ADS Guidance Material

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CHAPTER 3 - ADS APPLICATION

3.1 INTRODUCTION

3.1.1 Purpose

3.1.1.1 In line with normal ICAO practice, this document was developed as a companion document to the ATN Automatic Dependent Surveillance - ADS - SARPs. It may be read alongside the ATN ADS SARPs, in order to provide a greater understanding of the specification itself. Alternatively, readers who simply want to understand the purpose of the ADS Application rather than the detail of the specification may read it instead of the ATN ADS SARPs.

3.1.1.2 This document also provides some historical information on the development of the ADS Application and explanations as to why the ADS Application is specified the way it is, including corresponding notes and recommendations, in the SARPs.

3.1.2 Scope

3.1.2.1 This document provides guidance material for those implementing of the Automatic Terminal Information Service as part of the ATN Flight Information Service Application.

3.1.2.2 This document does not define any mandatory or optional requirements for the ADS Application, neither does it define any recommended practices. This document does not instruct users on how to use the ADS Application in a particular operational environment.

3.1.2.3 The ADS SARPs are dedicated to Air Traffic Services. Aeronautical Operational Control (AOC) may choose to use the ADS SARPs as a model for their own applications.

3.1.3 History

3.1.3.1 The ADS Panel has forged the requirements for the ADS application over a period of several years. These are laid out in a living document that is known as the ADS Manual (see [4]). The ADS SARPs were based on the operational requirements specified in the ADS manual.

3.1.3.2 At its first meeting, the ATN Panel established a working group (WG3) to develop SARPs for the applications and upper layers. The working group, in its turn, established a sub-group (SG2) to develop validated SARPs and guidance material for four applications – Context Management (CM), Automatic Dependent Surveillance (ADS), Controller Pilot Data Link Communications (CPDLC), and Flight Information Services (FIS).

3.1.3.3 The application SARPs were validated through a number of methods, but chiefly through the development of independent implementations of the applications, and the successful running of interoperability trials between them.

3.1.3.4 ICAO approved the SARPs Configuration Control Board (CCB), which was established to manage any changes required to the SARPs.

3.1.4 Structure of Guidance Material

3.1.4.1 Chapter 3.1 – INTRODUCTION - contains the reason for providing guidance material as well as the scope. In addition, it provides a brief overview of ADS functionality, ADS's relationship with other SARPs, and identifies applicable reference document.

3.1.4.2 Chapters 3.2 – OVERALL GENERAL FUNCTIONALITY - describes generic concepts that are used throughout the ADS SARPs and guidance material. This chapter also covers some implementation issues that are not addressed in the SARPs.

3.1.4.3 Chapter 3.3 - ADS SERVICE DESCRIPTION - gives a functional breakdown of the various services that ADS provides. It describes a peer to peer interaction, including reasons for why particular information is used or not used, and what operations on the information are expected.

3.1.4.4 Chapter 3.4 – ADS CHAPTER - clarifies any functionality that was not addressed in Chapter 3 on a chapter by chapter basis.

3.1.4.5 Chapter 3.5 - DIMENSIONS - gives some sample encoding sizes for guidance on what capacities need to be allowed for in order to meet normal operational expectations.

3.1.4.6 Chapter 3.6 - INDEXES / TABLES – contains an index of the ASN.1.

3.1.4.7 Chapter 3.7 - EXAMPLE SCENARIOS - gives some examples that describe typical scenarios one can expect in course of normal ADS operation.

3.1.4.8 Chapter 3.8 - EXAMPLE ENCODING - outlines some actual sample PER encoding of typical ADS messages.

3.1.5 ADS Application Overview

3.1.5.1 Summary

3.1.5.1.1 The ADS application is designed to give automatic reports to a user, that are derived from on-board navigation and position-fixing system, including aircraft identification, four-dimensional position and additional data as appropriate. The ADS reports give positional as well as other information likely to be of use to the air traffic management function, including air traffic control. The aircraft provides the information to the user under one of four circumstances:

a) under a contract (known as a demand contract) agreed with the ground system, the aircraft provides the information immediately and once only;

b) under a contract (known as a periodic contract) agreed with the ground system, the aircraft provides information on a regular basis;

c) under a contract (known as an event contract) agreed with the ground system, the aircraft provides information when certain events are detected by the avionics;

d) under emergency conditions the aircraft provides information on a regular basis with no prior agreement with the ground system (known as an emergency contract); an event or periodic contract must already exist before an emergency contract can be established.

3.1.5.1.2 In addition, the ADS application provides a means to forward ADS reports from the ground system that has contracts with an aircraft, to another ground system.

3.1.5.1.3 The avionics are capable of supporting contracts with at least four ATC ground systems simultaneously. Moreover, they are also capable of supporting one demand, one event and one periodic contract with each ground system simultaneously.

3.1.5.2 Establishment and Operation of a Demand Contract

3.1.5.2.1 This function allows the ground system to establish a demand contract with an aircraft, and then for the conditions of that contract to be realised. Realisation of the contract involves the sending of a single report from an aircraft to the ground system.

3.1.5.2.2 Any number of demand contracts may be sequentially established with an aircraft. Basic information is sent with the report (see 3.1.5.2.5). Optionally, at the request of the ground system, other information may also be sent (see 3.1.5.2.6).

3.1.5.2.3 The ground system sends a demand contract request to the avionics. This contains an indication of which optional information is required. The avionics then determines whether or not it is able to comply with the request. If the avionics can comply with the demand contract request, it sends the report as soon as possible. If the avionics cannot comply with the request, it sends a negative acknowledgement to the ground system indicating the reason for its inability to accept the contract.

3.1.5.2.4 If the avionics can partially comply with the request, it sends a noncompliance notification accepting those parts of the contract with which it can comply.

3.1.5.2.5 Each report always contains the following basic information:

a) the 3-D position of the aircraft;

b) the time;

c) an indication of the aircraft's navigational accuracy and ACAS status (figure of merit).

3.1.5.2.6 The demand contract stipulates which of the optional information fields are to be included in the ADS report. Optionally, a report contains an indication of:

a) the projected profile, indicating the position and predicted time of the next way point, and the position of the following way point;

b) the ground vector, indicating the track, ground speed and vertical rate;

c) the air vector, indicating the heading, air speed and vertical rate;

d) weather information, indicating wind speed, wind direction, temperature and turbulence;

e) the aircraft address (this is the 24 bit address unique to each airframe – not a network address);

f) the navigational intent, indicating the predicted location of the aircraft at some time in the future (as indicated in the demand contract) and, for any intermediate points where altitude, track or speed change is predicted to occur, the projected distance, track, altitude and time are given;

g) extended project profile, indicating the predicted position, altitude and time for the next several way points (as indicated in the demand contract).

3.1.5.3 Establishment and Operation of an Event Contract

3.1.5.3.1 This function allows the ground system to establish an event contract with the aircraft, and then for the conditions of that contract to be realised. Realisation of the contract involves the sending of reports from the aircraft to the ground system when certain contracted events occur.

3.1.5.3.2 Only one event contract may exist between the ground system and avionics at any one time, but this may contain multiple event types. A set of basic information is sent with every report, and depending on the event that triggered the sending of the report, other information may also be included. The contract that is agreed states the event types that are to trigger reports and also any values needed to clarify those event types.

3.1.5.3.3 It is possible to request one or more of the following event types:

a) Vertical rate change. This can be triggered in two ways. If the vertical rate threshold is positive, then the event is triggered when the aircraft's rate of climb is greater than the vertical rate threshold. If the vertical rate threshold is negative, then the event is triggered when the aircraft's rate of descent is greater than the absolute value of the vertical rate threshold.

b) Waypoint change. This is triggered by a change to the next waypoint. This change is normally due to routine way point sequencing, but could be triggered by a waypoint which is not part of the ATC clearance but is entered by the pilot for operational reasons.

c) Lateral deviation change. This is triggered when the absolute value of the lateral distance between the aircraft's actual position and the aircraft's expected position on the active flight plan becomes greater than the lateral deviation threshold.

d) Altitude range deviation. This is triggered when the aircraft's altitude becomes greater than the altitude ceiling or less than the altitude floor.

e) Airspeed change. This is triggered when the aircraft's airspeed differs negatively or positively from its value at the time of the previous ADS report containing an air vector, by an amount which is equal to the airspeed change threshold which is specified in the event contract request.

f) Ground speed change. This is triggered when the aircraft's ground speed differs negatively or positively from its value at the time of the previous ADS report containing a ground vector, by an amount which is equal to the ground speed threshold which is specified in the event contract request.

g) Heading change. This is triggered when the aircraft's heading differs negatively or positively from its value at the time of the previous ADS report containing an air vector, by an amount which is equal to the heading change threshold which is specified in the event contract request.

h) Extended projected profile change. This is triggered by a change to any of the set of future waypoints that define the active route of flight. The number of waypoints covered in the contract is either defined by a time interval (i.e. any waypoint planned to be achieved in the next N minutes), or by number of way points (i.e. any waypoint in the next N).

i) FOM (Figure of Merit) change. This is triggered by a change in the navigational accuracy, navigational system redundancy or traffic alert and collision avoidance system (ACAS) availability.

j) Track angle change. This is triggered when the aircraft's track angle differs negatively or positively from its value at the time of the previous ADS report containing a ground vector, by an amount which is equal to the track angle change threshold which is specified in the event contract request.

k) Altitude change. This is triggered when the aircraft's altitude differs negatively or positively from its value at the time of the previous ADS report, by an amount which is equal to the altitude change threshold which is specified in the event contract request.

3.1.5.3.4 Acceptance of an event contract request implicitly cancels an existing event contract, if one exists. That is, there is no concept of modifying an existing event contract.

3.1.5.3.5 The ground system sends an event contract request to the avionics. This contains the types of event to be reported on, and the necessary parameters for that event (e.g. if the event is an altitude range deviation, then the upper and lower thresholds must be sent). The avionics then determines whether or not it is able to comply with the request. If the avionics can comply with the event contract request it sends a positive acknowledgement immediately (possibly as part of an ADS report). If the contracted event occurs, an ADS report is sent.

3.1.5.3.6 If the avionics cannot comply with the request, it sends a negative acknowledgement to the ground system indicating the reason for its inability to accept the contract.

3.1.5.3.7 If the avionics can partially comply with the request, it sends a noncompliance notification accepting those parts of the contract with which it can comply.

3.1.5.3.8 For lateral deviation, altitude range and vertical rate change, if the event occurs, a report is sent every 60 seconds while the limit(s) specified in the contract are exceeded. For all other events, a single report is sent every time the event occurs.

3.1.5.3.9 The event contract request contains an indication of the events to be reported on, together with clarifying information as follows:

a) lateral deviation change - containing the lateral deviation threshold;

b) vertical rate change - containing the vertical rate threshold;

c) leaving a given altitude range - containing the upper and lower altitude thresholds;

d) way-point change - containing no further clarifying information;

e) air speed change - containing the airspeed change threshold;

f) ground speed change - containing ground speed change threshold;

g) heading change - containing heading change threshold;

h) extended projected profile change - containing either a projected time or a number of way points;

i) figure of merit change - containing no further clarifying information;

j) track angle change - containing the track angle change threshold;

k) altitude change - containing altitude change range.

3.1.5.3.10 The choice of additional optional information blocks in the ADS report is made as follows:

a) if the triggering event is a vertical rate change, a lateral deviation change, an altitude deviation change, a ground speed change, a track angle change or an altitude change, then the ADS report will contain the ground vector;

b) if the triggering event is a way point change, then the ADS report will contain the projected profile;

c) if the triggering event is an air speed change or heading change, then the ADS report will contain the air vector;

d) if the triggering event is an extended projected profile change, then the ADS report will contain the extended projected profile;

e) if the triggering event is a FOM change, then the ADS report will contain no additional information other than the basic information contained in every ADS report.

3.1.5.3.11 Some event contracts require the air system to report when some parameter differs from a previously reported value by some amount. If one or more of these event types are requested in the contract (and the air system can support them), then the air system will send back a baseline report at the time it accepts the contract. This baseline report contains values against which the event will be measured. For example, if the heading-change event is used, with a value of four degrees in the event contract, then the air system will immediately return a baseline report containing the air vector and ground vector. At some time in the future, if the aircraft's heading varies from the value stated in the air vector by more than four degrees, an event report will be triggered. Events that require a baseline report to be sent are:

a) air-speed-change;

b) ground-speed-change;

c) heading-change;

d) track-angle-change;

e) level-change.

3.1.5.4 Establishment and Operation of a Periodic Contract

3.1.5.4.1 This function allows the ground system to establish a periodic contract with the aircraft, and then for the conditions of that contract to be realised. Realisation of the contract involves the sending of reports from the aircraft to the ground system at regular intervals (the reporting rate). Only one periodic contract may exist between a ground system and the avionics at any one time.

3.1.5.4.2 A set of basic information is sent with every report. Optionally, at the request of the ground system, other information may also be sent; furthermore they may be sent at a time interval which is a multiple of the reporting rate. The contract that is agreed includes the reporting rate, the optional information to be sent and the rate at which they are to be sent.

3.1.5.4.3 The ground system sends a periodic contract request to the avionics. This contains the basic reporting rate and an indication of which optional information blocks are required and how often they are to be sent relative to the basic rate (i.e. every time, every second report, every third report etc.). The avionics then determines whether or not it is able to comply with the request. If the avionics can comply with the periodic contract request it sends its first report immediately, and then sends other reports at the intervals requested. If it cannot send the first report immediately, it sends a positive acknowledgement first to indicate its acceptance of the contract.

3.1.5.4.4 Acceptance of a periodic contract request implicitly cancels an existing periodic contract, if one exists. That is, there is no concept of modifying an existing periodic contract.

3.1.5.4.5 If the avionics cannot accept the contract, it sends a negative acknowledgement to the ground system indicating the reason for its inability to accept the contract.

3.1.5.4.6 If the avionics can partially comply with the request, it sends a noncompliance notification accepting those parts of the contract with which it can comply.

3.1.5.4.7 The periodic contract request may optionally contain any of the following information:

a) reporting interval;

b) flight id modulus;

c) projected profile modulus;

d) ground vector modulus;

e) air vector modulus;

f) weather modulus;

g) airframe id modulus;

h) navigational intent modulus and projection time;

i) extended projected profile modulus and projection time or the amount of information required.

3.1.5.4.8 Moduli indicate the multiple of the reporting rate that the information block is sent at (e.g. weather modulus of 5 means that the weather information block is sent with every 5th report).

3.1.5.5 Cancellation of Contracts

3.1.5.5.1 This function allows the ground system explicitly to cancel a contract that is in operation. The ground system sends a cancel contract message to the avionics. The avionics cancels the contract and acknowledges the cancellation.

3.1.5.5.2 Implicit cancellation occurs when a periodic contract is in place, and then the ground system establishes a new periodic contract - the first one is implicitly cancelled on the establishment of the second; similarly with event contracts. Demand contracts are implicitly cancelled as soon as the report is sent. There are no additional information flows associated with implicit cancellation.

3.1.5.5.3 The ground system may also cancel all contracts in a single cancel all contracts message. The avionics cancels all contracts and acknowledges the cancellation.

3.1.5.6 Establishment and Operation of Emergency Contracts

3.1.5.6.1 This function allows the avionics to initiate emergency mode (either on instruction from the pilot or on its own initiative), which establishes an emergency contract between the avionics and all ground systems with which it has a connection. Realisation of the contract involves the sending of ADS emergency reports from the avionics to the ground system at regular intervals (the reporting rate).

3.1.5.6.2 Any existing periodic contract is suspended pending the cancellation of the emergency contract. Normal operation of event contracts is maintained. Initially the emergency reporting rate is the lesser of 60 seconds or half any existing periodic contract rate (if one exists). The position, time and FOM are sent with each ADS report, and the aircraft address and ground vector sent with every fifth.

3.1.5.6.3 The avionics send reports to all ground systems with which it has event or periodic contracts at the emergency reporting rate.

3.1.5.6.4 The ADS emergency report has the same structure as normal ADS reports, except that the optional elements are fixed as described above.

3.1.5.7 Modifying an Emergency Contract

3.1.5.7.1 This function allows the reporting rate of an emergency contract to be modified.

3.1.5.7.2 The ground system sends an emergency contract modification message to the avionics. The avionics modifies the reporting rate of the emergency contract, and then sends the emergency reports at the new interval. This only effects the emergency contract between the ground system making the request and the aircraft.

3.1.5.7.3 If the avionics is unable to change the reporting rate, the avionics will send a negative acknowledgement.

3.1.5.8 Cancellation of Emergency Contract

3.1.5.8.1 This function allows the aircraft to cancel the emergency contracts.

3.1.5.8.2 The avionics sends a cancel emergency message to the ground. If there was a periodic contract in place before the emergency was declared, then it is reinstated immediately after the emergency mode is cancelled. When the aircraft performs this function, emergency contracts with each ground system that it is in contact with are cancelled.

3.1.5.8.3 It is possible that, during the operation of an emergency contract, the ground system either replaces the periodic contract (using ADS-periodic-contract request), or cancels a periodic contract (using ADS-cancel). It may also be possible that no periodic contract is in place and, during the operation of an emergency contract, the ground system requests a new periodic contract (using ADS-periodic-contract request). It may also be possible that several of these events occur sequentially during the operation of an emergency contract.

3.1.5.8.4 In any of these cases, once the emergency contract is cancelled by the aircraft system, the latest of these requests is put into operation. If the latest thing to happen is a new ADS-periodic-contract request, then it will be brought into affect immediately. If the latest thing to happen is an ADS-cancel request (for the periodic contract), then no periodic contract will be re-instated on completion of the emergency contract.

3.1.5.9 ADS Report Forwarding

3.1.5.9.1 This function provides a method for a ground system to forward ADS reports received from an aircraft to another ground system. This function is initiated by a ground system having established one or more successful ADS contracts.

3.1.5.9.2 The initiating system sends an ADS start forward request to the receiving system; this may contain the first ADS report.

3.1.5.9.3 Having established communication, the initiating system can forward as many reports as it needs to. An ADS forward report contains the identification of the aircraft that the report is related to and either a periodic, event, demand, or emergency report.

3.1.5.9.4 When it wishes to break the communication link, the initiating system sends an ADS end forward request. If, at any time during the communication, the receiving system wishes to break the communication link, it must abort the connection.

3.1.5.10 Aborts

3.1.5.10.1 This function allows the airborne system, the ground system or the communications system to abort a connection in cases where a serious problem has occurred.

3.1.5.10.2 If the communications part of the airborne or ground system, or the network itself, detects an error, either in itself or in the protocol arriving from its peer, it will initiate an ADS provider abort.

3.1.5.10.3 If the user part of the airborne or the ground system detects an error, it has the option of initiating an ADS user abort.

3.1.5.10.4 In either of these cases, the result is that the connection is closed down immediately. Some of the messages already transmitted, but not yet confirmed, may be lost in transit. There is nothing to prevent the ground system attempting to make contact with the aircraft immediately following this.

3.1.6 Inter-Relationships With Other SARPs

3.1.6.1 There is no interaction between the ADS SARPs and the other CNS/ATM-1 Applications SARPs.

3.1.6.2 The ADS SARPs make use of the Upper Layer Application SARPs [[3]] to perform dialogue service functions required by the ADS Application.

3.1.7 Structure of SARPs

3.1.7.1 All the air-ground SARPs are produced to a standard format. This has greatly helped the maintenance of document stability, commonality and presentation. The ADS SARPs are no different in basic layout from all other air-ground applications SARPs, except that the air-ground aspects of the application are in a separate section (2.2.1) to the ground-ground parts (2.2.2).

3.1.7.2 The ADS SARPs constitute the second part of sub-volume 2.

3.1.7.3 SARPs Section 2.2.1.1 - INTRODUCTION - gives a very brief, high level description of ADS, as an application enabling ADS services to be provided to a pilot via the exchange of messages between aircraft avionics and ground ADS systems. Since this overview contains no information directly related to the stipulation of specific standards, it is almost entirely written as series of informative notes.

3.1.7.4 SARPs Section 2.2.1.2 - GENERAL REQUIREMENTS - contains information and high level requirements for the maintenance of backward compatibility and error processing.

3.1.7.5 SARPs Section 2.2.1.3 - ABSTRACT SERVICE - defines the abstract service interface for the ADS Application. The ADS Application Service Element (ADS-ASE) abstract service is described from the viewpoint of the ADS-air-user, the ADS-ground-user and the ADS-service-provider.

3.1.7.6 SARPs Section 2.2.1.4 - FORMAL DEFINITION OF MESSAGES - describes the contents of all permissible ADS messages through definition of the ADS ASN.1 abstract syntax. All possible combinations of message parameters and their range of values are detailed.

3.1.7.7 SARPs Section 2.2.1.5 - PROTOCOL DEFINITION - splits up the specification of the ADS protocol into three parts: sequence diagrams for the services covered by the abstract service, protocol descriptions and error handling for the ADS Air and Ground-ASEs, and State Tables.

3.1.7.8 SARPs Section 2.2.1.6 - COMMUNICATION REQUIREMENTS - specifies the use of Packed Encoding Rules (PER) to encode/decode the ASN.1 message structures and stipulates the Dialogue Service requirements, including Quality of Service (QoS).

3.1.7.9 SARPs Section 2.2.1.7 - ADS USER REQUIREMENTS - describes the requirements imposed on the ADS-users concerning ADS messages and interfacing with the ADS-ASEs.

3.1.7.10 SARPs Section 2.2.1.8 - SUBSETTING RULES - specifies conformance requirements, which all implementations of the ADS protocol obey. The protocol options are tabulated, and indication is given as to whether mandatory, optional or conditional support is required to ensure conformance to the SARPs. These subsetting rules will permit applications to be tailored to suit individual ground implementations, commensurate with the underlying task, while still maintaining an acceptable level of interoperability.

3.1.7.11 SARPs Section 2.2.2 – ADS REPORT FORWARDING APPLICATION – is structured in eight chapters in the same way as 2.2.1.

3.1.8 References

[1] Automatic Dependent Surveillance Application, Annex 10, Volume III, Part 1, Chapter 3 (ATN), Appendix A, Sub-volume II - Air-Ground Applications, section 2.2.1

[2] Automatic Dependent Surveillance Report Forwarding Application, Annex 10, Volume III, Part 1, Chapter 3 (ATN), Appendix A, Sub-volume II - Air-Ground Applications, section 2.2.2

[3] Upper Layer Communications Service, Annex 10, Volume III, Part 1, Chapter 3 (ATN), Appendix A, Sub-volume IV

[4] Draft ICAO Manual of Air Traffic Service (ATS) Data Link Applications, ICAO ADS Panel, Draft version 0.4, 20 September 1996

[5] Introduction and System Level Requirements, Annex 10, Volume III, Part 1, Chapter 3 (ATN), Appendix A, Sub-volume I

3.2 OVERALL GENERAL FUNCTIONALITY

3.2.1 General

3.2.1.1 ADS is defined as two different applications – one handling the air-ground exchanges and the other handling the ground-ground exchanges. The former is called ADS, and the latter is called ADS Report Forwarding (sometimes abbreviated ARF).

3.2.2 Topology

3.2.2.1 Air-Ground Link

3.2.2.1.1 The primary connection that is made in ADS is between the aircraft and the ground system. The connection is always initiated by the ground system, by the process of setting up an ADS contract. In like manner, the ground system is always responsible for closing the connection down. During the connection, the airborne system is always reactive, apart from when an emergency is initiated. An emergency is initiated either by heuristics within the avionics, or by the pilot. In these circumstances, the airborne system automatically establishes an emergency contract with every ground system with which it has event or periodic contracts. For ground systems that have just requested a demand contract in a single shot, no emergency contract is established.

3.2.2.2 Ground Forwarding

3.2.2.2.1 A secondary connection type is available to allow forwarding of ADS reports on ground-based networks. One ATSU system may forward one or more ADS reports to another ATSU. The sending ATSU is responsible for both establishing and closing the connection. During the connection, the receiving system is purely a sink for information. No response is generated to anything. The only thing that the receiving system is capable of initiating is an abort.

3.2.2.3 Overall Topology

3.2.2.3.1 Figure 3.2-1 shows the overall topology of the ADS and ADS report forwarding applications. Each aircraft may have ADS contracts with a number of ground systems. Each ground system may have ADS contracts with a number of aircraft. When a ground system has one or more ADS contracts with an aircraft, these are supported over a transport connection between the two. Ground systems may also have connections with other ground systems in order to support the ADS report forwarding application.

3.2.2.3.2 Each air-ground connection can support several ADS contracts of different types at the same time. Thus if a ground system has an event and periodic contract with an aircraft, and also sends up occasional demand contracts, then all these will use the same connection.

3.2.2.3.3 Typically, a system will have some maximum limit of the number of connections it can have. An aircraft must be able to support at least four connections, with four different ground systems. However, there is no requirement that limits them to four. Operational scenarios have been identified that may require the use of all four connections for ATC purposes. It may be useful, for example, for an aircraft to support a fifth connection for AOC purposes – but at least four must be available for ATC purposes.

3.2.2.3.4 A ground system, on the other hand, will probably have a much larger maximum. The ADS application for a busy air traffic control centre may have to support hundreds of connections. In an area where there are few aircraft, there may only be a requirement for a few tens of connections.

3.2.2.3.5 So the maximum number of connections for a ground system is highly dependent upon the area where it is installed. An aircraft, on the other hand, must be able to support at least four, and there is no operational need that is anticipated for any more.

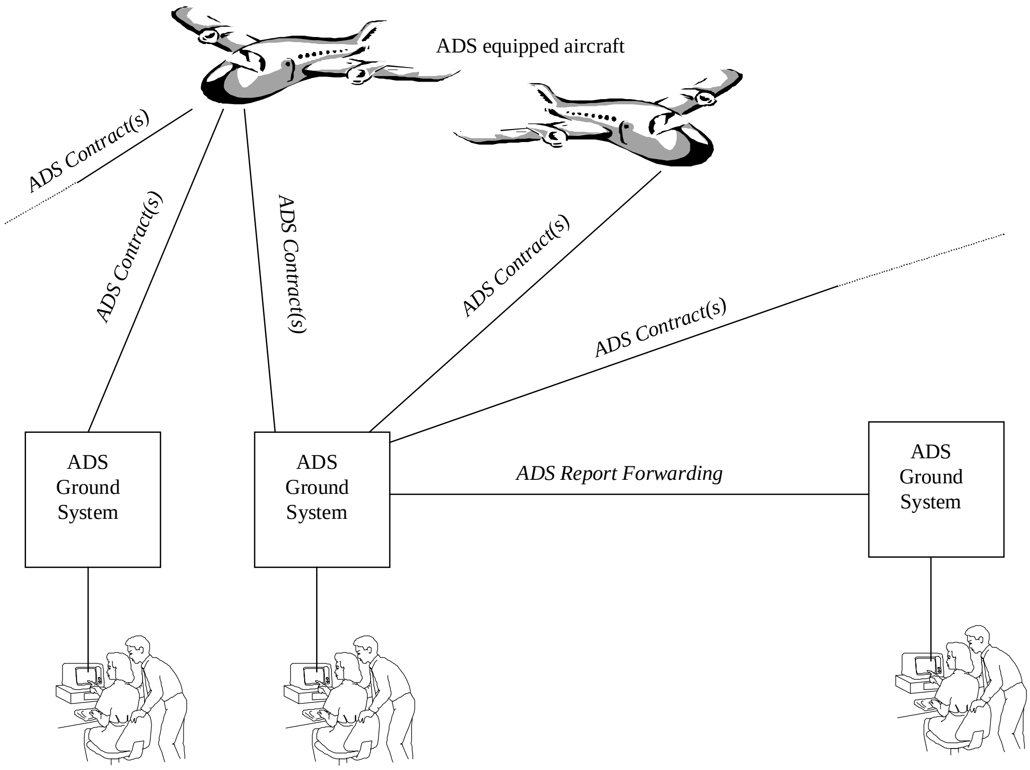

Figure 3.2-1. Overall Topology of the ADS and ADS Report Forwarding Applications

3.2.2.3.6 There is a requirement that an aircraft must be able to have contracts with at least four ground systems. However, there is nothing to prevent an aircraft system being able to support more than four. To avoid undue complication of the following text, the case of an aircraft supporting four ground systems has been assumed. The reader is invited to make his/her own adjustments if they are dealing with an aircraft that supports more than four ground systems.

3.2.2.3.7 In order for the airborne system to support contracts with *four* ground systems, it must be able to support at least *five* connections. Suppose that four ground systems (A, B, C and D) have contracts with an aircraft. A fifth ground system (E) issues a periodic contract (say) to the same aircraft. The airborne system must have the resources to receive the fifth connection, and then to refuse it. In doing so, it must inform ground system E that it is working at its maximum capacity, and it must also inform E of the ICAO facility designators of the systems A, B, C and D. Thus, if the aircraft is moving into the sector covered by E, the controller at E has enough information to call A, B, C or D (by telephone perhaps) and ask that they discontinue their contracts with the aircraft.

3.2.2.4 Central Server Architecture

3.2.2.4.1 The ADS application was designed to allow the direct connection of a ground system to an aircraft, and the subsequent forwarding of ADS reports to other ground systems. This provides the opportunity to develop a central ADS server for a region.

3.2.2.4.2 The concept of a central ADS server for a region is that a single ground system (the central ADS server) acts for all the ground based systems in the region for supply of ADS data. The central server would establish contracts with all aircraft in the region, and then forward reports to appropriate ground systems. For example, all reports concerning aircraft in a particular sector would be forwarded to the system operating for that sector.

3.2.2.4.3 For every aircraft entering the region, the central server would establish ADS contracts. Depending on the policy for the region, periodic and/or event reports could be established to monitor the progress of the aircraft. The central server would then be required to make a decision, for each ADS report received, where to forward it to. For example, it could be forwarded to the ground system where the aircraft's controller was operating, and, if the aircraft was close to a boundary, the neighbouring controller's systems as well.

3.2.2.4.4 The concept of a central server is beneficial since it reduces the use of air-ground bandwidth (only one connection is ever in place), and it only requires one system that has the full ADS functionality. All the other systems only require facilities to receive forwarded ADS reports.

3.2.2.4.5 In order for such a concept to work, the main constraint is that there must be a common policy regarding what contracts to set up. All systems must require the same type of contracts.

3.2.3 Internal Architecture

3.2.3.1 Type of ASE in ADS

3.2.3.1.1 The ADS application defines two types of ASE - the ADS-ASE and the ARF-ASE. The ADS-ASE has two variations - the ADS-air-ASE and the ADS-ground-ASE. These are used in all air to ground links. The ADS-ARF-ASE also has two variations - the initiating and the receiving ADS-ARF-ASE. These are used for the ADS report forwarding function.

3.2.3.2 ADS-ASE Functionality

3.2.3.2.1 The ADS-ASEs are responsible for all aspects of air-ground communication related to ADS. They encode and decode the PDUs. They maintain a state machine that only allows PDUs to be sent at an appropriate time, and detect if the peer application sends PDUs at an inappropriate time.

3.2.3.3 ARF-ASE Functionality

3.2.3.3.1 The ARF-ASEs are responsible for all aspects of ground based communication related to ADS. They encode and decode the PDUs. They maintain a state machine that only allows PDUs to be sent at an appropriate time, and detect if the peer application sends PDUs at an inappropriate time.

3.2.3.4 ADS-User Functionality

3.2.3.4.1 In the model of the ADS, there is a module called the ADS-user. The functionality of the ADS-user is described in 2.2.1.7. The ADS-ground-user is responsible for initiating the contracts and making the ADS-reports available to the end user. There are very few requirements placed on the ADS-ground-user. This allows the implementors a great deal of freedom in the method of implementation of this component.

3.2.3.4.2 The ADS-air-user is responsible for the operation of the ADS contracts. On receipt of the contract, it is responsible for responding to the request and then creating and submitting ADS reports in line with the contract. Most of the requirements for user functionality fall within the area of the ADS-air-user. There are few requirements for the ARF-users, and so the implementors have a great deal of scope in this area.

3.2.3.5 Product Architecture

3.2.3.5.1 The SARPs have defined an abstract model for the purposes of definition. That is, it has split the functionality between the ASE and the user and has defined an abstract interface between the two. It is strongly emphasised that there is no requirement on an implementor to build such an interface. If it is convenient, from an engineering perspective, to build an interface between two modules that embody the functionality of the ASE and the user, then the implementor is free to do so. However, if it is more convenient to build the system with interfaces in other places, then that is also acceptable. In testing a product to see if it conforms to the SARPs, no test can be made to test internal interfaces within the system.

3.2.3.5.2 Also note that the internal structure of the ATN ASE is not standardised across applications; for instance, ADS ASE is defined as several modules while CM is defined as a only one.

3.2.4 Implementation Dependent Functionality

3.2.4.1 The SARPs specify some of the requirements for the user, but leave a lot up to the implementors. There are no requirements that state how the user interface appears, how ADS interacts with the flight data processing systems, how ADS interacts with higher level functionality and with other applications such as CM and CPDLC. All this is implementation dependent.

3.2.4.2 It must be expected that between the functionality specified in the SARPs and the human user, there will be a wealth of features, probably exceeding the functionality of the SARPs. For example, there may be sets of standard contracts that are used under certain conditions that are automatically set up without the knowledge of the controller. The controller's screen may show the positions of aircraft based on a mixture of radar and ADS; automated functions may use ADS to extract information from the aircraft's flight management system and compare it with information stored in the filed flight plan. None of these features are described in the SARPs.

3.2.5 Rationale for ASE/User Split

3.2.5.1 The rationale for the split in functionality between the ASE, the user and the implementation dependent parts is as follows:

3.2.5.2 The ASE contains all the functionality that is necessary to ensure the interoperability at the syntactic level. That is, two valid implementations of ASEs will be able to interact, passing data to each other in the correct order. They will be able to check the format of the data, ensure that it has been sent at an appropriate point in the dialogue and ensure that the peer ASE is behaving according to the requirements in the SARPs also. The ASE thus ensures interoperability.

3.2.5.3 The SARPs defines some requirements for the user. These are the minima that are required to ensure the semantic interoperability of the two peers. That is, it explains how the data that is transported by the ASE is interpreted. Thus it explains how each type of contract is interpreted and how it operates.

3.2.5.4 Some care has been taken to ensure that the requirements are not over-specific. That is, they do not specify things that are not absolutely essential to the syntactic and semantic interoperability of the ADS function. Different manufacturers can build this implementation dependent part in different ways, without effecting the interoperability between different implementations. This implementation dependent part has not been specified in the SARPs, but will be specified by individual product manufacturers or regional standards.

3.2.6 Inter-relationship with other ATN Applications

3.2.6.1 There is no interaction required between the ADS Application and the other CNS/ATM-1 Data Link applications. The ADS application is a stand-alone application which can be developed, certified, installed and operated completely independently from the other ATN Applications.

3.2.6.2 There is a technical relationship between the ADS and CM applications. In order for a ground system to initiate the first contract with an aircraft, it must know the address of the ADS application in the aircraft. It is anticipated that this will normally be done using the CM application. When the aircraft approaches an FIR boundary, it will initiate CM. This will pass the address of the aircraft's ADS application to the ground system. Alternatively, the ground system from the previous FIR may pass the address of the ADS application using the CM-forward function. The ground system must have some way of storing the addresses it receives. Following this sequence of events, the ground system is able to initiate ADS contracts with the aircraft.

3.2.6.3 From a technical point of view, there is no relationship between the ADS application and either CPDLC or FIS. Operationally, they could be linked in a single service. For example, ADS could be used by the controller to obtain an extended projected profile. This could be used to compare the aircraft's flight plan with the filed flight plan. If there is a discrepancy, the ground system could used CPDLC to warn the aircrew of the discrepancy. Such operational linkage of the different applications is beyond the scope of the SARPs.

3.2.7 Ground ADS Exchanges

3.2.7.1 Functionality is defined in the SARPs to allow a ground system to forward the ADS reports that it has received to another ground system. The functionality of this ADS report forwarding function is very simple: The initiating system opens a connection with the receiving system. It then transmits ADS reports to the receiving system, and then closes the connection. Provided that the receiving system has implemented this functionality, it has no option but to receive the ADS reports. The only action the receiving system can take is to abort the connection.

3.2.7.2 The initiating system may send any ADS reports it has in any order. The reports are identified by the aircraft-id and each reports contain a time and date stamp. Thus the receiving system is able to identify the reports accurately, and is able to discard reports that are not relevant.

3.2.8 Dialogue Management

3.2.8.1 General

3.2.8.1.1 The term "dialogue" here refers to the end-to-end communication path provided by the Dialogue Service Provider. The Dialogue Service is described in detail in the ULA SARPs [3]. A dialogue is mapped directly onto a transport connection.

3.2.8.1.2 The dialogue is always initiated by the ground system, by the process of setting up an ADS contract. In like manner, the ground system is always responsible for closing the dialogue.

3.2.8.1.3 The dialogue service provider is used by the ADS-ASEs for the following purposes:

- establishment, graceful release and abort of a dialogue,
- transfer of unstructured data,
- support for quality of service and version number negotiation, and
- application naming.

3.2.8.2 Optimisation of the use of dialogues

3.2.8.2.1 The ADS service hides the use of the underlying communication service to the ADS-users. The ADS users are aware when contracts are established and cancelled. However, they are not necessarily aware of when dialogues are started and ended.

3.2.8.2.2 Multiplexing over a single dialogue of ADS contracts set up between a ground and an airborne ADS system is supported by the ADS protocol. One demand contract, one event contract, one emergency contract and one periodic contract can be multiplexed in parallel on a single dialogue (although a periodic contract is suspended during the operation of an emergency contract). The time required to establish the dialogue before any operational data can be exchanged penalises only the first ADS contract. The dialogue multiplexing is performed by the Low Interface Module.

3.2.8.3 Dialogue Establishment

3.2.8.3.1 When the establishment of a new ADS contract is requested by the ADS-ground-user, if no dialogue is already in place, then a dialogue is established. During this process, data related to the ADS contract are exchanged. During the time of the dialogue establishment, no new ADS service request can be accepted by the ADS-service provider (apart from ADS-user-abort).

3.2.8.3.2 On receipt of an ADS contract request, if a dialogue is already in place, it is used immediately for data transmission.

3.2.8.3.3 The SARPs prohibit an ADS-air-ASE from requesting the establishment of a dialogue.

3.2.8.4 Dialogue Release

3.2.8.4.1 The dialogue is closed when there are no contracts left in place, that is, when all contract have been completed or cancelled. Without explicit action from the pilot or a ground operator, the ground ADS system triggers the release of the dialogue.

3.2.8.4.2 The dialogue can be abruptly terminated by an abort condition from the ADS-ground-ASE at any time after the D-START request has been issued by the ADS-ground-ASE, and by the ADS-air-ASE at any time after the D-START indication has been received.

3.2.8.4.3 The SARPs prohibit an ADS-air-ASE from requesting the release of a dialogue.

3.2.9 Protocol Monitoring

3.2.9.1 General

3.2.9.1.1 The ADS ASE controls that the protocol is correctly handled by the peer and can be correctly operated locally. The generation and transmission of expected responses are monitored by the peer ADS ASE.

3.2.9.1.2 In case a serious error is detected, the dialogue in place with the peer ADS system is aborted and all contracts in place or being established are cancelled. Active ADS-users are informed of this situation by a ADS-provider-abort indication received at both side and providing a reason for the abort. These cases are described in the following sections.

3.2.9.2 Exception Handling

3.2.9.2.1 Service Timers

3.2.9.2.1.1 In case of a confirmed service (ADS-demand-contract, ADS-event-contract, ADS-periodic-contract, ADS-cancel-contract, ADS-cancel-all-contracts, ADS-modify-emergency-contract, and ADS-cancel-emergency-contract), the generation and the transmission of the response expected to be issued by the remote ADS-user or ADS-ASE are monitored by the ADS ASEs by activating a timer. If the APDU corresponding to the confirmation or ADS-report indication is not received by the requesting ADS ASE within a locally specified period of time, the dialogue is aborted. Both ads-users are informed of this situation by a ADS-provider-abort indication with a reason "timer expiry". This timer is a technical service timer and is not directly connected to any operational timers set, except that it ought to be sufficiently larger than any operational timer to prevent "nuisance" timer-expiration aborts.

3.2.9.2.1.2 The reception of the D-END confirmation is also monitored. If not received, the ultimate action is for the ADS-ground ASE to try to abort the dialogue. As the ADS-users are not active any more, no ADS-abort indication is generated.

3.2.9.2.2 An Unrecoverable Internal Error occurred

3.2.9.2.2.1 The unrecoverable system error is intended to cover cases where a fault causes a system lockup or the system to become unstable (e.g. the system get short of memory). If the system has enough resources to do it, it will abort the connection and inform both the local user and the peer of the situation with the abort reason "unrecoverable system error".

3.2.9.2.2.2 The unrecoverable system error is written as a recommendation in the SARPs instead of a requirement, a it is recognised that, depending on the nature of the error in the system, it may not be possible to regain control in order to either perform an abort, or inform the user of the abort situation.

3.2.9.2.3 The received primitive or APDU was not expected.

3.2.9.2.3.1 On receipt of a dialogue service indication or confirmation, the ASE checks that the APDU transmitted in the user data parameter of this primitive is authorised for this particular dialogue service primitive. If the received APDU is not authorised, this means that the peer made an error and is not running the protocol correctly. The dialogue is therefore aborted by the ASE receiving the APDU with the reason "invalid PDU".

3.2.9.2.3.2 On receipt of a dialogue service indication or confirmation, the ASE checks that the invoked dialogue service is authorised in its current state. If the primitive is not authorised, this means that the sequencing of the dialogue primitives defined for the ADS protocol has not been respected by the peer. The dialogue is therefore aborted by the ASE receiving the out of sequence primitive with the reason "sequence error".

3.2.9.2.4 The Start dialogue has been rejected by the peer

3.2.9.2.4.1 When the ADS-air-ASE receives a dialogue start indication it is required to accept the dialogue. If the ADS-ground-ASE receives a rejection of the dialogue start which was initiated by the airborne system, the airborne ADS system has not operated correctly. An abort indication is given to the ADS-ground-user with reason "sequence error".

3.2.9.2.4.2 If the ADS-ground-ASE receives a rejection of the dialogue start which was initiated by the dialogue service, an abort indication is given to the ADS-ground-user with reason "cannot establish contact".

3.2.9.2.5 The End dialogue has been rejected by the peer

3.2.9.2.5.1 When all contracts are completed, the D-END request is invoked to shut down the dialogue. Upon receipt of the corresponding D-END indication, the ADS-air-ASE's only choice is to accept the D-END by setting the D-END response *Result* parameter to the abstract value "accepted". If for some reason this value is not present (as checked in SARPs section 2.2.1.5.4.6.1), then the ADS-ground-ASE will abort the dialogue with reason "dialogue-end-not-accepted". Since there are no active users any more, no indication is given to the ADS-ground-user.

3.2.9.2.6 The expected APDU is missing

With the exception of the D-END primitives, if the user data parameter of a received indication or confirmation does not contain an APDU, this means that the peer has not run the ADS protocol correctly. The ASE fails to decode an APDU, and so the dialogue is aborted by the ASE receiving the empty primitive with the reason "decoding error".

3.2.9.2.7 The received APDU cannot be decoded

3.2.9.2.7.1 If the received PDU cannot be decoded, a decoding error is raised highlighting a transmission error or an encoding error by the APDU sender. The dialogue is therefore aborted by the ASE receiving the invalid APDU with the reason "decoding error".

3.2.9.2.8 The requested QOS does not match the one specified in the FIS SARPs

3.2.9.2.8.1 The ATN Sub-Volume 1 ([5]) dictates the values used for application service priority and RER quality of service parameters for all ATN applications. These values must be adhered to so proper levels of flight safety and performance are maintained. For ADS, the values used are "high priority flight safety messages" for application service priority and "low" for RER quality of service. If these values are not present (as checked in sections 2.2.1.5.4.8 and 2.2.2.5.4.7 of the SARPs), then the ADS ASE will abort with reason "invalid-QOS-parameter".

3.2.10 Version Number Negotiation

3.2.10.1.1 The current version of the SARPs identifies the version number to be 1. In the future, it can be anticipated that further operational requirements will emerge, and therefore there is a need to develop further versions of the ADS SARPs.

3.2.10.1.2 Although this SARPs is not able to put any requirements on future versions of the SARPs, some consideration has been given for the future: It can be foreseen that there will be a time when there will be a mixture of aircraft and ground system ADS applications in the world - some implemented to version 1 of the ADS SARPs, and some to version 2 (and possible version 3 and beyond).

3.2.10.1.3 When the CM application exchanges addresses, it also exchanges the version numbers of the applications that are running on the ground and in the aircraft. It is the responsibility of the ground system to ensure that it does not attempt to establish a contract with a system that is working on a different version of ADS.

3.2.10.1.4 When the ADS report forwarding application is run, the situation is somewhat different. There is no exchange of addresses and version numbers through CM. Therefore, the version number of the application is passed during initiation of the connection. The receiving application must check the version number, and ensure that it can work to the same version number that the sending application has. If it is working on a lower version number, it can refuse the connection and pass to the initiating system the version number that it is implemented to.

3.3 FUNCTIONALITY OF SERVICES

3.3.1 Introduction

3.3.1.1 This section describes first the information required by the ASEs from the ADS-users. Then, it considers ADS functions in turn and provides an overview of the data flow within the ASE which handles the service primitives.

3.3.2 Concepts

3.3.2.1 Users of the ADS service are termed *ADS-ground-user* and *ADS-air-user* or just *ADS-user* when it applies to both air and ground. The ADS-user represents the operational part of the ADS system. It is either the final end-user (e.g. a crew member or controller) or an automated system. The ADS-user that initiates a ADS air-ground or ground-ground service is termed the *calling* ADS-user or *initiator*. The ADS-user that the initiator is trying to contact is termed the *called* ADS-user or *responder*.

3.3.3 ADS Service Parameters

3.3.3.1 Aircraft Identifier

3.3.3.1.1 This parameter contains a 24 bit aircraft address which uniquely identifies an aircraft. The information is always provided by the ADS-ground-user when invoking an ADS-demand-contract, ADS-event-contract or ADS-periodic-contract request. The information is provided to the dialogue service provider and is used to locate the airborne ADS application address.

3.3.3.2 Class of Communications Service

3.3.3.2.1 This parameter contains the class of communications service required for the ADS contracts with a given aircraft. The information may be provided by the ADS-ground-user when invoking an ADS-demand-contract, ADS-event-contract or ADS-periodic-contract request. If the ADS-ground-user already has one or more contracts with the aircraft, the parameter is ignored. If there are no contracts in place with the aircraft, the information is provided to the dialogue service provider and is used to select the class of communications service that is provided. If there are no contracts in place with the aircraft and the parameter is not provided, the dialogue service provider selects the class of communications service to use.

3.3.3.3 Contract Details

3.3.3.3.1 This parameter contains the details of either a demand, event or periodic contract. The information is provided by the ADS-ground-user when invoking an ADS-demand-contract, ADS-event-contract or ADS-periodic-contract request. The information is delivered, unchanged, to the ADS-air-user and is used to determine the conditions of the contract.

3.3.3.4 Contract Type

3.3.3.4.1 This parameter contains an indication of the type of contract (demand, event or periodic). The information is provided by the ADS-air-user when invoking an ADS-report request, and by the ADS-ground-user when invoking an ADS-cancel-contract request (although in this latter case - the value of "demand contract" is not permitted). It is provided to the ADS-ground-user in the ADS-report indication for information purposes. It is provided to the ADS-air-user in the ADS-cancel-contract indication in order to indicate which contract to cancel.

3.3.3.5 Emergency Report Details

3.3.3.5.1 This parameter contains the emergency report that is provided as part of an emergency contract. The information is provided by the ADS-air-user when invoking an ADS-emergency-report request. It is provided to the ADS-ground-user for information.

3.3.3.6 Event Type

3.3.3.6.1 This parameter contains an indication of the type of event that has occurred in an event contract. The information is provided by the ADS-air-user when invoking an ADS-report request for an event contract. (Note that an event contract can require reports on more than one type of event, some of which may report the same information. It is therefore necessary to report which type of event occurred.) The information is provided to the ADS-ground-user for information.

3.3.3.7 ICAO Facility Designation

3.3.3.7.1 This parameter contains the four to eight character ICAO facility designation of the ground system that is initiating the request. The information is provided by the ADS-ground-user user when invoking an ADS-demand-contract, ADS-event-contract or ADS-periodic-contract request, but only when the ground system has no contracts in place with the aircraft already. The information is provided to the ADS-air-user. If, at a later stage, the ADS-air-user has to reject an attempt to make a contract because its capacity is exceeded (e.g. it can only have contracts with four ground systems, and it already has contracts with four ground systems), then the ADS-air-user supplies this information to the ADS-ground-user when delivering its negative acknowledgement.

3.3.3.8 Positive Acknowledgement

3.3.3.8.1 This parameter contains no information - it is either present or absent. It may be provided by the ADS-air-user when invoking an ADS-report request. It is present if the ADS-air-user wishes to acknowledge an ADS-demand, ADS-event or ADS-periodic contract. It is absent otherwise. The information is provided to the ADS-ground-ASE as input to its state machine, and also to the ADS-ground-user for information.

3.3.3.9 Positive Acknowledgement of Modification

3.3.3.9.1 This parameter contains no information - it is either present or absent. It may be provided by the ADS-air-user when invoking an ADS-emergency-report request. It is present if the ADS-air-user wishes to acknowledge an ADS-emergency-contract-modification request. It is absent otherwise. The information is provided to the ADS-ground-ASE as input to its state machine, and also to the ADS-ground-user for information.

3.3.3.10 Reason

3.3.3.10.1 This parameter indicates the reason for an abort. It is provided by an ADS ASE when invoking ADS-provider-abort indication. It is used by the ADS-user for information.

3.3.3.11 Reply

3.3.3.11.1 This parameter contains a positive acknowledgement, a noncompliance notification or a negative acknowledgement. It is provided by the ADS-air-user when invoking an ADS-demand-contract, ADS-event-contract or ADS-periodic contract response. The information is provided to the ADS-ground-ASE as input to its state machine, and also to the ADS-ground-user for information.

3.3.3.12 Report Details

3.3.3.12.1 This parameter contains the ADS report that is provided as part of a demand, event or periodic contract. The information is provided by the ADS-air-user when invoking an ADS-emergency-report request. It is provided to the ADS-ground-user for information.

3.3.3.13 Reporting Interval

3.3.3.13.1 This parameter contains a requested reporting interval for an emergency contract. The information is provided by the ADS-ground-user when invoking an ADS-modify-emergency-contract request. It is used by the ADS-air-user to select a new interval for providing emergency reports.

3.3.4 Demand Contract Service

3.3.4.1 The ADS-demand-contract service is used to set up an ADS demand contract between the ADS-ground-user and the ADS-air-user. It is initiated by the ADS-ground-user.

- The ADS-demand-contract request is passed to the ground HI module, which examines it to see which module to pass it to. The request is passed to the ground DC module.
- The ground DC module generates an ADS-demand-contract-PDU and passes it to the ground LI module. It also starts timer t-DC-1 in order to monitor the time before a reply is received.
- The ground LI module decides how to use the dialogue service. If a dialogue already exists, it makes use of that dialogue. It uses the D-DATA service to pass the APDU to the airborne system. If no dialogue exists, it uses the D-START service to pass the APDU.
- The APDU is passed, via the upper layers and the network and emerges in the air LI module.
- The air LI module examines the APDU in order to determine which module to pass it to. The APDU is passed to the air DC module.
- The air DC module recognises the APDU as an ADS-demand-contract-PDU and passes an ADS-demand-contract indication to the air HI module.
- The air HI module passes it to the ADS-air-user.

3.3.4.2 The ADS-air-user then processes the ADS-demand-contract indication.

- The ADS air user examines the demand contract and determines one of the following:
  - if it can fulfil the request in its entirety, or
  - if it can obtain some of the information requested, but not all, or
  - if it cannot fulfil the request.
- It then replies (respectively) with:
  - an ADS-report request (including a positive acknowledgement parameter), or
  - an ADS-demand-contract indication (indicating noncompliance indicating the items of information that it is not able to supply), followed by an ADS-report request, or
  - an ADS-demand-contract indication (indicating negative acknowledgement).

3.3.4.3 The reply is then send to the ADS-ground-user.

- On receipt of an ADS-demand-contract response and/or ADS-report request, the ADS HI module decides where to pass it, and passes it to the air DC module.
- The air DC module then formulates the appropriate PDU (ADS-demand-report-PDU, ADS-noncompliance-notification-PDU, or ADS-negative-acknowledgement-PDU) and passes it to the air LI module.
- The air LI module then passes the PDU to the ground using a D-DATA request (if a connection is already open) or a D-START response (if no D-START response has yet been given).
- The upper and lower layers then pass the PDU to the ground ADS ASE.
- The ground LI module examines the PDU and determines that it must be passed to the ground DC module.
- The ground DC module stops the t-DC-1 timer, decodes the PDU and generates an ADS-report indication, or an ADS-demand-contract confirmation (depending on which type of PDU it was passed). This is passed to the ground HI module.
- The ground HI module then passes the ADS-report indication or the ADS-demand-contract response to the ADS ground user.
- If a noncompliance notification was sent, the actions described in this section will occur twice, once for the ADS-noncompliance-notification-PDU, and once for the ADS-demand-report-PDU.

3.3.4.4 An ADS demand contract cannot be cancelled. A second ADS contract cannot be initiated until the first has responded either with a negative acknowledgement, or an ADS report.

3.3.4.4.1 It must be noted that the ADS demand contract service is different to the ADS periodic and event contracts in one major respect. In the later, it is possible to reply to the ADS contract request with a positive acknowledgement, and then later on provide the ADS report. This allows a periodic or event report to be set up over, say, a thirty second timeframe before the first report is sent. The demand contract, on the other hand, does not have this option.

3.3.4.4.2 The operational requirement for the demand contract is that the information is provided as soon as possible. Thus its intended use is for a ground system that requires "instant" information. Normal operational use of ADS is intended to be through periodic and event contract. The periodic contract, therefore, does not allow the possibility of delaying the provision of the ADS report. If some element that is requested from the report is not available immediately, then the ADS air user responds with a noncompliance notification, and send what information it does have immediately.

3.3.5 Event Contract Service

3.3.5.1 The ADS-event-contract service is used to set up an ADS event contract between the ADS-ground-user and the ADS-air-user. It is initiated by the ADS-ground-user.

- The ADS-event-contract request is passed to the ground HI module, which examines it to see which module to pass it to. The request is passed to the ground EC module.
- The ground EC module generates an ADS-event-contract-PDU and passes it to the ground LI module. It also starts timer t-EC-1 in order to monitor the time before a reply is received.
- The ground LI module decides how to use the dialogue service. If a dialogue already exists, it makes use of that dialogue. It uses the D-DATA service to pass the APDU to the airborne system. If no dialogue exists, it uses the D-START service to pass the APDU.
- The APDU is passed, via the upper layers and the network and emerges in the air LI module.
- The air LI module examines the APDU in order to determine which module to pass it to. The APDU is passed to the air EC module.
- The air EC module recognises the APDU as an ADS-event-contract-PDU and passes an ADS-event-contract indication to the air HI module.
- The air HI module passes it to the ADS-air-user.

3.3.5.2 The ADS-air-user then processes the ADS-event-contract indication.

- The ADS air user examines the event contract and determines one of the following:
    - if it can fulfil the request in its entirety, or
    - if it can fulfil the request in its entirety, but cannot respond with the first report within half a second, or
    - if it can obtain some of the information requested, but not all, or
    - if it cannot fulfil the request.

- It then replies (respectively) with:
  - an ADS-report request (including a positive acknowledgement parameter), or
  - an ADS-event-contract indication (indicating positive acknowledgement), followed by an ADS-report request when the information is available, or
  - an ADS-event-contract indication (indicating noncompliance), followed by an ADS-report request indicating the items of information that it is not able to supply, or
  - an ADS-event-contract indication (indicating negative acknowledgement).

3.3.5.3 The reply is then send to the ADS-ground-user.

- On receipt of an ADS-event-contract response and/or ADS-report request, the ADS HI module decides where to pass it, and passes it to the air EC module.
- The air EC module then stops the t-EC-1 timer, formulates the appropriate PDU (ADS-event-report-PDU, ADS-positive-acknowledgement-PDU, ADS-noncompliance-notification-PDU, or ADS-negative-acknowledgement-PDU) and passes it to the air LI module.
- The air LI module then passes the PDU to the ground using a D-DATA request (if a connection is already open) or a D-START response (if no D-START response has yet been given).
- The upper and lower layers then pass the PDU to the ground ADS ASE.
- The ground LI module examines the PDU and determines that it must be passed to the ground EC module.
- The ground EC module decodes the PDU and generates an ADS-report indication, or an ADS-event-contract confirmation (depending on which type of PDU it was passed). This is passed to the ground HI module.
- The ground HI module then passes the ADS-report indication or the ADS-event-contract response to the ADS ground user.
- If a noncompliance notification or a positive acknowledgement was sent, the actions described in this section will occur twice, once for the ADS-noncompliance-notification-PDU or ADS-positive-acknowledgement-PDU, and once for the ADS-event-report-PDU.

3.3.5.4 The ADS-air-user then continues to fulfil the terms of the ADS contract by sending ADS-reports when one of the specified events occur.

- On receipt of an ADS-report request, the ADS HI module decides where to pass it, and passes it to the air PC module.
- The air EC module then formulates the ADS-periodic-report-PDU and passes it to the air LI module.
- The air LI module then passes the PDU to the ground using a D-DATA.

- The upper and lower layers then pass the PDU to the ground ADS ASE.

- The ground LI module examines the PDU and determines that it must be passed to the ground EC module.

- The ground EC module decodes the PDU and generates an ADS-report indication. This is passed to the ground HI module.

- The ground HI module then passes the ADS-report indication to the ADS ground user.

3.3.5.5 At any time during the lifetime of the contract, the ADS ground user may cancel the event contract by invoking the ADS-cancel service.

- On receipt of an ADS-cancel request, the ground HI module decides where to pass it, and passes it to the ground EC module.

- The ground EC module then formulates the ADS-cancel-contract-PDU and passes it to the ground LI module.

- The ground EC module starts the t-EC-2 timer.

- The ground LI module then passes the PDU to the air using a D-DATA.

- The upper and lower layers then pass the PDU to the air ADS ASE.

- The air LI module examines the PDU and determines that it must be passed to the ground EC module.

- The air EC module decodes the PDU and generates an ADS-cancel indication. This is passed to the air HI module.

- The air HI module then passes the ADS-cancel indication to the ADS air user.

- The air EC module then creates an ADS-positive-acknowledgement-PDU and passes it to the air LI module.

- The air LI module then passes the PDU to the ground using a D-DATA.

- The upper and lower layers then pass the PDU to the ground ADS ASE.

- The ground LI module examines the PDU and determines that it must be passed to the ground EC module.

- The ground EC module stops the t-EC-2 timer, decodes the PDU and generates an ADS-cancel confirmation. This is passed to the ground HI module.

- The ground HI module then passes the ADS-cancel confirmation to the ADS ground user.

3.3.6 Periodic Contract Service

3.3.6.1 The ADS-periodic-contract service is used to set up an ADS periodic contract between the ADS-ground-user and the ADS-air-user. It is initiated by the ADS-ground-user.

- The ADS-periodic-contract request is passed to the ground HI module, which examines it to see which module to pass it to. The request is passed to the ground PC module.
- The ground PC module generates an ADS-periodic-contract-PDU and passes it to the ground LI module. It also starts timer t-PC-1 in order to monitor the time before a reply is received.
- The ground LI module decides how to use the dialogue service. If a dialogue already exists, it makes use of that dialogue. It uses the D-DATA service to pass the APDU to the airborne system. If no dialogue exists, it uses the D-START service to pass the APDU.
- The APDU is passed, via the upper layers and the network and emerges in the air LI module.
- The air LI module examines the APDU in order to determine which module to pass it to. The APDU is passed to the air PC module.
- The air PC module recognises the APDU as an ADS-periodic-contract-PDU and passes an ADS-periodic-contract indication to the air HI module.
- The air HI module passes it to the ADS-air-user.

3.3.6.2 The ADS-air-user then processes the ADS-periodic-contract indication.

- The ADS air user examines the periodic contract and determines one of the following:
    - if it can fulfil the request in its entirety, or
    - if it can fulfil the request in its entirety, but cannot respond with the first report within half a second, or
    - if it can obtain some of the information requested, but not all, or
    - if it cannot fulfil the request.
- It then replies (respectively) with:
    - an ADS-report request (including a positive acknowledgement parameter), or
    - an ADS-periodic-contract indication (indicating positive acknowledgement), followed by an ADS-report request when the information is available, or
    - an ADS-periodic-contract indication (indicating noncompliance), followed by an ADS-report request indicating the items of information that it is not able to supply, or
    - an ADS-periodic-contract indication (indicating negative acknowledgement).

3.3.6.3 The reply is then send to the ADS-ground-user.

- On receipt of an ADS-periodic-contract response and/or ADS-report request, the ADS HI module decides where to pass it, and passes it to the air PC module.

- The air PC module then formulates the appropriate PDU (ADS-periodic-report-PDU, ADS-positive-acknowledgement-PDU, ADS-noncompliance-notification-PDU, or ADS-negative-acknowledgement-PDU) and passes it to the air LI module.

- The air LI module then passes the PDU to the ground using a D-DATA request (if a connection is already open) or a D-START response (if no D-START response has yet been given).

- The upper and lower layers then pass the PDU to the ground ADS ASE.

- The ground LI module examines the PDU and determines that it must be passed to the ground PC module.

- The ground PC module stops the t-PC-1 timer, decodes the PDU and generates an ADS-report indication, or an ADS-periodic-contract confirmation (depending on which type of PDU it was passed). This is passed to the ground HI module.

- The ground PC module starts the t-PC-2 timer.

- The ground HI module then passes the ADS-report indication or the ADS-periodic-contract response to the ADS ground user.

- If a noncompliance notification or a positive acknowledgement was sent, the actions described in this section will occur twice, once for the ADS-noncompliance-notification-PDU or ADS-positive-acknowledgement-PDU, and once for the ADS-periodic-report-PDU.

3.3.6.4 The ADS-air-user then continues to fulfil the terms of the ADS contract by sending ADS-reports at regular intervals.

- On receipt of an ADS-report request, the ADS HI module decides where to pass it, and passes it to the air PC module.

- The air PC module then formulates the ADS-periodic-report-PDU and passes it to the air LI module.

- The air LI module then passes the PDU to the ground using a D-DATA.

- The upper and lower layers then pass the PDU to the ground ADS ASE.

- The ground LI module examines the PDU and determines that it must be passed to the ground PC module.

- The ground PC module decodes the PDU and generates an ADS-report indication. This is passed to the ground HI module; while doing this is stops the t-PC-2 timer, resets it, and starts it again.

- The ground HI module then passes the ADS-report indication to the ADS ground user.

3.3.6.5 At any time during the lifetime of the contract, the ADS ground user may cancel the periodic contract by invoking the ADS-cancel service.

- On receipt of an ADS-cancel request, the HI module decides where to pass it, and passes it to the ground PC module.
- The ground PC module then formulates the ADS-cancel-contract-PDU and passes it to the ground LI module.
- The ground PC module starts the t-PC-3 timer.
- The ground LI module then passes the PDU to the air using a D-DATA.
- The upper and lower layers then pass the PDU to the air ADS ASE.
- The air LI module examines the PDU and determines that it must be passed to the ground PC module.
- The air PC module decodes the PDU and generates an ADS-cancel indication. This is passed to the air HI module.
- The air HI module then passes the ADS-cancel indication to the ADS air user.
- The air PC module then creates an ADS-positive-acknowledgement-PDU and passes it to the air LI module.
- The air LI module then passes the PDU to the ground using a D-DATA.
- The upper and lower layers then pass the PDU to the ground ADS ASE.
- The ground LI module examines the PDU and determines that it must be passed to the ground PC module.
- The ground PC module stops the t-PC-3 timer, decodes the PDU and generates an ADS-cancel confirmation. This is passed to the ground HI module.
- The ground HI module then passes the ADS-cancel confirmation to the ADS ground user.

3.3.7 Emergency Contract Service

3.3.7.1 While the ADS air user has ADS contracts in place, it may choose to initiate an emergency contract. This will be initiated either by one of the aircrew, or the avionics on detection of a problem. The ADS air user invokes ADS-emergency-report requests at regular intervals.

- On receipt of an ADS-emergency-report request, the ADS HI module decides where to pass it, and passes it to the air EM module.
- The air EM module then formulates the ADS-emergency-report-PDU and passes it to the air LI module. It also requests the PC module to suspend operation of its periodic contract, if it has one in place.
- The air LI module then passes the PDU to the ground using a D-DATA.

- The upper and lower layers then pass the PDU to the ground ADS ASE.

- The ground LI module examines the PDU and determines that it must be passed to the ground EM module.

- The ground EM module decodes the PDU and generates an ADS-emergency-report indication. This is passed to the ground HI module. It also requests the PC module to suspend operation of its periodic contract, if it has one in place.

- If the t-EM-1 timer is running, the ground EM module stops it, resets it and restarts it.

- The ground HI module then passes the ADS-emergency-report indication to the ADS ground user.

- This action is repeated at regular intervals. (The EM modules only request the PC modules to suspend operation for the first time through.)

3.3.7.2 The ADS-modify-emergency-contract service is used to change the reporting interval for emergency contracts. It is initiated by the ADS-ground-user.

- The ADS-modify-emergency-contract request is passed to the ground HI module, which examines it to see which module to pass it to. The request is passed to the ground EM module.

- The ground EM module generates an ADS-modify-emergency-contract-PDU and passes it to the ground LI module. It also starts timer t-EM-2 in order to monitor the time before a reply is received.

- The ground LI module uses the D-DATA service to pass the APDU to the airborne system.

- The APDU is passed, via the upper layers and the network and emerges in the air LI module.

- The air LI module examines the APDU in order to determine which module to pass it to. The APDU is passed to the air EM module.

- The air EM module recognises the APDU as an ADS-modify-emergency-contract-PDU and passes an ADS-modify-emergency-contract indication to the air HI module.

- The air HI module passes it to the ADS-air-user.

3.3.7.3 The ADS-air-user then processes the ADS-modify-emergency-contract indication.

- The ADS air user examines the ADS-modify-emergency-contract indication and determines one of the following:

    - if it can change to the request reporting rate, or

    - if it cannot fulfil the request.

- It then replies (respectively) with:
  - an ADS-emergency-report request (including a positive acknowledgement parameter), or
  - an ADS-modify-emergency-contract response (indicating negative acknowledgement).

3.3.7.4 The reply is then send to the ADS-ground-user.

- On receipt of an ADS-modify-emergency-contract response and/or ADS-emergency-report request, the ADS HI module decides where to pass it, and passes it to the air EM module.
- The air EM module then formulates the appropriate PDU (ADS-emergency-report-PDU or ADS-negative-acknowledgement-PDU) and passes it to the air LI module.
- The air LI module then passes the PDU to the ground using a D-DATA request.
- The upper and lower layers then pass the PDU to the ground ADS ASE.
- The ground LI module examines the PDU and determines that it must be passed to the ground EM module.
- The ground EM module stops the t-EM-2 timer, decodes the PDU and generates an ADS-emergency-report indication, or an ADS-modify-emergency-contract confirmation (depending on which type of PDU it was passed). This is passed to the ground HI module.
- The ground HI module then passes the ADS-emergency-report indication or the ADS-modify-emergency-contract confirmation to the ADS ground user.

3.3.7.5 At any time during the lifetime of the emergency contract, the ADS air user may cancel the emergency contract by invoking the ADS-cancel-emergency service.

- On receipt of an ADS-cancel-emergency request, the HI module decides where to pass it, and passes it to the air EM module.
- The air EM module then starts the t-EM-3 timer, formulates the ADS-cancel-emergency-PDU and passes it to the air LI module.
- The air LI module then passes the PDU to the air using a D-DATA.
- The upper and lower layers then pass the PDU to the ground ADS ASE.
- The ground LI module examines the PDU and determines that it must be passed to the ground EM module.
- The ground EM module stops the t-EM-1 timer, decodes the PDU and generates an ADS-cancel-emergency indication. This is passed to the ground HI module.
- The ground HI module then passes the ADS-cancel-emergency indication to the ADS ground user.

- The ground EM module then creates an ADS-positive-acknowledgement-PDU and passes it to the ground LI module.
- The ground LI module then passes the PDU to the air using a D-DATA.
- The upper and lower layers then pass the PDU to the air ADS ASE.
- The air LI module examines the PDU and determines that it must be passed to the air EM module.
- The air EM module stops the t-EM-3 timer, decodes the PDU and generates an ADS-cancel-emergency confirmation. This is passed to the air HI module.
- The air HI module then passes the ADS-cancel-emergency confirmation to the ADS air user.

3.3.8 Abort Service

3.3.8.1 At any time while there are contracts in place, the ADS ground user or the ADS air user may abort the connection by invoking the ADS-user-abort service. The following description describes the action being initiated by the ADS ground user. The ADS air user can ipso facto initiate the sequence of events.

- On receipt of an ADS-user-abort request, the HI module decides where to pass it, and passes it to the ground AB module.
- The ground AB module then requests the ground LI module to abort. It also requests all other modules to cease operation.
- The ground LI module invokes D-U-ABORT request.
- The upper and lower layers then pass the request to the air ADS ASE.
- The air LI module examines the PDU and determines that it must be passed to the air AB module.
- The air AB module generates an ADS-user-abort indication. This is passed to the air HI module. It also requests all other modules to cease operation.
- The air HI module then passes the ADS-user-abort indication to the ADS air user.

3.3.8.2 If any of the modules within the air ASE or the ground ASE detects a problem, either in itself, or in the response it has got from its peer, it can abort the connection. The following description describes the action being initiated by the ADS ground ASE. The ADS air ASE can ipso facto initiate the sequence of events.

- The module detecting the error requests the ground AB module to abort.
- The ground AB module then creates an ADS-provider-abort-PDU, and passes it to the ground LI module. It also creates an ADS-provider-abort indication and passes it to the ground HI module. It requests all other modules to cease operation.
- The ground HI module invokes the ADS-provider-abort indication.

- The ground LI module invokes D-U-ABORT request.
- The upper and lower layers then pass the request to the air ADS ASE.
- The air LI module examines the PDU and determines that it must be passed to the air AB module.
- The air AB module generates an ADS-provider-abort indication. This is passed to the air HI module. It also requests all other modules to cease operation.
- The air HI module then passes the ADS-provider-abort indication to the ADS air user.

3.3.8.3 If the upper or lower layers detect an error, then they will generate a D-P-ABORT indication at both the ADS air ASE and the ADS ground ASE.

- The air and ground LI modules determine that the D-P-ABORT must be passed to the air AB module.
- The air and ground AB modules generate an ADS-provider-abort indication. These are passed to the air and ground HI modules. They also request all other modules to cease operation.
- The air and ground HI modules then pass the ADS-provider-abort indication to the ADS air and ground users.

3.3.8.4 A full list of errors that generate an abort can be found in section 3.2.9.

3.3.9 Cancel All Contracts Service

3.3.9.1 The ADS-Cancel-all-contracts service is used by the ADS ground user to cancel all the contracts that the ground user has with the aircraft.

- On receipt of an ADS-cancel-all-contracts request, the HI module decides where to pass it, and passes it to the ground LI module.
- The ground LI module then creates an ADS-cancel-all-contracts-PDU and passes it to the air using a D-END.
- The upper and lower layers then pass the PDU to the air ADS ASE.
- The air LI module examines the PDU and passes an ADS-cancel-all-contracts indication to the air HI module.
- The air HI module then passes the ADS-cancel-all-contracts indication to the ADS air user.
- The air LI module then invokes D-END response.
- The upper and lower layers then pass the response to the ground ADS ASE.
- The ground LI module creates an ADS-cancel-all-contracts confirmation and passes it to the ground HI module.

- The ground HI module then passes the ADS-cancel-all-contracts confirmation to the ADS ground user.

3.3.10 Automated Connection Closure

3.3.10.1 After completion of any actions resulting from the arrival of a PDU from the aircraft, the ground LI module checks the status of all modules. If there are no contracts current, it closes the connection with the aircraft.

- The ground LI module invokes D-END request.
- The upper and lower layers then pass the request to the air ADS ASE.
- The air LI module invokes D-END response.
- The upper and lower layers then pass the request to the ground ADS ASE.

3.3.11 ADS Report Forwarding

3.3.11.1 The ADS-start-forward service is used to initiate the forwarding of ADS reports to another ground system.

- The ADS user invokes ADS-start-forward request.
- The ARF ASE in the initiating system creates an APDU and invokes D-START request.
- The ARF ASE in the receiving system receives the D-START indication checks the version number of the initiating system to see if it is compatible.
- If the version numbers are compatible, the ARF ASE in the receiving system then invokes ADS-start-forward indication and D-START response (accepting the connection).
- The ARF ASE in the initiating system receives the D-START confirmation and invokes ADS-start-forward confirmation.

3.3.11.2 The ADS-forward-report service is used to forward an ADS reports to another ground system. It is invoked by the initiating system, and may be invoked repeatedly once the connection is set up.

- The ADS user invokes ADS-forward-report request.
- The ARF ASE in the initiating system creates an APDU and invokes D-DATA request.
- The ARF ASE in the receiving system receives the D-DATA indication and invokes ADS-forward-report indication.

3.3.11.3 The ADS-end-forward service is used to complete the forwarding of ADS reports to another ground system.

- The ADS user invokes ADS-end-forward request.
- The ARF ASE in the initiating system invokes D-END request.
- The ARF ASE in the receiving system receives the D-END indication, invokes ADS-end-forward indication, and invokes D-END response (accepting the closure).
- The ARF ASE in the initiating system receives the D-END confirmation.

3.4 ADS SARPs Section Description

3.4.1 SARPs Section 2.2.1.2 – General Requirements

3.4.1.1 SARPs Section 2.2.1.2.1 - Version Number

3.4.1.1.1 This section is included to allow the CM application to exchange version numbers of the ADS application. It is necessary to allow for future versions of the protocol to be negotiated by CM. It has no effect on the ADS functionality.

3.4.1.2 SARPs Section 2.2.1.2.2 - Error Processing Requirements

3.4.1.2.1 In the abstract service definition, each service has a set of parameters and the abstract syntax of those parameters specified. Thus information which is not a valid syntax is not allowed to be input.

3.4.1.2.2 In the protocol definition, there is a requirement that no service is permitted to be called when the ASE is in an inappropriate state. Thus making use of the abstract services is not permitted at these times.

3.4.1.2.3 An implementation would not normally allow the user to take such invalid actions; however, there is no requirement to prevent an implementation from allowing this. The error processing requirements section thus says that *if* the implementation allows the user to enter invalid information, the system must inform the user that an entry error has occurred.. In that case, the error is locally detected and the dialogue does not need to be aborted.

3.4.2 SARPs Section 2.2.1.3 – The Abstract Service

3.4.2.1 The Concept of an Abstract Service

3.4.2.1.1 Section 2.2.1.3 concerns the ADS abstract service. The following paragraphs provide an explanations of the term "Abstract Service".

3.4.2.1.2 In order to define the ADS ASE (i.e. the part of the ADS abstract service provider that contains the protocol machine – see section 2.2.1.5 of the SARPs), it is necessary to describe its reactions to both PDUs arriving from the peer application, and the inputs from the user. The PDUs are well defined in the protocol. The actions of the user, however, are not. The SARPs do not attempt to dictate the actions of the user except where absolutely necessary. Despite this, in order to define the ASE it is necessary to have a clear definition of user actions.

3.4.2.1.3 In order to get around this conundrum, an "abstract service" is defined. An abstract service is a textual description of the interactions between the user and the ASE. These interactions are precisely defined in section 2.2.1.3 of the SARPs. Having this definition allows the ASE to be specified precisely in terms of its reactions to the arrival of PDUs and the invocation of the services by the user. This, therefore, is the reason for defining the abstract service.

3.4.2.1.4 The abstract service interface is defined as being an interface between the ASE and the "user-part" of the software. These are known as the ADS ASE and the ADS user. The ADS user is *not* generally the human user; it is that part of the system that uses the ADS ASE.

3.4.2.2 The Concept of APIs

3.4.2.2.1 If one was to buy an ADS application, one would be buying a suite of executable code. From the code itself it is impossible to know whether or not the abstract service interface has actually been implemented. Therefore the ADS SARPs do not require that the abstract service interface has to be built. It only requires that, when one examines it from an external point of view, it behaves in the same way as if it had been built. This is the explanation of statement 2.2.1.3.1.1 in the SARPs.

3.4.2.2.2 Thus the implementors may choose to build an ADS application with a real internal interface that corresponds to the abstract service interface, or they may choose not to – it is entirely up to them. However, it must be realised that there are a number of good reasons why one might not want to build a system with an interface exactly like the abstract service interface. Examples include:

- There may be a more efficient way of building the software.
- The abstract service interface does not include parameters that are needed locally, but do not affect the state machine; for example, a real interface might include an indication of which aircraft an ADS report has come from.
- It may not be easy to build the abstract service from the development tools that are being used.
- The abstract service interface does not have any programming language bindings. A real interface would require an interface defined in a particular programming language.

3.4.2.2.3 Implementation of the abstract service interface is not mandated by the ADS SARPs. The requirements for ADS set out by ICAO are limited in scope – they are designed only to ensure interoperability between air and ground systems, and to ensure that they meet the stated functionality requirements. The ADS SARPs do not specify the nature of any internal interface within the software, nor do they specify the human interface. Individual implementation projects must define their own internal interfaces to suit their own requirements.

3.4.2.2.4 In summary, an abstract service interface is defined in the SARPs in order to be able to define the ASE protocol machine. It does not have to be built in any implementation. A real implementation of the ADS SARPs would normally be expected to define its own internal interfaces.

3.4.2.2.5 The ADS application abstract service consists of eleven functions listed in 2.2.1.3.2.1.

3.4.2.3 Functional Model of the ADS Application

3.4.2.3.1 Figure 2.2.1.3-1 shows an abstract model for the ADS application. This figure is duplicated in figure 3.4-1. Just as with the abstract service, this model shows a design of the ADS application, breaking it down into modules. However, there is no requirement that an implementation actually builds it this way. The figure is presented here in order to explain the terms that are used throughout the document. It is not required that the design of an implementation follows this structure.

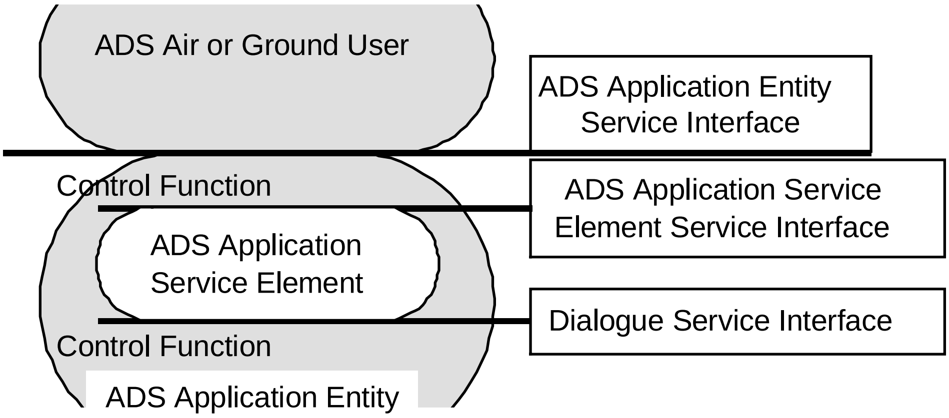

Figure 3.4-1: Abstract Model for the ADS Application

3.4.2.3.2 The figure shows three modules:

- the ADS user (which could be an ADS air user or and ADS ground user);
- the control function;
- the ADS ASE (application service element - which could be an ADS air ASE or and ADS ground ASE).

3.4.2.3.3 In addition, it defines the ADS application entity as the control function together with the ADS ASE.

3.4.2.3.4 Abstract interfaces are shown between the different modules:

- the ADS application entity service interface – which is the same as the abstract service interface defined in 2.2.1.3;
- the ADS application service element service interface – which is also the same as the abstract service interface defined in 2.2.1.3;
- the dialogue service interface – which is defined in the upper layer architecture SARPs, and is identical for all air/ground applications.

3.4.2.3.5 Since the ADS application entity service interface is identical with the ADS application service element service interface, the control function module passes primitive calls directly from one to the other without interference.

3.4.2.4 SARPs Section 2.2.1.3.3 – Conventions

3.4.2.4.1 Service Primitives

3.4.2.4.1.1 The ADS SARPs defines 14 services (ADS-demand-contract, ADS-event-contract, ADS-periodic-contract, ADS-report, ADS-cancel, ADS-cancel-all-contracts, ADS-emergency-report, ADS-modify-emergency-contract, ADS-cancel-emergency-contract, ADS-user-abort, ADS-provider-abort, ADS-start-forward, ADS-report-forward and ADS-end-forward). Each primitive consists of the name of the ADS service and a suffix that indicates at what point in the service the primitive occurs (request, indication, response, confirmation), e.g. ADS-demand-contract request. The primitives are further explained below:

- the ADS user that initiates the service calls on the ADS ASE to perform an action – this is called the "request";
- after the request is passed to the ADS ASE on the other side of the communications link, it uses the service to pass the information on to its ADS user – this is called the "indication";
- the ADS user that has received the indication may choose to respond to it, in which case it calls upon its ADS ASE to send a reply – this is called the "response";
- finally, the ADS ASE receiving the response provides its ADS user (which started the sequence of events) with the information – this is called the "confirmation".

3.4.2.4.1.2 The terms "request", "indication", "response" and "confirmation" are well understood in the field of communications protocols. A given ADS service need not use all four primitives. Some ADS services make use of one (indication), some two (request and indication or request and confirmation), some three (request, indication and confirmation) and some all four (request, indication, response and confirmation). These primitives are illustrated in Figure 3.4-2.

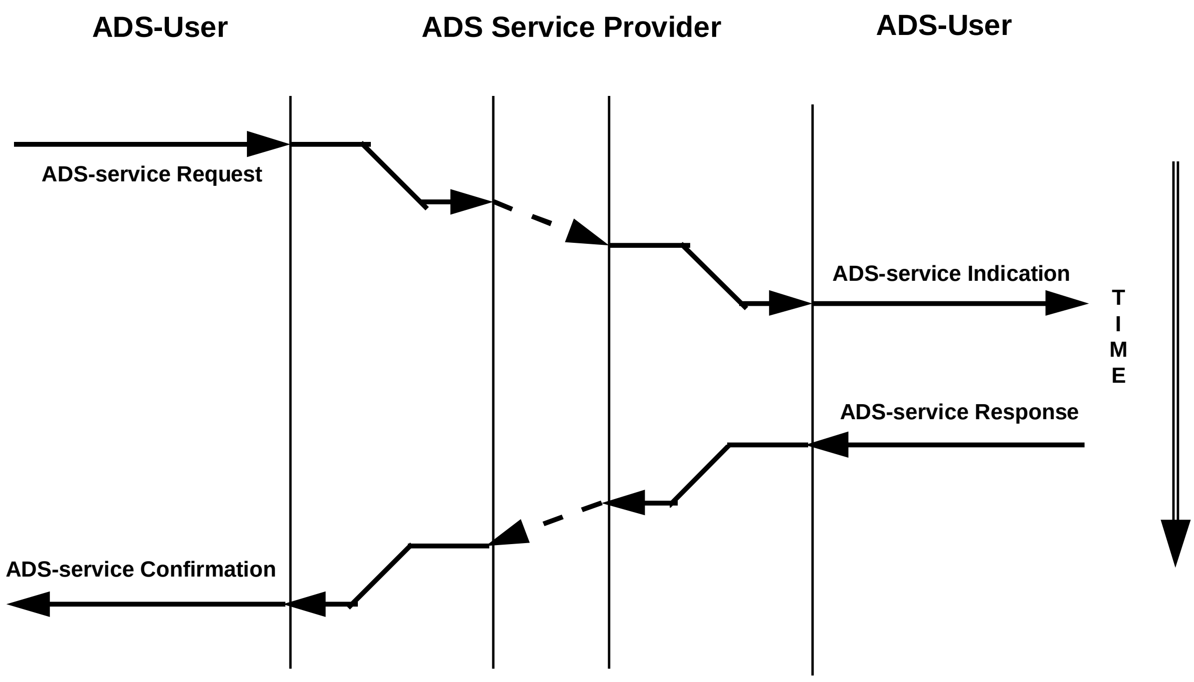

Figure 3.4-2. Generic ADS-User Primitives

3.4.2.4.1.3 A *confirmed ADS service* is one that involves a handshake between the user that requests the service and the user that is informed that the service has been requested. Figure 3.4-2 and Figure 3.4-3 illustrate the confirmed ADS services.

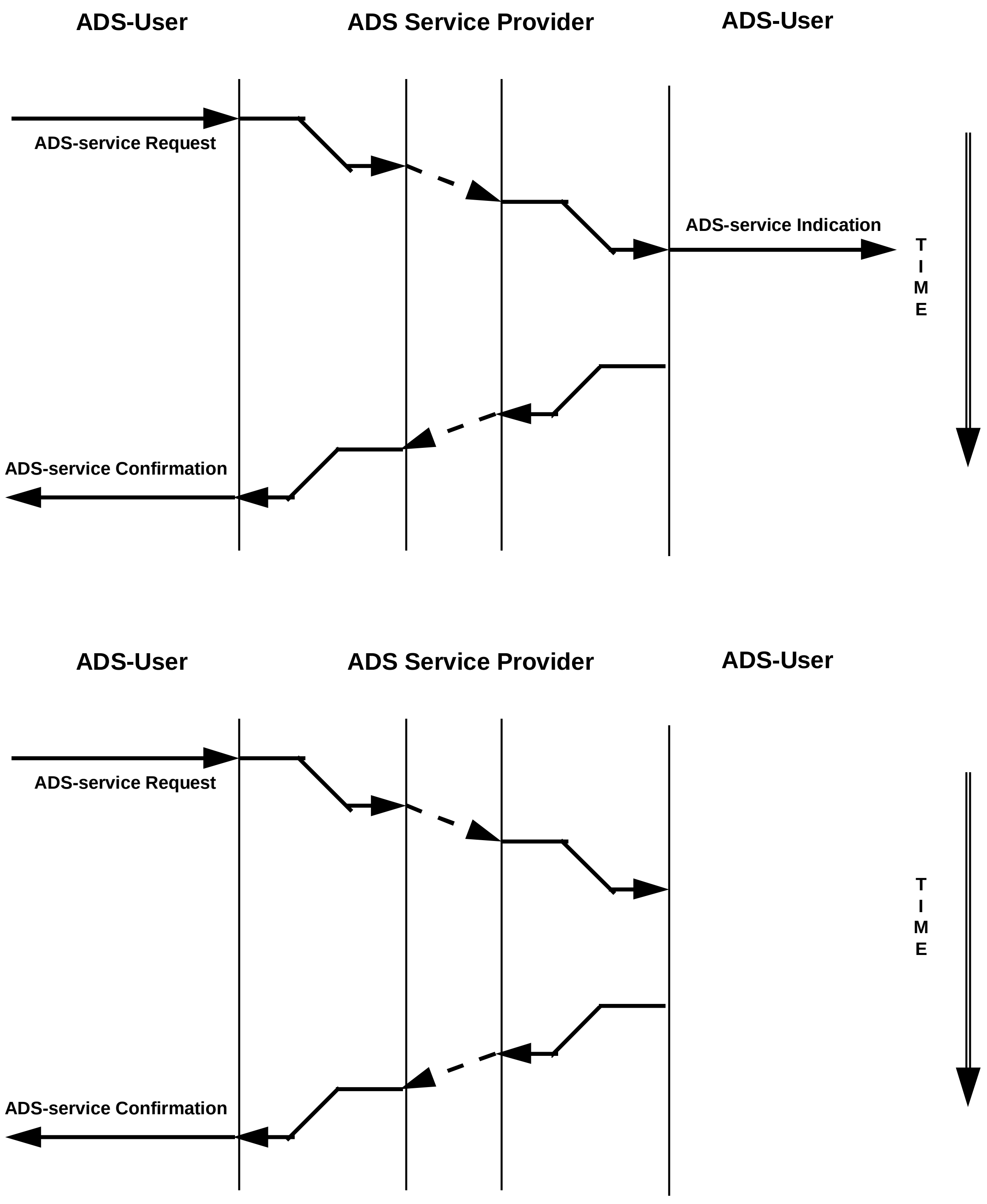

Figure 3.4-3: Other confirmed ADS services

3.4.2.4.1.4 An *unconfirmed ADS service* involves no handshake. Figure 3.4-4 illustrates an unconfirmed service.

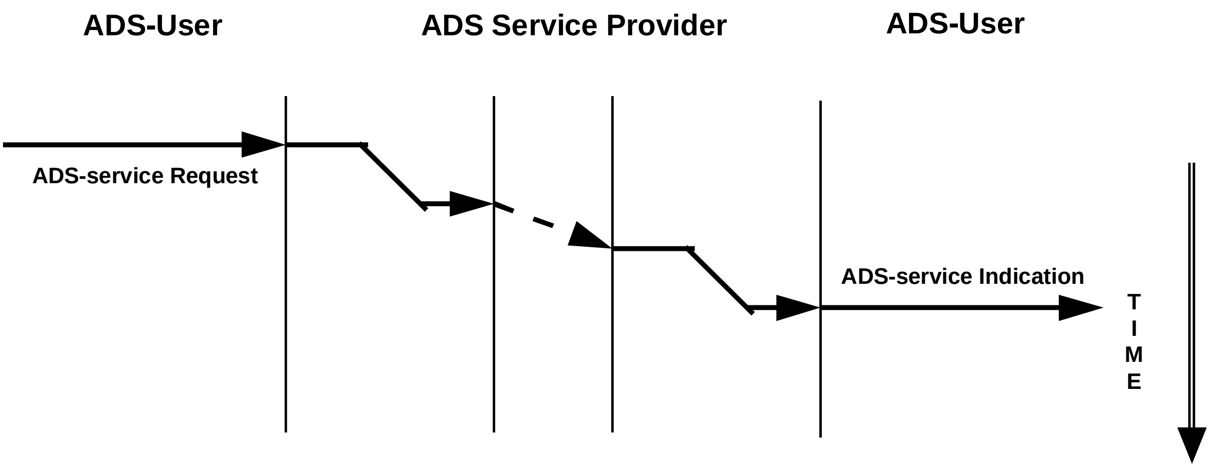

Figure 3.4-4. Generic Unconfirmed ADS Service

3.4.2.4.1.5 For a provider-initiated service, an indication primitive is given to both ADS-users. The provider-initiated service is generated by the service provider in response to an internal condition. Figure 3.4-5 illustrates a provider-initiated service.

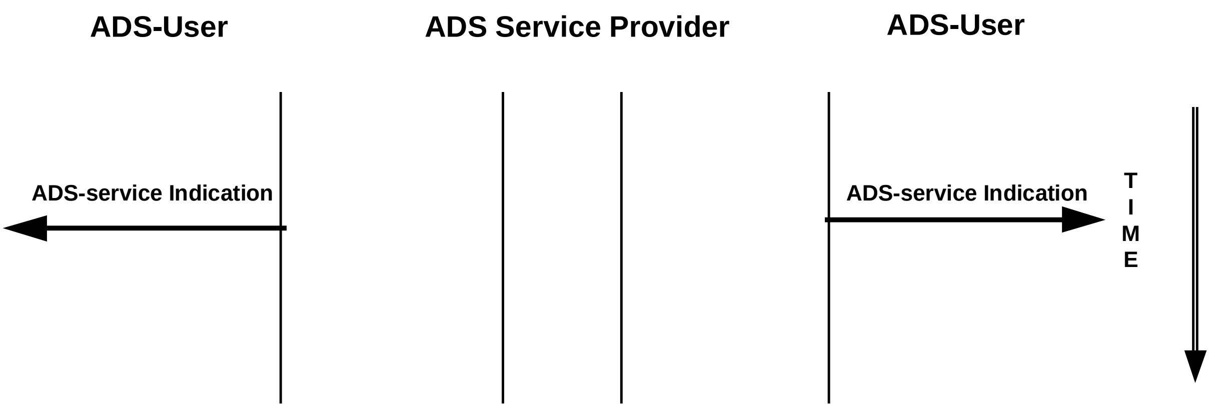

Figure 3.4-5. ADS Service Provider-initiated Service

3.4.2.4.2 Detailed Service Descriptions

3.4.2.4.2.1 Each of the detailed service descriptions is defined in the same way. Firstly there is either one or two tables indicating the parameters of the service and their status in each of the primitives. Secondly, each of the parameters has a short description, and a statement of what the abstract syntax of the parameter is. This is further described in the following sections.

3.4.2.4.3 Service Primitive and Parameters

3.4.2.4.3.1 Each service has a set of parameters. (One may choose to think of the service as a procedure or function calls in a programming language.) The parameters used in the request, indication, response and confirmation are different. (Thus one may choose to think of them as four different, but related, procedure calls.)

3.4.2.4.3.2 The services are depicted in the SARPs by primitive and parameter tables. An example of such a table is shown in Table 3.4-1. Not all services require all primitives to be used. That is, if a particular primitive is not needed due to reasons like redundant information being relayed, then the parameter column for that primitive is omitted. If a parameter column for a primitive is present, but all of the parameters are left blank, that means that the primitive is used by the service but does not carry any data.

Parameter Name	*Req*	*Ind*	*Rsp*	*Cnf*
Aircraft identifier	M			
Class of communication service	U			
Contract details	M	M(=)		
Reply			M	M(=)
ICAO facility designation	C	C(=)		

Table 3.4-1: Description of the ADS Service Primitives

3.4.2.4.3.3 For a specific primitive, each parameter is described by a value that dictates the terms under which that parameter is used. If the use of any parameter does not follow the rules as set forth by the primitive and parameter tables, there is an error in the implementation. The abbreviations used in the primitive and parameter sections are described below:

- blank – this means that the specific parameter will not be used in this service primitive.
- C – this means that the parameter is conditional upon some state. A “C” differs from a “U” (User Option) due to the fact that if the stated condition exists, the parameter must be supplied, while a “U” means that the parameter’s use is wholly up to the user. The exact conditions under which the parameter is used is explained in the text.
- C(=) – typically this is used when a request has an optional parameter. The C(=) will be in the "indication" position of the table. It means that if the user provides the parameter in the request, then it must also be present in the indication – what is more, it must have the same value as the parameter in the “request” column. The same applies to the “response” and “confirmation” columns.
- M – this means that the parameter must always be present, and no option not to use it exists.
- M(=) – this means that the parameter must always be present. If the parameter is in the "indication" column, then it must have a value equal to that of the “request” column. The same applies to the “response” and “confirmation” columns.
- U – this means that the use of the parameter is a user option. Therefore the presence of the parameter is optional, and will be used based upon user requirements.

3.4.2.4.4 When there are no parameters specified in the table (e.g. ADS-user-abort), this means that the service has the primitives listed in the table, but no parameters are needed.

3.4.2.4.5 A number of the services are presented with two parameter tables (ADS-demand-contract, ADS-event-contract and ADS-periodic-contract). The reason for this is that they may be operated in one of two ways. They may be operated with a request, indication, response and confirmation, or they may be operated with a request and indication only. Both cases are shown for these services.

3.4.2.4.6 The services ADS-demand-contract, ADS-event-contract and ADS-periodic-contract each has an optional parameter called "Class of communications service". Each of these services may all be called when a connection is in place, or when one is not in place. If the connection is not in place, then this parameter is used to help set up the connection. If the connection is in place already, then this parameter is not needed.

3.4.2.4.7 The class of communications service is defined as an optional parameter, therefore it may be provided when the connection is in place, or may be omitted when the connection is not in place. The behaviour defined in these cases is: if provided when a connection is in place it is ignored; if not provided when a connection is not already in place the SARPs states that "there is no routing preference". In practice this means that the implementors are free to choose what to do, for example, a default value could be chosen, a random value could be chosen or something else.

3.4.2.4.8 Throughout these service descriptions every parameter is described. In particular, there is a note that explains the purpose of the parameter, and a mandatory statement that states what values it may contain. In many cases, the mandatory statement states that if must conform to a named ASN.1 abstract syntax. These can be found in section 2.2.1.4.

3.4.2.5 Service Parameters

3.4.2.5.1 Throughout these service descriptions every parameter is described. In particular, there is a note that explains the purpose of the parameter, and a requirement that states what values it may contain.

3.4.2.5.2 Some primitive parameters have the same contents as APDU fields in the ASN.1 description. In most cases, the ADS-ASE is tasked to copy the parameter value within the APDU field. In order to avoid confusion by defining identical data structures twice, the type of those primitive parameters is specified by simply referring to the corresponding ASN.1 type in the APDU. The ASN.1 is used in the service definition as a syntax notation only and does not implicitly imply any local encoding of these parameters. The implementation of these parameters remains a local implementation issue.

3.4.2.5.3 For the other parameters, the syntax is described by enumerating the authorised abstract values.

3.4.2.6 ADS Services

3.4.2.6.1 This section lists the ADS services, and explains why each is a confirmed or an unconfirmed service.

3.4.2.6.2 ADS-demand-contract, ADS-event-contract and ADS-periodic-contract can be either confirmed or unconfirmed services. An ADS-air-user may reply to any one of these services by sending an ADS-report immediately. In such cases, the ADS contract service is unconfirmed. The ADS-report effectively carries the confirmation with it in the *acknowledgement* parameter. If the ADS-air-user replies with a positive or negative acknowledgement or a noncompliance notification, then it is a confirmed service. These services need to be confirmed since the ADS-ground-user needs to know at what point the contract is in place in order that it can monitor the results. For example, if a periodic contract is in place and the ADS-ground-user changes the contract, then the receipt of the confirmation signifies the point at which the change of contract takes place.

3.4.2.6.3 The ADS-report service is unconfirmed, since there is no requirement for the airborne system to know when the ground system has received the report.

3.4.2.6.4 The ADS-cancel and ADS-cancel-all-contracts services are both confirmed. It is necessary to confirm the service since the cancellation may cross with an ADS-report being sent from the aircraft. The ground system must know when the cancellation has been received so that it knows when to expect a cessation of ADS-reports. Neither service has a response primitive; the response is generated automatically. This is because the ADS-air-user has no option but to accept a cancellation.

3.4.2.6.5 The ADS-emergency-report service is unconfirmed, since there is no requirement for the airborne system to know when the ground system has received the report.

3.4.2.6.6 The ADS-modify-emergency-contract service is sometimes a confirmed service and sometimes an unconfirmed service. When the modification is accepted by the airborne system, an acknowledgement is sent down with the next ADS-emergency-report - this acts as the confirmation. When it is rejected, the airborne system confirms the service.

3.4.2.6.7 The ADS-cancel-emergency service is an unconfirmed service since there is no requirement for the airborne system to know when the ADS-cancel-emergency arrived at the ground.

3.4.2.6.8 The ADS-user-abort service is an unconfirmed service since there is no requirement for the initiating system to know that the abort has arrived at the peer.

3.4.3 SARPs Section 2.2.1.4 – Formal Definition of Messages

3.4.3.1 Introduction

3.4.3.1.1 The ADS abstract syntax 2.2.1.4 and 2.2.2.4 is written in a notation that is called ASN.1. It is strongly recommended that the reader is familiar with ASN.1 before attempting to understand the detail of these sections.

3.4.3.2 ADS SARPs 2.2.1.4.1 Encoding/Decoding Rules

3.4.3.2.1 This section defines which APDUs the systems must be able to encode and decode.

3.4.3.2.2 An APDU (Application Protocol Data Unit) is a sequence of bits that are passed from one peer application to another. The sequence of bits is a concrete representation of a message that is passed between applications. For example, the ASN.1 defines a message for an ADS-demand-contract. An APDU for this message will be a sequence of bits representing the information to be carried.

3.4.3.2.3 A system is not required to be able to encode or decode all messages specified in the ASN.1 description. An air system is not required to be able to encode an ADSGroundMessage APDU nor to decode an ADSAircraftMessage APDU.

3.4.3.3 ADS ASN.1 Abstract Syntax

3.4.3.3.1.1 SARPs sections 2.2.1.4 and 2.2.2.4 define the abstract syntax of the protocol. That is, it defines the structure of the PDUs that are to be sent between aircraft and the ground systems. It is written in a notation that is called ASN.1. It is strongly recommended that the reader is familiar with ASN.1 before attempting to understand the detail of this SARPs section.

3.4.3.3.1.2 Data types exchanged by ADS ASEs are described in the ADS SARPs by using a machine-independent and language-independent syntax. There is no constraint put on the implementors concerning the machine nor the development language to be selected for implementing the protocol.

3.4.3.3.1.3 The ASN.1 module *MessageSetVersion1* contains the data types of the protocol data units handled by the ADS ASEs. Unlike common OSI ASEs (e.g. ACSE), no object identifier has been attached to the ADS ASN.1 specification. Indeed, the ULCS architecture releases the applications from negotiating during the dialogue establishment the applicable abstract syntax. Object identifiers related to ADS applications (application context name and version number) are defined in the ULCS SARPs.

3.4.3.4 ADS ASN.1 Organisation

3.4.3.4.1 This section defines the abstract syntax of the protocol. That is it defines the structure of the PDUs that are to be sent between aircraft and the ground systems. It is written in a notation that is called ASN.1. It is strongly recommended that the reader is familiar with ASN.1 in order to understand the details of section 2.2.1.4.2.

3.4.3.4.2 The ASN.1 itself is organised into a number of different sections:

- Aircraft generated and Ground generated message choice
- Ground generated and aircraft generated message components – protocol data units
- Reports and their components
- Components of contracts
- Miscellaneous components
- Common components
- ADS Report Forwarding Application

3.4.3.4.3 The top level (which will typically be used as an entry point by any ASN.1 compiler), is titled "Aircraft generated and Ground generated message choice". It consists of two structures: one is a choice of PDUs generated by the aircraft, and the other is a choice of PDUs generated by the ground system.

3.4.3.4.4 The ASN.1 is written in such a way that every type is defined after it is used. This is sometimes a requirement in an ASN.1 compiler.

3.4.3.4.5 There are some components of reports that contain data from the aircraft sensors, for example, temperature, which is a component of weather. Comments that explain the units that the value is measured in and the range of values follow each of these. So that temperature, for example, can range from minus 100 degrees to plus 100 degrees Centigrade in steps of a quarter of a degree.

3.4.3.4.6 An index of the types defined in the ASN.1 is given in section 3.6.

3.4.3.5 ASN.1 Tags

3.4.3.5.1 Tags are used in ASN.1 to allow to distinguish data types when confusion is possible. For instance, when a data type contains two optional elements of the same type, if only one is encoded then there is no means for the decoder to know which element the decoded value is attached to.

3.4.3.5.2 Even if tag values are not used by the Packed Encoding Rules, the ASN.1 grammar mandates the use of tags in some cases. When specifying the CM data types, the following rules have been used:

- tags are always used within CHOICE data type, starting at 0 and then incremented by 1 for each entry;

- tags are not used at all in SEQUENCE data type when no confusion is possible. When an optional element is defined, all elements in the sequence are tagged.

3.4.3.6 Extensibility Markers

3.4.3.6.1 In order to allow the upgrade of the ASN.1 specification when new requirements are determined, the extensibility ASN.1 feature (ellipse, depicted by “...”) has been used in applicable data types, for example, AbortReason. This allows future modifications to data types as the applications evolve while retaining backwards compatibility.

3.4.3.7 Handling Numerical Values

<<Wait for FP to write more text for this >>

3.4.3.8 Entry Points

3.4.3.8.1 The top level (which will typically be used as an entry point in any ASN.1 compiler), is titled "Aircraft generated and Ground generated message choice". It consists of two structures: one is a choice of PDUs generated by the aircraft, and the other is a choice of PDUs generated by the ground system.

3.4.3.8.2 An index of the types defined in the ASN.1 is given in section 6.

3.4.3.9 Time Representation

3.4.3.9.1 Data types have been specified for containing time indication (Date, DateTime, Year, Month, Hours, Minutes, Seconds). This way of representing time is preferred over the pre-defined ASN.1 representations (GeneralizedTime and UTCTime) for optimization of the PER encoding.

3.4.3.10 Reason Code

<< ADDITIONAL TEXT TO BE ADDED IF THE PROPOSED SOLUTION TO PDR 97080002 IS ACCEPTED>>

3.4.3.10.1 In an earlier version of the SARPs, there was a reason code called "cannot-meet-reporting-rate". This was put in to indicate, in response to a periodic contract, that the requested reporting rate could not be met. One of the changes in the SARPs that was made subsequently was that, if the aircraft could not meet the report rate, it delivered a default value reporting rate. During this change, the reason code "cannot-meet-reporting-rate" was not removed. When this defect was noticed, there were several implementations of ADS in existence. In order to avoid changing these implementations, the value for "cannot-meet-reporting-rate" was left in the ASN.1, but the name was changed to "undefined-reason" - thus allowing the old and new versions to interoperate.

<< END OF ADDITIONAL TEXT >>

<< ADDITIONAL TEXT TO BE ADDED IF THE PROPOSED SOLUTION TO PDR 97080002 IS ***NOT*** ACCEPTED>>

3.4.3.10.2 In an earlier version of the SARPs, the reason code "cannot-meet-reporting-rate" was added. This was put in to indicate, in response to a periodic contract, that the requested reporting rate could not be met. One of the changes in the SARPs that was made subsequently was that, if the aircraft could not meet the report rate, it delivered a default value reporting rate. During this change, the reason code "cannot-meet-reporting-rate" was not removed. When this defect was noticed, there were several implementations of ADS in existence. In order to avoid changing these implementations, the value for "cannot-meet-reporting-rate" was left in the ASN.1 - thus allowing the old and new versions to interoperate. However, it must not used.

<< END OF ADDITIONAL TEXT >>

3.4.3.11 Unbounded ASN.1 Types

3.4.3.11.1 There are a number of unbounded ASN.1 types in the definition of ADS APDUs. In practice, an implementation must have a maximum size for every type in order to reserve sufficient memory. The following paragraphs provide guidance on the maximum size that should be implemented.

3.4.3.11.2 The definition of Noncompliance Notification is:

```
NoncomplianceNotification ::= CHOICE

{

        demand-ncn      [0] SET OF ReportType,

        event-ncn       [1] SET OF EventTypeContracted,

        periodic-ncn    [2] SET OF ReportTypeAndPeriod,

        ...

}
```

3.4.3.11.3 The three sets are unbounded. A valid implementation will not put more that seven ReportTypes in a NoncomplianceNotification for a demand-ncn, more than eleven

EventTypeContracted in a NoncomplianceNotification for a event-ncn, or eight ReportTypeAndPeriod in a NoncomplianceNotification for a demand-ncn.

3.4.3.11.4 The definition of GroundSystemsUsingService is:

GroundSystemsUsingService ::= SEQUENCE OF Ia5String (SIZE(4..8))

3.4.3.11.5 This is used to inform a ground user that the air system capacity has been used up. e.g. if the implementation allows contracts with six ground systems, then when a seventh attempts to make a connection, GroundSystemsUsingService is used to inform the seventh ground user of the ICAO facility designations of the first six.

3.4.3.11.6 In an aircraft implementation, the maximum size for this type should be set by the maximum number of ground systems that the implementation can have contracts with. e.g. If the aircraft allows contracts with six ground systems, then this type should have a maximum size of six.

3.4.3.11.7 In a ground system implementation, some limit should be set. A size of, say, twenty is unlikely to be exceeded in any realistic implementation.

3.4.4 SARPs Section 2.2.1.5 Protocol Definition

3.4.4.1 SARPs Section 2.2.1.5.1 Sequence Rules

3.4.4.1.1 Time sequence diagrams or message sequence diagrams are used to denote the relationship between the primitives that form an ADS service and the order in which they occur, e.g. the indication/confirmation primitives occurs some time after the request/response primitives.

3.4.4.1.2 Inherent to the service model is the notion of queuing. The ADS-service indications and confirmations are delivered to the ADS-users in the order that the corresponding ADS-service requests and responses were issued. One exception to the notion of queuing is the abortive services (ADS-user-abort and ADS-provider-abort services) which may overtake other primitives and empty the primitives in the queue. Figure 3.4-5 illustrates this concept.

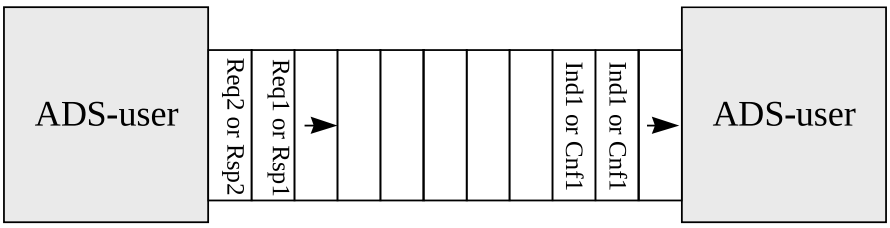

Figure 3.4-5: Communication Queue

Figure 3.4-6. Message Sequence Diagram

3.4.4.1.3 Each figure has the same structure. There are four vertical lines that separate the five major components in the ADS system. From left to right, they are:

- the ADS ground user – that part of the ground system that uses the ADS service to provide information to human users;
- the ADS ground ASE – that part of the ground system that implements the ADS protocol;
- the dialogue service provider – that part of the ground system, the air system and the networks that, together, provide the dialogue service, as defined in the upper layer architecture – on the figures this is the thin strip down the middle;
- the ADS air ASE – that part of the air system that implements the ADS protocol;
- the ADS air user – that part of the avionics that implements the ADS contracts.

3.4.4.1.4 The middle three sections of the diagrams (ADS ground ASE, dialogue service provider and ADS air ASE) together form the ADS service provider, and are labelled as such on the diagrams.

3.4.4.1.5 The outer two vertical lines represent the ADS abstract service. Any lines crossing them represent the invocation of one of the ADS service primitives. The ADS service primitives are labelled in the ADS user part of the figure.

3.4.4.1.6 The inner two vertical lines represent the Dialogue service. Any lines crossing them represent the invocation of one of the Dialogue service primitives. The Dialogue service primitives are labelled in the ADS ASE part of the figure.

3.4.4.1.7 The diagrams represent a sequence of events. Time is always considered to run down the figure from the top (representing the earliest time) to the bottom (representing the latest time).

3.4.4.1.8 If the ASEs set timers, these are marked on the figures by vertical lines with arrows at both ends. This is depicted in figure 3.4-6 by the "t_{timer}" label.

3.4.4.1.9 Note that the time sequence diagrams in the SARPs representing abort situations can be overlaid on top of any of the other figures to represent an abort in action.

3.4.4.2 ADS SARPs 2.2.1.5.2 ADS Service Provider Timers

3.4.4.2.1 This section lists the service provider timers that are defined in the protocol, and suggests values for them.

3.4.4.2.2 The purpose of the service provider timers in the ADS service provider is not operational. For operational reasons, there may be a requirement to have other timers that are shorter than the ones described here. The purpose of these service provider timers is only to ensure that the ASE protects itself when communicating with a system that has failed to respond.

3.4.4.2.3 Most, if not all, operational systems will require operational timers of much shorter duration than the values set for the service provider timers. The value of operational timers will also vary according to the operational scenario in which the aircraft is flying. The SARPs does not specify the value of the operational timers, nor does it insist on their implementation. For every operational system, values of operational timers will need to be calculated. Also, the action that must be taken if the operational timer expires must be specified. Examples of such actions are: an ADS-user-abort request is made and a connection is made with a different class of communications service; the connection could be left open while the controller contacts the aircraft via R/T; the colour of the aircraft on the user interface could change.

3.4.4.2.4 For example, suppose a ground system sends a demand contract to an aircraft. Suppose further that the aircraft system has not implemented the ADS protocol correctly, and it locks up without sending the result back to the ground system. The ground system will be in a state that is waiting for a result. The specification prevents the ground system from sending up another demand contract until the first has been dealt with. This combination of events would make the ground system lock up unless a service provider timer is used. When in this state, the t-DC-1 service provider timer will eventually reach its maximum value. The ground system can then abort the connection. Thus the ground system protects itself from getting locked up because of another system’s failure.

3.4.4.2.5 Note that the values set in these timers have been calculated thus: It has been assumed that the slowest possible network is in operation and that all systems in the path have their maximum delay. Should a reply to a request take longer than this, then it is assumed that something must be failing somewhere.

3.4.4.2.6 The assignment of values for timers must be optimised based on operational testing of the application. In such testing, incompatible timer values and optimum combinations can be identified. Implementations of ADS protocol are required to support configurable values for all timers and protocol parameters, rather than having fixed values. This allows modification as operational experience is gained.

3.4.4.3 SARPs Section 2.2.1.5.3 ADS-ASE Protocol Description

3.4.4.3.1 The ADS service provider is described in the SARPs as finite state machines or protocol machines (PM). The protocol machine for a particular service starts in an initial state (IDLE). Events, which are service primitives received from the ADS-users above or the Dialogue Service provider below, as they occur, trigger activity on the part of the PM. As part of this activity, actions may be required (service primitives issued to the ADS-users and/or the underlying Dialogue Service provider).

3.4.4.3.2 The protocol description explains the rules by which the ASEs work. There is a detailed specification of actions taken by the ASEs when triggered by certain events:

- the arrival of a PDU through the dialogue service;
- the invocation of one of the service primitives by the user;
- the expiration of one of the internal technical timers;
- an unrecoverable system error.

3.4.4.3.3 In order to resolve a somewhat complex specification, both the ground and the air ASEs have been broken up into a number of internal modules. The behaviour of each is specified separately. In addition to the four triggers specified above, individual modules may also be triggered into action by the other modules within the same ASE.

3.4.4.3.4 Both air and ground ASEs have modules that mirror each other. However, apart from the AB module, the actions of the air and ground mirrored modules are different but complementary. The modules are:

- HI module – the main job of the HI module is to select which module must handle the primitives that are invoked by the user.
- LI module – the main jobs of the LI module are a) to select which module must handle the PDU passed to it from the dialogue service, and b) to manage the dialogue, selecting which dialogue service must be used at any given time.
- DC module – the job of the DC module is to manage demand contracts.
- EC module – the job of the EC module is to manage event contracts.
- PC module – the job of the PC module is to manage periodic contracts.
- AB module – the job of the AB module is to handle abort situations.

3.4.4.3.5 There is a requirement that the ASE does not accept the invocation of primitives when no actions are described for that primitive in that state (2.2.1.5.3.2). Some explanation of this statement is needed:

3.4.4.3.6 Each module has several different states. When a module is in a particular state, only some primitives are permitted to be invoked. For example, if an ADS-periodic-contract request is invoked, it is not permitted to invoke a second ADS-periodic-contract request until a reply has been received for the first one. There is no statement in the description of the protocol that explains what the ground ASE must do if it receives a second ADS-periodic-contract request before the reply to the first one has been received. The SARPs therefore requires (by statement 2.2.1.5.3.2), that the ground user must not invoke an ADS-periodic-contract request during this period.

3.4.4.3.7 Thus only actions which are permitted are described. If an action is not described, then it is not permitted.

3.4.4.4 SARPs Section 2.2.1.5.5 ADS-ASE State Tables

3.4.4.4.1 State tables are provided. These are an exact reflection of the ADS protocol description, in a condensed form. The state tables are only presented for guidance, since the textual protocol description always takes precedence.

3.4.5 SARPs Section 2.2.1.6 Communication Requirements

3.4.5.1 SARPs Section 2.2.1.6.1 Encoding Rules

3.4.5.1.1 This section states that PER (Packed encoding rules) must be used to encode the PDUs. PER is an ISO standard and is particularly efficient at encoding data. Implementors may use ASN.1 compilers to generate code that creates PER automatically.

3.4.5.2 ADS SARPs 2.2.1.6.2 Dialogue Service Requirements

3.4.5.2.1 The dialogue service requires a number of parameters to operate. SARPs sections 2.2.1.6 and 2.2.2.6 define those parameters that are not defined elsewhere.

3.4.5.2.2 In addition to the ClassOfCommunication parameter provided by the contract initiator, other Quality of Service (QOS) parameters are attached by the ASE to the dialogue supporting the communication. Values for the Application Priority and the Residual Error Rate are constant for the FIS(ATIS) application and therefore are not requested to the users.

3.4.5.2.3 The Application Priority is set by default to the abstract value "High Priority Flight Safety Messages".

3.4.5.2.4 The Residual Error Rate is set by default to the abstract value "low".

3.4.5.2.5 The underlying layers provide a checksum and realise the requirement for message integrity. It is not necessary, therefore, to provide application level integrity by means such as redundancy checks and confirmation of services.

3.4.6 SARPs Section 2.2.1.7 ADS User Requirements

3.4.6.1 The requirements set out in this section are those defined by the ADS panel in the ICAO manual of ATS datalink communications. It explains how contracts are realised. For further explanation – see the ADSP manual.

3.4.6.2 Purpose of Section 2.2.1.7 and 2.2.2.7

3.4.6.2.1 The SARPs makes a clear distinction between what assures interoperability between ADS air and ground components, and that which is operationally acceptable. Sections 2.2.1.3 to 2.2.1.6 and 2.2.2.3 to 2.2.2.6 guarantee that different implementations will interoperate, but they do not guarantee that the service offered is operationally acceptable. For example, they ensure the correct exchange of a periodic contract, its acknowledgement, and subsequent reporting. They do not ensure that the information that is provided in the ADS reports is what is agreed in the contract, or that it is provided at the correct rate.

3.4.6.2.2 Sections 2.2.1.7 and 2.2.2.7 ensure that the ADS contracts behave in a way that is operational acceptable. 2.2.1.7, for example, ensures that the information provided in a periodic contract is the information that is required by the contract and that the reporting rate is that required by the contract.

3.4.6.2.3 To clarify this further, 2.2.1.7 and 2.2.2.7 ensure a degree of operational acceptability. For example, although it ensures that ADS reports are delivered on time with the correct information, there is no assurance that the information is that which is required by the controller. The information required by the controller will be dependant upon the use that is being made of ADS at that particular time.

3.4.6.2.4 Other aspects of the ADS application that are not defined in 2.2.1.7 or 2.2.2.7 are the sources, required accuracy and latency of the information provided in an ADS report. For example, when a *level* is provided as part of the *position* parameter, there is no requirement stated that requires the information to be obtained from a certain type of equipment, whether it is a single value taken from the last reading from the equipment or an average of several readings taken in the last few seconds, and there is no requirement stating that the most recent equipment reading must have been taken within a particular number seconds. These decisions are currently left up to the equipment manufacturer. It is anticipated that requirements will emerge in the future.

3.4.6.3 Demand Contracts

3.4.6.3.1 A demand contract allows the ground system to ask for a single ADS report from an aircraft. The operation of demand contracts is described in 3.1.5.2.

3.4.6.3.2 Note that, unlike event and periodic contracts, demand contracts do not permit the aircraft to return a positive acknowledgement, followed by an ADS report some time later. The reason for this is as follows: It is anticipated that normal operation will use event and/or periodic contracts. The use for demand contracts is, therefore, expected to be for cases when the controller needs an immediate response to a query outside the normal surveillance operation. The requirement is that the information is required as soon as possible. The aircraft can use the positive acknowledgement as a form of delay, and this is therefore prohibited in a demand contract.

3.4.6.3.3 If the ADS-air-user can satisfy the demand contract in its entirety and within a short space of time (0.5 seconds is recommended), then it sends an ADS-report immediately.

3.4.6.3.4 If the ADS-air-user supply some of the information required in the demand contract, but not all of it, then it sends a noncompliance notification immediately, followed by an ADS report which supplies the information that it has available. This only applies if some of the optional information is unavailable.

3.4.6.3.5 If the ADS-air-user cannot supply some of the mandatory information for an ADS-report, or cannot supply it within a short space of time (0.5 seconds is recommended), then it will reply with a negative acknowledgement.

3.4.6.4 Event Contracts

3.4.6.4.1 An event contract allows the airborne system to send one or more ADS reports if and when a given event occurs. The operation of event contracts is described in 3.1.5.3.

3.4.6.4.2 There are a number of different ways that an event contract can generate ADS reports:

a) All event contract that report on a variation from the current parameter value require a baseline report (e.g. heading change event). The baseline report is generated immediately on acceptance of the contract. Further reports are generated when the event occurs.

b) Some event contracts provide a single report when the event occurs (e.g. change in the next waypoint).

c) Some event contracts provide reports at a rate of one every sixty seconds while the aircraft is outside the parameters of the event contract. The aircraft will stop reporting as soon as it comes back into the parameters again (e.g. altitude range event).

3.4.6.4.3 In an event contract, the ground system has no choice over the information that is provided in the ADS report. The choice of optional fields within the ADS report is fixed by the type of contract. Thus the term "optional fields" is, in the case of event contracts, not a true reflection of the SARPs.

3.4.6.4.4 If the ADS-air-user is able to meet the terms of the event contract (that is, it is able to detect the events requested in the contract, and can supply the information required in the ADS report), then one of the following will occur:

- If the type of contract requires a baseline report (e.g. for a heading change event), or if the event has already occurred (e.g. the aircraft is already flying outside the altitude range given in the contract), then the ADS-air-user may send an ADS report which contains an acknowledgement of the contract immediately. Alternatively, the ADS-air-user could send a positive acknowledgement followed by an ADS report.

- If the type of contract does not require a baseline report, and if the event has not already occurred, then the ADS-air-user sends a positive acknowledgement immediately.

3.4.6.4.5 If the ADS-air-user is not able to detect some of the events requested in the contract, but it can detect some others, then it sends a noncompliance notification.

3.4.6.4.6 If the ADS-air-user cannot detect any of the events requested in the contract, or it is not able to generate the information required for the ADS reports which are sent when the event occurs, then it sends a negative acknowledgement.

3.4.6.5 Periodic Contracts

3.4.6.5.1 A periodic contract allows the aircraft to send ADS reports at regular intervals. The operation of periodic contracts is described in 3.1.5.4.

3.4.6.5.2 The periodic contract will be suspended by the aircraft if it initiated an emergency contract. The periodic contract is not operational until the emergency contract is ended.

3.4.6.5.3 If the ADS-air-user is able to generate the mandatory and the optional information required by the contract at the rate requested, then one of the following occurs:

- If the ADS-air-user is able to generate the first report required by the contract within a short space of time (0.5 seconds is recommended), then it does so.
- If it is not able to generate the first report required by the contract within a short space of time (0.5 seconds is recommended), then it sends a positive acknowledgement, followed by the first report at the time it is able to do so.

3.4.6.5.4 If the ADS-air-user is able to generate all the mandatory information in an ADS report, but is not able to generate some or all of the optional information that is requested, then it sends back a noncompliance notification followed by an ADS report.

3.4.6.5.5 If the ADS-air-user is able to generate all the mandatory information in an ADS report, but is not able to generate ADS reports at the rate that is requested, then it sends back a noncompliance notification followed by ADS reports at the default rate of 60 seconds.

3.4.6.5.6 If the ADS-air-user is not able to generate all the mandatory information in an ADS report, then it sends back a negative acknowledgement.

3.4.6.6 Emergency Contracts

3.4.6.6.1 An emergency contract allows the aircraft to send ADS emergency reports to ground systems at regular intervals during an emergency situation. The operation of emergency contracts is described in 3.1.5.6.

3.4.6.6.2 An emergency contract is initiated and cancelled by the airborne system. During the emergency contract, the ground system may cancel the event and/or periodic contract that was in operation at the beginning. In this situation, only the emergency contract is in place. Under these circumstances, when the aircraft cancels the emergency contract, the ground system will subsequently close the connection to the aircraft.

3.4.6.6.3 The ground system has very little control over the emergency contract. It cannot change the information that is reported in the emergency report, and it cannot cancel the contract without cancelling all contracts. It can only modify the emergency reporting rate, or cancel all the contracts.

3.4.6.6.4 The establishment of an emergency contract is done by sending an ADS emergency report. It is not acknowledged.

3.4.6.7 Maximum Number of Connections

3.4.6.7.1 An implementation of an airborne system will have an in-built maximum number of external connections that it can support. The SARPs require the airborne system to support contracts with at least four ground systems. This will require it to have the ability to accept at least five connections in the short term. The additional (fifth) connection must be available to allow the ADS-air-user to inform any ground system that attempts to establish a further contract, that it cannot do so.

3.4.6.7.2 The operational requirement from which this is derived states that the airborne system must allow contracts from at least four *ATC* systems. An implementation must, therefore, be able to distinguish between ATC connections from any other type of connection. It can do this by examining the class of communications service parameter, or the ICAO facility designation parameter.

3.4.6.7.3 One method of implementation is to reserve four connection "slots" for exclusive ATC usage. Connection attempts from non-ATC users would either have to be refused, or use non-reserved "slots".

3.4.6.7.4 Another method of implementation is to allow all connection attempts to establish a connection. When the maximum number of connections has been made, the latest one is examined to see if it is an ATC connection. If it is, then the others are examined to see if they are ATC connections. If there are less than four ATC connections, then at least one of the non-ATC connections is aborted to allow the ATC connection to be made.

<< ADDITIONAL TEXT To be added if the proposed solution to PDR 97060004 is accepted >>

3.4.6.8 Loss of Information Source

3.4.6.8.1 If the information requested in a contract is not available because the equipment on board is not capable of providing the information, then the aircraft will return a noncompliance notification at the start of the contract.

3.4.6.8.2 If the information requested in a contract is available normally, however, during the operation of the contract it becomes unavailable, e.g. the equipment fails, then one of two things can happen: If the information is part of the basic report (i.e. position, timestamp or FOM) then this is considered a very serious error, and the aircraft aborts the connection. If the information is one of the optional elements, then this is considered a minor error. In this case, the aircraft simply omits the information from the report. The ground user knows what the report is supposed to contain, and can therefore determine that the information has become unavailable. It is up to the ground implementation to continue receiving incomplete reports, to request a new contract or to cancel the contract altogether.

<< END OF ADDITIONAL TEXT >>

3.4.6.9 Report Forwarding

3.4.6.9.1 ADS report forwarding allows a ground system to forward ADS reports to another ground system. The operation of report forwarding is described in 3.1.5.9.

3.4.6.9.2 There is no negotiation over which of the reports to forward. The receiving system has to accept whatever is sent to it. Thus it is required that an agreement exists between the two ground systems beforehand, or through some non-standardised means, regarding which reports to forward and when.

3.4.7 SARPs Section 2.2.1.8 Subsetting Rules

3.4.7.1 There is some functionality within the ADS SARPs that ground system implementors may choose not to incorporate. For example, if a particular implementation of a ground system is designed always to use event and demand contract, then there is no requirement for it to have the code for periodic contracts implemented. An aircraft, on the other hand, must have the code to allow recognition of periodic requests, since it may fly into an area that does use periodic contracts.

3.4.7.2 There are some combinations of functionality that allow interoperability, and some that do not. This section defines the combinations of functionality that allow interoperability. Note that the aircraft must have full technical functionality to be SARPs compliant. (This does not imply that the system is not SARPs compliant, if part of the functionality is temporally unavailable.)

3.4.7.3 The combinations of functionality are defined in a set of tables.

- Version number – only one version is defined. This is a placeholder for when future versions are defined.
- Protocol Options – this defines a number of options for parts of the protocol that may be implemented. The options may be implemented together. Each has a name associated with it – the predicate.
- ADS-ground-ASE configurations – this defines seven combinations of protocol options, each of which yields a coherent protocol.
- ADS-air-ASE configurations – this defines a single combination of protocol options, which is the only combination that yields a coherent protocol.
- Supported ADS service primitives – this defines the conditions under which the service primitives are applicable.
- Supported ADS APDUs – this defines the conditions under which the PDUs are applicable.

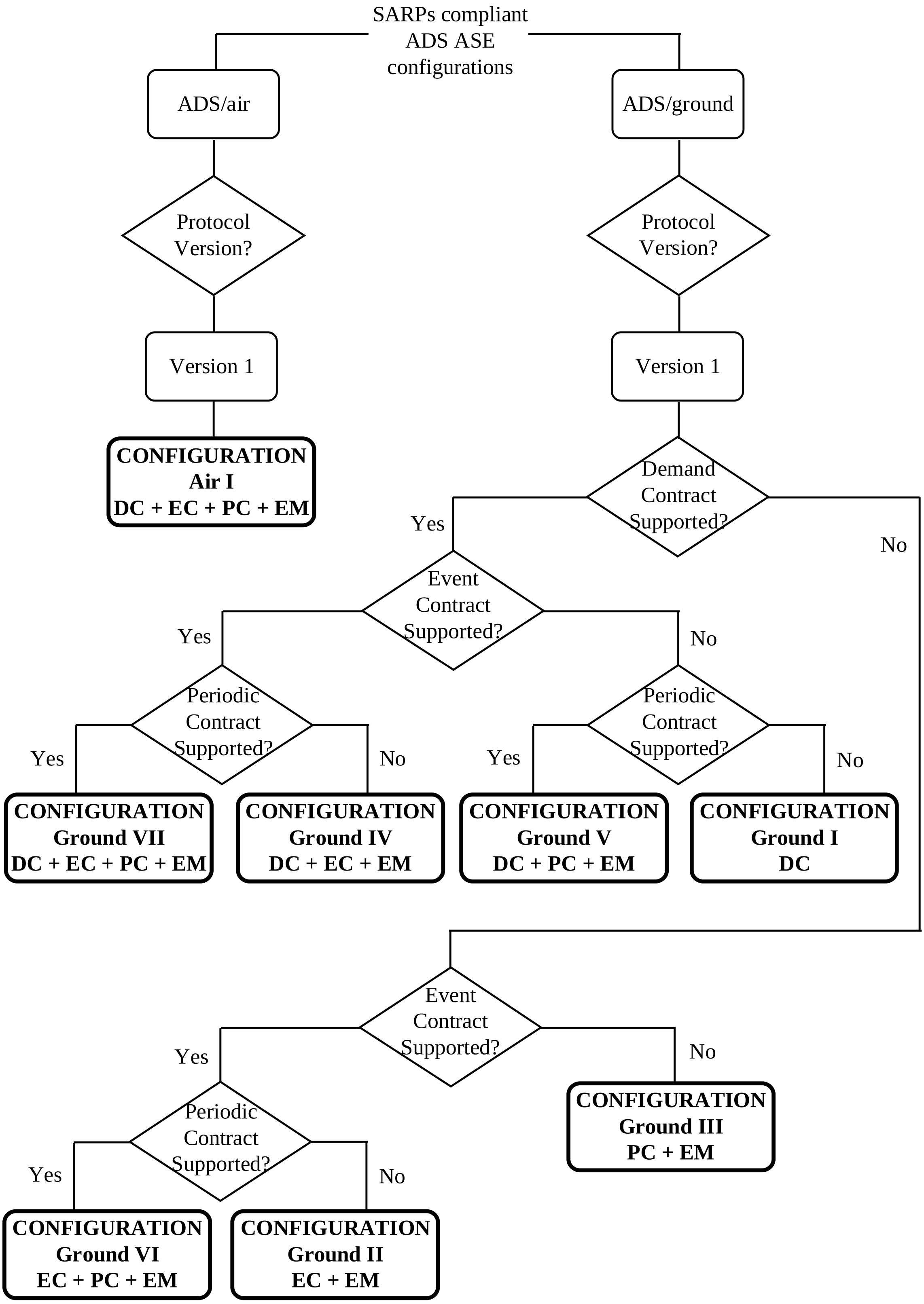

Figure 3.4-7: ADS Subsetting Rules

3.4.7.3.1 The subsetting rules define those subsets that are technically possible. The SARPs do not address the operational acceptability of these subsets. There is one exception to this: It is technically possible for an aircraft system to be implemented without emergency contracts. However, from an operational point of view this is unacceptable, and so has not been included as a valid subset.

3.4.7.4 The subsetting rules define subsets of the protocol. It is also possible to define subsets of user functionality beyond the rules defined in the SARPs. An aircraft may not be equipped to provide all the information required by a contract, and it may reply with a noncompliance notification or negative acknowledgement. For example, if an aircraft is not equipped to supply weather information, when a contract requests weather information, it may reply with a noncompliance notification. Similarly, if the aircraft is unable automatically to detect a particular event type, it may reply to a request for the event type with a negative acknowledgement. Under all circumstances, however, the aircraft must be able to recognise and process these contract requests, even if it cannot meet the terms of the contract. This type of subsetting is not covered in the SARPs Aircraft Functionality Options.

3.4.7.4.1 In the aircraft, all the functionality is mandatory, that is, there are no valid subsets other than implementing everything. This is because the aircraft must be able to support all contracts that the ground system requests of it.

3.4.7.4.2 It is theoretically possible for an aircraft system not to implement emergency contracts. However, this is considered operationally unacceptable, and is therefore not a valid option in the SARPs.

3.4.7.4.3 In the aircraft, it is possible to support part of the functionality of a contract - in that the equipment on board may not be able to handle a particular event or supply a particular piece of information. This optional functionality is handled by the use of the noncompliance notification. Such optional functionality is not covered in this section.

3.4.7.5 Ground System Functionality Options

3.4.7.5.1 The ground system does not have to implement the complete functionality described in the SARPs. A set of valid subsets is defined. These subsets have been chosen on the grounds of technical feasibility rather than a set of operational requirements. Examination of the options and comparison with the operational requirements of the system being built is therefore recommended.

3.4.7.5.2 The simplest option is that of only implementing the demand contract. This might be used in a scenario where ADS is not used for surveillance, but only used to check the extended projected profile against the filed flight plan for example.

3.4.7.5.3 All other options require the implementation of the emergency contract, since, if either the event or periodic contracts are implemented, then there is a possibility that the aircraft will initiate an emergency contract. The other functionality can include one of the following three combinations:

- event contract
- periodic contract
- both event and periodic contract

3.4.7.5.4 Each of these three options can be implemented either with demand contracts or without. Thus there are a total of seven options for ground systems.

3.4.7.5.5 Of course, the ground system may offer less than the full functionality of a given contract type. For example, a ground system periodic contract need never implement the request for intermediate-intent, and never implement the functionality of receiving an intermediate-intent.

3.4.7.6 Report Forwarding Options

3.4.7.6.1 When implementing ADS report forwarding, there are only two options - either implement an initiating system or a receiving system. A system that implements both initiating and receiving functions must implement them as two separate applications.

3.5 DIMENSIONS

3.5.1 PDU Size

3.5.1.1 Theoretical Limits

3.5.1.1.1 Theoretically, the aircraft could be requested to provide a report with all possible types of information, including an extended projected profile with the maximum number of waypoints. The largest PDU that the aircraft will be required to produce will thus depend on the maximum number of waypoints that the flight management system can generate. Where the flight management system is capable of generating the maximum number of way points, then the largest APDU that the aircraft could generate is 1399 octets. The ground system must not request a report that is bigger than the maximum size that it can cope with.

3.5.1.1.2 The maximum APDU size for the ADS Report Forwarding application is only slightly bigger, and also fits into 1399 octets.

3.5.1.1.3 A major limiting factor with PDUs of this size is likely to be the bandwidth of the air-ground subnetwork. Current technology only provides limited bandwidth across the air-ground subnetwork, and so large amounts of data transmitted could flood it. The size of contract requests and other ground initiated PDUs are very small by comparison, and all airborne systems must be built with the capability to receive all requests from the ground.

3.5.1.2 A second limiting factor is likely to be the memory capacity of the airborne system. Many implementations will be built into existing equipment which have limited memory available for storage of the data structures used to build and examine PDUs. Such implementations may have to recognise when they cannot cope with a contract because of memory limitations, and respond with a noncompliance notification or negative acknowledgement Error Handling.

3.5.1.2.1 Should either airborne or ground system receive a PDU that is too large for it to manage under its current circumstances (e.g. lack of memory due to other applications), it will be unable to decode it. The system must abort the connection under these circumstances.

3.5.1.2.2 Table 3.5-1 gives typical sizes for the APDUs used in ADS.

Scope	*APDU*	*Typical Size*	*Comments*
Uplink	aDS-cancel-all-contracts-PDU	1 octet	
	aDS-cancel-contract-PDU	1 octet	
	aDS-cancel-emergency-acknowledgement-PDU	1 octet	
	aDS-demand-contract-PDU	2 octets	This can be up to 4 octets if short term intent and/or extended projected profile is chosen.
	aDS-event-contract-PDU	5 octets	This can be up to 16 octets if all options

Scope	*APDU*	*Typical Size*	*Comments*
			are chosen; 5 octets covers 2 events only.
	aDS-modify-emergency-contract-PDU	2 octets	
	aDS-periodic-contract-PDU	5 octets	A contract for the basic report only is 3 octets; the addition of other optional blocks of information in the contract increases the APDU size to up to 13 octets.
	aDS-provider-abort-PDU	1 octet	
Downlink	aDS-cancel-emergency-PDU	1 octet	
	aDS-demand-report-PDU	15 octets	15 octets gives the basic report only (i.e. no optional information). With all the optional information extended to the maximum size, this can reach 1399 octets, although most of this is the full extended projected profile. Without this, the maximum size is 102 octets.
	aDS-emergency-report-PDU	15 octets	This can go up to 22 octets when aircraft address and ground vector information is included every fifth report.
	aDS-event-report-PDU	20 octets	20 octets covers the basic report together with a ground vector. The ASN.1 will allow this to reach a size of over 1399 octets. In practice, restrictions in the user part of the SARPs (2.2.1.7) prevent it being as big as this.
	aDS-negative-acknowledgement-PDU	2 octets	Normally this will be 2 octets - but it could be more if it is reporting that the maximum capacity is exceeded - in this case it will be at least 18 octets, possibly more can be expected.
	aDS-noncompliance-notification-PDU	20 octets	This can be up to 71 octets if there are a lot of noncompliances. 20 octets gives a single noncompliance.
	aDS-periodic-report-PDU	15 octets	15 octets gives the basic report only (i.e. no optional information). With all the optional information extended to the maximum size, this can reach 1399 octets, although most of this is the full extended projected profile. Without this, the

Scope	*APDU*	*Typical Size*	*Comments*
			maximum size is 102 octets.
	aDS-positive-acknowledgement-PDU	2 octets	
	aDS-provider-abort-PDU	2 octets	
Ground	aDS-forwarded-report-PDU	17 octets	17 octets gives the basic report only (i.e. no optional information). With all the optional information extended to the maximum size, this can reach 1402 octets, although most of this is the full extended projected profile.
	aDS-provider-abort-PDU	1 octet	

Table 3.5-1: Typical sizes of APDUs

3.5.2 Rate of Message Transmission

3.5.2.1 Limits

3.5.2.1.1 The required maximum transmission rate for periodic and emergency contracts is one message per second. Thus, in theory, an aircraft must be able to handle transmission of the maximum size report at a rate of one per second to four different ATS ground systems. There are a number of factors that limit the rate of transmission, which include:

- the speed at which raw data can be gathered from the avionics;
- the processing power of the aircraft ADS system;
- the processing power of the airborne router;
- the bandwidth available on the air-ground subnetwork.

3.5.2.1.2 In practice, therefore, it is unlikely that this theoretical limit can be reached. It is for this reason that the aircraft is able to report to the ground that it is not able to meet the requested rate. In order for the airborne system to be able to calculate if it can meet the required reporting rate, it will have to have some information about the four factors listed above. Note that the fourth factor - the bandwidth available on the air-ground link - is dependent upon the subnetwork in operation at the time; this factor is therefore dynamic, whereas the first three are static. Some means of communicating the bandwidth available on the air-ground link to the ADS processor will have to be in place. The ground system controls the rate of report delivery on the periodic and emergency contracts. It must therefore request a rate that it can handle.

3.5.2.2 Error Handling

3.5.2.2.1 Should the aircraft be requested to deliver a rate that it determines is not possible, it will reply with a noncompliance notification and default to a 60 second rate. A condition may occur where a periodic contract has been accepted, and it is subsequently found that the reporting rate cannot be met. There is no way for the airborne system to negotiate a slower reporting rate once it has accepted it. There are two options available to the implementors:

- the aircraft could abort the connection;
- the aircraft could deliver at a slower rate.

3.5.2.2.2 If the bandwidth on the air-ground link is the problem, there may be congestion in the router, in which case it may be preferable to abort the connection. If the problem is obtaining raw data from the avionics, then it may be preferable to deliver at the slower speed, and allow the ground system to abort or change the rate as it desires. For the ground system, if it receives ADS reports at a slower rate than requested, the implementation has three options:

- the ground system could abort the connection;
- the ground system could request a new contract at a slower rate;
- the ground system could do nothing, accepting the rate as supplied.

3.5.3 Number of Connections

3.5.3.1 Limits

3.5.3.1.1 The SARPs requires that an aircraft is capable of managing at least four connections at the same time. That is, four ground systems may attempt to establish contracts, and the period of those contracts overlaps. Moreover, each of the ground systems may set up a periodic contract, an event contract, and a demand contract. Thus the aircraft must be able to handle all twelve contracts simultaneously. Although the aircraft must be able have contracts with at least four ground systems, there are no requirements that prevent an implementation managing more than four.

3.5.3.1.2 The operational requirement is for four ATSUs to have contracts. There may be other organisations, for example, the airline, which may also want to set up ADS contracts. In these circumstances, an implementation could be designed to manage more than four connections. In order to be compliant with the SARPs, the airborne system must reject a non-ATC system that is "using up" one of the four connections reserved for ATC systems. The only way the airborne system has of doing this is through examination of the ICAO facility designator. The airborne system must trust the ground based systems to set this up correctly.

3.5.3.1.3 There is no equivalent requirement for a ground system. In theory, a ground system implementation could manage only one connection. It seems unlikely that such an implementation would be useful. Careful consideration ought to be give to the requirements of the ground system before any limits are set.

3.5.3.1.4 In the air system, an attempt may be made to exceed the maximum number of connections set by the implementation (which must be four or more). In this case there is a requirement that the aircraft rejects the attempt to establish a contract while returning a list of the ground systems that already have connections. This will allow a controller to examine the list of connected systems, determine if there are any that are inappropriate, and contact them (for example, by telephone, or some automatic means) asking them to release their connection. The ground system initiates all ADS connections, and there is, therefore, no similar requirement of them. Of course, the ground system must have some local means of preventing more connections to be set up than it is designed to manage.

3.5.3.1.5 Ground forwarding can also be used to distribute the information to more ground systems.

3.5.3.1.6 For further guidance on sizes, see ICAO Manual of Air Traffic Services (ATS) Data Link Applications Part III, Chapter 3, Appendix A, Table 3A-1.

3.6 ASN.1 Index

3.6.1 ASN.1 Section Index

3.6.1.1 The ASN.1 discussed here is in two parts. The first part lies in section 2.2.1.4.2 of the ADS SARPs, and holds the main body of the ASN.1. In addition, there is a second section of ASN.1 in the ADS Report Forwarding Applications SARPs in 2.2.2.4.2.

3.6.1.2 Within the main body of the ASN.1, there are six sections divided up by comments crossing the page. Together with the ADS Report Forwarding ASN.1, there are seven sections. These have been given a section number S1 – S7, and are listed in the table below. These section numbers are not in the SARPs themselves, but have been included here to make the reading of the table in the following section easier. They can be used to determine the location of the ASN.1 type definition within the SARPs.

Section reference	*ASN.1 Section*
S1	Aircraft generated and Ground generated message choice
S2	Ground generated and aircraft generated message components – protocol data units
S3	Reports and their components
S4	Components of contracts
S4	Miscellaneous components
S6	Common components
S7	ADS Report Forwarding Application

Table 3.6-1. ASN.1 Sections

3.6.2 ASN.1 Type Index

3.6.2.1 The following table lists each ASN.1 type defined in the ADS SARPs in alphabetical order[1]. In order to enable the definition to be found more easily, a cross reference to the ASN.1 section is given.

3.6.2.2 The third column lists those ASN.1 types that are used in the definition of the ASN.1 type in the first column, and the fourth column lists those ASN.1 types that use it. The third and fourth columns are therefore inverse references.

3.6.2.3 For primitive types, the last two columns indicate the range and resolution of the type.

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
AbortReason	S2	-	ADSAircraftPDUs ADSGroundPDUs ADSRFPDUs	-	-
ADSAircraftPDUs	S1	ADSDemandReport ADSEmergency ADSEventReport NegativeAcknowledgement ADSPeriodicReport PositiveAcknowledgement AbortReason	-	-	-
ADSDemandReport	S2	ADSReport	ADSAircraftPDUs	-	-
ADSEmergency	S2	ADSEmergencyReport	ADSAircraftPDUs	-	-
ADSEmergencyReport	S3	Position	ADSEmergency	-	-

[1] In retrospect, it would have been better to present the ASN.1 itself in alphabetical order in the SARPs. However, it is not possible to make such dramatic changes once the document is under change control. Please accept the editor's apologies.

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
		DataTimeGroup FigureOfMerit AircraftAddress GroundVector	ForwardedReport		
ADSEventReport	S2	EventTypeReported ADSReport	ADSAircraftPDUs	-	-
ADSForwardedReport	S7	AircraftAddress ForwardedReport	ADSRFPDUs	-	-
ADSGroundPDUs	S1	CancelContract DemandContract EventContract ModifyEmergency PeriodicContract AbortReason	-	-	-
ADSPeriodicReport	S2	ADSReport	ADSAircraftPDUs	-	-
ADSReport	S3	Position DateTimeGroup FigureOfMerit AircraftAddress ProjectedProfile GroundVector AirVector Weather ShortTermIntent ExtendedProjectedProfile	ADSDemandReport ADSEventReport ADSPeriodicReport ForwardedReport	-	-
ADSRFPDUs	S7	ADSForwardedReport AbortReason	-	-	-

Type	ASN.1 Section	Types used by this type	Types using this type	Range	Resolution
AircraftAddress	S3	-	ADSEmergencyReport ADSForwardedReport ADSReport	24 bits exactly	1 bit
AirSpeed	S3	Mach Ias	AirVector	-	-
AirSpeedChange	S4	-	EventContract	For Mach 0.005 - 1.275 For IAS 1 - nnnn	For Mach 0.005 Mach For IAS 1 knot
AirVector	S3	DegreesDirection AirSpeed VerticalRateChange	ADSReport	-	-
CancelContract	S2	-	ADSGroundPDUs	-	-
Date	S6	Year Month Day	DateTimeGroup	-	-
DateTimeGroup	S6	Date Time	ADSEmergencyReport ADSReport	-	-
Day	S6	-	Date	1 to 31	1 day
DegreesDirection	S4	-	AirVector EventContract GroundVector IntermediateIntent	0.1 to 360 degrees	0.1 degrees
DemandContract	S2	ProjectionTime ExtendedProjectedProfileRequest	ADSGroundPDUs	-	-
Eta	S6	Time	ExtendedProjectedProfile ProjectedProfile	-	-
EventContract	S2	LateralChange VerticalRateChange	ADSGroundPDUs	-	-

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
		LevelRange AirSpeedChange GroundSpeedChange DegreesDirection ExtendedProjectedProfileRequest LevelChange			
EventTypeContracted	S5	-	NoncomplianceNotification	-	-
EventTypeReported	S5	-	ADSEventReport ForwardedReport	-	-
ExtendedProjectedProfile	S3	Position Eta	ADSReport	-	-
ExtendedProjectedProfileModulus	S4	Modulus ExtendedProjectedProfileRequest	PeriodicContract	-	-
ExtendedProjectedProfileRequest	S4	-	DemandContract EventContract ExtendedProjectedProfileModulus	Time interval 15 minutes to 20 hours Number of waypoints 1 to 128	Time interval 15 minutes Number of waypoints 1
FigureOfMerit	S3	PositionAccuracy	ADSEmergencyReport ADSReport	-	-
ForwardedReport	S7	ADSReport EventTypeReported ADSEmergencyReport	ADSForwardedReport	-	-
GroundSpeedChange	S4	-	EventContract	0 to 300 knots	1 knot
GroundSystemsUsingService	S5	-	Reason	4 to 8 characters	1 character
GroundVector	S3	DegreesDirection VerticalRateChange	ADSEmergencyReport ADSReport	Ground-speed -50 to 2200 knots	Ground-speed 1 knot
Ias	S4	-	AirSpeed	0 to 1100 knots	1 knot
IntermediateIntent	S3	DegreesDirection	ShortTermIntent	Distance 1 to 8000 nautical miles	Distance 1 nautical mile

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
		Level ProjectionTime			
LateralChange	S4	-	EventContract	0 to 200 nautical miles	0.1 nautical miles
Latitude	S6	Sign	Position	degrees 0 to 90 Minutes 0 to 59 Tenth seconds 0 to 59.9 seconds	degrees 1 Minutes 1 Tenth seconds 0.1 seconds
Level	S6	-	IntermediateIntent LevelRange Position	-750 to 100000 feet	10 feet
LevelChange	S4	-	EventContract	10 to 5000 feet	10 feet
LevelRange	S4	Level	EventContract		
Longitude	S6	Sign	Position	degrees 0 to 180 Minutes 0 to 59 Tenth seconds 0 to 59.9 seconds	degrees 1 Minutes 1 Tenth seconds 0.1 seconds
Mach	S4	-	AirSpeed	0.5 to 4 mach	0.001 mach
ModifyEmergency	S2	ReportingInterval	ADSGroundPDUs	-	-
Modulus	S5	-	ExtendedProjectedProfileModulus PeriodicContract ShortTermIntentModulus	1 to 255	1
Month	S6	-	Date	1 to 12	1 month
NegativeAcknowledgement	S2	RequestType Reason	ADSAircraftPDUs	-	-
NoncomplianceNotification	S2	ReportType EventTypeContracted ReportTypeAndPeriod	ADSAircraftPDUs	-	-

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
PeriodicContract	S2	ReportingInterval Modulus ShortTermIntentModulus ExtendedProjectedProfileModulus	ADSGroundPDUs	-	-
Position	S6	Latitude Longitude Level	ADSEmergencyReport ADSReport ExtendedProjectedProfile ProjectedProfile ShortTermIntent	-	-
PositionAccuracy	S3	-	FigureOfMerit	-	-
PositiveAcknowledgement	S2	RequestType	ADSAircraftPDUs	-	-
ProjectedProfile	S3	Position Eta	ADSReport	-	-
ProjectionTime	S4	-	DemandContract IntermediateIntent ShortTermIntent ShortTermIntentModulus	1 minute to four hours	1 minute
Reason	S5	GroundSystemsUsingService	NegativeAcknowledgement	-	-
ReportingInterval	S4	-	ModifyEmergency PeriodicContract	Seconds scale 1 to 59 seconds Minutes scale 1 to 120 minutes	Seconds scale 1 second Minutes scale 1 minute
ReportType	S5	-	NoncomplianceNotification	-	-
ReportTypeAndPeriod	S5	-	NoncomplianceNotification	-	-
RequestType	S5	-	NegativeAcknowledgement PositiveAcknowledgement	-	-
ShortTermIntent	S3	Position	ADSReport	-	-

Type	*ASN.1 Section*	*Types used by this type*	*Types using this type*	*Range*	*Resolution*
		ProjectionTime IntermediateIntent			
ShortTermIntentModulus	S4	Modulus ProjectionTime	PeriodicContract	-	-
Sign	S6	-	Latitude Longitude	-	-
Time	S6	TimeHours TimeMinutes TimeSeconds	DateTimeGroup Eta	-	-
TimeHours	S6	-	Time	0 to 23 hours	1 hour
TimeMinutes	S6	-	Time	0 to 59 minutes	1 minute
TimeSeconds	S6	-	Time	0 to 59 seconds	1 second
VerticalRateChange	S4	-	AirVector EventContract GroundVector	-30000 to 30000 feet per minute	10 feet per minute
Weather	S3	-	ADSReport	Wind speed 0 to 300 knots Wind direction 1 to 360 degrees Temperature -100 to 100 degrees Centigrade Turbulence 0 to 15 (units to be decided)	Wind speed 1 knot Wind direction 1 degree Temperature 0.25 degrees Centigrade Turbulence 1 unit
Year	S6	-	Date	1996 to 2095	1 year

Table 3.6-2. ASN.1 Type Index

3.6.3 ASN.1 Glossary

***ADS Event Report**:* ADS information consisting of a sequence of *Event Type* and *ADS Report*.

ADS Emergency Report: ADS information consisting of the following sequence:

a) Position,
b) Time Stamp,
c) FOM,
d) Aircraft Identification (optional), and
e) Ground Vector (optional).

ADS Report: ADS information consisting of the following sequence:

a) Position,
b) Time Stamp,
c) FOM,
d) Aircraft Identification (optional),
e) Projected Profile (optional),
f) Ground Vector (optional),
g) Air Vector (optional),
h) Meteorological Information (optional),
i) Short Term Intent (optional), and
j) Extended Projected Profile (optional).

***Aircraft Identification**:* Field 7 of the ICAO flight plan.

***Air Speed**:* Provides airspeed as a choice of the following*:* *Mach*, *IAS*, or *Mach* and *IAS*.

Air Speed Change: Provides the threshold of change for either Mach speed or indicated air speed that requires that an avionics generate an ADS report when the current aircraft speed differs more than the specified threshold from the air speed in the last ADS report.

Air Vector: Provides the air vector as a sequence of *Heading*, *Air Speed*, and *Vertical Rate*.

***Altitude**:* Specifies altitude.

Altitude Ceiling: The altitude above which an Altitude Deviation Event is triggered. Provided as an *Altitude.*

***Altitude Change**:* Provides the threshold of change for altitude that requires the avionics to generate an ADS report when the current altitude differs by more than the specified threshold from the altitude in the last ADS report.

Altitude Floor: The altitude below which an Altitude Deviation Event is triggered. Provided as an *Altitude*.

Altitude Range Change: Threshold of change permissible between altitudes in consecutive ADS reports.

Cancel Contract: Allow the ground to cancel event and/or periodic contracts in effect.

***Contract Type**:* Indicates which type of ADS contract is specified: demand, event, or periodic.

Demand Contract: Indicates that an avionics is to generate an ADS report containing the indicated data upon receipt of the contract. The data that can be indicated includes: aircraft identification, projected profile, ground vector, air vector, meteorological information, short term intent, and extended projected profile.

Distance: Distance.

ETA: Estimated time of arrival at a waypoint.

Event Contract: Indicates *Event Types* and the threshold for the specified event types.

Event Type: An indication of what type of ADS event is specified:

a) Vertical rate change,
b) Way-point change,
c) Lateral deviation change,
d) Altitude change,
e) Altitude range deviation,
f) Airspeed change,
g) Ground speed change,
h) Heading change,
i) Extended projected profile change,
j) FOM (Figure of Merit) field change, and
k) Track angle change.

Extended Projected Profile*:* Provides a sequence (1-128) of waypoint position data and ETA at the specified waypoint.

Extended Projected Profile Change*:* Indicates that an ADS report be generated when there is a change in the extended projected profile.

Extended Projected Profile Modulus: Sequence of *Modulus* and *Extended Projected Profile Request.*

Extended Projected Profile Request*:* a choice indicating whether the extended projected profile information is to be provided on a time or waypoint interval, and the interval of the specified choice.

Following Way Point: Indicates the waypoint after the next way point.

FOM: Indicates the figure of merit of the current ADS data. The information consists of the *Position Accuracy* and indications 1) whether or not multiple navigational units are operating, and 2) whether or not ACAS is available.

FOM Field Change: Indicates that an ADS report be generated when any FOM field changes.

Ground Speed*:* Provides ground speed.

Ground Speed Change: Provides the threshold of change for ground speed that requires the avionics to generate an ADS report when the current aircraft ground speed has differed by more than the specified threshold from the last ADS report.

Ground Vector: Provides the ground vector of an aircraft provided as a sequence of *Track*, *Ground Speed*, and *Vertical Rate*.

***Heading**:* Provides aircraft heading in degrees.

Heading Change: Provides the threshold of change for heading in degrees that requires the avionics to generate an ADS report when the current heading has differed by more than the specified threshold from the last ADS report.

***IAS**:* Indicated air speed.

***ICAO Facility Designator**:* The 8 letter code which uniquely defines an ICAO ATSU facility.

Intermediate Intent: Set of points between current position and the time indicated in *the Short Term Intent*. Consists of a sequence of the following: *Distance*, *Track*, *Altitude* and *Projected Time.*

Lateral Deviation Change: Provides the threshold of change for lateral value that requires the avionics to generate an ADS report when the current lateral deviation exceeds the specified threshold.

***Latitude**:* Latitude in degrees, minutes, and seconds.

***Longitude**:* Longitude in degrees, minutes, and seconds.

***Mach**:* Air speed given as a Mach number.

Mach and IAS: Air speed provided as both *Mach* and *Indicated Air Speed*.

Meteorological Information: A sequence of *Wind Direction*, *Wind Speed*, *Temperature* and *Turbulence*.

***Modulus**:* Provides a multiplier on the basic ADS report interval.

Next Time: Time at next waypoint.

Next Way Point: specifies the next waypoint in the avionics.

Noncompliance Notification: used to indicate partial compliance to a contract.

Periodic Contract: Provides the requirements for the generation of ADS reports. The periodic contract provides the reporting interval, and the modulus for when and what optional data is included in an ADS periodic report.

Position: Provides aircraft position information using a sequence of *Latitude*, *Longitude*, and *Altitude.*

Position Accuracy: An indication of the navigational accuracy.

Projected Profile: A sequence of *Next Way Point*, *Next Time*, and *Following Waypoint*.

Projected Time: Predicted time at a particular point.

Reporting Interval: Provides the required ADS reporting interval.

Report Type: Indicates which type of ADS report is provided: demand, event or periodic.

Request Type: A choice indicating which type of ADS request is being uplinked. The choices are as indicated below:

a) cancel event contract,

b) cancel periodic contract,
c) demand contract,
d) event contract,
e) cancel emergency,
f) modify emergency,
g) periodic contract, or
h) cancel all contracts.

Short Term Intent*:* A sequence of *Position, ETA,* and *Intermediate Intent (optional)* data structures.

Temperature*:* Temperature in degrees Celsius.

Track: Provides track angle in degrees.

Track Angle Change: Provides the threshold of change for track angle in degrees which triggers avionics to generate an ADS report when the current track angle differs by more than the specified threshold from the track angle in the last ADS report.

Turbulence*:* Indicates severity of turbulence on a scale of 0-15.

Vertical Rate: Rate of climb/descent (climb positive, descent negative).

Vertical Rate Change: The threshold of change for vertical rate that requires the avionics to generate an ADS report when the current vertical rate differs by more than the specified threshold from the vertical rate in the last ADS report.

Way Point Change*:* Change in the next waypoint information.

Wind Direction: Wind direction in degrees.

Wind Speed: Wind speed.

3.7 EXAMPLE SCENARIOS

3.7.1 Introduction

3.7.1.1 This section contains a set of example scenarios of use. The purpose of this section is to demonstrate some scenarios that are theoretically possible using ADS. It is not meant to indicate what is required from an operational point of view.

3.7.2 Demand Contract in Isolation

3.7.2.1 A ground system requests an aircraft to provide an extended projected profile for its complete flight in a demand contract, and the aircraft returns its extended projected profile. This scenario could be used by a ground system that wants to compare the aircraft's flight plan with its own record of the flight plan stored in the flight data processing system. This could be initiated automatically for every aircraft as it approaches the FIR boundary. The controller may be unaware of this activity taking place.

3.7.3 Periodic Contract in Isolation

3.7.3.1 A ground system requests an aircraft to provide a periodic contract with:

- a period of 20 seconds;
- a ground vector every 15th report (i.e. every 5 minutes);
- weather information every 36th report (i.e. every 12 minutes).

3.7.3.2 This scenario could be used by a ground system that wants to track an aircraft closely over non-radar airspace. The weather information could be used to provide early indication of poor conditions for another aircraft following the first.

3.7.4 Event Contract in Isolation

3.7.4.1 A ground system requests an aircraft to provide an event report under the following conditions:

- the aircraft goes above 37300 feet or below 36700 feet (level range);
- the aircraft deviates from its course laterally by more than half a nautical mile (lateral deviation change);
- the aircraft's navigational accuracy changes (FOM change).

3.7.4.2 The first two constraints conceptually box the aircraft in. No reports are generated provided that it does not deviate outside the level range, nor half a nautical mile laterally and the FOM does not change. This creates a three dimensional tube through which the aircraft can fly. Reports are generated if the aircraft leaves this zone. Should some of the aircraft's navigational equipment fail, it may be unable to determine if it is within these limits with the same degree of accuracy. In such a case, a report will be generated to inform the controller of the change in the ability of the aircraft to determine its position. The controller will thus be able to make allowances for aircraft deviations and/or degraded performance. Note that the event will also be triggered if the ACAS availability changes.

3.7.5 Periodic and Emergency Contract

3.7.5.1 A ground system has established a periodic contract with an aircraft reporting at 90-second intervals. During the operation of this contract, an emergency occurs on the aircraft, such as the failure of an engine. The avionics detects this failure and automatically signals the ADS system. The ADS system immediately suspends the periodic contract with the ground system. It then initiates an emergency contract, reporting at 45-second intervals. The ground system indicates to the controller that an emergency is in place (say by showing the aircraft in a different colour). This allows the controller to contact the aircraft through a voice link or CPDLC in order to determine what to do. If the emergency is not detectable by the avionics (e.g. a medical emergency of one of the passengers or crew), the pilot can initiate the emergency contract. If the emergency is rectified and the pilot cancels the emergency contract, the ADS system reverts to the periodic contract it had with the ground system beforehand.

3.8 EXAMPLE ENCODING

3.8.1 ADS-demand-contract PDU

3.8.1.1 The following is an example of the encoding of an ADS-demand-contract-PDU. The demand contract requests the following information:

- aircraft address
- air vector
- extended projected profile for the next 30 way points

Element	*Sub-element*	*Value*	*Encoding*	*Comments*
ADSGroundPDUs CHOICE		aDS-demand-contract-PDU [3]	0 000011	no extension used the CHOICE 3 is selected
SEQUENCE			0 1001001	no extension used selection of 1st, 4th and 7th elements
aircraft-address [0]		NULL		no encoding for NULL
project-profile[1]				
ground-vector [2]				
air-vector [3]		NULL		no encoding for NULL
weather [4]				
short-term-intent [5]				
extended-projected-profile [6]				
	CHOICE	number-way-points [1]	1	the CHOICE 1 is selected
	INTEGER	30	0011101	the INTEGER 30 encoded as 30-1 (i.e.29), since 1 is the lower bound of the range

Table 3.8-1. ADS-demand-contract-PDU encoding

3.8.1.1.1 Thus the PDU is encoded as 00000110 10010011 00111010, or in hexadecimal: 06 93 3A.

WARNING - THIS ENCODING NEEDS TO BE CHECKED

3.8.2 ADS-noncompliance-PDU

3.8.2.1 The following is an example of the encoding of an ADS-noncompliance-PDU. The noncompliance indicates that the extended projected profile is not available. It contains:

- aircraft address
- air vector

Element	*Sub-element*	*Value*	*Encoding*	*Comments*
ADSAircraftPDUs CHOICE		aDS-noncompliance-notification-PDU [5]		
Noncompliancenotification CHOICE		demand-ncn [0]		
SET OF				
ReportType ENUMERATED		aircraft-address (0)		
ReportType ENUMERATED		air-vector (3)		

Table 3.8-2. ADS-noncompliance-PDU encoding

3.8.2.1.1 Thus the PDU is encoded as XXXXX, or in hexadecimal: XXXXXX.

WARNING - THIS ENCODING NEEDS TO BE CHECKED

<<TBC>>

3.8.3 ADS-report-PDU

3.8.3.1 The following is an example of the encoding of an ADS-report-PDU. The ADS report contains:

- position
- timestamp
- fom
- aircraft address
- air vector

Element	*Sub-element*	*Value*	*Encoding*	*Comments*

Element	*Sub-element*	*Value*	*Encoding*	*Comments*
ADSAircraftPDUs CHOICE		aDS-demand-report-PDU		
ADSDemandReport				
SEQUENCE				
report ADSReport				
SEQUENCE				
position [0]				
SEQUENCE				
Latitude				
SEQUENCE				
	sign	ENUMERATED plus (0)		
	degrees	INTEGER 51		
	minutes	INTEGER 29		
	tenths-seconds	INTEGER 129		
Longitude				
SEQUENCE				
	sign	ENUMERATED plus (1)		
	degrees	INTEGER 0		
	minutes	INTEGER 4		
	tenths-seconds	INTEGER 260		
Level		INTEGER 2900		
time-stamp[1]				
SEQUENCE				
SEQUENCE				
	year	INTEGER 2016		
	month	INTEGER 9		
	day	INTEGER 4		
SEQUENCE				
	timeHours	INTEGER 17		
	timeMinutes	INTEGER 35		
	timeSeconds	INTEGER 49		
fom [2]				
SEQUENCE				
	position-accuracy	ENUMERATED under1nm (5)		
	multiple-navigational-units-operating	BOOLEAN FALSE		
	acas-operational	BOOLEAN TRUE		
aircraft-address [3]		BITSTRING 11110000 1100110010101010		
air-vector [6]				
SEQUENCE				
	heading	INTEGER 40		

Element	Sub-element	Value	Encoding	Comments
	air-speed [1] CHOICE			
	ias [1]	INTEGER 514		

Table 3.8-3. ADS-demand-report-PDU encoding

3.8.3.1.1 Thus the PDU is encoded as XXXXX, or in hexadecimal: XXXXXX.

WARNING - THIS ENCODING NEEDS TO BE CHECKED

<<TBC>>