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ADS EUROPE 97
Complementary Analysis Studies

ADS/ATN Operational Concepts Feasibility

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SECTION CONTROL

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GLOSSARY

ACM	ATC Communication Management
ACNZ	Airways Corporation of New Zealand
ADAP	Automated Downlink of Airbone Parameters
ADS	Automatic Dependent Surveillance
ADSE	ADS Equipment
ADSP	ADS Panel
AMSS	Aeronautical Mobile Satellite Services
AOR/E	Atlantic Ocean Region/East
AOR/W	Atlantic Ocean Region/West
APANPIRG	Asia Pacific Air Navigation Planning and Implementation Regional Group
ARINC	Aeronautical Radio Inc
ASA	Air Services Australia
ATMG	Air Traffic Management Group
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
CAA	Civil Aviation Authority
CADAG	NAT SPG Communications, Automation and Datalink Applications Group
CAP	Controller Access Parameters
CENA	Centre d'Etudes de la Navigation Aérienne
CIC	Clearances and Information Communications
CNS/ATM	Communication, Navigation, Surveillance Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
DARPS	Dynamic AirborneRoute Planning System
DCL	Departure Clearance
DGAC	Direction Générale de l’Aviation Civile
DLIC	Data Link Initiation Capability
DSC	Downstream Clearance
DYNAV	Dynamic Route Availability
D-FIS	Data Link Flight Information Services
D-OTIS	Data Link Operational Terminal Informations Service
D-RVR	Data link Runway Visual Range
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
ECAC	Europeran Civil Aviation Conference

EEP	Extended Projected Profile
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FLIPCY	Flight Plan Consistency
FMC	Flight Management Computer
GES	Ground Earth Station
GPS	Global Positioning System
HF	High Frequency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFALPA	International Federation of Air Traffic Controllers Association
IFATCA	International Federation of Airlines Pilots Association
INMARSAT	International Maritime Satellite
IOR	Indian Ocean Region
ISPACG	Informal South Pacific ATS Co-ordinating Group
MTN	Mega Transport Network
NATS	National Air Traffic Services
NAT SPG	North Atlantic Systems Planning Group
NM	Nautical Mile
ODIAC	Operational Development of Integrated Air/Ground data communication Sub-group
OEP	Oceanic Entry Point
OSI	Open Systems Interconnection
RNAV	Area Navigation
RNP	Required Navigation Performance
SAP	System Access Parameters
SARPS	Standards and Recommended Practices
SEAC	Secrétariat d'Etat de l'Aviation Civile
SIGMET	Significant Meteorological Information
SOFREAVIA	Société Française d'Etudes et de Réalisations d'Equipement Aéronautiques
STNA	Service Technique de la Navigation Aérienne
VHF	Very High Frequency
VDL	VHF Data Link

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1. INTRODUCTION

1.1 ADS Europe Complementary Analysis Studies calls for proposals

At the end of 1997, Eurocontrol issued a requirements specification for two studies to complement the ADS Europe 97 Trials, and to address some issues identified in Eurocontrol's ADS Feasibility Work Programme, which intends to evaluate to what extent ADS will be safe and cost-effective if deployed in European airspace. This feasibility programme and the issues it will address are defined in a Eurocontrol document [1] entitled "European ADS Scenarios and Research and Development Programme" and known as the "Blue Book".

The two studies consist in (a) comparing the performance characteristics of ADS over ATN with the FANS1/A equivalent protocol stack, and (b) exploring the feasibility of ADS operational requirements currently under consideration by CADAG, ISPACG, and ODIAC for use over ATN and INMARSAT aviation datalinks.

1.2 ADS EUROPE Complementary Analysis Studies Contract

In response to the requirements specification, SOFREAVIA and the UK National Air Traffic Services (NATS Ltd), both members of the ADS EUROPE 97 Consortium , jointly presented a proposal to Eurocontrol.

The two studies have been handled concurrently, but independently. NATS and Sofréavia both shared the responsibility of the study (b), while Sofréavia , with the support of the Service Technique de la Navigation Aérienne (STNA) undertook the entire responsibility for the study (a).

Study (a) has been contracted by the Eurocontrol Experimental Centre, ADS Studies and Trials Project, with support from the Eurocontrol ATN Infrastructure Project, while study (b) has been contracted by the Eurocontrol ADS Programme.

1.3 Document overview

This document explores the feasibility of ADS operational requirements currently under consideration by NATSPG/CADAG, ISPACG, and ODIAC for use over ATN and INMARSAT aviation datalinks.

1.4 Study objectives

As operational concepts involving the ADS application are being defined and experimented throughout the world, the capability of a given system to support these various concepts has been questioned. The objective of the study is to use the example of the ADS Europe implementation in order to provide an answer to this question. According to Eurocontrol's Work package 3 general description, this study contributes to Eurocontrol's objectives by considering different scenarios and striving to determine strengths and weaknesses of the ATN/AMSS implementation.

The document comprises four parts:

- The presentation of operational concepts defined, or that are currently being defined, within expert groups such as ODIAC, CADAG/NATSPG for the NAT region, and ISPACG for the South Pacific region.
- The identification of ADS scenarios derived from the study of the operational concepts and compatible with the ADS Europe capabilities to be performed during trials sessions.
- The reporting of the trials results.
- The conclusion and recommendations.

2. ADS OPERATIONAL CONCEPTS

2.1 ODIAC OPERATIONAL CONCEPTS

2.1.1 ODIAC presentation

The Operational Development of Initial Air/Ground data Communications (ODIAC) is an Eurocontrol Task Force defining European operational requirements for the introduction of Air/Ground data communications for Air Traffic Management in the ECAC area. ODIAC's activities are overseen by the Operational Requirements and Data Processing Team of the EATCHIP Phase III work programme.

The purpose of ODIAC's work is twofold:

- defining the operational requirements for EATCHIP Phase III technical work,
- providing the International Civil Aviation Organisation (ICAO) groups, in particular the Automatic Dependent Surveillance (ADSP), with the EUROCONTROL Member States and Aviation Organisations operational requirements.

2.1.2 Operational concepts

ODIAC has defined a number of data link services in order to provide an operationally oriented description of the use of data communication for Air Traffic Services, thus defining a general operational concept for the ECAC area.

These data link services fall into four categories:

- The CPDLC services, which comprise the ATC Communication Management (ACM) service, the Clearances and Informations Communications (CIC) service, the departure Clearance (DCL) service, the Downstream Clearances service (DSC).
- The ADAP services which comprise the Controller Access Parameters (CAP) service,
- The D-FIS service which comprise the Data link Operational Terminal Information Service (D-OTIS) and the Data link Runway Visual range (D-RVR) service.
- and a number of other services under finalization, which comprise the Datalink Initiation Capability (DLIC), the Flight Plan Consistency (FLIPCY) service, the Dynamic Route availability (DYNAV) service, the Pilot Preferences Downlink (PPD) service, the System Access Parameters (SAP) service, and the Data Link SIGMET service.

The study of these services showed that two of them could involve the ADS application : the CAP and the FLIPCY services.

2.1.2.1 Controller Access Parameters Service

The Controller Access Parameters service aims at enhancing the ATC surveillance and the availability of aircraft parameters to the controller by extracting and downlinking data from the airborne system. It is anticipated that this service would normally be implemented over Mode-S Specific Services. However, a subset of the CAP service could also be implemented using the ADS application as an interim or complementary solution. In this alternative method, parameters like Speed, Mach number, Vertical rate, Wind speed and direction could be provided to the controller via the Earth Reference group, Air Reference group and Meteorological group defined in the ADS application.

These groups being available with the ADS Europe implementation, the study will test the CAP service feasibility in an ADS/ATN/AMSS environment through a specific scenario that is described in chapter 3.2.1 below.

2.1.2.2 Flight Plan Consistency Service

The Flight Plan Consistency service enables to check that the ATC flight plan corresponds to the aircraft flight plan loaded in the FMC. It is anticipated that this service could be implemented over the ADS application.

However, the feasibility of this service can not be verified with the ADS Europe platform as the service is based on the ICAO SARPS ADS application [2] while the ADS Europe platform is based on the ARINC 745-2 standard [3]. The Extended Projected Profile (EPP) group, which enables the receipt of airborne flight plan data, is not included in the ARINC 745-2 message set and hence is unavailable in the ADS Europe project. Hence the evaluation of this service feasibility is unfortunately not possible within this current study.

2.1.3 Conclusion

As a conclusion, the study of the operational services developed by the ODIAC task force showed that two services could be based on the ADS application; and the ADS Europe platform could be used to evaluate the feasibility of only one of them.

2.2 ISPACG OPERATIONAL CONCEPTS

2.2.1 ISPACG Presentation

The Informal South Pacific ATS Co-ordinating Group (ISPACG) which comprises ATS providers, communication service providers, airframe and equipment manufacturers, airlines and representatives of IATA, ICAO, IFATCA and IFALPA, meets periodically to co-ordinate and plan the air traffic management improvements in this region. The ATS providers attending include the Airways Corporation of New Zealand (ACNZ), Air Services Australia (ASA), the US Federal Aviation Administration, CAA Fiji and the Secrétariat d'Etat de l'Aviation Civile of French Polynesia, part of the French DGAC. On the manufacturers side, Boeing and Airbus attend (with their aircraft products respectively the FANS-1 and FANS-A packages), while on the airline side, United Airlines, Qantas and Air New Zealand are the main participants. Since the establishment of the group in 1991, the ISPACG has dedicated its efforts to the FANS implementation for the benefits of the airspace users and ATS providers.

For the past 5 years, the developments planned in the South Pacific region aimed at improving route planning (notably by making better use of wind information). These developments included the following steps:

- setting-up a network of flexible tracks (or ‘flextracks’) between Sydney and Los Angeles and between Auckland and Los Angeles;
- the implementation of a dynamic management of these flextracks, called DARPS (Dynamic Aircraft Route Planning System). This has been scheduled by the ISPACG for operation in 98, and requires aircraft to be equipped with the "FANS-1 Package". (FANS-1 is a Boeing specific avionics fit for use in Boeing 747-400s aircraft, and offers data link and GPS capabilities; a compatible package - FANS-A - will be available on some of the Airbus families of aircraft in 1998).
- a phased reduction of separations minima, from 100NM to 30NM lateral and longitudinal.

To achieve these goals, ISPACG developed a general CNS/ATM Operational Concept, with a number of prerequisites defined for each of the goals. These prerequisites are presented in the following chart.

Operational Services	Prerequisites
DARP	CPDLC capabilities.
Separation minima 50NM Long / 50 NM Lat	- RNP10, - CPDLC position reports or ADS, - Direct voice communication system (SATCOM voice, Direct HF or CPDLC).
Separation minima 30NM Long / 30 NM Lat	- RNP4, - ADS, - Direct voice communication system (SATCOM voice, Direct HF or CPDLC).

This general operational concept identifies that ADS capabilities are recommended for the 50 NM lateral and longitudinal separation minima, and are required for the 30 NM lateral and longitudinal separation minima. Consequently, only these two of ISPACG's objectives are covered by this study.

A more detailed description of the ISPACG's ADS-based Operational concept is presented hereafter.

2.2.2 ISPACG's ADS-based Operational concept

ISPACG's ADS-based operational concept has been developed over the result of separation minima studies carried out by the Member States of the Asia/Pacific Air Navigation Planning and Implementation Regional group (APANPIRG).

These studies consisted of two collision risk model studies which determined the lateral and longitudinal separation minima for ADS and RNAV based air traffic control. As a result, a number of requirements have been identified. They are listed below.

2.2.2.1 Applicable requirements for 50Nm lateral and longitudinal separations in an ADS environment

-a) The aircraft performance shall be approved RNP10 or better. This performance shall be met over the entire route of flight.

-b) A voice backup (HF, Satcom, CPDLC ...) shall exist,

-c) Voice backup performance shall be compliant with the following requirement,

-d) The transmission delay for a position report (ADS, CPDLC or Voice backup) plus the time for a controller to detect a conflict plus the time for an uplink clearance plus the pilot reaction time shall be less than 7 minutes,

-e) When an aircraft fails to report at a required position or time, the controller is required to take action within three minutes to try to establish communications. If communication has not been re-established within five minutes after the normal communication check time, the controller would be required to take action to achieve some alternative form of separation.

-f) The controller shall be aware within three minutes that an aircraft has not answered to a clearance or has failed to report a position.

-g) In an ADS environment, separation shall be established by reference to a display system which enables the controller to assess the distance between aircraft. Separation exists if the observed longitudinal separation on the display is equal or greater than the appropriate minimum. As a consequence, it is considered that a display system is required for a 50NM separation minima.

-h) The aircraft and the ground system shall use a common time reference with a one second precision.

2.2.2.2 Applicable requirements for 30 Nm lateral and longitudinal separations in an ADS environment

The requirements for 50 Nm lateral and longitudinal are also applicable for the 30Nm lateral and longitudinal separation minima, with the exception of requirement a) which shall be replaced by the following one:

a) The aircraft performance shall be approved RNP4 or better. This performance shall be met over the entire route of flight.

Based on these requirements and using an extension of the original Reich aircraft collision risk model, the studies estimated the following collision risk estimates:

Collision Risk Estimates
(Fatal accidents per flying hour)

Required Navigation Performance	Separation standard (Nm)	Max. Permitted time between reports (minutes)	Point estimate of collision risk
4 or better	30	15	8.7×10^{-9}
10 or better	50	15	1.03×10^{-9}
10 or better	50	30	2.63×10^{-8}

The APANPIRG's studies selected a target level of safety of 2×10^{-8} fatal accidents per flying hour for the South Pacific region. In consequence, a 50Nm lateral and longitudinal separation minima with RNP10 and 30 minutes ADS reporting rate did not reach the target level of safety, and a 15 minute reporting rate for both 50Nm and 30Nm separation minima has been retained.

Taking into account the result of these studies, and IFALPA and IFATCA's wishes requesting the use of the ADS application as a prerequisite to reduce the separation minima, ISPACG agreed to first aim at reducing separation minima to 50Nm lateral and longitudinal based on a RNP10 aircraft capability and a 15 minute ADS reporting interval.

To complement the separation minima studies, which did not identify a required communication performance, it has been decided that the communication performance requirement would correspond to an end-to-end transit delay of 60 seconds or less for 95% of the messages delivered. No other additional requirement has been identified by ISPACG. As a consequence, each ATS provider only considered the requirements listed above to design its own ADS ground system. As these requirements were very general, different implementation choices have been selected among the ATS providers, leading to some national implementation differences.

2.2.3 National Implementations

The description of the national implementations relies on information presented at the different ISPACG meetings. At the date of completion of the current study, national implementations have not reached a common level of maturity, and some of the descriptions given hereafter are still subject to changes. The description given hereafter can however be considered as a good indication on the intentions for national implementations.

2.2.3.1 Air Services Australia's implementation choices

Air Services Australia (ASA) is the only member of ISPACG using ADS not only for covering the Oceanic airspace, but also for covering its non-radar domestic airspace.

ASA designed a system where the ADS system area is divided into cells. Periodic contracts will be established with a default reporting rate defined for the cell in which the aircraft is located. Higher reporting rates will be the default for areas of higher traffic density.

Default rates will be set to minimise the involvement of controllers in the management of contracts. Controllers will have the ability to alter the default reporting rates manually for the purpose of separation assurance.

Default contracts for the Oceanic airspace will be:

- 15 minute reporting rate for Basic group,
- 15 minute reporting rate for Predicted Route group,
- Projected intent group at a 45 minute periodicity.

Extrapolation will be based on the use of the current position of and the Projected Intent group information. If the Projected Intent group is unavailable (default value reported due to the time of FMC calculation), the extrapolation algorithm uses the Predicted Route group.

The system will provide the following tools for monitoring ADS tracks:

- Distinctive symbols to differentiate between the display of position information based on actual ADS report and the display of information based on an extrapolation.

- An ADS route conformance warning will alert the controller when the projected intent group received from the aircraft does not conform with the flight plan held by the Flight Data Processing System.

- A route adherence monitoring will alert the controller if a report received from an aircraft is outside a corridor calculated along the flight plan route.

- a cleared level adherence monitoring, based on the "altitude range change" event will alert the controller if the aircraft deviates vertically from the cleared level held in the flight data record.

2.2.3.2 Airways Corporation of New Zealand's implementation choices

Airways Corporation of New Zealand designed a system which enables the controllers to request every kind of ADS contract (periodic, demand or event). However, the lateral deviation event, waypoint change event, and a 15 minute rate periodic contract will be requested automatically when the aircraft enters the ACNZ's FIR.

The extrapolation will be based on the use of the basic and the predicted route groups.

Conflict probe and conflict detection tools will be implemented. The conflict detection will be automatically activated on each report receipt. The conflict probe will check that the distance separation minima is applied by using the last reported position of one aircraft and the extrapolated position of the others one.

The conflict probe tool will be initiated manually on controller's request. It will enable the detection of a potential separation minima infringement between two controller's selected aircraft.

2.2.3.3 US Federal Aviation Administration's implementation choices

The FAA is currently in the process of defining the requirement specification of their ADS system, and thus no presentation has been made during the last ISPACG meeting. According to informal discussions, the system should be based on the use of the projected intent group for the extrapolation, and should implement a conflict probe. Some interaction between CPDLC messages and ADS contracts establishment should exist to deal with offset clearances for example.

2.2.3.4 SEAC/DGAC's implementation choice

The SEAC/DGAC designed a system where controllers only have the capability to request some on-demand contracts, in order to minimise controllers workload. Other types of contracts will be handled automatically by the system.

When the aircraft enters the FIR, the system initiates a default periodic contract, the waypoint change event contract and the lateral deviation event. On each report receipt, the system checks that the reported position is inside a corridor computed along the ground flight plan. If the position is outside the corridor, the controller is warned and the system initiates automatically an "abnormal case periodic contract" with a shorter period. As soon as the reported position is back in the corridor, the system re-initiates the default periodic contract, and the lateral deviation event if required.

The default periodic contract will request :

- the Basic group with a periodicity of 15 minutes,
- the Predicted Route group with a periodicity of 15 minutes,
- the Meteorological group with a periodicity of 30 minutes.

The abnormal case periodic contract will request :

- the Basic group with a periodicity of 5 minutes,

- the Earth Reference group with a periodicity of 5 minutes.

In the normal situation, the system extrapolates ADS tracks using the current position reported in the basic group and the next waypoint information reported in the predicted route group. When the "abnormal case periodic contract" is initiated, the extrapolation is based on the current position and on the ground vector reported in the earth reference group.

The system provides the following tools for monitoring separation minima :

- a separation circle around the tracks,
- a measurement vector to indicate the distance and heading between two tracks.

Due to the low level of traffic, the system will not provide automatic conflict probe or conflict prediction tools.

2.2.4 Conclusion

The study of ISPACG’s ADS-based operational concept has shown that the requirements for 50Nm or 30 Nm longitudinal and lateral separation minima were very general and, as a consequence, generates some differences in the systems’ implementation in the South Pacific region. However, a number of common characteristics can be derived from this study:

a) The normal reporting interval is a 15 minute rate,

b) The Basic group and Predicted Route group are always requested by the different implementations,

c) The maximum envisaged reporting rate is a 5 minute rate,

d) 95 % of messages shall be delivered in less than 60 seconds.

These characteristics will be used to define the operational scenarios to be tested on the ADS Europe platform.

2.3 NATSPG OPERATIONAL CONCEPTS

2.3.1 NATSPG Organisation & planned ATM improvements

Air Traffic Services in the North Atlantic Region are provided under the auspices of the ICAO North Atlantic Systems Planning Group (NATSPG). The management of the service is carried out by the Implementation Management Group (IMG) which comprises representatives from all the North Atlantic ATS Provider States. In order to advise the IMG in specialist areas, there are a number of subgroups which report to it. These include the Air Traffic Management Group (ATMG), the Communications, Automation and Datalinks Applications Group (CADAG) and the Mathematicians Implementation Group (MIG).

Operational issues, including the development of possible future operational concepts, are the responsibility of the ATMG. The IMG has defined a phased series of improvements to ATS on the North Atlantic as follows:

- Reduced Vertical Separation Minima (RVSM) from 2000ft vertical separations in the Organised Track System (OTS) to 1000 ft. This was introduced in March 1997 and has already provided significant benefits. Its introduction was possible due to improvements in aircraft altimetry accuracy and did not require any other changes to ground ATC systems or aircraft avionics apart from the introduction of a height monitoring capability to confirm that individual aircraft systems were operating with the required accuracy.

- The next stage is Reduced Longitudinal Separation Minima (RLSM) . Longitudinal separations are currently 10 minutes along an oceanic track but it is planned to reduce this to 7 mins. It is planned that this will be achieved by accurately synchronising the time used in both the aircraft avionics and the ground ATC systems. This is mainly a procedural issue and no further changes to the avionics or ground systems will be necessary. It is currently planned to implement this phase at the end of 1998.

- The third stage is Reduced Horizontal Separation Minima (RHSM) from the current 60 nm separation between horizontal tracks to 30nm. This stage will be coupled with a further reduction in longitudinal separations from 7 mins to 5 mins.

  This is the first stage which requires ground systems and avionics to be upgraded and it has been stated that an ADS and CPDLC capability will be required to meet this phase. Hence it is dependent on the relevant system upgrades being available and approved for operational use. Currently, planned timescales indicate this capability will be available in 2000.

These stages are defined in more detail in the ATM Implementation Plan [4] currently under development by the NATSPG subgroups.

2.3.2 NAT Operational concept

North Atlantic air traffic is dominated by two major axes. The first of these links Europe (and the Middle East) to North America and the second links the Eastern Seaboard of North America to the Caribbean, South America and Bermuda. A substantial proportion of NAT traffic, namely that operating between the cities of central Western Europe and those of Eastern and Central North America is, in fact, concentrated within a relatively limited band of airspace.

The major traffic flow between Europe and North America takes place in two distinct surges during each 24 hour period due to passenger preference, time zone differences and the imposition of night-time noise curfews at the major airports. The westbound surge leaves European airports in the late morning/early afternoon and arrives at North American East Coast airports typically some 2 hours later local time - given the time difference. The eastbound surge leaves the North American airports in mid/late evening arriving in Europe at early/mid morning (local time). Consequently, the diurnal distribution of this traffic has a distinctive tidal pattern characterised by two sharp peaks passing 30°W - the first centred on 0400 UTC (almost exclusively eastbound) and the second centred on 1500 UTC (almost exclusively westbound).

Although a number of fixed trans-Atlantic tracks exist, the bulk of traffic operates on tracks which vary from day to day dependent on meteorological conditions. The variability of the wind patterns would make a fixed track system unnecessarily penalising in terms of flight time and consequent fuel usage. Nevertheless, the volume of traffic along the core routes is such that a complete absence of any designated tracks (ie a free flow system) would currently be unworkable given the need to maintain procedural separation standards in airspace largely without radar surveillance.

As a result, an Organised Track System (OTS) is set up on a diurnal basis for each of the westbound and eastbound flows. Each OTS comprises a set, typically 5-8, of parallel or nearly parallel tracks, positioned in the light of prevailing winds and to meet airline requests to suit the traffic flying the busy core tracks.

The designation of an OTS facilitates a high throughput of traffic by ensuring that aircraft on adjacent tracks are separated for the entire oceanic crossing - at the expense of some restriction in the operator`s choice of track. In effect, where the preferred track lies within the geographical limits of the OTS , the operator is obliged to choose an OTS track unless he flies above or below the System. Where the preferred track lies clear of the OTS the operator is free to fly it by nominating a random track. Trans-Atlantic tracks therefore fall into three categories, namely OTS, Random or Fixed.

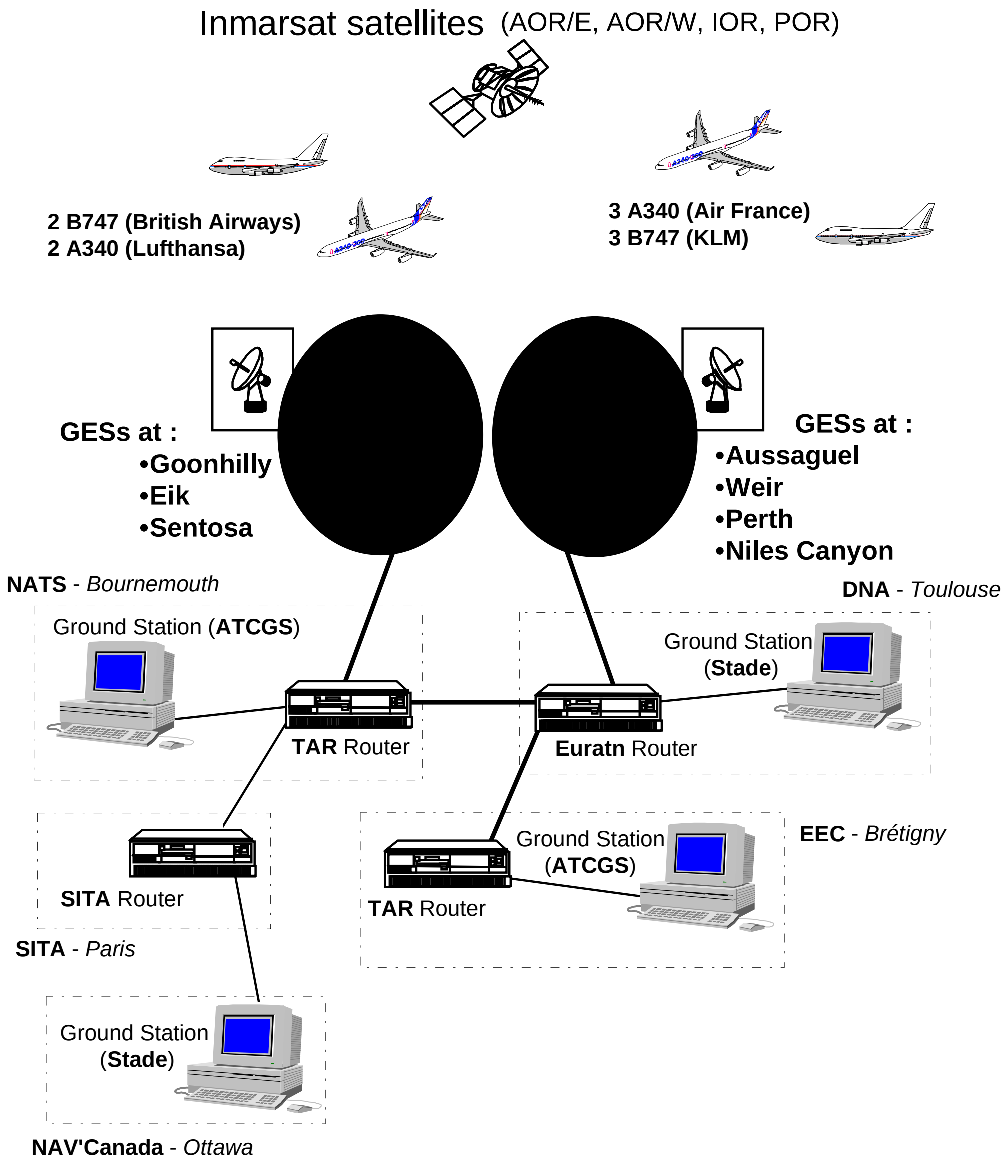
The planned ATM improvements discussed in 2.3.1 are all based on increasing capacity by reducing vertical, longitudinal and horizontal separations within the OTS and to provide an improved capability to permit manoeuvres such as step climbs that will allow operators to optimise flight profiles. This, together with a need to continue to provide a transition path for older aircraft, means that use of an OTS in the NAT is planned to continue.

3. TRIALS DESCRIPTION

3.1 ADS EUROPE INFRASTRUCTURE

The ADS Europe infrastructure implements a network of ATN routers and end-systems, supporting via Inmarsat data-3 satellite communications, the Arinc 745-2 ADS exchanges between ten commercial airliners and up to 4 ground systems. Communications involve the lowest 4 layers of the ATN communications stack (up to and including Transport level).
The systems, both airborne and ground based, are experimental ones, and some of the optional groups defined in the Arinc 745-2 characteristic have not been implemented.

The following figure illustrates the connection of systems making up the ADS Europe infrastructure:



3.2 Scenario descriptions

Scenarios have been defined considering the operational concepts studies and the characteristics and constraints imposed by the ADS Europe project.

3.2.1 ODIAC derived scenario

The scenario has been determined by the ODIAC description of the Controller Access Parameters (CAP) service. Among operational requirements, the CAP description service identifies that the maximum time elapsed between the measurement of the on-board parameter and its delivery to the controller working position shall be 8 seconds 99.996% of the time. In an ADS environment, this has been interpreted as:

- a communication performance requirement where an ADS report shall be delivered in less than 8 seconds 99.996% of the time,
- an ADS reporting rate requirement which shall be at least an 8 second rate.

Consequently, the ADS scenario related to this service consists in requesting, at a 8 second reporting rate, the following groups:

- the Basic group (mandatory),
- the Air Reference group to gain access to the Mach number data,
- the Earth Reference group to gain access to the vertical rate data,
- the Meteorological group, to gain access to the wind direction and speed.

The trial results based on this scenario will help to determine if an ADS/ATN/AMSS system can be used as a complementary tool for the implementation of the Controller Access Parameters service in the ECAC region.

3.2.2 ISPACG derived scenario

The scenario derived from the ISPACG operational concept study consists in requesting the following groups at a 15 minute reporting rate :

- the basic group,
- the predicted route group,

to check that the communication performance requirement is achievable with the ADS Europe platform.

3.2.3 NAT/ATMG derived scenario

The purpose of this trial was to demonstrate that the ADS EUROPE system was capable of supporting the operational scenarios for the use of ADS and CPDLC that have been developed by the ATMG subgroup of the NATSPG. There are eleven scenarios in total but many of these are designed to cater for situations such as the aircraft deviating from its planned track.

With commercial aircraft flying normal scheduled flights and routes, such scenarios could not be trialled and it was therefore decided to limit the scenario used for this trial to the one defined for routine flight monitoring (without message Ground Forwarding). This is defined in Scenario 3 of the set developed by ATMG and is defined in detail in Annex C of this report. (NB: No attempt to simulate the CPDLC activity was carried out during the trial since ADS EUROPE has no CPDLC capability).

It was further necessary to adapt this scenario before it could be trialled using the ADS EUROPE infrastructure. This was because the ATMG scenarios are written for ADS and CPDLC applications compliant with the ICAO CNS/ATM-1 SARPs. ADS EUROPE implemented an ADS application based on the message set defined in ARINC 745-2 and, while the principles are similar, there are some significant differences. In particular, the ARINC 745-2 message set does not include the Extended Projected Profile (EPP) message which provides for downlinking up to 128 waypoints programmed into the aircraft`s Flight Management System (FMS). The use of the EPP message is specified in the ATMG scenarios and its use is particularly relevant for conformance monitoring purposes. For the purpose of this trial the Predicted Route Group (PRG) was used which gives details on the Next and (Next+1) waypoints programmed into the FMS. Also, it should be noted that the ADS event contract functionality is different; the SARPs require continuous reports (1 minute reporting rate) when a deviation event occurs until the aircraft returns within limits while ARINC 745-2 requires only a single, one shot report when the deviation first occurs.

Some changes were therefore required to run the ATMG scenario using an ARINC 745-2 ADS application. In order that the differences can be identified, a column titled “ADS Trial Action has been added to the original scenario table and this is included in Annex C. This allows a direct comparison between the ADS trials activity (shown in italics in this column) and the operational scenario which would take place in a CNS/ATM-1 application environment. However, this is considered to be close enough to the original ATMG scenario to demonstrate its feasibility.

4. TRIALS RESULTS

4.1 SYSTEM LIMITATIONS

As mentioned above, the ADS Europe systems are experimental. This resulted in limitations to be imposed on the scenarios that could be tested (as already noted: the Aircraft Intent group was for example not available). Other limitations, caused by technical problems encountered during the experimentation period, were also encountered.

The most significant of these problems was caused by difficulties in maintaining the X25 virtual circuits that support the air-ground communications. For reasons still not fully explained, the GESs often generated reset messages, that led to abnormal delays, and many early connection terminations. This limited the overall availability of aircraft for the scenario tests.

The one way transfer delay associated with the satellite communication (the time elapsed between the transmission of a report and its reception on the ground) was also difficult to assess, as most of the trials aircraft available did not have a UTC synchronised ADSE clock. Indeed, within the fleet of equipped aircraft, only four had an ADSE synchronised to a GPS clock, but unfortunately three of these suffered from various kinds of problems affecting the availability of ADS data, and the remaining one had its GPS connection inoperative during the experimentation period.

4.2 ODIAC DERIVED SCENARIO (CAP) RESULTS

In order to make good use of the various possibilities offered by the ADS Europe infrastructure and to try and test different configurations, the same scenario was played under different conditions. The scenario presented in paragraph 3.2.1 (an 8 second periodic contract with the Earth Reference, Air Reference and Meteorological groups with each report) was thus tested with different aircraft (fitted with different systems):

- an Air France Airbus 340 equipped with a Sextant Avionique ADSE,
- and a KLM Boeing 747-400 equipped with a Racal Avionics ADSE.

The communication paths used for these trials were also different:

- the Inmarsat IOR satellite, the Aussaguel GES and the Transpac network, for the test with the KLM aircraft,
- the Inmarsat AOR/W satellite, the Weir GES, the Sita MTN and the Transpac network, for the test with the Air France aircraft.

Finally, the flight phases were also different: the scenario was played with the Air France aircraft as it was cruising above the Atlantic Ocean, on Paris-Bogota flight, and a few minutes after take-off, on the Singapore-Jakarta leg of an Amsterdam-Jakarta flight for the KLM aircraft.

The objectives of these tests were as follows:

- to establish whether the ADS Europe systems (including the communication link) could sustain an 8 second reporting rate. The periodicity usually adopted for ADS exchanges in the ADS Europe project was indeed significantly longer (in the 5 minute range). Short period contracts had been tested in 1996, and the ADS Europe Final Report stated that the shortest interval which could be supported continuously was 15 seconds (i.e. almost twice as much as the periodicity required for the current CAP scenario).

- if such contracts were technically achievable with the ADS Europe systems, to estimate their value, by monitoring:
  - ⇒ the transmission periodicity of the reports,
  - ⇒ the reception periodicity of the reports,
  - ⇒ the content of the reported information (in order to ensure that the data reported were updated at a rate that could cope with the requested periodicity).

As one of the objectives of the operational scenario studied is to continuously (99.996% of the time) keep data that are not more than 8 seconds old, the accuracy of the reports time stamps would have been essential. However, as explained above, this has not been possible during the experimentation. Figures dating from earlier trials (when a GPS synchronisation was available), relative to the transmission delay encountered with the same infrastructure, in similar conditions, and reported in the ADS Europe 97 Final Report [5], indicate that it would be impossible to reach this objective (minimum delay around 6 seconds, with a mean around 10-11 seconds).

The trial performed must thus be seen as a minimum systems test, which does not take the transmission delay into account.

Regarding the first objective, it must be noted that the tests were run for slightly more than 30 minutes, and then stopped on purpose. It had indeed been decided that the technical possibility to sustain an 8 second periodicity would be demonstrated on an interval of such duration (representing the transmission of more than 200 reports).

The results obtained during the tests performed with the CAP derived scenario are illustrated by detailed diagrams in Annex A. They are summarised below:

- the ADS Europe avionic systems are able to sustain an 8 second periodic ADS reporting rate (problems encountered during the test involving the Air France flight will be discussed below).

- the data update rate is compatible with an 8 second report periodicity;

- the requested reception periodicity cannot be satisfactorily achieved by the ADS Europe infrastructure. On this last point, the analysis conducted on the data recorded could not establish the cause of this limitation. The data collected cannot prove whether the variation of transmission times can be attributed to the satellite sub-network current level of performance, or to the way it is used in the ADS Europe implementation (e.g.. inadequate tuning of parameters ? Upper communications protocol not appropriate ?...)

The data collected during the test involving the Air France flight revealed a temporary ADSE faulty behaviour, which could not be explained. The ADSE had been delivering reports at the requested rate for 9 minutes, it then failed to deliver the equivalent of 125 reports. The transport connection was maintained despite this lack of reception of ADS messages as the ADSE kept sending transport acknowledgement messages. After almost 17 minutes, an ADS report containing invalid data was received, and then nominal reports followed as if nothing had happened. The test was manually stopped after 34 minutes, as initially planned.

Beside this unexplained break, the reception of reports was more troubled than during the test with the KLM flight, as shown by the figures in Annex A. On a particular occasion (report number 18), a downlinked message was apparently lost. This resulted in its retransmission once the "window" upper limit was reached (transport protocol). The difference in performance could be due to the difference in communication path involved, the link to the KLM aircraft being more direct for these particular trials.

4.3 ISPACG DERIVED SCENARIO RESULTS

As indicated in the paragraph 3.2.2, the ADS contract derived from the ISPACG operational concept is 15 minute periodic, with the Predicted Route Group requested with each report. The test approach detailed in the previous paragraph was also adopted for this test. The analysis however focused on the respect of transmission and reception periodicities, as there was no doubt that:

- the systems could sustain a 15 minute periodic rate,
- the downlinked parameters would be updated at a rate compatible with this much longer period.

Because of the duration required to collect a significant number of reports during a single flight, it was not possible to test the scenario with a non-changing communication environment (as done with the CAP derived scenario). The scenario was run for more than 6 hours during an Amsterdam-Rio de Janeiro flight, the communication path consisting successively in:

- the Inmarsat AOR/E satellite, the Aussaguel GES and the Transpac network,
- the Inmarsat AOR/W satellite, the Weir GES, the Sita MTN and the Transpac network.

The change of communication path did not disturb the trial.

The periodicity of the reports transmission and reception is graphically presented in Annex B. Beside the known limitation concerning the availability of the estimated time over the next waypoint, the ADS Europe systems could handle this scenario satisfactorily.

4.4 NAT/ATMG DERIVED SCENARIO RESULTS

4.4.1 General

The purpose of this trial was to demonstrate that the ADS EUROPE system was capable of supporting the operational scenarios for the use of ADS that have been developed by the ATMG subgroup of the NATSPG. Eleven scenarios have been defined in total but, for the reasons mentioned in section 3.2.3, it was decided to limit the scenario used for this study to that defined for routine flight monitoring (without message ground Forwarding). This is defined in Scenario 3 of the set developed by ATMG and details are given in Annex C of this report.

4.4.2 Intention

The initial intention of these series of trials was to demonstrate that the proposed scenario is feasible and can be run using a “live” ADS infrastructure. In the course of the work NATS identified a further objective to see if the calculation of the ETA at the Oceanic Entry Point (OEP) is adequately made before the point is reached.

The purpose of this was that discussions with controllers identified a potential problem situation. Normally, controllers receive estimates of the ETA for a flight`s arrival at the OEP from the Scottish Domestic Centre and this triggers providing its oceanic clearance. However, there are occasions where an aircraft does not provide this estimate and proceeds into the oceanic FIR without obtaining a clearance. If this happens with the current system, the first time OACC know about the aircraft is when they start receiving position reports and they may then need to take quick action to avoid any conflicts.

The concern is that, when an aircraft is CNS/ATM equipped, the flight crew will know that the aircraft has logged on to the ATN and may think that there is no need for them to give an estimate for the OEP and obtain their oceanic clearance. The OEP estimate is needed since it would be used by the ground FDPS to trigger the placing of the appropriate ADS contract. Hence, if the estimate was not received, there could be a danger of the aircraft entering the Oceanic FIR without an ADS contract in place and it would not provide any position reports. As a fallback, it was thought that it could be possible to use the estimates from the ADS Ground System for an ETA at the OEP when the aircraft logs on. Therefore it would be useful to see how accurate these were.

It was also originally hoped that NAV CANADA would be able to participate and the scenario includes a planned handover of ADS contracts to be co-ordinated by telephone. Unfortunately, because of equipment moves and other demands on NAV CANADA resources at the time, this was not feasible within the limited period available to meet the timescale requirements for this report

4.4.3 Outline Aircraft ADS Agreement

After the aircraft passes through 2000 ft and then FL200, a 15 minute reporting interval, with the Predicted Route Group downlinked with the Basic Report, and also a Waypoint Event contract is put in place and forms the main body of the agreement. Hence waypoints are downlinked as an Event when a waypoint changes. An Altitude Event contract of +/- 300 ft is placed around FL310 to alert if/when the aircraft penetrates those boundaries (after reaching that level), and a Lateral Deviation alert of +/- 5 nm is placed around the track.

On passing 30W (ie on entering the Gander FIR airspace), the reporting interval is changed to 45 min

4.4.4 Comments

The calculation of the Oceanic Entry Time on the active Flight Progress Strip in the ATC Ground System used by ATMDC is based on a simple algorithm using the Mach No. assigned in the Flight Plan. In practice, this algorithm would be enhanced, so these results are a “worst case”.

The initial design for Scenario 3 included the switching on a Waypoint Event contract whilst the aircraft is still within domestic airspace. This may need to be changed, as it is not the operational intention to ask for Waypoint events in domestic airspace, but to rely on the 15 min basic report only.

During the trials, connection was maintained at Transport Level (ATN), and no loss of application data was noted. The AORE and AORW satellites were used for all flights, routing through the GES at Goonhilly, and any transfer between satellites was invisible to the application. There were no links to operational ATC during any of these trials and any comments below such as “Routed Direct” (DCT) are deduced from the data.

4.4.5 Results

During the trial period in March 1998, the British Airways aircraft were monitored on five North Atlantic flights and outline details are as follows (Full details of each run together with annotated plots are shown in Annex D):

4.4.5.1 Run 1

Aircraft:	G-BNLZ		
Flight:	BAW283	From/to:	Heathrow/Los Angeles
BA Flight Plan received		Yes at:	12:36 UTC
		entered at:	13:00 UTC
Plot (see Annex D):			Fig 1a, Fig 1b

Estimates for Oceanic Entry Point 61N010W

ADSE time **Data Point** **Estimate**

12:47	SHAPP	13:51
12:49	MARGO	13:53
12:54	basic report	13:55 (Estimate stabilises OEP minus 51 mins)
13:09	basic report	13:55
13:24	basic report	13:55
13:24	STN	13:55
13:39	basic report	13:55
13:54:30	61N010W	13:55

4.4.5.2 Run 2

Aircraft: G-BNLZ
Flight: BAW269 From/to: Heathrow/Los Angeles

BA Flight Plan received Yes at: 15:48 UTC
entered at: 16:27 UTC

Plot (see Annex D): Fig 2

Estimates for Oceanic Entry Point 61N010W

ADSE time	Data Point	Estimate
16:16	thru' FL155	18:16
16:24	basic report	18:00
16:25	TNT	17:35
16:31	abm POL	17:36
16:38	basic report	17:37
16:51	DCT BILLY	17:37
16:53	basic report	17:36 (Estimate stabilises OEP minus 43 mins)
17:08	basic report	17:36
17:09	abm STN	17:36
17:23	basic report	17:36
17:26	BILLY	17:36
17:36	61N010W	17:36

4.4.5.3 Run 3

Aircraft: G-BNLI
Flight: BAW283 From/to: Heathrow/Los Angeles

BA Flight Plan received: No
Estimated Plan entered at 13:01 UTC

Plot (see Annex D): Fig 3a, Fig 3b

Estimates for Oceanic Entry Point 53N010W

ADSE time	Data Point	Estimate
13:08	ABM ABAGU	13:22 (for 53N010W)
13:15	ABM SHA	13:21 (for 53N010W)
at 13:22 the OEP on the FPS was changed to 54N015W		
13:31	ABM BURAK	13:48
13:40	basic report	13:48
13:48	54N15W	13:48

4.4.5.4 Run 4

Aircraft: G-BNLI
Flight: BAW285 From/to: Heathrow/San Francisco

BA Flight Plan received Yes at: 14:06 UTC
entered at: 14:32 UTC

Plot (see Annex D): Fig 4

Estimates for Oceanic Entry Point 56N010W

ADSE time	Data Point	Estimate
15:23	passing 2000’	17:50
15:33	passing FL200	16:55
15:35	WELIN	16:33
15:42	TNT	16:34
15:46	MCT	16:30 (Estimate stabilises OEP minus 44 mins)
15:47	HAYDO	16:30
15:48	basic report	16:30
15:55	REMSI	16:30
16:03	basic report	16:30
16:04	BESOP	16:30
16:11	DUNLO	16:30
16:18	basic report	16:30
16:30	56N010W	16:30

4.4.5.5 Run 5

Aircraft: G-BNLI
Flight: BAW283 From/to: Heathrow/Los Angeles

BA Flight Plan received:	Yes	at:	10:19 UTC
	entered at:		11:19 UTC

Plot (see Annex D): Fig 5a, Fig 5b, Fig 5c

Estimates for Oceanic Entry Point 56N010W

ADSE time	Data Point	Estimate
12:23	passing 2000’	14:52
12:31	basic report	14:01
12:34	passing FL200	13:35
12:42	TNT	13:33
12:46	MCT	13:27
12:47	HAYDO	13:27
12:49	basic report	13:27
12:54	REMSI	13:27
13:04	BESOP	13:28
13:04	basic report	13:29 (Estimate stabilises OEP minus 25 mins)
13:11	ABM DUNLO	13:29
13:19	basic report	13:29
13:29	56N010W	13:29

4.4.6 NAT Scenario Conclusions

The results obtained demonstrate that the ATMG Scenario 3 (Routine flight monitoring), adapted to suit the capabilities of the ADS EUROPE 97 trials system, is feasible when used with aircraft flying in the North Atlantic. Hence, the indications are that the operational requirements are achievable.

On the four runs where appropriate data was obtained, the ETA at the Oceanic Entry Point stabilised between 25 and 60 minutes (Mean 43 mins) before the aircraft reached the OEP. This set of results is limited due to the short timescale for carrying out these scenario trials. However, it is planned to continue work and obtain more data in this area as part of ongoing NATS trials activities in support of North Atlantic implementation.

5. CONCLUSION AND RECOMMENDATIONS

The objective of the study was to evaluate the feasibility of operational concepts being defined for core European airspace, the South Pacific region and the North Atlantic region. As a first result, it appears that these operational concepts are still under definition and hence were still rather general thus reducing the pertinence of the feasibility evaluation. In addition, ADS Europe project standards were not identical to those used for the definition of the North Atlantic or European operational concepts which assume the use of ADS as defined in the ICAO CNS/ATM-1 SARPs [2]. This, together with limitations imposed by using aircraft operating regular airline scheduled services significantly reduced the number of operational scenarios that could be tested with the ADS Europe 97 system.

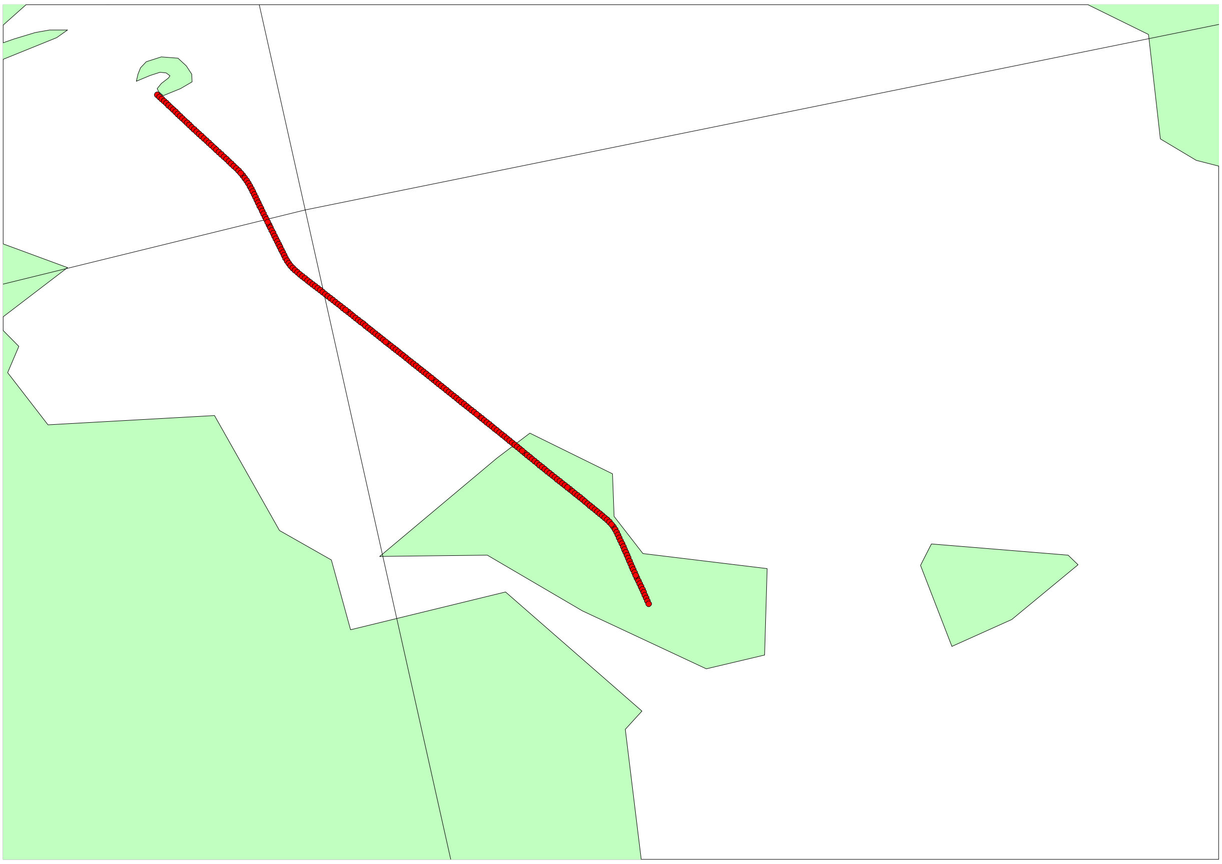
However, through the test of the two ADS scenarios for the North Atlantic and South Pacific regions, the study has shown that an ADS/ATN/AMSS system (such as ADS Europe 97) could meet the operational requirements identified for oceanic airspaces. In addition, useful initial information has been obtained on using data available from onboard avionics (such as the FMS) in conjunction with CNS/ATM-1 systems to provide, in advance, estimated arrival times at the Oceanic Entry Point. NATS plans to continue work in this area as part of ongoing ADS trials activity in support of North Atlantic implementation.

It has also been apparent that the use of this experimental AMSS/ATN based ADS system would not meet the performance required for areas such as European continental airspace identified in the ODIAC scenario for the Controller Access Parameters (CAP) service. Hence, if the ADS application is intended to be used in the European continental airspace for surveillance purposes, it is therefore recommended to either investigate the possibility of significantly enhancing such a system, or to conduct feasibility investigations on using other ATN subnetworks (eg VDL, Mode-S).

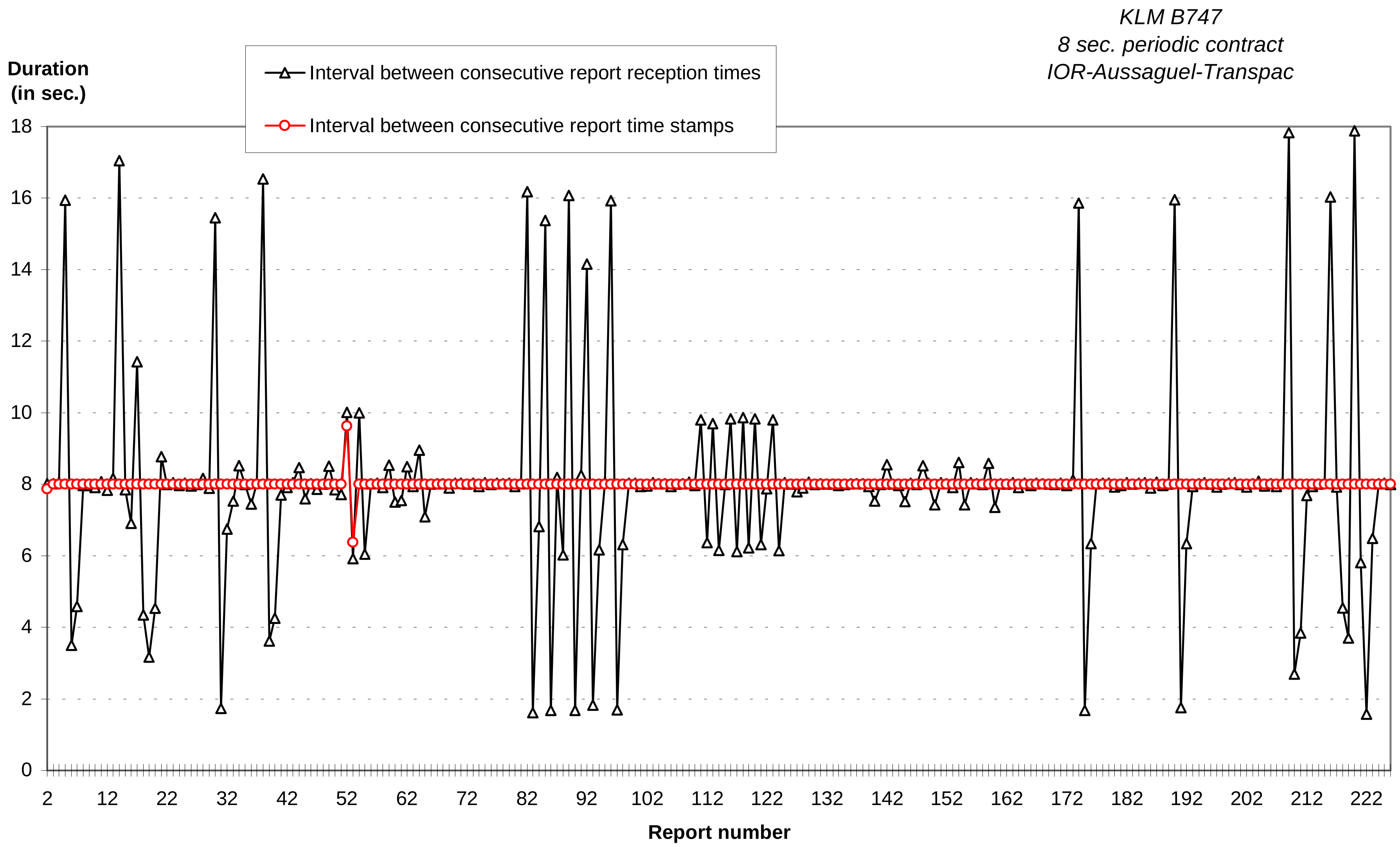
Annex A. Detailed results of CAP derived scenario runs

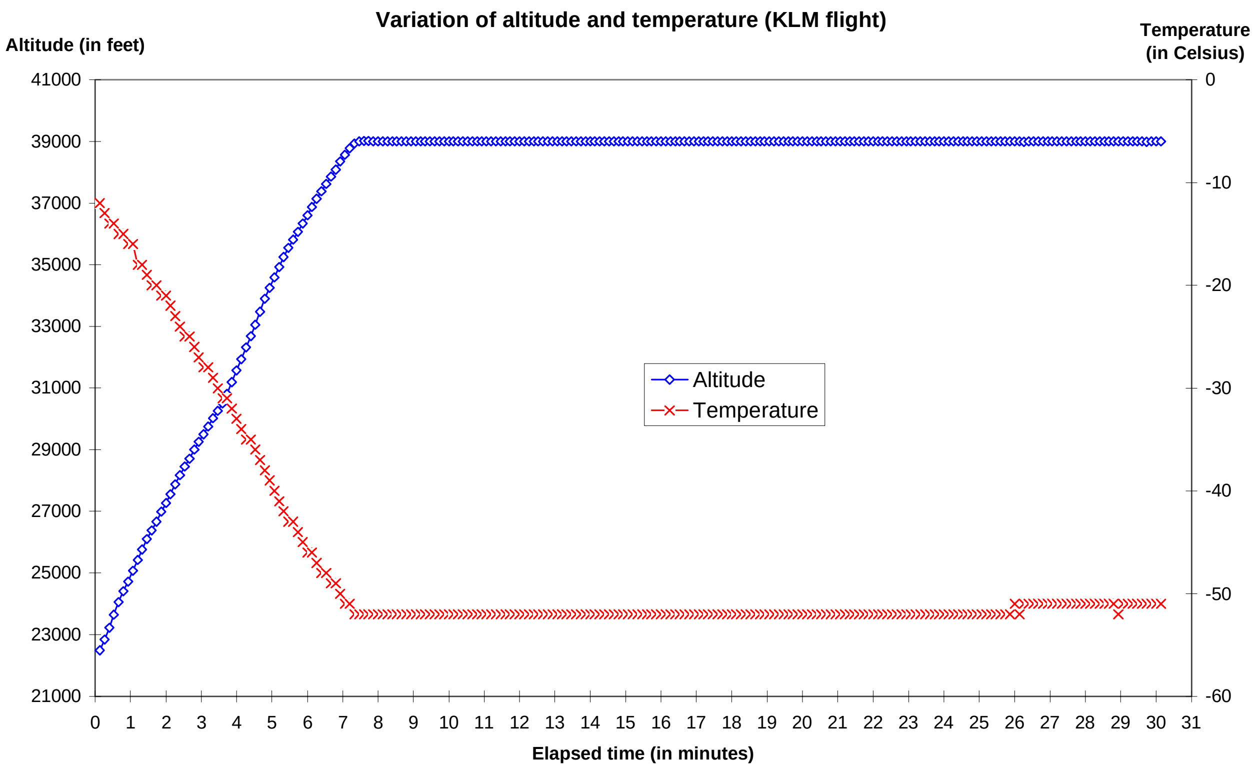
Test during the KLM Singapore-Jakarta flight

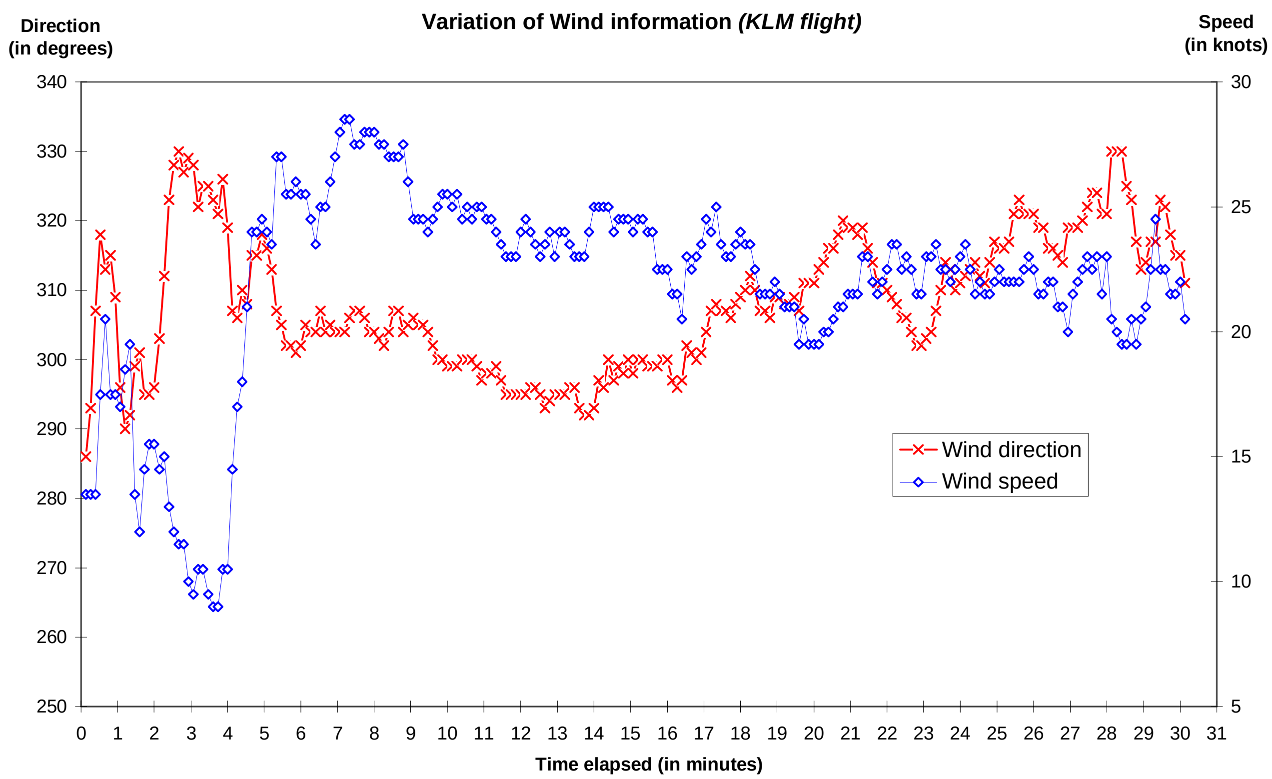
The figure below illustrates the trajectory of the KLM flight used for the test, as derived from the ADS reports. The duration of intervals between the reception of consecutive reports, and of the intervals between consecutive time stamps is graphically shown on the next page. The variation of the other parameters downlinked is depicted in the following figures.

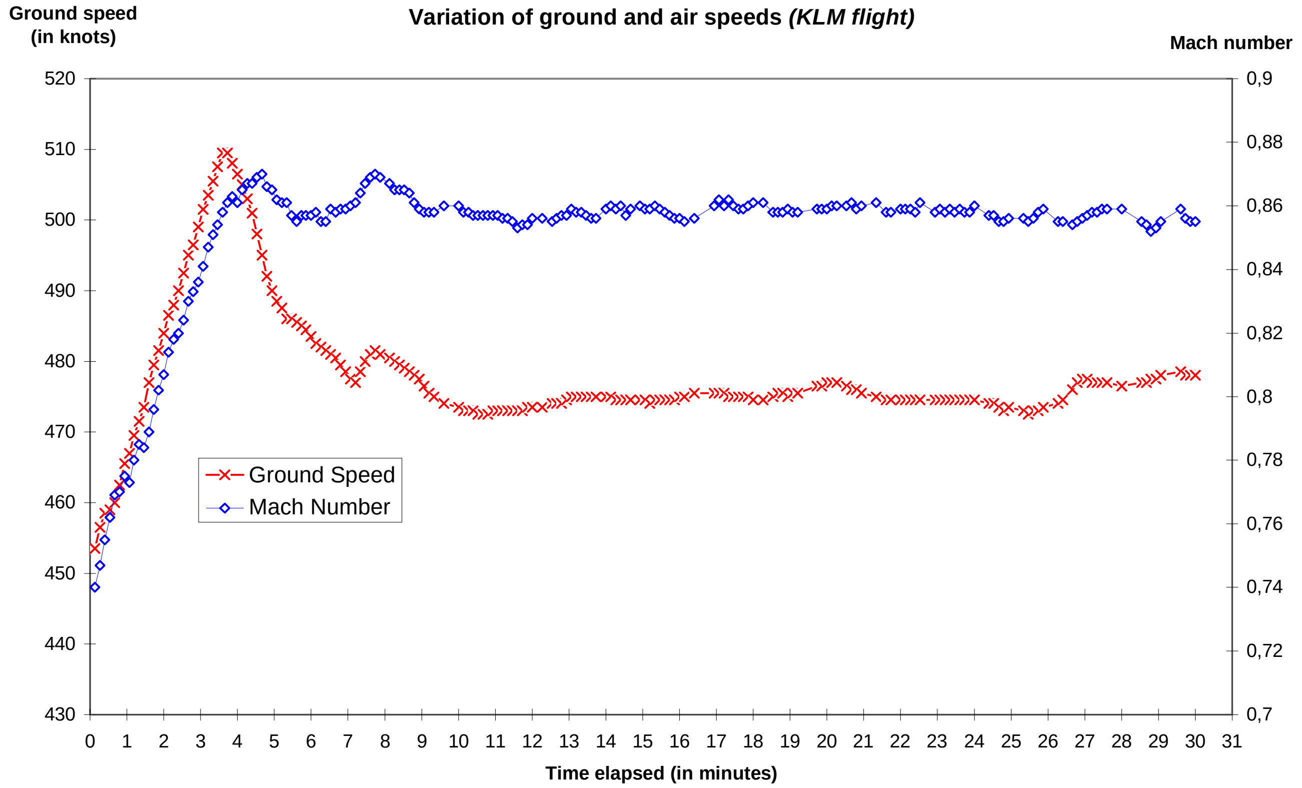


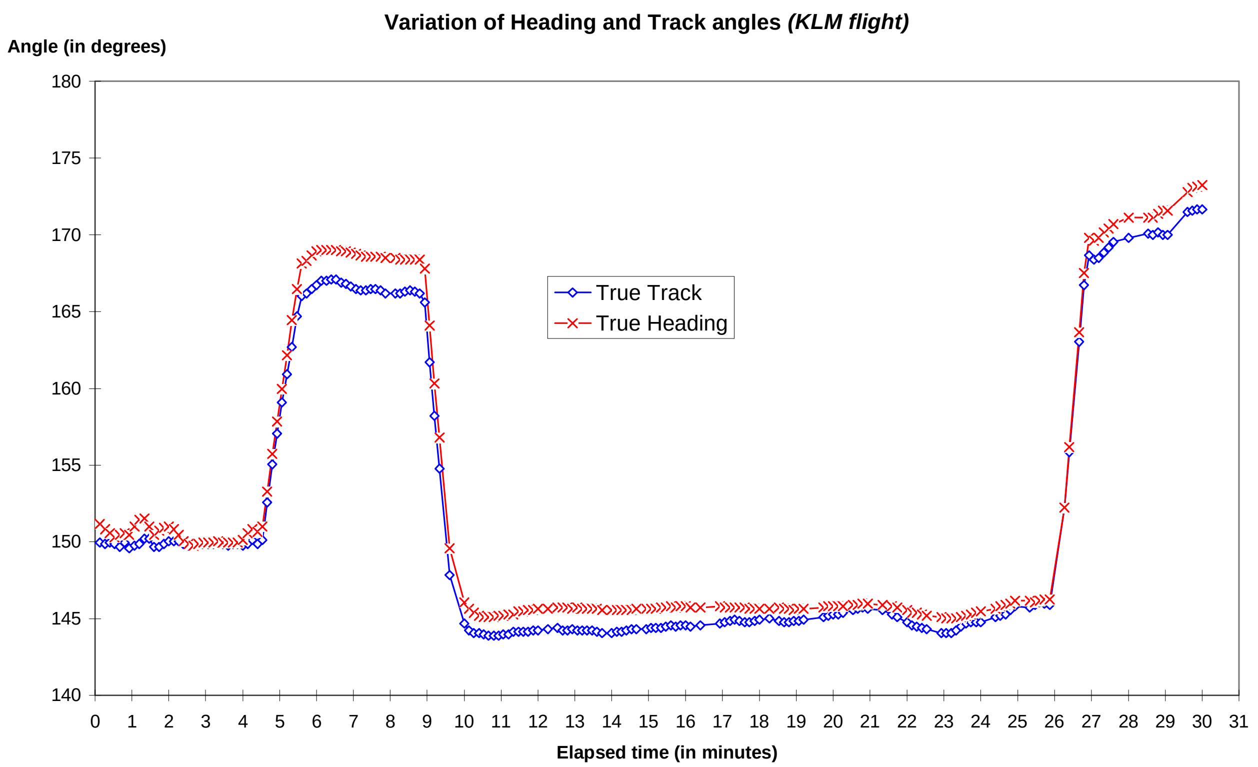
Part of the KLM Singapore Jakarta flight tracked at an 8 second periodic rate


KLM B747
8 sec. periodic contract
IOR-Aussaguel-Transpac
Duration (in sec.)
Interval between consecutive report reception times
Interval between consecutive report time stamps
0
2
4
6
8
10
12
14
16
18
2
12
22
32
42
52
62
72
82
92
102
112
122
132
142
152
162
172
182
192
202
212
222
Report number


Variation of altitude and temperature (KLM flight)
Altitude (in feet)
Temperature (in Celsius)
41000
39000
37000
35000
33000
31000
29000
27000
25000
23000
21000
0
-10
-20
-30
-40
-50
-60
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Altitude
Temperature
Elapsed time (in minutes)

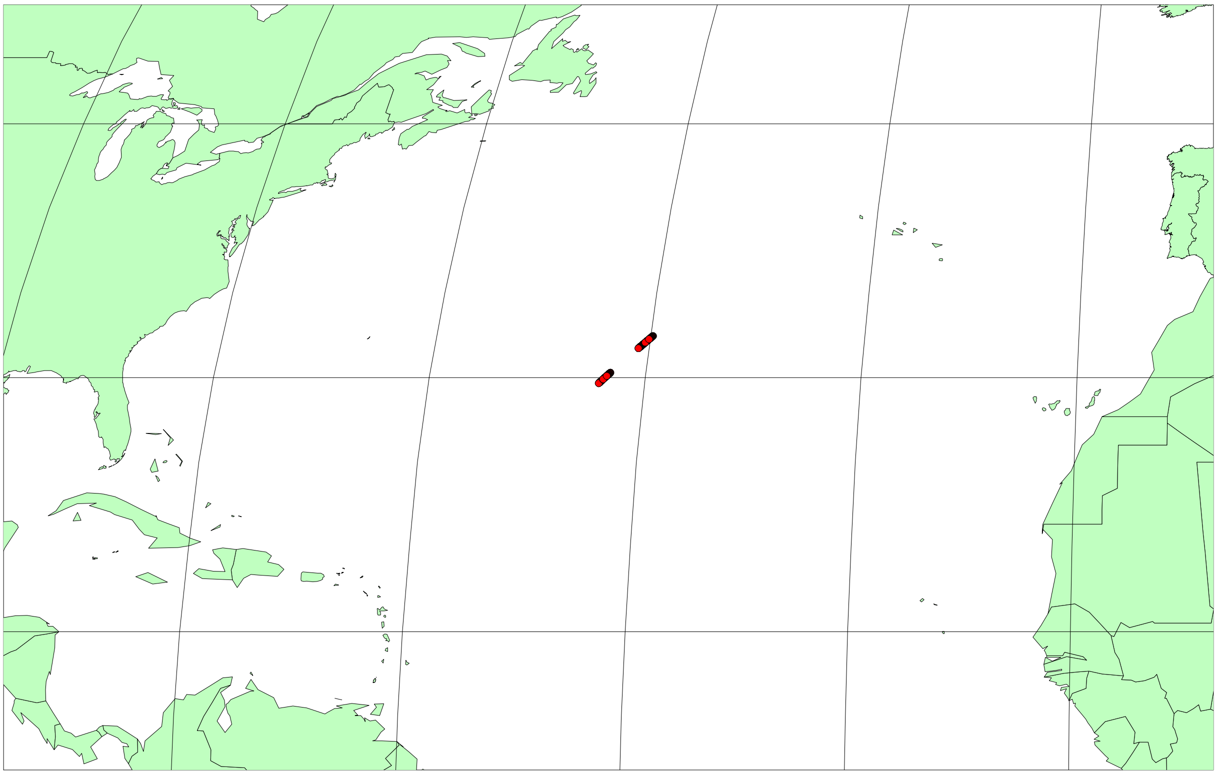

Variation of Wind information *(KLM flight)*
Direction (in degrees)
Speed (in knots)
340
330
320
310
300
290
280
270
260
250
30
25
20
15
10
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Wind direction
Wind speed
Time elapsed (in minutes)


Ground speed (in knots)
Variation of ground and air speeds *(KLM flight)*
Mach number
520
510
500
490
480
470
460
450
440
430
0,9
0,88
0,86
0,84
0,82
0,8
0,78
0,76
0,74
0,72
0,7
Ground Speed
Mach Number
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Time elapsed (in minutes)

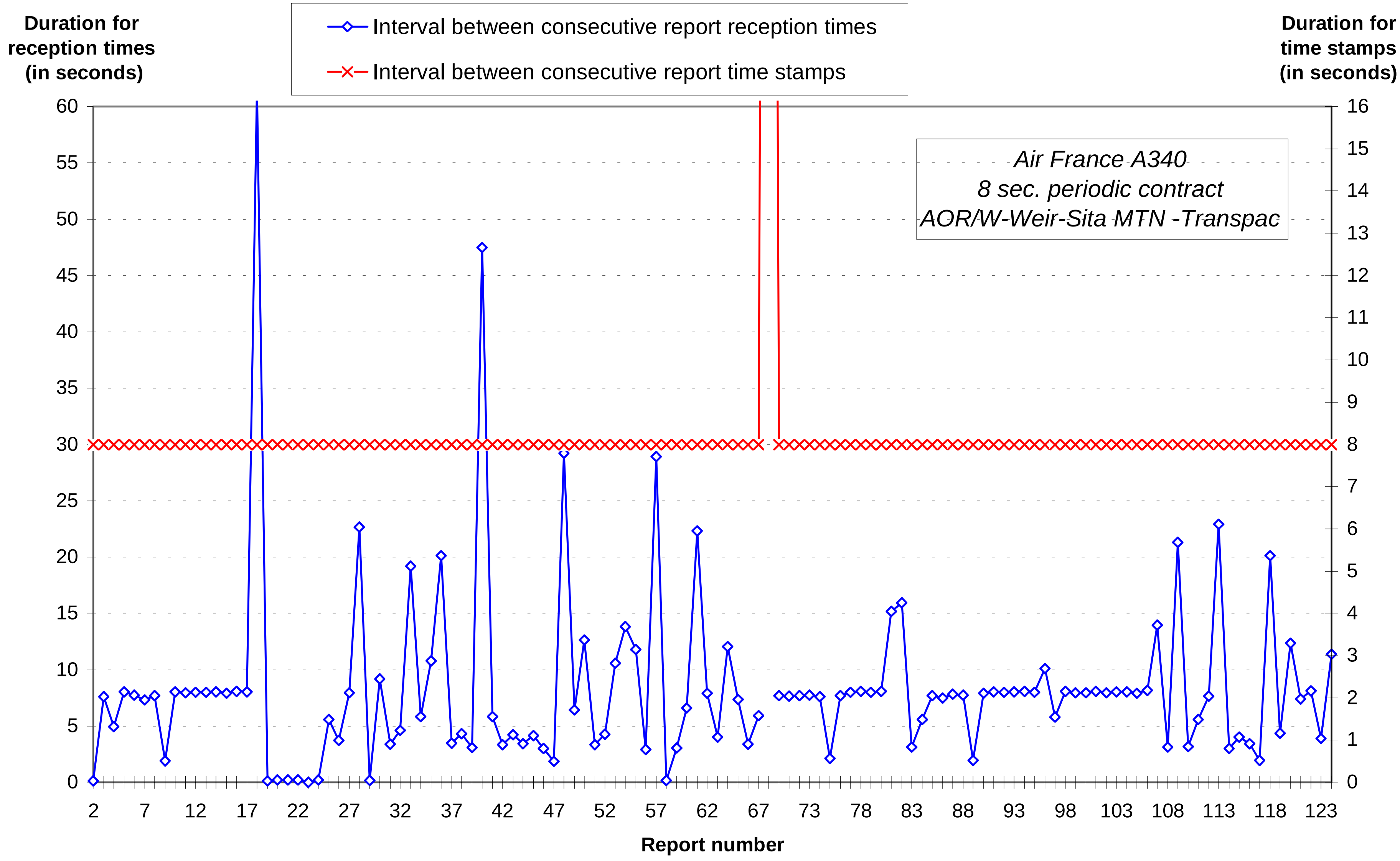

Variation of Heading and Track angles *(KLM flight)*
Angle (in degrees)
180
175
170
165
160
155
150
145
140
True Track
True Heading
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Elapsed time (in minutes)

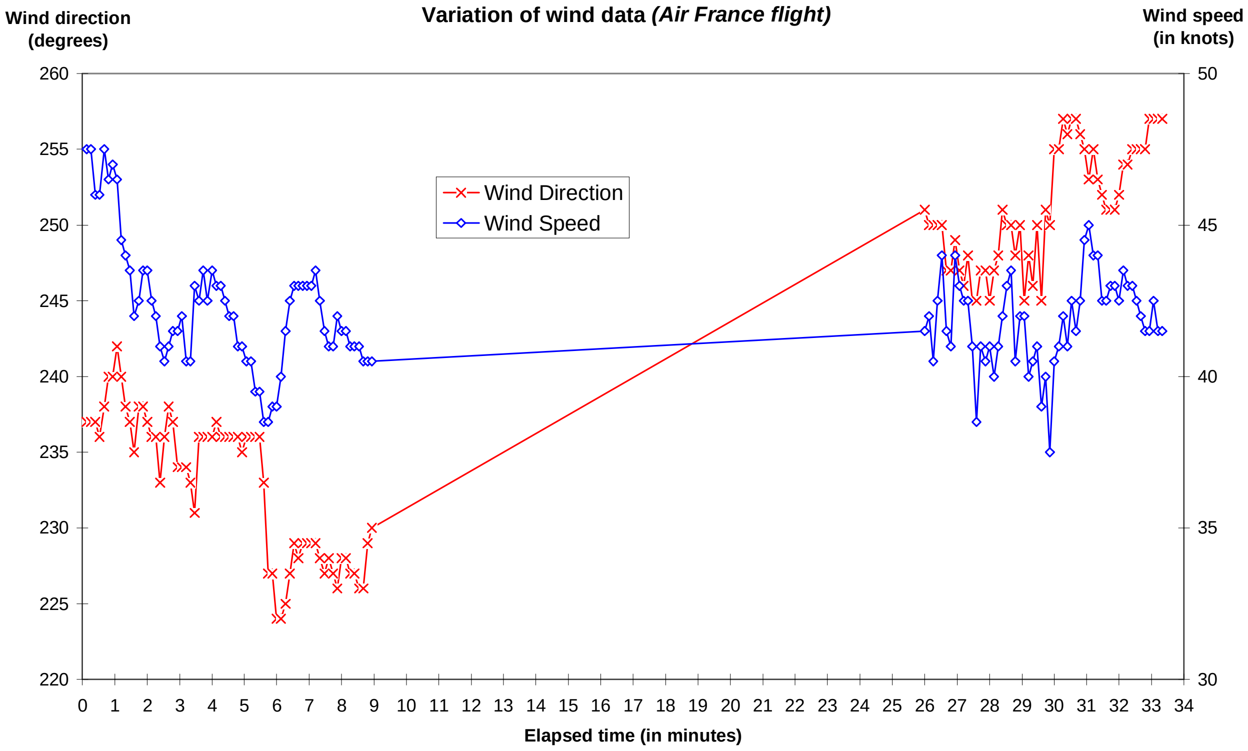
Test during the Air France Paris-Bogota flight

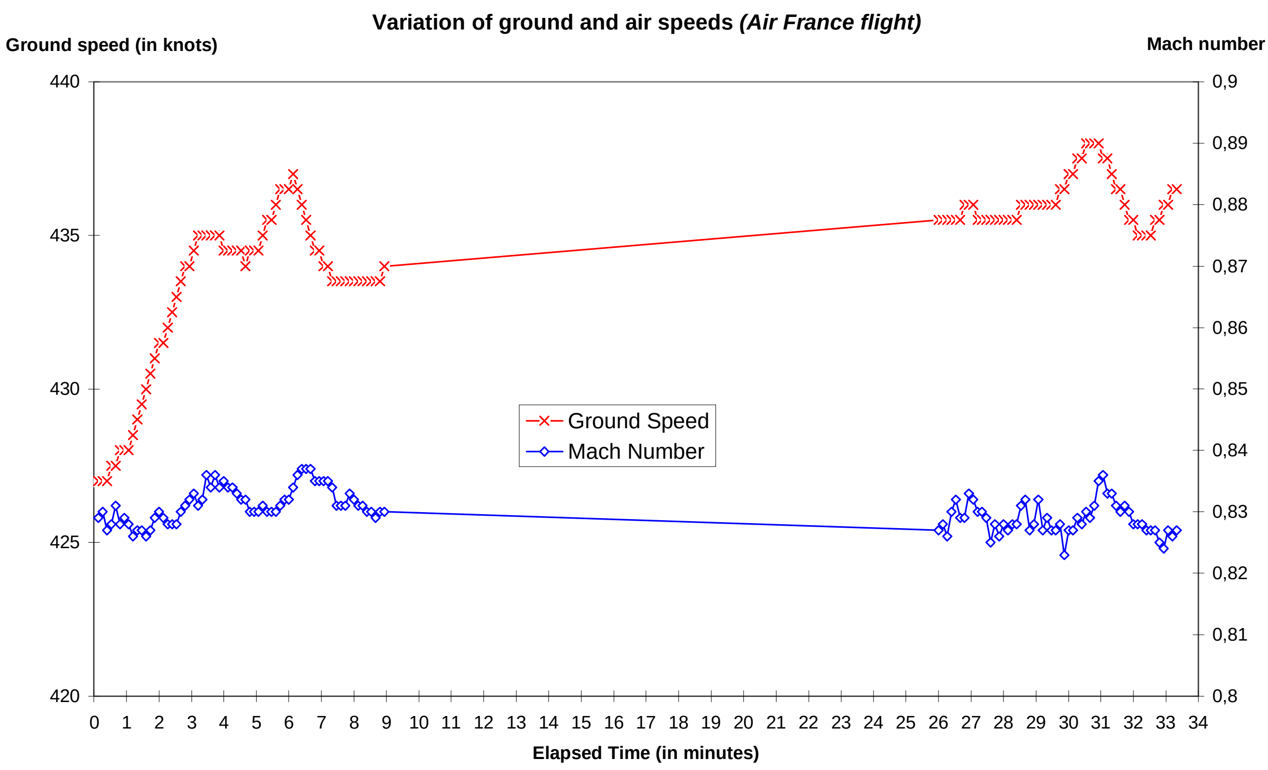
The figure below illustrates the trajectory of the Air France flight used for the test, as derived from the ADS reports. The duration of intervals between the reception of consecutive reports, and of the intervals between consecutive time stamps is graphically shown on the next page. The variation of the other parameters downlinked is depicted in the following figures.

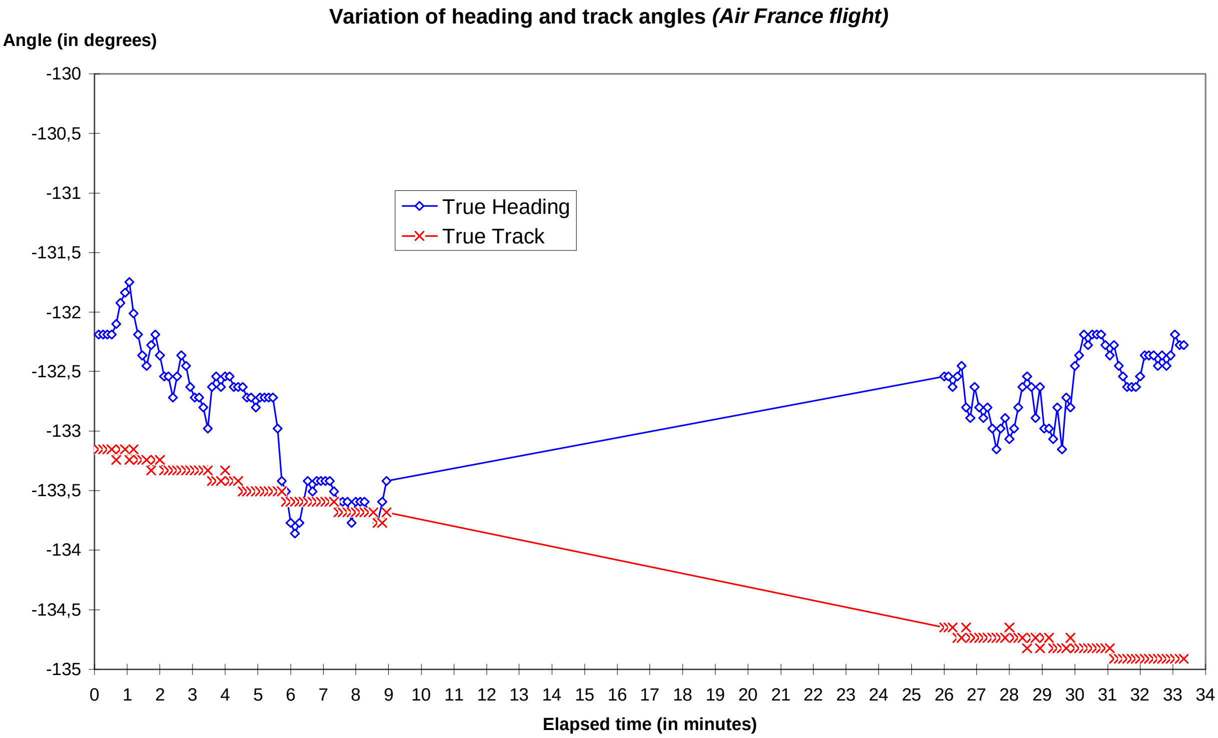


Part of the Air France Paris Bogota flight tracked at an 8 second periodic rate


Duration for reception times (in seconds)
Interval between consecutive report reception times
Interval between consecutive report time stamps
Duration for time stamps (in seconds)
Air France A340
8 sec. periodic contract
AOR/W-Weir-Sita MTN -Transpac
Report number

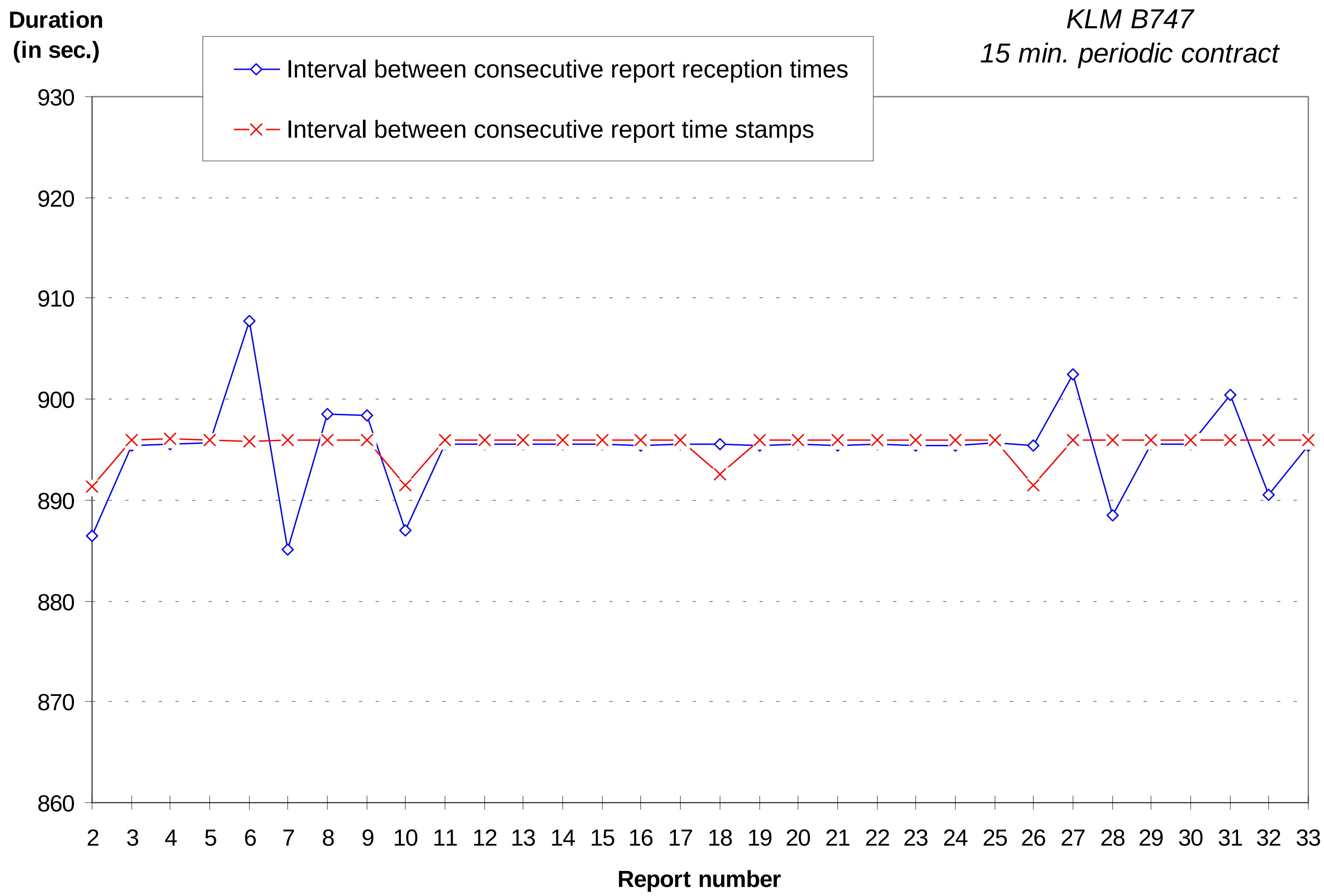

Wind direction (degrees)
Variation of wind data (Air France flight)
Wind speed (in knots)
260
255
250
245
240
235
230
225
220
50
45
40
35
30
Wind Direction
Wind Speed
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Elapsed time (in minutes)


Variation of ground and air speeds (Air France flight)
Ground speed (in knots)
Mach number
440
435
430
425
420
0,9
0,89
0,88
0,87
0,86
0,85
0,84
0,83
0,82
0,81
0,8
Ground Speed
Mach Number
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Elapsed Time (in minutes)


Variation of heading and track angles *(Air France flight)*
Angle (in degrees)
-130
-130,5
-131
-131,5
-132
-132,5
-133
-133,5
-134
-134,5
-135
True Heading
True Track
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Elapsed time (in minutes)

Annex B. Detailed results of the ISPACG derived scenario run

The figure below illustrates the trajectory of the KLM flight used for the test, as derived from the ADS reports. The duration of intervals between the reception of consecutive reports, and of the intervals between consecutive time stamps is graphically shown on the next page.
It should be noted that the Arinc745 format translates the 900 second periodicity requested by the user in an actual 896 second period in the ADS uplinked message.


Duration
(in sec.)
KLM B747
15 min. periodic contract
Interval between consecutive report reception times
Interval between consecutive report time stamps
930
920
910
900
890
880
870
860
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Report number

Annex C. NAT Scenario

The attached scenario is one (Scenario 3) of the eleven scenarios defined by the ATMG for the use of ADS and CPDLC on the North Atlantic and covers the scenario for routine monitoring of aircraft on NAT flights.

These scenarios were originally developed for ADS and CPDLC applications conforming to the CNS/ATM-1 SARPs and some changes were required to run it using an ARINC 745-2 ADS application as used in ADS EUROPE. In order that the differences can be identified a column titled “ADS Trial Action” was added to the original scenario table . This allows a direct comparison between the ADS trials activity (shown in italics in this column) and that which would take place in a CNS/ATM-1 application environment.

It should be noted that the scenarios also identify how CPDLC would be used in conjunction with ADS. No attempt to simulate CPDLC activity was carried out during this trial since ADS EUROPE has no CPDLC capability.

The scenario attached was used for Runs 2 to 5; the only difference on Run 1 was that it was attempted to estimate the Oceanic Entry Point(OEP) time and uplink a new periodic contract 15 minutes before OEP. This proved difficult to estimate accurately and, following discussions with operational personnel, it was considered to be unnecessary. Step 9 of the scenario was therefore deleted (this is shown struck out).

Scenario 3: Routine flight using air/ground datalinks (without message ground-forwarding) (As flown on Runs 2-5)

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
1	Not greater than 90 minutes before entry into Shanwick FIR.	Aircrew initiate DLIC LOGON procedures to log-on to the FDPS2 by generating and transmitting a DLIC LOGON Request. The LOGON message will contain the aircraft-unique identifier (the 24 bit aircraft address) and the data link applications it can support. The aircraft does not have to be airborne to initiate the LOGON procedure.	*ATMDC obtain Flight Plan from BA ops and enter it into the ATC GS to form Electronic Flight Progress Strip (EFPS).* *ATMDC start Aircraft Scenario* ***OCEANIC-SC3.*** *Aircraft initiates LOGON. Initial downlink is Basic Group, Airframe and Flight Identification (FID). (Note - FID on Flight Plan may need amending to reflect crew insertion)*			The LOGON process will be either initiated manually by the aircrew or automatically by the avionics upon power-up. The process by which an aircraft logs on to a particular ground system is currently being developed by the ATN Panel. For the purpose of data correlation in the NAT Region, the aircraft ID, aerodrome of departure and destination shall be included in the LOGON request.

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
2						FDPS2 responds to the aircraft's request to receive a data link service. It correlates the aircraft-unique identifier with the aircraft identification stored in its database and registers the aircraft's data link capabilities.
3			*After successful LOGON, ATMDC uplink Agreement* ***OSC3-1*** *which is 30 min Basic Reporting, Vertical Rate Event (.GT. 500 fpm) and Altitude Event Request for passing FL20 (to signify when airborne). On receiving this Alert passing FL20, ATMDC uplink Agreement* ***OSC3-2*** *which is 30 min Basic Reporting and Altitude Event Request for passing FL200.* *NAVCANADA initial contract is Basic only, 45 min reporting interval.*	A successful LOGON invokes the ADS application to issue an Initial Contact Agreement.	A successful LOGON invokes the CPDLC application to facilitate two way data communications when required.	

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities	
			ADS Trial Action	**ADS Application**	**CPDLC Application**	**Notes**
4			*On receiving the alert passing FL200, ATMDC issue Agreement **OSC3-3** which is 15 min reporting interval for Basic Group + Predicted Route Group, plus Waypoint Events.* .	FDPS2 automatically issues an ADS Initial Contact Agreement. This establishes an ADS Demand Contract for the immediate provision of the Basic Group, Extended Projected Profile (EPP) as stored in the FMS and Flight Identification group.		
5		The avionics automatically sends the ADS Basic Group, EPP and Flight Identification group.	*The Avionics automatically sends ADS Basic Group, PRG with FID part of Basic Group.* *EFPS is automatically updated with new estimates, and any changes to Plan. Any deviation from the Plan causes an Alert.*			The EPP is checked for conformance to the flight plan stored within FDPS2, and the estimate times are used to update the flight plan. If an aircraft logs on and no flight plan is stored within FDPS2, the aircraft is contacted by voice and the necessary information obtained for a FPL to be created.
6			*ATC GS uses the PRG to determine the ETA into the Shanwick FIR.*	FDPS2 uses the EPP to determine the desired entry point and ETA into the Shanwick FIR.		

Ref	Time or Aircraft Position	Action of Aircrew or Avionics			Ground Based Flight Data Processing Facilities	
			ADS Trial Action	ADS Application	CPDLC Application	Notes
7	About 60 minutes before entry into Shanwick FIR.	The aircrew request the establishment of a CPDLC Downstream Data Authority (DDA) link with Shanwick Oceanic Area Control Centre ('Shanwick').				On establishment of the DDA link, FDPS2 will only permit access to those CPDLC message elements that comprise the Downstream Clearance (DSC) service, i.e. strategic rather than tactical message elements.
8					Shanwick automatically confirms the link establishment.	
9				FDPS2 issues Pre-Shanwick (Domestic) ADS Agreement by establishing an ADS Periodic Contract for the provision of the Basic Group and EPP every 15 minutes.		
10	45 minutes before entry into the Shanwick FIR.	The avionics automatically sends the Basic Group and the EPP.	*The avionics automatically sends the Basic Group and the PRG.*			FDPS2 uses the EPP information to check for any changes in boundary estimate. FDPS2 alerts the controller if an alteration to the time has occurred.

Ref	Time or Aircraft Position	Action of Aircrew or Avionics			Ground Based Flight Data Processing Facilities	
			ADS Trial Action	ADS Application	CPDLC Application	Notes
11			*The Basic Group and PRG are received by the ATC GS and EFPS is automatically amended.*	The Basic Group and EPP are received by FDPS2.		The FDPS2 database is updated with this information (if necessary).
12		The aircrew transmit requested Oceanic Clearance using the DDA link using the CPDLC DSC service.				DSC: Downstream Clearance. Only an aircraft can initiate the DSC service.
13					FDPS2 receives CPDLC message requesting preferred Oceanic Clearance, including the point and time of entry into Shanwick FIR, and passes it to the Controller.	
14					The controller determines the Oceanic Clearance, constructs the CPDLC response and authorises FDPS2 to send it to the aircraft.	The requested clearance is probed using FDPS2 to check for conflicts.
15		The avionics receives the clearance and displays it to the aircrew.				
16		The aircrew update the clearance into the FMS (if necessary).	*Any changes to the Plan are automatically downlinked when the update is entered, and the EFPS is amended accordingly.*			

Ref	Time or Aircraft Position	Action of Aircrew or Avionics			Ground Based Flight Data Processing Facilities	
			ADS Trial Action	ADS Application	CPDLC Application	Notes
17		The aircrew acknowledge receipt of the clearance by sending the CPDLC message WILCO.				The DDA link is not terminated by the aircrew. This is to allow for the potential of reclearances as a DDA link can only be aircrew initiated and if the link was terminated, the controller could not pass the reclearance message.
18					The WILCO message is received by FDPS2.	If the WILCO is not received within 5 minutes, then FDPS2 issues a warning to the controller.
19	30 minutes before entry into Shanwick FIR.	The avionics automatically send the Basic Group and EPP.	*The avionics automatically send the Basic Group and PRG.*			This is sent as part of the Pre-Shanwick (Domestic) agreement.
20			*The Basic Group and PRG are received by ATC GS.*	The Basic Group and EPP are received by FDPS2.		FDPS2 checks that the correct Oceanic Clearance is stored in the FMS.
21	15 minutes before entry into Shanwick FIR.	The avionics automatically send the Basic Group and EPP.	*The avionics automatically send the Basic Group and PRG.*			This is sent as part of the Pre-Shanwick (Domestic) agreement.
22			*The Basic Group and PRG are received by ATC GS.*	The Basic Group and EPP are received by FDPS2.		FDPS2 checks that the correct Oceanic Clearance is stored in the FMS.

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
23	5 minutes before entry into the Shanwick FIR.			FDPS2 issues ADS Boundary Agreement to establish an ADS Event Contract for the notification of a Waypoint Event (i.e. entering the Shanwick FIR), along with provision of the Basic Group and Extended Projected Profile.		
24	Aircraft crosses the boundary and enters Shanwick FIR.	Entry of the aircraft into the Shanwick FIR generates the issue of the waypoint event comprising: the Basic Group and Extended Projected Profile in accordance with the Boundary Agreement.	*Waypoint Change Event automatically downlinks alert, current position, Next & Next + 1 waypoints.*			Shanwick becomes the Current Data Authority (CDA).

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
25			*On passing OEP (defined as 4W for Trials purposes), ATMDC issues Agreement* ***OSC3-4*** *to establish the following Contracts:* *<u>Periodic Contract</u>:* *Every 15 mins, Basic and PRG.* <u>*Event Contract:*</u> *For the report of the following events:* *Lateral Deviation Event (more than 5nm off track) to provide alert and Basic Group.* *Altitude Event Trigger (more than 300 ft above or below cleared level) to provide alert and Basic Group.* *Vertical Rate Event of +500 fpm to trigger alert if aircraft receives en-route climb clearance. Re-uplink Altitude Event Trigger when level achieved.* *Waypoint Change Event, downlink Basic Group + Predicted Route Group.*	FDPS2 issues ADS Standard Agreement to establish the following contracts: <u>Periodic Contract:</u> Every 15 minutes the Basic Group and Projected Profile are to be reported. <u>Event Contract:</u> For the report of the following events: Lateral Deviation Event (more than 5nm off track), provision of the Basic Group. Level Range Deviation Event (more than 300ft above or below cleared level), provision of the Basic Group. EPP Change Event, provision of the new EPP.		The periodic generation and receipt of ADS messages triggered by the Periodic Contract are not shown in this scenario. However, they would be triggered and received by FDPS2 every 15 minutes. Furthermore, this scenario assumes that the aircraft does not deviate from its cleared flight profile (by more than the thresholds established in the Event Contract) and thus no ADS messages from the Event Contract are triggered.

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
26					FDPS2 sends CPDLC message to the avionics advising that Shanwick is the CDA.	
27		The avionics automatically terminates the DDA link (if open) upon detection that the DDA has become the CDA.				
28	Flight proceeds across Shanwick FIR.		*Periodic reports are sent every 15 minutes in accordance with the Standard Agreement.*	Periodic reports are sent every 15 minutes in accordance with the Standard Agreement.	Routine CPDLC messages are exchanged.	
29	About 15 minutes from entry into Gander FIR.					

Ref	Time or Aircraft Position	Action of Aircrew or Avionics			Ground Based Flight Data Processing Facilities	
			ADS Trial Action	ADS Application	CPDLC Application	Notes
30			*ATMDC establishes contact with NAVCANADA ('phone) and advises a/c Flight Level.* *NAVCANADA uplinks Agreement for Periodic Contact with 15 min interval for* *Basic Group and PRG,* *Waypoint Change Event,* *Altitude Event Trigger (more than 300 ft above or below cleared level) to provide alert.* *If aircraft receives en-route climb clearance, re-uplink Event when level achieved.*		FDPS2 instructs avionics to make DLIC CONTACT with Gander. FDPS2 informs the aircraft that Gander is the NDA and instructs it to establish the connection.	NDA: Next Data Authority. This scenario assumes that there is no ground-ground data communications link between Shanwick and Gander and hence the aircraft has to use the CONTACT functionality of the DLIC application.
31		The avionics make DLIC CONTACT with Gander and establishes a CPDLC NDA link.				
32				Gander FDPS automatically issues ADS Initial Contact Agreement.		

Ref	Time or Aircraft Position	Action of Aircrew or Avionics		Ground Based Flight Data Processing Facilities		
			ADS Trial Action	ADS Application	CPDLC Application	Notes
33			*NAVCANADA confirms to ATMDC that they have established a connection*		Gander automatically confirms the establishment of the CPDLC NDA link.	
34	The aircraft leaves the Shanwick FIR and enters the Gander FIR.			FDPS2 terminates the Shanwick ADS Agreements.	FDPS2 sends a CPDLC link end request to the aircraft. This clears the CDA link with Shanwick and the NDA automatically becomes the CDA.	Gander becomes the CDA.
35		A waypoint event is triggered and the ADS Basic Group sent to Gander in accordance with the ADS Initial Contact Agreement. The avionics automatically terminates the CPDLC link with Shanwick, informs Shanwick of the termination of the link, enables its CPDLC CDA link with Gander and sends a Monitoring RT (MRT) message to Gander.	*A waypoint event is triggered and the ADS Basic Group sent to NAVCANADA in accordance with the ADS Initial Contact Agreement.* *A waypoint event is triggered and the ADS Basic Group, Next & Next + 1 is sent to ATMDC .* *At 32W (for Trials purposes) ATMDC change Agreement to **OSC3-5** which is 45 min Basic only and Waypoint event (for monitoring purposes)*			

Ref	Time or Aircraft Position	Action of Aircrew or Avionics			Ground Based Flight Data Processing Facilities	
			ADS Trial Action	ADS Application	CPDLC Application	Notes
36				Gander FDPS issues ADS Standard Agreement.		
37	Aircraft proceed along Gander FIR.		*At Fishpoint (defined as 60W for Trials purposes) ATMDC cancels Waypoint Event and Flight Plan.* *For Trials purposes ATMDC issues standard End Of Flight Agreements until landing. This are Basic, Ground, Met, Air every 5 min with vertical rate event and altitude trigger, with contract changes at FL200 to 1 minute then at FL100 to 30 secs in the descent and approach, terminating the connection at 300 ft.* *At Fishpoint, NAVCANADA cancels Waypoint Event and issues standard End Of Flight Agreement until landing.*			

Annex D. Detailed results of ADS LiveTrials of NAT Scenario 3

This Annex (D) provides the detailed results obtained during each of the five trial runs together with annotated plots of each run identifying the appropriate ADS reports. (The plots are screen prints from the geographic display on the ATC Ground System which have been annotated to show details of the ADS reports).

D.1 Detail Run 1

Special Notes:

First run of Scenario. ADSE Clock time noted as 13 minutes behind UTC. As the Flight Progress Strips are based on this time, they will not match with the live strip, but this does not matter for trials purposes.

Flight Plan:

DCT WOBUN DCT WELIN UA2 POL UB4 TLA UN601 STN UN610 61N010W/M085F310 66N020W 68N030W 69N040W/M085F330 69N050W 69N060W/M085F350 NCAB YBE

Plan entered at 13:00 (12:47 ADSE time) was
Mach 0.85 FL310 STN 61N010W 66N020W 68N030W 69N040W 69N050W 69N060W

Initial domestic routeing was POL RIBEL SHAPP MARGO TLA STN. The aircraft actually routed MARGO direct STN, missing TLA.

<u>**ADSE Time**</u>	<u>**Data**</u>
12:16	Trigger through 2000’
12:26	Trigger through FL200 location just past WELIN
	Uplinked request for 15 min Basic + PRG + Waypoints Event
	Downlinked position plus PRG, showing Next = TNT Next + 1 = POL
12:30	Waypoint Change Event, route Direct (DCT) POL. Climbing through FL270
	Next = POL Next + 1 = RIBEL
12:40	Waypoint Change Event, at POL at FL280
	Next = RIBEL Next + 1 = SHAPP
12:41	Periodic basic group + PRG
12:42	Waypoint Change Event, at RIBEL at FL280

Next = SHAPP Next + 1 = MARGO

12:47 Waypoint Change Event, at SHAPP climbing through FL294
(Note: miss TLA) Next = MARGO Next + 1 = STN

12:49 Waypoint Change Event, at MARGO at FL310
Next = STN Next + 1 61N010W

12:54 Re-uplink Contract to force 15 min timings to be "15 mins before OEP", plus Event Contract for Altitude Floor FL307, Ceiling FL313, Lateral Deviation 5 nm.

(This re-uplink was omitted in subsequent Trials as it proved difficult to calculate accurately, and was later judged not to be required)

12:54 Periodic basic group + PRG
13:09 Periodic basic group + PRG
13:24 Periodic basic group + PRG
13:24 Waypoint Change Event, at STN at FL310
Next = 61N010W Next+1 66N020W
13:39 Periodic basic group + PRG
13:54 Periodic basic group + PRG
13:54:30 Waypoint Change Event, at 61N010W at FL310
Next = 66N020W Next + 1 68N030W
14:09 Periodic basic group + PRG
14:12 Altitude Alert climbing through FL313 to FL330
14:13 Uplink Event Contract for Altitude Floor FL307, Ceiling FL333, Lateral Deviation 5 nm
14:15 Demand uplinked for PRG
14:18 Demand uplinked for Air Group to get Mach No.
14:24 Periodic basic group + PRG
14:39 Periodic basic group + PRG
14:49 Waypoint Change Event, at 66N020W at FL330
Next = 68N030W Next + 1 69N040W
14:53 Periodic basic group + PRG
15:08 Periodic basic group + PRG
15:23 Periodic basic group + PRG
15:25 Waypoint Change Event, at 68N030W at FL330
Next = 69N040W Next + 1 69N050W

15:35 Altitude Alert climbing through FL333 to FL350
15:35 Passing 033W Uplinked request for 45 min Basic + PRG + Waypoints Event
15:55 Waypoint Change Event, at 69N040W at FL350
Next = 69N050W Next + 1 69N060W
16:20 Periodic basic group + PRG
16:24 Waypoint Change Event, at 69N050W at FL350
Next = 69N060W Next + 1 6830N070W

16:53 Waypoint Change Event, at 69N060W at FL350
Next = 6830N070W Next + 1 6730N080W

End of run passing 060W

Figures not available in soft-copy will be inserted in the final report.

Fig 1a British Airways B747-400 (Heathrow/Los Angeles)
UK Domestic Airspace

Fig 1b British Airways B747-400 (Heathrow/Los Angeles)
Shanwick/Oceanic Airspace

D.2 Detail Run 2

Special Notes:

A/C logged on as BAW268. The plan had to be re-entered to pick up this Flight ID. ADSE Clock 13 minutes behind UTC.

Flight Plan:

DCT WOBUN DCT WELIN UA2 POL UB4 TLA UN601 STN UN610 61N010W/M085F330 65N020W 68N030W 69N040W 70N050W 70N060W/M085F350 NCAA 6939N070W

Plan entered at 16:27 UTC (16:14 ADSE time) was
Mach 0.85 FL310 STN 61N010W 65N020W 68N030W 69N040W 70N050W 70N060W

Initial domestic routeing was TNT POL TLA NEVIS STN BILLY. The aircraft actually routed TNT DCT BILLY.

ADSE Time	Data
16:08	Trigger through 2000’ No uplink of Contract for Event passing FL200 (System problem)
16:24	Demand shows a/c passing FL256, pst WELIN. Uplinked request for 15 min Basic + PRG + Waypoints Event
16:24	Periodic basic group + PRG shows Next = TNT Next + 1 ABM POL
16:25	Waypoint Change Event, at TNT passing FL268 Next = ABM POL Next +1 = TLA
16:31	Waypoint Change Event, at ABM POL passing FL310 Next = TLA Next +1 = NEVIS
16:38	Re-uplink of Contract, cancelled in error due other traffic.

16:38 Periodic basic group + PRG shows Next = STN Next + 1 = BILLY
(Waypoint Change Event missed upgrading Next, Next +1)
16:51 Waypoint Change Event, near NEVIS route DCT BILLY
Next = ABM STN Next +1 = BILLY
16:53 Periodic basic group + PRG
17:08 Periodic basic group + PRG FL330
17:09 Waypoint Change Event, at ABM STN at FL330
Next = BILLY Next +1 = 61N010W
17:23 Periodic basic group + PRG
17:26 Waypoint Change Event, at BILLY
Next = 61N010W Next +1 = 65N020W
17:36 Waypoint Change Event, at 61N010W
Next = 65N020W Next +1 = 68N030W
17:36 Uplink Event Contract for Altitude Floor FL307 Ceiling FL313, Lateral Deviation 5nm
17:36 Altitude Alert passed FL313 (a/c at FL330)
17:38 Periodic basic group + PRG
17:38 Uplink Event Contract for Altitude Floor FL327 Ceiling FL333, Lateral Deviation 5nm
17:53 Periodic basic group + PRG
18:08 Periodic basic group + PRG
18:23 Periodic basic group + PRG
18:31 Waypoint Change Event, at 65N020W
Next = 68N030W Next +1 = 69N040W
18:35 Waypoint Change Event to Re-Route
Next = 6640N025W Next +1 = 68N030W
18:37 Periodic basic group + PRG
18:52 Periodic basic group + PRG
18:57 Altitude Alert passing FL333 to FL350
18:59 Waypoint Change Event, at 6640N025W
Next = 68N030W Next +1 = 69N040W
19:07 Periodic basic group + PRG
19:22 Periodic basic group + PRG

19:24 Waypoint Change Event, at 68N030W
Next = 69N040W Next +1 = 70N050W
19:37 Periodic basic group + PRG passing 033W
Uplink Request for 45 min Basic + PRG + Waypoints Event
20:04 Waypoint Change Event, at 69N040W
Next = 70N050W Next +1 = 70N060W
20:22 Periodic basic group + PRG
20:40 Waypoint Change Event, at 70N050W
Next = 70N060W Next +1 = 70N070W
21:07 Periodic basic group + PRG
21:09 Waypoint Change Event, at 70N060W
Next = 6926N070W Next +1 = 6730N080W

End of run passing 060W

Insert:

Fig 2 **British Airways B747-400 (Heathrow/Los Angeles)**
Shanwick Oceanic Airspace

D.3 Detail Run 3

Special Notes:

As the Flight Plan was not available from BA, a guess was made as to the intended route and a plan entered. As this was incorrect, and the aircraft was given a direct routeing, the “Off Plan Alert” on the End System was triggered. This is not the Deviation Alert from the aircraft. This aircraft is equipped with GPS, and so the ADSE clock is accurate.

Flight Plan (correct)

CPT UG1 STU UG1 SHA UN535 BURAK UN533 54N015W /M085F330 54N020W 55N030W 55N040W 57N050W PRAWN/M085F350

Plan entered at 13:01 was
Mach 0.85 FL310 52.26N 006.23W 52.6N 007.58W 52.83N 010W 55N 020W 56N 030W 56N 040W 57N 050W 56N 060W

Initial domestic routeing was DIKAS STU SLANY DIMUS ABAGU SHA BURAK. The aircraft was routed DCT STU, then DCT 54/15.

ADSE Time **Data**

ADSE Time	Data		
12:28	Trigger through 500 fpm		
12:29	Trigger through 2000’		
12:40	Trigger through FL200	location South of CHELT on UG1	
	Uplinked request for 15 min Basic + PRG + Waypoints Event		
	Downlinked position plus PRG, showing	Next = DIKAS	Next + 1 = STU
12:45	Waypoint Change Event, given DCT STU at FL260		
		Next = STU	Next +1 = SLANY
12:49	Waypoint Change Event, given DCT 54N015W (OEP) at FL310		
		Next = ABM STU	Next +1 = ABM SLANY

12:54 Waypoint Change Event, at ABM STU
Next = ABM SLANY Next +1 = ABM DIMUS
12:55 Periodic basic group + PRG
12:58 Waypoint Change Event, at ABM SLANY
Next = ABM DIMUS Next +1 = ABM ABAGU
12:59 Waypoint Change Event, recalculation
Next = ABM DIMUS Next +1 = ABM ABAGU
13:00 Waypoint Change Event, at ABM DIMUS
Next = ABM ABAGU Next +1 = ABM SHA
13:08 Waypoint Change Event, at ABM ABAGU
Next = ABM SHA Next +1 = 5327N 01145W
13:10 Periodic basic group + PRG
13:15 Waypoint Change Event, at ABM SHA
Next = 5327N01145W Next +1 = 54N015W
13:25 Periodic basic group + PRG
13:25 Uplink Event Contract for Altitude Floor FL307 Ceiling FL313, Lateral Deviation 5nm
13:31 Waypoint Change Event, at 5327N01145W
Next = 54N015W Next +1 = 54N020W
13:34 Altitude Alert passing through FL313 for FL330
13:40 Periodic basic group + PRG at FL330
13:48 Waypoint Change Event, at 54N015W
Next = 54N020W Next +1 = 55N030W
13:55 Periodic basic group + PRG
14:10 Periodic basic group + PRG
14:12 Waypoint Change Event, at 54N020W
Next = 55N030W Next +1 = 55N040W
14:24 Periodic basic group + PRG
14:39 Periodic basic group + PRG
14:54 Periodic basic group + PRG
15:00 Waypoint Change Event, at 55N030W
Next = 55N040W Next +1 = 57N050W

15:09 Periodic basic group + PRG
15:09 Periodic basic group + PRG passing 033W
Uplink Request for 45 min Basic + PRG + Waypoints Event
15:44 Waypoint Change Event, at 55N040W
Next = 57N050W Next +1 = PRAWN
15:54 Periodic basic group + PRG
16:31 Waypoint Change Event, at 57N050W
Next = PRAWN
16:34 End of run passing 060W

Insert:

**Fig 3a British Airways B747-400 (Heathrow/Los Angeles)
UK Domestic Airspace**

Fig 3b British Airways B747-400 (Heathrow/Los Angeles)
Shanwick/Oceanic Airspace

D.4 Detail for Run 4

Special Notes:

This aircraft is equipped with GPS, and so the ADSE clock is accurate.

Flight Plan.

DCT WOBUN DCT WELIN UA2 TNT/F310 UP6 56N/010W/M085F340 56N020W 57N030W 58N040W 58N050W/M085F350 58N060W DCT YVF

Plan entered at 14:32 was Mach 0.85 FL310 WOBUN WELIN TNT 56N010W 56N020W 57N030W 58N040W 58N050W 58N060W YVF

Domestic routeing was WOBUN WELIN TNT MCT HAYDO REMSI BESOP DUNLO.

ADSE Time	Data		
15:21	Trigger through 500 fpm		
15:23	Trigger through 2000'		
15:33	Trigger through FL200	location just past WELIN	
	Uplinked request for 15 min Basic + PRG + Waypoints Event		
	Downlinked position plus PRG, showing		
		Next = TNT	Next + 1 = MCT
15:42	Waypoint Change Event, at TNT at FL280		
		Next = MCT	Next + 1 = HAYDO
15:46	Waypoint Change Event, at MCT		
		Next = HAYDO	Next + 1 = REMSI
15:47	Waypoint Change Event, at HAYDO		
		Next = REMSI	Next + 1 = BESOP

15:50 Periodic basic group + PRG
15:55 Waypoint Change Event, at REMSI at FL310
Next = BESOP Next + 1 = DUNLO
16:04 Waypoint Change Event, at BESOP at FL323
Next = DUNLO Next + 1 = 56N010W
16:05 Periodic basic group + PRG at FL328
16:11 Waypoint Change Event, at DUNLO at FL330
Next = 56N010W Next + 1 = 56N020W
16:20 Periodic basic group + PRG
16:29 Waypoint Change Event, at 56N010W
Next = 56N020W Next + 1 = 57N030W
16:29 Uplink Event Contract for Altitude Floor FL307 Ceiling FL313, Lateral Deviation 5nm
16:29 Altitude Alert passing through FL313 for FL330 (a/c at FL330)
16:34 Uplink Event Contract for Altitude Floor FL327 Ceiling FL333, Lateral Deviation 5nm
16:35 Periodic basic group + PRG
16:50 Periodic basic group + PRG
17:05 Periodic basic group + PRG
17:15 Waypoint Change Event, at 56N020W
Next = 57N030W Next + 1 = 58N040W
17:20 Periodic basic group + PRG
17:35 Periodic basic group + PRG
17:35 Altitude Event Trigger passing through FL333 for FL350
17:50 Periodic basic group + PRG at FL350
17:59 Waypoint Change Event, at 57N030W
Next = 58N040W Next + 1 = 59N050W
18:04 Periodic basic group + PRG
18:19 Periodic basic group + PRG
18:19 Periodic basic group + PRG passing 033W
Uplink Request for 45 min Basic + PRG + Waypoints Event
18:42 Waypoint Change Event, at 58N040W
Next = 59N050W Next + 1 = 5901N05955W

19:04 Periodic basic group + PRG
19:21 Waypoint Change Event, at 59N050W
Next = 5801N05955W   Next + 1 = 5712N06237W
19:49 Periodic basic group + PRG
20:00 Waypoint Change Event, at 5804N05931W re-route
Next = 5801N05955W   Next + 1 = 5522N08000W
20:34 Periodic basic group + PRG
20:34 End of run passing 060W

Insert:

Fig 4 **British Airways B747-400 (Heathrow/San Francisco)**
UK Domestic Airspace

D.5 Detail for Run 5

Special Notes:

This aircraft is equipped with GPS, and so the ADSE clock is accurate. The Flight Plan was sent via SITA. It was noted during the trial that additional non-ATC Waypoints were inserted by the aircraft at 015W, 025W, 055W.

Flight Plan.

DCT WOBUN DCT WELIN UA2 TNT UP6 56N/010W/M085F310 58N020W/M085F330 60N030W 61N040W 62N050W 62N060WM085F350 DCT TEFFO

Plan entered at 14:32 was
Mach 0.85 FL310 WOBUN WELIN HAYDO BESOP DUNLO 56N010W 58N020W 60N030W 61N040W 62N050W 62N060W TEFFO

Domestic routeing was WOBUN WELIN TNT MCT HAYDO REMSI BESOP DUNLO.

ADSE Time	Data		
12:22	Trigger through 500 fpm		
12:23	Trigger through 2000’		
12:34	Trigger through FL200	location just past WELIN	
	Uplinked request for 15 min Basic + PRG + Waypoints Event		
	Downlinked position plus PRG, showing		
		Next = TNT	Next + 1 = MCT
12:42	Waypoint Change Event, at TNT at FL280		
		Next = MCT	Next + 1 = HAYDO

12:46 Waypoint Change Event, at MCT
Next = HAYDO Next + 1 = REMSI
12:47 Waypoint Change Event, at HAYDO
Next = REMSI Next + 1 = BESOP
12:49 Periodic basic group + PRG
12:54 Waypoint Change Event, at REMSI at FL310
Next = BESOP Next + 1 = ABM DUNLO
13:04 Waypoint Change Event, at BESOP at FL330
Next = ABM DUNLO Next + 1 = 56N010W
13:04 Periodic basic group + PRG
13:11 Waypoint Change Event, at ABM DUNLO
Next = 56N010W Next + 1 = 58N020W
13:19 Periodic basic group + PRG
13:28 Waypoint Change Event, at 56N010W
Next = 58N020W Next + 1 = 60N030W
13:28 Uplink Event Contract for Altitude Floor FL307 Ceiling FL313, Lateral Deviation 5nm
13:29 Altitude Alert passing through FL313 for FL330 (a/c at FL330)
13:31 Waypoint Change Event, at 5608N01032W new Waypoint insertion (non ATC)
Next = 5707N01500W Next + 1 = 58N020W
13:34 Periodic basic group + PRG
13:37 Uplink Event Contract for Altitude Floor FL327 Ceiling FL333, Lateral Deviation 5nm
13:52 Waypoint Change Event, at 5707N01500W
Next = 58N020W Next + 1 = 60N030W
13:52 Periodic basic group + PRG
14:07 Periodic basic group + PRG
14:14 Waypoint Change Event, at 58N020W
Next = 60N030W Next + 1 = 61N040W
14:17 Waypoint Change Event, at 5810N02040W new Waypoint insertion (non ATC)
Next = 5907N025W Next + 1 = 60N030W
14:22 Periodic basic group + PRG
14:35 Waypoint Change Event, at 5907N02500W

Next = 60N030W   Next + 1 = 61N040W

14:37 Periodic basic group + PRG
14:52 Periodic basic group + PRG
14:55 Waypoint Change Event, at 60N030W
Next = 61N040W   Next + 1 = 62N050W
15:07 Periodic basic group + PRG
15:07 Periodic basic group + PRG passing 033W
Uplink Request for 45 min Basic + PRG + Waypoints Event
15:34 Waypoint Change Event, at 61N040W
Next = 62N050W   Next + 1 = 62N060W
16:11 Altitude Alert passing through FL333 for FL340
16:11 Waypoint Change Event, at 62N050W
Next = 62N060W   Next + 1 = 6129N06300W
16:13 Waypoint Change Event, at 6201N05041W new Waypoint insertion (non ATC)
Next = 6205N05500W   Next + 1 = 62N060W
16:27 Periodic basic group + PRG
16:28 Waypoint Change Event, at 6205N05500W
Next = 62N060W   Next + 1 = 6129N06300W
16:32 Waypoint Change Event, at 6205N05602W New Waypoint insertion DCT
Next = 62N060W   Next + 1 = 5910N08000W
16:46 End of run passing 060W

Insert:

Fig 5a **British Airways B747-400 (Heathrow/ Los Angeles)**
UK Domestic Airspace

Fig 5b British Airways B747-400 (Heathrow/Los Angeles)
Shanwick Oceanic Airspace

Fig 5c British Airways B747-400 (Heathrow/Los Angeles)
Shanwick Oceanic Airspace