Due to the increased needs for sharing information among airborne platforms (both manned and unmanned) as well as the desire to use an airborne infrastructure to rapidly deploy communications capabilities to ground-based users in disaster areas, there has been a renewed interest in the research, design, and development of airborne communications networks. Airborne networks are mobile networks characterized by their high aircraft speeds and platform dynamics, long line-of-sight transmission ranges, and significant cost of integration for communication systems. This Feature Topic, Enabling Next Generation Airborne Communications, considers several types of airborne communications systems, including air traffic management (ATM) systems, networks of unmanned aerial vehicles (UAVs), and military airborne tactical networks.

The safety and security of people is of paramount importance in air transportation systems. Airborne networking helps achieve this objective by enhancing the situational awareness of an aircraft through information sharing among aircraft and by reducing the latency of voice and data communications. Next generation air transportation systems expect to have enhanced communication, navigation, and surveillance. With the Federal Aviation Authority (FAA)’s efforts in the United States to integrate unmanned aerial systems into the National Airspace System (NAS) progress, airborne networks play an even greater role in air transportation systems. Airborne networking requires advances in physical layer communications, mobility management, and network and security protocols, among others. These advances, in turn, will lead to advances in air traffic control, coordination and cooperation among aircraft, and enhanced safety and security for people in the air as well as on the ground.

Current ATM systems will reach their capacity limits in the next few years in both Europe and the United States. As a result, ATM modernization is required to address the increasing congestion and meet the future demands of sustainable air traffic worldwide. Increased and more complex information exchange between controllers and pilots demands the use of modern communications technologies, and an upgrade from conventional ATM systems toward Future Air Traffic Management Infrastructure (FCI) for ATM. Projects Single European Sky Air Traffic Management Research (SESAR) in Europe and Next Generation Air Transportation (NextGen) in the United States are intended to completely overhaul ATM. One of the key technologies enabling ATM modernization is Automatic Dependent Surveillance — Broadcast (ADS-B), a cooperative surveillance technology for tracking aircraft positions. In contrast to standard radar surveillance technologies that measure the range and bearing of an aircraft from a ground-based antenna, ADS-B allows aircraft to determine their own position using a Global Navigation Satellite System (GNSS) and then to broadcast it periodically over a radio frequency to ground stations or other aircraft in the proximity. By 2020, scheduled flights will be required to send continuous location updates with ADS-B-capable transponders. Data link components of FCI for ATM include the L-Band Digital Aeronautical Communications System (LDACS) for air-ground communications, a dedicated data link to be used at large airports, a satellite component, and a direct air/air data link. System integration is needed among these components. ATM modernization will enable more complex flight trajectories, reduce fuel consumption, and increase capacity, efficiency, and safety, especially during take-off and landing. The first three articles in this Feature Topic relate to components of FCI to support ATM.

The first article, “LDACS: A Future Aeronautical Communications for Air-Traffic Management” by M. Schnell et al., describes in detail the role of LDACS, the future air/ground ATM communications technology within the FCI. Specific attention is given to a promising LDACS technology candidate, LDACS1, and its extensions that can provide navigation and surveillance services using a common ground infrastructure.

The second article, “Realities and Challenges of NextGen Air Traffic Management: The Case of ADS-B” by M. Strohmeyer et al., considers another component of the new ATM architecture, ADS-B, which is planned to replace current radar systems for tracking aircraft position. The article analyzes the current state of the ADS-B system through a comprehensive large-scale measurement campaign. The authors argue that there are a number of problems that cause severe concerns for safety and security of future air traffic, and that the ADB-S standard, in its current state, is not likely suitable as a sole and secure means of separation assurance or collision avoidance.

As we develop new concepts and technologies for future aeronautical communications, flight trials and experiments are

This work was sponsored in part by the Assistant Secretary of Defense — Research and Engineering (ASD R&E) under Air Force Contract # F48721-05-C-0002. Opinions, interpretations, recommendations, and conclusions are those of the authors and are not necessarily endorsed by the United States Government.

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necessary to validate these technologies under real environmental conditions. The third article, “Flight Trial Demonstration of Seamless Aeronautical Networking” by Plass et al., details flight trials of the next generation aircraft communications system that integrates all the aeronautical service domains within a common IPv6-based aeronautical network. The results demonstrate the flexibility and scalability of the network and the seamless service coverage provided by the integrated architecture.

UAV technology has rapidly improved in recent years, as witnessed by the diversity of platform sizes, shapes, capabilities, and configurations. UAVs are used to support both military and civil missions as they enable applications such as wide area surveillance, situation management, disaster relief, environmental monitoring, firefighting, policing, maritime patrol, search and rescue, and command and control (C2) among many others. Typical UAV missions and applications are supported by multiple entities in the air and on the ground; hence, air-to-air, air-to-ground, and air-to-satellite communication links are generally required for successful operation. Communications between these entities enables physical coordination and safety of flight as well as data fusion and dissemination. Air-to-ground links can provide data dissemination back to a ground station or restored ground-to-ground communications when cell towers or line-of-sight ground communications have been lost. Air-to-air links permit data dissemination, and reach back to C2 nodes and/or wired infrastructure over longer distances. The design of link technologies and networking architectures to support collaboration between these air and ground nodes is an active area of research for both civil and military communications systems.

The fourth article, “Application-Driven Design of Aerial Communication Networks” by Torsten et al., addresses a key issue that comes into play when building networks of micro aerial vehicles (MAVs). Generally, MAV platforms must rely on existing communication technologies as MAVs cannot afford the extra cost or weight of a dedicated communication system. The authors propose an approach that consists of choosing the best network (or combination of networks) by considering the requirements of the target application with respect to the characteristics of the available communication technologies. They also show the limitations of these communications technologies arising from the fact that these technologies were not specifically designed for the desired applications or the airborne environment.

Communications between military aircraft has been a critical area for several decades. Airborne tactical networks (ATN) support low–medium data rate communications between rapidly moving aircraft separated by hundreds of nautical miles. Commercial technologies that have enabled rapid wireless capacity growth are generally not applicable in this domain. For example, the infrastructure that supports the cellular industry cannot be replicated in the wireless tactical domain; hence, ATNs must enable multihop wireless communications. Also, carrier sense multiple access schemes commonly used widely in the cellular domain are not applicable, as propagation delays can be up to a few milliseconds and hence much larger than packet transmission times. Despite these challenges, advances in signal processing, wireless communications, and mobile networking can help us to develop next generation ATNs that support larger numbers of users with significantly higher total network capacity, increased flexibility, improved connectivity, and faster response times.

The final article, “Design Considerations for Next-Generation Airborne Tactical Networks” by B. Cheng et al., describes the desired capabilities of a next generation tactical network and the challenges associated with providing those capabilities. The article provides an overview of the unique characteristics of the air tactical domain and the key design challenges associated with improving performance. The article shows how technology improvements and innovations at the physical, link, and network layers as well as cross-layer optimization provide promising solutions to allow us to satisfy emerging communications needs in the air tactical domain.

Note from Sean Moore, Editor-in-Chief. IEEE Communications Magazine: One of the authors of this article, Aradhana Narula-Tam, is also a GUEST EDITOR of this Feature Topic, which is exempt to Magazine policy. An exception was made in this case, however, because of agreed-upon conditions during the development of this Feature Topic. To ensure fairness, quality, and policy enforcement, the article was independently reviewed outside of the Feature Topic’s review process by members of the Magazine’s editorial board and their selected reviewers, as well as the Editor-in-Chief.

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