1. **INTRODUCTION**

1.1 The present state of aeronautical mobile communications systems standards and technologies has been essentially shaped by the vision developed over a decade ago by the Special Committee on Future Air Navigation Systems (FANS). In the course of its activities, the committee determined that it would be necessary to develop new systems that would overcome limitations of conventional systems and allow air traffic management (ATM) to develop on a global scale. It also concluded that satellite technology offered a viable solution to overcome the shortcomings of conventional ground-based systems and to meet the future needs of the international civil aviation community.

1.2 The shortcomings that the FANS Committee identified amounted to essentially three factors:

   a) the propagation limitations of current line-of-sight systems;

   b) the difficulty, caused by a variety of reasons, to implement current communications, navigation, and surveillance (CNS) systems and operate them in a consistent manner in large parts of the world; and

   c) the limitations of voice communications and the lack of digital air-ground data interchange systems to support automated systems in the air and on the ground.

1.3 In September 1991, the Tenth Air Navigation Conference met to consider and endorse the concept of a future air navigation system, as developed by the FANS Committee, to meet aviation needs well into the next century. The FANS concept, which became known as the communications, navigation, surveillance/air traffic management (CNS/ATM) system, involves a complex and interrelated set of technologies, dependent largely on satellites. The conference produced a set of recommendations covering the full spectrum of CNS/ATM activities. These recommendations were the main foundation for the subsequent work on development of Standards and Recommended Practices (SARPs) (see Section 2), operational trials, air navigation planning and implementation.

2. **AERONAUTICAL COMMUNICATIONS SYSTEMS DEVELOPMENT WITHIN AMCP**

2.1 Over the last decade, the Aeronautical Mobile Communications Panel (AMCP) has been tasked to work on several of the issues identified by the FANS Committee and by the Tenth Air Navigation Conference. In particular, the panel has undertaken studies and development of Standards, Recommended Practices, and Guidance Material on satellite communications, on improvements to the use of the VHF spectrum, and on digital data links in several radio bands. Several amendments to Annex 10 have been introduced, including:

   a) Amendment 70 (effective 9 November 1995), including new SARPs for the aeronautical mobile-satellite service (AMSS);
b) Amendment 71 (effective 7 November 1996), including specifications for the Mode S subnetwork of ATN, material relating to the introduction of 8.33 kHz channel spacing, changes to material related to the protection of air-ground communications in the VHF band and technical specifications relating to the RF characteristics for the VHF digital link (VDL);

c) Amendment 72 (effective 6 November 1997), including SARPs and guidance material for VHF digital link (VDL-Mode 2);

d) Amendment 73 (effective 5 November 1998), including material relating to the ATN and changes to specifications of the Mode S subnetwork.

e) Amendment 74 (effective 4 November 1999), including SARPs for HF data link;

f) Amendment 75 (effective 2 November 2000), including changes to the AMSS SARPs introducing a new antenna type, a new voice channel type and enhanced provisions for interoperability among AMSS systems; changes to the VDL SARPs to reduce potential interference to current VHF voice communication systems caused by VDL transmitters; and changes to the VHF voice communication SARPs to enhance immunity to interference from VDL transmitters on board the same aircraft.

g) Amendment 76 (effective 1 November 2001), including ATN system management, security and directory services; integrated voice and data link system (VDL Mode 3); and data link satisfying surveillance applications (VDL Mode 4);

h) Amendment 77 (effective November 2002), including changes to SARPs addressing issues encountered during tests and operational trials of the Mode S data link subnetwork.

2.2 Work continues in the AMCP on the effective and efficient use of aeronautical radio spectrum, the maintenance of communications systems standards to ensure continued viability and the examination of future requirements and systems to meet the increasing demands of ATM.

3. ATM SYSTEM REQUIREMENTS AND REQUIRED COMMUNICATION PERFORMANCE

3.1 The ATM Operational Concept Document (Attachment A to State letter SP 58/4-02/56) characterizes air traffic management (ATM) as “the dynamic, integrated management of air traffic and airspace — safely, economically, and efficiently — through the provision of facilities and seamless services in collaboration with all parties.” In turn, “the ATM System is a system that provides ATM through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground and/or space-based communications, navigation and surveillance.”

3.2 In the intervening years since the FANS Committees completed their work, several States and all ICAO regions embarked on ATM implementation programmes intended to improve aviation operations by making use of CNS/ATM technologies. However, it was later recognized that technology was not an end in itself, and that a comprehensive concept of an integrated and global ATM system, based on clearly-established operational requirements, was needed. This concept, in turn, would form the basis for the coordinated implementation of CNS/ATM technologies based on clearly-established requirements.
3.3 According to the concept, “the key issue is to eliminate, to the maximum extent possible, the need for duplication of ATM functionality within aircraft and/or ground systems. The solutions chosen by a State or region need not be technologically complex. Simple solutions, *inter alia*, changes to airspace organization and management, alignment of procedures, or strategic adjustment to flight schedules, etc. may achieve significant benefit in some States or regions. Others may require high levels of automation and technology.”

3.4 A guiding principle in the development of the ATM operational concept with respect to technology is that the concept “addresses the functions needed for ATM without reference to any specific technology and is open to new technology. Surveillance, navigation and communication systems, and advanced information management technology, are used to combine functionally the ground-based and airborne system elements into a fully integrated, interoperable, and robust ATM system. This allows flexibility across regions, homogeneous areas or major traffic flows to meet the requirements of the concept.

3.5 Vital to ATM is the interchange of information, or communications, and the technologies that support it. The Operational Data Link Panel (OPLINKP) has developed [is developing] the operational concept for required communications performance (RCP) to support ATM (the attachment to State Letter SP 52/4-01/85 refers). RCP is defined as a statement of the performance requirements for operational communication in support of specific ATS functions. RCP is a statement of the performance requirements for operational communication in support of specific ATS functions. RCP is specified in terms of communication process time, integrity, availability, and continuity of function, covering all the elements of the operational communication process.

3.6 According the draft RCP operational concept, “communications can be used to exchange information between controller and pilot, controller and controller, human and machine, and from machine to machine and pilot to pilot. Some of these information exchanges are in direct support of the operational communication element of the CNS/ATM system; others are characteristic of technical communication, which might be associated with any of the elements of the CNS/ATM system, including navigation and surveillance. The RCP concept must ultimately cover all of these types of communications. Because of the complexity of the issues involved in creating a concept which can be applied to all of the possible types of communications, the work to date had focussed on:

a) controller-pilot voice and data link communications; and

b) development of a flexible framework which can be expanded to cover all forms of communications where the use of an RCP type might be utilized.”

3.7 The elements of the CNS/ATM system are interrelated. There are areas wherein communications may be necessary to support the navigation or surveillance element or both at the same time. In some cases, such as with the automatic dependent surveillance (ADS) application, the navigation element also provides information to the surveillance element. The elements of the CNS/ATM system are used in combination to provide functions supporting ATM. There are functions that use communications, navigation, and surveillance elements.

3.8 From an operational perspective aircraft, communications networks, and ground systems need to achieve an appropriate level of performance related to communications. The level of performance to be achieved must be stated clearly and unambiguously and be specified in a technology-independent manner so that it covers all existing and emerging systems.
3.9 The acceptance of data communication as a technology for the CNS/ATM system, in addition to voice communication, means that a technology independent method of determining and specifying communication performance is desired. This will allow flexibility in selecting either voice or data, provided that it has been shown to meet the required communication performance.

3.10 The contribution of the human element can be a significant factor within the context of RCP. Communication is more than the transmission of a set of words, characters, tones, or electronic data; it is the transfer of information between sender and receiver, the content of which can be readily understood by both. This transfer of information must meet the RCP type for the applicable ATS function.

3.11 Both the human and technical elements can be included within the RCP by:

a) determining an RCP type for the entire operational communication process;

b) separating and allocating the RCP type by:

   1) determining required technical communication performance;

   2) determining human-machine interaction times;

   3) determining maximum permissible post-message-reception reaction times; and

   4) determining how the RCP parameters other than time (i.e. integrity, availability and continuity of function) may apply to b) and c);

c) validating the assigned RCP type and the technical and human processing parameter values for suitability of operation; and

d) developing operational procedures as necessary.

4. AREAS FOR FURTHER WORK

4.1 Notwithstanding the development of new aeronautical communication systems and the improvements to existing ones over the last decade, elements of the shortcomings that were identified by the FANS Committee a decade ago are still present today. The ATM Operational Concept document lists several limitations to the provision of air traffic services, including *inter alia*:

a) disparate services and procedures resulting from differing systems and limited system and decision support tools;

b) a reliance on increasingly congested voice radio communications for air-ground exchanges;

c) limited facilities for real-time information exchange between ATM, aerodromes and aircraft operators, resulting in less than optimal responses to real-time events and changes in the users’ operational requirements;

d) the limited ability to maximize benefits for aircraft with advanced avionics; and
4.2 A number of avenues may be followed to deal with those limitations.

4.3 In the area of aeronautical mobile communications, a serious limiting factor both to present operations and future growth is the scarcity of the available radiofrequency spectrum. In several areas, frequency congestion has increased in the past decade despite the introduction of digital communication capabilities, and shows no signs of abating for the foreseeable future. ICAO continues to focus on this issue through the AMCP, through its participation in International Telecommunication Union (ITU), and by providing assistance to Contracting States in protecting the integrity of aeronautical spectrum allocations in seeking new techniques to make efficient use of available spectrum.

4.4 In addition to this, the AMCP continues to review the technical specifications for existing voice and data communications systems that are contained in Annex 10. Improvements have been made in the past decade, as listed above in the various amendments to Annex 10, and more are expected as the operational use of digital data link systems increases and the technologies develop. There is no evidence that any of the existing services that are specified in Annex 10 will be abandoned in the foreseeable future. Accordingly, work continues to ensure that the Standards are kept up to date, and that they are applicable and interoperable on a global basis.

4.5 With respect to the future advanced digital voice and data communications systems, AMCP is monitoring research and development work on air-ground communications, including the use of new modulation schemes, protocols, and frequency bands. Further work within ICAO should aim to support the evolution of voice and data link applications by way of such new technical solutions. This evolution should enable international civil aviation to meet future communication requirements in a spectrum-efficient manner and enable gradual implementation of the ATM operational concept. A tentative description of future evolution scenarios for aeronautical mobile communication systems is provided in Appendix B to the report on this agenda item.