NEWSKY – A CONCPET FOR NETWORKING THE SKY FOR CIVIL AERONAUTICAL COMMUNICATIONS

M. Schnell and S. Scalise, German Aerospace Center (DLR), D-82234 Wessling, Germany

Abstract

In this paper, an overview of the NEWSKY project is given. This project is funded by the European Commission within the 6th framework program and will start in January 2007. The NEWSKY project is a feasibility study to clarify if it is possible to establish a heterogeneous network for aeronautical communications which is capable to integrate different communications systems as well as different applications into a single global aeronautical network. The envisaged applications comprise not only air-traffic control and management but also airline and passenger communications.

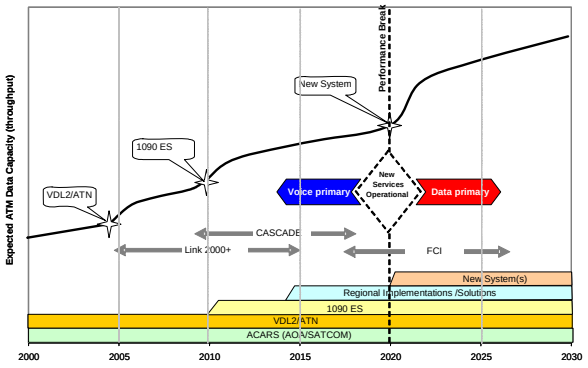

Figure 1: Expected development of the data communication needs for ATC/ATM and roadmap for the introduction of new ATC/ATM communications systems (Source: Eurocontrol).

I Introduction

Today, flying is still one of the safest ways to travel or transport goods worldwide. The Air-Traffic Control (ATC) and Air-Traffic Management (ATM) systems achieving this level of safety are well established and work very reliably. However, the expected ongoing growth in air-traffic will lead to bottlenecks in air transportation in the near future if existing ATC/ATM systems and paradigms are not changed. This is especially true for aeronautical communications, a key enabler for an efficient and safe air transportation system. The capacity of the existing ATC/ATM communications infrastructure is already strongly saturated and according to Eurocontrol it is expected that the existing systems in Europe will be overloaded within the next 10-15 years even after realization of already planned and partly introduced amendments as indicated in **Figure 1**.

Aeronautical communications can be subdivided into two main areas, the safety critical ATC/ATM communication which also covers airline communications (AOC, AAC) and the commercial aeronautical passenger communication (APC). Currently, safety critical communication is mainly based on voice communication using DSB-AM (Double-Sideband Amplitude Modulation) which is an over 50 year old analogue communications technique which uses the available spectrum very inefficiently. Besides analogue voice communications data link applications based on VDL (VHF Digital Link) Mode 2 are currently introduced according to Eurocontrol's Link 2000+ [1] and Cascade [2] programs. However, it is expected that the introduction of VDL Mode 2 data link communications will only extend the deadline for capacity saturation up to 2020 as shown in **Figure 1**. Moreover, a global coverage with acceptable communications performance is still missing today, especially, for remote and oceanic areas. For commercial APC, there already exist some proprietary solutions to connect passengers during the flight to the communication networks of the world. These approaches are based on satellite communications like "Connexion by Boeing" [3] or Inmarsat's "Swift Broadband" [4].

The Federal Aviation Administration (FAA) and Eurocontrol have already identified the upcoming bottlenecks in ATC/ATM communications and have started to develop the "Future Communications Infrastructure" (FCI) under the framework of the International Civil Aviation Organization (ICAO). Besides the development of new concepts and paradigms, one

important part of the FCI is the development of new aeronautical communications systems which are capable to cope with the demands and requirements of future ATC/ATM concepts. In a first step, requirements for future aeronautical communications systems have been developed [5] and a screening of potential technologies has been carried out [6]. Considering first outcomes of the FCI, the future ATC/ATM communications system will consist of several link technologies to be able to fulfill the manifold requirements and demands. Both ground- and satellite-based communications systems will be needed. Moreover, another system for airport communications is desirable which is able to assist the implementation of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) which are desperately needed for improving the throughput of airports, another main bottleneck in air transportation. In addition, a paradigm change is in preparation where data will replace voice as primary means for ATC/ATM communications as shown in **Figure 1**.

In summary, there will be several different systems for aeronautical communications in the future for both safety critical ATC/ATM communications and commercial APC. Up to now, these systems are supposed to work in parallel each requiring its own infrastructure onboard the aircraft as well as on ground. What is currently missing is an integrating approach. Therefore, DLR have proposed their innovative concept of "Networking the Sky" which aims at integrating the different systems for aeronautical communications – ground-based, satellite-based, as well as airport systems, and systems based on ad-hoc networks between aircraft – into a global heterogeneous communications network, thus, realizing an ATC/ATM communications system which is completely transparent to the users. In addition, this global, heterogeneous network is intended to transport both ATC/ATM information and APC. This approach enables to reuse existing infrastructure which has been setup for a certain application by other applications, e.g. use satellite communications for ATC/ATM which is already available for APC. Of course, ATC/ATM communications has to be prioritized over APC to ensure that safety critical communication always "wins" over APC and arrives in time at the right place with the required Quality of Service (QoS).

The reminder of this paper is organized as follows. In Section 2, an overview of the NEWSKY project is given which is funded by the European Commission (EC) and will start beginning of next year. Benefits and challenges of the NEWSKY approach are discussed in Section 3 and 4, respectively. Section 5 concludes the paper with a short summary and an outlook.

II The NEWSKY Project

To realize the vision of "Networking the Sky", the feasibility study NEWSKY ("Networking the Sky") has been initiated within the 6th EC framework program. The proposal has been positively evaluated and the contract with the EC is currently under preparation. The expected starting date for NEWSKY is January 2007. The duration of the project is 30 month and, therefore, the project will last until the end of June 2009. Approximately 250 person month of work will be invested during the project duration.

The NEWSKY consortium comprises seven partners from four different European countries. Besides DLR as project coordinator and one of the main contributors, TriaGnoSys GmbH and the Deutsche Flugsicherung GmbH (DFS) are involved as additional German partners. From Austria, the University of Salzburg and Frequentis GmbH contribute to NEWSKY. Alcatel Alenia Space is the French partner within the consortium and QinetiQ Ltd from Great Britain completes the consortium. With this European mix of partners all the required competencies are available to successfully carry out the study.

The main goal of the NEWSKY project is to show that the integration of different communications systems and different applications (ATC, ATM, AOC, AAC, APC) into a global, heterogeneous network for aeronautical communications is feasible and how this integration can be achieved. As illustrated in Figure 2, ground-based as well as satellite-based communications systems, airport communications systems for A-SMGCS applications, and communications systems for direct aircraft-aircraft communications based on ad-hoc networking are considered. Integrating different communications systems and application into a global, heterogeneous network creates several benefits on the one hand but also has some

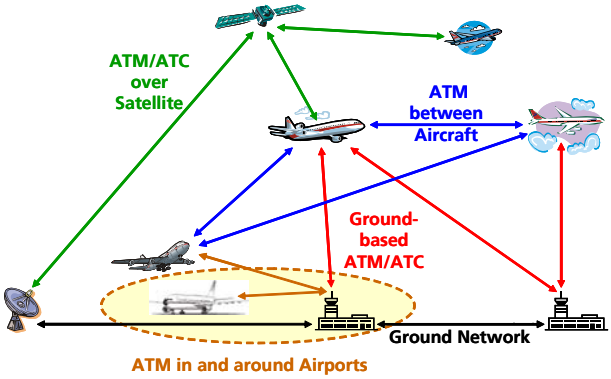

Figure 2: Integration of different aeronautical communications systems into a global airborne network to realize the vision of "Networking the Sky".

challenges to be solved on the other hand. The most important challenges are to ensure the different levels of QoS for the different applications and to ensure network security. Benefits and challenges are detailed in Sections 3 and 4, respectively.

To achieve the NEWSKY goal, the following five main objectives have been defined which also reflect the working program of the project.

Develop a Framework for the ATM Network Transformation

A unitary framework is developed for the transformation of the currently disparate ATM communications infrastructure into a seamless global network. This goal is achieved by producing a network transformation concept, a mission definition, a business case study, a deployment plan, and a long-term concept evolution study.

Identify the Relevant Application Scenarios and Service Requirements

Application scenarios as well as high level NEWSKY service requirements which are used for both the NEWSKY network design and the NEWSKY validation are defined. To achieve this goal, inputs from all relevant bodies are considered, e.g. ICAO and Eurocontrol. Moreover, feedback from airspace users is collected by organizing workshops with airlines, airports, Air Navigation Service Providers (ANSPs), aeronautical communications service providers, and Eurocontrol.

Develop the Framework for the NEWSKY Network Concept and Architecture

An architectural analysis and design is performed leading to the definition of the NEWSKY network concept. This goal is achieved by splitting this task into the design and definition of the network architecture on the one side and the system architecture on the other side. Whereas the network architecture is related to the different ISO/OSI layers, the system architecture addresses the different system components comprising the different communication segments, i.e., the air-ground, ground-ground, air-air, and space segment.

Design and Evaluate the NEWSKY Integrated Airborne Network

Based on the developed framework for the NEWSKY network concept a detailed NEWSKY network design is performed which mainly comprises the ISO/OSI layers 2, 3, and 4. To achieve this goal, four key network aspects, namely resource management, routing, handover, and security, are considered in detail. Moreover, the interrelations between these four key network aspects are taken into account to ensure the benefits of the network centric NEWSKY approach.

Validate the NEWSKY Integrated Airborne Network Design

The benefits of the NEWSKY integrated airborne network design are assessed. Especially, coverage and reliability as well as capacity, throughput, and delay of the NEWSKY network are determined and compared to the current situation in aeronautical communications. To perform this assessment both simulations and laboratory trials are carried out.

Validation Using Simulations

The simulations are performed in a two step approach using a network topology simulator and an end-to-end ATM network simulator. Whereas the first simulator takes into account realistic air-traffic scenarios to determine the dynamic of the network topology and provide a statistical characterization of the communication links, the second simulator is a pure network simulator for ISO/OSI layers 2, 3, and 4 using the results from the first simulator to model the lower layers. The

simulations are used to validate the performance of the designed networking algorithms, to optimize and fine tune the relevant parameters, and to refine the NEWSKY network architecture.

Validation in Laboratory Trials

The laboratory trials are performed to show the feasibility of the NEWSKY concept in a real environment. With the developed laboratory test-bed a limited subset of some critical network functionalities, like seamless handover between different communication segments, for certain applications, like VoIP or real-time information streaming, is validated.

III Benefits of the NEWSKY Approach

The NEWSKY approach shows a high potential for benefits in aeronautical communications which are summarized below:

- Compared to a single communication link an integrated network inherently achieves increased redundancy which in turn increases availability and reliability of the overall communications system.
- The coverage of the overall system is increased, since different communications systems with different application areas are combined.
- NEWSKY integrates several communication links which are specially adapted to different environments, e.g., Wireless Local Area Network (WLAN) based technology for airport communications and satellite-based communications for remote or oceanic areas. This enables globally optimized network performance.
- The integrated NEWSKY approach ensures interoperability between different communication links and, thus, provides a seamless ATM system which is fully transparent to the end users.
- The different communication links within NEWSKY cover the whole available Aeronautical Mobile (Route) Services (AM(R)S) and Aeronautical Mobile Satellite (Route) Services (AMS(R)S) spectrum. As global integrated network NEWSKY realizes the most flexible and efficient use of the available aeronautical spectrum allocations as shown in **Figure 3**.

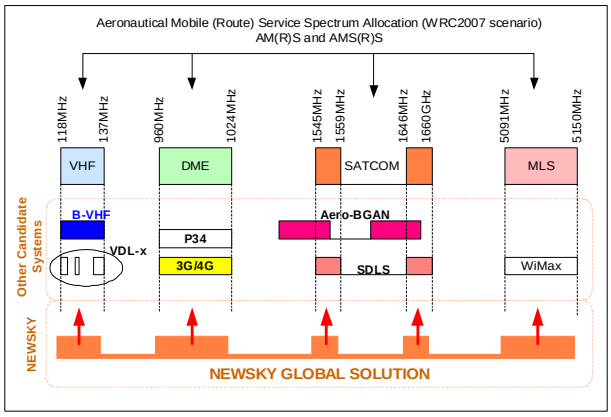

Figure 3: Flexible and efficient use of available aeronautical spectrum allocations.

- The NEWSKY concept is especially designed for global, integrated aeronautical communications and, thus, is tailored to aeronautical requirements and needs.
- A single integrated airborne avionics system covers the whole variety of communication links and can be used for different application classes (ATC/ATM, AOC, AAC, APC). Moreover, surveillance data links for ADS-B can also be included. This is a business case enabler making the introduction of new communications technologies more attractive to airlines.
- The NEWSKY network architecture is a modular concept which is easily reconfigurable and extendable. New communication link technologies can be easily included and phased-out technologies withdrawn.
- The modular NEWSKY network architecture enables easier introduction of future communication links. Note, deployment of new communication links within an existing architecture is a crucial problem nowadays.

As a result, these benefits of the NEWSKY approach realize future aeronautical communications with considerably increased capacity, coverage, and reliability. This improved communications capability ensures that aeronautical communications will be able to cope with the expected growth in future air-traffic on an even increased level of safety.

IV Challenges of the NEWSKY Approach

Besides its benefits the NEWSKY approach also includes several challenges which have to be addressed and solved before an implementation of the NEWSKY concept is possible. First of all, an adaptation layer as common interface towards the different link technologies has to be designed to ensure that the transmission over different communication links is completely transparent to the end users. This entails the design of appropriate

- routing algorithms, capable of coping with the fast changes in the network topology,
- system-level resource management strategies, to make sure that the "best" available link is selected at any point in time and that the available network resources are globally used in an optimized way, bearing in mind that different applications may have very different QoS requirements,
- seamless handover techniques, to ensure that the aforementioned QoS requirements can be maintained during the handover from one communication link technology to another; this is a relevant technological challenge, since different link technologies might offer different data transmission capacities and different latencies.

Generally speaking, a basic concept for networking has to be developed and evaluated with respect to performance, coverage, reliability, and robustness. The integration of different applications – ATC/ATM and APC – requiring to establish appropriate QoS classes and priority rules to ensure that safety critical communication is always served with the required priority and QoS, represents another major challenge of the NEWSKY approach.

In addition, network security is an issue of paramount importance, especially for ATC/ATM. The communication between pilots and controllers has to be secure, i.e. eavesdropping as well as creating or changing of information by a third party has to be securely avoided. This can be achieved by incorporating authentication, encryption, and integrity information about the transmitted data into the network functionality.

V Summary and Outlook

Within the next 15-20 years, aeronautical communications will undergo significant changes to meet the needs a safe and efficient future air transportation system requires. Besides the development of new technologies for aeronautical communications, several paradigm shifts are expected to take place: From pure ATC towards more tactical and strategic ATM with considerable more responsibility on the pilots' side; from mainly voice communications towards data communications only assisted by voice where necessary; from strict division between safety relevant and non-safety relevant applications towards a combined approach for ATC/ATM, AOC, AAC, and APC applications.

Within the NEWSKY project, a feasibility study is carried out, if and how a global, heterogeneous aeronautical communications network can be established and if such an approach is capable to meet the needs of future aeronautical communications.

Within the Mobile Communication Network Architecture (MCNA) study, related work has been carried out in the US, recently. This study has been performed under the Advanced CNS (Communications, Navigation, and Surveillance) Architectures and System Technologies (ACAST) project of the NASA Glenn Research Center [7]. The study results will be taken into account during the initial phase of the NEWSKY project.

References

[1] http://www.eurocontrol.int/link2000

[2] http://www.eurocontrol.int/cascade

[3] M. de La Chapelle, "Broadband Connectivity to Aircraft and Passengers – a Progress Report", *23rd*

AIAA International Communications Satellite Systems Conference, Rome, Italy, September 2005.

[4] M. Richharia and E. Trachtman, "Broadband Global Area Network Air Interface Evolution", *23rd AIAA International Communications Satellite Systems Conference*, Rome, Italy, September 2005.

[5] Eurocontrol/FAA Future Communications Study Operational Concepts and Requirements Team, "Communications Operating Concept and Requirements for the Future Radio System" (COCR), Version 1.0, 03.03.2006.

[6] N. Fistas, J. Pouzet, "Future Communications Infrastructure: Development of Technology Shortlist for Further Investigations", *WP13 of ICAO ACP WG-C*, Montreal, Canada, March 2006.

[7] http://acast.grc.nasa.gov/resources

Email Addresses

Michael.Schnell@dlr.de

Sandro.Scalise@dlr.de