APPENDIX A

FUTURE AERONAUTICAL MOBILE COMMUNICATION SCENARIOS

1. INTRODUCTION

1.1 It has been recognized that the aeronautical mobile communication infrastructure must evolve to accommodate new functions and to provide the adequate capacity and quality of services required to support air traffic management (ATM) requirements. At the same time, system performance must meet the various levels of required communication performance (RCP) that are, or will be established for these services. A major constraint to an increase in communication system capacity is the limited availability of radio spectrum that is dedicated to aeronautical services. In some areas, the present very high frequency (VHF) spectrum is already heavily congested.

2. STEPS IN THE EVOLUTION

2.1 Three (partially overlapping) steps in the evolution of aeronautical mobile communications may be considered to address the existing constraints:

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 to define and implement new systems that operate outside the VHF band. In certain regions, in a period that will depend on air traffic density and ATM procedures, the VHF spectrum is expected to experience a new saturation resulting in new constraints for the delivery of air traffic services. To solve this new VHF saturation, systems operating outside the VHF band must to be defined and implemented. 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. Two examples of these new non-VHF systems are the future satellite system and the future terrestrial system which are described in a companion information paper.

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 step two.

2.2 Several communication scenarios describing these three steps are presented in the next sections.

3. SCENARIO ORGANIZATION

3.1 The scenarios proposed for consideration are based on analysis and validation by AMCP experts. Several issues that require further investigation are listed in Section 6. The scenarios are illustrated by diagrams (see appendix) that describe the evolution of the communications infrastructure over time. The horizontal time axis is not specified, since decisions to implement new systems depend from factors that may vary from region to region (such as system saturation or implementation of new ATM procedures).
The scenarios are separated into voice and data link services. Data link service is further distinguished as data link communications service and data link surveillance service. Certain linkages exist for the choice of systems to support different services. For example, the following grouping of systems may occur:

a) VDL Mode 2 and then VDL Mode 4 for data link communications services, SSR Mode S extended squitter or/and VDL Mode 4 for data link surveillance services, with 8.33 kHz DSB-AM for voice; or

b) VDL Mode 2 and then VDL Mode 3 for data link communications services, SSR Mode S extended squitter or/and UAT for data link surveillance services, with VDL Mode 3 for voice.

For each of the services, three operational situations with different constraints have been identified:

a) oceanic and low/medium air traffic density regions where only a limited ground-based communication infrastructures can be deployed;

b) low/medium air traffic density regions where a full ground-based communication infrastructures can be deployed; and

c) high air traffic density terrestrial regions where ground-based communication infrastructures can be deployed.

Different local conditions mean that migration to a new system may not occur at the same time in different regions or even within the same main region.

### 4. SCENARIO DESCRIPTION

#### 4.1 Voice services

*Oceanic and low/medium air traffic density regions where only a limited ground-based communication infrastructure can be deployed (Figure A1)*

In these regions, voice services will continue to be supported over high frequency (HF) systems. However, since this system suffers a poor audio quality as well as significant operational constraints, some or all of these communications can be transferred to current or future aeronautical mobile-satellite service (AMSS) systems.

Where a ground based infrastructure is available locally such as in terminal areas or on specific routes, communications are supported over the 25 kHz DSB-AM system. On a regional basis, considering economical or operational requirements, these services could also be supported over the 8.33 kHz DSB-AM or the VDL Mode 3 system.
Low/medium air traffic density regions where a full ground-based communication infrastructure can be deployed (Figure A2)

4.1.3 In these regions, the communications are supported over the 25 kHz DSB-AM system. On a regional basis, considering economical or operational requirements, these services could also be supported over the 8.33 kHz DSB-AM or the VDL Mode 3 system.

High density terrestrial regions where a full ground-based communication infrastructure can be deployed (Figure A3)

4.1.4 In high air traffic density regions such as the northeastern United States and the core area of Europe the communications 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 based on regional implementations. The migration will be implemented in such a way as to avoid spectrum saturation.

4.1.5 In the core area of Europe a new VHF spectrum saturation is expected around 2015. The lack of available spectrum will prevent the implementation of a new VHF system. Therefore, future satellite and/or terrestrial systems operating in other bands could be developed and implemented in time to provide the required additional capacity. These systems would support new communication loads and relieve some of the VHF congestion, thus enabling enhanced quality of service and making a part of the VHF spectrum available for new services.

4.1.6 A new VHF system could be implemented in the VHF spectrum released by the transfer of communication to future satellite and/or terrestrial systems.

4.2 Data link services

Oceanic and low/medium air traffic density regions where only a limited ground-based communication infrastructures can be deployed

4.2.1 Data link communications service (Figure A4)

4.2.1.1 In these regions, the Boeing FANS 1 and the Airbus FANS A applications and pilot data link communications (CPDLC) are currently supported by AMSS (including the capability of ATN/Data 3 services) and could be supported by HF data link. When a future satellite system is available in these regions, they could be utilized to provide improved QoS.

4.2.1.2 Where a ground based infrastructure is available locally such as in terminal areas or on specific routes, data messages in accordance with the industry standard ARINC Characteristic 623 will be introduced using the aircraft communications addressing and reporting system (ACARS). These messages will migrate to AOA (ACARS over aviation VHF link control (AVLC)) 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, considering economical or operational requirements, these services could also be supported over the VDL Mode 3 or VDL Mode 4 systems.

4.2.2 Data link surveillance services (Figure A5)
4.2.2.1 The data link surveillance services will be supported by the SSR Mode S extended squitter, the UAT, or the VDL Mode 4 based on regional implementations. ADS-C services could be supported if required using the data link as identified in 4.2.1.

**Low/medium air traffic density regions where a full ground-based communication infrastructures can be deployed**

4.2.3 Data link communications services (Figure A6)

4.2.3.1 In these regions, data messages in accordance with the industry standard ARINC Characteristic 623 will be introduced using the ACARS system. These messages will migrate to AOA 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, considering economical or operational requirements, these 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 The data link surveillance services will be supported by the SSR Mode S extended squitter, the UAT, or the VDL Mode 4 based on regional implementations.

**High density terrestrial regions where ground-based communication infrastructures can be deployed**

4.2.5 Data link communications services (Figure A8)

4.2.5.1 In these regions, data messages in accordance with the industry standard ARINC Characteristic 623 will be introduced using the ACARS system and will migrate to AOA 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 will be provided based on regional implementations.

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 free a part of the VHF band for the eventual introduction of a new VHF system providing an increased capacity as required.

4.2.6 Data link surveillance services (Figure A9)

4.2.6.1 The data link surveillance 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 will be introduced using the UAT, or the VDL Mode 4 based on regional implementations. ADS-C services could be supported if required using the data link as identified in 4.2.1.
5. **OPERATIONAL TRANSITION CONSIDERATIONS**

5.1 Systems using different operational modes may give rise to modifications to ATS operational procedures that are optimised for system characteristics. As aircraft transition 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.

5.2 A critical element of the three step evolution path is the availability of VHF spectrum for the introduction of new services, the transfer of services from the VHF band to other bands, and the introduction of new VHF services to take their place. Significant study of future ATS requirements for ATM, the corresponding RCP levels, and the technical characteristics of proposed future systems to meet these requirements will be needed.

5.3 Different regions have different CNS infrastructures and traffic density therefore regional plans need to be developed taking in consideration several factors such as VHF congestion if any and its time frame, new data link applications, available system alternatives, economical and operational requirements.

5.4 Regional planning bodies need to undertake fact finding missions to identify what is needed, when it is needed and how it can be met. The following issues in this regard need to be studied and analysed when developing regional plans:

   a) VHF congestion problem (where, when);
   b) the need for integrated voice/data systems;
   c) ATM requirements and needed data link;
   d) assessment of available alternatives and their timeframe; and
   e) issues related to services provided by commercial entities.

6. ** ISSUES TO BE INVESTIGATED**

6.1 When assessing the scenarios presented in this appendix, the following issues must be addressed by ICAO or any other relevant organizations (e.g. RTCA):

   a) the availability of radiofrequency spectrum to support the future scenarios;
   b) the definition of an on-board architecture supporting the integration of the multiple communication systems considered in the scenarios;
   c) the suitability of the present and future communication systems considered in the scenarios to support the emerging ATM requirements and meet RCP levels;
   d) human factors considerations and human machine interfaces associated with the introduction of new systems; and
e) costs.
ATTACHMENT
(English only)

SCENARIO DIAGRAMS

On the diagrams the introduction of a service is associated with a trigger such as:

a) capacity: increase of the telecommunication infrastructure capacity;

b) quality: improve the quality of the voice exchanges;

c) coverage: improve the 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 CPDLC message ICAO SARPs compliant;

g) CPDLC Ph 2: second set of CPDLC message ICAO SARPs compliant; and

h) ARINC 623: DCL/PDC and ATIS data link applications character oriented.
Figure A1. Voice services in oceanic and low/medium air traffic density regions where only a limited ground-based communication infrastructure can be deployed.

Figure A2. Voice services in low/medium air traffic density regions where a full ground-based communication infrastructure can be deployed.
Figure A3. High density terrestrial region where a full ground-based communication infrastructure can be deployed
ADS-B

SSR Mode S Extended Squitter or VDL Mode 4 or UAT

Time

Figure A5. Data link surveillance services in oceanic and low/medium air traffic density regions where only a limited ground-based communication infrastructure can be deployed
Figure A6. Data link communications services in low/medium air traffic density regions where a full ground-based communication infrastructure can be deployed.

Figure A7. Data link surveillance services in low/medium air traffic density regions where a full ground-based communication infrastructure can be deployed.
Figure A8. Data link communications services in high density terrestrial regions where a full ground-based communication infrastructure can be deployed

Figure A9. Data link surveillance services in high density terrestrial regions where a full ground-based communication infrastructure can be deployed