Whitepaper

Future Aircraft Communications

Contents

1. Introduction

By 2035, out of necessity, Air Traffic Services (ATS) and Airline Operational Control (AOC) connectivity will have evolved with the integration of modern Radio Frequency (RF) engineering techniques and technologies, while simultaneously aligning with broader goals of improving flight safety, enhancing airspace efficiency, and promoting environmental sustainability.

This paper outlines the 2035 airline vision for the civil aviation communications domain, the 'C' in CNS (Communications, Navigation and Surveillance). The technological evolution outlined in this paper is not bound by legacy avionics but rather considers non-traditional avionic solutions where benefits can be anticipated at a cost and in a timeframe acceptable to airlines.

The concepts can inform further discussion by airlines, telecommunications organizations, avionic and airframe Original Equipment Manufacturers (OEMs), Air Navigation Service Providers (ANSPs), regulatory authorities, standards organizations, other concerned organizations and individuals, and the International Civil Aviation Organisation (ICAO).

The airline position on current Communications, Navigation and Surveillance technologies are outlined in the International Air Transport Association (IATA) **User Requirements for Air Traffic Services (URATS)**.

2. Headwinds

Air Traffic Management (ATM) depends on avionic connectivity. This is currently facilitated by High Frequency (HF), Very High Frequency (VHF) and Satellite Communications (SatCom). However, driven by local channel saturation, provider aborts (PAs), regional technological divergence and ongoing issues with Controller Pilot Data Link Communications (CPDLC) when using Very High Frequency Data Link Mode 2 (VDLM2), a compelling need exists to not only upgrade legacy aeronautical communications technologies but to also ensure services are globally harmonized, maximizing efficient use of the frequency spectrum.

Politically, the telecommunications industry will continue to dominate frequency spectrum regulatory action, increasing pressure on aviation to share or vacate significant parts of current aeronautical allocations, or problematically occupying bands adjacent to those used for safety of flight. Aviation will experience increasing commercial and political pressure as the modern Radio Frequency (RF) engineering designs and sharing techniques employed by other spectrum users continue to impact legacy avionic systems.

Civil aviation can no longer afford the cost and operational complexity of regional divergence in the development and deployment of avionic technology. Aviation is a global industry dependent on harmonized, interoperable, and interference free Communications, Navigation and Surveillance as a prerequisite for safety of flight.

Significant airline investment must occur to transition the civil aviation 'C' domain from reactive to proactive; from 20th to 21st century technology, capabilities, and efficiency. However, airlines should be able to realize a return on these investments in the form of operational benefits, efficiency, and reduction in negative impacts on the environment. At the same time, safety of life is aviation's #1 priority and continued use of aeronautical spectrum, free from Radio Frequency Interference (RFI), is an essential element towards achieving this goal.

3. Tailwinds

Telecommunications infrastructure has potential to enhance ATS by upgrading cockpit voice communications to Voice Over Internet Protocol (VoIP), facilitate improved data link communications, provide more efficient data sharing, and aid in the optimization of flight operations by facilitating enhanced air/ground data exchange to dynamically account for issues such as weather and airborne proximity traffic.

Integration of mainframe grade ground-based cloud computing facilities dynamically interacting with more limited cockpit equipage, e.g., Flight Management Systems (FMS), would enable a huge leap forward in communications driven flight efficiency.

While commercial telecommunications standards and infrastructure are current enablers for some aviation related operations, e.g., Beyond Visual Line of Sight (BVLOS) Unmanned Aircraft System (UAS) command and control (C2), it is likely that significant contributions to mainstream civil aviation ATS communications will be predicated on the widespread deployment of 6G.

As a step towards harmonious coexistence, enhanced cooperation between the aviation and telecommunications industries (and their respective regulators) can ensure that new telecom standards and infrastructure facilitate ATS communications suitable for 21st century operations, to the benefit of both industries.

Over the coming decade, telecom enabled satellites will be a significant part of commercial communications infrastructure and present opportunities to both aviation and telecommunications industries to cooperate for mutual benefit. Oceanic and remote airspace communications may be a first step in this joint evolution. In addition to 5G and 6G enabled satellites, aviation can also benefit from the investment, technology, licensed spectrum, and terrestrial infrastructure being deployed by the telecommunications industry.

At the same time, airlines are making massive investments in environmentally better aircraft and engines, and coordinating industry action to implement revised operating procedures and infrastructural measures on a drive to Fly Net Zero by 2050.

4. The Future of Air-Ground Communications

By 2035 the overlap between the telecommunications and aviation industries will be unavoidable and multi-industry solutions will be a basis for harmonious spectrum coexistence. Airlines will rely on a mix of Commercial Off The Shelf (COTS) and legacy technologies for communications needs. Intra-aircraft networks are expected to enable *aircraft as a node* functionality, enhancing safety and efficiency of flight, especially in oceanic and remote airspace. Dual or triple stacking avionics will not be a pragmatic option for airline operations.

While the introduction of Artificial Intelligence (AI) in avionic systems will lag its deployment in other industries, AI will eventually and inevitably simplify and enhance cockpit communications by controlling radio selection, modulation scheme and spectrum usage based on specific airspace, phase of flight and the local RFI environment.

Real-time data offloading via 6G will allow for enhanced predictive maintenance strategies and support dynamic flight profile management, including AI optimization of flight paths for fuel efficiency and weather.

To facilitate enhanced cockpit integration with augmented user interfaces, and to enable more timely software and hardware update cycles, some cockpit applications will be off-loaded from traditional 'black box' avionic units to 'connected' Electronic Flight Bags (EFBs).

Software-configurable Aircraft Interface Device (AID) will become standard equipage on most in-production airplanes and as a retrofit for some in-service airplanes.

Rationalization of High Frequency (HF) infrastructure and related avionics will be driven by successful global implementation of Direct Controller Pilot Communications (DCPC) using legacy SatCom and space based as well as terrestrial telecommunications infrastructure. In addition to

GEO[1] satellites, MEO[2] and LEO[3] constellations will enable communications service delivery to both cockpit and cabin.

5. The Path Towards the Future

While ATN B1 and ATS B2 are used over ATN/OSI today, some airframe and avionic OEMs foresee the introduction of ATS B2 over ATN/IPS by 2032. In parallel, the telecommunications industry will deploy services based on 6G, and the aviation industry must therefore ensure that there is consideration in the 6G standards for aeronautical use of the technology. Avionic OEMs will then have new ATS and AOC options based on telecommunications infrastructure using global rather than regional specifications.

To achieve harmonious coexistence between the aviation and telecommunications industries, civil aviation regulatory agencies must integrate specialists from the telecommunications industry in defining and certifying new avionics, and vice versa. Disjointed equipage mandates applicable only to aircraft while ANSPs are excluded from the requirement, are untenable. Interoperability of ATM development programs across regions will be vital to ensuring global, borderless, airspace operations with a simplified (and lighter) suite of avionics. If properly coordinated, telecommunications standards and infrastructure (such as those being developed for 6G) can provide a path towards globalization for some aeronautical C, N and S services that would otherwise diverge into utilizing regional technological solutions.

AOC will lead the transition towards enhanced use of non-traditional aircraft connectivity. ATS will follow the AOC path and provide connectivity through the same links. At the same time, civil aviation could benefit from additional technologies derived from military programs, including optical communications for both on-board intercommunications networks and newfound applications such as cybersecure, high-speed gate links, e.g., those used for automated software updating.

Robust cybersecurity will be essential for Voice Over Internet Protocol (VoIP), the protection of mission critical data links, and possibly be employed across the full range of Communications, Navigation, and Surveillance systems, and protocols. Flight simulator facilitated studies and empirical evidence has shown that a range of avionic systems such as EGPWS, LOC, G/S, ACAS, GNSS etc. can be spoofed. It may eventually be necessary to introduce specific cybersecurity training for pilots to help them differentiate between system failures and cyberattack.

Ideally, cyber hardened avionics need to provide flight crew with definitive indications that segregate the annunciation of system failure, network issue, or cyberattack. Whether it is an erroneous GPS position report, or a dubious CPDLC uplink - having some way of automatically detecting the probability that the situation is being caused by a nefarious external entity would be beneficial to pilots in flight.

Commercial demand and regulatory action will drive optimization of civil aviation spectrum. Integrated solutions providing combinations of Communication, Navigation and Surveillance applications will complement COTS for safety and backup purposes. New technologies will enable transition from Communications, Navigation and Surveillance silos to integrated CNS and will require legacy technology to vacate parts of the spectrum.

While some airlines are displaying an appetite for the use of commercial telecommunications infrastructure to reinvent legacy applications such as Type B, Gate-Link, Maintenance, Repair and Overhaul (MRO) operations, and real-time offloading of AOC and maintenance data, many others are tied to 'flat-rate per ship' contracts whereby a decrease in VHF AOC data traffic will not result in a corresponding decrease in Communications Service Provider (CSP) charges.

Aeronautical standards organizations such as Radio Technical Commission for Aeronautics (RTCA) and

[1] **Geosynchronous Equatorial Orbit**
[2] **Medium Earth Orbit**
[3] **Low Earth Orbit**

European Organisation for Civil Aviation Equipment (EUROCAE) along with regulatory agencies such as European Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA), need to incorporate telecommunications industry representation in relevant sub-groups and work programs. The pace of civil aviation regulatory development must also quicken with certification processes reflecting the commercial value of, and increasing demand for, spectrum. Traditional, decades long avionic development and deployment cycles, will not be sustainable commercially and operationally.

Telecommunications and aviation industries need to jointly define 6G specifications to enable multi-industry benefits including those related to high-altitude/high-speed operations. Telecommunications infrastructure, including satellites, may well form part of a future, global, Alternative Positioning, Navigation and Timing (APNT) network. Telecommunications entities including MITRE Engenuity are currently leading the development and deployment of telecoms infrastructure for aeronautical use. Additionally, new entrants operating under the Unmanned Traffic Management (UTM) banner have already deployed commercial telecommunications as their preferred infrastructure for C2, including for BVLOS operations.

5.1. Considerations for Transition

It is self-evident that the global airline fleet cannot transition to modern communications technology on an abrupt timeline. Therefore, during the transition to newer and more capable technology, some existing ground communications infrastructure needs to be maintained.

However, just as UTM has embraced the best that innovative commercial telecommunications have to offer, airlines need to encourage their avionic OEMs to stretch into the future with new concepts and systems, in cooperation with telecommunications industry representatives such as GSMA.

A step into the aeronautical communications future may be the timely use of commercial telecommunications to offload AOC and maintenance data. That, of itself, will take some pressure off saturating VHF channels in certain regions. Since AOC is airline-controlled communications, individual operators can introduce new and novel technology in coordination with innovative avionic developers and/or telecommunications providers.

6. Conclusions

By 2035, use of state-of-the-art telecommunication standards, modern RF engineering, and COTS will be essential for harmonious coexistence and mutual benefits for the aviation and telecommunications industries. With some urgency, the desired aeronautical characteristics of 6G need to be defined and incorporated in relevant telecommunications industry specifications.

Integrated communication, navigation, and surveillance is a key element of future avionics, and coordinated effort must be made to modernize aviation CNS systems. More resources need to be devoted to tackling spectrum inefficiency and RFI.

To ensure the interference free coexistence of the aviation and telecommunications industries, and to maximize the benefits of aeronautical use of telecommunications spectrum and infrastructure, ICAO, IATA, regulators, certification authorities and ATM development programs must engage with the telecommunications industry at the political and engineering levels. Only with proactive engagement by airlines, avionic and airframe OEMs, regulators, standards organizations, and the telecommunications industry, will civil aviation ensure that next generation avionics are more capable, efficient, and resistant to RFI.