Recommendations
For
Aviation Communications Research Investments

Prepared by:

Air Traffic Services Subcommittee
Aviation Communication Research and Technology Subgroup
Research, Engineering and Development Advisory Committee

April 29, 2003

Executive Summary

In June 2001, at the request of the Federal Aviation Administration (FAA), the Research, Engineering and Development Advisory Committee (REDAC) Air Traffic Services Subcommittee formed a subgroup to review current FAA research and development planning for aviation communications evolution. The REDAC asked the subgroup to define what communications research would be required to accomplish the planned evolution and to identify key ATM communication attributes for the post 2020 period.

The Aviation Communications Research and Technology (ACRT) Subgroup held its first meeting on August 22, 2001. The Subgroup met six times to gather information and draft this report. ACRT Subgroup participants included representatives of Department of Defense (DoD) and EUROCONTROL.

The ACRT Subgroup believes that the communication planning contained in the FAA NAS Architecture documentation is the correct path for evolving the U.S. aviation communications infrastructure for the near- and mid-term and that the FAA's NEXCOM program is sufficiently flexible to accommodate the needs of the U.S. aviation industry while at the same time replacing FAA's aging air-ground radio infrastructure.

The Subgroup, however, is concerned about the lack of coordination between the United States and Europe in their near-term plans to replace the 25 kHz radio technology. The FAA is moving ahead with VDL-3 technology (early radios will have 8.33 kHz, 25 kHz and VDL Mode 2/3), while Europe has chosen 8.33 kHz technology as an interim step. The Subgroup believes that the United States and Europe should work together to define the far-term globally interoperable civil aviation communication system.

The ACRT Subgroup found numerous research projects for far-term communications at NASA, DOD and Eurocontrol, but is concerned about the integration of those projects into a Global Communications System. The subgroup is also concerned that numerous technical issues remain unanswered.

The ACRT Subgroup recommends the FAA:

- Focus research on the communications systems that will be introduced into the NAS in the post 2015 time frame (far-term). Research on domestic communications systems for the near- (2003 – 2008) and mid-term (2008 – 2015) should be limited to resolving issues associated with deployment of those systems identified in the NAS Architecture. Research, however, is still required to provide mid-term enhanced communication services in oceanic and remote area airspace.

- Perform research and analyses to determine a range of communication system performance requirements that match scenarios for the future air transportation system.

- Include, as part of research, a cost-benefit analysis of the various implementation strategies for communications systems.

- Develop an aviation communications system roadmap based on a range of future air transportation concepts of operation and growth projections.

- Determine whether it is feasible and/or desirable to adapt DoD-developed communications technologies for civilian use.

- Create a joint NASA/FAA Communications, Navigation and Surveillance (CNS) Area Work Team within the NASA/FAA Interagency Air Traffic Management Integrated Product Team (IAIPT) to coordinate communications research.

- Work with NASA, DoD, and industry to ensure that planned investments are not duplicative

- Provide strong global leadership in setting the communications research agenda.

    - Increase resources dedicated to international forums and associated committee work to ensure adopted solutions are compatible with technology being developed in the United States

    - Lead an international effort to reach global consensus on operator and user communication system(s) equipage, timing of investments, and operational concepts

Introduction

In June 2001, the FAA requested its REDAC Air Traffic Services Subcommittee to form a subgroup to review current FAA planning for aviation communication systems evolution in the near and far term, and to determine what communications research would be required to accomplish the planned evolution. The REDAC also charged the subcommittee to look at other technologies, alternative architectures, and to recommend what research, if any, would be required to explore these alternatives for application to the U.S. civil aviation communication system. (See Appendix A for Terms of Reference provided the subgroup.)

The ACRT Subgroup held its first meeting on August 22, 2001. (See Appendix B for Membership Listing of the ACRT.) Since that time, the Subgroup has queried government, research centers, academia, and industry about their perspectives on the future aviation communications system. This report summarizes the Subgroup's deliberations and recommendations for a communications system architecture for 2015 and beyond, and identifies the research required to develop and deploy this future communications system.

Background

During the course of six meetings, the ACRT Subgroup gathered information from government agencies (DoD, FAA, NASA, and EUROCONTROL), industry (Raytheon, Boeing, ITT, BAE Systems, Lockheed Martin, Computer Networks and Software Inc., and ARINC), associations (Air Traffic Control Association, Airline Pilot Association, Air Transport Association, and the Small Aircraft Manufacturers Association), John Hopkins University, and Federally Funded Research and Development Centers (Massachusetts Institute of Technology/Lincoln Laboratory and MITRE Center for Advanced Aviation System Development). The following summarizes the information collected by the ACRT Subgroup.

1. Evolution of Aviation Communications Systems as Defined by the National Airspace System Architecture

The FAA's NAS Architecture is an evolutionary modernization blueprint designed to help the Agency plan for projected needs for the next 15-20 years. The Architecture is based on the RTCA/FAA NAS Concept of Operations for the near-term, mid-term, and far-term (beyond 2010) and focuses on enhancing current capabilities with updates to procedures, roles, responsibilities, new equipment, and new automation functions. A new, well-defined and integrated communications infrastructure will be required to provide an efficient and secure distribution of the information to support this architecture and to address the shortfalls of the current NAS information exchange. This infrastructure must adopt current and emerging information and security technologies and standards to satisfy the NAS information distribution needs.

The current state of FAA planning for the evolution of the NAS communications infrastructure can be found by using the FAA's on-line Capability Architecture Tool Suite – Internet (CATS-I) available at http://www.nasarchitecture.faa.gov/Tutorials/CATS101_Internet.cfm. CATS-I is an interactive web browser that provides access to the programmatic and technical data of the NAS Architecture. Using CATS-1, the Subgroup found that from the present to the 2015 end date of the NAS Architecture, the aviation-related communications envisioned by FAA consists of a voice communications network and a data communications network. These networks do and will continue to include ground-ground and air-ground capabilities. The systems include:

- Voice communications network: Legacy systems already in place will continue well into the 2010 timeframe with expected replacements to begin deployment in 2008/9; transition to the new equipment/systems could extend well into the 2020s. Throughout this time period, equipment will be upgraded as the FAA transitions from a hybrid digital/analog to an all-digital communications network. (Legacy systems include: VHF radios; Back-Up Emergency Communications System; Voice Switching and Control System; Terminal Voice Switch; Flight Service Station Voice Switch; FTS-2000; etc.)

- Data communications network: The present NAS Architecture provides an evolution from today's National Airspace Data Interchange Network (NADIN) data packet switching network, inter-facility communications links, surveillance data links, and Very High Frequency Data Link (VDL) Mode 2 to a system with enhanced capabilities such as next generation air/ground radio communications system (VDL Mode 3), widespread use of the aeronautical telecommunications network, and link enhancements from the FTS-2001 systems. Point-to-point connections of surveillance, inter-facility, automation, and information management systems remain part of the NAS Architecture design through year 2015. The FAA is investigating the feasibility of a complete rework of the NAS Architecture data transmission and data management system design to incorporate benefits of wide area network technology. If feasibility and information requirements analyses prove promising, future revisions to the NAS Architecture will include an evolution to a wide area information network infrastructure with the capability to support extensive information sharing (aircraft position, future planned positions, weight, push back time from the gate, etc.) with reduced latency, increased situational awareness, and more effective collaborative decision making by the pilot, controller, and supporting/controlling organizations.

2. Divergence in Near- and Mid-Term Evolution of Air-Ground Communications

FAA

The FAA's Next Generation Air/Ground Communications (NEXCOM) program is developing VDL Mode-3 technology to meet future FAA air-ground voice and data communication requirements throughout the continental United States. As a result, the Agency is addressing many of the immediate research and development (R&D) issues necessary to support its successful implementation. Near term controller-to-pilot data link needs are being met with the use of VDL Mode-2 data link services with a planned transition to VDL Mode-3 technology. In the Oceanic domain, the FAA plans to acquire the services of an independent provider to support air traffic services communications. For ground-to-ground communications, the FAA intends to move to a point-to-point digital communications infrastructure that provides for the integration of voice, data, and video and combines operational and non-operational data over the same network. This overall communications architecture is designed to provide additional capacity to support the ever-increasing demand for voice and data communications and to increase system efficiencies and reduce costs. Many of these new technologies are expected to be operational by 2010.

EUROCONTROL

EUROCONTROL has adopted the use of 8.33 kilohertz (kHz) technology for the air traffic control voice communications in the high altitude sectors of European airspace and will continue migration of 8.33 kHz technology to other airspace as frequency congestion makes use of 25 kHz channels impractical. Initial controller-to-pilot data link services

will be via VDL Mode-2. Still to be decided is how air traffic data link services will be provided once VDL Mode-2 capabilities are exceeded.

DoD

DoD is developing and deploying the Joint Tactical Information Distribution System (Link 16). JTIDS is a communications, navigation, and identification system intended to exchange surveillance and command and control information among various military platforms. It provides multiple access, high capacity, jam-resistant, digital data and secure voice communication, navigation, and identification. Currently Rockwell-Collins is under contract with the U.S. Navy to reduce the size and cost of the system by first reducing the size of the power amplifier, then reducing the overall size of the system terminal. Total reduction in is expected to be in the 50 to 70 percent range. Prototypes are currently being manufactured and tested.

In addition, DoD is developing a multimode radio which uses open system architecture and can accommodate many different waveforms. Raytheon displayed an eight-waveform prototype at one of the Subgroup meetings.

3. Work Underway on the Next Generation Communication System (Far-term)

NASA

NASA is performing advanced communications research and technology (R&T) for possible NAS applications in the post-2015 timeframe. These activities are being managed by NASA's Aviation Safety Program (AvSP) and Aviation System Capacity (ASC) Program.

Because weather is a contributing factor in approximately 30 percent of all air carrier and general aviation accidents, NASA's AvSP is sponsoring work on the dissemination of timely and intuitive weather information to commercial air transport and low-end general aviation cockpits for enhanced crew situational awareness to in-flight atmospheric/ weather hazards. NASA's AvSP Weather Information Communications work encompasses:

- Weather information communications requirements development;
- Weather data link architecture studies and analyses;
- Ground-based (primarily VHF) Flight Information Service (FIS)/weather data link technology development via cooperative agreements with industry;
- Satellite-based (L, S, and Ku-band) FIS data link development; and
- Airborne-based data link development for automatic reporting of meteorological data and aircraft in-situ weather hazard reporting.

Although the FIS data link R&T is planned for deployment during the 2005-2015 timeframe, it is expected that these capabilities will serve aviation for at least 20 years from time of initial implementation. NASA studies have indicated that weather cannot justify its own unique data link; it must ride along with other applications. Thus the R&T is focused on adapting technologies being developed for other purposes. Examples include:

- A broadcast variant of the ICAO VDL Mode-2 standard has been developed for FIS general aviation data link;

- The air transport VDL Mode-2 technology is being adapted to accommodate FIS traffic along with AOC and ATM traffic; and

- L, S, and Ku-band commercial satellite data links are being adapted (primarily with respect to avionics) for both air transport and general aviation FIS.

NASA's ASC Program is sponsoring limited communications R&T under its Advanced Air Transportation Technologies (AATT) and Virtual Airspace Modeling & Simulation (VAMS) projects. The AATT Advanced Communications for Air Traffic Management (ACATM) activity is primarily focused on air traffic management (ATM) performance evaluation over broadband satellite communications in the post-2015 timeframe. ACATM has partnered with Boeing in developing a Ku-band aeronautical terminal and phased array antenna system enabling experimentation of ATM concepts via a conceptual satellite-based architecture. Given the extreme frequency congestion at VHF, ACATM is investigating broader band satellite architectures for future ATM communications.

The VAMS communications R&T activity is focused on the development of computer models of key communications components of the NAS. These models are planned for subsequent integration into a virtual airspace model allowing, via advanced computer simulations, for the design, trade-off, and evaluation analysis of future ATM concepts. Through the VAMS capability, advanced ATM concepts with the potential for greatly improving the capacity of the NAS will be investigated.

DoD

The Defense Advanced Research Projects Agency's Next Generation (XG) Communications program is working to develop systems with autonomous sensing of the spectrum environment for unused gaps/frequency bands. These available unused 'dead' bands would be exploited for communications without compromising connectivity to existing users. Given the fact that frequency congestion is a continuing problem for FAA, EUROCONTROL, and DoD, this technology would optimize use of the frequency spectrum. A cooperative R&D program of this nature could yield benefits for both military and civil aviation.

EUROCONTROL

EUROCONTROL is looking at alternative aviation communications architectures that would enable the incorporation of new commercially available communication technology, such as cellular telephone networks, wide-band communications, internet protocol (TCP/IP Version 6), space based communications, and software configurable radio technology. Currently EUROCONTROL is drafting a research program that will evaluate these communication technologies for their applicability to future aviation communication requirements as the first step in developing an architecture for the future (beyond 2015) European aviation communications system.

4. Evolution towards a Global Communications System

The FAA promotes global interoperability through its continued participation as the United States representative on ICAO panels. ICAO's Aeronautical Mobile Communications Panel has been tasked by the Aeronautical Navigation Commission to develop a proposal that supports the requirement for a common interoperable communication infrastructure beyond 2010. (The time frame is not as important as the fact that an interoperable solution is desired.) This proposal, scheduled for presentation at the ICAO Air Navigation Conference in September 2003, focuses on ATM air-ground communications and considers alternative communications architectures with complementary technologies (including 8.33; VDL Mode-2, -3, and -4; wideband, high frequency voice and data link; and satellite communications) to achieve needed communication services.

Findings

The Subgroup believes that the communication planning contained in the FAA NAS Architecture documentation is the correct path for evolving the U.S. aviation communications infrastructure for the near- and mid-term and that the FAA's NEXCOM program is sufficiently flexible to accommodate the needs of the U.S. aviation industry while at the same time replacing FAA's aging air-ground radio infrastructure.

The Subgroup, however, is concerned about the lack of coordination between the United States and Europe in their near-term plans to replace the 25 kHz radio technology. The FAA is moving ahead with VDL-3 technology (early radios will have 8.33 kHz, 25 kHz and VDL Mode 2/3), while Europe has chosen 8.33 kHz technology as an interim step. The Subgroup believes that the United States and Europe should work together to define the far-term globally interoperable civil aviation communication system. To accomplish such joint planning, the United States will have to provide leadership, system engineering resources, and technology application research.

In the aftermath of the tragic events of September 11, 2001, there are increased requirements for aircraft security information to be transmitted via air-ground communication links and increased security requirements for all aviation communications. Because of these increasing security concerns, the ACRT Subgroup encourages the civilian aviation sector to study the DoD communications infrastructure which affords secure transmissions, high data throughput, high reliability, and has been adopted by NATO, signifying European military acceptance. It is possible that some elements or technologies of the DoD communications infrastructure will be applicable to civil aviation.

The ACRT Subgroup's research findings are based on Subgroup discussions, information received from the presentations, and from the Subgroup member's individual viewpoints. The "Findings" are divided into two segments. The first section discusses communication systems as defined by the current NAS Architecture (near- and mid-term), and the second section addresses the future communication systems (far-term).

Research for near- and mid-term communications systems (operational use before 2015)

1. Except for improvements outlined in the FAA's NAS Architecture, incorporating other proposed domestic communication services would not provide a major benefit to near-or mid-term air traffic management capability. Research for near- and mid-term communications systems as defined in the NAS Architecture should be focused on resolving issues centered on benefits, affordability, interfaces, certification criteria, etc., that might be encountered in the deployment of these systems. This research should address the information needs of the stakeholders (airlines, pilots, controllers, dispatchers, service providers) who use each system.

    - The near- and mid-term research agenda should be focused on deployment-related issues.

    - Research and technology application tasks identified in the research agenda should be reviewed by a research coordinating organization – ensuring all needs are addressed and redundant efforts are reduced.

2. Research is required to provide mid-term, enhanced, cost-effective oceanic and remote area communications for broad classes of aircraft to keep pace with the growth of traffic in these areas.

3. Detailed concepts of use must be defined for those communications systems defined in the outer years (2010-2015) of the NAS Architecture. To develop these concepts of use, the following technical issues must be answered:

        - Should a wide-area data communications architecture be substituted for the present NAS architecture communications network design?

        - What are the system level design requirements for the replacement voice communication switches scheduled to begin operation in 2008 – 2010?

        - What are the information processing loads, required availability, latency, and interface requirements for the required data transmission system in 2010-2015?

        - What is the transition strategy from the present voice communication digital/analog communications system to an all-digital communications system?

4. For near and mid-term candidate communications system, issues to be resolved by research include:

- What is the overall communications architecture that would effectively use this communications system?

- What are the economic, acceptance and policy drivers for the introduction of new communications capabilities/technology and what event/events will require that introduction?
  - Potential for global acceptance
  - Spectrum loading, efficiency and availability;
  - Initial and operation and maintenance costs to FAA and operators;
  - Signal range, data rate, availability, continuity, integrity, latency, etc.;
  - Pilot and controller performance, workload and stress using the system;
  - Projected acceptance of pilots, controllers, technicians, and other users of the services provided by the system;
  - Advantage over a procedural based solution
  - Cost, difficulty of certification, ease of modification of existing airframes and ground based communication sites; and
  - Transition strategy from present system to new system.

Research for far-term communications systems (operational use after 2015)

5. Research resources must be devoted to determine communications performance goals associated with an air transportation system required in the post-2015 time frame, develop alternative communication system operational concepts (consistent with the far term RTCA/FAA NAS Concept of Operation) that would support these goals, evaluate the alternatives, and design the implementing architecture.

    - A research agenda should be developed to support this future communications system definition process.

    - Research tasks identified in the agenda should be reviewed by a research coordinating organization – ensuring all needs are addressed and redundant efforts are reduced.

    - A major result of this research should be a globally accepted Concept of Operations for future communications, navigation, surveillance and air traffic management communications.

6. CNS systems have historically been developed and implemented as completely separate systems built on diverse technology bases. The FAA should examine the feasibility of developing a more integrated CNS system which would potentially would use the spectrum more efficiently and would be lower in cost than separate systems

7. The current NASA communications research activities are making a significant strides in demonstrating weather in the cockpit; broadband SATCOM concepts; and, the Airborne Internet. These communications activities reside in separate NASA research programs (AATT, AvSP, Small Aircraft Transport System) and their objectives are therefore narrowly focused to achieve NASA's safety and capacity technology goals. NASA is not currently funded or organized to address the entire end-to-end system requirements to ensure that the new technology and services can work together and contribute to an optimal integrated communications network that achieves total system benefits for all.

9. A roadmap for Future Communications Systems Policy Decisions is missing. Although the FAA has developed the NAS Architecture as a plan for the evolution of air traffic related communication services through 2015, the Agency must assume a larger role in designing the future global air transportation system communications system. An overall design is required to allocate effectively growing services across a limited aviation radio spectrum. An aviation communications system roadmap should be developed based on future air transportation growth projections for the time period beyond 2015. Identifying the time frames when communication policy decisions are required will help set the far-term communications research agenda. The feasibility of adapting DoD-developed communications technology for civilian use should be examined.

10. The United States, through FAA, must fully participate in international aviation policy- and procedure-making forums.

    - Work by the FAA has resulted in an ICAO draft of a high-level future air traffic management operational concept that is in alignment with the planning by the United States. ICAO will approve this operational concept in the near future. Further work will be required for an underlying global communications operational concept.

    - The U.S. should increase resources dedicated to these international forums and associated committees. The FAA should consider increased use of U.S. industry and other government agency resources in its ICAO work.

    - A unified European approach to aviation technology and in ICAO committee work is beginning to bias the international view towards European technology solutions. Truly global technology solutions (adequately representing the interests of the U.S.) can only be achieved if the U.S. increases the amount of studies and analyses it accomplishes in support of the ICAO committees, work groups, and regional planning and implementation groups.

11. For far-term candidate communications systems, the same issues need to be resolved via research as those suggested for near- and mid-term systems (see Finding 4 above).

Recommendations

1. The FAA and NASA must focus research on the communications systems that will be deployed in the post 2015 time frame (far-term). Research on communications systems for the near- and mid-term should be limited to resolving issues associated with the implementation of these systems.

2. The FAA and NASA need to conduct the necessary research required to provide mid-term enhanced cost-effective oceanic and remote area communications for broad classes of aircraft to keep pace with the growth of traffic in these areas.

3. The FAA must perform research and analyses to develop a range of communication system performance requirements that match growth/non-growth scenarios for the future air transportation system. These performance requirements can then be used to develop communications concepts of use and for implementing communication system designs. This research should be directed at developing and deploying a future global communications system design that has sufficient flexibility to address the full range of possible performance and economic requirements.

4. A part of the FAA research program should include an analysis of costs vs. benefits for the various communications systems implementation strategies.

5. The FAA should develop an aviation communications system roadmap based on the future air transportation concept of operations and growth projections. Identifying time frames when decisions are required will help the FAA establish the communications research agenda for far-term systems. The FAA should develop this roadmap in coordination with the aviation community, and should give serious consideration to application of DoD-developed communications technology.

6. The FAA should create with NASA a CNS Area Work Team within the NASA/FAA Interagency Air Traffic Management Integrated Product Team (IAIPT). This team will coordinate on-going CNS Research and Technology activities and to establish an enhanced collaboration with EUROCONTROL and DoD. Specific areas/issues to be investigated include:

    - Globally inter-operable systems: Global solutions are needed for secure, integrated communications - air/ground, ground/ground, air/air

    - Architectures for integrated communications/navigation/surveillance information infrastructure

    - Space-based technologies, especially for communications and surveillance
        - Broadband satellite communications for en-route and oceanic
        - Space-based surveillance and oceanic surveillance (ADS over satellite communication links, multi-lateration)

- Spectrum issues:
  - Assessment of far term spectrum requirements
  - Spectrum (bandwidth) management research:
    - Applications across spectral boundaries for better spectrum use and improved global interoperability
    - Dynamic bandwidth allocation

- Oceanic needs: research is required to provide enhanced communication/surveillance/navigation services in oceanic airspace

- Communication policy needs: research must provide information required to set U.S. communication policy.

The area work team will determine if potential areas for application look promising and what, if any, issues might surround that application. The team will also ensure that research and development programs in technology application areas include resources for answering questions peculiar to adapting these technologies to a civilian air transportation system.

- Benefit/cost studies

- Human factors studies (pilots and controllers)

- Certification questions (e.g. software radio certification)

7. FAA must provide strong leadership in setting the communications research agenda. FAA should develop a potential communications architecture for that 2020+, thereby identifying areas for the communications research. To accomplish its leadership and analysis roles, the FAA needs to rapidly increase its in-house system engineering capability.

8. The FAA and NASA must be cognizant of each other's, DoD's, and industry's communication R&T investments to eliminate duplicate investments.

9. The FAA, as the U.S. aviation community spokesperson in ICAO communication system forums, must increase its resources dedicated to these international forums and associated committee work to ensure adopted solutions are compatible with technology being developed in the United States. After safety related work, this activity should have highest priority for in-house resources. The FAA should consider increased use of U.S. industry and other government agency resources in its ICAO work.

10. The FAA should lead an international effort to reach global consensus on operator and user communication system(s) equipage, timing of investments, and operational concepts.

Appendix A

Subgroup on Aviation Communications
Research and Technology

Terms of Reference

The Aviation Communications Research and Technology Subgroup is a workgroup of the Research, Engineering, and Development Advisory Committee Subcommittee on Air Traffic Services. The Terms of Reference for this workgroup is as follows:

1. Recommend the needed research programs to meet global ATM voice and data communication requirements in the near-term (NAS Architecture 4.0) as well as the long term (post 2020).

2. Develop and recommend NASA-FAA Communications Research and Technology program integration mechanisms, and take full advantage of DoD's research in communications.

3. Identify and recommend an approach for achieving Recommendation 5.0 of the NARC Report; specifically,

   > "The FAA should take the lead within the US in a worldwide effort to establish the next generation global standard voice and datalink communications system."

4. Identify key ATM communications design guidelines and attributes for the post 2020 period.

Mr. John Kern is the appointed chair of the ARCT Workgroup and Mr. Tom Proeschel is the Designated Federal Official.

Key Milestones.

Initiate Activities: September 2001

Draft Report: May 2002

Final Report March 2003

Revised 2/12/02

Appendix B

Aviation Communications Research and Technology (ACRT) Subgroup

Membership

Mr. John Kern (Chairman)	Consultant
Mr. Joseph McCormick	Consultant
Mr. Robert Kerczewski	NASA Glenn Research Center
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Mr. Paul Fiduccia	Small Aircraft Manufacturers Association
Mr. Eugene Gonzales	United States Navy
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Mr. Martin Pozesky	MTPA
Mr. Mark Cato	ALPA
Mr. Terry Persell	BAE Systems
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Mr. Philippe Renaud	EUROCONTROL
Mr. Tom Proeschel (DFO)	FAA