ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

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

FUTURE AERONAUTICAL MOBILE COMMUNICATION SCENARIOS

(Presented by the Secretariat)

SUMMARY

This paper is based on material developed by the Aeronautical Mobile Communications Panel (AMCP). It discusses future aeronautical mobile communications scenarios as may develop over the next two decades, and presents some of the issues to be investigated in connection with the scenarios. Diagrams illustrating the scenarios are provided in the appendix.

Action by the conference is in paragraph 6.

1. INTRODUCTION

1.1 It is generally recognized that the aeronautical mobile communication infrastructure has 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. A major constraint on the evolution of the infrastructure in high-density areas where the very high frequency (VHF) spectrum is already heavily congested or is approaching congestion is the limited availability of radiofrequency spectrum dedicated to aeronautical mobile communication services.

2. STEPS IN THE EVOLUTION

2.1 The following three (partially overlapping) steps in the evolution of the aeronautical mobile communications infrastructure have been developed taking into account the spectrum availability constraints mentioned above.

2.1.1 The first step is the introduction or the expansion of the voice and data link systems that are included in Annex 10 or which are presently under development.

2.1.2 The second step is the definition and implementation of new terrestrial and/or satellite systems that operate outside the VHF band. This step will be required only in 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 will provide capacity that is initially complementary to VHF. By taking over some communications services that were originally provided over VHF, this step will then reduce VHF congestion.

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

2.2 Several communication scenarios describing the three steps are presented in the next sections. The purpose of the scenarios is to reflect the likely evolution of the communication infrastructure over time for areas with different traffic density. The scenarios are 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. To this end, they should be used as a baseline in future related ICAO activities, and further developed as required while ensuring consistency with the global ATM operational concept, including identified operational requirements.

3. SCENARIO ORGANIZATION

3.1 The scenarios are illustrated by the diagrams contained in the appendix. The time scale is not specified, since decisions to implement new systems depend on factors whose timing may vary from area to area (such as system saturation or implementation of new ATM procedures).

3.2 Separate scenarios are defined for voice and data link services. Within the data link service, separate scenarios are defined for data link communications service and data link surveillance service. The data link surveillance service in turn includes automatic dependent surveillance - contract (ADS-C) and automatic dependent surveillance - broadcast (ADS-B). Certain linkages exist for the choice of systems to support different services. For example, the following grouping of systems may occur:

a) initial implementation of VDL Mode 2 followed by implementation of VDL Mode 4 for enhanced data link communications[1] services (air-ground and air-air), SSR Mode S extended squitter or/and VDL Mode 4 for data link surveillance services , with 8.33 kHz DSB-AM to provide increased voice capacity; or

b) initial implementation of VDL Mode 2 followed by implementation of VDL Mode 3 for enhanced data link communications services (air-ground), SSR Mode S extended squitter or/and universal access transceiver (UAT)[2] for data link surveillance services, with VDL Mode 3 to provide increased voice capacity.

3.3 For each of the services, three operational situations with different constraints have 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 infrastructures can be deployed; and

c) high density terrestrial areas.

3.4 Due to different local conditions, migration to a new system may not occur at the same time in different regions or even within the same region.

4. SCENARIO DESCRIPTION

4.1 Voice services

Oceanic and low/medium density areas where only a limited ground-based communication infrastructure can be efficiently deployed (Figure A1)

4.1.1 In these areas, voice services will continue to be supported by the current high frequency (HF) system. However, since the system provides poor audio quality and is subject to frequency congestion and to significant operational constraints, some or all of these communications can be transferred to current or future aeronautical mobile-satellite service (AMSS) systems. Transfer of routine communications to HF data link (HFDL) may also offer improvements.

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[1] Currently, Annex 10 states that VDL Mode 4 SARPs apply to surveillance applications. A proposal developed by the eighth meeting of AMCP to amend Annex 10 to enable the future use of VDL Mode 4 as a general purpose communication data link has been transmitted to States and international organizations for comments.

[2] Draft SARPs for the UAT are under development by the Aeronautical Communications Panel (ACP, formerly AMCP).

4.1.2 Where a ground based infrastructure is available locally, such as in terminal areas or on specific routes, voice communications are supported over the 25 kHz DSB-AM system. In areas, where congestion in the VHF band is experienced, or where dictated by economic or operational requirements, this service could also be supported by the 8.33 kHz DSB-AM or the VDL Mode 3 system.

Low/medium density areas where a full ground-based communication infrastructure can be deployed (Figure A2)

4.1.3 In these areas, voice services are supported by the 25 kHz DSB-AM system. In areas where congestion in the VHF-band is experienced, or where dictated by economic or operational requirements, this service could also be supported over the 8.33 kHz DSB-AM or the VDL Mode 3 system.

High density terrestrial areas (Figure A3)

4.1.4 In high density areas (e.g. in parts of the United States and Europe), voice services currently operated over the 25 kHz DSB-AM system will be transferred to the 8.33 kHz DSB-AM system or to the VDL Mode 3 system on the basis of regional agreements. The migration will be implemented in such a way as to avoid saturation of the VHF-band.

4.1.5 In the core area of Europe, saturation of the VHF band is expected to occur again around 2015, despite the introduction of 8.33 kHz channel spacing, thus preventing further growth of voice services. Therefore, future satellite and/or terrestrial systems operating in other bands could be developed and implemented in time to provide the required additional capacity. The introduction of these systems would gradually relieve the congestion in the VHF band, eventually enabling the introduction of a new VHF system providing increased capacity as required.

4.2 Data link services

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

4.2.1 Data link communications service (Figure A4)

4.2.1.1 In these areas, the Boeing FANS 1 and the Airbus FANS A applications and controller — pilot data link communications (CPDLC) are currently supported by AMSS and could be supported by HFDL. Future satellite systems may also be introduced to provide improved quality of service.

4.2.1.2 Where a ground-based infrastructure is available locally, such as in terminal areas or on specific routes, the approach described in section 4.2.3 could be followed.

4.2.2 Data link surveillance services (Figure A5)

4.2.2.1 ADS-B services will be supported by the SSR Mode S extended squitter, the UAT, or the VDL Mode 4 on the basis of regional agreements. ADS-C services can be supported by the systems identified in 4.2.1.

Low/medium density areas where a full ground-based communication infrastructure can be deployed

4.2.3 **Data link communications services (Figure A6)**

4.2.3.1 In these areas, data messages in accordance with the industry standard ARINC Characteristic 623 will be introduced using ACARS. These messages will migrate to AOA (ACARS over aviation VHF link control (AVLC)) over VDL Mode 2 to improve the capacity and the quality of service. For the introduction of CPDLC services, the ATN/VDL Mode 2 service will be implemented. On a regional basis, where dictated by economic or operational requirements, enhanced data link services could also be supported over the VDL Mode 3 or VDL Mode 4 systems.

4.2.4 **Data link surveillance services (Figure A7)**

4.2.4.1 ADS-B services could be supported by the SSR Mode S extended squitter, the UAT, or the VDL Mode 4 on the basis of regional agreements. ADS-C services can be supported by the systems identified in 4.2.3.

High density terrestrial areas

4.2.5 **Data link communications services (Figure A8)**

4.2.5.1 In these areas, data messages in accordance with the industry standard ARINC Characteristic 623 will be introduced using the ACARS system and will migrate to AOA over VDL Mode 2 to improve the capacity and the quality of service. For the introduction of CPDLC Phase 1 services for non time-critical messages, the ATN/VDL Mode 2 service will be implemented. For introducing CPDLC Phase 2 services for time critical messages, VDL Mode 3 or VDL Mode 4 services could be provided on the basis of regional agreements.

4.2.5.2 In case of congestion of the VHF spectrum resulting in lack of capacity, the VDLs will be complemented by additional future satellite and/or terrestrial systems operating outside the VHF band. The introduction of these systems would gradually relieve the congestion in the VHF band, eventually enabling the introduction of a new VHF system providing increased capacity as required.

4.2.6 **Data link surveillance services (Figure A9)**

4.2.6.1 ADS-B services will be supported by the SSR Mode S extended squitter in the initial phase. Where the ATM service requirements or the RCP levels cannot be met, a complementary data link could be introduced using the UAT, or the VDL Mode 4, on the basis of regional agreements. ADS-C services can be supported by the systems identified in 4.2.5.

5. ISSUES TO BE INVESTIGATED

5.1 In the course of the development of the scenarios presented in this paper, a number of issues have been identified as requiring further consideration. They are briefly summarized here as a basis for additional work beyond this Conference.

5.2 A critical element of the three-step evolution path, particularly in high density areas, is spectrum availability. During the first step, VHF spectrum needs 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 is conditional on availability of appropriate spectrum in the new bands; during the third step, the introduction of new VHF services is conditional on availability of sufficient spectrum in the VHF band.

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

5.4 Systems using different operational modes may give rise to different ATS operational procedures that are optimised for system characteristics. As aircraft cross boundaries between areas or regions that operate different types of systems, pilots will be required to manage these procedures. Human factors and human machine interfacing will have significant impacts on the efficiency and ultimately on the safety of these new procedures.

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

6. ACTION BY THE CONFERENCE

6.1 The conference is invited to agree to the following recommendation:

Recommendation 7/xx — Future aeronautical mobile communication scenarios

That ICAO:

a) further develop through appropriate ICAO technical and operational bodies the scenarios contained in the appendix while ensuring consistency with the global ATM operational concept, and use them as a baseline in its work on future aeronautical mobile communications;

b) investigate and develop relevant material on the following issues related to the scenarios:

1) availability of spectrum to support the scenarios;

2) emerging ATM requirements and RCP levels to be supported by the communication systems considered in the scenarios;

3) human factors and human-machine interface aspects of the introduction of new communication systems and procedures; and

4) technical, operational and economic considerations associated with the integration of the multiple communication systems considered in the scenarios.

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APPENDIX

SCENARIO DIAGRAMS

On the diagrams the introduction of a service is associated with one of the following trigger events:

a) capacity: increase of the telecommunication infrastructure capacity;

b) quality: improvement of quality of voice exchanges;

c) coverage: improvement of coverage;

d) ADS-B: automatic dependent surveillance broadcast;

e) FANS 1/A: Boeing/Airbus data link avionics applications;

f) CPDLC Ph 1: first set of SARPs-compliant CPDLC messages;

g) CPDLC Ph 2: second set of SARPs-compliant CPDLC messages; and

h) ARINC 623: departure/pre-departure clearance (DCL/PDC) and automatic terminal information service (ATIS) character oriented data link applications.

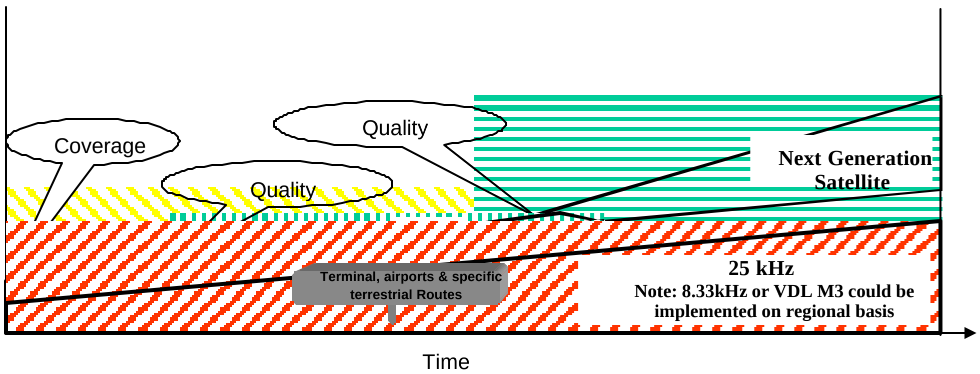

Figure A1. Voice services in oceanic and low/medium density areas where only a limited ground-based communication infrastructure can be deployed

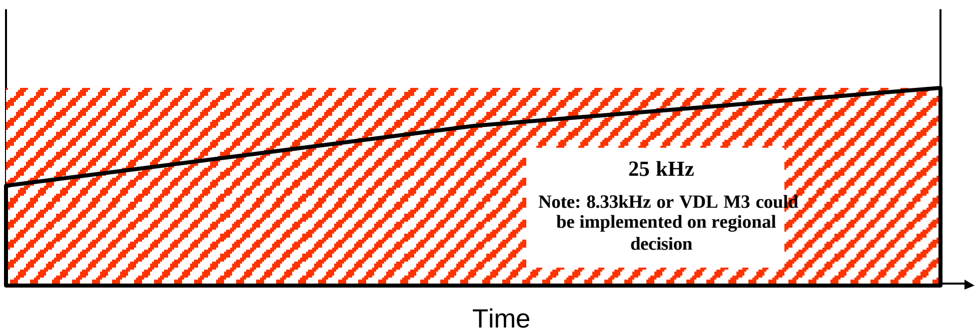

Figure A2. Voice services in low/medium density areas where a full ground-based communication infrastructure can be deployed

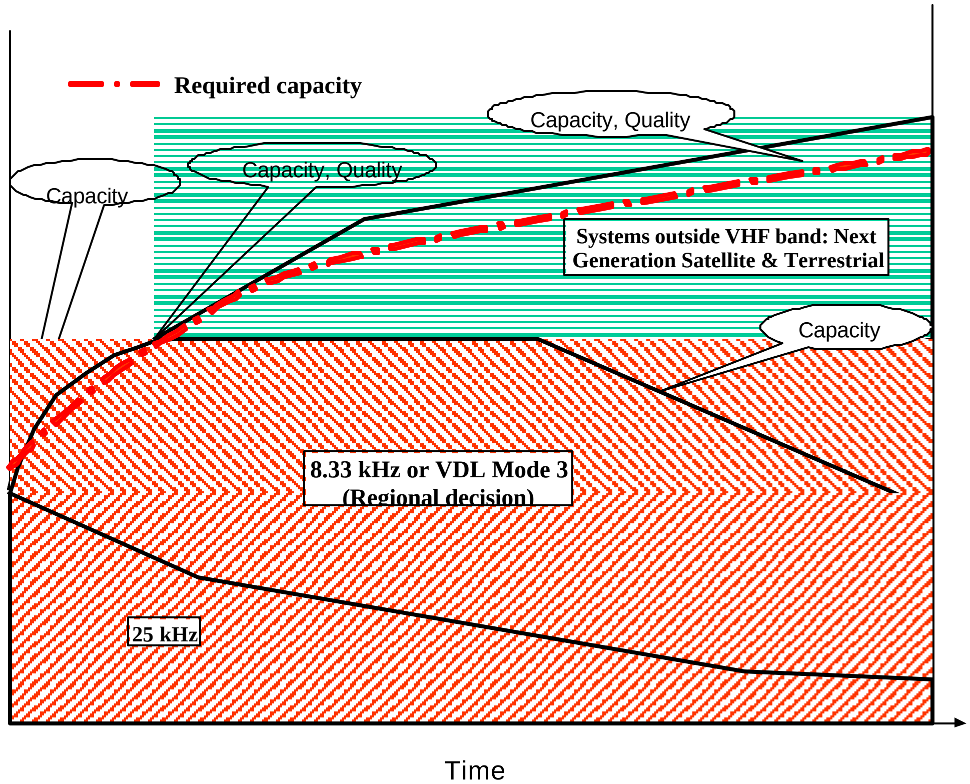

Figure A3. Voice services in high density areas

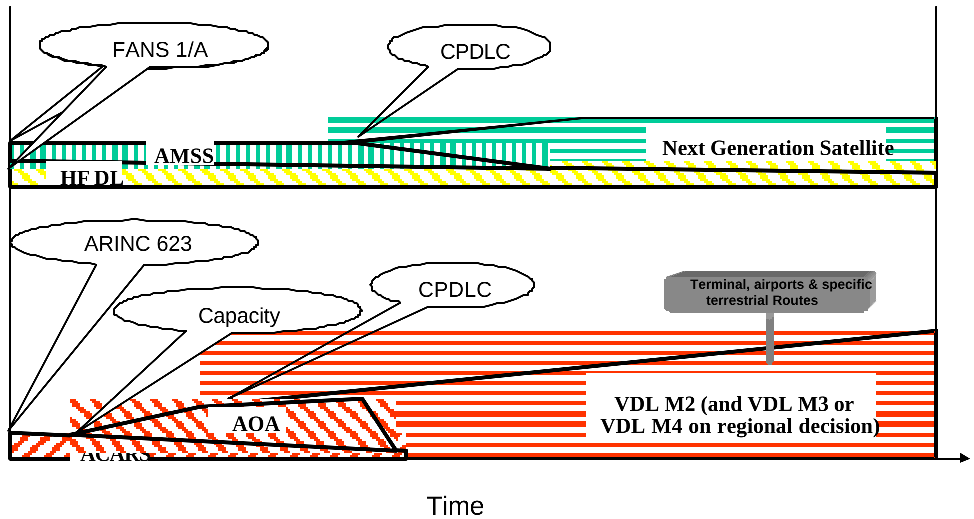

Figure A4. Data link communications services in oceanic and low/medium density areas where only a limited ground-based communication infrastructure can be deployed

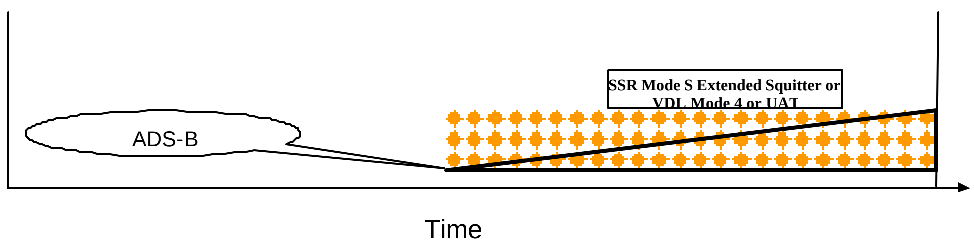

Figure A5. Data link surveillance services in oceanic and low/medium density areas where only a limited ground-based communication infrastructure can be deployed

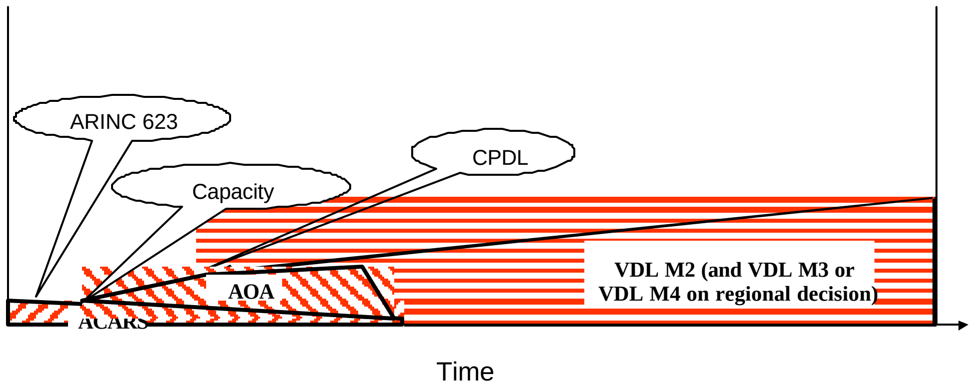

Figure A6. Data link communications services in low/medium density areas where a full ground-based communication infrastructure can be deployed

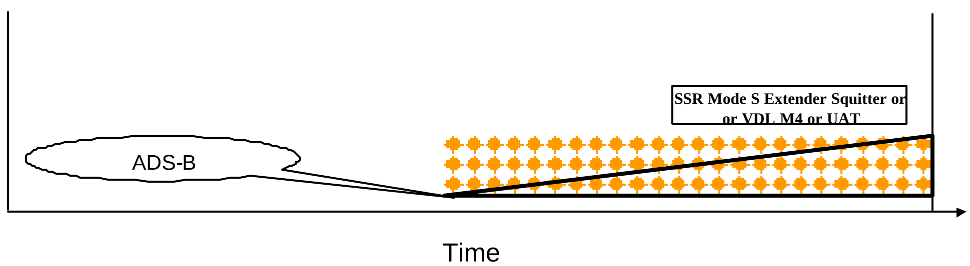

Figure A7. Data link surveillance services in low/medium density areas where a full ground-based communication infrastructure can be deployed

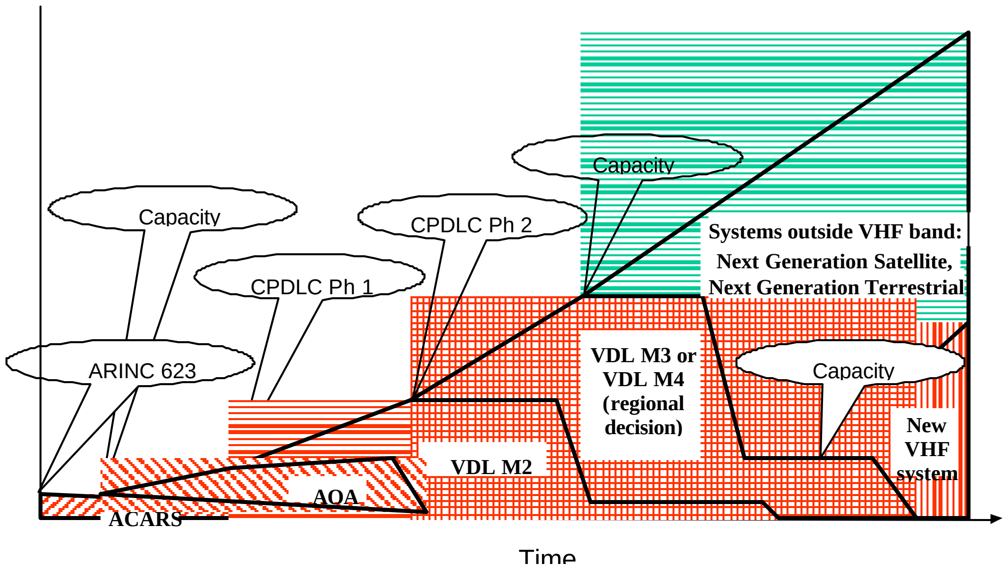

Figure A8. Data link communications services in high density terrestrial areas

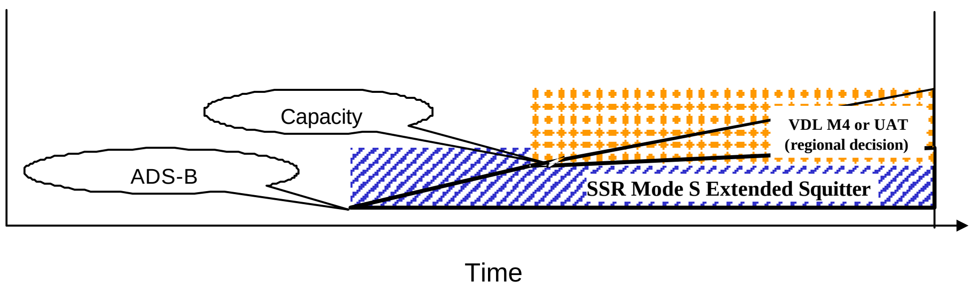

Figure A9. Data link surveillance services in high density terrestrial areas

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