Understanding the Future Air Navigation System (FANS) 1/A

Presented by: Asad Afridi
Presented to: RAeS Pakistan

August 2015
“Vision without Action is a day-dream, Action without Vision is a nightmare.”

ICAO Workshop Nairobi - 2012
How an airplane can go missing in 2014?

The flight made last voice contact with ATC (01:19 MYT) in less than an hour after takeoff when it was over the South China Sea - the aircraft disappeared from ATC’s radar screens 3 minutes later.

"We mustn't allow this to happen. We must know what caused that airplane to disappear."

Sir Tim Clark
Difficulties

Navigating over featureless vast expanses of water for thousands of miles,

The weather, especially in the North Atlantic Ocean, is treacherously unpredictable.

Since the middle of the 20th century, however, transatlantic flight has been routine, for commercial, military, diplomatic, and other purposes.

Experimental flights (in balloons, small aircraft, etc.) still present challenges for transatlantic fliers.
On 14–15 June 1919, British aviators Alcock and Brown made the first non-stop transatlantic flight in their Vickers Vimy IV twin-engined bomber (converted for the long flight by replacing the bomb carriers with extra petrol tanks).

They took off from St. John's, Newfoundland and landed in Ireland, to grab the prize of £10,000 offered in April 1913 by “The Daily Mail” to “the aviator who shall first cross the Atlantic in an aeroplane in flight from any point in the USA, Canada or Newfoundland and any point in Great Britain or Ireland" in 72 continuous hours“.

Their flight paved the way for commercial transatlantic aviation.

The Prize was a £10,000 reward (£1,020,000 = $1,600,000 as of 2015)
Lindbergh Flies the Atlantic, 1927

His Problems?
- Weather
- Direction
- Language

"Which way is Ireland?"

Lindbergh also dispensed with non-essential equipment like radios, sextant and a parachute – except for inflatable raft.

The Orteig Prize was a $25,000 reward ($340,067 as of 2015)
• Global Flights

There are about 20,000 airplanes in the world as of 2013. Boeing projects demand for new airplanes to top 35,000 over the next 20 years. (ask.com)

On average, there are 93,000 daily flights originating from about 9,000 airports around the world. At any given time, there are between 8,000 and 13,000 planes in the air around the globe. (ask.com)
Projected Passenger Growth on US Flag Carriers

US Domestic flights ~ 25% increase
US International Pax traffic ~ 67% increase

Predictions made in 2007 based on 2005 figures

Source: FAA
Source: FAA

**DELAYS WILL INCREASE**

*Average Delay per Flight (Minutes)*

![Graph showing delays per flight from January to November, with 2004 and 2014 data compared. The graph indicates an increase in delays from January to November.*]
• Airspace Growth
- Another Airspace Perspective
• Upper Space

- The FAA expects unprecedented demands on the National Airspace System and the nation’s Air Traffic Control system over the next 10 years:
  - Doubling of air traffic operations
  - Increase in space operations

- The NAS was not designed to handle high-speed spacecraft.
- Different tools, processes, and procedures will be necessary to minimize the impact of space operations in the NAS.
Technologies are changing at a faster pace. Gone are the days when an isolated Radar or a few ILSs would suffice.

- Global Navigation Satellite System (GNSS),
- Instrument Landing System (ILS),
- Microwave Landing System (MLS),
- Very High Frequency (VHF) Omni-directional Radio Range (VOR),
- Non-directional Radio Beacon (NDB) and
- Distance Measuring Equipment (DME).

Yesterday’s System still Prevailing

- Ground centric – emphasis on the ground systems less on aircraft capability.
- Human centric and un-automated - One sector, one controller, one frequency, a finite number of aircraft.
- Aging Radar Infrastructure (youngest – 43 yrs old in USA)

Source: FAA

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In 1983 ICAO creates Special Committee on FANS which introduced the CNS / ATM concept.

FANS 1/A

Solutions

Early 1990s

FANS-1

Later

Future ??? Air Navigation System

3 Decades old idea – it’s implementation still lying in future
While emphasizing importance of investigation, Captain Don Wycoff added that “in 2014, there is technology that can significantly enhance the ability to locate a missing aircraft. This technology must become the standard across the industry.”

Such technologies include: . . . . ; more accurate and near real time position reporting of aircraft location via satellite; Controller Pilot Datalink Communications (CPDLC); Aircraft Communication and Reporting System (ACARS) and Automatic Dependent Surveillance - Broadcast (ADS-B).
FANS 1/A

- Worldwide Avionic Mandates - Summary

  • ADS-B Out
    Dec 2013 FL350-FL400

  • ADS-B Out
    Jan 2020 New A/C CofA
    Jan 2020 Fleet Retro-Fit Date

  • ADS-B Out
    Jan 2015 New A/C CofA
    Dec 2017 Fleet Retro-Fit

  • ADS-B Out
    Dec 2013 Above FL285

  • ADS-B Out
    Dec 2013 FL350-FL400

  • ADS-B Out
    Dec 2013 Above FL285

  • ADS-B Out
    Dec 2013 FL350-FL400

  • ADS-B Out
    Dec 2013 Above FL285

  • ADS-B Out
    Dec 2013 FL350-FL400

  • ADS-B Out
    Dec 2013 Above FL285

North Atlantic Tracks (NAT) FANS 1/A Data Link

- Feb 2013 NAT OTS FL360 to FL390 (Phase 1)
- Feb 2015 NAT OTS FL350 to FL390 (Phase 2a)
- Dec 2017 NAT Region FL350 to FL390 (Phase 2b)
- Jan 2020 NAT Region FL290 & Above (Phase 2c)

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CORRIGENDUM

Extension of Date of Opening I/T No. HQCAA/1992/072/XXCP Tender Notice for “ADS-B Complete System Along with Its Commissioning And Testing at Remotes (Pasni Lakpass, Rojhan Dalbandin And Laram Top) QTY 05

2. The date of opening of above mentioned tender notice inquiry is extended up to 21-01-2015. Opening time and clauses would remain the same.

Additional Director CP&C
Headquarters Civil Aviation Authority
Phone: 021-99242674, Fax: 021-99242675

Source: CAA Pakistan

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The Civil Aviation Authority (CAA) has directed all airline operators to equip their aircrafts with global tracking to provide early notice of abnormal flight behaviour, an official said on Friday.

The directives have been issued in line with the amendments to the International Civil Aviation Organization (ICAO) guidelines. Following the disappearance of Malaysia Airline Flight MH-370, a special multidisciplinary meeting regarding Global Flight Tracking was held at the ICAO Headquarters from May 12 to 13, 2014, the official said.

The multidisciplinary meeting concluded that the global tracking of airline flights should be pursued as a matter of priority to provide early notice of, and response to abnormal flight behaviour.

The CAA directives have been issued to the Pakistan International Airlines (PIA), Shaheen Air International, Airblue Limited and Air Indus (Pvt) Limited for which the implementation deadline is November 12, 2015, the official said.

Sources said the directives have been conveyed to the airline operators after a lapse of nine months. Being a part of the ICAO and having all reference and guidance, the CAA should have conveyed such a significant requirement much earlier.

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• Evolutionary Path

1922 ATC begins

1930 Control Tower

1935, an airline consortium opened the first Airway Traffic Control Station

1940s Impact of radar

Airway Centers

1960s & 70s

FANS 1/A

1980s FANS

CNS/ATM Environment

ATC Environment

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• The Paradigm Shift

Past

Procedural
Estimate the current and planned a/c positions

Today

Radar
Know the current and estimate planned a/c positions

Future

Trajectory
Know & share the current and planned a/c positions

A tremendous Revolution
• Air Traffic Control (ATC) Environment

The Air Traffic Control (ATC) system relies heavily on voice communications between air traffic controllers and pilots. It is to relay control instructions and other information critical to safe and expeditious flight.
• CNS/ATM Environment

Communication & Navigation Satellites (SATCOM & GNSS)

VHF/HF antenna

Ground Network

Airline AOC

Information Service

Satellite Antenna

ATC Center

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• Shared Responsibility
**What is FANS 1/A?**

FANS is an avionics system which provides direct data link communication between the pilot and the Air Traffic Controller. FANS-1/A is a range of Future Air Navigation System (FANS) products. The communications include air traffic control clearances, pilot requests, and position reporting.

**Ultimate Goal**

To move towards Communication, Navigation and Surveillance (CNS) / Air Traffic Management (ATM) Systems and away from Air Traffic Control (ATC).
The goal of FANS 1/A is to improve safety and performance related to Communication, Navigation and Surveillance (CNS) / Air Traffic Management (ATM) activities within the operating environment.

- **Safety**: Lower stress on crew
- **Performance**: HF traffic is reduced, clearing the channel. Poor quality of HF is no longer an issue. No impact from increased solar flares in 2013.
- **Communications**: Standardized message set removes language barrier
- **Standardization**:
History of FANS 1/A

- FANS 1/A comprises:
  - ACARS
  - CPDLC
  - ADS-B

VHF / HF / SatCom Communication

ACARS over VHF / HF / SatCom

FANS 1/A over ACARS (CPDLC)

FANS 1/A over ACARS (ADS-B)

SITA introduced the VHF ACARS services in the early 1980’s to support movement messages.
• Future Air Navigation System

Source: Boeing
Airline Operational Communications (AOC) Use of ACARS

- Character-based messaging protocol established in 1978
- Aircraft movement messages (OOOI)
- Hundreds of message formats and applications

SITA introduced the VHF ACARS services (VHF AIRCOM) in the early 1980's to support movement messages.

- Today, majority of the world's airlines are VHF AIRCOM customers with over 4,000 aircraft and additional 1,000+ BizJets
- The 5,000+ aircraft which use the service collectively generate 400,000+ messages per day

In addition to basic movement information, AOC applications have evolved to include:

- FANS 1/A
- Electronic Flight Instrument System
- Inertial Reference Systems
- Global Positioning System
- Flight Management System
- Communications / Data Management Unit
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FANS 1/A Deployment

Graphic courtesy of The Boeing Company

© Honeywell International, Inc.
• Airline Operational Communications (AOC) Use of ACARS

• Aircraft movement messages (OOOI)
• The 5000+ aircraft which use the service collectively generate 400,000+ messages per day
• In addition to basic movement information, AOC applications have evolved to include:
  • engine monitoring
  • flight planning
  • Weight & Balance,
  • Takeoff Data Calculation
  • Weather Information
  • Fuel information
  • Gate information

ACARS is considered to be a mission critical service

• Character-based messaging protocol established in 1978
• Hundreds of message formats and applications

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• Today, majority of the world’s airlines are VHF AIRCOM customers with over 4,000 aircraft and additional 1,000+ BizJets
### ACARS OOOI –

**Home Station**
- Park/Taxi
- Take-Off
- Depart/Climb
- En Route
- Approach
- Land
- Taxi/Park

**Remote Station**
- From Aircraft

#### From Aircraft
- Out
- Off
- Engine Data
- Position Reports
- Weather Reports
- Delay Information
- ETA
- Performance Reports
- Voice Requests
- Engine Data
- Maintenance Information
- Oceanic ADS

#### To Aircraft
- PDC
- ATIS
- DDTC
- Weight & Balance
- Flight Plans
- Weather Reports
- Re-routing Information
- TWIP
- Oceanic Clearances

#### Out of Gate
- Off Ground
- On Ground
- In Gate

**FANS 1/A**

Source: SITA

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Air Traffic Services (ATS) Use of ACARS

- According to industry estimates, there are approx. 5000+ FANS 1/A equipped aircraft today........and the number is growing!

- A number of ATS providers around the world have/are planning initial ATS data link services:
  - Departure Clearance (DCL) / Pre-Departure Clearance Services (PDC)
  - Oceanic Clearance Services (OCM)
  - Digital-ATIS (D-ATIS) Services
- To date, FANS 1/A services have been introduced in remote and oceanic airspace

ACARS is considered to be a mission critical service

- SITA currently provides direct FANS 1/A communications services to 20 ATS providers including the FAA, Eurocontrol, France, Spain, South Africa, Singapore, Australia and India
SITA FANS customers

- Boeing Test System (Seattle)
- Eurocontrol Maastricht
- US FAA (Oakland, Anchorage, New York)
- Boeing
- Aerospatiale Toulouse
- Korea Airports Authority (Gimpo)
- Australia (Papeete)
- CAA Uzbekistan
- CAO Iran (Tehran) (Tashkent)
- Taiwan CAA
- Egypt CAA (Cairo)
- AAI India
- CAD Hong Kong (Calcutta, Madras)
- DCA Myanmar (Columbo) (Yangon)
- CAA Singapore
- DCA Mauritius
- Airports Fiji
- ASECNA Madagascar (Antananarivo)
- ATNS South Africa (Johannesburg)
- Airservices Australia (Brisbane, Melbourne)

Source: SITA

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The Future Air Navigation System (FANS) provides a means for direct communication between the pilot and Air Traffic Control (ATC) through data link technology.

How the Data Link System is Connected

VHF radio, HF radio or SatCom systems are used to enable digital transmission of short, relatively simple messages between the aircraft and ATC.
FANS 1/A

• VHF AIRCOM Coverage
- Satellite AIRCOM Coverage (Inmarsat)

Atlantic Ocean Region West (AOR-W), at 54 degrees West
Atlantic Ocean Region East (AOR-E), at 15.5 degrees West
Indian Ocean Region (IOR), at 64 degrees East
Pacific Ocean Region (POR), at 178 degrees East
FANS 1/A

- Satellite AIRCOM Coverage (Inmarsat)

98% of the world’s landmass and all ocean regions

10% of the world’s landmass

Source: Inmarsat
• Data Link System Service:
• Data Link System Service:
• Data Link Communication

Source: Duncan Aviation
• FANS 1/A Technologies – Controller Pilot Data Link Communications (CPDLC)

- Pilot can request and/or acknowledge changes to aircraft speed, altitude and route using standard ATC phraseology.
- The pilot is provided with a standard set of responses to these instructions or requests.
- “Free Text” messages are used when information needs to be exchanged that is not conforming to these defined formats.

CPDLC is “text messaging” between the pilot and ATC for aircraft control instead of using voice communication.

- Functionality contained in Flight Management Computer and/or Communications Management Unit
- Utilize SATCOM (FANS) and VHF Data Links
- CPDLC has two effective forms, a pre-defined message set and free text. The CPDLC message set provides a fixed set of responses to clearances, information, or request message elements which correspond to standard ATC voice phraseology.

Source: SITA

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• B777 – Standard MCDU

FANS 1/A

Multi-purpose / Multi-function Control and Display Unit
Control Display Unit (CDU or MCDU) provides the primary human/machine interface for data entry and information display.
• FANS 1/A Technologies (CPDLC)
• Standard MCDU Display

Multi-purpose / Multi-function Buttons Assume roles depending what is displayed

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FANS 1/A Technologies (CPDLC) | ATC Logon Procedures

1. Types the ATSU four-letter ICAO designator and presses LOGON.
2. Enters the flight number and selects the FLT NO button.
3. Then activates a SEND button at the top right of the display.

On selection, the pilot will see LOGON SENDING then LOGON SENT and finally LOGON ACCEPTED.

Pilot performs an initial logon manually:
• FANS 1/A Technologies (CPDLC)
• CPDLC Message Responses
  – When a clearance uplink is received, the crew will have to respond with ACCEPT, REJECT, or STANDBY.
• FANS 1/A Technologies (CPDLC)
• CPDLC Message Responses
  – If the ACCEPT response is selected, a WILCO message is inserted that will be downlinked to the ATSU.
• FANS 1/A Technologies (CPDLC)
• CPDLC Message Responses
  – A response is required within one minute of receiving message
  – If the flight crew determines they will need a significant amount of time to respond to a message, they should send a STANDBY Message.
• FANS 1/A Technologies (CPDLC)
• ATC Request Page
  – The ATC REQUEST page is used to input requests for altitude, speed, offset and flight plan changes.
• FANS 1/A Technologies (CPDLC)
PIA Tested CPDLC with Maastricht UAC in 2006
Initiative taken by then CP (Tech) Capt. Naveed A. Aziz
Since then all PK North Atlantic Flights use CPDLC as per mandate.

Upper Airspace since 2007
• Space Based Augmentation System (SBAS) Growth
  – The existing GNSS do not meet the operational requirements set by the ICAO for use during the most critical phases of aircraft flight, in particular final approaches. To solve it, ICAO decided to standardize several GNSS augmentation systems including SBAS.
  – The SBAS concept is based on GNSS measurements by accurately-located reference stations deployed across an entire continent.
  – The GNSS errors are then transferred to a computing centre, which calculate differential corrections and integrity messages which are then broadcasted over the continent using geostationary satellites as an augmentation or overlay of the original GNSS message.
  – SBAS messages are broadcast via geostationary satellites able to cover vast areas.
Global Navigation Satellite Systems

Geostationary Satellites

Reference Stations

Computing Centre

Augmentation Or Overlay Of The Original GNSS Message
• Space Based Augmentation System (SBAS) Growth – The current SBAS

SBAS compensate for certain disadvantages of GNSS in terms of accuracy, integrity, continuity and availability.

WAAS – Wide Area Augmentation System (US, Canada, Mexico)
EGNOS – European Geostationary Navigation Overlay Service (Europe)
MSAS – Multifunctional Satellite Augmentation System (Japan)
GAGAN – GPS Aided Geostationary Augmented Navigation (India)
SDCM – System for Differential Correction and Monitoring (Russia)
• Space Based Augmentation System (SBAS) Growth
  – The current SBAS

WAAS – Wide Area Augmentation System (US, Canada, Mexico)
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GAGAN – GPS Aided Geostationary Augmented Navigation (India)
SDCM – System for Differential Correction and Monitoring (Russia)
• Space Based Augmentation System (SBAS) Growth – The current/future SBAS
Air Navigation Service Responsibilities

Total airspace: 2.8 million Sq.NM (9.5 M Sq.Km)

Oceanic: 1.74 million Sq.Nm
(Bay of Bengal, Arabian Sea & Indian Ocean)

Continental: 1.04 million Sq.NM
4 FIRs
Kolkata, Delhi, Mumbai, Chennai

12 neighboring States

Source: CAA India Presentation_NextGEN_by_CVO

FANS 1/A
• Flight Management System (FMS)

- FMS provides
  - Navigation
  - Flight Planning
  - Trajectory Prediction
  - Performance Computations
  - Guidance
• ADS-B System Description

**Automatic**: Periodically transmits information with no pilot or operator input required.

**Dependent**: Position and velocity vector are derived from the Global Positioning System (GPS) or a Flight Management System (FMS).

**Broadcast**: Transmitted information available to anyone with the appropriate receiving equipment.

**Surveillance**: A method of determining position of aircraft, vehicles, or other assets.
• **ADS-B System Description**

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Homemade 1090MHz ADS-B dipole antenna. A simple homemade antenna can receive 1090 MHz signals.
• ADS-B System Description

Flightradar24

get most of the aircraft position data from our network of about 7,000 ADS-B receivers around the world. ADS-B data is transmitted from the aircraft transponder through radio signals that can be picked up by an ADS-B radio receiver. There are several ADS-B receivers on the market and it's also possible to build your own ADS-B receiver for about USD 100. By installing a receiver you can help us increase coverage by up to about 250-400 km (150-250 miles) in all directions depending on your location.

If you have it share it.
If you don’t have it get it.
You can even host it professionally.

If you already have an ADS-B receiver, you can share your data with Flightradar24 by downloading our data sharing software.

If you want to buy or build your own ADS-B receiver, you can buy the hardware from stores on the Internet.

If you want to host a professional receiver with ADS-B and MLAT capability, you can apply for our Flightradar24 ADS-B / MLAT receiver.
• ADS-B System Description

Do you want to build your own FlightAware PiAware ADS-B Ground Station?

You can now build and run your own ADS-B ground station that can be installed anywhere and receive real-time data directly from airplanes on your computer.

Your ground station can run FlightAware’s PiAware software to track flights within 100-300 miles (line of sight, range depending on antenna installation) and will automatically feed data to FlightAware. You can track flights directly on your FlightAware device or via FlightAware.com.

Users sending ADS-B data to FlightAware will see live (non-delayed) data, have their own data highlighted on FlightAware track logs, see additional information on ADS-B from elsewhere, receive custom statistics and more information on ADS-B sites around the world. As a thank you for your contribution to our community, FlightAware offers a free Enterprise Account (USD30.95/mo value) to users who share their data.

Getting started is fast and easy!

Using the instructions below, the process should take about 2 hours and the parts cost about USD100/EUR80.

Already running dump1090 on a Raspberry Pi?

View the PiAware installation page to install the latest version on your Pi.

So is FlightAware
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FlightAware
Live Flight Tracker
ADS-B Data
PK301/20Aug
ISB – KHI
A320/AP-BLC
• ADS-B = Old RADAR

**GPS**: Shows pilots their position but not normally used by ATC

**Secondary radar**: Tracks plane and its identity via transponder

**ACARS**: Transmits aircraft data to the ground

**Primary radar**: Can only show approx position. No radar coverage 240km from land

**Flight data**

**Air traffic control (ATC)**
• ADS-B Data-link
  – Two ADS-B “links” or frequencies are approved by the FAA
    • Mode S “extended squitter” (1090 MHz)
      - Used for most commercial aircraft
    • Universal Access Transceiver (UAT) (978 MHz)
      - Typically used for other aircraft and vehicles
  – Dual links may require a multilink or ADS- Rebroadcast (ADS-R) function to ensure 1090 and UAT users see each other
• ADS-B Cockpit Displays
- ADS-B Applications in Published Standards
  - (EVAcq) Enhanced Visual Acquisition
  - (AIRB) Basic Airborne
  - (VSA) Visual Separation on Approach
• ADS-B Applications in Published Standards – (SURF) Basic Surface
• ADS-B Applications in Published Standards
  – (ITP) In Trail Procedures
• ADS-B Applications in Published Standards
  – (TSAA) Traffic Situational Awareness w/ Alerts
  – (IM) Interval Management
  – (CAVS) CDTI Assisted Visual Separation
• **ADS-B CDTI**
  – Cockpit Display of Traffic Information (CDTI)
  – Aircraft / vehicle
    “broadcasts” known GPS position and additional data

• **ADS-B message includes:**
  – **Heading**
  – **Altitude**
  – **Call sign**
  – **Speed**
  – **Distance**
  – **Aircraft category**
– Radar like display for ADS-B traffic in aircraft cockpit or vehicle
– Other capabilities include broadcast traffic information, terrain, and weather (via FIS-B and TIS-B services)

Traffic Information Service – Broadcast (TIS-B)
Flight Information Service – Broadcast (FIS-B)

• ADS-B message includes:
  – Heading
  – Altitude
  – Call sign
  – Speed
  – Distance
  – Aircraft category
• ADS-B Broadcast Services
  – Traffic Information Service – Broadcast (TIS-B)
    • TIS-B broadcasts surveillance data
  – Flight Information Service – Broadcast (FIS-B)
    • Graphical NEXRAD Weather, meteorological observations, and Terminal Area Forecasts (TAFs) broadcast from ground stations

• Early planned enhancements include graphical Temporary Flight Restrictions (TFRs) and additional graphical weather products.
• ADS-B Proposed Capabilities

**Air-to-Air**
- Improved Separation Standards
- Improved Low-Visibility Approaches
- Enhanced See and Avoid
- Enhanced Operations for En Route Air-to-Air

**Air-to-Ground**
- Surveillance Coverage in Radar / Non-Radar Airspace

**Ground-to-Ground**
- Improved Navigation on Taxiways
- Enhanced Controller Management of Surface Traffic

**Ground-to-Air & Self-Contained**
- Weather and SSR Traffic to the Cockpit
- Affordable Reduction of Controlled Flight into Terrain (CFIT)
• Why deploy an ADS-B system?
  – An ADS-B system provides the air/ground infrastructure upon which applications can be deployed when available to obtain additional benefits

  • Air-to-air applications
  • Other information services
  • Surveillance Information
• Project Scope
  – In July 2008, CANSO agreed to conduct a Cost Benefit Analysis for the ADS-B project over the South China Sea involving Indonesia, Vietnam and Singapore.
  – The study was conducted with the support of IATA and CANSO members (FAA and CAAS) and completed in 2009.
• Project Scope
• Project Scope
• Study Assumptions
  – ADS-B data sharing across FIRs
  – Provision of VHF to adjacent Air Navigation Services Providers (ANSPs) when required
  – Provision of radar-like separation in restricted airspace
  – Analysis based on extrapolation of CAAS traffic data and IATA’s demand projections
  – Estimated infrastructure cost

• Traffic Demand Forecast
  – Given the recent economic downturn and the volatility of projections, CANSO conducted a sensitivity analysis based on the following scenarios:
    • Low: 3% growth
    • Medium: 5% growth
    • High: 7% growth
**Aircraft Equipage**

About 61% of aircraft in the area were transmitting ADS-B data although this does not take into account the certification or accuracy of the data. 61.00%

About 61.9% were assessed to be ADS-B capable. 61.90%

25% of the remaining were assessed as retrofit ready (during scheduled maintenance). 9.5%

With an effective mandate, more than 85% of aircraft would be ADS-B (Out) capable. 85%

- New aircraft delivered are all ADS-B capable.
- Fleet retirements due to economic climate will enhance capabilities.
- Retrofit timelines would be encouraged by an effective mandate.
• **Benefits - Optimum Flight Altitudes**
  – Examine fuel savings for flights that currently do not receive optimum altitude
  – Examine flights that are currently delayed before receiving optimum altitude.
• **Benefits - Capacity Increase**

![Example of Hourly Demand](image)

- **Benefits**
  - Capacity Increase

*Source: CANSO*
• Benefits - Capacity Increase
  – Examined
    • delays due to limited capacity vs. the demand forecast.
    • hourly demand vs. hourly capacity and run a queuing model to estimate delay difference between baseline capacity and new ADS-B enabled capacity
  – Monetize delay savings benefit in terms of reduced Aircraft Direct Operating Costs and Passenger Value of Time.
• Costs – Infrastructure
  – ADS-B stations
  – VHF radio & communications circuits
  – ATM system upgrades where applicable
  – Project management & training
  – Recurrent costs e.g. maintenance and spares
  – Supporting infrastructure if needed
• Business Case
  – Net Present Value (NPV) \([> 0]\)
  – Benefit to Cost Ratio (B/C ratio) \([> 1]\)
  – Internal Rate of Return (IRR) \([> \text{Cost of Capital}]\)
  – Payback Year
• Project milestones for initial phase of ADS-B implementation over the South China Sea (22 February 2011 status)

A Installation of ADS-B ground stations
- Natunas and Matak - completed
- Singapore - completed
- Con Son - 2H 2012

B Installation of VHF stations and links
- Natunas and Matak - 1H2012
- Conson - 2H2012

C Signing of ADS-B data and VHF radio facility sharing agreement
  i) Between Indonesia and Singapore - 2H2010 completed
  ii) Between Vietnam and Singapore - 2H2011 completed

D Signing of LOA between Ho Chi Minh and Singapore ACCs - 1H2012

E Issue AIC on aircraft equipage mandate - 2H 2010 completed

F Technical Monitoring of ADS-B operations - 1H 2012

G Operational trial and implementation - 2H 2012/implementation 2H2013

H Exclusive ADS-B operations for L642 and M771 above FL290 - 2H2013
Proposed ADS-B coverage for additional high density routes over the South China Sea

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Source: CANSO
• Myanmar ADS-B Implementation Plan

- Radar
- ADS-B

- 5 ADS-B stations proposed
- 3 SSR radar for En-route
- 1 PSR for Terminal

Source: CANSO
Potential ADS-B coverage for high density routes over Bay of Bengal

Source: CANSO
India and Myanmar: ADS-B sites announced to-date

Source: CANSO
Potential ADS-B coverage for high density routes over Bay of Bengal (Andaman and Nicobar Islands + Coco Islands)

Source: CANSO
Potential ADS-B coverage for high density routes over Bay of Bengal

High Density Routes Benefitting from ADS-B Coverage
Potential ADS-B coverage from sites
Plan for ADS-B Implementation in APAC

Source: CANSO
• The ‘Silk Route’ north of the Himalayas
• Only open to FANS 1/A aircraft
• Uses all aspects of FANS 1/A: C, N, S and ATM
• Shorter, greater access to preferred flight levels
• Time savings from 20 mins to 1 hour BKK <-> LHR
# ADS-C vs. ADS-B

<table>
<thead>
<tr>
<th>Item</th>
<th>ADS-C</th>
<th>ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas of Operations</td>
<td>Oceanic / Remote North Atlantic North Pacific South Pacific</td>
<td>Continental Airspace Semi-Remote Hudson Bay Gulf of Mexico</td>
</tr>
<tr>
<td>Network</td>
<td>Satellite and VHF ACARS</td>
<td>Ground-Based receiver stations only</td>
</tr>
<tr>
<td>Equipment Requirements</td>
<td>FMS SATCOM VHF VDL (ACARS)</td>
<td>Transponder 1090ES/UAT GPS</td>
</tr>
<tr>
<td>Crew Requirements</td>
<td>Must log onto system</td>
<td>Automatic - No crew interaction required</td>
</tr>
<tr>
<td>LOA Requirements</td>
<td>Yes (LOA A056)</td>
<td>Only outside of US</td>
</tr>
</tbody>
</table>

*ADS-C and ADS-B share the same purpose – aircraft surveillance*

*However their functionality, equipment requirements, and areas of operations are vastly different*
In non-FANS procedural aircraft separation, errors in navigation and potential errors in voice communication between the flight crew and ATC are considered when determining the necessary airspace separation between aircraft.
Through a satellite data link, aircraft equipped with FANS can transmit Automatic Dependent Surveillance-Contract (ADS-C) reports with actual position and intent information at specified time intervals automatically. The position report is based on the accuracy of the GPS position sensing.

Digital data communication between the flight crew and the ATC drastically reduces the possibility of error, and allows for reduced aircraft separations in airspace. Increased airspace capacity means a greater availability of desired routes for the aircraft operating within that airspace.
By 2015, even aircraft that would normally fly a random route across the Atlantic might not be allowed to transition through the North Atlantic Track System (NATS) if they are not equipped for FANS, resulting in less-than-optimal routing.

User’s Benefits – Optimal Routing

- Fewer delays on the ground while awaiting clearance
  - Fully automated position reporting
  - Digital data link communication with ATC
  - Request / receive clearances on (M)CDU
  - Auto acceptance of clearances into flight plan
  - HF radio used only as backup - no noisy communication.

Impact of Noncompliance

- Longer / Less Desirable Routing
- Longer Flight Times / More Fuel / Less Cargo, Pax / Late Delivery
Improvement Pools for Time and Fuel Savings

**Estimated Benefit Pool Actionable by ANSPs**

<table>
<thead>
<tr>
<th>Estimated Average Time (per flight)</th>
<th>Estimated Fuel Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxi</td>
<td><code>~5 min</code></td>
</tr>
<tr>
<td>Cruise</td>
<td><code>~3 min</code></td>
</tr>
<tr>
<td>Approach (100nm and in)</td>
<td><code>~3 min</code></td>
</tr>
</tbody>
</table>

*Under Review

Source: FAA and Eurocontrol

Asad Afridi
• User’s Benefits – Continuous Descent and Approach

Entire descent & approach:
- Least possible thrust
- Highest possible altitude

Today's std practice
6~10 step downs

Source: Smiths Aerospace
• User’s Benefits – Continuous Descent and Approach

GREEN RNP APPROACH BENEFITS

- Lower Noise
- Reduced Track Mile Distance
- Less Fuel Consumed
- Reduced Emissions

Continuous Descent Arrival (Idle Thrust) Integrated with RNP Approach
• User’s Benefits – Today’s Arrival

• Lower airspace “manually” adjusts streams to correct merge point times
• Higher fuel burn, higher environmental impact, decreased predictability
User’s Benefits – Tailored Arrival

- Clearances based on merge point time delivered prior to TOD for maximum use of automation
- “Windows” used to ensure separation from other streams, and to optimize for a/c type
- Lower fuel burn, lower environmental impact, increased predictability

- The pilot initiates request to ATC while the aircraft still is in its cruise phase.
- ATC sends the pilot a clearance that includes a descent profile with speed and altitude restrictions, as applicable.
- The pilot loads the clearance directly into the aircraft’s flight management system, which controls the descent.
At San Francisco Airport, more than 1700 complete and partial tailored arrivals were completed between December 2007 and June 2009 using the B777 and B747 aircraft. The tailored arrivals saved an average of 950kg of fuel and ~ $950 per approach. Complete tailored arrivals saved approximately 40% of the fuel used in arrivals. For one year period, four participating airlines saved more than 524,000 kg of fuel and reduced the carbon emissions by 1.6 million kg.
• **User’s Benefits – Tailored Arrival**

- Airports and Partners Participating in Tailored Arrival Concept
- Source: Glover (Boeing)

Source: Washington University in St. Louis

**Key Partners and Participants**

- **Air New Zealand**
- **ANA**
- **Boeing**
- **FAA**
- **Japan Airlines**
- **NASA Ames**
- **Singapore Airlines**
- **United Airlines**
- **Qantas**
- **AMS**
- **LAX**
- **MIA**
- **SFO**
- **Air Traffic Control, The Netherlands**
- **Boeing**
- **KLM**
- **Eurocontrol Maastricht Upper Airspace Center**
- **National Aerospace Laboratory, The Netherlands**
- **Transavia**
- **Martin Air**
- **Boeing**
- **Air Service Australia**
- **Air Traffic Alliance**
- **Emirates**
- **Qantas**
- **Singapore Airlines**
- **Thales**
• User’s Benefits – Performance Based Navigation (PBN)
  – PBN includes both Area Navigation (RNAV) and Required Navigation Performance (RNP)
  – RNP allows an aircraft to fly a specific path between two 3D-defined points in space.
Area navigation (RNAV) is a method of instrument flight rules (IFR) navigation that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons.

RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting.
• User’s Benefits - Performance Based Navigation (PBN)
  – On-Board Performance Monitoring and Alerting in RNP

**RNAV 1**

Track Centerline

1 Nautical Mile 95% of time

**RNP 1**

Track Centerline

1 Nautical Mile 95% of time

PILOT ALERT

Source: FAA
User’s Benefits - Performance Based Navigation (PBN)

Evolving PBN worldwide for optimized airspace utilization

Conventional Routes
Today’s airways connect ground-based navigation aids

RNAV
Area Navigation (RNAV) routes follow defined “waypoints”

RNP
Required Navigation Performance (RNP) routes within specified “containment area”

PBN Roadmap
(e.g. Advanced RNP, 4D trajectories)

Limited Design Flexibility

Increased Airspace Efficiency

Optimize Use of Airspace
**User’s Benefits - Close Formation Flying (CFF)**

Can be used to reduce the fuel burn or extend the range.

The aircraft could take-off from different airports and then fly in formation over large distances before peeling-off for landing at required destinations.

Source: Washington University in St. Louis

Source: FANS 1/A

Asad Afridi

August 2015
• User’s Benefits - Close Formation Flying (CFF)
  – Study by Bower et al. (2009) on five FedEx flights from Pacific Northwest to Memphis.

With tip-to-tip gaps ~ 10% of the span, the fuel savings were ~ 4%;
With a tip-to-tip overlap of 10% of the span, the overall fuel savings were ~ 11.5%.
This translated into savings of 700,000 gallons of fuel/year for set of five flights.

Two B727-200, Two DC 10-30 and One A300-600F were employed in the study.
• User’s Benefits - Summary

Passengers
- Access to accurate flight information anytime, anywhere
- Optimize travel routes
- Reduce the waiting time
- Increase the right to know of the operation of flights

ATC
- Help approach tower controllers plan flights taking off and landing sequence in advance to reduce airport congestion
- Help flight controllers realize air traffic flow management, reduce side effects caused by the delay

Airlines
- Improve flight regularity
- Participate in making decisions for flights taking off and landing
- Enhance the predictability of the flight operation of Airlines
- Reduce delays, reduce costs

Airports
- Better allocation of airport resources
- Provide better services to customers
- Optimize allocation of parking bays
- Increase throughput of passengers
• Mandates and operational requirements – Review
  – Over the next few years, a number of changes will apply to the performance of avionics equipment in order to comply with technical and operational requirements.
  – This is a short review of the related concepts and technical solutions related to civil aviation, such as: ACAS/TCAS II, LINK 2000+, VHFCOM 8,33Khz Spacing, ADS-B, P-RNAV, APV & LPV.
FANS Mandates
FANS technology is being implemented in oceanic and domestic airspace around the world. Here is a timeline for mandates:

Feb 2013
2 Centre Most desirable tracks, FL360-FL390 (inclusive), require FANS 1/A+

Jan 2014
∅ 1 FANS 1/A in NATS

Feb 2015
Ø 2A Expanded FANS 1/A Airspace
- All NAT Organized Track System (OTS) FL350-FL390 (inclusive and no exemptions)
- Two center (most desirable) tracks will have a half degree track between them

Nov 2015
∅ 2B
- FANS 1/A required in all ICAO NAT region FL350-FL390, inclusive

Dec 2017*
∅ 2C
- FANS 1/A required throughout the ICSO NAT region FL290 and above

Jan 2020*

* Will not apply if surveillance is available by radar or ADS-B, or if above 80 degrees north, or in the NY Oceanic FIR.
* Oceanic Centers Gander and Shanwick have also stated they will not allow “shadowing” over the OTS without FANS 1/A+ equipment.

Asad Afridi
August 2015

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A survey was conducted by Honeywell on Aviation Mandated Survey. This analysis is based on a blind online survey conducted with Aviation International News to gauge awareness and readiness for impending international aviation regulatory mandates. Results are tallied from 365 global respondents, including operators, pilots, airlines, and corporate flight departments, who participated in the April 2014 survey.

Which mandate are you most concerned about?

What mandate topic do you want to know more about?

For more info: aerospace.honeywell.com/mandates
2014 Aviation Mandate Survey by Honeywell

Level of Readiness for the Mandates

- **ADS-B**
  - Haven’t given much thought: 10.6%
  - Thinking about preparing: 26.8%
  - Compliance is planned or budgeted: 26%
  - Compliance is a work in progress: 22.1%
  - Compliance Complete: 14.5%

- **Mandatory Datalink FANS/PM-CPDLC**
  - Haven’t given much thought: 23%
  - Thinking about preparing: 17.6%
  - Compliance is planned or budgeted: 16.2%
  - Compliance is a work in progress: 11.9%
  - Compliance Complete: 31.3%
- 2014 Aviation Mandate Survey by Honeywell
- Level of Readiness for the Mandates

**LEVEL OF READINESS FOR THE MANDATES**

- FANS 1/A+
  - North Atlantic Region
  - 38.4%

- Single European Sky (SES)
  - Datalink Service/Link 2000
  - 53.9%
• 2014 Aviation Mandate Survey by Honeywell
• Level of Readiness for the Mandates

**LEVEL OF READINESS FOR THE MANDATES**

- Haven't given much thought
- Thinking about preparing
- Compliance is planned or budgeted
- Compliance is a work in progress
- Compliance Complete

**Flight Data Recorder (FDR)**

- 31.2% Haven't given much thought
- 13% Thinking about preparing
- 7.6% Compliance is planned or budgeted
- 6.8% Compliance is a work in progress
- 41.4% Compliance Complete

**TCAS 7.1**

- 17.3% Haven't given much thought
- 19.6% Thinking about preparing
- 17.9% Compliance is planned or budgeted
- 12.3% Compliance is a work in progress
- 33% Compliance Complete
• 2014 Aviation Mandate Survey by Honeywell
• Level of Readiness for the Mandates

Source: 2014 Aviation Mandate Survey by Honeywell
Data Link Regulatory Time Lines

NAT FANS 1/A
Feb. 2013 – 2 NAT Tracks FL360-390
Proposed 2015-2018 Expand to MNPS

Eurocontrol ATN/PM-CPDLC
End of FANS1/A Exemption
On Forward Fit
January 1, 2014

Eurocontrol ATN/PM-CPDLC
Retrofit Date
February 7, 2015
ADS-B Out Timeline

- Gulf of Mexico: DO-260A or later
- Hudson Bay: DO-260 or later
- Australia: DO-260 or later, SA Aware GPS
- Singapore: DO-260 or later
- Indonesia: DO-260 or later
- Australia: DO-260 or later
- Hong Kong: DO-260 or DO-260A
- Hong Kong: DO-260 or DO-260A
- EASA: DO-260B or later
- EASA ADS-B Out: DO-260B or later
- FAA ADS-B Out: DO-260B or later

Star icons:
- ★ = Improved Access (Helos)
- ★★ = Preliminary Dates
- ★★★ = Firm Dates

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TCAS Change 7.1 Timeline

Eurocontrol C7.1
Forward Fit – March 1, 2012

Eurocontrol C7.1
Retrofit – December 1, 2015

FAA TCAS C7.1 - TCAS II is version 7.1. To ensure compatibility with international standards, the FAA encourages the installation of this software as soon as practical.

A US Mandate may be coming
TCAS/ACAS Change 7.1 Timeline

- **EASA TCAS C7.1**: Forward Fit by 01-Mar-2012
- **HK TCAS C7.1**: Forward Fit by 01-Jan-2014 for Hong Kong Registered Aircraft
- **EASA TCAS C7.1**: Retrofit by 01-Dec-2015
- **HK TCAS C7.1**: Retrofit by 01-Jan-2017 for Hong Kong Registered Aircraft

Source: Honeywell
PM CPDLC / Link 2000+ Implementation Schedule

* Lifetime exemption for aircraft with FANS 1/A

01-Jan-2011
New Aircraft

Operational incentives to use PM CPDLC through limited FANS 1/A service

01-Jan-2014
** Transport State Aircraft

05-Feb-2014
Retrofit Aircraft

*** Exemption for Aircraft Built Before 1997

05-Feb-2014

**Aircraft with airworthiness certificates issued prior to 1 January 2014 with ED-100 certified FANS 1/A have a lifetime exemption to Link 2000+ PM CPDLC

**Transport state Aircraft entering service after 1 January 2014 and using civilian data link services must have Link 2000+ PM CPDLC

***Aircraft built before 1997 are exempt if out of service by 31 December 2017

Source: Honeywell
Global ADS-B Out Timeline

Gulf of Mexico
ADS-B Out
DO-260A or later

Hudson Bay
ADS-B Out
FL 350-400
DO-260 or later

Australia
Retrofit Fit (FL 290+)
DO-260 or later

Singapore
Retrofit (FL 290+)
DO-260 or later

Indonesia
Retrofit (FL 290+)
DO-260 or later

Hong Kong
PBN Routes (FL 290+)
DO-260 or DO-260A

Hong Kong
HKG FIR (FL 290+)
DO-260 or DO-260A

Australia
SA Aware GNSS

EASA
Forward Fit
DO-260B or later

FAA ADS-B Out
Forward Fit and Retrofit
DO-260B or later

EASA ADS-B Out
Retrofit
DO-260B or later

ADS-B In
No known rules (U.S. Senate FA Disauthorization Bill states 2018 for ADS-B In)

Source: Honeywell
Recorders Mandates Timeline

- **FAA CVR 120mins**
  - Forward Fit by 07-Apr-2010

- **FAA CVR 10mins RIPS**
  - Forward Fit by 07-Apr-2010

- **FAA FDR 8Hz Rate**
  - Forward Fit by 06-Dec-2010

- **FAA CVR DLR**
  - Forward Fit by 07-Apr-2010
  - Retrofit when datalink is installed

- **FAA CVR 120mins**
  - Retrofit by 07-Apr-2014

- **EASA CVR DLR**
  - Forward Fit by 08-Apr-2014

- **FAA 90 Day ULD**
  - Forward Fit by 01-Mar-2015

**Source:** Honeywell

**Notes:**
- **DLR** = Datalink Recording
- **= Preliminary Dates**
- **= Firm Dates**

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Asad Afridi
August 2015
# Data Link

<table>
<thead>
<tr>
<th></th>
<th>FANS-1/A</th>
<th>ATN-B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Also Called</td>
<td>FANS-1/A+</td>
<td>PM-CPDLC, Datacomm, Link 2000+</td>
</tr>
<tr>
<td>Where is it used?</td>
<td>Oceanic/Remote</td>
<td>Domestic</td>
</tr>
<tr>
<td>Position Reporting</td>
<td>YES: ADS-C</td>
<td>NO</td>
</tr>
<tr>
<td>Text Messaging</td>
<td>Yes: CPDLC</td>
<td>Yes: CPDLC</td>
</tr>
<tr>
<td>Using</td>
<td>SATCOM/VHF</td>
<td>VDL Mode 2</td>
</tr>
<tr>
<td>Protocol</td>
<td>AFN over ACARS</td>
<td>ATN-B1</td>
</tr>
<tr>
<td>Backup</td>
<td>HF Voice</td>
<td>VHF Voice</td>
</tr>
</tbody>
</table>

*FANS-2/B is FANS-1/A and ATN-B1 integrated within the FMS*
PM-CPDLC, CVR Mandate Timeline

- FAA CVR CPDLC Recording
  - Part 135 operators (only if A/C has CPDLC)
  - December 2010

- FAA CVR CPDLC Recording
  - Part 91 operators (only if A/C has CPDLC)
  - April 6, 2012

- Eurocontrol PM-CPDLC
  - Forward Fit
  - February, 2013

- Eurocontrol PM-CPDLC
  - Forward Fit, End of FANS 1/A Exemption
  - January 2014

- Eurocontrol PM-CPDLC
  - Retrofit
  - February 2015

- Eurocontrol PM-CPDLC
  - Non-Compliant A/C can’t fly in Europe
  - January 2017


= Preliminary Date
= Published Date
ADS-B and TCAS 7.1 Mandate Timeline

- Eurocontrol TCAS 7.1
  Forward Fit
  March 2012

- Australia ADS-B Out
  Ops Requirement above FL290, DO-260?
  November 2013

- Eurocontrol ADS-B Out
  Forward Fit, DO-260B
  January 2014

- FAA ADS-B Out
  Forward-fit & Retrofit, DO-260B
  November 2014

- Eurocontrol TCAS 7.1
  Retrofit
  January 2015

- Eurocontrol ADS-B Out
  Retrofit, DO-260B
  January 2017

- FAA ADS-B Out
  Ops Requirement in Controlled Airspace

* = Preliminary Date
** = Published Date

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Worldwide Avionic Mandates - CPDLC

- CPDLC is being implemented in WACAF States.
- Brazil and Chile using CPDLC.
- CPDLC is in use in the APAC region in FIRs (e.g., Singapore, Australia, New Zealand, Japan, India, China, Myanmar, Etc.).

Datalink forward fit compliance for all new aircraft operating above FL285 became compulsory in Europe in 2011 to assist in reducing frequency congestion.

The 7th February 2013 is the date of availability of the end to end Service, which includes the ground capability. This date does not change the applicability of the aircraft forward fit date of 1st January 2011.

Flights shall be fitted with and operate CPDLC/ADS-C equipment from Feb. 2013, on 2 specified core tracks between FL360 and FL390 within the OTS and from Feb. 2015, in specified portions of NAT MNPS Airspace.

Adequate number of MID carrier’s fleet are ready. Plans are in some MID States. Test on FANS will be conducted specially (Egypt, Saudi Arabia, Iran).

ESAF

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
FANS aircraft w/airworthiness certificate issued prior to Jan 1, 2014 are exempt from DLS IR for their useful life. Aircraft w/o ops approval are not exempt.
No temporary exemption is available for the 2015 retrofit date.
Permanent exemptions are forever for that aircraft type.
(LINK TO EC Implementing Rule No. 29/2009 see Art. 3 Para’s. 1 - 5)

ATN for use in USA by 2016.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
• Worldwide Avionic Mandates — VDL2

VDL2 will be utilized more often as more aircraft become equipped with digital ACARS.

DLS IR mandated above FL285 in ECAC airspace for aircraft delivered after 2011 and by 2015 for retrofit. VDL2 is the baseline technology but other technology may be acceptable if demonstrated compliance w/standards and has regulatory acceptability.

(LINK TO EC Implementing Rule No. 29/2009 see Art. 3 Para’s. 1 – 5)

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
VDL Mode 3 with data dates is tentative. In the US in the high/super-high en route structure.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
• Worldwide Avionic Mandates — VDL4

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
Satellite voice communications (SATCOM) may someday enable Direct Controller Pilot Communications (DCPC) by voice in oceanic and remote airspace. The ICAO Inter-regional SATCOM Voice Ad Hoc Task Force (IRSVTF) is developing SATCOM Voice Ad Hoc Task Force (SVGM) which should be published for global use by the end of 2012.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
RNAV (RNAV1) for enroute 2010 and beyond in Europe. RNAV used for some arrivals and departures since 2007. Limited RNP4 operations in the WATRS. RNP10 or better mandatory from 2011 in WATRS Plus airspace. A trial implementation of reduced longitudinal separation of 5 minutes between ADS-C equipped aircraft commenced in March 2012. and will continue as a trial until March 2014. (LINK TO ATMG/39 Para. 2.3)

RNAV above FL180 in USA by 2015 and all altitudes in continental USA by 2020. RNP2 at/and above FL290 in USA by 2015. RNP for busy enroute and terminal airspace by 2020.

RNAV 5 (formally RNP 5) already implemented enroute.

RNAV and RNP10 is being used in Oceanic sectors of SAM States of Argentina, Brazil and Uruguay.

RNAV and RNP10 is being used in Oceanic sectors of Angola and South Africa.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
Currently there is no mandate in the European Union for P-RNAV, and conventional (non-RNAV) terminal area procedures will continue to be provided for the near future.

RNAV above FL180 in USA by 2015 and all altitudes in continental USA by 2020.
RNP2 at/and above FL290 in USA by 2015.
RNP for busy enroute and terminal airspace by 2020.

MID PBN Implementation targets for short (2008-2012) and medium (2013-16) terms attached.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
• **Worldwide Avionic Mandates — ADS-C**

Flights shall be fitted with and operate ADS-C equipment from Feb. 2013, on 2 specified core tracks between FL360 and FL 390 within the OTS and from Feb. 2015, in specified portions of NAT MNPS Airspace.

LINK TO NAT SPG 47 see Conclusions 47/1 & Sec 3.1.3 - 3.1.14

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
• Worldwide Avionic Mandates — ADS-B In

Eurocontrol will have some “ADS-B in” by 2011. “ADS-B in” to be mandated in the NAT in 2025?

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
Worldwide Avionic Mandates — ADS-B Out

The world’s first nationwide satellite-based air navigation surveillance system has been put into operational use in Australia since end of December 2009. Being implemented in New Zealand, Japan Oceanic, Indonesia, Etc.

Initial implementation in Canada - Hudson Bay Basin area. The USA implemented ADS-B over the Gulf of Mexico in 2010 and intends to have nationwide ADS-B coverage by 2013 and full mandatory implementation by 2020.

Source: CNS/ATM TECHNOLOGY DEVELOPMENT ROADMAP As of 29/05/2012
All aircraft 11+ seats, CVRs must record last two hours of cockpit audio, have an independent backup power source to allow continued recording for nine to 11 minutes if all aircraft power sources are lost or interrupted, and must use solid-state technology. FDRs must retain the last 25 hours of recorded information.
FANS 1/A

• Mandates and operational requirements – Review

ACAS/TCAS II SW 7.1

Traffic Collision Avoidance System - EASA issued mandate for all aircraft with a Max Take Off Weight above 5,700 kg to comply with ACAS/TCAS-II, version 7.1 by December, 2015.

LINK 2000+

similar to the FANS/CPDLC system used in North Atlantic Airspace uses VDL Mode 2 datalink and Aeronautical Telecommunications Network (ATN) instead of ACARS.

European Data-link system - EASA issued mandate for all aircraft above FL285 to have a compliant system installed by February, 2015.

VHFCOM 8,33Khz Channel Spacing

VHFCOM 8,33Khz Spacing modification adds additional voice channels to the system. General requirement expected no later than 2018.
### ADS-B

Automatic Dependant Surveillance Broadcast Systems – EASA issued mandate for all aircraft with a Max Take Off Weight above 5,700 kg or Maximum True Air Speed greater than 250 kts. to be compliant with Mode S Enhanced Surveillance and “ADS-B out” by December, 2017 for retrofits. January, 2015 for forward fit.

### P-RNAV

Precision Area Navigation System – With a continuously increase in airports implementing P-RNAV procedures, non-PRNAV compliant aircraft risk de-routings or delays at congested airports.

### APV/LPV

Approach Procedure with Vertical Guidance - With a continuously increase in airports implementing APV-LPV procedures, non-APV/LPV compliant aircraft risk de-routings or delays at congested airports.
• Worldwide Avionic Mandates - Summary

**Source:** Various
### Worldwide Avionic Mandates - Summary

<table>
<thead>
<tr>
<th>Mandate</th>
<th>Region</th>
<th>New A/C CofA Date</th>
<th>Fleet Retro-Fit Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS-B OUT v1</td>
<td>Australia Asia-Pacific</td>
<td>December 12, 2013</td>
<td>December 12, 2013</td>
</tr>
<tr>
<td>DATA LINK RECORDING</td>
<td>FAA-registered a/c with CPDLC</td>
<td>Part 135 – Dec 2010; Part 91 – April 2012</td>
<td>Not required*</td>
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<tr>
<td></td>
<td>EASA-registered</td>
<td>April 8, 2014</td>
<td>Not required</td>
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### Worldwide Avionic Mandates - ADS-B OUT v1

<table>
<thead>
<tr>
<th>Region</th>
<th>Flight Levels</th>
<th>New &amp; Fleet A/C Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>FL350-FL400</td>
<td>November 2012</td>
</tr>
<tr>
<td>Australia</td>
<td>Above FL285</td>
<td>December 12, 2013</td>
</tr>
<tr>
<td>Singapore, Hong Kong, Vietnam, Taiwan</td>
<td>Above FL285</td>
<td>December 12, 2013</td>
</tr>
</tbody>
</table>
• Worldwide Avionic Mandates - ADS-B OUT v1

Source: Gulfstream – General Dynamics

Mandate in Effect Now for Hudson Bay FL350 to FL400
• Worldwide Avionic Mandates - ADS-B OUT v2
  – Surveillance technology similar to ADS-B OUT v1 with enhanced level of position accuracy.

<table>
<thead>
<tr>
<th>Region</th>
<th>New A/C Date</th>
<th>Fleet A/C Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>January 8, 2015</td>
<td>December 7, 2017</td>
</tr>
<tr>
<td>U.S.</td>
<td>January 1, 2020</td>
<td>January 1, 2020</td>
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</table>
FANS 1/A

- Worldwide Avionic Mandates - FANS 1/A+ in North Atlantic Region

<table>
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<tr>
<th>Region</th>
<th>Flight Levels</th>
<th>New &amp; Fleet A/C Date</th>
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</thead>
<tbody>
<tr>
<td>North Atlantic - Two Tracks in OTS</td>
<td>FL360-390</td>
<td>February 7, 2013</td>
</tr>
<tr>
<td>North Atlantic - All Tracks in OTS</td>
<td>FL350-390</td>
<td>February 5, 2015</td>
</tr>
<tr>
<td>Entire North Atlantic Region</td>
<td>FL350-390</td>
<td>December 7, 2017</td>
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<tr>
<td>Entire North Atlantic Region</td>
<td>FL290 &amp; Above</td>
<td>January 30, 2020</td>
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• **Worldwide Avionic Mandates - Link 2000+ Enforcement**

<table>
<thead>
<tr>
<th>Region</th>
<th>Flight Levels</th>
<th>New A/C Date</th>
<th>Fleet A/C Date</th>
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</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Above FL285</td>
<td>January 1, 2014</td>
<td>February 5, 2015</td>
</tr>
</tbody>
</table>
• Worldwide Avionic Mandates - Data Link Recording (DLR)
  – Records CPDLC / Text messages on the CVR
  – DLR mandated by country of registry Overview

<table>
<thead>
<tr>
<th>Region</th>
<th>New A/C Date</th>
<th>Fleet A/C Date</th>
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<tbody>
<tr>
<td>Europe</td>
<td>April 8, 2014</td>
<td>No Retrofit Date</td>
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<tr>
<td>US – Part 135</td>
<td>December 2010</td>
<td>No Retrofit Date*</td>
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<tr>
<td>US – Part 91</td>
<td>April 2012</td>
<td>No Retrofit Date*</td>
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</table>
### Approach: ADS-B Program Segments

<table>
<thead>
<tr>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
<th>Segment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Targeted ADS-B Infrastructure Deployment</td>
<td>• Complete ADS-B NAS Wide Infrastructure Deployment</td>
<td>• Complete Avionics Equipage</td>
<td>• Complete Removal of Targeted Legacy Surveillance</td>
</tr>
<tr>
<td>• ADS-B “Out” Notice of Proposed Rulemaking Issued</td>
<td>• ADS-B “Out” Final Rule Published</td>
<td>• Targeted Removal of Legacy Surveillance</td>
<td></td>
</tr>
<tr>
<td>• Begin Avionics Equipage</td>
<td>• Continue Avionics Equipage</td>
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<tr>
<td>• Expand TIS-B / FIS-B Infrastructure</td>
<td>• Complete TIS-B / FIS-B Deployment</td>
<td></td>
<td>• TIS-B Removal</td>
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</tr>
<tr>
<td>• Begin Initial Aircraft to Aircraft Application Deployment</td>
<td>• Continue Initial Aircraft to Aircraft Application Deployment</td>
<td>• Complete Initial Aircraft to Aircraft Application Deployment</td>
<td></td>
</tr>
<tr>
<td>• Additional Aircraft to Aircraft Requirements Definition</td>
<td>• Additional Aircraft to Aircraft Requirements Definition</td>
<td>• Additional Aircraft to Aircraft Requirements Definition</td>
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<tr>
<td></td>
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</tbody>
</table>
Proposed Schedule: Segments 1, 2, 3, 4

- **Segment 1 (2007 – 2010):**
  - Begin Avionics Equipage: FY 2007
  - Additional Aircraft to Aircraft Requirements Definition: FY 2007 – FY 2010
  - Begin Initial Aircraft to Aircraft Application Deployment: FY 2008
  - Targeted ADS-B Infrastructure Deployment: FY 2010

- **Segment 2 (2010 – 2014):**
  - ADS-B “Out” Final Rule Published: FY 2010
  - Continue Initial Aircraft to Aircraft Application Deployment: FY 2010 – FY 2014
  - Additional Aircraft to Aircraft Application Deployment: FY 2010 – FY 2014
  - Additional Aircraft to Aircraft Requirements Definition: FY 2010 – FY 2014
  - Complete TIS-B / FIS-B Deployment: FY 2012
  - Complete ADS-B NAS Wide Infrastructure Deployment: FY 2013
  - Complete 40% Avionics: FY 2014

- **Segment 3 (2015 – 2020):**
  - Additional Aircraft to Aircraft Requirements Definition: FY 2015 – FY 2020
  - Additional Aircraft to Aircraft Application Deployment: FY 2015 – FY 2020
  - Complete 100% Avionics: FY 2020
  - Complete Initial Aircraft to Aircraft Application Deployment: FY 2020

- **Segment 4 (2021 – 2025):**
  - Complete Removal of Targeted Legacy Surveillance: FY 2023
  - TIS-B Removal: FY 2025
  - Complete Additional Aircraft to Aircraft Application Deployment: FY 2025
• Program Issues
  – ADS-B “Out” Mandate Strategy
    • User acceptance critical to success
  – ADS-B Back-up Strategy Requires Refinement
    • GPS availability interdependencies affects airborne navigation and surveillance
    • Existing primary and/or secondary surveillance
  – Operational Air Traffic
    • Separation Standards
    • ATC Display
  – Ability of Users to Remove Selected Legacy Avionics with Full ADS-B Implementation
  – Effects of 1090 Mhz Uplink Saturation in High Density Airspace (VDL M2 – a possible solution)
Aviation System Throughput
While maintaining safety, triple the Aviation System throughput, in all weather conditions, within 10 years
Aviation System Throughput

While maintaining safety, triple the Aviation System throughput, in all weather conditions, within 10 years.

Benefits:
- Enable significant improvements to critical transportation infrastructure
- Assure safe, reduced delay flight as air traffic density increases
- Improve mobility for public
- Improve air-traveler’s time productivity

CHALLENGES


Operations Systems
- FAA NAS Architecture
  - Phase I
  - Phase II
  - Phase III
- Terminal Area Productivity
- Extended Operations Systems
- Advanced Air Traffic Technology
- Technology for Advanced Operational Concepts

Aviation Safety Program
- Phase I
- Phase II

Information Technology & Aviation Operation Systems

Aircraft Configuration
- Short-Haul Civil Tilt Rotor
  - Industry
  - Industry /DoD/FAA
- Short-Haul Civil Tilt Rotor 2

Rotorcraft, Airframe Systems & Propulsion Systems

OUTCOMES

Safe, efficient air traffic management with all-weather operation beyond current clear-weather capacity

Real-time, distributed intelligent automated aviation system-wide monitoring with safety and operational advisories

Expanded, high productivity utilization of short-runway and runway independent aircraft within an expanded NAS

High productivity, weather tolerant vehicle systems with intermodal operations capability

CHALLENGES


Operations Systems
- FAA NAS Architecture
  - Phase I
  - Phase II
  - Phase III
- Terminal Area Productivity
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- Advanced Air Traffic Technology
- Technology for Advanced Operational Concepts

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- Phase II

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Real-time, distributed intelligent automated aviation system-wide monitoring with safety and operational advisories

Expanded, high productivity utilization of short-runway and runway independent aircraft within an expanded NAS

High productivity, weather tolerant vehicle systems with intermodal operations capability
• FANS 1/A Equipment
  – Aircraft approval for FANS operations require a Letter of Authorization (LOA) from the FAA and equipment installation under a Supplemental Type Certificate (STC) or OEM Service Bulletin in accordance with AC 20-140B, to include:
    • Flight Management System (FMS),
    • Communications Management Unit (CMU),
    • Level ‘D’ SatCom system, i.e. Inmarsat or Iridium
    • External annunciator “cube” or installation integrated into flight displays
    • Aural Alert - a sonalert or some other means to provide a “Signature” aural advisory to alert the flight crew of incoming CPDLC messages
    • Data Capable Cockpit Voice Recorder (CVR) (AC 20-160),
• FANS 1/A Equipment - SatCom Considerations
  – FANS 1/A data link operations in remote oceanic airspace are transmitted via SatCom or VDL Mode 2 if within range. Verify with the SatCom provider that it is an ARINC 741-compliant system.
  – Per AC 20-140B the SatCom Technical Standard Order (TSO) requirements are as follows:
    • Inmarsat’s SatCom (Inmarsat Data 2)-TSO-C132
    • Iridium’s SatCom (i.e. Short Burst Data, SBD)-TSO-C159a
  – Currently there are no SatCom systems on the market meeting these TSO requirements. The FAA has stated that an Alternate Means Of Compliance (AMOC) will be accepted for the short term for capable SatCom systems without TSO approval.
• Worldwide Requirements and Mandates - European Mandate: Link 2000+ Programme
  – Data link communications is a key element of the Single European Sky (SES) initiative and equipage for FANS.
  – The European implementation of CPDLC in upper airspace is outlined in the SES Data Link Services Implementing Rule (DLS IR) legislation published in January 2009 (EC Reg. 29/2009). The original IR requires all existing aircraft operating above FL285 in European airspace to be retrofitted for the Link 2000+ Programme by February 15, 2015, but this is likely to slide to 2017 or 2018. The final decision will be made in November of 2014.
Worldwide Requirements and Mandates - US Mandate

- The FAA plans to start implementing FANS 1/A technologies in domestic airspace as early as 2015, where data link will be used for clearances over VHF Data link Mode 2 system that is about 10 times faster than the existing VHF network.
- The main industry standards describing the operation of FANS-1/A products are ARINC 622 and EUROCAE ED-100/RTCA DO-258.
- Both the new Airbus A-380 and Boeing 787 have FANS-1/A capability.
- ATC services are now provided to aircraft equipped with FANS-1/A in other Oceanic airspaces such as the North Atlantic.
- Although many of FANS-1/A's known deficiencies with respect to its use in high density airspace were addressed in later versions of the product (FANS-1/A+), it has never been fully adopted for use in continental airspace.
Global CNS/ATM Timeline (Civil Aviation Regions)

**NAS**
- 2005 RVSM
- 2009 FDR
- 2011 FutureComm
- 2012+ ADS-B
- 2004-15 RNP-2
- 2010-15 RNP-1 RNAV (terminal)

**ATLANTIC**
- 2001 RVSM (WATRS)
- 2002 RVSM (NAT)
- 2008 RNP-4
- 2015 FANS 1/A (AFN, CPDLC, ADS-C)

**EUROPE**
- 1998 BRNAV (RNP-5)
- 1999 8.33 kHz VHF (FL245)
- 2001 FM Immunity
- 2002 RVSM
- 2004-10 PRNAV
- 2005 ACAS II (Transports)
- 2006 8.33 kHz VHF (FL195)
- 2009 Mode S with ELS
- 2009 Mode S with EHS
- 2010-14 ATN/VDL-2 or FANS 1/A+/VDL-2
- 2010-15 RNP-1 RNAV (terminal)
- 2012+ – ADS-B

**MIDDLE EAST**
- 2003 RVSM

**PACIFIC**
- 1998 RNP-10
- 2000 RVSM (Oceanic)
- 2002 RVSM (Asia)
- 2005 RNP-4
- 2005 30/30 Separation FANS 1/A (CPDLC, ADS-C, AFN, RNP-4)
- 2012+ ADS-B

**Acronym Glossary:**
- ACAS: Airborne Collision Avoidance System
- ADS-C: Automatic Dependent Surveillance - Contract
- ADS-B: Automatic Dependent Surveillance - Broadcast
- AFN: Air Traffic Services (ATS) Facilities Notification
- ATN: Aeronautical Telecommunication Network
- BRNAV: Basic Area Navigation
- CPDLC: Controller Pilot Data Link Communications
- ELS: Elementary Surveillance
- EHS: Enhanced Surveillance
- FANS 1/A: Future Air Navigation System
- FDR: Flight Data Recorder (Data Link Messages)
- Mode S: Mode Select
- NAT: North Atlantic
- PRNAV: Precision Area Navigation
- RNP: Required Navigation Performance in nautical miles
- RVSM: Reduced Vertical Separation Minimum
- VDL: Very High Frequency Data Link
- VHF: Very High Frequency
- WATRS: West Atlantic Route System

Current as of 18 Mar 07
Revised as of Mar 15

Source: USAF
### Summary

<table>
<thead>
<tr>
<th>Maturity</th>
<th>FANS has matured over the past three decades from an aircraft OEM cost saving feature to a necessity for effective worldwide airspace management and communication advancements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandates</td>
<td>Several areas are mandating FANS 1/A capability and excluding non-equipped aircraft from airspaces with the most desirable and cost saving routes.</td>
</tr>
<tr>
<td>Benefits</td>
<td>Equipping for FANS 1/A operations and usage can provide a return on investment for aircraft dependent upon operating in those airspaces, and provides substantial operator benefits.</td>
</tr>
</tbody>
</table>
Any Questions

Thank You
Supplementary Slides
ICAO is attempting to assist States in GNSS satellite-based communications, navigation and surveillance/air traffic management (CNS/ATM) systems.
• Evolution of Aviation Wireless Communications

- 1960: PanAm Satcom Demo
- 1965: SATCOM (ATS, AOC, APC)
- 1970: HF Data Link
- 1975: GPS
- 1980: VDL Mode 2
- 1985: PETAL II & LINK 2000
- 1990: CPDLC I&IA
- 1995: VDL Mode 4
- 2000: SATCOM (ATS, AOC, APC)
- 2005: CPDLC II & III
- 2010: FANS Committee
- 2015: CNS/ATM - FANS 1&A
- 2020: ATN - ISO Definition
- 2025+: ATN - IPv? Definition
- 2025+: EACARS & AVPAC Attempts
- 2025+: ACARS

Source: Computer Networks & Software, Inc.
### Global Customers of the Wireless Aviation Market

<table>
<thead>
<tr>
<th>Type</th>
<th>Size Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Aviation</td>
<td>15,000 Aircraft plus (times # of passengers)</td>
</tr>
<tr>
<td>Business Aviation</td>
<td>25,000 Aircraft plus</td>
</tr>
<tr>
<td>General Aviation</td>
<td>100,000 Aircraft plus</td>
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<tr>
<td>Cargo Aviation</td>
<td>10,000 Aircraft plus</td>
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<tr>
<td>Military</td>
<td>50,000 Aircraft plus</td>
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<tr>
<td>Government</td>
<td>184 Countries of ICAO</td>
</tr>
</tbody>
</table>

Source: Computer Networks & Software, Inc.
Weather Impacts on National Airspace System

Causes of NAS Delays in 2004:
- Weather: 76%
- Closed Runway: 4%
- Equipment: 1%
- Volume: 14%
- Other: 5%

Rankings of Impact to the NAS by Significant Weather Elements:
- TSTM: 24%
- VSBY: 17%
- WIND: 14%
- CEILING: 14%
- SNOW: 9%
- ICING: 7%
- TURBO: 7%
- FZ PCCP: 8%

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NOAA/NWS

Source: MetEd sponsored by NOAA's National Weather Service (NWS)
### Phase of Flight and Weather Impacts

<table>
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<tr>
<th></th>
<th>Terminal</th>
<th>Departure</th>
<th>En Route</th>
<th>Approach</th>
<th>Terminal</th>
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<tr>
<td>Freezing or</td>
<td>Freezing or frozen precipitation and any thunderstorm hazard, including</td>
<td>Wind, wind shear, microbursts, turbulence, icing, and thunderstorms may</td>
<td>Jet stream winds, mountain waves, turbulence, icing, thunderstorms, and volcanic ash may</td>
<td>Wind, wind shear, microbursts, turbulence, icing, and thunderstorms may impact arrival and</td>
<td>Freezing or frozen precipitation and any thunderstorm hazard, including lightning or strong winds,</td>
</tr>
<tr>
<td>frozen</td>
<td>precipitation and any thunderstorm hazard, including lightning or strong</td>
<td>impact departure operations.</td>
<td>impact on route operations.</td>
<td>approach operations.</td>
<td>may impact ramp and taxiway operations.</td>
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<td>precipitation</td>
<td>winds, may impact ramp and taxiway operations.</td>
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<tr>
<td>and any</td>
<td>Wind, wind shear, low ceiling, and/or visibility may impact terminal</td>
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<tr>
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<td>taxiway</td>
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<td>operations.</td>
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Are we ready for the future?

“Whilst it has taken us 100 years to serve 65 billion passengers, another 65 billion passengers will take flight in the next 15 years”.

Michael Gill
ATAG Executive Director
Aviation Benefits Beyond Borders
• NextGen: Improving Service Delivery

Today’s NAS

Ground-based Navigation and Surveillance
Air Traffic Control Communications By Voice
Disconnected Information Systems
Air Traffic “Control”
Fragmented Weather Forecasting
Airport Operations Limited By Visibility Conditions
Forensic Safety Systems

NextGen

Satellite-based Navigation and Surveillance
Clearance Trajectories and Routine Information Sent Digitally
Information More Readily Accessible
Air Traffic “Management”
Forecasts Embedded into Decisions
Operations Continue Into Lower Visibility Conditions
Prognostic Safety Systems

Source: FAA and Eurocontrol
• Acronyms
  – AC - Advisory Circular
  – ADS-B - Automatic Dependent Surveillance-Broadcast
  – ADS-C - Automatic Dependent Surveillance-Contract
  – AMOC - Alternate Means of Compliance
  – AFN - ATS Facilities Notification
  – AOC - Airline Operational Control
  – ACARS - Aircraft Communications Addressing and Reporting System
  – ATC - Air Traffic Control
  – ATM - Air Traffic Management
  – ATN - Aeronautical Telecommunications Network
  – ATS - Air Traffic Service
  – CM - Context Management
  – CMU - Communications Management Unit
  – CNS - Communication, Navigation and Surveillance
  – CPDLC - Controller Pilot Data Link Communications
  – CSP - Communication Service Provider
  – CVR - Cockpit Voice Recorder
  – DLS IR - Data Link Services Implementing Rule
  – DSP - Datalink Service Providers
• Acronyms
  – FANS - Future Air Navigation System
  – FDR - Flight Data Recorder
  – FMS - Flight Management System
  – GPS - Global Positioning System
  – HF - High Frequency
  – ICAO - International Civil Aviation Organization
  – LOA - Letter of Authorization
  – NATS - North Atlantic Track System
  – OEM - Original Equipment Manufacturer
  – OOOI - Out/Off/On/In
  – OTS - Organized Track System
  – RLatSM - Reduced Lateral Separation Minimum
  – RLongSM - Reduced Longitudinal Separation Minimum
  – SBAS - Satellite-Based Augmentation System
  – SatCom - Satellite Communications
  – SES - Single European Sky
  – SCN - Software Control Number
  – STC - Supplemental Type Certificate
  – TC - Type Certificate
• Acronyms
  – VDL - VHF Datalink
  – VHF - Very High Frequency
• Acronyms
  – Air Traffic Management (ATM)
  – Air Traffic Control (ATC)
  – Air Traffic Services (ATS)
  – Communication, Navigation, & Surveillance (CNS)
  – Airline Operational Communications (AOC)
  – Flight Operations
  – Maintenance
  – Airport/Ramp Operations
  – Airline Administrative Communications (AAC)
  – Airline Passenger Communications (APC)
  – Entertainment
  – Departure Clearance (DCL)
  – Pre-Departure Clearance Services (PDC)
  – Oceanic Clearance Services (OCM)
• Air Traffic Management (ATM)
  – Predeparture Clearance
  – Taxi Clearance
  – Context Management
  – Controller to Pilot Data Link Communication
  – Automatic Dependent Surveillance
  – Waypoint Position Reporting
  – Emergency Messages
  – Future Air Navigation System
  – Oceanic Clearance
  – Future Free Flight
  – Flight Information Services
  – Airport Terminal Information Service
  – Digital Airport Terminal Information Service
  – Flight Information Services Broadcast
  – Notice to Airmen
  – METAR
  – Terminal Weather Information to Pilots
  – Local Area Augmentation System
  – Wide Area Augmentation System
  – Cockpit Voice (ATC)
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACARS</td>
<td>Aircraft Comm, Addressing and Reporting System</td>
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<tr>
<td>ACARS MU</td>
<td>ACARS Management Unit</td>
</tr>
<tr>
<td>ACAS</td>
<td>Airborne Collision Avoidance System</td>
</tr>
<tr>
<td>ACMS</td>
<td>Aircraft Condition Monitoring System</td>
</tr>
<tr>
<td>ACP</td>
<td>Actual Communication Performance</td>
</tr>
<tr>
<td>ADF</td>
<td>Automatic Direction Finder</td>
</tr>
<tr>
<td>ADIRS</td>
<td>Air Data Inertial Reference System</td>
</tr>
<tr>
<td>ADS</td>
<td>Automatic Dependent Surveillance</td>
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<tr>
<td>ADS-B</td>
<td>ADS-Broadcast</td>
</tr>
<tr>
<td>AFN</td>
<td>ATC Facilities Notification</td>
</tr>
<tr>
<td>AFS</td>
<td>Auto Flight System</td>
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<tr>
<td>AIDS</td>
<td>Aircraft Integrated Data System</td>
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<td>AIM-FANS</td>
<td>Airbus Interoperable Modular FANS</td>
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<td>AOC</td>
<td>Aeronautical Operational Communication</td>
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<tr>
<td>AOA</td>
<td>ACARS over AVLC</td>
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<td>Airborne Situational Awareness</td>
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<td>Actual Monitoring Performance</td>
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<td>Audio Management Unit</td>
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<tr>
<td>BDS</td>
<td>Comm-B Designated Subfield</td>
</tr>
<tr>
<td>BFE</td>
<td>Buyer Furnished Equipment</td>
</tr>
<tr>
<td>BRNAV</td>
<td>Basic Area Navigation</td>
</tr>
<tr>
<td>CBA</td>
<td>Cost Benefit Analysis</td>
</tr>
<tr>
<td>CDTI</td>
<td>Cockpit Display of Traffic Information</td>
</tr>
<tr>
<td>CFDIU</td>
<td>Centralized Fault Display Interface Unit</td>
</tr>
<tr>
<td>CMA</td>
<td>Context Management Application</td>
</tr>
<tr>
<td>CMC</td>
<td>Central Maintenance Computer</td>
</tr>
<tr>
<td>CNS</td>
<td>Communication, Navigation and Surveillance</td>
</tr>
<tr>
<td>CNS/ATM</td>
<td>CNS / Air Traffic Management</td>
</tr>
<tr>
<td>CPDLC</td>
<td>Controller-Pilot DataLink Communication</td>
</tr>
<tr>
<td>CT</td>
<td>Cabin Terminal</td>
</tr>
<tr>
<td>DA</td>
<td>Decision Altitude</td>
</tr>
<tr>
<td>DCDU</td>
<td>Data Communication Display Unit</td>
</tr>
<tr>
<td>DGNSS</td>
<td>Differential GNSS</td>
</tr>
<tr>
<td>DME</td>
<td>Distance Measuring Equipment</td>
</tr>
<tr>
<td>ECAM</td>
<td>Electronic Centralized Aircraft Monitoring</td>
</tr>
<tr>
<td>EFIS</td>
<td>Electronic Flight Instrument System</td>
</tr>
<tr>
<td>EIS</td>
<td>Electronic Instrument System</td>
</tr>
<tr>
<td>EIS</td>
<td>Electronic Instrument System</td>
</tr>
<tr>
<td>EWD</td>
<td>Engine &amp; Warning Display</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FANS</td>
<td>Future Air Navigation System - see CNS/ATM</td>
</tr>
<tr>
<td>FCU</td>
<td>Flight Control Unit</td>
</tr>
<tr>
<td>FG</td>
<td>Flight Guidance</td>
</tr>
<tr>
<td>FIS</td>
<td>Flight Information Services</td>
</tr>
<tr>
<td>FLS</td>
<td>FMS Landing System</td>
</tr>
<tr>
<td>FMS</td>
<td>Flight Management System</td>
</tr>
<tr>
<td>FWC</td>
<td>Flight Warning Computer</td>
</tr>
<tr>
<td>GBAS</td>
<td>Ground Based Augmentation System</td>
</tr>
<tr>
<td>GCAS</td>
<td>Ground Collision avoidance System</td>
</tr>
<tr>
<td>GLS</td>
<td>GPS Landing System</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GPWS</td>
<td>Ground Proximity Warning System</td>
</tr>
<tr>
<td>HF(HFDR)</td>
<td>High Frequency (Data Radio)</td>
</tr>
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</table>
### Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>HFDL</td>
<td>High Frequency DataLink</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>ILS</td>
<td>Instrument Landing System</td>
</tr>
<tr>
<td>ISPACG</td>
<td>Informal South Pacific Atc Coordination Group</td>
</tr>
<tr>
<td>LAAS</td>
<td>Local Area Augmentation System</td>
</tr>
<tr>
<td>LADGPS</td>
<td>Local Area Differential GPS</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LR</td>
<td>Long Range (A330/340 family)</td>
</tr>
<tr>
<td>MCDU</td>
<td>Multipurpose Control and Display Unit</td>
</tr>
<tr>
<td>MLS</td>
<td>Microwave Landing System</td>
</tr>
<tr>
<td>MMR</td>
<td>Multi-Mode Receiver</td>
</tr>
<tr>
<td>MSAW</td>
<td>Minimum Safety Altitude Warning</td>
</tr>
<tr>
<td>OSI</td>
<td>Open System Interconnection</td>
</tr>
<tr>
<td>RCP</td>
<td>Required Communication Performance</td>
</tr>
<tr>
<td>RD</td>
<td>Research &amp; Development</td>
</tr>
<tr>
<td>RFC</td>
<td>Request For Change</td>
</tr>
<tr>
<td>RMO</td>
<td>Retrofit Modification Order</td>
</tr>
<tr>
<td>RNav</td>
<td>aRea Navigation</td>
</tr>
<tr>
<td>RNP</td>
<td>Required Navigation Performance</td>
</tr>
<tr>
<td>RSP</td>
<td>Required Systems Performance</td>
</tr>
<tr>
<td>RTA</td>
<td>Required Time of Arrival</td>
</tr>
<tr>
<td>RVSM</td>
<td>Reduced Vertical Separation Minima</td>
</tr>
<tr>
<td>SA</td>
<td>Single Aisle (A318/319/320/321 family)</td>
</tr>
<tr>
<td>SARPs</td>
<td>ICAO Standard And Recommended Practices</td>
</tr>
<tr>
<td>Satcom</td>
<td>Satellite Communication</td>
</tr>
<tr>
<td>Satnav</td>
<td>Satellite Navigation</td>
</tr>
<tr>
<td>SBAS</td>
<td>Satellite Based Augmentation System</td>
</tr>
<tr>
<td>SDAC</td>
<td>System Data Acquisition Concentrator</td>
</tr>
<tr>
<td>SDU</td>
<td>Satellite Data Unit</td>
</tr>
<tr>
<td>SFE</td>
<td>Supplier Furnished Equipment</td>
</tr>
<tr>
<td>SMGCS</td>
<td>Surface Movement Guidance and Control System</td>
</tr>
<tr>
<td>SSR</td>
<td>Secondary Surveillance Radar</td>
</tr>
<tr>
<td>STC</td>
<td>Supplemental Type Certificate</td>
</tr>
<tr>
<td>STCA</td>
<td>Short Term Conflict Alert</td>
</tr>
<tr>
<td>STDMA</td>
<td>Self organizing Time Division Multiple Access (VHF)</td>
</tr>
<tr>
<td>TAWS</td>
<td>Terrain Avoidance Warning System</td>
</tr>
<tr>
<td>TCAS</td>
<td>Traffic Collision Avoidance System</td>
</tr>
<tr>
<td>TIS</td>
<td>Traffic Information Service</td>
</tr>
<tr>
<td>VDL</td>
<td>VHF Data Link</td>
</tr>
<tr>
<td>VHF (VDR)</td>
<td>Very High Frequency (VHF Data Radio)</td>
</tr>
<tr>
<td>VOR</td>
<td>VHF Omni-directional Range</td>
</tr>
<tr>
<td>WAAS</td>
<td>Wide Area Augmentation System</td>
</tr>
<tr>
<td>WB</td>
<td>Wide Body (A300/310 family)</td>
</tr>
<tr>
<td>XPDR Mode S</td>
<td>Transponder Mode Selected</td>
</tr>
</tbody>
</table>

Source: Airbus
FANS product development

- Consistent with
  - Air Traffic Alliance Roadmap
  - ICAO ATMCP concept

Pre-FANS
Airline Datalink
C: AOC over ACARS
S: Transponder
N: Classical means
ATM: Conventional Air Traffic Control procedures

FANS A/FANS A+
Oceanic/Remote airspace/Accommodation
C & S: ATC & AOC datalink over ACARS
N: GPS-based
ATM: ATC processes enhancement with initial A/G automation

FANS B
High Density airspace
C: ATC over ATN
S: Elementary & Enhanced Surveillance
N: RNP, MLS, GLS
ATM: First Applications of A/G automation to ATC/ATM

“CNS/ATM"
North America, Europe
ASAS Package 1
4D Trajectory Management
Automated support to Air Traffic Management

Source: Airbus

August 2015
Asad Afridi
Air Navigation Service Responsibilities

Total airspace: 2.8 million Sq.NM (9.5 M Sq.Km)

Oceanic: 1.74 million Sq.NM (Bay of Bengal, Arabian Sea & Indian Ocean)

Continental: 1.04 million Sq.NM

4 FIRs: Kolkata, Delhi, Mumbai, Chennai

12 neighboring States

Source: CAA India Presentation_NextGEN_by_CVO

Asad Afridi
### Key Elements of technology upgrade for NextGen

| COM           | Transition from Voice to Data Communication.  
|               | Digital communication – through satellite  
|               | voice as a back up when complete data communication is used back |
|               | GAGAN (GPS Aided Geo Augmented Navigation) to support Satellite Navigation  
|               | The ground based navigation equipments retained as a back-up |
| SUR           | Radars would continue to be primary surveillance equipment in high density traffic and terminal approach areas.  
|               | The upcoming technologies in surveillance, ADS-B and wide area multilateration to be used in combination to provide augmented surveillance capability  
|               | Surveillance over oceanic areas through ADS-CPDLC |

Source: CAA India Presentation_NextGEN_by_CVO
WORLD WIDE TREND IN GNSS IMPLEMENTATION

- Traditional navigation systems are ground based which have site limitations and range problems.
- Wide Area Augmentation System (WAAS-USA) is the first certified SBAS system operational from July 2003.
- Multi-Satellite Augmentation System – (MSAS-Japan) is certified for aviation use from September 2007.
- European Geo-stationary Navigational Overlay Service – EGNOS (Europe) has received certification for aviation use with effect from July 12, 2010.
- GPS Aided GEO Augmented Navigation – GAGAN (India) Prestigious project for India is expected to be certified by June 2013.
Air Navigation Service Responsibilities

Total airspace: 2.8 million Sq.NM (9.5 M Sq.Km)

Oceanic: 1.74 million Sq.Nm (Bay of Bengal, Arabian Sea & Indian Ocean)

Continental: 1.04 million Sq.NM

4 FIRs: Kolkata, Delhi, Mumbai, Chennai

12 neighboring States

Source: CAA India Presentation_NextGEN_by_CVO
Airways

• Referred to as “highways in the sky” because very much like the national highway system
• Like streets most airways bidirectional, but some are one way
• Most pilots flying without visual reference to the ground use them
• Low(1,200-18,000)/High(18,000-45,000) Altitude
  – Prop Planes – “Victor” airways
  – Jets - Jetways
Airspace

• Airspace – All open sky covering the United States from less than one inch to outer space

• Restrictions from A-G – A being most restrictive
  – A (18,000-60,000 feet) - populated mostly jets traveling long distances
  – B to D surround airports with control towers and are shaped like funnels
  – E is around small airports with no control tower
  – G is everything else
  – SUA – special use airspace
Brief History of DataComm

ICAO creates Special Committee on FANS which introduced the CNS/ATM concept

ICAO established ATN Panel to develop SARPs

Boeing develops FANS 1 to meet the needs of oceanic airlines

Europe PETAL trials

US CPDLC trials

Universal agreement to harmonization via ATN B2

Europe establishes mandate for Link2000 (ATN) by 2013-2015

ICAO 214/WG78 Standards

2013

2012

2000

1993

1983

Source: 6-rtca

Asad Afridi

August 2015
Approximately 40% of Controller Workload ('Hello, Goodbye' - IC/TOC)

Aircraft in communication with sector A, under control of sector A

Aircraft in communication with sector B, under control of sector A

Aircraft in communication with sector B, under control of sector B

Transfer of Communications Point

Transfer of Control Point

Sector A

Sector Boundary

Sector B

Source: 6-rtca
**Benefits of Basic Controller-Pilot DataComm**

Moving routine communications from voice digital datalink

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Capacity</td>
<td>Controllers can handle more traffic</td>
</tr>
<tr>
<td>Reduced Delay</td>
<td>Reduced frequency congestion, More efficient weather reroutes</td>
</tr>
<tr>
<td>Enhanced Safety</td>
<td>Reduce ‘mis-communications’</td>
</tr>
<tr>
<td>Increased ATC Services</td>
<td>Reduce controller workload</td>
</tr>
</tbody>
</table>

**FAA stated goals for program:**
- Align with user needs and provide operational benefits
- Meet international commitments
- Set path to deliver the future NextGen services