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# **Aeronautical Air-Ground Data Link Communications**

**Mohamed Slim Ben Mahmoud  
Christophe Guerber, Nicolas Larrieu  
Alain Pirovano and José Radzik**

**ISTE**

**WILEY**



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# Contents

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<b>FOREWORD</b> . . . . .	ix
<b>INTRODUCTION</b> . . . . .	xiii
<b>CHAPTER 1. CURRENT COMMUNICATION RADIO SYSTEMS FOR DATA LINK.</b> . . . . .	1
1.1. History and definition. . . . .	1
1.1.1. From voice to data link . . . . .	1
1.1.2. Communication traffic classes . . . . .	3
1.1.3. Main actors and organizations . . . . .	5
1.2. Systems architecture . . . . .	8
1.2.1. ACARS. . . . .	8
1.2.2. FANS 1/A . . . . .	11
1.2.3. ATN baseline 1 and FANS 2/B. . . . .	13
1.3. Radio subnetworks for air–ground communications. . . . .	21
1.3.1. Radio resource management . . . . .	21
1.3.2. VHF communications . . . . .	25
1.3.3. SATCOM . . . . .	34
1.3.4. HF communications . . . . .	44
<b>CHAPTER 2. EMERGING AND FUTURE COMMUNICATION RADIO SYSTEMS FOR DATA LINK</b> . . . . .	49
2.1. Data link related research projects . . . . .	49
2.1.1. Topics of interest . . . . .	49

2.1.2. European project: SESAR . . . . .	52
2.1.3. North American project: NextGen . . . . .	55
2.1.4. Designing emerging communication systems for data link (for both SESAR WP and NextGen technologies) . . . . .	56
2.2. Emerging communication systems . . . . .	57
2.2.1. Integrated end-to-end communication architecture . . . . .	57
2.2.2. Future aeronautical communication systems . . . . .	59
<b>CHAPTER 3. CHALLENGES AND RESEARCH DIRECTIONS . . . . .</b>	<b>79</b>
3.1. Sharing information: the SWIM concept . . . . .	79
3.1.1. Why does ATM need SWIM? . . . . .	79
3.1.2. SWIM principles . . . . .	81
3.1.3. SWIM technical components . . . . .	81
3.2. Multilink operational concept . . . . .	83
3.2.1. Multilink operational concept requirements . . . . .	83
3.2.2. Vertical handover in MLOC . . . . .	84
3.3. IP mobility . . . . .	87
3.3.1. IP mobility requirements for the FCI . . . . .	88
3.3.2. IP mobility candidate solutions. . . . .	88
3.3.3. IP mobility: open issues . . . . .	89
3.4. Traffic segregation . . . . .	90
3.4.1. Context . . . . .	90
3.4.2. Traffic segregation and priority management strategies. . . . .	91
3.4.3. Certification issues for multiplexing solutions (from a safety point of view) . . . . .	93
3.5. Aeronautical network communications security . . . . .	94
3.5.1. Levels of deployment for security mechanisms . . . . .	95
3.5.2. Security controls coordination . . . . .	98
3.6. Future aeronautical communication means: AANET (Aeronautical Ad Hoc Network) . . . . .	100
3.6.1. AANET-based air/ground communications . . . . .	100



3.6.2. AANET principles and properties . . . . .	101
3.6.3. AANET access layer considerations. . . . .	104
3.6.4. AANET communications performances . . . . .	106
<b>CONCLUSION</b> . . . . .	<b>109</b>
<b>APPENDIX</b> . . . . .	<b>113</b>
<b>BIBLIOGRAPHY</b> . . . . .	<b>121</b>
<b>INDEX</b> . . . . .	<b>127</b>



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## Foreword

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For most of the public, aviation is a wonder predominantly related to the capability to fly. When you look at an aircraft, you see its particular aerodynamic shape, its wings and engines. You rarely look at the various antennas that surround the fuselage. When you think of the pilot skills, you rarely think about voice and data communications unless you are an aviation professional.

Communication – visual, voice and data – has always been one of the fundamentals of aviation and one of its biggest challenges after being capable of flying. Communicating over remote parts of the world, in any condition, at the right time, from a mobile position flying several hundred knots has always been a challenge and will remain as such in the future. In our well-connected world, it seems strange that highly technological vehicles like aircrafts are not connected all the time to their mother ground station or to Air Traffic Control (ATC). Some very recent events did remind us of the true reality; it is still not achieved homogeneously in all parts of the world and in any segment of the flight.

Nevertheless, the challenges of Aeronautical Communication remain the same, even more stringently in the future environment.

Air-ground communication is constrained physically and the management of the frequency spectrum is now becoming increasingly difficult due to the number of high-revenue-generating competing applications: satellite services and communication, TV, phone applications, etc. But aviation cannot bear to weaken what has always been an essential condition for safe flying: the robustness of air-ground communications.

Some communications are critical and have the “Safety of Life” status. Enough priority should always be given to them in real time and the Quality of Service (QoS) should be ensured any time.

Though the capacity of air–ground communication channels is not so large, future needs will demand increased data throughput, seamless communication capability and increased data integrity. Depending on the type of exchange, the latency of the communication will play a big role in the operational acceptability of proposed technologies. Satellite communications, which may be available in remote areas of the world, may not offer the required performance in dense traffic areas. Therefore no simple obvious solution is available yet and a global solution for air–ground data link communications will result from a combination of capabilities using multilink and multi-frequency features as well as perhaps using a real information network at some point.

One of the big paradoxes of aviation, a highly technological domain, is its difficulty in moving toward new technologies. The reason is very simple. The lifetime of an aircraft is more than 40 years. This means that presently you would find aircrafts in the sky produced in the 1970s and designed in the 1960s. Those aircrafts still need to fly safely in our common sky and be operated globally in a harmonized way. Interoperability is thus becoming an impediment to technological moves. During the same time, the telecommunication industry and the information system industry have evolved toward continuous evolution that leads you to change your smartphone or computer frequently. Due to the cost and consequences of aircraft retrofits, as well as safety requirements, those strategies cannot be envisaged in aviation, thus creating the need for great anticipation in design and systems development, both in the air and on the ground, and the obligation to maintain operation of old technologies in an interoperable way with newly developed ones.

This book introduces the challenges in relation to Data Link Communications in Aeronautics. When I was asked whether I would accept writing a few lines as a foreword, I was very honored, essentially for three reasons:

- I have regretted throughout my entire career not being able to benefit from such a book. I still believe books are necessary in order to build your

mind, understand the various components of a question and support you in your own developments;

– pedagogy should be supported by books and during my time at ENAC, French Civil Aviation University, I strongly encouraged the professors to develop written support for pedagogy. Computer-based Training, Powerpoints and live classes all contribute to knowledge building but nothing replaces a book that you may open anytime a question arises in your mind;

– writing such a book is a real challenge in a very fast moving and highly technological environment. I am sure its development was not so easy but I am also convinced that, Alain, José, Slim, Christophe and Nicolas have greatly benefitted from popularizing and sharing their respective knowledge. I am proud to have contributed to attracting some of them to aviation.

This book describes the fundamental principles of Aeronautical Data Communications but it also tries to introduce the reader to its evolution, which is the key for future air traffic management modernization. Indeed, the future aviation system should be highly based on data management and its backbone will be data communication. In a 4D environment where the ability to manage complex air traffic situations will depend on the accuracy of the trajectory planning, Data Communications and especially air–ground data link communications will play an essential role. Thus, the future system should also be based on a cooperative management of the scarce resources, among them airspace and airport capacity. Collaborative Decision Making (CDM) is a buzz word in the civil aviation domain. But CDM cannot develop without data sharing and communication. This will concern critical air traffic management communication as well as aircraft operation communication not only for air–ground but also for ground–ground communication.

Understanding the challenges, knowing the various technologies available, anticipating the ones which are under development and sensing the trends is then essential for all actors of the aviation industry, not only the manufacturing industry but also the operators, Airlines and Air Navigation Service Providers, maintenance services and all components of the global aviation system. ICAO has been at the heart of all evolution since it was created 70 years ago. It has been setting the necessary international standards and procedures in order to ensure safety and efficiency of air transportation. In reading Article 37 of the ICAO convention, which is about international

standards and procedures, you will notice that the first item for which international standards are needed is “Communications systems”.

This book will provide young (and not so young) aviation professionals the capacity to contribute to the collective and challenging effort in order to manage the growth of aviation in a safe and ordered manner in dealing with the air–ground data link communications matters. It should also support developments toward identified challenges like the integration of remotely piloted aircraft in non-segregated airspace, for which everybody will easily understand the importance of command and control communication. It is not less than a new type of air–ground data link communications which will be critical also. Cybersecurity is another increasing challenge. When the civil aviation system was created, it was conceived as an open system working in a peaceful environment. For a few decades, security matters have taken an increasing place in the civil aviation system. With the advent of IT technologies, potential threats will be constantly mitigated in order to continue providing a safe and secure system to aviation actors. The protection of air–ground data link communications from those threats, without impeding or slowing the operational communication, is a real challenge.

But this book should also allow communication experts to understand the specific challenges in relation to aviation and adapt particular solutions to aviation that are arising from the telecommunication and network industry.

I hope you will enjoy reading and using this book as much as I did. I also hope to see some updated versions in the years to come and I really would like to thank Alain, José, Slim, Christophe and Nicolas for their teamwork, recognizing the difficulty of putting complex and very advanced concepts into simple language. Writing in English was for sure another challenge. Thank you and bravo!

Farid ZIZI  
President of the ICAO Air Navigation Commission  
October, 2014

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# Introduction

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## **I.1. Objectives and motivations**

In both contexts of constant increasing air traffic and migration of air-ground communications from analog voice to digital data, the current, emerging and future communication systems face a great challenge: providing efficient links with suitable capacity, availability and integrity.

During each flight phase, an aircraft has generally at least two means in order to communicate with the ground. Furthermore, the communication systems may be different depending on the considered airspace. For instance, in continental areas, direct links with ground stations can be provided whereas in oceanic areas satellite-based solutions represent an alternative solution.

Considering the offered services, aircraft communications are classified in two main groups. First, cockpit services include both Air Traffic Services Control (ATSC) for pilots and controllers, and Air Operation Control (AOC). ATSC/AOC services are considered safety-related. Second, services can be also provided in cabin for airline administrative purposes Airline Administrative Communications (AAC) or for passengers. These latter services are considered non-safety related and in order to ensure a complete segregation between safety and non-safety services, they are based on dedicated communication systems.

As the traditional communications means for safety related services are about to reach their capacity limits, new solutions are proposed and several research projects aim at designing more efficient communication systems.