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ELEVENTH AIR NAVIGATION CONFERENCE

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REPORT OF COMMITTEE B TO THE CONFERENCE ON AGENDA ITEM 7

The attached report has been approved by Committee B for submission to the Plenary.

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Chairman
Committee B

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(20 pages)

Agenda Item 7 : Aeronautical air-ground and air-to-air communications

7.1 INTRODUCTION

7.1.1 Under this agenda item, the meeting reviewed the developments on aeronautical mobile communications since the Tenth Air Navigation Conference and in particular considered the planned evolution of existing communication systems and the potential development of future ones in the framework of the global air traffic management operational concept.

7.2 BACKGROUND

7.2.1 The meeting recalled that in September 1991, the Tenth Air Navigation Conference had met to consider and endorse the concept of a future air navigation system, as developed by the Special Committee on Future Air Navigation System (FANS) to meet aviation needs well into the next century.

7.2.2 The meeting noted with appreciation that since the Tenth Air Navigation Conference, ICAO technical bodies had conducted significant development work addressing the communications issues identified by the FANS Committee and by the Tenth Air Navigation Conference. As a result, several amendments to Annex 10 had been introduced, including:

a) Amendment 70 (applicability date: 9 November 1995), including new Standards and Recommended Practices (SARPs) for the aeronautical mobile-satellite service (AMSS);

b) Amendment 71 (applicability date: 7 November 1996), including specifications for the Mode S data link, 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 (applicability date: 6 November 1997), including SARPs and guidance material for VHF digital link (VDL-Mode 2);

d) Amendment 73 (applicability date: 5 November 1998), including material relating to the ATN and changes to specifications of the Mode S data link and subnetwork;

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

f) Amendment 75 (applicability date: 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 (applicability date: 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 (applicability date: 28 November 2002), including changes to SARPs addressing issues encountered during tests and operational trials of the Mode S data link subnetwork; and

i) Amendment 78 (expected to become applicable in November 2003), including consequential amendments to ATN SARPs relating to the inclusion of VDL Modes 3 and 4 in the table of priorities.

7.2.3 Work had also been conducted on the optimal 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.

7.2.4 The meeting recognized that, notwithstanding the developments over the last decade, elements of the shortcomings that had been identified by the FANS Committee were still present, 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

e) the long lead-times involved in developing and deploying improved systems in aircraft fleets or in the ground infrastructure.

7.2.5 It was noted that a number of activities were being conducted to address those limitations:

a) in its participation to International Telecommunication Union (ITU) activities, ICAO was actively supporting the introduction of additional radiofrequency spectrum allocations to meet requirements for increased communication capacity and new applications. In parallel, ICAO was also promoting the development of new techniques to increase the efficiency of use of the existing aeronautical spectrum allocation;

b) with regard to the provisions for voice and data communications systems contained in Annex 10, ICAO activities focused on ensuring that SARPs were up to date and applicable and interoperable on a global basis; and

c) with respect to future digital voice and data communications systems, research and development work on air-ground communications was being monitored, including the use of new modulation schemes, protocols, and frequency bands.

7.2.6 The meeting noted that these activities would be continued to enable international civil aviation to meet future communication requirements in a spectrum-efficient manner and enable gradual implementation of the ATM operational concept.

7.3 IMPLEMENTATION STATUS AND PROGRAMMES

7.3.1 The conference was provided with information on status of the activities undertaken by several States and international organizations towards the operational implementation of various air-ground data links in support of air traffic services (ATS) applications.

7.3.2 A summary of the information is shown in the following paragraphs.

7.3.3 Implementation of air-ground data links in Japan

Transition to VDL

7.3.3.1 The meeting was informed that the Japan Civil Aviation Bureau (JCAB) was in the process of studying the future implementation of VDL Mode 3, recognizing that ATS providers needed a reliable and high-speed VHF voice and data communication system and that the rapid growth in air traffic required a dramatic increase of VHF channel capacity. The Electronic Navigation Research Institute (ENRI) had been working on research and development (R&D) of the VDL Mode 3 system since 1998 and would be conducting actual flight tests for evaluation of data link performance and voice quality in 2003.

Transition to AMSS

7.3.3.2 The meeting noted that, in order to cope with the rapid increase of international traffic in North Pacific (NOPAC), JCAB had decided to develop a new aeronautical satellite system called multifunctional transport satellite (MTSAT) in 1994. In addition to its SBAS functions (Section 6.1.3 refers), the MTSAT system also supported aeronautical mobile-satellite service (AMSS) functions. The AMSS function of MTSAT system was fully compliant with the AMSS SARPs and fully supported all types of aeronautical communications defined by ICAO.

7.3.3.3 The meeting was informed that there would be two aeronautical satellites, MTSAT-1R and MTSAT-2 available for the Asia and Pacific Region. There were also two aeronautical satellite centres where two GESs were implemented in each centre. The instantaneous switch over between two satellites and four GESs fully assured in the MTSAT. This redundant architecture would provide highly reliable AMSS to users, which would strongly support the reduction of the lateral and longitudinal separations over NOPAC and Central Pacific (CENPAC). With the MTSAT-1R scheduled for launch in early 2004, JCAB intended to apply 50 NM longitudinal separation minimum using DS/CPDLC for appropriately equipped aircraft. With the MTSAT-2 scheduled for launch in early 2005 and obtaining operational experiences, JCAB would further reduce the longitudinal separation minimum to 30 NM.

7.3.3.4 The ATS messages through MTSAT system in Japanese FIR would be handled by JCAB in the same manner as very high frequency (VHF) and high frequency (HF) voice communications in the current ATS environment, whereas the aeronautical operational control (AOC), aeronautical administrative communication (AAC) and aeronautical public communications (APC) messages would be handled separately by a service provider (SITA). JCAB had signed an operational agreement with Inmarsat, which was providing AMSS services worldwide, in order to assure full interoperability between MTSAT and the Inmarsat system. Therefore, the aircraft earth station (AES) currently operating in the Inmarsat system would be able to use the MTSAT system without any modification to aircraft systems by simply adding MTSAT data to their satellite data unit (SDU).

7.3.4 **Data link flight information services (DFIS) applications in China**

7.3.4.1 The meeting was informed that China had commenced operations at Hong Kong International Airport on the dissemination of the ATIS and VOLMET via data link (D-ATIS and D-VOLMET) and on pre-departure clearance (PDC) delivery to aircraft via data link. Aircraft equipped with the appropriate aircraft communications addressing and reporting system (ACARS) and the required software (compliant to AEEC Specifications 618, 620, 622 and 623) could access and/or receive the full script of the D-ATIS, D-VOLMET and PDC messages. China was considering to extend the D-ATIS and PDC delivery services via data link to other major airports in China. At the same time, use of other data link technologies, including ACARS over aviation VHF link control (AOA) and VHF digital link (VDL) was being explored.

7.3.4.2 The meeting noted that the known intrinsic limitation of the ACARS system did not have a significant impact on information of broadcast nature, such as DFIS, as information could be accessed at the will of the pilots in advance. The implementation of DFIS through the ACARS system could also promote more efficient utilization of avionics that were already available. The identified operational and/or safety benefits gained as a result of these applications of data link flight information services were noted with appreciation.

7.3.5 **Implementation of ICAO air-ground data link by ARINC**

HFDL

7.3.5.1 The meeting was informed that ARINC had initiated service of its SARPs-compliant HFDL system in January 1998. During 2003, fourteen geographically diverse HFDL ground stations, transmitting on 30 active frequencies, would provide near global (with the exception of Antarctica) air-ground data link coverage. An adaptive frequency management programme changed the active frequencies at each site in response to atmospheric conditions, such as day-night temperature changes and ionospheric anomalies, to achieve optimum propagation and to avoid interference with nearby HFDL ground stations or HF voice stations. ARINC would expand site configurations as required by equipage and usage growth. There were nearly 300 aircraft equipped with HFDL (mostly transmitting for AOC and AAC). Operational availability exceeded 99 per cent with an uplink message success rate greater than 97 per cent. An operational trial of HFDL in support of waypoint position reporting was under way in the North Atlantic.

VDL

7.3.5.2 In 2002, ARINC had installed and deployed thirteen VDL Mode 2 ground stations to provide coverage for the US FAA's CPDLC Build 1 programme in the Miami Air Route Traffic Control Center (ARTCC). The associated infrastructure included redundant ATN air-ground and ground-ground routers. Deployment of VDL Mode 2 (in an ATN environment) by ARINC was planned in Europe for the operational use of CPDLC at the Maastricht Upper Area Control Center (UACC) . Further deployment was also foreseen in Japan.

7.3.6 **SITA AIRCOM data link service**

7.3.6.1 The meeting was informed that SITA VHF AIRCOM service provided near global coverage with over 700 VHF stations deployed in over 170 countries around the world. The service was used by over 5 000 aircraft on a daily basis, primarily for AOC.

7.3.6.2 The SITA Satellite AIRCOM Data Link service was being used by over 1 500 aircraft that generated an average of 50 000 kilobits of traffic on a daily basis and provided global coverage (except polar regions) via the Inmarsat geo-stationary satellites. The service was currently used in ACARS mode but had been capable of providing AMSS SARPs-compliant services since its launch.

7.3.6.3 Both the VHF and Satellite AIRCOM services supported FANS-1/A operations. The SITA deployment of VDL Mode 2 services had started in 2001. At present there were 25 sites with operational VDL Mode 2 service and this number would increase to over 40 sites by the end of the first quarter of 2004.

7.3.7 **FAA's next generation air/ground communications (NEXCOM) and Capstone programmes**

NEXCOM

7.3.7.1 The meeting noted that VDL Mode 3 had been selected by the United States FAA for its NEXCOM programme to fulfil requirements for added spectrum capacity, replacement of ageing air-ground communication infrastructure, high-integrity secure and interference-free data path. To facilitate transition, development of a ground-based multi-mode digital radio (MDR) capable of VDL Mode 3, and analog 25 kHz/8.33 kHz operation had been undertaken. Final operational approval of the radio was in progress.

7.3.7.2 Three manufacturers were developing multi-mode avionics that would incorporate VDL Mode 3 for the commercial air transport, business aviation and general aviation markets. The Certification Branch of the FAA was currently developing technical standard orders (TSO) to support the installation approval process of the users. A system demonstration involving pre-production avionics and the ground test bed was scheduled at the William J. Hughes Technical Centre for November 2003. The production version of these radios would be certified and available for purchase beginning in 2005.

7.3.7.3 A rapid development effort of the ground system was underway and a full-scale development of the ground system was scheduled to begin in early 2005 and continue through 2007 allowing for first implementation of a fully digital air-ground infrastructure in selected sectors by 2009.

Capstone

7.3.7.4 As part of the United States FAA's Capstone programme, there were over 180 aircraft in Alaska equipped with universal access transceiver (UAT)[1]. Additionally, ten ground stations had been installed. In January 2001, the FAA had approved the use of UAT/ADS-B to support "radar-like services" for equipped aircraft in areas of Western Alaska without radar coverage. This represented the first operational use of ADS-B to support air traffic services. The Capstone programme was planning to upgrade the installed avionics and ground stations to comply with UAT RTCA MOPS. Additionally, the programme planned to award new contracts for 200 additional avionics suites to equip aircraft in Southeast Alaska and for 30 new ground stations.

7.3.8 Air-ground data link implementation in Europe

7.3.8.1 Information on the LINK 2000+ Programme launched by the European Organisation for the Safety of Air Navigation (EUROCONTROL) was presented to the meeting, addressing the objectives of the programme, its time scales and the modalities of the data link implementation in Europe. The meeting noted that the objective of the programme was to implement air-ground data link services for air traffic control (ATC) in the core area of Europe, based on the aeronautical telecommunication network (ATN) and VHF digital link Mode 2 (VDL Mode 2). The selected technology combination had been successfully used by EUROCONTROL in operational trials.

7.3.8.2 The meeting was informed that the programme concentrated on the implementation of controller-pilot data link communications for en-route ATC, including ATC communication management used to transfer aircraft silently between sectors or centres, ATC clearances used to request and issue ATC clearances and ATC microphone check, used to alert pilots about a blocked voice frequency. In addition it provided a migration path to ATN/VDL Mode 2 for services already existing over ACARS, such as DCL, D-ATIS and oceanic clearance.

7.3.8.3 The EUROCONTROL Maastricht Upper Area Control Centre would provide the services from 2003 onwards, followed by other centres of the described region in 2006 and 2007. This stepped implementation of data link equipped centres would allow pilots to get accustomed gradually to data link operations and is not considered a disadvantage. The controller-pilot data link communications would reduce controller and aircrew workload and voice congestion. The meeting noted that full benefits of data link would only become available when a large majority of flights was equipped and that; therefore, EUROCONTROL was investigating the possible need for a mandate for data link equipage.

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[1] UAT is a broadcast data link designed for ADS-B applications. SARPs development for the UAT is under way within the Aeronautical Communications Panel (ACP).

7.3.9 Modernization of aeronautical communications in India

7.3.9.1 The meeting noted that, considering the increase in air traffic growth over Indian terrestrial airspace, the oceanic airspace of the Bay of Bengal and the Arabian Sea and advent of new technology and infrastructure in the data communication, the Airports Authority of India (AAI) had drawn plans to improve air-ground communication infrastructure using satellite technology in accordance with the regional communications, navigation, and surveillance/air traffic management (CNS/ATM) plan. Implementation of the plan was being carried out in phases.

7.3.10 Modernization of the Brazilian VHF data link communications services

7.3.10.1 The meeting was informed that the Brazilian DATACOM system was an air-ground digital communication system operating in the VHF band and aimed at reducing the amount of voice communications through automatic data transmission. The system allowed exchange of ATS, AOC and AAC messages between ground users (ATC facilities and airlines) and aircraft. The system was based on ACARS technology. A modernization programme was under way, aimed at introducing VDL Mode 2 technology to optimize data link traffic in those sites already approaching saturation levels. Departure clearance and digital ATIS air traffic services would be supported.

7.4 ADS-B DATA LINKS

7.4.1 The meeting recalled that automatic dependent surveillance-broadcast (ADS-B) was defined in Annex 10 as a surveillance technique in which aircraft automatically provided, via a broadcast mode data link, data derived from on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position, and additional data as appropriate.

7.4.2 Progress in the development of an ADS-B concept of use had been discussed under Agenda Item 1, which focused on the role of ADS-B as an enabling concept in support of a global ATM operational concept. In that context, it had been noted that one of the constraints to be taken into account as a part of the activities leading to the implementation of ADS-B was the availability of standardized technology. Thus, the meeting proceeded to address some of the associated issues from a technical standpoint.

7.4.3 Comparative analyses/data link evaluations

7.4.3.1 The meeting was informed that, at the request of the Air Navigation Commission (ANC), the Aeronautical Mobile Communications Panel (AMCP) had considered a comparative analysis of the following three ADS-B data links:

a) secondary surveillance radar (SSR) Mode S extended squitter;

b) VHF digital link (VDL) Mode 4; and

c) universal access transceiver (UAT).

7.4.3.2 In the course of the analysis, the data links had been assessed and compared against a number of criteria. The criteria used included those considered in earlier assessments of data links for surveillance applications carried out by AMCP, criteria derived from RTCA minimum aviation system performance standards (MASPS) for ADS-B, and additional criteria supplied by the European Organisation for the Safety of Air Navigation (EUROCONTROL) to the joint FAA/EUROCONTROL Technical Link Assessment Team (TLAT). In order to evaluate system performance in several different air traffic situations, two air traffic scenarios (a high-density one and a low-density one) had been used as representative of future environments. The meeting noted with appreciation the substantive amount of effort invested and the wealth of technical information provided in the analysis developed by the AMCP. It was noted that each of the three data links could be seen to have relative advantages over the others with regard to some criteria.

7.4.3.3 The meeting was also informed that over the past several years a number of States and organizations had participated in activities to develop and evaluate ADS-B technologies and the operational applications enabled by those technologies. One of these efforts was a cooperative activity between the United States FAA and EUROCONTROL. This activity had included the evaluation of three candidate ADS-B link technologies (i.e. Mode S extended squitter, VDL Mode 4, and UAT) and had been conducted by the TLAT. In addition, further studies by a consortium of European companies had been funded by the Directorate General for Energy and Transport of the European Commission.

7.4.3.4 The FAA had also conducted additional technical and economic studies that were focused on the use of ADS-B within the United States. Likewise, EUROCONTROL had sponsored additional studies focused on the European applications for ADS-B. In addition, the United States FAA and EUROCONTROL had jointly sponsored a number of flight evaluations that had utilized single and multiple ADS-B link technologies. Other States, such as Australia and Sweden had conducted ADS-B evaluations using a single ADS-B link technology.

7.4.3.5 An APANPIRG ADS-B Study and Implementation Task Force had identified near-term applications and benefits of ADS-B in the ASIAPAC region and reviewed the available ADS-B data link, based on a comparison with ADS-B plans for other regions and avionics availability considerations.

7.4.4 Implementation decisions and recommendations at the regional and national level

7.4.4.1 Following its review of comparative analysis/data link evaluation activities, the meeting was informed of a number of national and regional implementation decisions and recommendations originating from several regions on the basis of the results of such activities.

United States link decision

7.4.4.2 The meeting was informed that in 2002 the United States FAA had announced a decision on the ADS-B links for use within the United States for the initial introduction of ADS-B services. Under this decision the SSR Mode S extended squitter was to be used for air transport and other high-performance aircraft while UAT was to be used on the typical general aviation aircraft. No actions had been taken to require ADS-B equipage. The UAT had been selected to provide ADS-B and associated services for the general aviation users because of its lower cost and greater uplink capacity, especially for flight information services — broadcast (FIS-B) services.

European data link recommendation

7.4.4.3 The meeting was informed that within EUROCONTROL, an ADS-B data link recommendation for the short and medium term had been elaborated, concerning primarily a data link option that could support ADS-B applications planned to be implemented in Europe in the time frame 2008 - 2012. It called for, inter alia, the SSR Mode S extended squitter to be accepted as the logical choice to support the early implementation of ADS-B applications (both air-to-ground and air-to-air) and to provide interoperability with the United States, with deployment to begin as soon as practicable.

ADS-B Implementation in Sweden

7.4.4.4 The meeting noted the implementation of ADS-B based on VDL Mode 4 in Sweden. Initial applications covered A-SMGCS and surveillance in areas presently not covered by radar.

Australian ADS-B network

7.4.4.5 The meeting was informed that, following operational trials conducted using ADS-B based on the SSR Mode S extended squitter for ATC ground surveillance, Airservices Australia planned to install a network of approximately twenty ADS-B ground stations across the non-radar areas of Australia to provide nationwide coverage at and above flight level 300, complementing coverage from a radar network down the east coast. The meeting noted that this plan was in line with the Asia/Pacific regional strategy.

Asia/Pacific regional strategies for ADS-B implementation

7.4.4.6 Following its review of available ADS-B data links (Sect. 7.4.3.5 refers), the ASIA/PAC Air Navigation Planning and Implementation Regional Group (APANPIRG) ADS-B Study and Implementation Task Force had unanimously recommended that the SSR Mode S extended squitter be used as the data link for ADS-B radar like services in the ASIA/PAC Regions in the near future. Subsequently, the fourteenth meeting of APANPIRG, held in August 2003, had endorsed the task force’s recommendation with the target date of January 2006.

Phased implementation of ADS-B in the Russian Federation

7.4.4.7 The meeting noted that the State Civil Aviation Authority of Russia had adopted the concept and programme of the phased implementation of ADS-B in Russia based on VDL Mode 4. It was planned to create a network of ADS-B ground stations. The equipment developed in the Russian Federation was presently being certificated. Implementation of ADS-B would start in 2004 in the Tyumen region.

ADS in Mongolia

7.4.4.8 The meeting noted that, based on findings from real-time simulations of a possible ADS infrastructure, a recommendation had been made in Mongolia to implement VDL Mode 4 ground stations supporting ADS-B to provide surveillance coverage for domestic traffic in the lower airspace.

Global and inter-regional considerations

7.4.4.9 The meeting reviewed the future aeronautical mobile communication scenarios for data link surveillance services developed by AMCP (section 7.5.1 refers). According to these scenarios, for high density terrestrial areas ADS-B services would be supported by the SSR Mode S extended squitter in the initial phase. Where the ATM service requirements or the RCP levels could not be met, a complementary data link could be introduced using the UAT, or the VDL Mode 4, on the basis of regional agreements. For oceanic and low/medium density areas, ADS-B services would be supported by the SSR Mode S extended squitter, the UAT, or the VDL Mode 4 on the basis of regional agreements.

7.4.4.10 The meeting was apprised of the position of the International Air Transport Association (IATA) on the implementation of ADS-B and noted that IATA supported the identification of the SSR Mode S extended squitter as the single, interoperable link in present regional transition plans, as the system satisfied the requirements posed by the initial applications and was available and mature, enabling early implementation. The meeting was also informed that IFALPA supported the establishment of the SSR Mode S extended squitter as the single interoperable link for initial implementation in order to gain operational experience

7.4.4.11 In addressing inter-regional harmonization considerations, the meeting noted that the FAA and EUROCONTROL had undertaken to coordinate strategies for the introduction of the initial ADS-B services within the United States and European airspace respectively. Common to both the United States and the European strategies for the introduction of the initial ADS-B services was the use of the SSR Mode S extended squitter as a common link technology for achieving interoperability in support of near-term ADS-B applications. It was also recalled that, in the course of the development of the Asia Pacific strategy for the implementation of ADS-B in the regions, a comparison with ADS-B plans had been performed.

7.4.4.12 Finally, with regard to avionics availability, it was noted that both Airbus and Boeing had announced plans to equip new commercial air transport class aircraft with SSR Mode S transponders supporting the transmission of SSR Mode S extended squitter for ADS-B. The most recent generation of airborne collision avoidance system (ACAS) and Mode S equipment had incorporated support for the extended squitter and, given the global use of ACAS in air transport class aircraft, the widespread availability of extended squitter based ADS-B services was becoming possible. The retrofit of commercial air transport aircraft with extended squitter capability for ADS-B had already begun by some commercial operators.

7.4.5 **Strategy for the near-term introduction of ADS-B**

7.4.5.1 In reviewing the available information on implementation decisions, the meeting noted that one of the key factors in the decision making process at the national and regional level appeared to have been the overriding requirement to ensure global interoperability while enabling the near term introduction of ADS-

B services. Such requirement was dictated by safety and efficiency reasons; was responsive to the needs of the user community; and had been extensively embraced and supported throughout the industry.

7.4.5.2 The meeting also noted that the majority of the States and international organizations that had provided information on their implementation decisions or recommendations had selected the SSR Mode S Extended squitter as an initial ADS-B link, based on a wide range of considerations, including but not limited to technical ones. This convergence could form a sound basis for achieving the desired global interoperability and the associated benefits. In this respect, the meeting noted with appreciation the efforts of States and regions that had fostered the convergence by endeavoring to coordinate their implementation choices to the extent possible.

7.4.5.3 At the same time, the meeting recognized that a significant number of States from several regions might not be in a position to fully support such convergence on a global near-term solution at the present time without further study and consideration. In particular, it was recognized that certain States might not have identified a near term need for introducing ADS-B in their airspace; or might be still in the process of selecting an appropriate ADS-B link technology; or might be conducting regional coordination in the interest of regional harmonization before committing to a technology choice; or might have already identified as their preferred technical solution one that was partly or wholly inconsistent with the implementation of the SSR Mode S extended squitter. In this regard, the meeting recognized that for the near term, other link technologies supporting the initial introduction of ADS-B applications may optionally be used on a local or regional basis either in addition to Mode S extended squitter or in lieu of Mode S extended squitter in support of local or regional operations.

7.4.5.4 The meeting agreed that the awareness of the substantive convergence achieved so far could provide a useful supporting element in the decision process of States that had not made their selection yet, in addition to the results of technical studies such as those conducted by AMCP, and to the information made available by States and organizations that had already completed the decision process.

7.4.5.5 On the basis of the above considerations with regard to potential near term ADS-B solutions, the meeting formulated the following Recommendation:

Recommendation 7/1 — Strategy for the near-term introduction of ADS-B

That States:

a) note that a common element in most of the approaches currently adopted for early implementation of ADS-B is the selection of the SSR Mode S extended squitter as the initial data link; and

b) take into account this common element to the extent possible in their national and regional implementation choices in order to facilitate global interoperability for the initial introduction of ADS-B.

7.4.6 Support of longer-term ADS-B requirements

7.4.6.1 The meeting recognized that, in the longer term, the current SSR Mode S extended squitter technology may not be able to fully satisfy all of the requirements for ADS-B services in all airspaces. It was therefore important to more fully define the evolution of the operational requirements for ADS-B; the evolution of the air traffic environments in which ADS-B must operate; and the evolution of the use of the 1 090 MHz channel in order to determine whether a link with greater performance would be required. Any long-term ADS-B solution would need to be integral with an overall long-term surveillance architecture that supported the required surveillance performance (RSP) associated with a set of internationally standardized ATS applications.

7.4.6.2 The long-term operational requirements would become the basis for ICAO to develop SARPs for an internationally standardized set of ADS-B applications, supporting both air-air and air-ground services. The meeting confirmed that the continued development within ICAO of alternative ADS-B link technologies was appropriate. However, it was felt that it was premature to select any specific long-term ADS-B link architecture for the support of global aviation needs. In the development of such architectures, care should be taken to ensure backward compatibility with the near term architecture and to make optimum use of the available data links already standardized by ICAO (such as VDL Mode 4) or currently undergoing standardization (such as the UAT). Other link technologies, or enhancements to existing ADS-B link technologies, that might emerge in the future would also need to be taken into account. In considering any candidate link technology, special attention should be paid to ICAO ADS-B operational requirements, frequency spectrum availability and aircraft integration considerations.

7.4.6.3 On the basis of the above considerations with regard to potential longer term ADS-B solutions, the meeting formulated the following recommendation:

Recommendation 7/2 — Support of longer term ADS-B requirements

That

a) States recognize that in the longer term the current SSR Mode S extended squitter technology may not be able to fully satisfy all of the requirements for ADS-B services in all airspaces; and

b) ICAO continue development of technical standards for ADS-B link technologies, including SSR Mode S extended squitter, VDL Mode 4 and UAT, with special attention being paid to ICAO ADS-B operational requirements, frequency spectrum availability and aircraft integration issues.

7.4.7 VDL Mode 4 considerations

7.4.7.1 The meeting was presented with an overview of the aircraft aspects of multiple VHF transmitter-receiver installations, with particular reference to co-site interference issues related to installation of VDL Mode 4 equipment on large air transport class aircraft. The conclusions of the overview was that, in order to accommodate on such aircraft VDL Mode 4 equipment for ADS-B applications, more onerous precautions needed to be taken at the frequency planning level than those generally required to accommodate other equipment operating in the VHF band.

7.4.7.2 The meeting was informed by the Secretary that the issue was currently under the consideration of the ACP, which had undertaken an assessment of the extent of the problem (including its relevance to other VDL modes in addition to Mode 4) and of potential solutions or mitigations. The Secretary also informed the meeting that the recommendations offered in the paper with regard to frequency planning would be submitted to the ACP for consideration.

7.5 FUTURE EVOLUTION OF CURRENT AERONAUTICAL MOBILE COMMUNICATIONS

7.5.1 Future aeronautical mobile communication scenarios

7.5.1.1 The meeting reviewed material developed by the AMCP discussing future aeronautical mobile communications scenarios as might develop over the following two decades, and presenting some of the issues to be investigated in connection with the scenarios. A set of diagrams summarizing the scenarios is included in the appendix to the report on this agenda item. The meeting concurred that the aeronautical mobile communication infrastructure had to evolve in order to accommodate new functions and to provide the adequate capacity and quality of services required to support evolving air traffic management (ATM) requirements within the framework of the global ATM operational concept. It also noted that a major constraint on the evolution of the infrastructure in high-density areas where the very high frequency (VHF) spectrum was already heavily congested, or was approaching congestion, was the limited availability of radiofrequency spectrum dedicated to aeronautical mobile communication services.

7.5.1.2 In its review of the AMCP material, the meeting observed that the scenarios were based on a three-step approach, whereby:

a) the first step was the introduction or the expansion of the voice and data link systems that were already included in Annex 10 or which were already under development;

b) the second step was the definition and implementation of new terrestrial and/or satellite systems that operated outside the VHF band. This step would be required only in some high-density areas, where the VHF spectrum is expected to experience saturation despite the introduction during the first step of more frequency efficient systems. This second step would provide capacity that was initially complementary to VHF. By taking over some communications services that were originally provided over VHF, this step would then reduce VHF congestion; and

c) the third step was the introduction of a new global VHF system making use of the spectrum that had been made available by the second step. This step would be envisaged only in high-density areas, and only in the longer term.

7.5.1.3 The meeting took particular note of the fact that the second and third step were intended only to be applicable in high-density areas. The meeting also noted that, while the purpose of the scenarios was to reflect the likely evolution of the communication infrastructure over time for areas with different traffic density, they were not intended to replace or pre-empt the relevant ICAO planning process, but merely to provide a common basis for discussion of the way forward in the development of the infrastructure. Separate scenarios were defined for voice and data link services. Within the data link service, separate scenarios were defined for data link communications service and data link surveillance service. The data link surveillance service in turn included automatic dependent surveillance — contract (ADS-C) and automatic dependent surveillance — broadcast (ADS-B). For each of the services, three operational situations with different constraints had been considered:

a) oceanic and low/medium density areas where only a limited ground-based communication infrastructure can be efficiently deployed;

b) low/medium density areas where a full ground-based communication infrastructure can be deployed; and

c) high density terrestrial areas.

7.5.1.4 The meeting noted that in the course of the development of the scenarios a number of issues had been identified as requiring further consideration.

7.5.1.4.1 A critical element of the three-step evolution path, particularly in high density areas, was spectrum availability. During the first step, VHF spectrum needed to be made available for the introduction of new services; during the second step, the transfer of services from the VHF band to other bands was conditional on availability of appropriate spectrum in the new bands; during the third step, the introduction of new VHF services was conditional on availability of sufficient spectrum in the VHF band.

7.5.1.4.2 The suitability of the present and future communication systems considered in the scenarios to support the emerging ATM requirements and RCP levels needed to be assessed in quantitative terms as a function of the operational environment.

7.5.1.4.3 Systems using different operational modes might give rise to different ATS operational procedures that were optimized for system characteristics. As aircraft crossed boundaries between areas or regions that operated different types of systems, pilots would be required to manage these procedures. Human factors and human machine interfacing would have significant impacts on the efficiency and, ultimately, on the safety of these new procedures.

7.5.1.4.4 The coexistence of multiple communication systems within each scenario and across different scenarios posed technical, operational and economic challenges that needed to be addressed. In particular, the definition of an on-board architecture supporting the integration of multiple systems should be undertaken.

7.5.1.4.5 It was observed that the scenarios also included use of aircraft communications addressing and reporting system (ACARS). In this regard, the conference was provided with information on the increasing use of ACARS for digital ATIS and pre-departure/oceanic clearance as well as FANS-1/A avionics package for controller-pilot data link communications (CPDLC) and ADS. It was noted that approximately 1 200 long haul aircraft had already been equipped with FANS-1/A and that airframe manufacturers were considering the introduction of that technology to smaller single-aisle aircraft. It was recognized that real operational benefits were being accrued through the use of the above-mentioned systems, mostly in oceanic/low-density airspace and for specific type of operations. In high-density airspaces, safety considerations may limit the use of ACARS/FANS-1/A for tactical CPDLC operations.

7.5.1.4.6 The meeting was informed about issues faced by the business aviation community in relation to the use of CPDLC/ADS. Specifically, it was stated that for business aviation there was no business case for equipage. Furthermore, the appropriate avionics (based on FANS-1/A or ATN technologies) were not yet available, and uncertainties associated with market and implementation plans of air navigation service providers were preventing their development for business aircraft. The meeting acknowledged the aforementioned problems and their relevance to planning and implementation of CNS/ATM.

7.5.1.4.7 It was also noted that the provision of ATS data link applications via FANS-1/A had not been subject to ICAO provisions. However, the Organization had promulgated to States its position on the early use of the package and its relationship to the envisaged end state via a State letter in December 1994. Similarly, guidance material on the operational accommodation of FANS-1/A aircraft in a system complying with the ICAO end state had been promulgated to States via another State letter in October 1998. It was noted that FANS-1/A continued to evolve technically through activities of relevant industry bodies.

7.5.2 Review of proposals on future development of air-ground communications

7.5.2.1 The meeting proceeded to consider a number of proposals addressing the future evolution of current aeronautical mobile communications, referring to the scenarios discussed above as required to assist in clarifying commonalities and divergences of the various proposals.

7.5.2.2 The meeting noted information supporting the definition of a future communications concept presented by EUROCONTROL. The contribution stressed that present global development plans could and should be harmonised in the near term through the use of multi-mode avionics capable of user-transparent and seamless operations in all ICAO Regions and that the pursuit of future communications solutions was best accomplished as a global activity. The future communications infrastructure should provide backward compatibility with the present infrastructure; be capable of both voice and data services; be able to operate in more than one band simultaneously in a spectrum efficient manner; be capable to provide expanded capacity as the needs of the aviation community dictate; have minimum economic impact on airspace users; and could potentially consist of more than one system (e.g. terrestrial and satellite). The meeting noted that EUROCONTROL was exploring the potential of new technologies for aviation (e.g. wide band communication systems based on evolving international telecommunications standards and satellite based systems). This would enable the financial benefits of commercial off the shelf (COTS) products to be realised, as well as allowing the flexible and effective use of radio spectrum. It was also noted that commercial technology, which offered the potential for attractive lower cost solutions to future aviation communications needs, might need certain modification to meet aviation community standards or air traffic quality of service levels. Hence, the convergence of aviation and commercial requirements needed to be promoted.

7.5.2.3 Another contribution stressed the need for ICAO to discuss the most appropriate VDL system for ATS operation taking into consideration the future voice traffic and data link traffic within the limited VHF frequency band for AMS, and to develop a transition plan for VDL on a global basis, once the selection was made on VDL based on the technological advantages and cost/benefit analysis. Additionally, ICAO should assist the transition to AMSS and encourage the use of AMSS for ATS in oceanic and remote airspace. ADS/CPDLC trial operations through AMSS should also be promoted on a global basis, so that technical and operational problems can be identified to ensure the smooth transition to actual ATS operations through AMSS.

7.5.2.4 An approach emphasizing the need for an interoperable air/ground communications solution from an airspace user's perspective was introduced. It concluded that multi-mode avionics supporting ICAO standardized systems could provide seamless VHF communications operation for international airspace users. This approach would allow regions to mitigate spectrum congestion at a pace appropriate to their anticipated usage. By maximizing service life of the VHF spectrum, it would minimize future investment costs and increases availability of voice and data link communications options for service providers. The meeting was informed that, in the United States, it was projected that a VDL-3 implementation should exceed 30 years of life expectancy. It was anticipated that, while in other high-density regions VHF band saturation could occur by 2015, in other regions a minimum 20-year useful life extension for the VHF band could be achieved. Thus, the use of multi-mode avionics should provide an effective solution for the aviation community and would allow significant time for the aviation community to explore next generation communications options.

7.5.2.5 A proposal from the CAR/SAM Regions concerning the future development of air-ground aeronautical communications noted that, according to the studies conducted by GREPECAS, the implementation of VDL Mode 2 in the medium term was considered feasible to support data link applications, such as CPDLC. The implementation of VDL Mode 3 or 4 would be subject to regional agreements, together with other future data link options.

7.5.2.6 The meeting was apprised of the position of IATA on aeronautical air-ground communications needs, according to which future development of the VHF air-ground infrastructure should converge to a single globally harmonized, compatible and interoperable system to reduce the proliferation of solutions based on national or regional priorities. The meeting noted that IATA encouraged the use of VDL Mode 2 to sustain the growth in data communications and the introduction of 8.33 kHz when needed to alleviate voice congestion. The meeting also noted that IATA Member airlines did not support the implementation of VDL Mode 3 considering the uncertain benefits and limited capacity gain. They also did not support implementation of VDL Mode 4 as it would add to the proliferation of VHF system alternatives and delay the needed overhaul of the VHF system.

7.5.3 Identification of common elements among the proposed approaches

7.5.3.1 The meeting noted that a variety of views had been presented with regard to the future evolution of aeronautical mobile communications. It was recognized that, while to a certain extent that variety could be attributed to different planning horizons being addressed by different contributions to the meeting, some differences remained even when comparable time frames were considered. For instance, within the scope of the first of the three potential evolutionary steps outlined in the AMCP scenarios, namely the introduction or expansion of the voice and data link systems already standardized by ICAO (Section 7.5.1.2 refers), a number of different approaches were currently being followed in different regions. When considering future evolution beyond the implementation of existing ICAO Standards towards the development of new generations of aeronautical communication technologies, additional potential divergences included matters as substantial as the proposed band of operation and the relative roles of terrestrial versus satellite technology and of commercial telecommunication technology versus purpose-developed aeronautical technology.

7.5.3.2 While the meeting acknowledged that each of the alternatives under consideration was valid and justifiable on its own terms, it was noted that the universally recognized benefits of harmonization and global interoperability of air ground communications should not be lost sight of when pursuing optimization of local solutions. Therefore, the meeting agreed that an effort must be made to identify common elements which could form the basis for a broad consensus on an evolutionary approach towards global interoperability. It was expected that a detailed strategy for future evolution could realistically be developed only by gradually building on such an evolutionary approach.

7.5.3.3 The meeting recognized that one such common element was the widespread recognition that in some high-density regions, after an initial period in which continued operation of current standard ICAO systems would be sustainable, saturation of the VHF band would become a real issue, and that measures should be taken with some urgency to address it. However, perception of the amount of urgency varied from region to region. In this regard, the meeting agreed that it would be useful if forecasts of anticipated saturation were conducted within ICAO to reach a consensus on the time frame in which it would occur. Another common element identified was that the successful gradual introduction of data communications should be continued to complement and replace voice for routine communications. The meeting also noted the emergence of multi-mode avionics, such as were being developed as a part of FAA validation and verification program of the VDL-3 technology. Availability of such equipment, complying with a wide range of ICAO Standards, could assist the transition towards global harmonization of air/ground communications (which remained the ultimate goal of ICAO standardization), although it would not necessarily provide a generally applicable remedy to communication capacity problems. In this regard, the meeting also noted that multi-mode receivers might not prove to be a cost-effective solution to overcome regional differences, and that harmonization was normally the most effective way of assuring interoperability.

7.5.3.4 On the basis of this understanding, the meeting developed the following recommendation:

Recommendation 7/3 — Evolutionary approach for global interoperability of air-ground communications

That States:

a) continue the use of currently implemented ICAO standardized systems for VHF band voice and data communications until such time as either saturation of the VHF band is approached or significant cost/benefit or safety advantages are expected from the implementation of other ICAO Standards;

b) continue efforts in maximizing efficient use of existing aeronautical spectrum allocations through spectrum management measures;

c) continue the progressive deployment of data communications on the basis of applicable ICAO Standards such as aeronautical telecommunication network (ATN) using VDL Mode 2 as dictated by evolving operational requirements with a view to complementing or replacing voice communications for most routine communications;

d) provide a forecast of anticipated VHF band saturation in high-density regions;

e) in view of the anticipated saturation of the VHF band for voice communication, consider transition to spectrally more efficient ICAO systems, and/or make increased use of data communications; and

f) investigate multi-mode avionics as a transitional method of achieving interoperability of air/ground communications, where global harmonization has not been achieved.

7.5.3.5 Another common theme that the meeting recognized as emerging from various contributions was the need to investigate the development of a future communication infrastructure, although there was not full agreement on the time frame over which actual deployment of the infrastructure would be required. This activity should include an investigation of the feasibility of new technology alternatives, including solutions outside the VHF band and wide band communication systems based on evolving international telecommunications standards and satellite based systems. Exploration of such systems should include an assessment of costs required to meet the safety critical standards of aviation, including certification costs. Evolutionary developments of standardized ICAO systems should also be considered as candidates components of the future infrastructure. The meeting recognized that these activities should be guided by operational needs and be conducted within the framework of the global ATM operational concept.

7.5.3.6 The meeting therefore agreed to the following recommendation:

Recommendation 7/4 — Investigation of future technology alternatives for air-ground communications

That ICAO

a) investigate new terrestrial and satellite-based technologies, on the basis of their potential for ICAO standardization for aeronautical mobile communications use, taking into account the safety-critical standards of aviation and the associated cost issues;

b) continue evolutionary development of existing standardized ICAO technologies with a view to increasing their efficiency and performance; and

c) assess the needs for additional aeronautical spectrum to meet requirements for increased communications capacity and new applications, and assist States in securing appropriate additional allocations by the ITU.

7.5.4 Guidelines on standardization of new aeronautical communication technologies

7.5.4.1 In connection with its consideration of future technology alternatives, the meeting reviewed a proposed approach to ICAO standardization of new aeronautical communication technologies and agreed to the following recommendation:

Recommendation 7/5 — Standardization of aeronautical communication systems

That, for new aeronautical communication systems, ICAO:

a) continue to monitor emerging communication systems technologies but undertake standardization work only when the systems meet all of the following conditions:

1) can meet current and emerging ICAO ATM requirements;

2) are technically proven and offer proven operational benefits;

3) are consistent with the requirements for safety;

4) are cost-beneficial;

5) can be implemented without prejudice to global harmonization of the CNS/ATM systems; and

6) are consistent with the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750)

b) include in Annex 10 provisions ensuring that the introduction of mandatory carriage of new equipment be based only on appropriate ICAO regional and inter-regional coordination; and

c) further limit SARPs for complex aeronautical systems to broad, system-level, functional and performance requirements and better capitalize on the work of other standard-making organizations so as to reduce the complexity/size of technical provisions.

7.5.4.2 The meeting also noted that aspects traditionally not fully taken into account in ICAO standardization activities could have a significant impact on the successful implementation of a standard. Such aspects included aircraft integration issues, cost and duration of the certification and operational approval process and the viability of business case for implementation from an avionics vendor/air frame manufacturer, airline and air traffic service provider perspective.

7.5.5 Use of VDL Mode 4 for point-to-point data communications

7.5.5.1 The meeting was informed of concerns with the use of VDL Mode 4 to support point-to-point data communications. It was recalled that ICAO State letter, AN 7/1.3.83-03/59, dated 27 June 2003, requested comments on a proposal for the amendment of Annex 10, Volume III. The proposed amendment included the deletion of existing Note 4 to paragraph 6.1 of Annex 10, which indicated that VDL Mode 4 SARPs apply to surveillance applications only. The letter noted that approval of the change would result in adding another point-to-point data link operating in the VHF band and that the use of VDL Mode 4 as a point-to-point data link would satisfy the same requirements and desirable features as were already included in the VDL Mode 3 data link, thereby introducing a proliferation of air/ground data links. The letter indicated that the matter might be addressed by the meeting, and that related recommendations from the meeting would be considered together with response from States to the letter.

7.5.5.2 The concerns presented to the meeting, in addition to those related to the potential proliferation of air/ground data links, included a number of technical issues/concerns and opposition from industry. In the discussion, the meeting noted that VDL Mode 4 would offer an air-to-air communication facility which went beyond the requirements and desirable features already satisfied by VDL Mode 3; that the ACP was working on the resolution of some of the technical issues highlighted; and that opposition from industry was less extensive than reported.

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