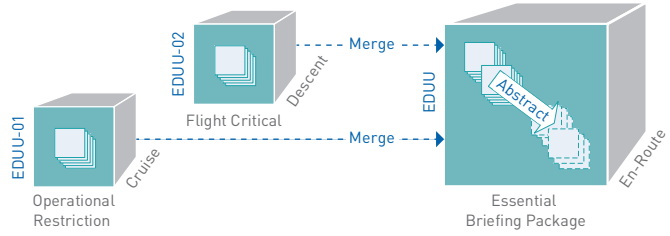


Illustration of the proposed theoretical framework for semantic container operations

We propose that the ATM information 'cube' hierarchically organises semantic containers along different dimensions relating to the container content, e.g. the geographic and temporal applicability, flight criticality, and flight phase for which the container content is relevant. We assume the existence of appropriate rule-based filtering mechanisms to collect ATM information into containers. It is also possible to merge individual containers in order to obtain more comprehensive ATM information and the messages themselves can also be further abstracted.

This project has received funding from the SESAR Joint Undertaking (under grant agreement No 699298) under the European Union's Horizon 2020 research and innovation programme. The views expressed are those of the author.

EUROCAE Standard ED-240A MASPS for Remote Tower Optical Systems

Author: Harald Milchrahm

In November 2018, EUROCAE published the standard ED-240A "MASPS for Remote Tower Optical Systems" which was developed by the Working Group 100 Remote & Virtual Tower with representatives of more than 40 different organisations from around the globe.

Frequentis Corporate Research contributed in acting as Main Editor of the standard comprising concept development, elaboration of technical aspects as well the integration of the document. The ED-240A MASPS (Minimum Aviation System Performance Standard) document pertains to remote tower optical systems and is applicable to all optical sensor configurations to be used for the implementation of remote Air Traffic Services (ATS) to an aerodrome. It describes the end to end performance of the optical sensor presentation that displays video images from cameras to the operator, which could be visible spectrum devices as well as infrared.

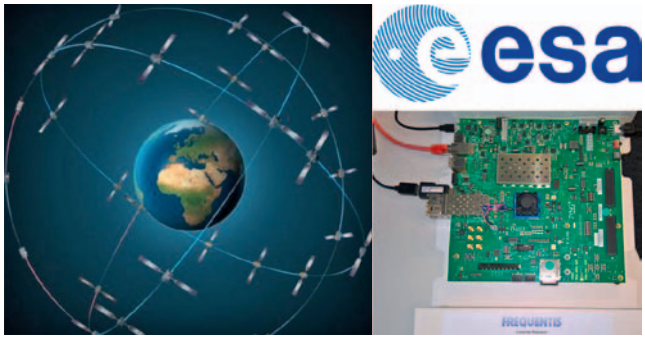
Remote tower visual presentation systems are one of the principle components to enable the provision of ATS from a remote tower facility and optical sensor presentations are a type of visual presentation, where the presentation displays visual and/or thermal images. Specifically, the ED-240A standard specifies the end to end performance of the Visual Tracking Function and the PTZ Object Following Function.

The standard will help vendors and customers to quantify an optimal operational system performance and to verify and certify it in a standardised way.

Software Defined Networking in IPv6 Satellite Networks

Author: Richard Prinz

Greek Philosopher Heraclitus' concept of ever present change – literally translated as 'everything flows' ('panta rhei') – was, in his view, the fundamental essence of the universe. Many would endorse this and it could be said that it is borne out by Low Earth Orbit (LEO) Satellite Constellation Networks (SCN). Today, they only consist of a few dozen satellites, but in future, LEO SCNs may number in excess of 1000.



Certain ground point remains within the footprint of some LEO satellites for a very short time. For Iridium satellites – moving at about 780 km height above Earth with 27,000 hm/h orbital speed and an orbital period of 100.5 minutes – this time is limited to about 10 minutes. Therefore, maintaining existing connections between communication peers (e.g. mobile ground nodes) without interruption, in spite of very dynamic SCN topology, could be regarded as challenging.

In an ongoing European Space Agency (ESA) project – "Development of on-board IP Router Protocol Stacks for Future Satellite Systems" (OBR)[1] – Frequentis has developed a novel concept. This provides constant IPv6 connections by using Software Defined Networking (SDN) technologies combined with a proprietary, newly developed, mobility protocol called 'Mobility Optimized Distributed Address Resolution' (MODARE).

To prove the proposed concept, a prototype SCN implementation was developed and is currently being tested in a virtual testbed of 100 Virtual Machines. This is based on reference IRIDIUM SCN with 66 satellites and includes necessary ground infrastructure components.

In co-operation with Airbus Defence and Space (ADS), realistic hardware platforms for next generation OBR-capable satellites were evaluated. Finally, the Xilinx Zynq UltraScale+ MPSoC platform was selected and is also integrated within the testbed. Memory and resource restrictions applicable to such a realistic platform posed a challenge but could be overcome with stripped-down embedded Linux.

The developed OBR-specific concepts, especially MODARE protocol, have potential to be re-used in other ESA activities.

[1] ESA-OBR – Development of on-board IP Router Protocol Stacks for Future Satellite Systems, https://artes.esa.int/funding/development-board-ip-router-protocol-stacks-future-satellite-systems-artes-51-ref-3a059

FREQUENTIS Digital Briefing Prototype within SESAR 2020 PJ17.01

Author: Josef Jahn

Summer 2018 saw the Frequentis Digital Briefing Prototype (ePIB) performing the first in a series of validation exercises in SESAR 2020 PJ17.01. Working with Leonardo SpA and several subsidiaries, Frequentis performed an in-flight briefing update in a simulator aircraft via a SWIM Purple Profile air-ground datalink. The Frequentis Digital Briefing implementation produced briefing information both in machine readable and human readable (PDF) format.

While the flight itself was simulated, live data from the Frequentis SWIM Demonstrator system was utilised. Running continually at Frequentis HQ since 2017, it processes global flight, weather and surveillance feeds, as well as aeronautical data coming from EAD, Eurocontrol Network Manager, FAA, and some of our customers with whom we have formed partnerships. Frequentis does not sell this data, but uses it to validate our platform and solutions and enrich demonstrations.

The Digital Briefing Prototype was significantly upgraded for the first SESAR 2020 Demonstration, switching to a performance-optimised application-centric AIXM 5.1 storage. Generating a complex briefing took several minutes in the SESAR 1 demonstrations whereas the upgraded solution did the same task in under 60 seconds.

Going forward, the ePIB functionality is currently being integrated into SmartSIS developed by Frequentis Cluj and Prague, under the leadership of Frequentis California. SmartSIS is a controller information system and air situation display capable of visualising all SWIM data, ATM and UTM surveillance information and, with the currently ongoing development, flight routes and flight briefing information. A complex transatlantic flight briefing can now be generated from worldwide live SWIM data in about 2–3 seconds, while European flights typically take well under one second to process.

The next SESAR 2020 validation exercises are planned for Q2 2019 and will facilitate both live data and our new electronic briefing solution based on SmartSIS.

SURECONF Satellite Secure Update Technology Now Transferable

Author: Richard Prinz

The challenge of maintaining satellite components after launch has traditionally necessitated the use of highly proprietary technologies. However, today's new generation satellites contain an increasing number of functionalities that utilise 'standard' hardware and software components and technologies to enable remote (re)configuration.

Remotely updating payloads of large satellite constellations where potentially hundreds are in orbit is, in principle, a task comparable to a telecoms provider needing to update millions of devices or remotely changing the configuration of an IT system deployed somewhere in the Australian Outback.

In these instances, it is not easy to fix problems resulting from failed software updates. Potential problems can arise due to the sheer number of devices requiring updates or the distance, efforts, and/or resources required to solve them. When you consider how today's consumer telecommunication devices, such as smartphones, can be updated through the installation of software which is actively 'pushed' by providers or via Apps where any new configurations are Over The Air (OTA), then the parallels and potential benefits of such pro-activity are obvious.

To address the complex challenges involved in updating Satellites, Frequentis has developed the SURECONF (Satellite Update & REConfiguration for On-board Networking Functions) concept within the framework of the ESA project OBR (On-Board Router) described elsewhere [1] in this Research Bulletin. The SURECONF design objective was to provide mechanisms for updating satellite on-board router functionalities, as well as addressing a much broader set of functions such as payloads, components of the operating system, or protocol stacks.

An extended reverse package manager, so called because updates are 'pushed' to the device instead of being requested by it, SURECONF enables the processing of update packages containing both update content and associated actions. The update packages and actions are digitally signed which provides very fine-grained control. Roll-back mechanisms and compartmentalisation of installed software are also included. Importantly, as with any external component, SURECONF can itself be updated by using its own internal mechanisms.

Having been initially developed for satellites, SURECONF can now be utilised in other scenarios where errors resulting from unsuccessful configuration and update processes may be difficult to fix.

[1] See page 8 in this Research Bulletin

First EUROCAE SWIM Service for Arrival Sequence

Author: Eduard Gringinger

Within the SESAR (Single European Sky ATM Research) programme, System Wide Information Management (SWIM) activities have reached a maturity level to the extent that the first SWIM services are now ready for standardisation.

In the area of extending the horizon of Arrival Management (AMAN) a relevant SWIM service has been identified, designed, and validated according to a published and applied 'SESAR Method on Services'.

Performance Standard ED-254 [1] specifies the information service design of an Arrival Sequence Service in the context of extended AMAN. Based on research and validation performed in the SESAR Programme, the Standard builds on the transversal EUROCONTROL SWIM standards [2], [3], [4] and provides a solid basis on which to implement SWIM Service instances for the Arrival Sequence Service.

Those service instances would be on a very high level of interoperability as they follow common requirements on the business and technical levels. The standard can also be used as a blueprint for the standards of other information service designs. The work has been elaborated by an expert team representing airports, airspace users, ANSPs, EASA, EUROCONTROL, the Ground Industry, and SESAR Joint Undertaking (SJU).

As a starting point, a platform independent approach was taken to describe a service design 'logically' to define the interfaces, operations, payloads, and other elements of the service without pre-empting any technical solution. At a later stage the focus was on technical service designs, placing the emphasis on aspects related to the so-called SWIM TI Profiles and technical interfaces, such as messaging technology, protocol stack, or data elements to be exchanged.

For future standardisation activities in the SWIM area, any stakeholder may initiate a new task. Interested parties are invited to contact the EUROCAE Secretariat at eurocae@eurocae.net.

[1] ED-254 - Arrival Sequence Service Performance Standard, https://eshop.eurocae.net/eurocae-documents-and-reports/ed-254/

[2] EUROCONTROL Specification for SWIM Service Description, edition 1.0, https://eur-registry.swim.aero/reference

[3] EUROCONTROL Specification for SWIM TI Yellow Profile, edition 1.0, https://eur-registry.swim.aero/reference

[4] EUROCONTROL Specification for SWIM Information Definition, edition 1.0, https://eur-registry.swim.aero/reference

FREQUENTIS experts and authors of this edition:

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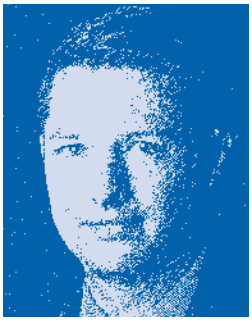

Eduard Gringinger

Main fields of research:
Data Scientist

Josef Jahn

Main fields of research:
SESAR, Enterprise Integration, Microservice Container, Security

Harald Milchrahm

Main fields of research:
SESAR SWIM, Tower Automation Systems, Remote Tower, Decision Support Tools

Michael Poiger

Main fields of research:
User Productivity and Human Performance methodology

Richard Prinz

Main fields of research:
Geographic Information Systems and Protocols (GIS) and Satellite Mobility Protocols

Jan Ziegler

Main fields of research:
ADS-B, Multilateration, Air Traffic Management Systems

FREQUENTIS

FREQUENTIS AG
Innovationsstraße 1
1100 Vienna, Austria
Tel: +43-1-811 50-0
www.frequentis.com