*International Civil Aviation Organization*
South American Regional Office
**Eleventh Workshop/Meeting of the SAM Implementation Group (SAM/IG/11) - Regional Project RLA/06/901**
Lima, Peru, 13 to 17 May 2013



**Agenda Item 5:** **Assessment of operational requirements in order to determine the implementation of communications, navigation, and surveillance (CNS) capabilities improvement for en-route and terminal area operations**

# EXPANDING FUTURE AIR NAVIGATION SYSTEM (FANS) UTILIZATION

(Presented by Boeing)

**SUMMARY**

This paper presents information concerning the Future Air Navigation System (FANS) in the interest of expanding its utilization and gaining the associated benefits in the SAM Region.

**Reference:**

- ICAO Seminar/Workshop on the Implementation of Ground-Ground and Air-Ground Data Links in the SAM Region

| | |
|---|---|
| ***ICAO strategic objectives*** | *A. Safety*<br>*B. Environmental Protection and Sustainable Development of Air Transport* |

## 1 Background

1.1 Relative to the recent ICAO Seminar/Workshop on the Implementation of Ground-Ground and Air-Ground Data Links in the SAM Region, Boeing would like to present information concerning the Future Air Navigation System (FANS) in the interest of expanding its utilization and gaining the associated benefits in the SAM Region.

## 2 Discussion

2.1 Please refer to the Attachment to this IP.

## 3 Suggested action

3.1 The meeting participants, particularly air traffic services providers and aircraft operators, are encouraged to jointly implement FANS and expand its utilization in the SAM Region in order to gain the benefits that it offers.

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# Expanding Future Air Navigation System (FANS) Utilization

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ICAO SAM IG/11

May 2013

# Expanding FANS Utilization

- Overview
- Benefits
- History
- Availability
- Components
- Boeing

# Overview: FANS and CNS/ATM

- FANS (paired with RNP4) offers a comprehensive CNS/ATM capability
- FANS is an important element of ICAO Aviation System Block Upgrade (ASBU) Block 0 (B0)
  - Module B0-10: Improved Operations through Enhanced En-Route Trajectories
  - Module B0-40: Improved Safety and Efficiency through the Initial Application of Data Link En-Route

# Overview: FANS Purposes

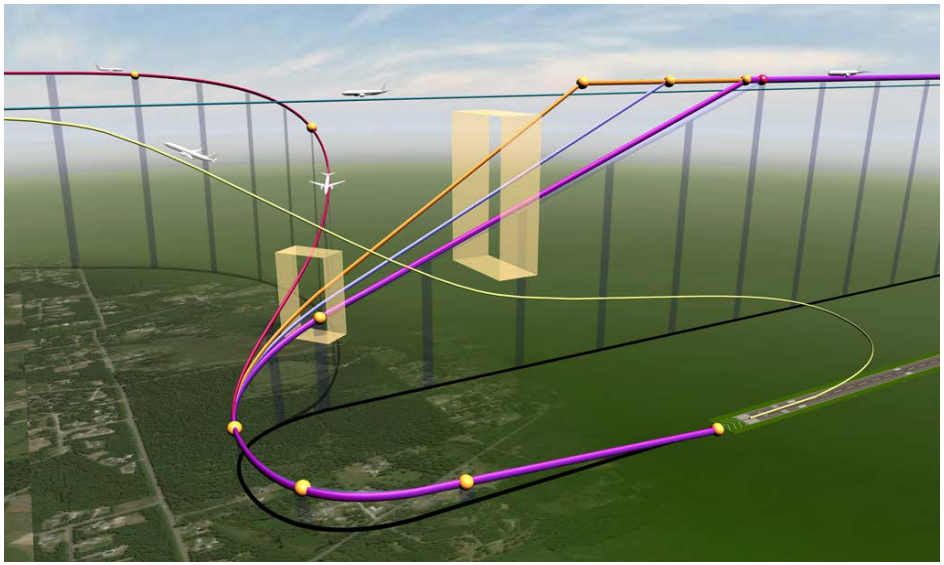
- Integrate avionics and ground automation
  - Enables initial trajectory-based operations (TBO) for Tailored Arrival (TA), Departure Clearance (DCL), Dynamic Airborne Reroute Procedure (DARP), etc. services
- Supplant voice communications as appropriate
  - Enables direct controller-pilot communications (DCPC) for controller intervention, pilot request and report, communications transfer, and similar capabilities

# Overview: FANS Operations

- FANS operations are standardized in the ICAO Global Operational Data Link Document (GOLD)
  - The GOLD is intended to maximize operational benefits by promoting seamless global data link operations
- ICAO Annex 11 requires “post-implementation monitoring to verify that the defined level of safety continues to be met”
  - As described in GOLD Appendix D, regional monitoring agencies (ISPACG CRA, SAT-FIT CFRA, etc.) conduct:
    - Required Communications Performance (RCP) and Required Surveillance Performance (RSP) monitoring
    - Investigation and disposition of FANS problem reports

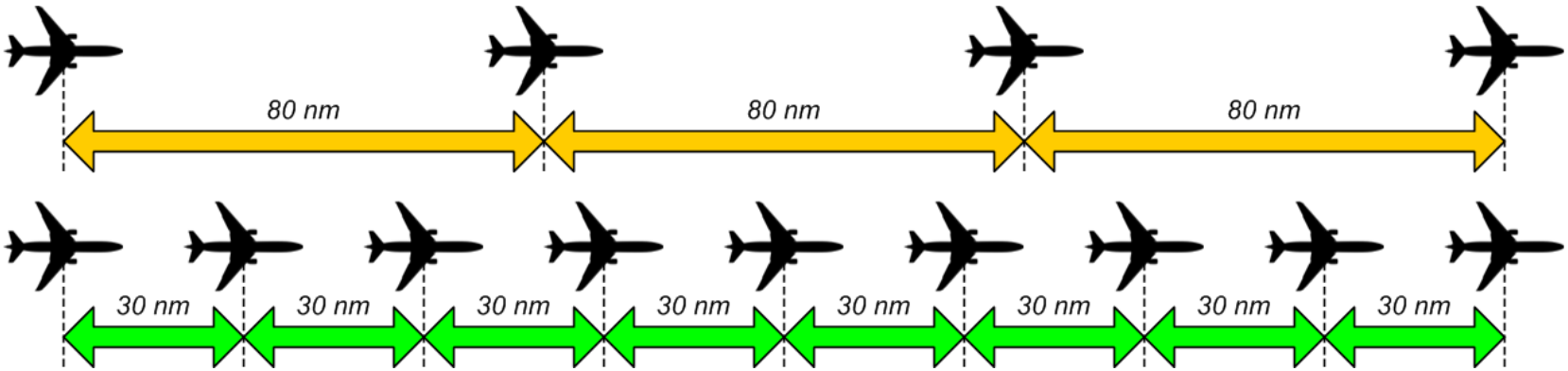
# Benefits: FANS Improves Operational Efficiency

- FAA estimated that lack of FANS and RNP4 use causes extra fuel burn of about 1.5M lbs. per year in Oakland Oceanic airspace
- Boeing determined that TA service reduced fuel burn by 500 to 2800 lbs. per arrival to San Francisco International airport



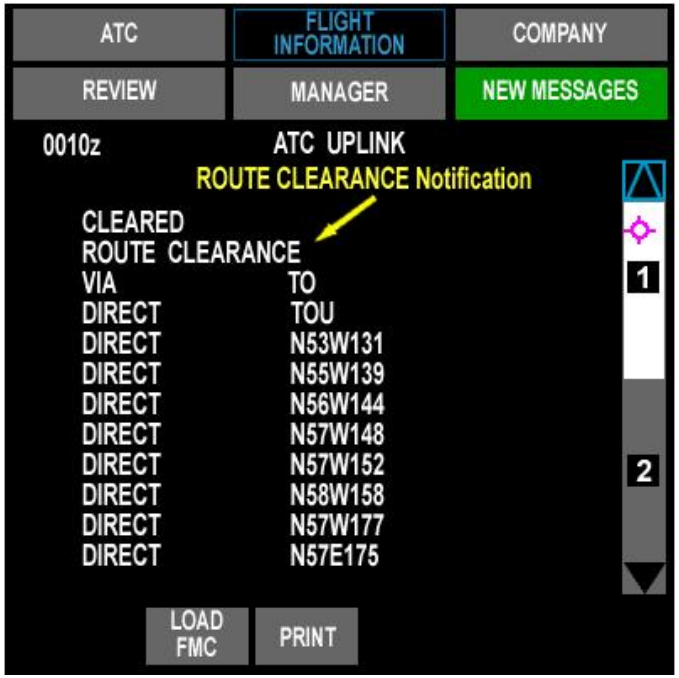
# Benefits: FANS Increases Airspace Capacity

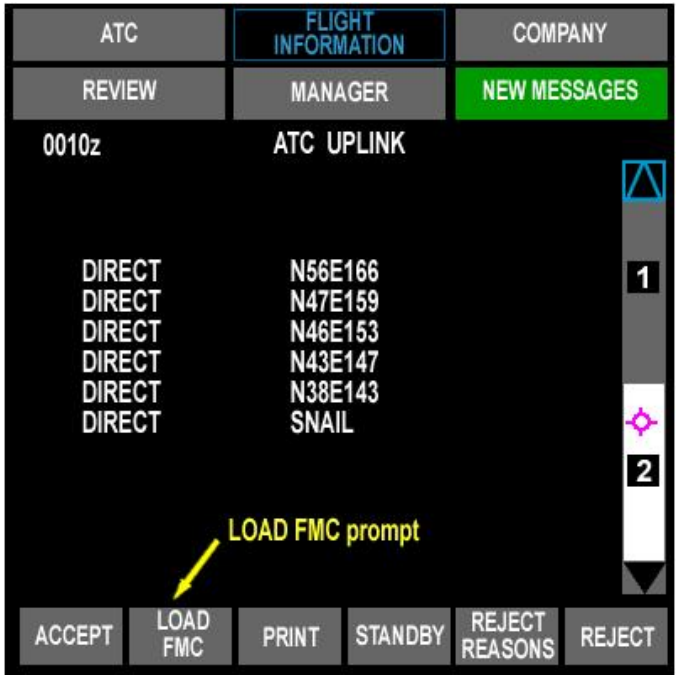
- In continental airspace, FANS enables reduced controller workload
  - Related European simulation predicted that workload reduced up to 29% and capacity increased up to 14%
- In oceanic, polar, and remote airspace, FANS enables reduced aircraft separation
  - Current goal is consistent reduction to 30 nm



# Benefits: FANS Enhances Safety

- CPDLC-enabled DCPC eliminates errors caused by verbal relay of messages through radio operators
- Avionics integration supports electronic transfer of data to prevent navigational errors (GNEs) caused by manual transcription of data



# History: FANS Concept

- 1983-1988: ICAO Future Air Navigation Systems (FANS) Committee developed the satellite-based communications, navigation, surveillance / air traffic management (CNS/ATM) concept
- 1989-1993: ICAO FANS Phase II Committee addressed implementation planning and standards development
- 1991: ICAO Tenth Air Navigation Conference (ANC) formally endorsed the CNS/ATM concept

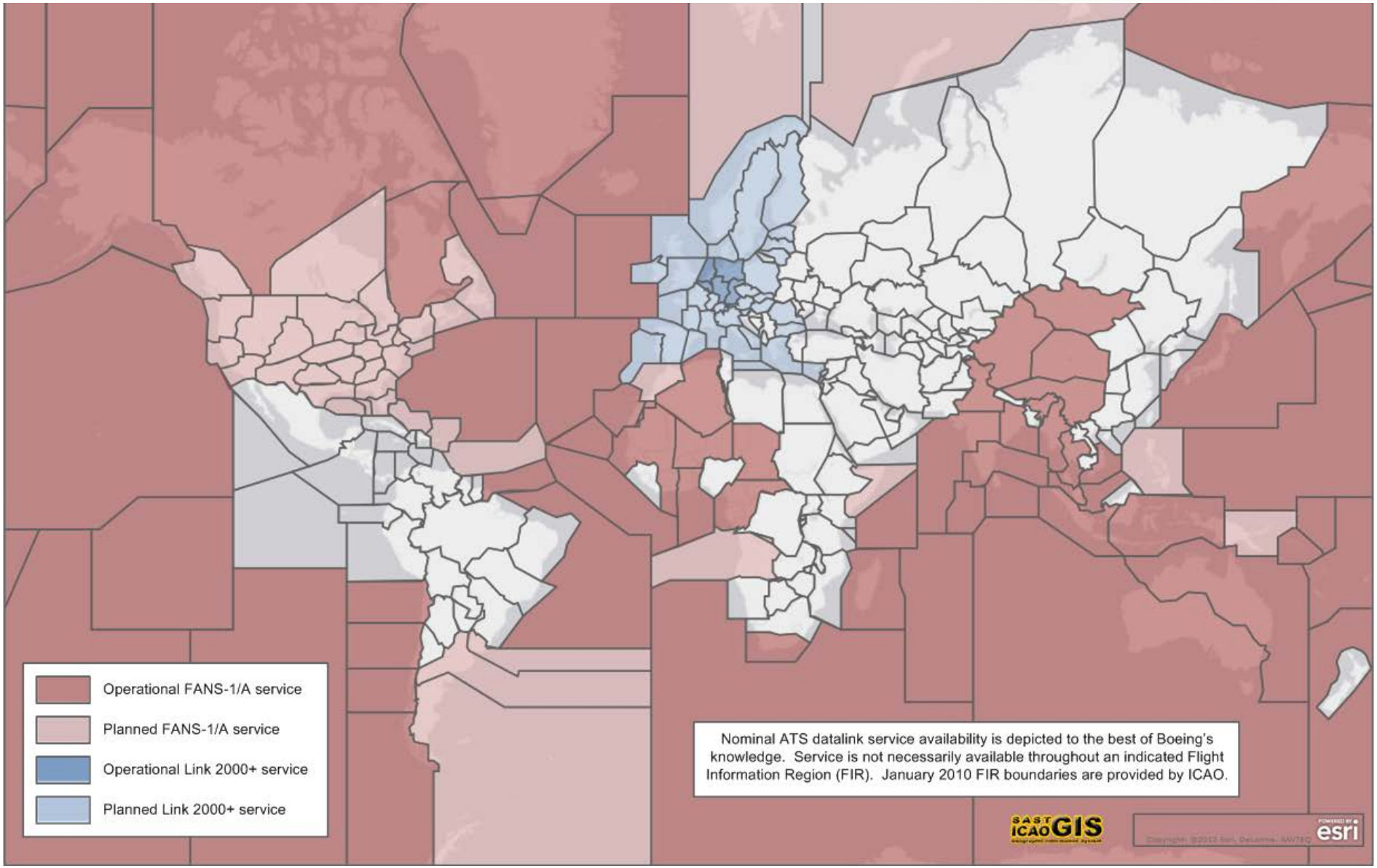
# History: FANS Implementation

- 1990-1995: Boeing, UAL, QFA, ANZ, FAA, ASA, ACNZ, others developed first FANS instantiation
  - Defined by RTCA DO-219, ARINC 745-2, ARINC 622-1
  - Boeing solution called “FANS-1”
- 2000: Airbus developed own “FANS-A” solution
  - Generic implementation called “FANS-1/A”
- 2005: Industry developed improved standard
  - Defined by RTCA DO-258A and ARINC 622-4
  - Generic implementation called “FANS-1/A+”
- Present: Increasing number of ATS providers and aircraft operators are using FANS

# Availability: FANS Programs and Mandates

- FANS is used across much of the world
  - NAT, SAT, IO, L888, SOPAC, CENPAC, NOPAC, Canada…
  - Phased mandate for the North Atlantic (NAT)
    - 2013: Specified tracks and flight levels within NAT OTS
    - 2015: Specified portions of NAT MNPS airspace
  - Chosen by FAA for Data Comm element of NextGen
    - DCL trials in progress with FDX at KMEM, UAL at KEWR next
    - **Represents validation for FANS use in continental airspace**
- FANS isn't available in some areas of the world
  - **Areas in which Boeing customers operate**

# Availability: ATS Datalink Map



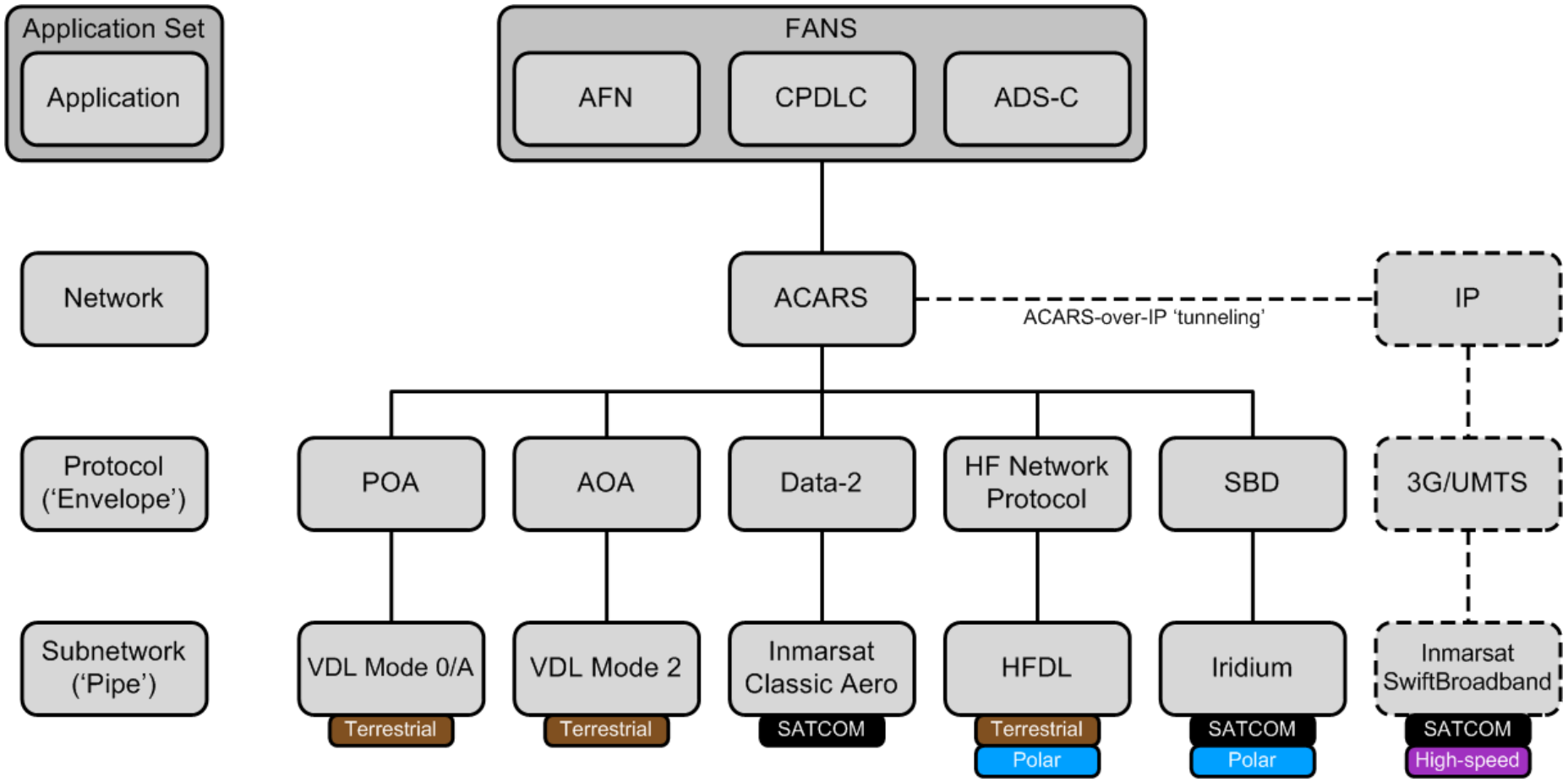
# Components: FANS Applications

- ATS Facilities Notification (AFN)
  - Flight crew manually “logs on” to initiate communications and allow correlation of aircraft registration and flight identifier
  - ATS facilities automatically perform subsequent transfers
- Controller-Pilot Data Link Communications (CPDLC)
  - 182 uplink message elements, 81 downlink message elements
  - Request and delivery of altitude, crossing constraint, offset, route, speed, etc. clearances and of position and similar reports
- Automatic Dependent Surveillance – Contract (ADS-C)
  - Aircraft deliver single, periodic, or event-based reports
  - Reports contain 4D position, identification, reference, and predicted route information for route conformance monitoring and aircraft separation assurance

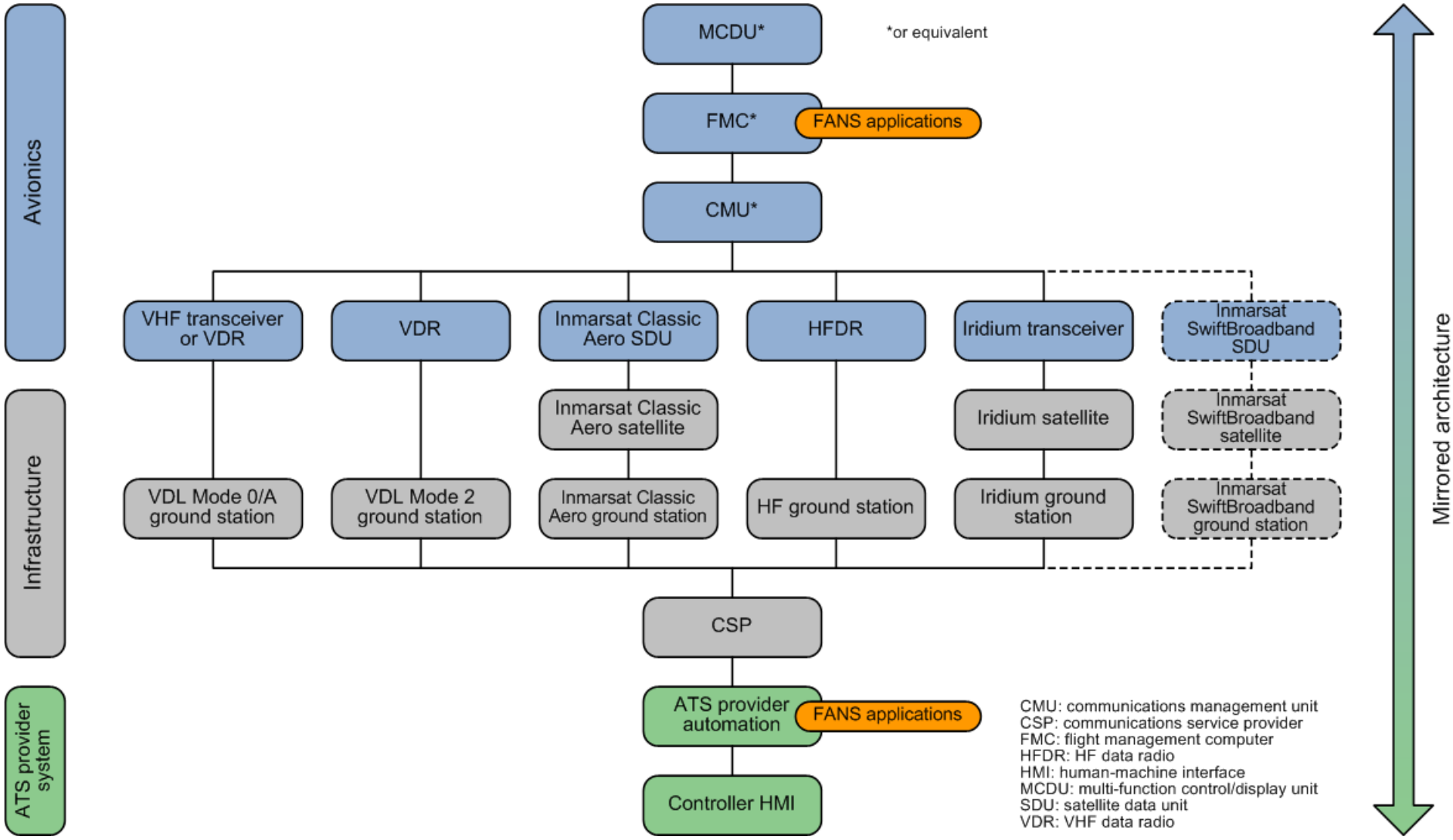
# Components: FANS Infrastructure

- Network: Aircraft Communications Addressing and Reporting System (ACARS)
  - ARINC and SITA communications service providers (CSPs) operate independent but internetworked ACARS networks
- Subnetworks: five (soon six), depending on operator's avionics choices
  - VDL Mode 0/A (using the "plain old" ACARS [POA] protocol)
  - VDL Mode 2 (using the ACARS over AVLC [AOA] protocol)
  - Inmarsat Classic Aero SATCOM (using the Data-2 protocol)
  - HF Data Link (HFDL) (using the HF network protocol)
  - Iridium SATCOM (using the Short Burst Data [SBD] protocol)
  - (In work: Inmarsat SwiftBroadband SATCOM [using IP])

# Components: FANS Conceptual Architecture



# Components: FANS Physical Architecture



# Boeing: FANS-Capable Commercial Airplanes

- **717** (option)
- **737-700/800/900** (option; FANS-1/A+ with U10.6 software)
- **747-400** (option)
- **747-8** (standard; FANS-1/A+)
- **757** (option with Pegasus FMC; FANS-1/A+ with Pegasus 2003 software)
- **767** (option with Pegasus FMC; FANS-1/A+ with Pegasus 2003 software)
- **777** (standard; FANS-1/A+ with Block Point 2003 software)
- **787** (standard; FANS-1/A+)
- **MD-11** (option with Pegasus FMC; FANS-1/A+ with “-922” software in development)
- **MD-90** (option with Pegasus FMC)

# Boeing: Evolving FANS Functionality (1/2)

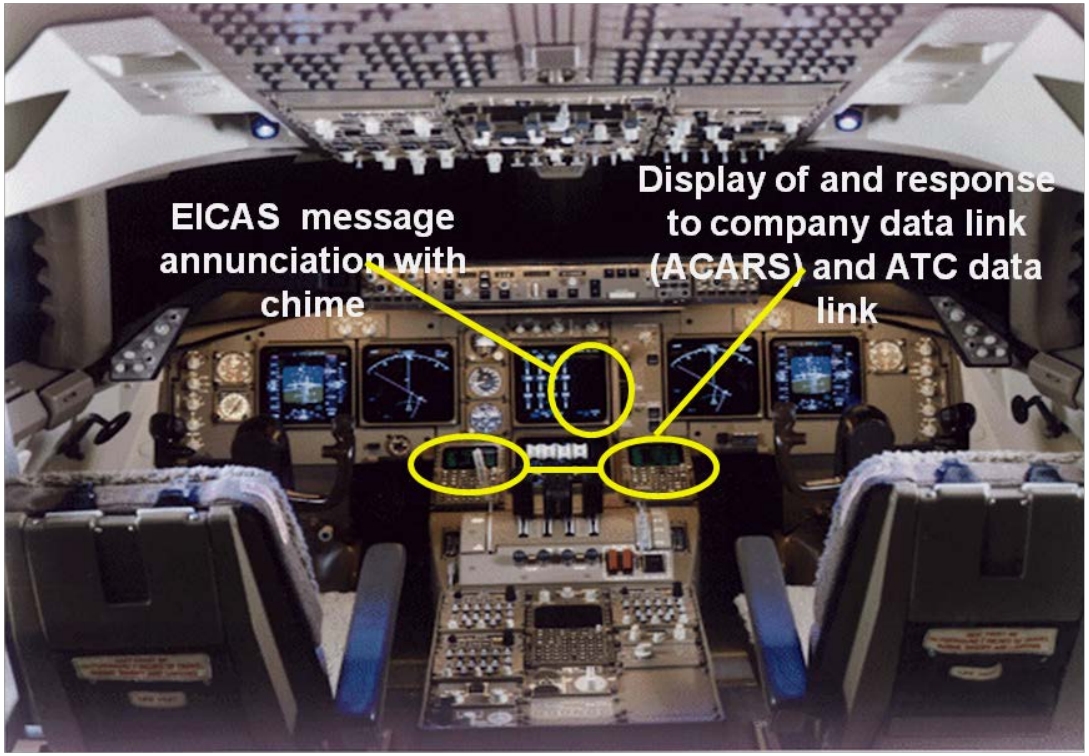
- FANS-1/A+ CPDLC uplink message latency detection function
- Loadable CPDLC uplink messages
  - 747-400 supports 10; 757, 767, and 777 support 15; 747-8 and 787 support 25
  - E.g., **`AT [position] CLEARED [routeclearance]`** loadable by FMC
  - E.g., **`CLIMB TO AND MAINTAIN [altitude]`** loadable by mode control panel (MCP)
- Glareshield-mounted **ACCEPT**, **REJECT**, and **CANCEL** CPDLC response buttons

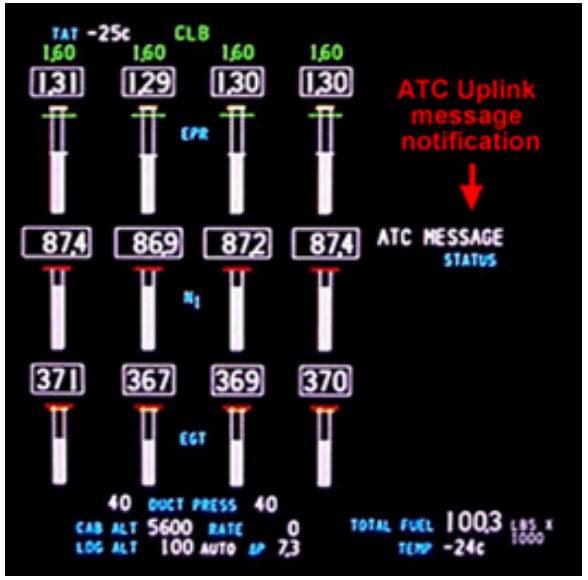
# Boeing: Evolving FANS Functionality (2/2)

- Large-format displays on 777 and 787 with dedicated display area ("data block")
- Dial feedback
  - E.g., if flight crew dials frequency contained in **`CONTACT [icaounitname] [frequency]`** instruction, then frequency shown in green (instead of white)
- Conditional clearance monitoring
  - E.g., if flight crew accepts **`AT [time] PROCEED DIRECT TO [position]`** clearance, then avionics provide visual and aural reminders of clearance at indicated time (or if clearance executed before indicated time)

# Boeing: 747-400 FANS Operation

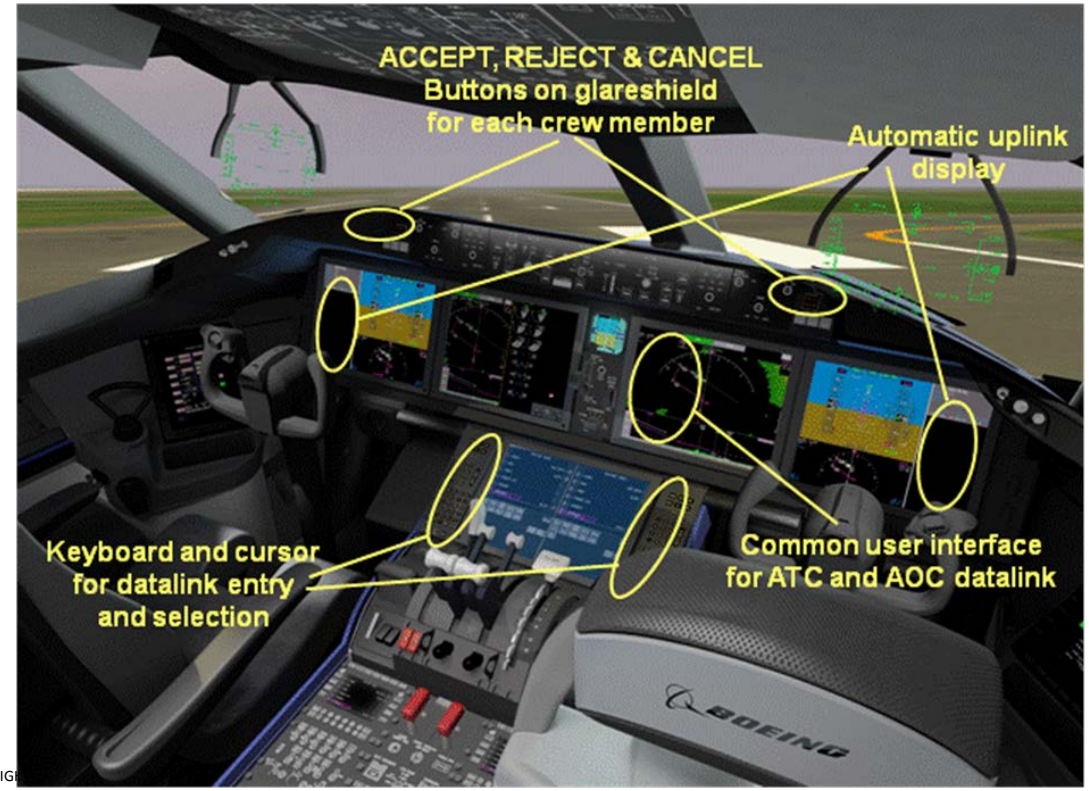
- MCDU provides primary interface
  - "ATC" key offers quick access to FANS functions
- EICAS provides **ATC MESSAGE** visual alerts
- MAWEA provides high-low chime aural alerts
- 737, 757, 767, MD-11 similar; all have MCDUs

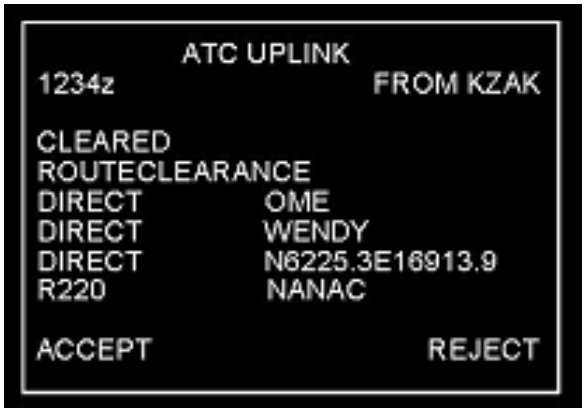



# Boeing: 787 FANS Operation

- Builds on 777 FANS operation
  - MFD and cursor provide primary interface, keyboard supports data entry
- Data block dual, larger, and in primary field of view
- EICAS provides **ATC** visual alerts and high-low chime aural alerts
- Glareshield-mounted CPDLC response buttons







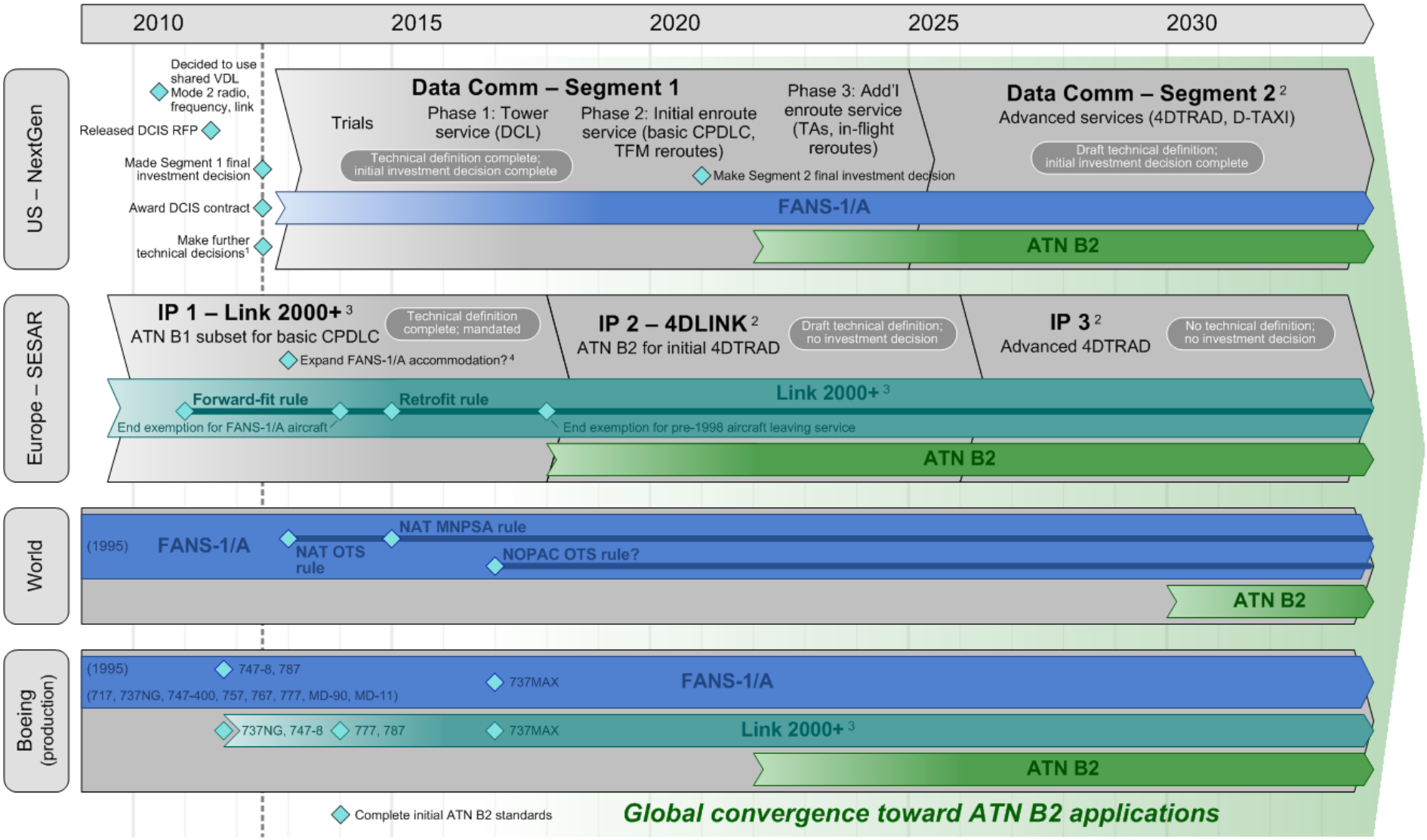
# Boeing: Avionics Labs

- Boeing operates multiple avionics labs
  - Avionics are same as those installed in actual airplanes
  - Avionics are connected to operational ACARS network
- Boeing occasionally performs limited FANS testing with ATS providers
  - ATS providers may be new to FANS or may be expanding existing FANS services
  - This testing is mutually beneficial because it supports both Boeing airplane and ATS provider system integration, test, and certification
- **Contact Boeing to discuss testing opportunities**

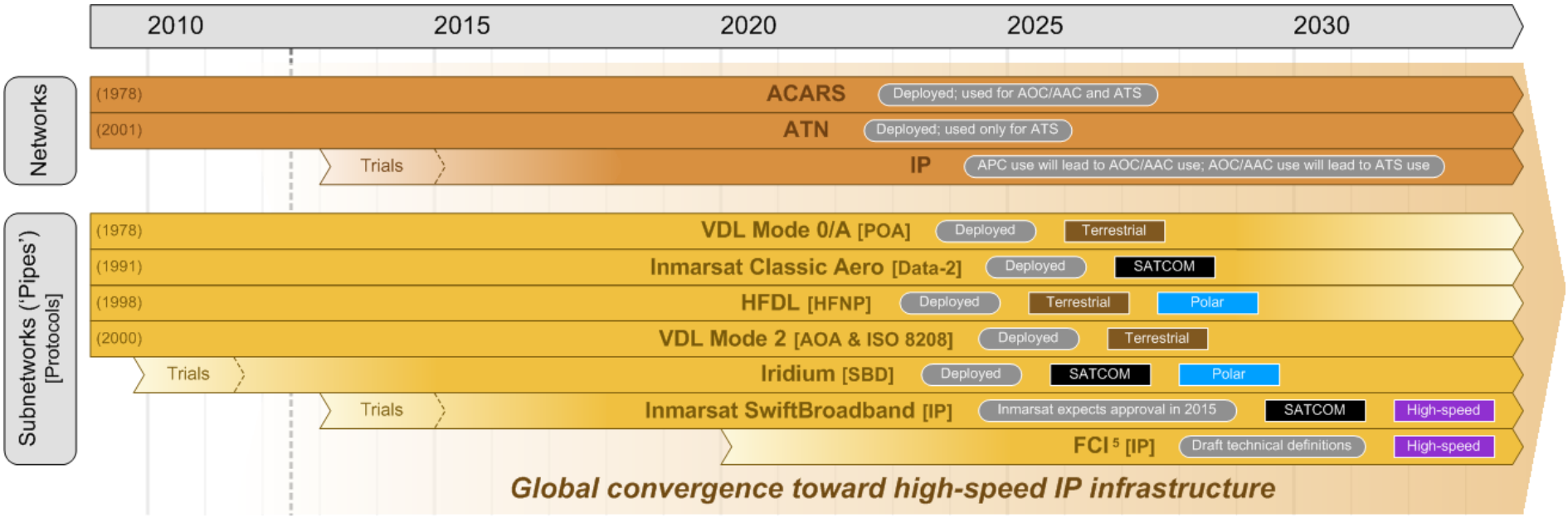
# Questions?

# *Backup*

# ATS Datalink Applications Timeline



# ATS Datalink Infrastructure Timeline



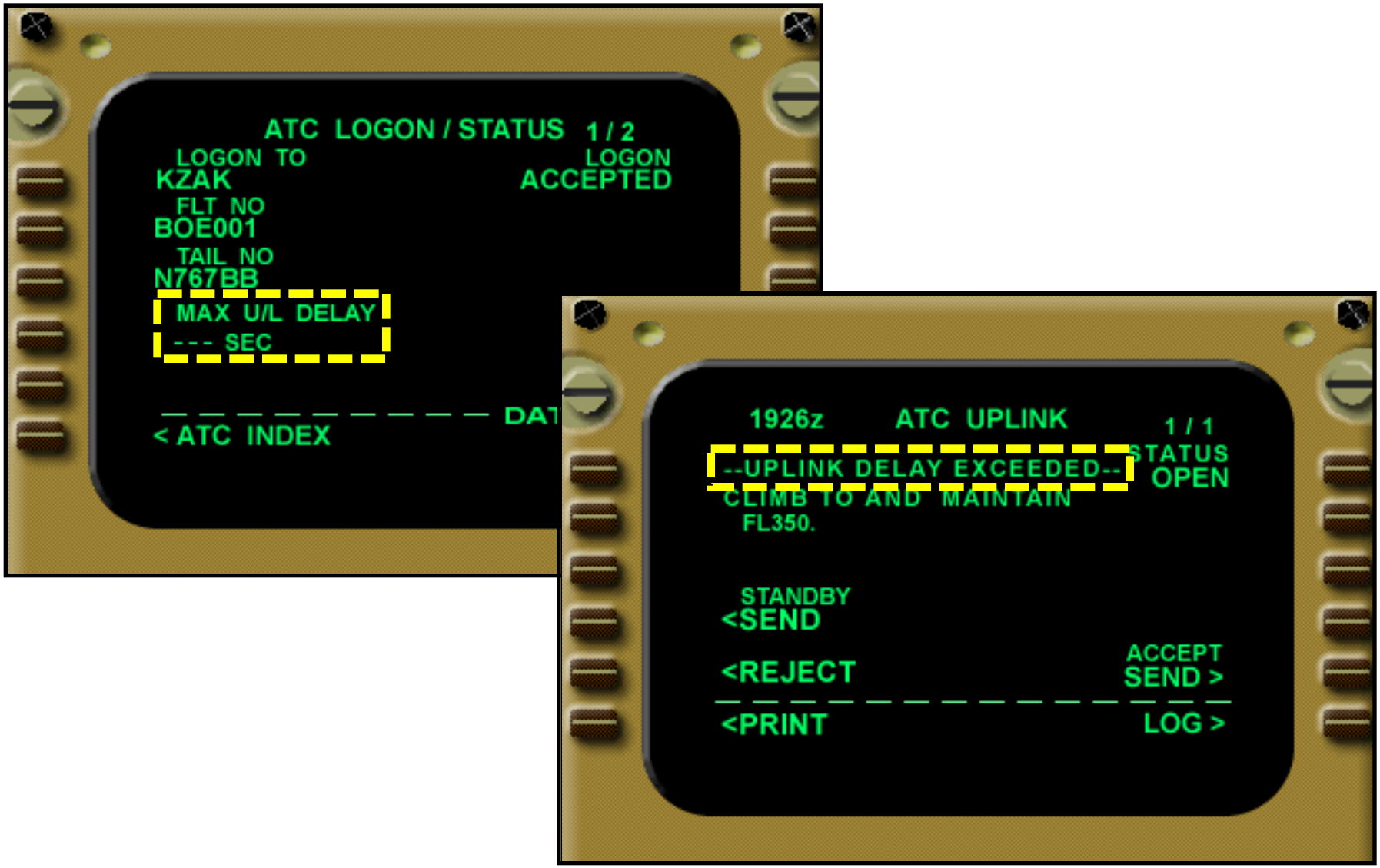
# Other ATS Datalink Application Sets

- Link 2000+
  - Subset of Aeronautical Telecommunications Network (ATN) Baseline 1 (B1) capability
  - Mandated in Europe for operation above FL285
  - Offers only about 25% of FANS-1/A+ functionality
  - Boeing FANS-2 is integrated combination of FANS-1 and Link 2000+ applications
- ATN Baseline 2 (B2)
  - In development by RTCA SC-214 & EUROCAE WG-78
  - Boeing FANS-3 will likely be integrated combination of FANS-1 and ATN B2 applications

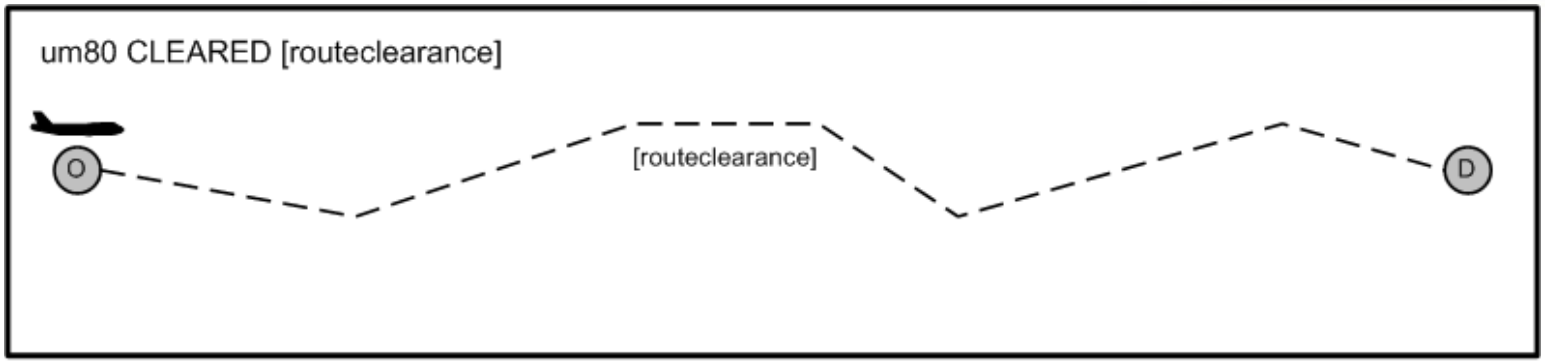
# FANS-1/A+ (1/2)

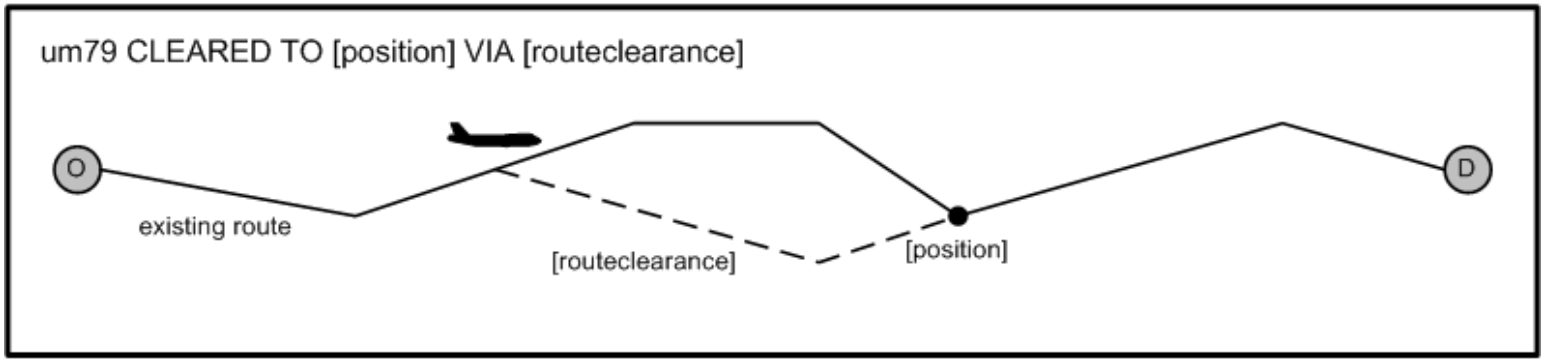
- Adds CPDLC uplink message latency (i.e., delay) detection function
- Driven by safety assessment for use in Europe
- Process
  - ATS facility sends maximum CPDLC uplink message latency value in free-text CPDLC uplink message
  - Crew manually enters value into avionics
  - Boeing: if avionics detect difference between current time and CPDLC uplink message timestamp that exceeds value, then avionics notify crew
    - Airbus: avionics discard message without notifying crew

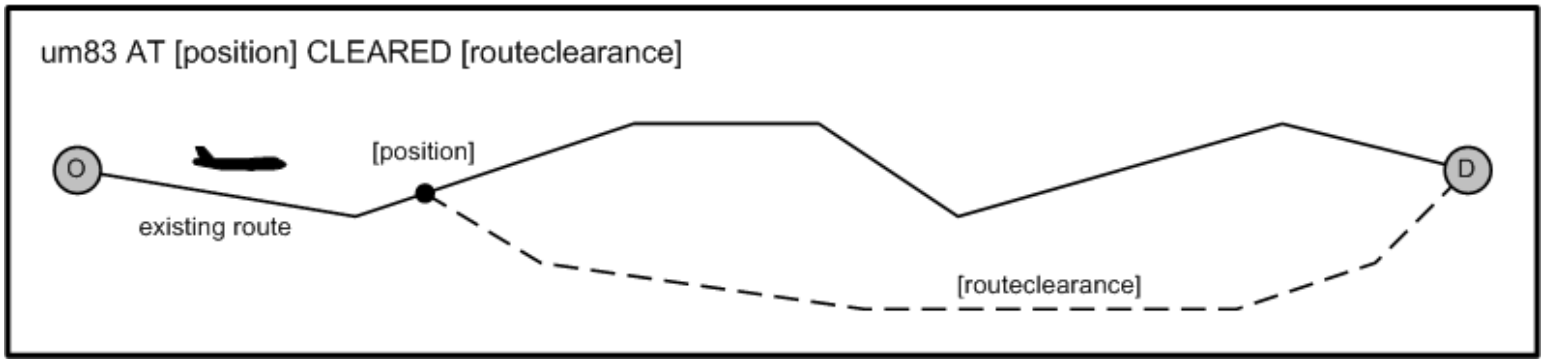
# FANS-1/A+ (2/2)



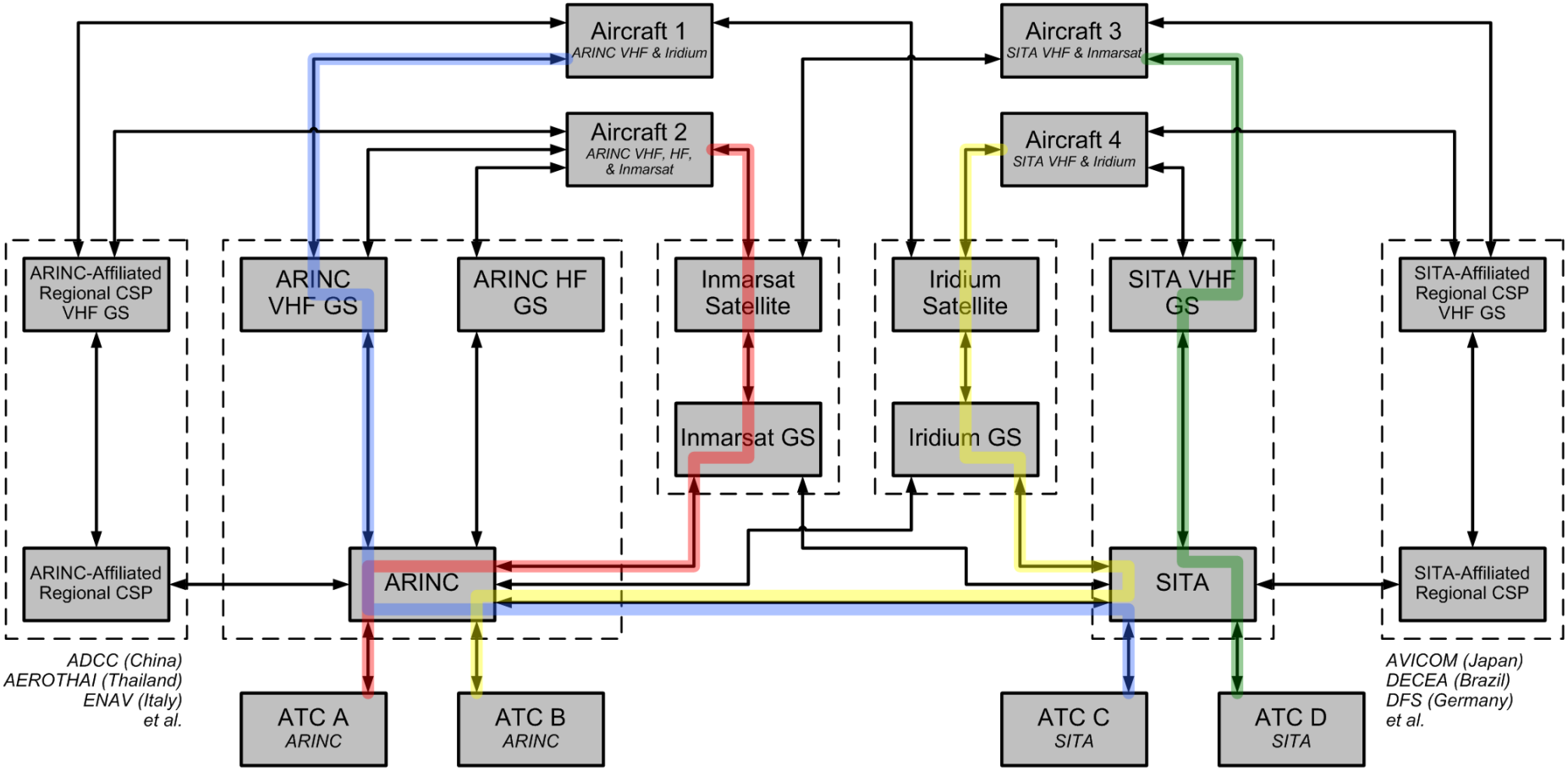
# CPDLC Route Clearances



# ACARS Networking & Internetworking




GS = Ground Station

= VHF path between ATC D (SITA) and Aircraft 3 (SITA)

= VHF path between ATC C (SITA) and Aircraft 1 (ARINC)

= Inmarsat SATCOM path between ATC A (ARINC) and Aircraft 2 (ARINC)

= Iridium SATCOM path between ATC B (ARINC) and Aircraft 4 (SITA)