



OPTIMI Lot 5

Work Package 3 - OPTIMI Recommendation

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1 Introduction

The Oceanic Position Tracking Improvement & Monitoring (OPTIMI) project was launched by the SESAR Joint Undertaking (SJU) after the tragic accident of Air France Flight 447, occurred over the Atlantic in June 2009, had shown that improvements were needed in the monitoring of air traffic in oceanic and remote low density airspace and in the coordination between ATS and Search and Rescue (SAR) services in these oceanic areas.

1.1 General objectives of OPTIMI and key issues

The aim of the OPTIMI project is to assess and trial the feasibility of implementing oceanic flight tracking services in the Atlantic (NAT, EUR and AFI regions) in order to improve the accuracy with which aircraft position is known, allowing better coordination and ATS service provision in normal operations and also in cases in which an unusual event occurs.

Key issues for the project were the following ones:

- The solution should be based on existing technology, so that it could be trialed in 2010 and implemented as of 2011, and be economically viable.
 - The OPTIMI project would identify and test the possibility of implementing oceanic flight tracking based on existing ADS-C and CPDLC technology.
 - The use of AOC datalink for these purposes (i.e. ACARS) and the possibility of down-linking Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) data in the moments following an unexpected or unusual event was also to be examined.
- Not only technical issues were to be examined, but also economic, social and regulatory and certification aspects.
- Search & Rescue (SAR) coordination procedures are key to the project. One of the main objectives was to examine how enhanced provision of event reporting and position tracking, and the use of appropriate procedures, could improve SAR reaction times.
- Another of the purposes of the project was to examine means by which recorder data could be downlinked to ground stations in order to speed up accident analysis and diagnosis, mitigating against the effect of failing to recover the FDR and CVR from an aircraft.

To achieve the project objectives, the work programme was divided into 5 lots:

- LOT 1, "Analysis of the current situation", where all the necessary analyses to document current situation throughout the NAT, EUR and AFI regions and expected evolution of equipment, procedures and services associated to the initiative were performed. It consisted of 2 Work Packages:
 - WP1: "Analysis of the baseline", which included the analysis of the current situation from the technical, operational, social, economic and regulatory perspectives.
 - WP 2: "Feasibility Analysis of Implementation of a Flight Tracking Service", where the technical and operational impact of potential flight tracking services in oceanic airspace was addressed, as well as their economic and regulatory implications.

- LOTS 2, 3 and 4: Three sets of in-flight demonstrations involving commercial flights in three different Atlantic oceanic regions (NAT, EUR and AFI, respectively) with the objective of assessing added value of ADS-C based flight tracking service and CPDLC, testing new coordination procedures, including SAR, and supporting the safety and economic assessments.
- LOT 5: “Elaboration of initial business case”, whose objective was to compile the findings coming from the previous lots into an initial business case that would help the future decision making process towards the eventual undertaking of the analysed technologies and practices. Three Work Packages were considered within this lot:
 - WP 1: “Initial Business Case elaboration”, consisting in the elaboration of a safety assessment and an economic assessment of new procedures or systems and an analysis of possible approaches to a final Business Case.
 - WP 2: “Support to SJU Regulatory Review”, consisting in the preparation of the necessary documentation to allow the SJU to obtain the regulatory opinion from NSAs.
 - WP 3: “Support to SJU recommendation”, consisting in the preparation of the necessary documentation to allow SJU to present a recommendation on early implementation of oceanic flight tracking service based on ADS-C.

1.2 Purpose of the document

This document constitutes the deliverable to OPTIMI Lot 5 WP3, whose purpose is to present the OPTIMI recommendations based on the analysis and conclusions of the previous tasks of the OPTIMI Project.

2 OPTIMI recommendation

2.1 Basis for OPTIMI recommendation

This section summarizes the main findings and conclusions of the different OPTIMI Work Packages, which constitute the basis for the OPTIMI recommendation presented in section 2.2.

2.1.1 Conclusions derived from OPTIMI Lot 1

The facts and conclusions derived from the analysis of the current situation (Lot 1 WP1) are the following ones:

- Currently three ATC services are provided in Atlantic oceanic airspace for the reporting of aircraft position:
 - FANS-1/A (A+) ADS-C messages, where the ADS-C contract is ground initiated
 - FMC- WPR
 - HF voice reporting (which is compulsory).
- FANS-1/A and FMC-WPR datalink services usually make use of a SATCOM network to provide the air/ground link, although VHF datalink can be used in close proximity to land where suitable coverage exists.

- FANS-1/A service availability is already widespread in the Atlantic. An ADS-C service is provided, or it is planned that it will be provided, in all NAT and EUR/SAM corridor airspace. These areas account for the vast majority of the transatlantic air traffic. In other parts of the Atlantic the service is partial or absent. Airline FANS-1/A equipage is at best 40%-50%.
- A CPDLC service is also provided via FANS in many oceanic FIRs. This service allows pilots and Air Traffic Controllers to communicate using text messages. CPDLC can also be provided via ATN, although this is in the early stages of deployment in European continental airspace.
- An ACARS service allowing aircraft communication with the AOC is also available in most OACs. Message types include position reports, meteorological updates, customised AOC messages and free text messages. This service operates over the ACARS network, usually using a SATCOM air-ground link, although VHF and HF datalink can be used where coverage exists.
- The availability of ACARS AOC services is good in the NAT and EUR/SAM corridor and is generally more widespread in the other areas than ADS-C and CPDLC services (there is approaching 100% ACARS equipage for AOC purposes).
- The deployment of ATN is in the initial stages, it is generally only available in non oceanic areas in the core EUR region. ATN provides CDPLC but not ADS-C functionality.
 - EC regulation EC29-2009 (Data Link Services Implementing Rule – DLS IR) mandates the carriage of Link2000+ compliant ATN/VDL2 datalink CPDLC equipment in designated areas of the EUR Region from the 1st of January 2011 for new aircraft (aircraft with an individual certificate of airworthiness issued on or after that date) and from 5th of February 2015 for retro-fit (aircraft with an individual certificate of airworthiness issued before the 1st of January 2011).
 - The DLS IR exempts aircraft fitted with RTCA DO-258A/EUROCAE ED-100A (or ED-100) compliant data link equipment and with an individual certificate of airworthiness first issued before 1 January 2014 for the life of that particular airframe. After this date aircraft equipped with data link equipment necessary to operate in oceanic airspace (FANS-1/A) would also need to equip with DLS IR compliant data link equipment in order to operate in the designated areas within the EUR Region.
- There are some initial discussions on mandatory FANS1-/A equipage in the North Atlantic region, for a 2015 time frame.
- Carriage of FDR and CVR equipment is a mandatory requirement. Equipage is, therefore, 100%. There is current technology that can readily downlink FDR content. This is currently limited to the Iridium satellite network, whilst most aircraft use the Inmarsat system.
 - There may be issues surrounding the FDR downlinking functionality due to existing local privacy arrangements at airlines and due to European data protection legislation.
- FANS-1/A aircraft sometimes do not log on to an OACC. This may be due to save message costs or due to failed log on attempts. Log-on failure due to technical difficulties is experienced by less than 1% of flights that attempt to log on. The most common reason for log-on failure is a discrepancy between the flight callsign and the aircraft registration contained in the AFN log on message and those contained in the flight plan held on the ground. It should be noted that in most systems a flight

plan is required against which to correlate the FANS1/A log-on request from the aircraft.

- Flight plans are sometimes not distributed to all relevant ATSUs. They are therefore sometimes absent in ground ATM systems and it is not uncommon for aircraft to transit Oceanic regions with no flight plan. This is sometimes due to incorrect filing by the airline, or incorrect processing and onward transmission by an ACC.
- Search and Rescue procedures are mature. ICAO Annex 11 identifies the procedures that should be followed in the case of an emergency. There is however potential for AOC/SAR investigation using information available in the AOCs via ACARS. However the availability of the new ATM tools Lateral Deviation Event and Altitude Range Change Event contracts or the increased frequency of FANS position reporting (e.g. from 60 minutes to 15/18 minutes) could have a greater impact on the SAR operations. These FANS supported enhancements will not require the engagement of new actors on the current SAR operations.
- There are apparent regional practices in co-ordination between OACCs and in SAR alerting procedures that deviate from ICAO SARPs.
- Several initiatives are ongoing, carried out by ICAO groups of the different regions, to harmonize procedures and to foster the transition from voice services to data link services at a global level. This is strongly supported by the airlines and should encourage the airline adoption of FANS-1/A.
 - The ICAO GOLD (Global Operational Data Link Document) global guidance Document is now mature enough to become a reference for oceanic remote areas.

Taking into account the OPTIMI key requirements and the previous findings, several options were considered as potential methods of providing a new service in Lot 1 – WP2 (Feasibility Analysis of Implementation of a Flight Tracking Service), focusing on those that should not require aircrew action during an unusual event or emergency scenario. The results of this analysis were the following ones:

- A FANS-1/A ADS-C based solution would be the optimum method of providing a flight tracking service in the short term in the Atlantic parts of the NAT, EUR and AFI ICAO regions.
 - ADS-C event contracts were identified as the **Core Short Term Solution** since event reports are a very effective way of alerting an air traffic controller to any divergence from clearance, which is likely to be the immediate effect of a catastrophic event.
 - ✓ The magnitude of the deviation from the intended flight path, or increase in vertical change rate, can be set at the initiation of the ADS-Contract. The following parameters are given as initial values:
 - Lateral deviation - 5 nautical miles;
 - Altitude range - 300 feet;
 - Altitude rate change – minus 5000 feet per minute.
 - ADS-C Periodic contracts and ADS-C demand contracts constitute the **Ancillary Short Term Solution**. They are delivered with the application that provides the core solution and, despite not being so effective for a rapid detection of unusual situations, they would also contribute to safety enhancing conformance monitoring and would be a back-up in case that the event report is lost or not generated (the periodic reporting rate increase from the current 40 to 60

minutes, dictated by the spacing of waypoints, to 15 or 18 minutes would greatly reduce any potential search area).

- The costs of SAR operations diminish significantly with increasing reporting frequency, although with diminishing returns as the cost of reporting begins to outweigh the benefit from further increases in frequency. The optimum for the overall costs is reached when the position reporting period is about 15 min.
- In several ground ATM systems ADS-C Lateral Deviation Event and Altitude Range Change Event contracts are implemented and in others, they are being implemented. A 15 minute periodic reporting rate is already being used in some SAT FIRs and the NAT region has plans to increase the ADS-C reporting rate and include ADS-C conformance contracts to support new ground ATM tools and increase the level of ATC services offered (separation reductions, capacity, and optimized flight profiles).
- A set of solutions that could also provide an enhanced oceanic flight tracking service but which could not be implemented in the short term were identified. The **Medium Term Solution** consists of:
 - Central position data repository for FANS-1/A and AOC messages. This position data repository would collect position and status data already available through various means (ADS-C, AOC), and make it available to stakeholders with a need for such data (ANSPs, SAR, Airlines), ensuring that the latest position information, regardless of the original sender and recipient, is available to all stakeholders in opportune time.
 - Flight Data Recorder Down Linking System.
- A number of potential solutions that could be implemented in the short term but which were either not deemed to be within the scope of the OPTIMI project, or were deemed to not be sufficiently mature to allow inclusion in the solution without further study, were also identified. These were included as **Recommendations for Further Study** (Short Term);
 - AOC Position and Aircraft Status Reports,
 - Improved Adherence to ATC Procedures by OACCs,
 - FANS-1/A Mandate and Incentives,
 - Automatically Generated Emergency FANS-1/A Based ADS-C Reports,
 - FDR/CVR Real-Time Transmission via Inmarsat,
 - ADS-C without Log-on.
- Pilot-initiated emergency FANS-1/A ADS-C reports, Pilot-initiated emergency FANS-1/A CPDLC reports and SATCom voice were deemed as not suitable as they are dependent on crew action.
- The engagement of the European Commission and the SJU, supporting other regional actors (ICAO, regional groups, governments, NSAs) could accelerate both the availability and the rate of utilization of FANS based flight tracking services in the whole Atlantic area.

2.1.2 Conclusions derived from OPTIMI Lot 2, Lot 3 and Lot 4

The feasibility of implementing FANS-1/A ADS-C flight tracking services to improve the accuracy with which aircraft position is known, allowing better provision of ATS and SAR services, has been demonstrated during the trials performed in Santa Maria FIR (Lot 2), Lisboa FIR (Lot 3) and Canarias FIR (Lot 4), and the efficiency of the so called OPTIMI Short Term Solution (Event contracts + Periodic contracts + Demand contracts) for the detection of unusual situations has been proved.

The main results and conclusions extracted from the analysis of the trials data and from the feedback received are presented below:

- Flight tracking:
 - Aircraft trajectory can be adequately followed thanks to the reception of ADS-C periodic reports (15 minute reporting rate), Waypoint Change event reports and the possibility of requesting demand contracts.
- Deviations detection with event reports:
 - Lateral Deviation Event reports are effective for the rapid detection of lateral deviations from the flight plan on board.
 - Altitude Range Event reports are effective for the detection of deviations from cleared flight level.
 - Altitude Range Event contracts, Lateral Deviation Event contracts and Vertical Rate contracts must be re-established once any of them has been triggered.
 - ✓ Automatic establishment of ADS-C event contracts is desirable.
 - Controllers consider these event contracts necessary to reduce time in the detection of emergency situations and SAR reaction times.
- Deviations detection only with periodic and/or demand reports:
 - In the worst case, assuming a constant angle of deviation of 25°, with a 5 minute reporting rate, the deviation would not be detected until the aircraft had a lateral deviation of about 17NM. If a 15 minute reporting rate were used, the lateral deviation could reach 50NM (or even greater depending on the angle of deviation).
 - In the case of a vertical deviation, in five minutes the aircraft could have crossed several flight levels before being detected.
 - Apart from the implications for the deviating aircraft, which in the OPTIMI framework is supposed to be in an emergency situation, these deviations could result in a potential conflict with aircraft on adjacent routes or flight levels. Based on this, controllers deem that the use of only periodic contracts does not constitute a solution for the rapid detection of deviations, even with a 5 minute reporting rate.
- Conformance monitoring:
 - The use of ADS-C predicted route information to detect inconsistencies between flight plan on ground and flight plan on board, allowing their correction before a dangerous situation may arise, is effective.
 - ADS-C data facilitates the use of conformance monitoring on ground systems to detect lateral deviations between ADS tracking data and the route data of the flight plan stored on ground, alerting controllers to the situation.

- Controllers recommend the use of these conformance monitoring tools in all ACCs, to allow the detection of inconsistencies as soon as the aircraft is transferred to the following ACC.
- ADS-C emergency mode:
 - Its activation is effective in alerting air traffic controllers to unusual situations.
 - It is possible to obtain frequent updated information on ground when it is activated.
 - No ADS-C emergency reports are received if there is not an active ADS-C connection with that ACC (no contracts established). It is not enough to have an accepted log-on with the corresponding ACC.
 - ✓ Automatic contract requests after log-on are recommended.
 - Although the way to activate the ADS emergency mode is simple, several buttons must be pressed before it is activated, which might not be possible in an emergency situation.
 - Although pilot initiated emergency ADS-C reports or emergency CPDLC reports are not considered part of the OPTIMI solution since they are dependent on aircrew action, they supplement the other FANS based solutions and will be a useful tool whenever pilot is able to initiate it, reducing reaction times on ground.
- SATCOM voice:
 - SATCOM voice communications in the trials were perfect on both sides, although small delays were perceived on board.
 - SATCOM voice activation takes some time, although this activation time is greatly reduced if ACC numbers are not to be searched on the general directory, but selected as the main numbers and assigned to two buttons in the cockpit communications panel.
 - Due to this dependency on crew intervention and the time required to set up the connection, it might not be possible in an emergency situation.
 - From the ground perspective, SATCOM voice would be very useful for controllers in case of an emergency to have the possibility to contact the flight at any time.
 - It is recommended that a procedure be established so that SATCOM numbers of all ACCs included in the flight plan are pre-recorded before the start of the flight and that they are updated for each new flight. A list of ATC SATCOM short numbers could be memorized and included in the on board display menu. A procedure should also be established in order to keep and distribute to ACCs and airlines an updated cross reference list of the Inmarsat short codes versus the real ACC numbers and to ensure that the contact numbers provided in AIPs or AICs for ACCs are reliable.
- Communications and ground systems performance:
 - A correct tuning of the system is necessary to avoid situations in which ADS-C reports, despite being generated by the aircraft and received on ground, might not be presented and/or used, due to communications delays and/or ground system management and configuration.
- SAR, pilots and controllers feedback:
 - SAR personnel consider that reaction times and search times can be greatly reduced thanks to the alerts generated and the information provided by ADS-C.

- ✓ It is not necessary for them to receive this information directly from the aircraft. It should be provided by ATCs when an unusual event is detected, using the adequate protocols.
- ✓ These protocols should be jointly developed by RCCs and ACCs in order to establish the criteria for the notification and intervention in case of emergency and in case of activation of ADS alerts due to non-planned deviations.
- ✓ As potential improvement areas it is suggested that, if technically possible, the aircraft should automatically send a CPDLC position report when the emergency mode is activated.
- Both, controllers and pilots, agree that safety is strongly increased with ADS-C and CPDLC.
- According to pilots experience, full FANS-1/A and AOC capabilities are essential and SATCOM recommendable in case of an emergency situation in oceanic airspace.
- Standardization of FANS-1/A procedures in the different FIRs and improvement of coordination between FIRs are needed.
- Crew concerns have been raised with respect to an ADS-C emergency mode activation that took place inadvertently during the trials flight (although out of the trials area) while they were flying in Atlantic FIR, since they were not contacted to confirm the emergency by any of the ACCs that were supposed to have received the emergency reports (SBAO and GOOO).
- The use of free text CPDLC, which is largely used, should be reduced and standard phraseology should be used in CPDLC messages.
- Some benefits are already being received by equipped aircraft (direct instructions are given more often to FANS-1/A equipped aircraft).
- ✓ Equipage and use of ADS-C and CPDLC on board should be encouraged or even incentivised to obtain greater benefits.

2.1.3 Conclusions derived from OPTIMI Lot 5

The conclusions derived from the initial safety assessment carried out in Lot 5 (WP1.1) for the OPTIMI flight tracking service (Core and Ancillary Short Term Solutions) are the following ones:

- A tailored and full assessment would be required for the introduction of the OPTIMI flight tracking service in any FIR, using the safety assurance process recognised by the associated ANSP. Nevertheless, the results obtained from the safety assessment performed in Lot 5 for Shanwick FIR can be considered broadly indicative for the introduction of the OPTIMI flight tracking service in oceanic airspace.
- The assessment, performed following the standard NATS process for safety management of changes to airspace procedures, supports the overall safety assurance claim for the introduction of the service in Shanwick FIR, i.e. the introduction of the OPTIMI flight tracking service is acceptably safe. This is based on the following claims:
 - Claim 1 – The introduction of the OPTIMI flight tracking service represents a safety improvement.

- ✓ The OPTIMI flight tracking service provides an improvement in oceanic flight tracking, alerting controllers rapidly to any lateral or vertical deviation from an intended flight path by aircraft logged-on with ADS-C. This represents a significant reduction in alerting time compared to current procedures, allowing for improved SAR coordination.
- ✓ Long term improvements can also be expected from the increased possibility of locating Flight Data Recorders (FDRs) and Cockpit Voice Recorders (CVRs) from lost aircraft.
- ✓ The initial analysis of safety data for Shanwick FIR from 01 Nov '09 to 31 Oct '10 has also shown that additional safety benefits are anticipated; the service could provide earlier notification of a deviation leading to a Safety Significant Event (SSE) in 35% of cases. Earlier notification comes from event reports in 17% of cases and from periodic reports in 18%. Most significantly 26.7% of Losses of Separation might be avoided via the introduction of the OPTIMI flight tracking service.
- Claim 2 – The introduction of the OPTIMI flight tracking service is compliant with recognised industry standards.
 - ✓ The changes associated with the introduced service have been, or will be, designed appropriately to recognised industry standards. Claim 2 is supported by the fact that elements of the OPTIMI flight tracking service are already in operation in several parts of the NAT and SAT regions.
- Claim 3 – No unacceptable risks are introduced with the OPTIMI flight tracking service.
 - ✓ Two hazards were identified in the risk assessment: (1) Controller induces conflict (deviation) between reporting aircraft and other aircraft or between other traffic (in normal flight operations); and (2) Controller induces conflict (deviation) between reporting aircraft and other aircraft or between other traffic (in distress flight operations).
 - ✓ The analysis of causal factors, pre-mitigation hazards frequencies, possible outcomes that could arise from the hazards and the severities and probabilities of each outcome reflects that, for NATS, all risks are class D only (i.e. the risk is acceptable and further mitigation is not mandated) without the consideration of the mitigation means.
 - ✓ Although for class D risks no mitigation means are required, the mitigations identified during the analysis should nevertheless be considered based on the “As Low As Reasonably Practicable” (ALARP) principle.
 - ✓ Therefore, for NATS, the airspace can be safely managed during implementation and transition of the service and ongoing ATM operations.

On the other hand, the Cost-Benefit Analysis performed for the OPTIMI flight tracking service (Core and Ancillary Short Term Solutions) has shown that there is no economic showstopper for the short term implementation of OPTIMI:

- Most costs are already in the baseline:
 - The FANS-1/A OPTIMI solution is already implemented or planned by almost all ANSPs analysed (only Santa Maria and Lisboa FIRs require some investment for its implementation).
 - It is considered that around 95% of the aircraft in the NAT area will be FANS 1/A equipped from 2015 to the end of the study as part of the baseline.

- Part of the communication costs are also included in the baseline since ADS-C reports are already being used in most of the FIRs, although with a different reporting rate in some of them.
- No communication cost increase is foreseen for ANSPs and the additional communications cost for airlines would vary between 0 and 10 € per flight, depending on the baseline (for a 6 hour oceanic flight and a 15 minute reporting rate periodic contract). These additional communication costs are marginal if compared to complete aircraft operating costs (they would represent just 0.03% of the total operating costs in the worst case).
- The only benefit to which it has been possible to assign a monetary value is the reduction of operational costs of the SAR, due to the reduction of the search area. Nevertheless, other qualitative benefits must be considered. These benefits relate among others issues to:
 - Increased situational awareness, leading to improved ATS services.
 - Increased chance of survival of accident victims, through more focused and more expeditious SAR action.
 - Increased likelihood of successful accident investigation, through an increased likelihood of FDR/CVR retrieval, leading to prevention of future accidents (which would not be limited to oceanic airspace).
 - Increased passengers trust.
 - Potential reduction of insurance costs for airlines.
 - Reduction of brand damage due to the loss of aircraft.
- In economic terms OPTIMI should not be considered as a standalone initiative as FANS-1/A equipage and use do offer other operational benefits.
 - If the interval between reports were decreased by ATCs for operational reasons, the financial penalty associated with OPTIMI would decrease. Conversely, the OPTIMI initiative may afford ATS an opportunity for improving efficiency (through reduced separation minima or more efficient vertical profiles). In any of the cases, if other applications were considered, the communication costs should be divided among them, improving the business case for OPTIMI.

Finally, the regulatory analysis has shown that:

- With regard to the OPTIMI Short Term Solution, the regulatory procedures and underlying standards are well established.
- There is a need to harmonise operational practises concerning the use of the relevant FANS-1/A functions between Atlantic Oceanic FIRs and globally. The ICAO Global Operational Data Link Document (GOLD) initiative is a potential mechanism for such harmonisation.
 - Amendment of the GOLD document should be considered to introduce features that have been identified as desirable by the OPTIMI project, such as automatic establishment of ADS-C event contracts, use of ADS-C based conformance monitoring tools and automatic contract requests after log-on.
 - Formal adoption of the GOLD in the SAT area is recommended.
- Regarding the OPTIMI Medium Term Solutions,
 - The Data Protection Directive (95/46/EC) may cause restrictions regarding the sharing and storage of information created on an aircraft.

- Regulations regarding FDR and CVR information are within the scope of the EU OPS 1 regulations as published in Commission Regulation (EC) No 859/2008 articles 1.085 and 1.160. The downlinking of information created on aircraft may necessitate modifications to this regulation, for example to include the conditions under which the information may be accessed on the ground or specifications for storage devices.
- Parliament and of the Council on investigation and prevention of accidents and incidents in civil aviation' (7442/10) may also require modification to account for the downlinking of information created on aircraft.
- The principles that apply to the SESAR SWIM concept, i.e. *"a clear regulation should be developed to define the boundaries of SWIM in ATM with clear rules to access and use. Roles, Responsibilities and Rules should be defined per stakeholder. Responsibilities and boundaries of ATM should be clearly specified based on policies that relate to the functional criticality of the different concept elements"*, would apply to a central repository of data position.

2.2 Summary of the OPTIMI recommendation

Taking into account all the facts and results presented in the previous section, it is recommended that:

- a 15 minute reporting rate periodic contract and event contracts with the 4 possible events [Waypoint Change, Lateral Deviation (5NM), Altitude Range (FL-300ft, FL+300ft) and Vertical Rate] be established in all FANS-1/A ACCs analysed in OPTIMI¹;
- equipage and use of ADS-C and CPDLC on board be encouraged or even incentivised; in the last case potential mechanisms should be evaluated.
- although the communications volume increase would be limited in the case of OPTIMI, there is a need to further investigate the optimisation, along the Communication Service Provision chain, of the cost created by the increase of the communications volume for ATC purposes in the oceanic areas;
- adequate protocols be jointly developed by RCCs and ACCs in order to establish the criteria for the notification and intervention in case of emergency and in case of activation of ADS alerts due to non-planned deviations;

It is also recommended that:

- OPTIMI tests be extended to other FIRs in the SAT in order to have a wider view of oceanic systems and procedures and to analyse the applicability of the OPTIMI conclusions to other FIRs;
- future research be made into the Medium Term solutions identified: "Central repository of FANS-1/A and AOC messages" and "Flight Data Recorder Down Linking Systems"

¹ These trigger values for event contracts have been considered adequate for the airspace analysed. Nevertheless, different values could be used in other oceanic airspaces, depending on the applicable separation standards. In the same way, if a more restrictive periodic reporting rate were required for other operational reasons, this rate should also be applied for the OPTIMI purposes.

APPENDIX A Acronyms

ACARS	Aircraft Communications Addressing and Reporting System
ACC	Area Control Centre
ACID	Aircraft Identification
ACK	Positive Acknowledgement
ADS-C	Automatic Dependent Surveillance – Contract
AEA	Air Europa
AENA	Aeropuertos Españoles y Navegación Aérea
AFI	ICAO AFI (Africa and Indian Ocean) Region
AFN	Air Traffic Services Facilities Notification
ANSP	Air Navigation Service Provider
AOC	Airline Operational Communications
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
CEDAR	Critical Event Detection And Reporting
CNS	Communication, Navigation and Surveillance
CPDLC	Controller Pilot Datalink Communications
CSP	Communications Service Provider
CTA	Control Area
CVR	Cockpit Voice Recorder
EMG	Emergency Message
ETA	Estimated Time of Arrival
EUR	ICAO EUR (European) Region
FANS	Future Air Navigation System
FANS-1/A	Boeing & Airbus implementations of FANS
FDR	Flight Data Recorder
FIR	Flight Information Region
FMC	Flight Manager Computer
FMS	Flight Manager System
GPS	Global Positioning System

HF	High Frequency
ICAO	International Civil Aviation Organisation
LAN	Local Area Network
MSAW	Minimum Safe Altitude Warning
NAT	ICAO NAT (North Atlantic) Region
NIM	Navigation Integrity Monitoring
NOTAM	Notice to Airmen
NPV	Net Present Value
OACC	Oceanic Area Control Centre
OCA	Oceanic Control Area
PSR	Primary Surveillance Radar
RCC	Rescue Coordination Center
RNP	Required Navigation Performance
RVSM	Reduced Vertical Separation Minimum
SACCAN	CANARIAS ADS/CPDLC System
SACTA	Air Traffic Control Automated System
SAR	Search and Rescue
SAT	South Atlantic Ocean
SESAR	Single European Sky ATM Research
SITA	Société Internationale de Telecommunications Aeronautiques
SJU	SESAR Joint Undertaking
SMR	Surface Movement Radar
SRR	Search And Rescue Region
SSR	Secondary Surveillance Radar
STCA	Short Term Conflict Alert
TED	Data Link Terminal
TMA	Terminal Manoeuvring Area
TPT	Traffic Display Terminal
UIR	Upper Information Region
VHF	Very High Frequency
WP	Waypoint Position
WPR	Waypoint Position Reporting

APPENDIX B References

[Ref. 1]	OPTIMI Lot 1 Work Package 1 deliverable: "Analysis of the baseline"
[Ref. 2]	OPTIMI Lot 1 Work Package 2 deliverable: "Implementation feasibility analysis of the OPTIMI Flight Tracking Service"
[Ref. 3]	OPTIMI Lot 2 (NAT Demonstrations) & Lot 3 (EUR Demonstrations) material and documentation
[Ref. 4]	OPTIMI Lot 4 Work Package 3 deliverable: "AFI Demonstrations Report"
[Ref. 5]	OPTIMI Lot 5 Work Package 1.1 deliverable: "Safety Assessment"
[Ref. 6]	OPTIMI Lot 5 Work Package 1.2 deliverable: "Cost Benefit Assessment"
[Ref. 7]	OPTIMI Lot 5 Work Package 2 deliverable: "Regulatory Review"