Networking the sky with new aircraft communication technology

May 14 2014

Air transportation is expected to at least double by 2050. Coping with these needs and the resulting overcrowded sky requires top-notch communication technologies - but the sector is not quite ready yet. The SANDRA project set out to improve aircraft by means of a coherent digital architecture.

Whilst more and more airlines provide their customers with in-flight access to the internet, pilots still have to work with technology from another era. Forget high-speed access to real-time information: the pilot operates in an isolated bubble where he must rely on decades-old analogue voice communications and non-IP low bit-rate data links. This can result in overly complex, disparate and inefficient communications which may potentially delay his reactions to unforeseen events.

Besides being inefficient, the current system cannot meet upcoming aeronautics challenges, such as congestion, insufficient capacity at airports, the need for increased data traffic, and requests for better cabin and passenger communication systems.

As part of the Single European Sky Initiative, SESAR (Single European Sky ATM Research) - a joint effort by the EU, Eurocontrol and industry to modernise and provide a high performance air traffic control infrastructure in Europe - is studying the evolution of aeronautical communications, while focusing on air traffic control and airline operational communications.

Coordinated by Selex ES and made up of 30 partners from Europe's leading aviation technology industry and research organisations, the SANDRA consortium has taken a more radical approach instead, which is able to revolutionise in-flight communications. Its newly developed technology involves connecting all aircraft applications and services to a single integrated aeronautical communication system based on networks, radio transmission and satellite links, which is global, digital and safe.

The SANDRA technology was successfully tested in trial flights in Germany, prompting the European Commission to select the flagship project for its communications around the new Horizon 2020 research programme. Massimiliano Amirfeiz, a member of the project coordination team, details the technologies used by SANDRA and their expected impact on future aeronautics.

What are the main objectives of the project?

The SANDRA project studied, implemented and demonstrated in flight a new system that will lead pilots into the digital world of the 21st century. A single system based on Internet Protocol technology, it is capable of transmitting data through multiple datalinks, directly to the ground and via satellite, digitally and at high speed, providing communication services for all aircraft needs, each with its own required quality of service and in a seamless way. Detailed information, such as the weather or traffic situation, can be exchanged between the control tower and the aircraft in a quick and reliable manner, thereby increasing air traffic safety.

Together with existing data-link technologies, such as VHF Data Link Mode 2 and Swift Broad Band Satcom, the SANDRA project also demonstrated for the first time in Europe the AeroMACS technology, the first of the three new IP-based broadband data-links (the other being L-DACS and IRIS Satcom) identified by the International Civil Aviation

Organization (ICAO) for future aeronautical needs. AeroMACS has been conceived to provide broadband wireless data connectivity over the airports to support airport operations, air-navigation service providers and airline applications.

Although new communication systems will eventually replace the current ones, we are likely to witness a lengthy period during which aircraft will be fitted with all systems for the sake of global interoperability. This is the forecast from SESAR, and the additional airborne equipment required during this transition phase severely threatens the realisation of the vision of future communications. It would create a considerable extra burden in terms of size, weight, complexity and cost in avionics if the new radio links are implemented in stand-alone equipment, as has traditionally been the case in communication avionics. To tackle this problem, SANDRA has also investigated the possible exploitation of the 'software defined radio' concept, in which radio communication system components that are typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are implemented by means of software on a computer, hence allowing different radios to be run in parallel over common processors as independent bits of software (waveforms). This would be a great step forward, in the same way that 'integrated modular avionics' revolutionised airborne electronics.

What is new or innovative about the project and the way it addresses this topic?

Trials validated the concept that aircraft should have multiple data links simultaneously active, which can be used for all communication needs from traffic control to airline operations and passenger services. This is to guarantee the best quality of services, as well as security and prioritisation. All this is based on Internet Protocol version 6, the most advanced IP protocol which will enter into service in ground networks in the coming years, and has already been identified by ICAO as a pillar for future aeronautical communications.

Trials have validated the feasibility of 'integrated modular radio' (IMR), an innovative avionic communication architecture whereby each single radio element can be reconfigured independently to operate a specific radio link as required, depending on the flight phase and geographical location. IMR will be a cornerstone of the SANDRA business model, bringing a wealth of advantages in terms of weight, cost of radio components, and reduced pilot workload. It should enable a less-painful transition between legacy and future communication baselines as it can support both. It is important to note that radio software configurability is critical to enable the future incorporation of future data-links such as L-DACS and IRIS Satcom.

AeroMACS has also been demonstrated for the first time in an integrated end-to-end network, providing a variety of services, ranging from pilot/controller digital communications to telemedicine and passenger private communications.

How will the switch to digital communications in aeronautics benefit the sector?

By supporting SESAR's concept of future datacentric cockpit communications, SANDRA is contributing to more efficient and safer flights, which will be particularly important as the volume of air traffic increases. The SANDRA system brings the most advanced multilink communications, integrating L-band and Ku-band satellite links, as well as AeroMACS ground links and the current VHF data link (VDL2). It uses industry standards such as IP, IEEE 802.16 (for AeroMACS), DVB-S2 and Inmarsat SwiftBroadBand. The system can be set up to choose the best available radio link, or the crew can select the link manually.

The use of industry standards means we can also integrate cockpit and cabin communications. The cockpit and cabin systems are separate for security purposes, but share the link. This will provide airlines with a cost-effective way of providing in-flight connectivity to both passengers and pilots.

What difficulties did you encounter and how did you solve them?

The new system was tested for the first time under real-flight conditions using the German Aerospace Center's ATRA (Advanced Technology Research Aircraft) test aircraft, which is a modified Airbus 320. The main challenge was in the integration of such a wide range of disparate systems comprising aeronautical applications, new communication avionics and networks on-board an aircraft. But the SANDRA system also includes corresponding communication technology on the ground - which researchers have installed at the German Aerospace Center (DLR) site in Oberpfaffenhofen and at the Toulouse- Blagnac Airport - and integrated external entities such as Inmarsat Satcom and SITA ground networks.

This allowed us to perform in-flight tests of the smooth exchange of data during a transition from one data-link technology to another. All this represented a challenge which the SANDRA consortium has been able to overcome thanks to consortium complementary expertise and motivation, as recognised by the EC project officer and independent reviewers.

How will SANDRA affect a pilot's routine and working conditions?

Where the new technology is available, the pilot will see all information related to weather, air traffic and current decisions at the same time as her/his colleagues on the ground who are in charge of air-traffic control. Automatic flight corrections to avoid critical situations and misunderstandings will therefore be much easier.

As an example, for landing in airports, the SANDRA system has a quick data-link that works via AeroMACS, providing the pilot with access to all required data indirectly via the local WLAN. And thanks to SANDRA's compatibility with previous technologies, the system can be used to land in any airport in the world. Depending on availability, the SANDRA system will automatically connect pilots to fast broadband connections or legacy datalink systems.

What are the next steps for product commercialisation, or your next research topics?

Various technologies and concepts have been investigated, not all with the same technology readiness level. AeroMACS is expected to be put into operation in major airports in 2018. A new protocol mechanism that allows existing aeronautical networks to operate through IP-based broadband data-links together with non-safety-related data traffic has also received great interest from industry. It will be further studied within SESAR and could enter into service in the coming years. Finally, our new communication avionic architecture, based on software-defined radio and integrated modular avionic technologies, has been recognised by major aircraft integrators as a good candidate for inclusion in new aircraft within the 2020-2025 time frame. SESAR projects dealing with multilink and IP-based technologies have recognised the work performed and will take advantage of SANDRA results in this area.

But whilst SANDRA has identified the building blocks, two things are still needed to make this new communication architecture a reality. First, the project's functional building blocks should be incorporated into a coherent set of physical units taking into consideration real aircraft environments and new avionic frameworks defined in other European-funded projects. Secondly, the cockpit migration to Internet Protocol technology, which is already a reality for ground networks, should be initiated. The latter requirement is the most difficult as it involves a cultural shift.

More information: sandra.aero/

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