

An Airborne Communications Roadmap for the U.S. Federal Air Marshal Service: Overview and Status

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Abstract

Following the events of September 11, 2001, the responsibilities, operations and numbers of the U.S. Federal Air Marshal Service (FAMS) were greatly expanded. With this expansion, new critical research and technology needs were identified, including the need for air to ground telecommunications capabilities. To address this need, the FAMS has created a working group to develop, deploy and enhance aviation communications with respect to security and law enforcement. This paper presents the working group's progress to date in generating a FAMS air-ground communications roadmap identifying expected communications services, technology maturity, and technology gaps over a timeline. The paper includes a communications preliminary requirements summary and system performance characteristics needed to meet identified operational needs. The system engineering process utilized is presented beginning with the identification of users, their operational needs and relevant constraints. The operational needs are translated to desired airborne communications services. System technical performance requirements associated with the identified services are summarized. In addition, notional communications architectures addressing the requirements are presented. Finally, future plans to identify and assess potential candidate systems and their associated technical architectures, gaps and barriers to implementation are discussed. The paper addresses the current, near term (within 5 years) and far term (10 years) timeframes for such an airborne communications system.

Introduction

The mission of the Federal Air Marshal Service (FAMS) is “to promote confidence in our Nation’s civil aviation system through the effective deployment of Federal Air Marshals, to detect, deter, and defeat hostile acts targeting U.S. carriers, airports, passengers, and crews.” Following the tragic terrorist attacks on September 11, 2001, the responsibilities, operations, and the numbers of Federal Air Marshals (FAMS) were greatly expanded. With this expansion, the need for improved air to ground communications capabilities for the FAMS and other law enforcement officers was identified. The provision of such capabilities would allow FAMS to securely and effectively communicate from air to ground, ground to air, air to air, and within the cabin of an aircraft. These capabilities are essential enablers in executing the mission of the FAMS. Accordingly, the FAMS has been aggressively pursuing the development of an air to ground communications system (AGCS) since 2002 through a public-private partnership with other government agencies and the private sector. For the purposes of this paper, the term, “air to ground communications system or AGCS,” encompasses the air to ground, ground to air, air to air, and intra-cabin communications capabilities. This paper presents an overview and status of the development of a roadmap for the AGCS.

Background

AGCS Air-to-Ground Working Group:

In June, 2003, the U.S. Congress tasked the FAMS to create and chair an Air-to-Ground Working Group (WG) to develop, deploy and enhance aviation communications as it relates to security and law enforcement. The WG is comprised of key AGCS stakeholders including a number of U.S. government agencies, commercial air carriers and aviation industry trade organizations. The WG consists of four committees (see Figure 1) comprised of relevant members from the WG: the Executive, Technical Evaluation, Policy and Security Committees; designated EC, TEC, PC and SC, respectively. The TEC,

PC and SC all report to the EC which acts upon information and recommendations received from the lower-level committees. The committees provide necessary policy (via the PC), technical (via the TEC) and aviation security (via the SC) expertise related to the development and implementation of the AGCS.

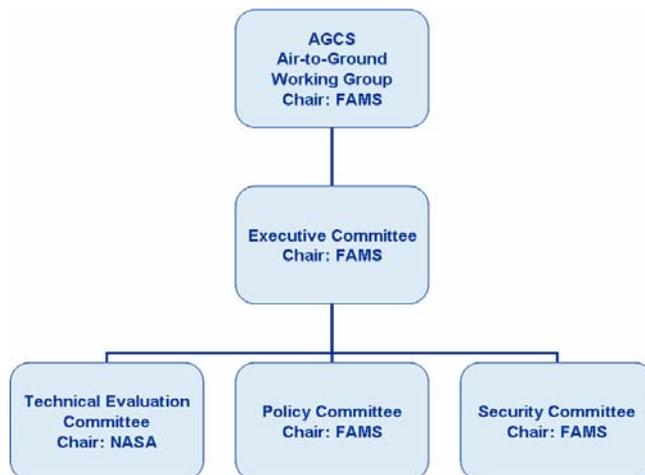


Figure 1. Working Group Organizational Structure

The WG is tasked to develop a (1) Technical Implementation Plan, or Roadmap, for time-phased options for implementation of the AGCS and, (2) a Business/Government Partnership to implement the Roadmap. The WG will recommend a “best approach” to develop and implement an AGCS producing recommendations with respect to viable systems, procurement, deployment, training, maintenance, program management, and inter-agency compatibility. Furthermore, the WG will devise a government-industry shared funding strategy to implement accepted “best approach” recommendations. The WG has delegated to the TEC the Roadmap development and to the EC the development and recommendation of the Business/Government Partnership and associated shared funding strategy to implement the AGCS Roadmap. It is important to note, the FAMS intent is to ultimately procure standard communications services and user equipment from commercial providers to meet its requirements; that is, the FAMS would be a subset of users/consumers of a broader communications service available to the aviation community system-wide. The balance of this paper will focus on the development of the AGCS Roadmap.

The overall goal of the WG is to define a communications *capability* satisfying the operational needs of the FAMS involving *aircraft* platforms. The capability should be a fully realizable, deployable and useable end-to-end solution. It should support FAMS communications within an aircraft and between other airborne and ground-based FAMS contacts. To accomplish the goal, the objective is to produce a AGCS Roadmap identifying available *communications services* (end-end capabilities provided to users), their associated *technology maturity* (commercially available options adopted by aviation with full aviation deployment potential over time), and *technology gaps* (unmet FAMS operational needs that existing and emerging technologies are deficient in addressing).

AGCS Roadmap Development and Status

Approach: The Roadmap is being developed via two, iterative cycles: a first pass during July-December, 2006; and a second pass during January-September, 2007. This is in order to satisfy the delivery requirement of the TEC for Pass One of the Roadmap to the EC during January, 2007. The focus of the first pass is on current and emerging technologies and systems capable of addressing FAMS’ current and near-term (within 5 years) communications requirements. The second pass will update results from the first pass and focus on technologies and systems capable of addressing unmet near-term requirements as well as far-term (within 10 years) requirements. These current, near and far term requirements are

designated as *Initial*, *Interim* and *Full* requirements in the Roadmap given the resulting operational capability achieved over time. Key elements of the approach pursued and associated results follow.

Scope: The AGCS consists of a number of sub-systems residing on-board the aircraft (Aircraft Segment), the ground (Ground Segment), and possibly in space (Space Segment) depending on the ultimate architecture selected (see Figure 2). The focus of the first pass of the Roadmap is on the three sub-systems illustrated in the figure. This is due to the fact that the FAMS' Portable Electronic Devices (PEDs) and the terrestrial communications sub-systems (beyond those associated with the transmission and reception of airborne signals) are already in existence and well defined. As such, the Roadmap seeks to define the optimal aircraft on-board and off-board sub-systems of the AGCS. It should be noted however, that more flexibility may exist in influencing the future FAMS PED and the terrestrial communications infrastructure in the context of the *Interim* and *Full* FAMS communications requirements in the mid to far-term (5-10 years).

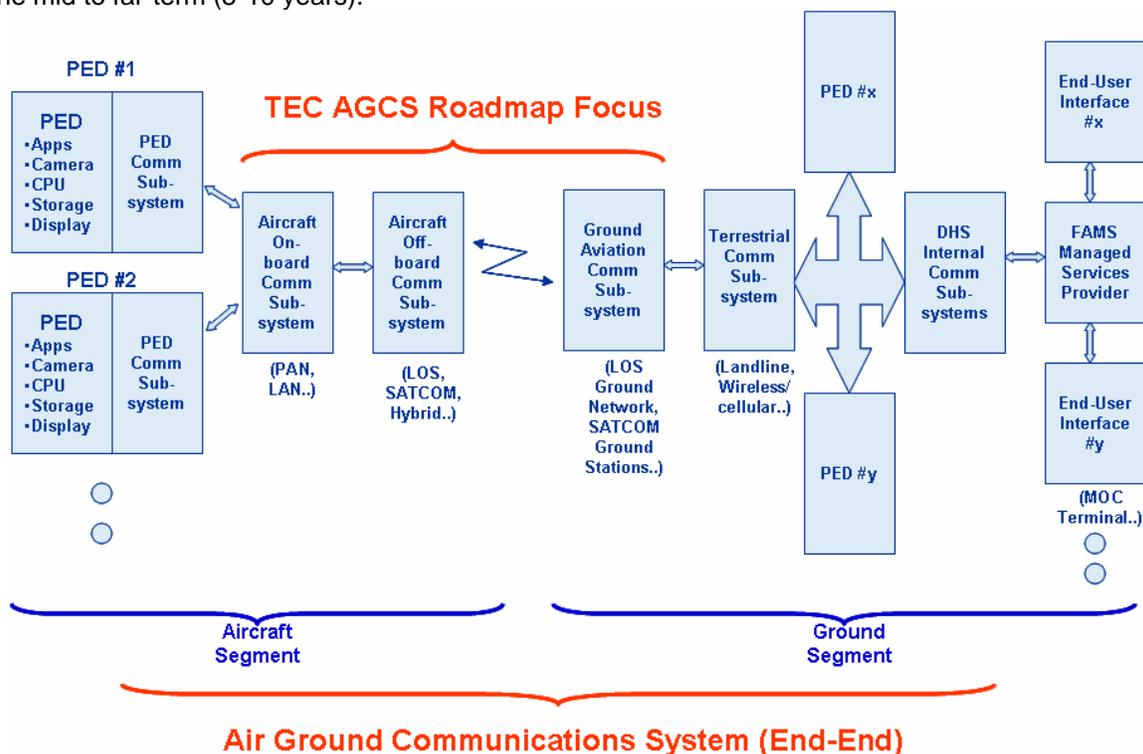


Figure 2. Air Ground Communications System (AGCS)

Constraints: A number of key constraints exist which must be considered during the Roadmap development. These include regulatory, operational, as well as programmatic constraints. Radio frequency interference to aircraft navigation and communications systems by on-board transmitting devices is of key concern to the FAA and aircraft operators. In general, air carriers desiring to permit cellular phone or PED use during flight must determine that the specific device model does not interfere with on-board communications and navigation systems for the specific type of aircraft the devices are to be used on. For the first generation FAMS PED, FAA testing met RTCA DO-160D standards for a specific configuration of multiple PEDs on-board an aircraft operating in "Bluetooth Chat" mode. Air carriers can refer to this testing as a basis for granting approval of PED use in the prescribed configuration. It is important to note, that cellular voice telephony on-board aircraft is a much tougher challenge than data exchange due to concerns regarding (1) interference with on-board systems and cellular ground networks, and (2) potential nuisance to other passengers. The RTCA and other groups are currently studying the numerous issues associated with airborne cellular phone use. Additional regulatory constraints include compliance to the Communications Assistance for Law Enforcement Act

(CALEA) by airborne communications providers. Aircraft operators also impose operational constraints on the AGCS. These include limitations on the use of electronic devices on-board aircraft (based on the determination of whether such devices pose interference to on-board systems), pilot-in-command approval to use of aircraft and personal communications systems (especially during sterile cockpit operations), and business case related issues associated with an airline equipping its aircraft with commercial communications equipment resulting in increased weight, power, drag and maintenance requirements. Programmatic constraints to the AGCS Roadmap include the aggressive 6 month schedule of Pass One, the unique Business/Government Partnership model and associated shared funding strategy for the implementation of the Roadmap, the focus on FAMS requirements as primary and other user AGCS requirements as secondary, and the desire to maintain all WG produced information and documents unclassified in the interest of open communication, and participation and the building of a strong Business/Government Partnership model for the eventual implementation of the Roadmap.

Users: The key relevant users of the AGCS were identified. These include first and foremost the FAMS. Prominent users of the AGCS will be the *Federal Air Marshals* in the field who are deployed in order to detect, deter and defeat hostile acts targeting U.S. air carriers, airports, passengers and crews. The FAMS field operations require telecommunications capabilities to address a number of mission needs including terrorist, criminal and other scenarios in the interest of maintaining aviation safety and security. The FAMS' *Mission Operations Center (MOC)* will also be a key user with the need to be in contact with the FAMS in the field worldwide on a 24/7 basis. As the chief coordination mechanism for the FAMS, the MOC will benefit greatly from the AGCS. The Transportation Security Administration's (*TSA Explosive Division*) will also be a potential user of the AGCS to conduct its mission of transportation explosives security. The *Force Multiplier Program (FMP)* does not appear to be a near term user of the AGCS, however, it is anticipated that FMP law enforcement officers at the federal, state and local levels could be users of the AGCS once implemented and in the far term. Finally, the *on-board flight crew* (flight attendants and pilots) are expected users of the AGCS as they are an active component in assisting and identifying situations within the aircraft requiring engagement or assistance by the on-board FAMS. In order to understand the operational context and how the various users could use the AGCS, a number of operational scenarios were developed as part of the Roadmap.

User Operational Service Needs: With relevant users identified, user operational service needs were investigated for both the on-board and off-board aircraft domains. On-board needs included cabin and cockpit communications requiring voice, text paging, instant messaging, and imagery exchange services. The data services were further divided into one-way data (broadcast, multicast or addressed) and two-way data including instant messaging and request/reply. On-board connectivity was also defined (FAM to FAM, FAM to pilot..). The various service needs were also mapped against phase of flight given the strong dependency of specific services to flight phase (departure gate, departure taxi, departure, en-route, arrival, arrival taxi and arrival gate). The resulting service needs were categorized as either *Initial* or *Interim* needs. *Full* service needs will be defined in the second pass of the Roadmap. Similarly, the off-board (air-to-ground) user operational service needs and connectivity were also developed and mapped against phase of flight and categorized as either *Initial* or *Interim*. Off-board services included those identified on-board along with the need for E-mail and Internet access.

Notional Communications Architectures: Notional architectures addressing the on-board and off-board aircraft communications needs were developed (see Figures 3, 4).

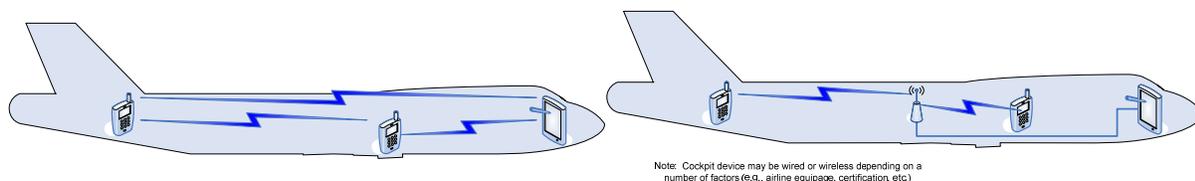


Figure 3. On-board Notional Architectures: Personal Area Networks (left) and Local Area Networks (right)

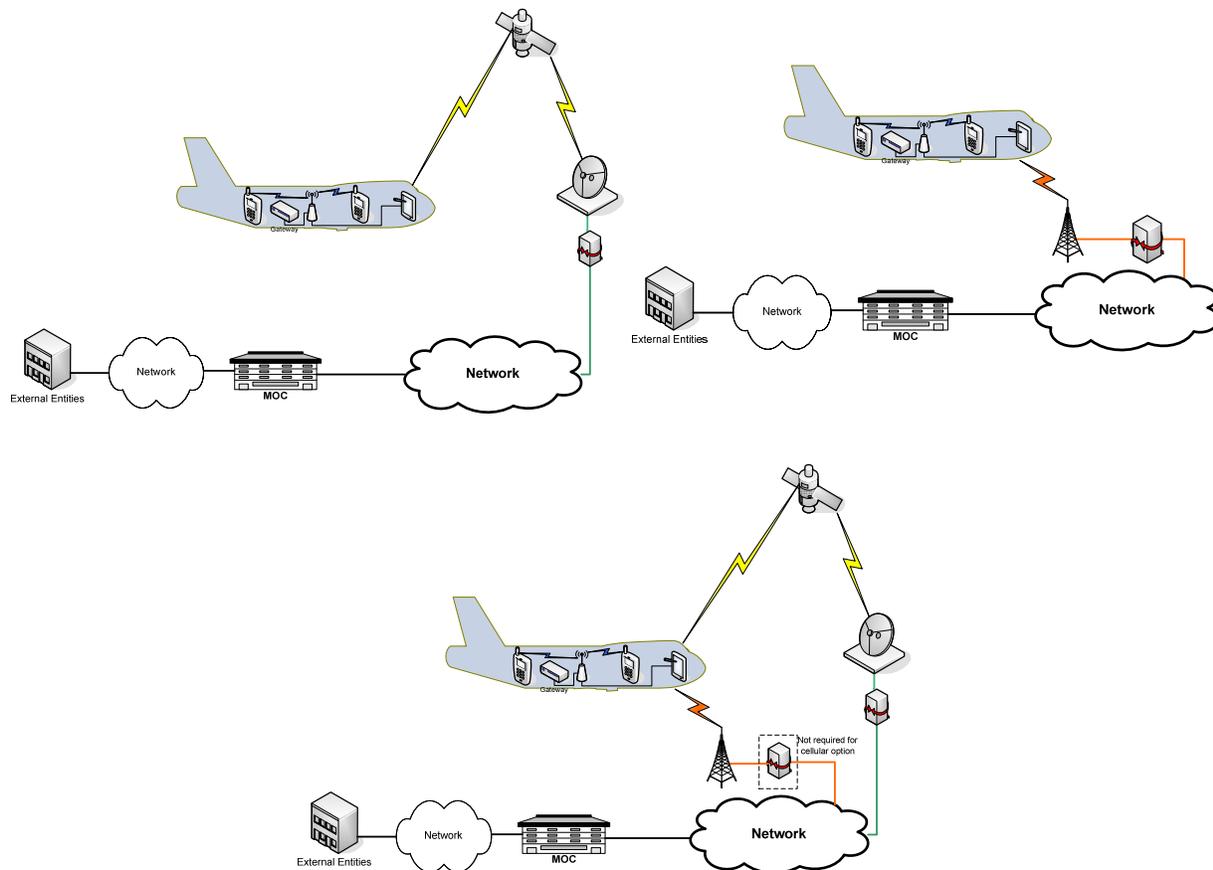


Figure 4. Off-board Notional Architectures: Satellite (top left), Terrestrial (top right) and Hybrid (bottom)

Communications System Performance Requirements: With the airborne communications services defined, key system-level and quality of service (QoS) performance requirements were established. In addition to the constraints presented earlier, it is desired for the AGCS to meet certain minimal performance metrics. These include *system availability/reliability* (measure of service being available to the user), *propagation/coverage* (measure of geographical signal availability), *spectrum* (measure of access to frequencies/rights), and performance requirements such as *capacity* (measure of ability to handle data traffic load), *latency* (measure of timeliness for data transfer), *link quality* (measure of link error rate), *accessibility* (measure of gaining access to channel when needed), *integrity* (measure of unintentional data corruption) and *security* (measure of data protection to unauthorized parties). A summary of the preliminary requirements is presented below.

- **Availability:** The desired AGCS availability is equivalent to at least that of “Routine Services”; an availability of 99% and a service restoration time of less than 1.68 hours.
- **Coverage:** The desired AGCS coverage is throughout all phases of flight (surface, terminal transition airspace and en-route), both nationally and globally.
- **Spectrum:** The desired operation of the AGCS is in frequency spectrum bands recognized by spectrum regulatory authorities nationally and internationally which are suitable and acceptable for aviation applications provided by the AGCS.
- **Capacity and Latency:** Capacity and latency are dependent on the types of service(s) to be provided on-board and off-board the aircraft at any given point in time; thus these performance parameters are mission and thus flight phase dependent. Due to mission and information sensitivity, only aggregate typical and peak per aircraft per phase of flight capacities are provided (see Table 1). Derivation of the capacities consider the latencies associated with the specific services.

- Link Quality: The minimum Bit Error Rate (BER) required is dependent on the specific service. For one-way data services, a minimum BER of 5×10^{-7} is desired. For digitized voice services, a minimum BER of 1% is desired.
- Accessibility: The ability to seize the channel when the system and channel is available is a measure of accessibility. This can be accomplished via such mechanisms as pre-emption and prioritization. *Initially*, no priority or pre-emption is expected. For the *Interim*, the AGCS services should have priority over non-AGCS users. For the *Full* requirement, the ability to pre-empt non-AGCS users is desired.
- Integrity: AGCS data should be received in a reliable manner, within the specified latency period.
- Security: *Initially*, end point devices should implement access control and encryption for both data at rest and in transit (across networks). For the *Interim*, two-factor authentication, stronger encryption algorithms at additional locations, and guaranteed prioritization and multiple data paths to mitigate congested or hostile situations should be provided.

| | GATE | TAXI | DEPARTURE | ENROUTE | ARRIVAL | TAXI | GATE |
|------------------|---------|---------|-----------|---------|---------|---------|---------|
| On-Board | | | | | | | |
| Initial: | | | | | | | |
| Typical | 0.6 | 0.3 | 0.3 | 0.3 | 0 | 0.3 | 0.3 |
| Peak | 876.6 | 876.6 | 0.3 | 12.3 | 0 | 876.3 | 876.3 |
| Interim: | | | | | | | |
| Typical | 0.9 | 0.9 | 0.6 | 0.9 | 0.6 | 0.9 | 0.9 |
| Peak | 11532.9 | 11556.9 | 12.6 | 11556.9 | 12.6 | 11556.9 | 11544.9 |
| Off-Board | | | | | | | |
| Initial: | | | | | | | |
| Typical | 0.6 | 0.6 | 0 | 0.3 | 0 | 0.6 | 0.6 |
| Peak | 108.6 | 108.6 | 0 | 0.3 | 0 | 108.6 | 108.6 |
| Interim: | | | | | | | |
| Typical | 20.6 | 20.6 | 0.6 | 20.6 | 0.6 | 20.6 | 20.6 |
| Peak | 574.6 | 574.6 | 0.6 | 574.6 | 0.6 | 574.6 | 574.6 |

Table 1. Summary of Preliminary Per Aircraft Aggregate Capacity Per Phase of Flight (in Kilobits/sec.)

Future Plans

Next steps in the Roadmap development include: the characterization of current and emerging communications systems and their associated technical architectures potentially able to address the AGCS *Initial* and *Interim* requirements (for Pass 1); evaluation of these candidate systems against established evaluation criteria in terms of their ability to address the requirements; recommendation of a AGCS technical architecture; identification of gaps, barriers to implementation and recommended solutions. At the completion of Pass One, Pass Two of the Roadmap will be initiated with a focus on any unmet *Interim* as well as investigating the far-term *Full* operational requirements.

Summary

Progress to date on the development of an AGCS Roadmap for the FAMS has been presented. The process used by the WG to develop the Roadmap and associated, appropriate preliminary results to date have also been presented. Finally, future plans on completing the Roadmap were discussed.

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