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datalink initiatives

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IFATCA
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NEWSLETTER
ON
DATA LINK
INITIATIVES



Introduction

Data link provides pilots and controllers with new means of communication, replacing bad quality HF communications with automatic position reports, text clearances, surveillance in remote and oceanic airspace, etc.

All over the world, data link is emerging in various local initiatives, from 15 years old FANS oceanic operations to an Australian extended continental surveillance and promising European and US data link communications in a very close future.

The aim of this technical newsletter is to present you briefly the technologies, networks and services involved before covering some major data link programmes and worldwide implementations.

Technologies and networks

Early airlines operational communications have paved the way for the first data link applications.

ACARS

Aircraft Communication Addressing and Reporting System (ACARS) is the first digital data link system for transmission of small messages between aircraft and ground stations via digital radio or satellite. It was adopted in the late 80s by airlines to collect operational information from the aircraft (phase of flight, fuel on board...) and *Aeronautical Operational Communications* (AOC) messages (weather requests, flight plans upload...) between the airline ground personnel and the cockpit crew.

[Figure 1] shows the main pilot interface and [Figure 2] details the ACARS architecture. The onboard ACARS *Central Management Unit* (CMU) is linked to a cockpit screen & keyboard called *Control Display Unit* (CDU also called MCDU - *Multipurpose CDU* - for Airbus and DCU - *Dedicated CDU* - for Boeing) for pilots to read and compose free text or pre-formatted messages (some airlines have prepared 75 different MCDU screens!).



Figure 1: ACARS MCDU

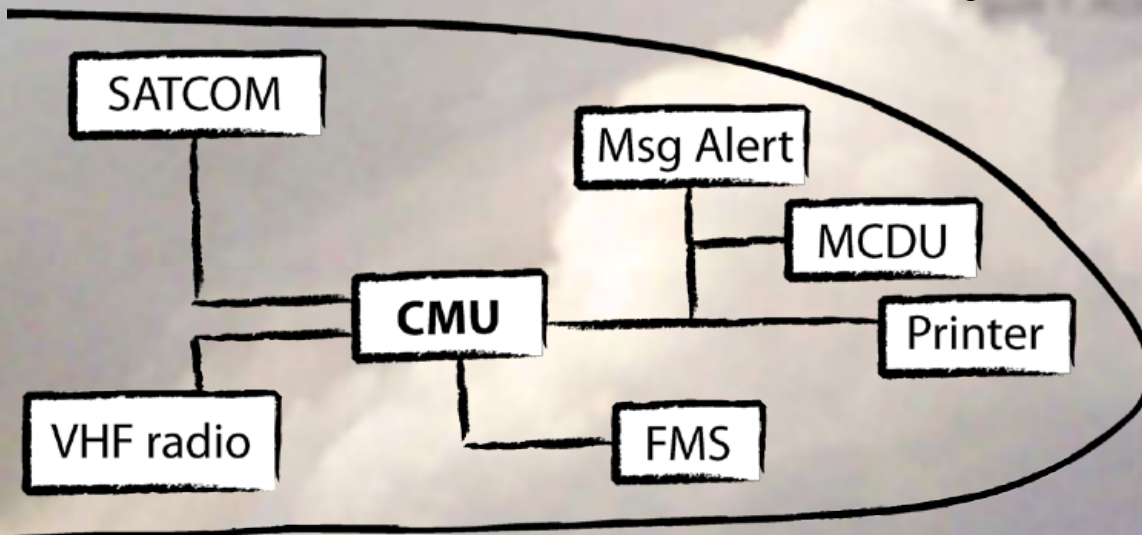


Figure 2: ACARS Architecture

There is also a link to the aircraft's *Flight Management System (FMS)* which allows airline dispatchers to send flight plans and weather information to the aircraft FMS.

Datalink messages are processed through subnetworks that two companies, SITA and ARINC, propose to airlines for commercial and operational communications. They have deployed a worldwide ACARS network of 1100 digital VHF ground radio stations [Figure 3] and digital HF ground stations (for polar communications) and also propose satellite bandwidth via Inmarsat satellites for oceanic and remote areas [Figure 4]. The 66 low earth orbiting IRIDIUM satellites are now available for the SITA and ARINC network.

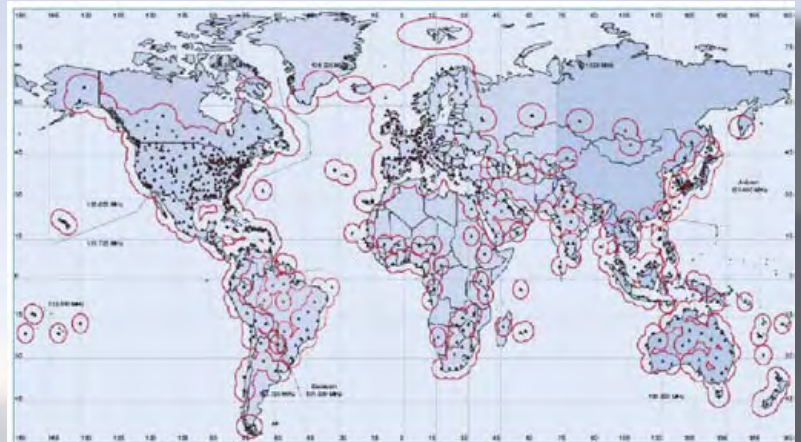


Figure 3: SITA VHF Data Link Ground Stations

ACARS modest data rate (2.4 kbit/s for the *Plain Old ACARS - POA*) is being improved with the introduction of the VDL2 technology (*VHF Data Link Mode 2*) thanks to both ARINC and SITA upgrade of digital VHF ground stations and new aircraft VDL2 receivers. The increased data rate of this new service called *ACARS over Aviation VHF link control (AOA)* is 31,5 kbit/s and represents a strong incentive for the industry to upgrade to VDL2 for their ACARS communications.

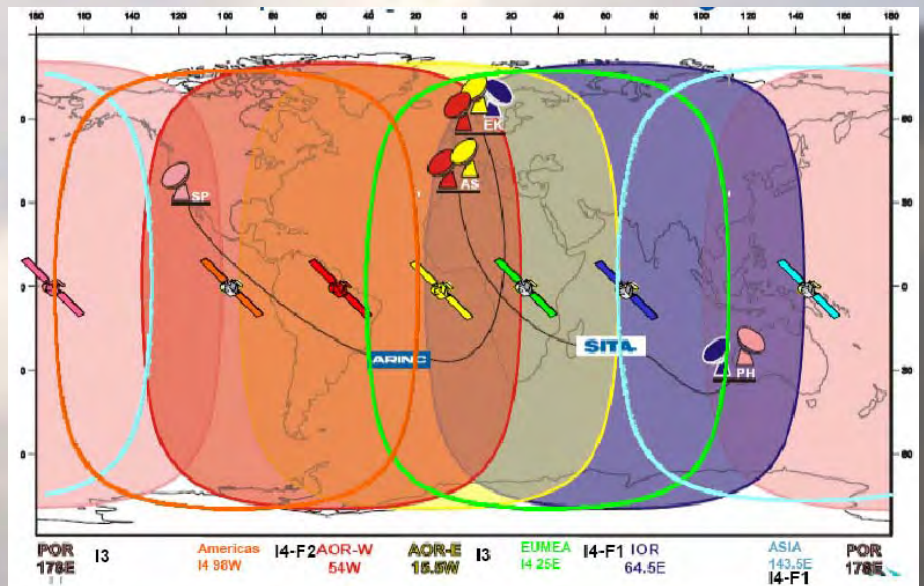


Figure 4: INMARSAT coverage

Besides airlines communications, ACARS allows the exchange of simple ATC messages with ground air traffic services units. ARINC623 is the name of the ACARS protocol for a limited set of services:

- Automatic Digital Terminal Information Service (D-ATIS)
- Pre Departure Clearance (DCL) [Figure 5]



Figure 5: ACARS Pre Departure Clearance

FANS

The most interesting use of ACARS since 1996 has been for oceanic ATC communications via dialogues and position reports in the *Future Air Navigation Services* (FANS).

FANS-1 (Future Air Navigation Services - 1) for Boeing aircraft and FANS-A for Airbus are an upgrade from ARINC623 ACARS protocol to the ARINC 622 FANS protocol.

FANS has allowed airlines and industry to implement in 1996 automatic periodical position reports where radar coverage was not possible for transoceanic flights. This application is called *Automatic Dependent Surveillance – Contract* (ADS-C) and will be explained later in this document.

HF communications can be replaced by clear and unambiguous text messages with the *Controller-Pilot Data Link Communications* (CPDLC) application, also detailed later in this document. An example of CPDLC dialogue is shown in [Figure 6].

More than 2,000 aircraft, mostly long haul aircraft, are now equipped with the FANS technology all over the world and exchange data link FANS ADS-C surveillance and FANS CPDLC communications with more than 20 Air Navigation Service Providers.

However, it has been recognized that the FANS lack the reliability and capacity required to be used safely in dense continental airspace (despite a recent upgrade called FANS-1/A+ to remove the risk of outdated messages delivery).

In these high density areas, all data link communications in the future will use the only network sponsored by ICAO, the *Aeronautical Telecommunications Network* (ATN).

ATN

The Aeronautical Telecommunications Network (ATN) is planned to replace ACARS network in the future and provides authentication, safety and true internetworking architecture. The ATN has been described in the ICAO Annex 10 with all the standard and recommended practices for the interconnection of air and ground systems.

FANS/ATN compatibility

Aircraft fitted with ACARS and VDL2 simply need a software upgrade to use the ATN. The problem is for aircraft already modified to operate FANS: they cannot use the ATN protocol. Airlines must choose how to equip their new aircraft: FANS for oceanic flights or ATN for continental operations [Figure 7].

An onboard solution [Figure 8] is planned for Boeing new aircraft (B737-NG, 747-400, 747-8, 777, 787) which



Figure 6: CPDLC dialogue

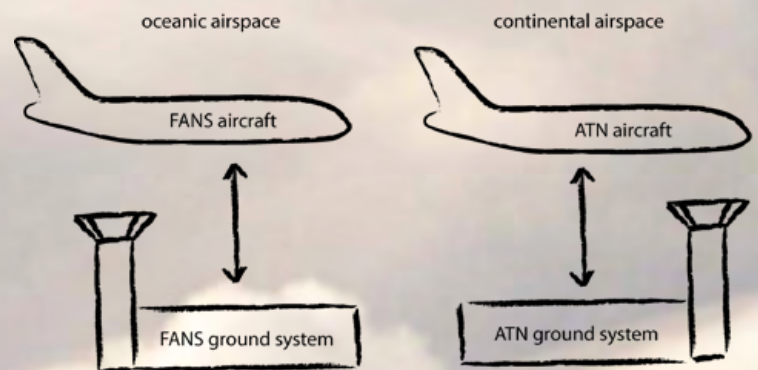


Figure 7: FANS and ATN incompatibility

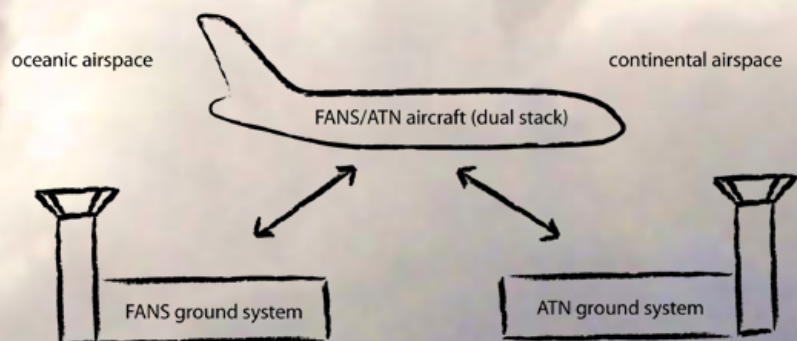


Figure 8: airborne dual stack

will have the possibility to be equipped with an FANS/ATN dual stack (called FANS-2) that will be able to switch in flight from oceanic FANS protocol to continental ATN protocol.

Airbus is similarly developing a version of FANS compatible with the ATN (FANS-B) but incompatible with FANS-1/A oceanic centres ground systems. All Airbus aircraft can equip with the FANS-1/A+ version for oceanic FANS operations and A320 can have instead the FANS-B version for continental ATN operations. A330-240 and A380 will have the possibility to opt for a FANS-1/A+ and FANS-B dual stack, and all A350 will have the dual stack.

Another solution [Figure 9] is the ground accommodation with a dual stack in the ground system. From a controller point of view, the issue is the the need for a clear display of data link equipped aircraft with no distinction between FANS or ATN aircraft, and a single list of messages. From a safety point of view, the issue is that the FANS protocol still has some flaws already corrected for the ATN protocol, especially for the risk of misdelivery of messages to a wrong aircraft.

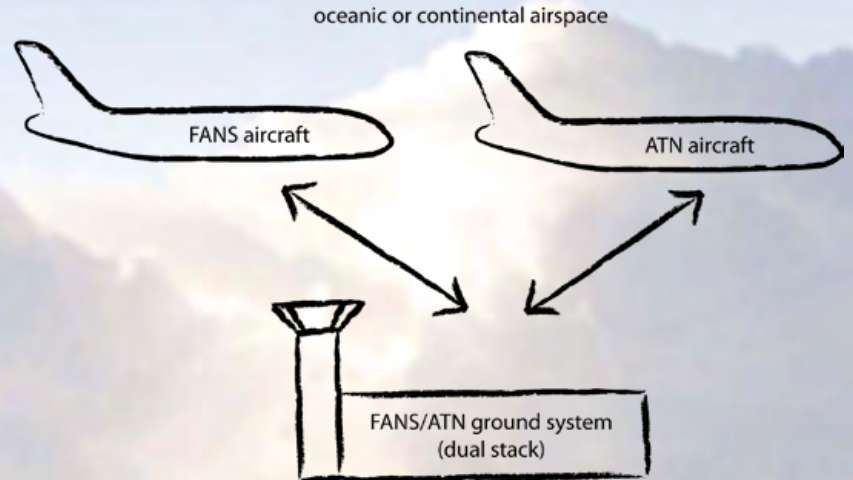


Figure 9: ground dual stack

Current ACARS, FANS and ATN implementations

Departure clearances and digital ATIS are in use with the ACARS technology in many countries, as shown in [Table 1].

FANS is also widely used in oceanic areas for communications (FANS CPDLC) and surveillance (FANS ADS-C) datalink capabilities.

The first ATN operational trials were conducted in Miami ACC between 2002 and 2004 but stopped because of the growing financial cost and the limited number of equipped aircraft (around 25).

Maastricht ACC, after a few trials, started in 2004 a successful programme based on financial incentives for companies equipping their aircraft with ATN CPDLC capabilities. ATN equipped aircraft have reached the number of 390 in 2008. Maastricht ACC also accommodates oceanic FANS aircraft, with a mandatory voice read-back for each CPDLC clearance. This first ATN CPDLC implementation will fit in the European programme LINK2000+ (described later in this document) aiming at the implementation of ATN CPDLC in all European countries between 2013 and 2015.

	DCL or PDC	D-ATIS	FANS	ATN VDL Mode 2
Africa		Egypt	Algeria Madagascar Mauritius South Africa	
Europe	Belgium Denmark	South Africa Austria Belgium Denmark	Maastricht	Maastricht
	France Germany	Finland France Germany	Iceland	
	The Netherlands	Ireland The Netherlands Norway	Norway	
	Sweden	Portugal	Portugal Russia Spain	
	UK	Sweden Switzerland UK	UK	
Middle East		Bahrain UAE		
Asia & Pacific	Australia China	Australia China	Australia China Fiji French Polynesia India Japan	
	Korea	Japan Korea	Lebanon Mongolia Mynamar New Zealand Singapore Sri Lanka	
		New Zealand Singapore		
		Taiwan Thailand		
Americas	Brazil Canada USA	Brazil Canada USA	Brazil Canada USA	
Countries operational	12	28	25	1
Airports operational	100	200	-	-

Table 1: Operational data link services in 2008

Applications and Services

Besides these early implementations, data link applications will offer many more surveillance and communications possibilities. Here is a short summary of all the data link applications divided into many services.

D-FIS application

Data link Flight Information Service is a data link application that provides the pilot with flight information such as text or graphical weather data, status of airports, airspace, facilities. It includes specific services such as:

- D-VOLMET: broadcast of regular meteorological information via data link
- D-ATIS: broadcast of Automatic Terminal Information Service [Figure 10]
- PDC: delivery of Pre-Departure Clearance message

CPDLC application

Controller-Pilot Datalink Communications are a supplementary means of communication to radio telephony. Pilot and controllers can exchange preformatted or free text messages that are transmitted via the different digital sub networks (INMARSAT satellites, HF or VHF digital radio).

In oceanic airspace and remote airspace, it's a safer means of communication than poor quality HF dialogues. CPDLC is currently in use in the Atlantic and Pacific oceans for FANS aircraft, and in Europe in Maastricht ACC for ATN aircraft (and for FANS aircraft with Maastricht ground accommodation).

The CPDLC application is a frame offering many services such as:

- ACM (ATC Communications Management): transfer of communications (new frequency)
- ACL (ATC Clearance): instructions such as level, speed, heading, route, new SSR...
- AMC (ATC Microphone Check): the controller can send this message to all aircraft on a

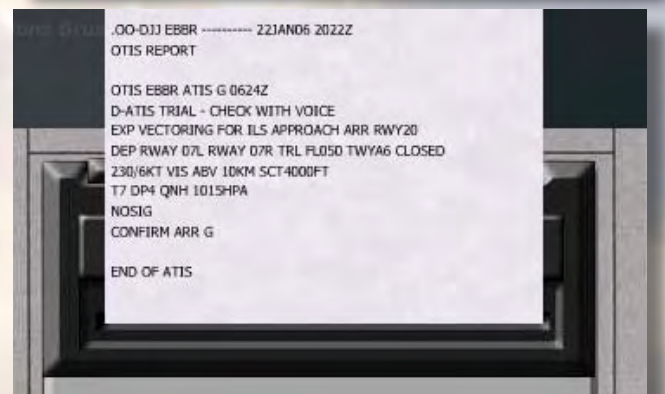


Figure 10: ACARS D-ATIS and NOTAM

Most Used Uplink Msg Elements - Jan08 to Dec08	Msg#	Total	% Used
CONTACT unit frequency	117	64355	14.330
CLIMB TO AND MAINTAIN level	20	54134	12.054
AT position CONTACT unit frequency	118	44146	9.830
free text	169	39710	8.842
REQUEST POSITION REPORT	147	37834	8.425
REPORT LEVEL level	129	31889	7.101
CLEARED TO DEVIATE UP TO distance direction OF ROUTE	82	27183	6.053
REPORT BACK ON ROUTE	127	26149	5.823
AT position MONITOR unit frequency	121	23193	5.165
SQUAWK code	123	20572	4.581
STANDBY	1	14547	3.239
UNABLE	0	7856	1.749
DUE TO TRAFFIC	166	7349	1.636
MAINTAIN BLOCK level THROUGH level	30	7147	1.591
MONITOR unit frequency	120	4805	1.070
CLIMB TO REACH level BY time	26	3843	0.856
PROCEED DIRECT TO position	74	2855	0.636
MAINTAIN level	19	2808	0.625
WHEN READY	164	2292	0.510
WHEN CAN YOU ACCEPT level	148	2258	0.503
RADAR SERVICES TERMINATED	154	1973	0.439
DESCEND TO AND MAINTAIN level	23	1687	0.376
CLIMB TO REACH level BY position	27	1636	0.364

Table 2: FANS messages sent by South Pacific ATS units in 2008

specific frequency

[Table 2] is a compilation of the most used CPDLC messages sent to pilots in the South Pacific.

ADS application

Automatic Dependent Surveillance is a surveillance application allowing aircraft to automatically provide data derived from on-board systems (aircraft identification, 4D position, etc). The system depends on Global Navigation Satellite System (GNSS) equipment for the position data.

ADS greatly improves safety in oceanic and remote areas by offering surveillance where no radar coverage is available.

There are two forms of ADS: Contract (ADS-C) and Broadcast (ADS-B).

ADS-C

Automatic Dependent Surveillance – Contract is a negotiated one-to-one relationship between an aircraft providing its ADS information and a specific ground facility. Currently only available for FANS aircraft and not for ATN aircraft, ADS-C reports are used in oceanic and remote areas to replace pilot position reports by HF voice reports. The ground center establishes the type of data and the frequency of the reports that the aircraft will send (usually every 10 minutes). Data is used to present the controller with an ADS-C tracks display [figure 11].

ADS-B

Automatic Dependent Surveillance – Broadcast is a slightly different surveillance system between one aircraft and several ground systems and surrounding aircraft [Figure 12]. ADS-B avionics broadcast identification, position, altitude, velocity and other data automatically twice every second. ADS-B ground stations use light antennas that cost the tenth of a radar station and can help cover remote continental areas where no SSR coverage is considered.

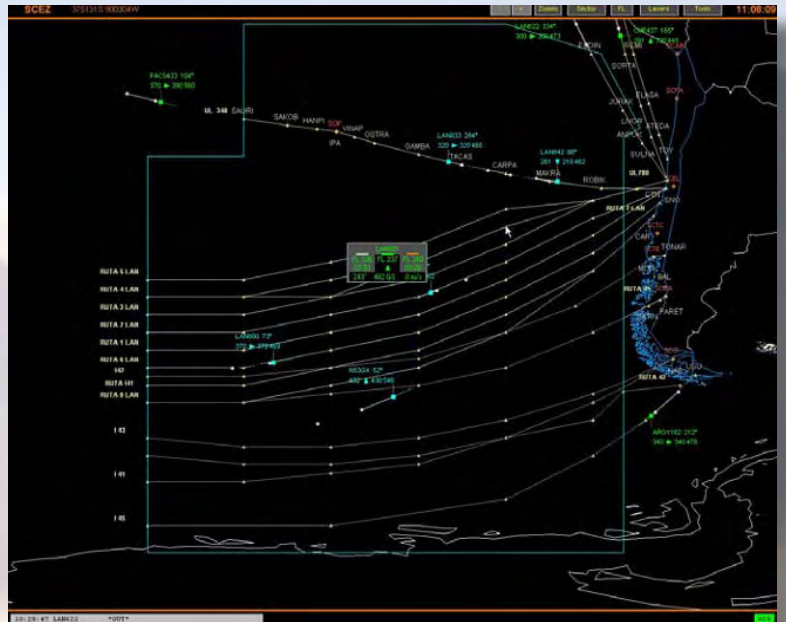


Figure 11: Santiago FIR Controller Display of ADS-C tracks

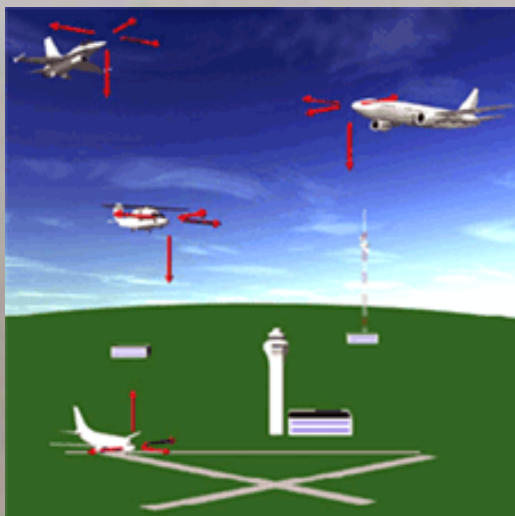


Figure 12: ADS-Broadcast



Figure 13: Cockpit Display of Traffic Information (CDTI) for ADS-B-In

Onboard ADS-B equipment consists in a transmission system to send ADS-B info (this functionality is called “ADS-B-out”). Aircraft can be additionally equipped with an ADS-B receiver to display the other ADS-B aircraft broadcast positions on a *Cockpit Display of Traffic Information* (CDTI, handheld or panel mounted or combined with navigation displays) [Figure 13]. This extra function is called “ADS-B-In”.

ADS-B is transmitted mostly on Mode S *Extended Squitter* (1090 MHz ES). Mode S Radar is the replacement for Monopulse SSR, providing unique 24bit aircraft addresses and selective interrogation [Figure 14]. Extended Squitter is a derivative technology of mode S that shares the 1090 MHz channel with mode A/C, mode S and TCAS. Aircraft send their position and data broadcasts (velocity, heading and in the future, intent) to mode S ground stations and surrounding aircraft.

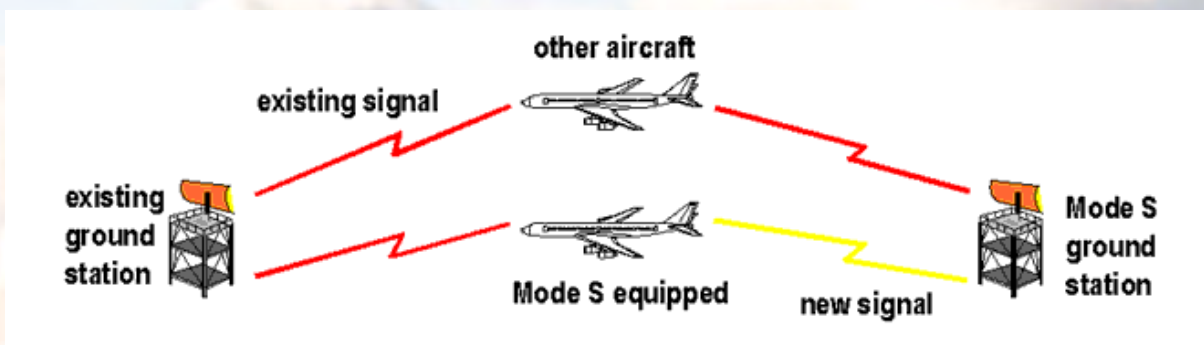


Figure 14: Mode S

Another sub-network selected for ADS-B is VHF data link Mode 4 (VDL4), a self organizing digital radio protocol with no master ground station. Contrary to Mode S 1090 MHz Extended Squitter, VDL4 can also uplink weather reports and other traffic “classical” radar positions relays (TIS-B *Traffic Information Service - Broadcast*, described below). Sweden has been using VDL4 for ADS-B for 10 years (even for buses at Arlanda airport!).

A third sub-network considered for ADS-B is the Universal Access Transceivers (UAT), specifically designed for ADS-B and operating on the less busy 978 MHz to offer a greater capacity than Mode S 1090 MHz. Like VDL4, UAT can also transmit weather reports and other traffic positions via TIS-B. The American FAA funded the development of UAT in the 90s to propose a light, cheap and efficient alternative to mode S for ADS-B onboard general aviation aircraft. It has been successful in the Alaska Capstone surveillance programme and in Guam, Puerto Rico, Samoa and Virgin Islands, and will be used on a wider scale in the USA.

Both VDL4 and UAT are independent of Mode S 1090MHz ES and require a specific ground translation and re-emission so that 1090 MHz ES aircraft can “see” VDL4 and UAT aircraft. This is a pilot awareness issue because pilots must know if they are under coverage of these re-emission ground stations before trusting their CDTI for a complete picture of surrounding traffic.

TIS-B

Traffic Information Service – Broadcast (TIS-B) is a service which allows ADS-B equipped aircraft to receive from a ground TIS-B station the position reports of surrounding simple transponder aircraft. Pilots can then see on their CDTI both ADS-B aircraft (directly with a refresh rate of 1 second) and simple transponder aircraft (with at least 5s updates).

[Figure 15] shows from left to right the ground SSR report relayed via a TIS-B station to the TIS-B aircraft for CDTI display.

Despite TIS-B use in Alaska, FAA's interest for the NextGen program and some experiments in Europe, TIS-B is not the most promising surveillance technique in remote areas: the radar coverage is usually poor in these remote areas where ADS-B implementation is justified, so one aircraft will generally receive more direct ADS-B reports than TIS-B ground-relayed SSR position reports.

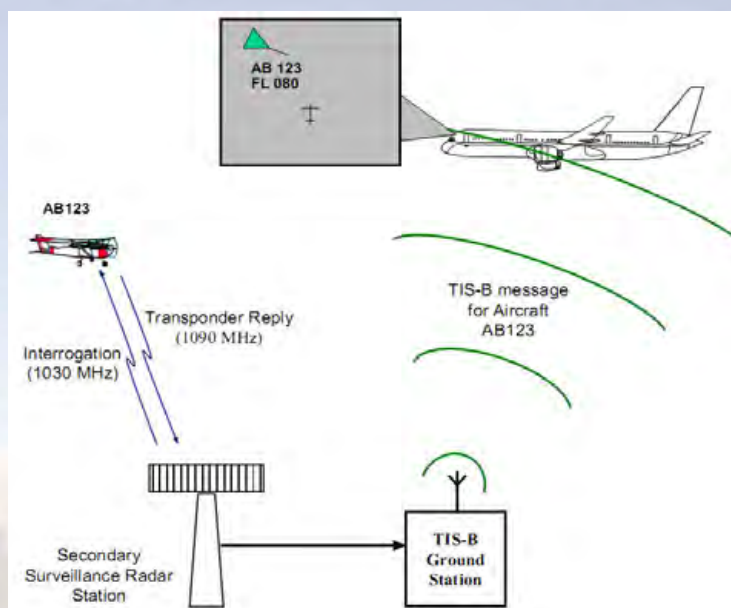


Figure 15: TIS-B

ATSAW

Airborne Traffic Situational Awareness (ATSAW) is the next step in surveillance increasing the flight crew's knowledge of the surrounding traffic situation. The CDTI will provide permanently updated traffic information (aircraft identification, position, direction, speed, vertical tendency, etc.) via ADS-B that will be used for advanced services such as:

- *In Trail Procedure* (ITP): longitudinal separation can be reduced when one ITP-equipped aircraft wants to cross the altitude of an ADS-B-out aircraft by using the information broadcast by this conflicting traffic [Figure 16].

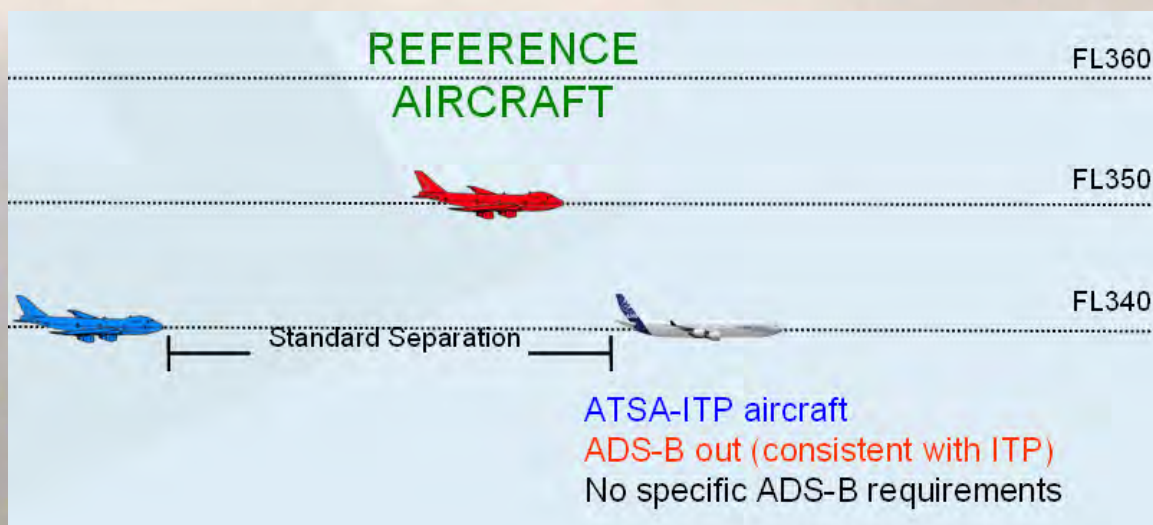


Figure 16: ITP aircraft (blue) can use position broadcasts of reference ADS-B-out aircraft (red) to reduce climb separation

- *Enhanced Traffic Situational Awareness on the Airport Surface (ATSA-SURF)*: it will improve safety by displaying other aircraft and vehicle on runways and taxiways [Figure 17].

- *Enhanced Visual Separation on Approach (ATSA-VSA)*: during visual approach procedures, it will be easier for the crew to acquire and maintain visual contact with other aircraft displayed on the CDTI.

ASAS

The *Airborne Separation Assistance System (ASAS)* uses the CDTI fed by data from either ADS-B or TIS-B to allow the pilots to perform tasks related to separation or spacing. The aim is to reduce the workload of the controller by transferring separation responsibility to the pilots.

For example the *Sequencing & Merging* application [Figure 18] allows the pilots (and the avionics systems) to achieve and maintain a given spacing behind a target aircraft. Trials have confirmed the high potential of this data link service to reduce controllers' workload when sequencing aircraft.

Sequencing & Merging Pilot Displays



Sequencing & Merging Controller Display

Figure 18: ASAS Sequencing & Merging

Another service called *Crossing & Passing* is supposed to help the pilot acquire a target and perform self separation with this target aircraft, relieving the controller of his separation responsibility and monitoring. This service will not be implemented in a near or mid term perspective, because of its dependence on reliable technology, modest workload reduction and delegation of responsibility controversial aspects.

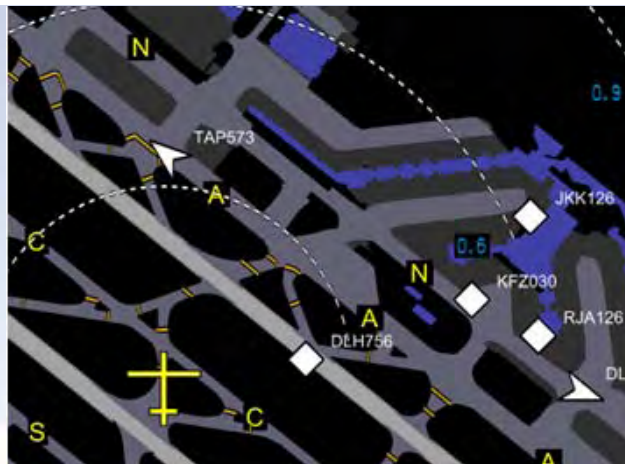


Figure 17: ATSA-SURF moving map with surrounding traffic

Major programmes

Europe is leading the way for ATN CPDLC and ADS-B, and the FAA will address both technologies in its future NextGen program.

USA data link: NextGen

The Next Generation Air Transportation System (NextGen) is the FAA plan to modernize the National Airspace System. Among other technologies (*System Wide Information Management – SWIM, Required Navigation Performance – RNP, Continuous Descent Approach – CDA, Network Enabled Weather, etc.*) ADS-B will play the major role.

Besides Alaska Capstone and Louisville UPS programs detailed below, the Gulf of Mexico will be the third area to adopt ADS-B surveillance for oil and gas platform helicopters with the aim of a complete ADS-B national coverage by 2013. ADS-B is also planned for additional functions such as TIS-B or FIS-B (*Flight Information Service – Broadcast*, where ADS-B ground stations send out graphical information from the National Weather Service and flight information such as temporary flight restrictions).

The Data Communications program is a major component of NextGen and covers the network aspects (ACARS, FANS, ATN) and a 3 segments approach towards the 2025 NextGen Vision:

Segment 1: Departure Clearance, D-ATIS & Taxi 'Out', communications management, en route clearances, initial 4D trajectories (Continuous Descent Approaches)

Segment 2 : airports and airspace status/delays/constraints, Taxi 'In', initial 4D agreements

Segment 3: Merging&Sequencing, Crossing&Passing, In Trail Procedure, widespread 4D agreements

[Figure 19] is a comparison of Nextgen Data Communications and its European counterparts (Link2000+, SESAR) timescales regarding the common data link services.

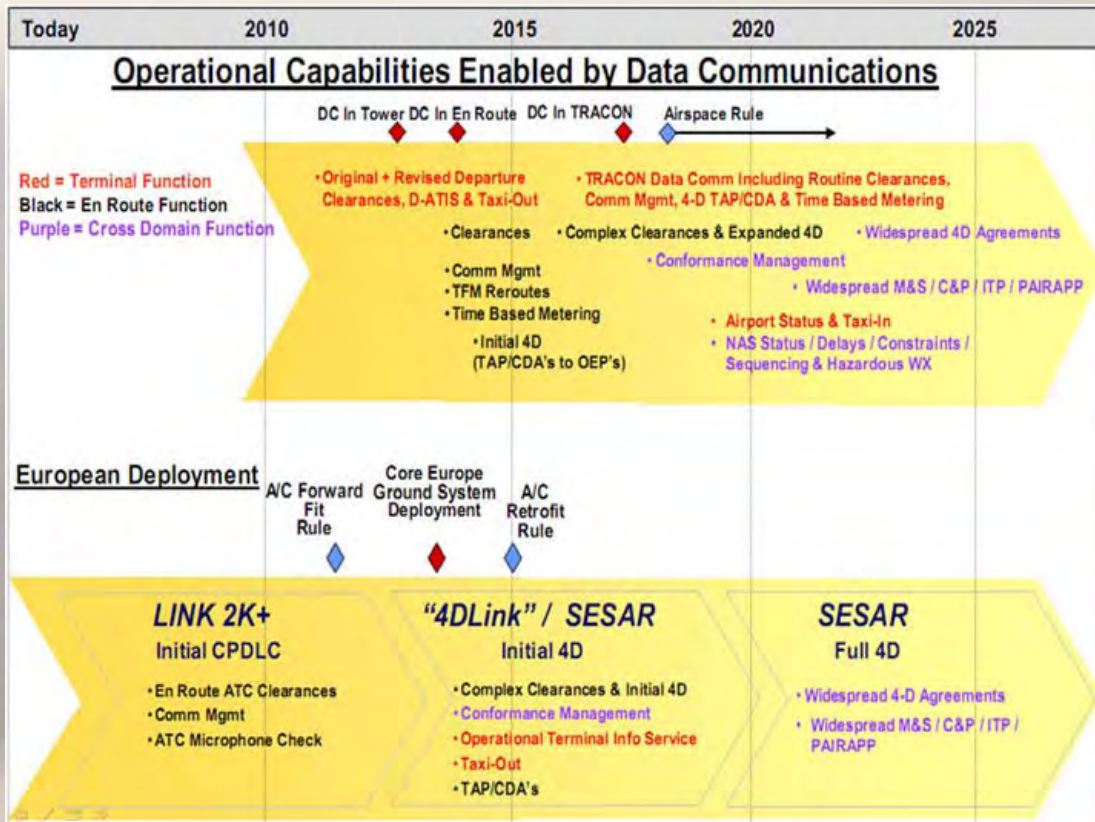


Figure 19: NextGen and European datalink deployments

SESAR

The *Single European Sky ATM Research* is a long term Research & Development programme to increase capacity and safety by adopting new technologies to improve ATM (GALILEO satellite navigation, automated decision support tools for ATC, user-based 4D trajectory, etc.). Data link will obviously play a major role in communications, surveillance and 4D trajectory management.

Two major European programmes, Link2000+ and CASCADE will provide the CPDLC and ADS-B baseline.

European CPDLC: Link2000+

The Eurocontrol Link2000+ programme targets an initial set of en-route CPDLC services (Communications Transfer Management, Clearances, Microphone Check) in the European airspace using the ATN and VDL2. Above FL285, all Single European Sky (except remote areas) should offer these CPDLC services by 2015, and the core area should start by 2013 [Figure 20]. Link2000+ has been recognized for SESAR mid-term baseline (2013).

Old or military aircraft, as well as FANS aircraft built before 2014 will be exempted of ATN/VDL2 equipment. A controversial issue is that ANSPs may be allowed to accommodate FANS aircraft on a voluntary basis.

Today, 390 aircraft are equipped for ATN/VDL2 and around 120 flights a day exchange data link communications with Maastricht UAC.

Germany DFS will start CPDLC in the beginning of 2010 in Karlsruhe ACC.

Italian ENAV will implement D-ATIS and DCL in Fiumicino and Malpensa airports using ACARS in 2009 and Link2000+ CPDLC services in Roma ACC in 2010.

Portugal NAV will start CPDLC in Lisbon ACC (and also FANS-1/A accommodation) and DCL and D-ATIS in Lisbon, Porto, Faro and Madeira airports over ACARS in the beginning of 2009. FANS CPDLC is offered in Santa Maria OACC since December 2006 via SITA network and Oceanic Clearance Delivery trials have begun in September 2007.

France DSNA has successfully experimented CPDLC in the EVALINK trials between January and March 2008 (with FANS accommodation that shown unacceptable message transit times) above FL345 (and depending on traffic load above FL270) in contact with Maastricht ACC airspace (for CPDLC communications transfer).

UK NATS offers FANS CPDLC since 2004 in Shanwick Oceanic Centre to 400 aircraft everyday. Major airports also propose DCL and D-ATIS. Link2000+ CPDLC will be running on NATS future en-route platform, iFACTS.

European ADS-B: CASCADE

While Link2000+ focuses on CPDLC, CASCADE will coordinate the ADS-B European implementation (Figure 21). This *Cooperative Air traffic services through Surveillance and communications*

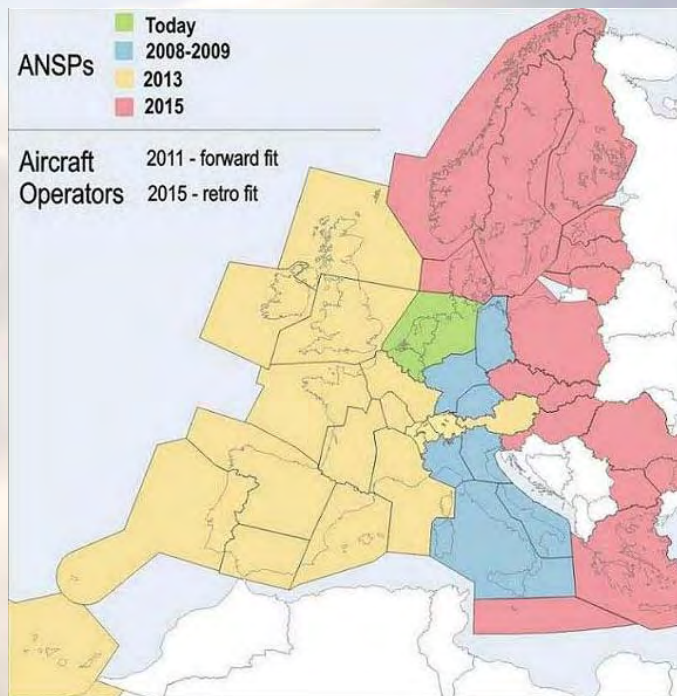


Figure 20: Link2000+ European CPDLC Program

Applications Deployed in ECAC (European Civil Aviation Conference) programme has published standards for ADS-B in Non Radar Areas (NRA) in December 2006 and currently works on ADS-B in Radar areas (RAD), In Trail Procedure (ITP), enhanced visual Separation on Approach (VSA) and ADS-B on the airport surface (APT and SURF).

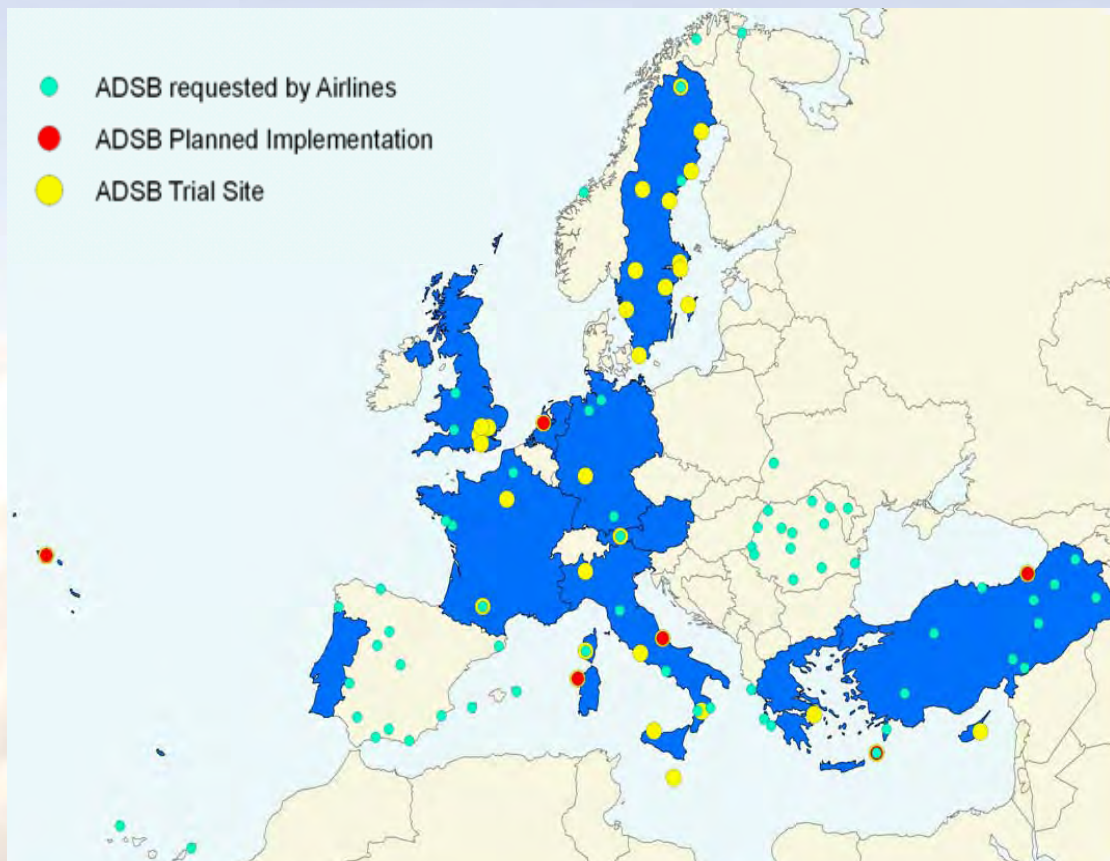


Figure 21: CASCADE European ADS-B Programme

Mode S has already been mandated for all aircraft, a key enabler for ADS-B which uses Mode S 1090 MHz Extended Squitter. A *Single European Sky Implementing Rule (SES IR)* will cover ADS-B-out in 2009 for a possible mandate in 2015.

Trials, simulations and studies involving 10 European states under the name of CRISTAL trials evaluate the surveillance potential of ADS-B across a range of airspace types and scenarios: CRISTAL General Aviation investigates the needs and constraints for general aviation ADS-B, UK NATS trial suggests that ADS-B surveillance could be used besides to radar coverage in congested areas, CRISTAL Med addressed the non radar areas, CRISTAL Iberia addressed the gaps in radar coverage and the ADS-B potential to increase surface surveillance (aircraft and vehicles), Ireland investigated long-range oceanic airspace, Austria tested ADS-B with multi-lateration and UK & Iceland tested In-Trail Procedure in CRISTAL ITP.

With 17 pioneer airlines, 500 aircraft and 7 pioneer ANSPs, CASCADE is now implementing ADS-B rescue helicopter operations in the North Sea (in combination with Wide Area Multilateration), ADS-B covering radar blind spots (Ajaccio, Pescara, Alghero) and providing surveillance in non-radar areas to improve approach services from procedural to surveillance-based (Azores, Kiruna in Sweden, Greek islands around Karphatos, Trazbon in Turkey). ADS-B-in should be implemented in Ostgota, Sweden, in 2009 for en-route situational awareness. Pioneer airlines have also suggested 70 implementation sites!

International data link bodies

IFATCA is represented in various panels and groups advancing the data link communications standards and services.

ICAO Separation and Airspace Safety Panel (SASP)

This ICAO panel develops SARPs, PANS and guidance material for the application of safety management to ATM systems and also analyses communication, navigation and surveillance performance needed to support new separation minima and ATM procedures.

Regarding data link activities, SASP will propose a PANS-ATM amendment for In Trail Procedure based on the results of the European CRISTAL ITP trial.

Besides the current 5 NM ADS-B separation minima, a new ADS-B 3NM separation standard will be published.

ICAO Aeronautical Surveillance Panel (ASP)

This panel has a technical work programme on ground and airborne surveillance systems in support of the ATM operational concept. It includes 1090 MHz Mode S Extended Squitter (and the need for mode A transmission), and ADS-B (producing some guidance material on the safety issue of broadcast data integrity).

Eurocontrol ADAS DUG

The Eurocontrol Advanced Datalink & ASAS Data Link User Group (ADAS DUG) produces Service Descriptions for advanced services not included in Link2000+ and CASCADE [Figure 22] but in line with SESAR: 4D trajectory applications, graphical D-TAXI, ASAS (Crossing & Passing, Sequencing & Merging).

SC214-WG78

The FAA and Eurocontrol have requested the American RTCA (Radio Technical Commission for Aeronautics) Special Committee 214 and European EUROCAE (European Organisation for Civil Aviation Equipment) Working Group 78 to develop common standards for data link services that will be used in SESAR and NextGen (clearances, D-TAXI, D-OTIS, 4D trajectory;...). These services are currently in the description phase before the operational hazard and performance assessment and the production of the final documents for the ANSPs: SPR (Safety and Performance Requirements) and Interop (ACARS, FANS and ATN interoperability for these data link services).

ICAO OPLINK Panel

ICAO identified the need for convergence between Atlantic FANS-1/A operations and European ATN CPDLC [Figure 23], beyond local accommodation. Furthermore, SESAR and NextGen being developed outside ICAO, there is a need to support the development of data link applications on a global basis.

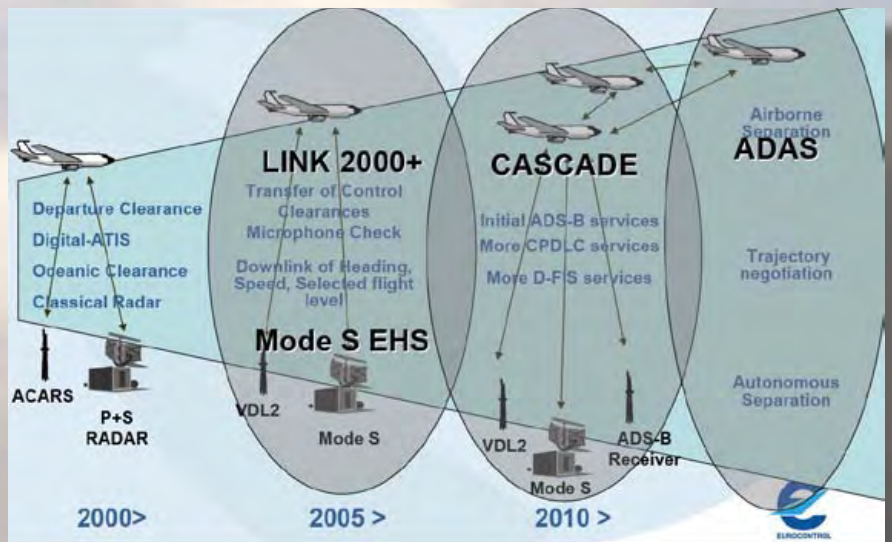


Figure 22: Eurocontrol ADAS long term objectives

The former OPLINK Panel (Operational Data Link Panel) will be reactivated to act as focal point for the consolidation and development of ATM data link operational requirements.

Worldwide implementations

Oceanic Operations

In a context of bad quality HF communications and broad separation minima, CPDLC and ADS-Contract bring unambiguous text communications, automatic position reports (using the FANS ADS-Contract), reduced separations of 50 NM with Required Navigation Performance of 10 (i.e. total system error no greater than 10 NM for 95% of the time) and 30 NM with RNP4, route and FL conformance ground monitoring, In-Trail Climb or Descent,...

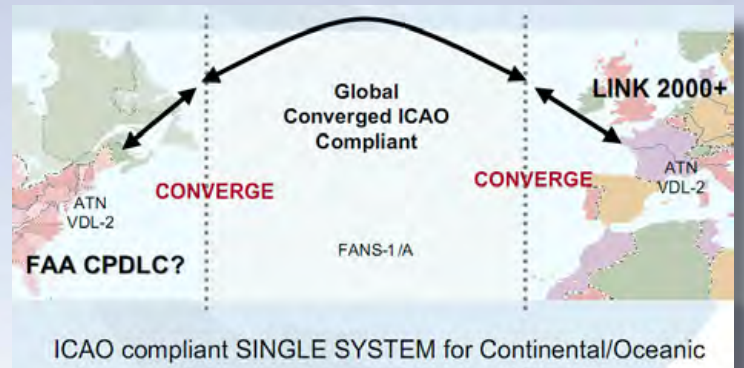


Figure 23: global convergence

North Atlantic (NAT)

Whereas the end goal remains SARPs compliant systems using the ATN, FANS aircraft are accommodated in the North Atlantic airspace for ADS-C [Figure 24]: Gander, Shanwick, Reykjavik, Santa Maria, Bodo and New York OCA. Bodo is the only OCA which does not offer FANS CPDLC. Reykjavik offers basic CPDLC requests (speed, altitude) with a free-text acknowledgement from the ground followed by a voice clearance. Santa Maria, Gander and Shanwick also offer CPDLC altitude and speed clearances and new frequency messages. Full CPDLC operations are provided in New York OCA.

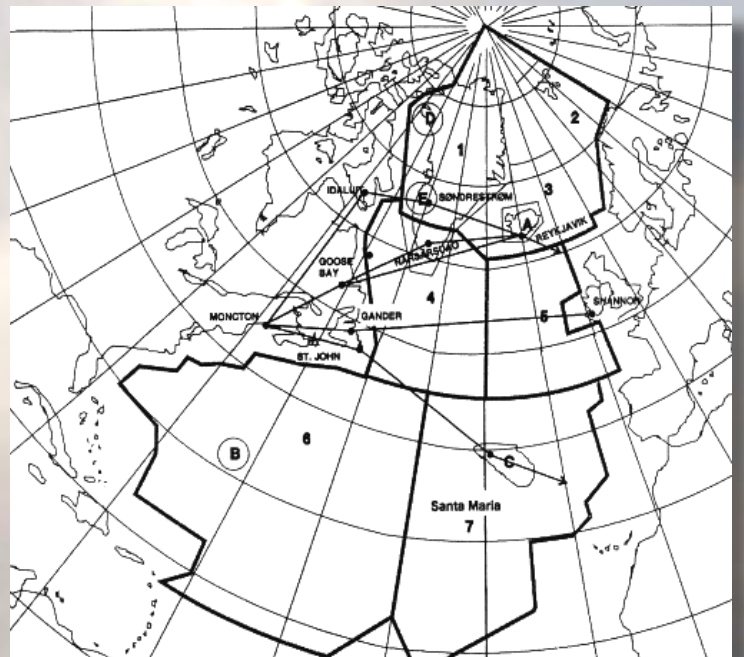


Figure 24: North Atlantic data link areas

Oceanic Clearance Delivery

Data link *Oceanic Clearance Delivery* (OCD) service is provided via digital VHF and satellite to ACARS equipped aircraft by Gander and Shanwick OACC.

ACARS flights request their oceanic clearance 90 minutes before the oceanic entry point with the Request for Clearance (RCL) downlink message. The clearance [Figure 25] contains a cleared oceanic flight level and a NAT track (or a cleared oceanic route if operating on a random route). The pilot sends a Clearance Acknowledgment (CLA) message and can request an amendment via voice; a re-clearance will be sent via data link via a number 1 to 9 to identify it in the pilot clearance acknowledgement (CLA).

OCD is also in trial in Santa Maria Oceanic Control Area since August 2007.

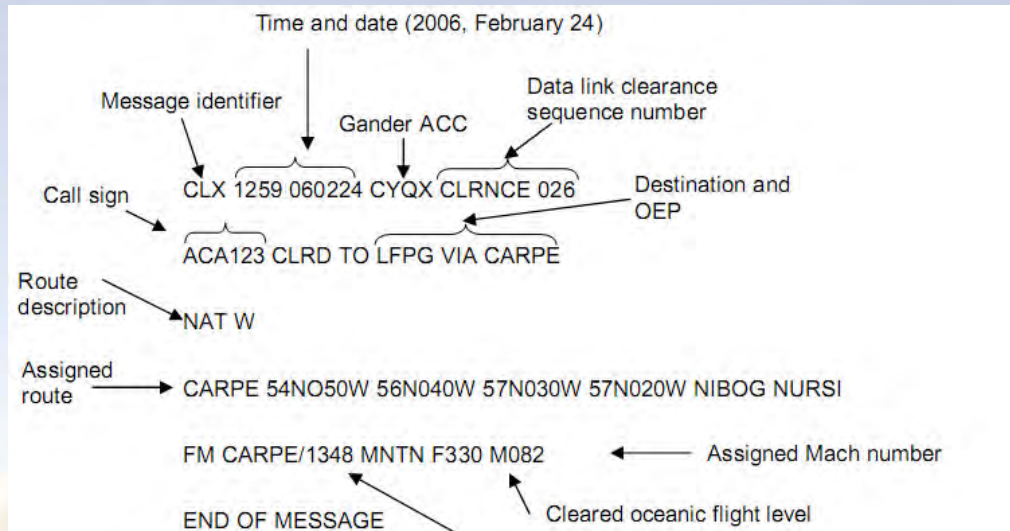


Figure 25: Gander Oceanic Clearance

South America

Brazil has already tested data link communications, and FANS CPDLC and ADS-C will be installed in Recife Center for Atlantico FIR services.

Argentina will implement FANS CPDLC and ADS-C for the oceanic sector of Ezeiza FIR.

South Atlantic

Spain is conducting FANS ADS-C and CPDLC trials in the Canarias FIR, currently with a voice readback for safety reasons.

FANS CPDLC and ADS-C are also in trial in Cape Verde's Sal Oceanic FIR.

In South Africa, Johannesburg uses Eurocat-2000 for ADS-C and CPDLC on oceanic routes to India (and next it will be for South Atlantic).

Africa

ASECNA (*Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar*, an agency representing 18 states) will install FANS-1/AADS-C and CPDLC in Antananarivo, N'Djamena, Niamey, Dakar, Abidjan.

Algeria, Mauritius, Angola and Morocco will also implement FANS CPDLC and ADS-C.

Egypt and South Africa already use D-ATIS. Rwanda will install it in Kigali.

Middle East

Bahrain, the UAE and Kuwait use D-ATIS.

Lebanon has adopted FANS-1/A and D-ATIS since November 2007.

Saudi Arabia will install 17 VDL2 ground stations, and D-ATIS in 14 airports.

South Pacific

FANS CPDLC has been used as the primary communications medium in oceanic airspace since 1995 in most of the South Pacific FIR [Figure 26]: in Oakland since 2000, Anchorage, Tokyo since 1998, Singapore, Bangkok, Hong Kong, Magadan, Tahiti, Ulan Bator.

ADS-C has been used in the Tokyo, Nadi, Tahiti, Auckland, Brisbane and Melbourne FIR since 2000 (but still in test in some FIR).

ADS-C is part of the FAA's Advanced Technologies and Oceanic Procedures (ATOP) and in trial in Oakland (since December 2005) and Anchorage (since April 2006) oceanic airspace.

In the Oakland FIR trial (started in 2005 and expanded to the whole FIR in March 2007) [Figure 27], FANS-1/A aircraft can expect SATCOM satellite CPDLC and ADS-C for 50 NM (with RNP-10) and 30 NM (with RNP-4) separations. Ocean21 is the integrated ground system required for 30/30, which provides oceanic controllers with integration of ADS-C and conventional position reports, CPDLC, interactive electronic flight strips and automated conflict prediction [Figure 28]. 30/30 separations are also implemented in other pacific FIR such as: Nadi, Honaria, Nauru, Tahiti, Fukuoka.



Figure 26: South Pacific FIRs using FANS

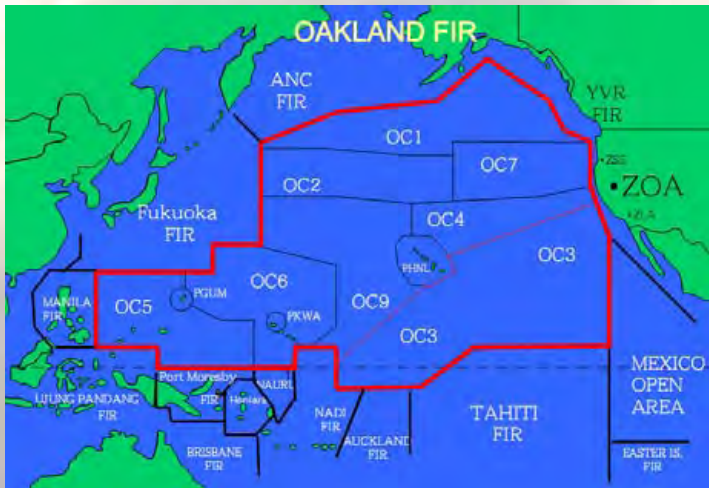


Figure 27: Oakland FIR Oceanic Sectors



Figure 28: Oakland FIR Controller Display

Tahiti

For more than 10 years an air situational display called VIVO allowed the visualization in oceanic airspace of FANS aircraft using ACARS satellite network and digital VHF in the vicinity of the island. A new visualization and flight plan system called TIARE has replaced VIVO in the end of 2008. Besides, ADS-B ground stations should be installed in 2010.

Asia

Vietnam conducted a successful trial in March 2007 of FANS ADS-C and CPDLC on 6 oceanic routes in Ho Chi Minh FIR. India has installed FANS ADS-C and CPDLC in Mumbai and Chennai FIR since 2006.

Japan is using ADS-C separations in Fukuoka FIR since April 2007.

FANS ADS-C and CPDLC is used in Fidji, Mongolia, Myanmar, New Zealand, Singapore and Sri Lanka airspaces.

Russia has a FANS-1/A compatible ground system in Madagan for polar routes n°3 (between New York and Honk Kong) and n°4 (between Detroit and Beijing).

Indonesia is conducting ADS-B (Broadcast) trials in Jakarta and Makassar ACC and relays the ADS-B data to Singapore ACC and Brisbane ACC.

Thailand is the first nation to announce ADS-B implementation plans in South East Asia.

China

Hong Kong is using DCL (Departure Clearance), D-ATIS and the ATN structure since 2001. DCL and D-ATIS should be available at other airports in 2008.

China will be equipped with 110 VDL2 ground stations by 2010 for ACARS operations. Some ground stations will be built for ATN trials.

ADS-B surveillance is planned for Western China, with already 2 ADS-B ground stations installed in Sichuan to compare with radar data and experiment on ground vehicles for airport surface movement surveillance.

The Silk Road {Figure 29} is a route between Europe and Asia in West China opened in January, 10th 2001 (code number is FANS-L888). Its whole range is over 2800km and it is valuable to pilots, compared to current air route across India and Middle-East). This route uses ADS-C and CPDLC, rather than radar surveillance and voice communication. ADS workstations have been installed in several ACC. A second ADS-C road is planned.



Figure 29: FANS Silk Road

Canada

NAV CANADA has implemented the use of ADS-B in January 2009 in the Hudson Bay (Montreal FIR) [Figure 30] between FL330 and FL370 or FL410 (radar surveillance only covers the East and West of the Bay). ADS-B ground stations have been installed around the Bay in 2008 (5 ground stations have been tested since December 2007) and a segregation is planned between ADS-B and non-ADS-B aircraft. A reduction in separation from 80 NM to 5NM between ADS-B aircraft has been approved after a safety study.

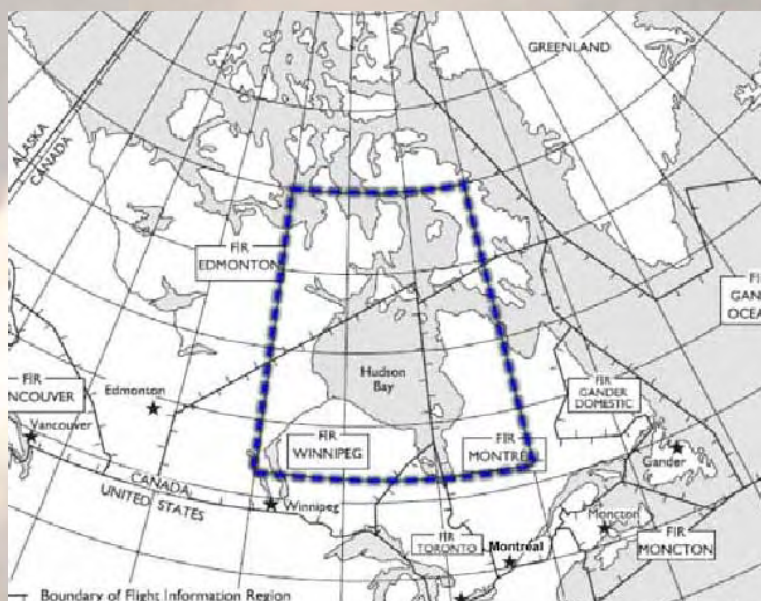


Figure 30: ADS-B in Hudson Bay

Alaska

The FAA declared ADS-B suitable for air traffic services in Alaska [Figure 31] after the Capstone program success (10 ADS-B ground stations, 200 aircraft) in increasing safety in the Yukon Delta and Southeast Alaska for the past 6 years. 13 more stations have been built in South East Alaska, for 175 aircraft. Weather information and surrounding traffic information (TIS-B) are also available.

5NM separation has been accepted after live traffic data shown the high accuracy of ADS-B surveillance. These studies will help the US nationwide ADS-B deployment.



Figure 31: Capstone

UPS in Louisville

The FAA has approved UPS airline for advanced ADS-B operations in Louisville using the CDTI [Figure 32] to provide traffic information for Merging & Spacing (controllers delegate the task of maintaining accurate in-trail spacing to the flight crew during the descent), assisted visual separation on approach and surface area movement management. More than 100 UPS aircraft have been equipped.

During the strategic ground setup phase, the UPS ground system sends speeds via ACARS to UPS pilots for an early regulation.

When passing the merge fix, pilots receive again with ACARS from UPS the Traffic To Follow and the time interval.

Then starts the tactical phase, where pilots use the CDTI to adjust their speed for Flight Deck Merging and Spacing [Figure 33].

The controller remains responsible for separation and intervenes if necessary.



Figure 32: Louisville UPS CDTI for Merging & Spacing

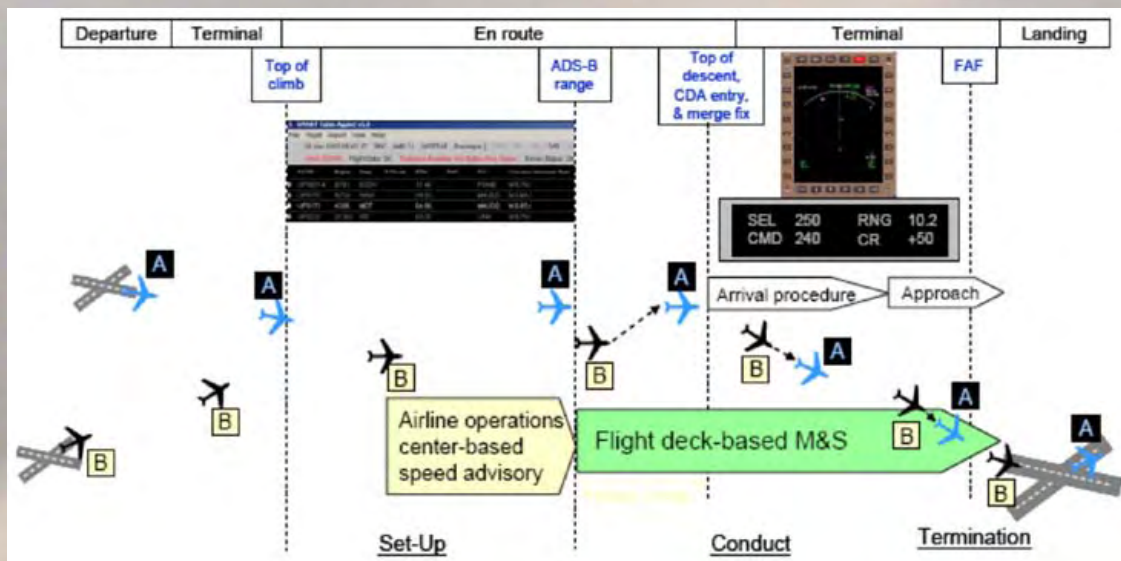


Figure 33: Louisville UPS Merging & Spacing Phases

Sweden's Green Approach

Scandinavian Airlines has performed more than 1,800 Continuous Descent Approaches (CDA) also called "green approaches" at Stockholm-Arlanda airport since January 2006. Via ACARS the expected Green Approach STAR is sent to the aircraft [Figure 34] which sends back a precise *Estimated Time of Arrival* (ETA) to the controller who can ask for a *Required Time of Arrival* (RTA). The aircraft FMS then follows the 4D trajectory, according to the time constraint, in an idle descent.

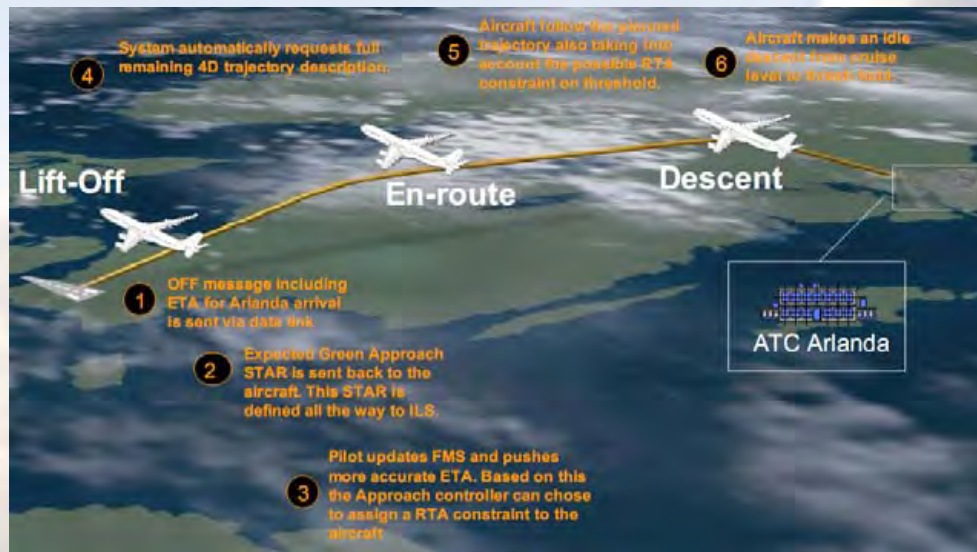


Figure 34: Sweden Green Approach

Australia

The Burnett Basin trial in 2001 showed that ADS-B performed as well as radar for surveillance (allowing Australia to approve a 5NM separation), that ADS-B ground stations cost one tenth the cost of en-route radar station, and that ADS-B avionics (1090 MHz Extended Squitter) could be installed even on helicopters or home built aircraft.

Australia plans to rely primarily on ADS-B for en-route surveillance (and GNSS for en-route and approach guidance at regional airports) in 2013. The current use of ADS-B through the Upper Airspace Program (10 ADS-B ground stations have been installed in non radar areas) will be extended to include most the Australia's busiest airspace (from 10 to 28 ground stations in the end of 2008) [Figure 34]. This program includes financial assistance to general aviation for the equipment of ADS-B avionics to Australian fleet (up to \$10k or \$15k per aircraft).

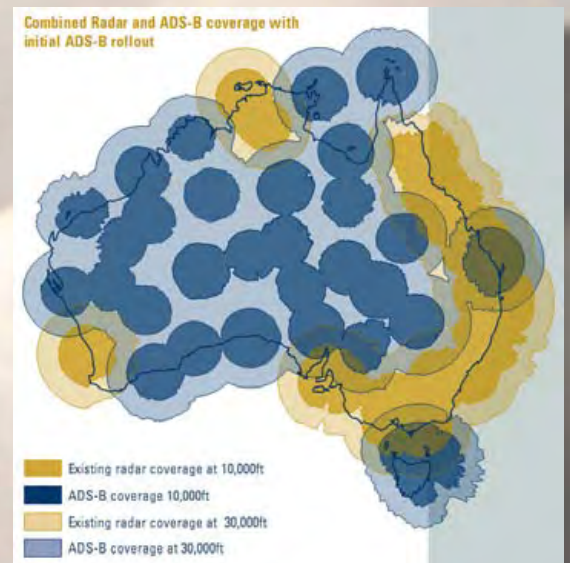


Figure 34: Australian radar (yellow) and ADS-B (blue) coverage

Trials on Tailored Arrivals (customised RNAV arrivals to reduce fuel consumption) have started in 2004 in Melbourne [Figure 35]. Tailored Arrival clearances are calculated on the ground according to the aircraft type and wind conditions, and transmitted via FANS CPDLC to the aircraft (and uploaded in the Flight Management Computer thanks to the FANS integration with the FMS). FANS ADS-C position reports help monitor the aircraft ability to comply with the Tailored Arrival different segments.

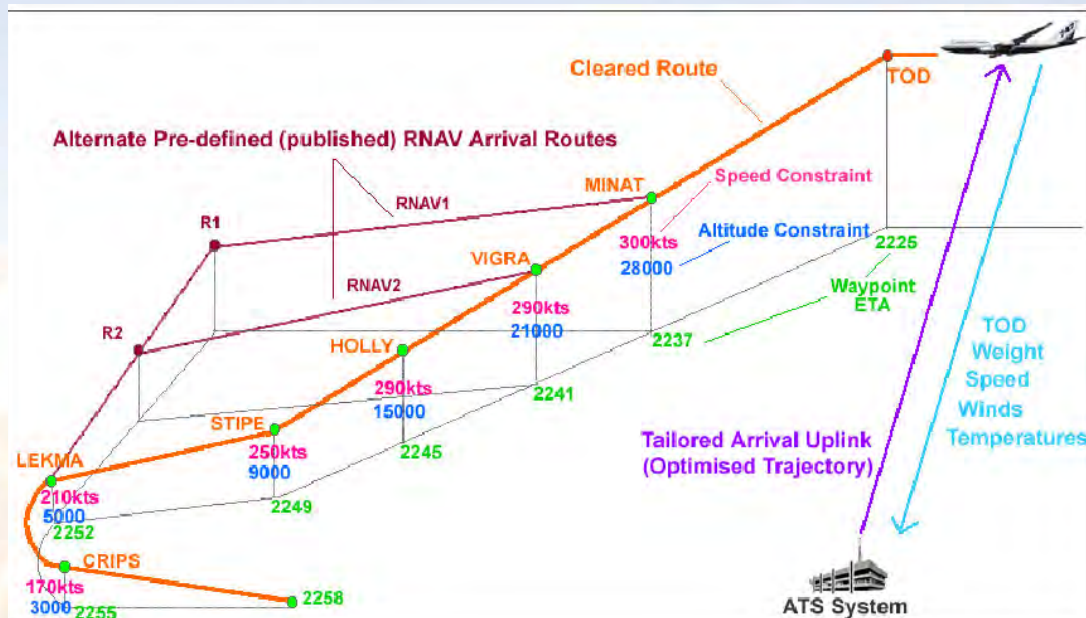


Figure 35: Melbourne FANS Tailored Arrival

Conclusions

From the old but upgraded FANS technology to the ICAO-sponsored open and robust but still incomplete ATN, there may be some confusion for ANSP, manufacturers, airlines and ANSPs when investing time and money in these new technologies whose benefits for capacity, safety and workload reduction have been proven in numerous trials and implementations.

Data link has been a reality for more than ten years for oceanic flights, and the transition from HF voice position reports to FANS Automatic Dependent Surveillance and Controller-Pilot Data Link Communications has greatly increased safety. Fuel efficiency, a popular argument today, could be attained through in-trail oceanic climbs and continuous descent approaches. In continental high density airspace, data link now has to prove that it can avoid technological divergence for surveillance and communication avionics and confusing or hazardous ground mitigations.

As air traffic controllers, we have a lot to gain from these new tools, in remote areas to replace HF communications and enjoy radar-like surveillance, and in dense airspace to reduce voice congestion and workload for repetitive tasks. However, we must pay attention to the elaboration of the new services in the numerous working groups, the choice of the implementation technologies by our ANSPs, the potential ground mitigations impacting our workload and the probable shift of responsibilities between pilots and controllers.