ARINC PROPRIETARY

Future Air Navigation Systems (FANS):
Controller to Pilot Data Link Communications (CPDLC)
Automatic Dependent Surveillance (ADS)
IMPLEMENTATION

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DEDICATION BEYOND EXPECTATION

ICAO Seminar on the Implementation of Aeronautical Surveillance and Automation Systems in the SAM Region

San Carlos de Bariloche, Argentina, 6 to 8 December 2010

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Topics Covered – CPDLC, ADS-C, CFRS, CADS

- Corporate Briefing
- Definition of Terms
- Avionics
- FANS process and setting
- Types of Messages
- Process
- CADS & CFRS
- Implementation
- CAR/SAM, NAT AND World Implementation

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Corporate - Remarkable Beginnings

- Since 1929, we've been…
  - Connecting and protecting—people and assets
  - Streamlining and simplifying—operations and communications
  - Founded by airlines per mandate of the USA FCC
  - Providing operational support to the States in the CAR/SAM Regions since its commencement

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Corporate – ARINC Structure

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Corporate

- ARINC is…
  - World leader in transportation communications and systems engineering
  - Approximately 3,300 employees
  - Global in reach: 128 offices worldwide and customers in 140 countries (Airlines, Airports, ATC and Government Authorities)
  - Focused on Commercial and Business Aviation, Airport Operations, Security, Government Information Technology, Surface Transportation, Defense
  - Permanent Research and Investigation

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Corporate - ARINC Leads the Industry

- Milestones
  - **1978**: Deploys operationally ACARS
  - **1995**: FANS1/A
  - **1997:** Starts operations on HFDL, the only provider of HFDL
  - **1998:** Tests on CPDLC/ADS-C in CAR/SAM regions
  - **2000:** Operational deployment of VDLM2
  - **2002:** Provides operational ATN/VDL service for CPDLC as FAA CPDLC Build 1 (Miami ARTCC) communications service provider
  - **2004:** Provides operational ATN/VDL M2 service for CPDLC as Eurcontrol Maastricht communication service provider

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Corporate – Commercial & Business Aviation

- Nearly 10,000 commercial aircraft take off and land each day with ARINC's help.
- Voice and data services for airline operations control and air traffic control
- Global air/ground communication networks
- Aircraft fleet support and maintenance
- Every year, we deliver more than 2.5 million ATC messages—error free.
- RVSM Monitoring in CAR/SAM Regions.
- Airports, more than 325 airlines use our systems at 120 locations worldwide
- Effective flight planning and following

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Definitions

- FANS - Future Air Navigation System (1995)
- ADS-C – Automatic Dependent Surveillance (aircraft automatically sending position reports according to a "contract")
- CADS – Central ADS
- CPDLC - Controller-Pilot Data Link Communications
- WPR – waypoint position reporting
- Contract – An established relationship between and ATC facility and Aircraft. Accomplished by a Log-On request by the aircraft, uplink response, and a final acknowledged by the aircraft. Allowing ATS applications to proceed.
- SMI – Standard Message Identification - 3 character ground message "label" – defines the type of message and which part of the avionics will process the message
- Label – 2 character air-ground block label – an SMI translates to a label.
- MFI – Message function identifier – used by peripheral devices to identify the message function (the label, sub label are all the same, only the MFI tells you the type of message)

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Basics

- Aircraft Communications Addressing and Reporting System (ACARS®)
- FANS
  - Some ATC only contract to receive ADS (automatic position reports)
  - Some ATC do CPDLC (sending and receiving ATC commands) and ADS
  - Some ATC also receive automatic waypoint reports
- FANS messages bit-oriented within the ATS systems and the converted to characters for transport over ACARS protocols.
  - Called ACARS-Convergence-Function (See ARINC 622)
  - ATS text not human readable during transport
- FANS messages have an application layer (32 bit) CRC (Cyclic Redundancy Check) and contain the tail in the message itself to assure that the ATC traffic reaches the correct aircraft gets the message and that the message content is uncorrupted.

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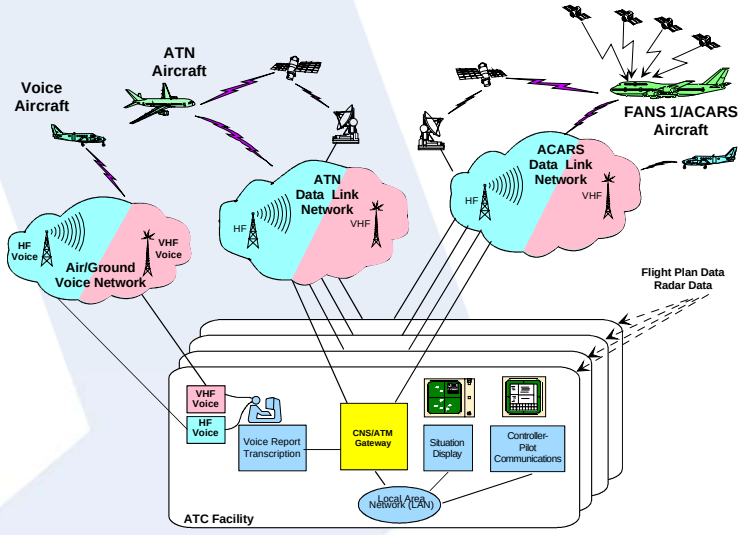
CPDLC/ADS-C - CNS/ATM Architecture



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Supporting media for FANS Application

- Satellite INMARSAT
- VHF Data Link
- VHF Mode 2 (VDL2) – 10 years operation 350 stations
- HFDL – High Frequency Data Link – In Process of Certification

– 14 stations

- Iridium – In Process of Certification

Original FANS 1 – FANS A

- BOEING
  - B-747-400, B-777, B-757, B-767
- AIRBUS
  - A-320, A-330/A-340

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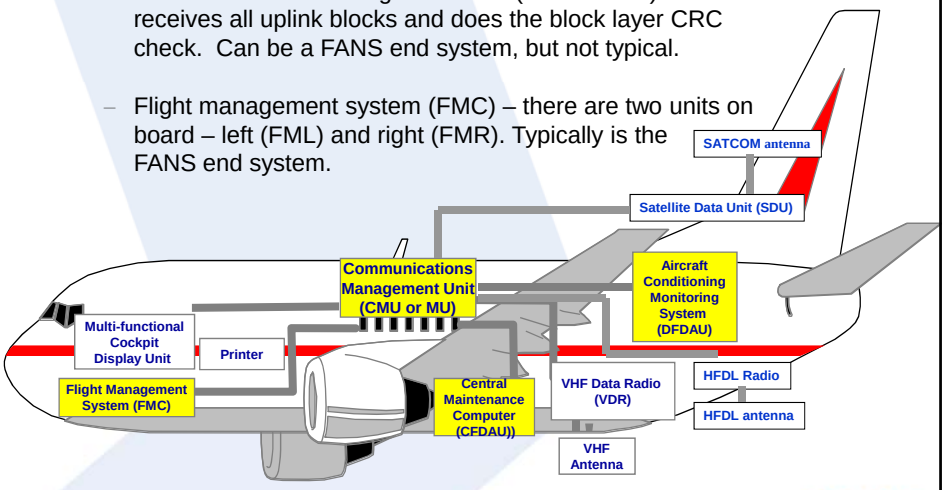
Key Components of Avionics sending - ACARS

- Avionics
  - Communications Management Unit (CMU or MU) – receives all uplink blocks and does the block layer CRC check. Can be a FANS end system, but not typical.
  - Flight management system (FMC) – there are two units on board – left (FML) and right (FMR). Typically is the FANS end system.



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What avionics equipment does FANS?

- FANS traffic can be handled either by the CMU (Communication management unit) or by the FMC (flight management computer). Which unit processes the traffic is determined by the software on the aircraft and also decide which SMI (Standard Message Identification) message set is used.
- MU – this might also be called a CMU (Communications management unit)
  - All messages to the aircraft pass through this unit first.
  - It either processes the message or passes to the peripheral devices.
- FMC – This is a peripheral device (Flight management system).
  - The data to this unit goes through the MU first and is passed on to the FMC.
  - This unit processes flight information – flight plans, winds,
  - Data can be manually entered by the pilot or automatically loaded through uplink messages
  - There are two FMC units on board – left and right (FML and FMR)
  - An input sent to the aircraft will go to the active FMC unit. Otherwise, the SMI will tell you which FMC computer is sending/receiving.
- Label/SMI
  - Label is used on uplinks/downlinks – air/ground,
  - SMI is used on inputs/outputs – ground)

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ACARS MU/CMUs Supporting the FANS Applications

- Message Path
  - Antenna (HF, VHF, SATCOM, Iridium, VDL2) to MU
  - MU does the block layer CRC (error) check is done to confirm each uplink block is correct
  - MU assembles the message and does the application layer CRC before displaying the message.
  - If the FANS message information is to be entered in the FMC – it must be done manually
- Label/SMI - these are directed to the MU
  - The MU uses the labels that are the A# on uplinks, B# on downlinks
    - Label - SMI - purpose
    - A0 – AFU – Initial contact (Uplink) from ATC
    - B0 – AFD – Initial contact (Downlink) from aircraft
    - A6 - RAR – Uplink Request ADS (position)
    - B6 – PAR – Downlink ADS (position) Report
    - AA – ATC – message from ATC
    - BA – ATC – message to ATC
    - There are additional “A” series uplinks and “B” series downlinks, but not currently in use. Some, such as B5 – POS, are used by the airline operations, so check the receiving address.

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Types of FANS messages: How to recognize them…

- In the free text of the message
  - AFN – log-on request/reply message (input or output)
  - CR1 – contract request (found on inputs only) – establishing ADS reporting
  - CC1 – confirm contract (found on outputs only)
  - DR1 – disconnect either empty or with an error condition (found on outputs only)
  - DIS – disconnect confirm from aircraft – normal disconnect (found on outputs only)
  - ADS – ADS message (input or output)
  - AT1 – CPDLC – aircraft controller directions or response from pilot (can be input or output) Directions to climb, descend, wilco, etc.

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Logon process – Required for any other FANS Exchange

- Logon between aircraft and ATC must occur first. This is basically a handshake.
  - 15-45 minutes prior to entering airspace, aircraft should initiate logon.
  - During a handoff, the ATC might initiate the logon.
  - This is the A0 from the ATC and the B0 from the aircraft.
  - The Log-on is necessary before ADS, CPDLC or WPR can occur.
  - The filed flight plan tail and flight number must match what the aircraft is using
  - The airline must be approved for the connection.
  - If the aircraft initiates the connection, it will use the 4 letter code for the ATC. The datalink service provider will translate the 4 letter code to a 7 character address for the ATC.
  - If the ATC initiates the connection, it will use the 7 letter code and the aircraft will respond with the 7 letter code.

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ADS process

- ADS connections
  - There can be up to 5 connections
  - All ADS connections have equal status
  - After the logon, the ADS contract will be sent immediately to the aircraft by the ATC.
  - Outputs will have “ADS” in the message text.
  - When the aircraft leaves the ATC airspace, the ATC will terminate ADS reporting (DIS uplink and downlink response)
  - If ADS report is overdue to the ATC or if the pilot or controller notices intermittent operation, either may elect to revert to voice reporting.
  - If controller becomes aware of corrupt or incorrect data, establish voice
  - If datalink fails, revert to voice.

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CPDLC Process

- CPDLC connections
  - There can be up to 2 connections
  - Only one can be active at any time.
  - Transfer from one ATC to another should be automatic
  - When a CPDLC message is received by the aircraft or controller that is unexpected or illogical , then revert to voice for clarification
  - Up to 5 message elements can be sent with the same message, but the number of elements should be kept to a minimum.
- Types of commands
  - Change altitude
  - Change course
  - Change voice ATC frequency
- Each command requires a response from the pilot or ATC. It might be as short as a Wilco, but it requires a response message.
  - Example: If the ATC orders a change in altitude, the pilot must respond with a wilco acknowledgement through a downlink message.

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ATC handoff Process

- The aircraft can have up to 4 connections simultaneously
  - This is in case of a 4 ATC region is crossed
- Procedure for handoff
  - New ATC establishes connection contract
  - Aircraft responds with ack to the new ATC
  - Old ATC sends up the cancel all contracts, terminate connection
  - Aircraft responds by sending sending down a disconnect response

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CNS/ATM Functions with non-FANS ATC Centers - CADS

- Centralized ADS – CADS
- Is a service provided by the Data Link service Provides
  - CADS translates FANS/ADS POS and MET for CAA's non equipped with CNS/ATM capable system
  - Message is converted to free text and send it via AFTN
  - Message applications
    - ATS facilities notification (AFN)
    - Automatic dependent surveillance (ADS)
    - Meteorological messages
  - Same information can be provided to airlines flight operations centers

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CNS/ATM Functions with non FANS aircrafts - CFRS

- Centralized Flight Management Computer (FMC) Waypoint Reporting Service (CFRS)
  - Allows non-FANS-equipped aircraft to send position reports in a manner similar to CADS
  - Position Reports from aircraft that have FMC WPR (Flight Management Computer Way Point Reporting) capability
  - Honeywell PIP (Product Improvement Package) or Pegasus avionics required
    - Boeing 757-200, Boeing 767-300, Airbus 310, Airbus 319

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Reasons for implementation CPDLC/ADS-C

- To take advantage of the avionics on board
- Situational awareness
- Surveillance and Traffic separation
- Search and Rescue
- ATC able to authorize RNAV Routes
- Promote new technologies
- Enhance Safety

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Considerations Previous implementation

- Traffic Analysis
- ADS-C/CPDLC equipped aircraft on the FIR
- Coordinate with adjacent FIRS
- Determine coverage
- Study possibility of using CFRS
- Review GOLD – Global Operational Data Link Document
- Evaluate the progress of ATN World Wide
- Integrated to the ATC center or stand alone display
- Select a Data Link Service Provider
- Coordinate with the FIT FANS 1/A Interoperability Team

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ARINC - CNS/ATM Gateway

- The CNS/ATM Gateway can be used as an ARINC stand-alone system or be integrated with an existing ATC system. Gateway modules are integrated with ATC equipment supplied by Aerospace Engineering, Alenia, Camp Systems, Hughes, Lockheed Martin, NITA, Northrop Grumman, Raytheon, Telephonics, and others.
- Supports seamless, simultaneous communications with voice, data link, FANS-1/A, and ATN-equipped aircraft
- Works with any air/ground network, not just ARINC's

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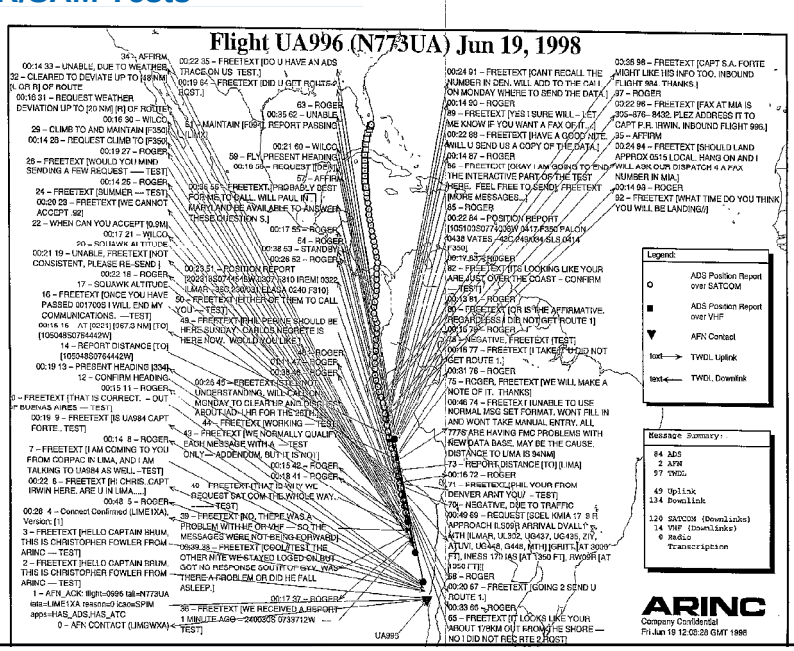
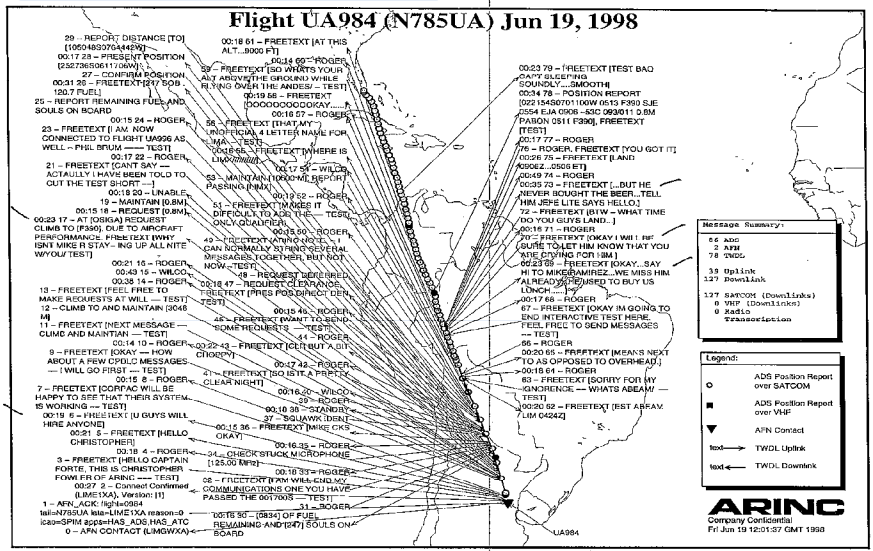
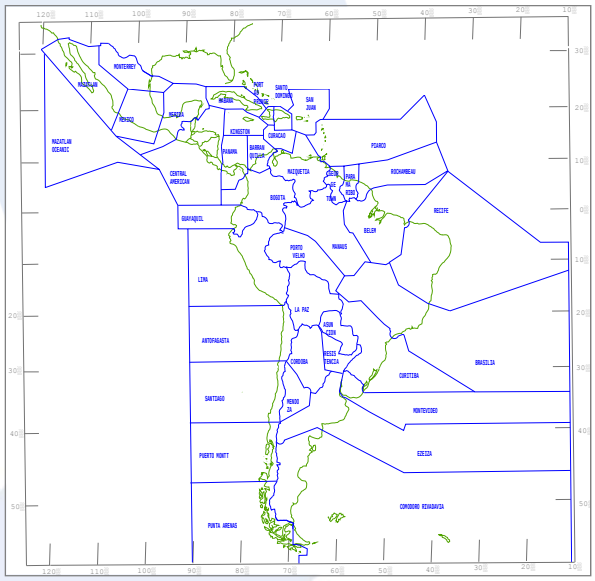
CAR/SAM Tests



CAR/SAM Tests



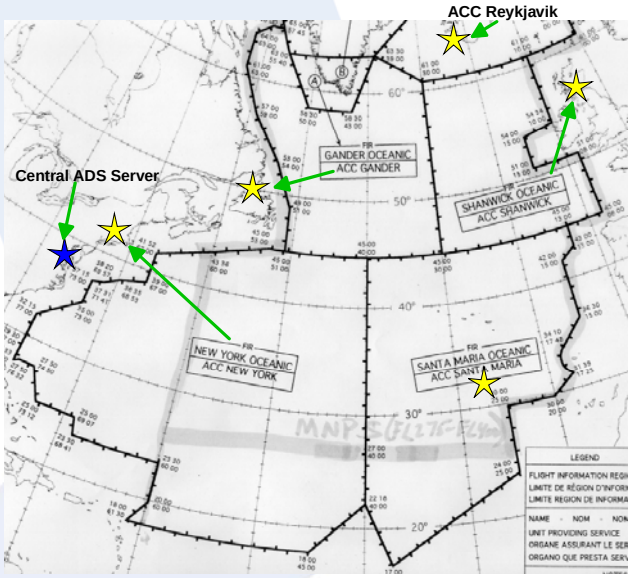
CAR/SAM – Implementation



CAR/SAM – Implementation

Recife	Brazil	DECEA
Atlantico	Brazil	DECEA
Curitiva	Brazil	DECEA
Montevideo	Uruguay	DINACIA (on Process)
Ezeiza	Argentina	ANAC
Comdo Rivadavia	Argentina	ANAC
Punta Arenas	Chile	DGAC
Puerto Mont	Chile	DGAC
Satiago	Chile	DGAC
Antofagasta	Chile	DGAC

North Atlantic



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Example on the NAT Airspace – Who does what?

- ADS (Automatic Dependent Surveillance – automatic position reporting)
  - Gander (CZQX)
  - Shanwick (EGGX)
  - Reykajvik (BIRD)
  - Santa Maria (LPPO)
  - Bodo (ENOB)
  - New York (KZWY)
- CPDLC (Controller Pilot Data Link Communication)
  - Gander
  - Shanwick
  - Reykjavic
  - Santa Maria
  - New York
- WPR (Waypoint Reporting)
  - Gander
  - Shanwick
  - Reyjavik
  - Santa Maria
  - Bodo
- CADS (Central Automatic Dependent Surveillance)
  - ARINC CADS - DDLCAXA
  - SITA CADS - QXSCDXS

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World Implementation

Anchorage	USA	FAA
Auckland	New Zealand	ACNZ
Bangkok	Thailand	AEROTHAI
Beijing	China	CAAC
Bodo	Norway	Avinor
Brisbane (Northern)	Australia	Airservices Australia
Cairo	Egypt	EHAC
Calcutta	India	AAI
Canarias	Spain	AENA
Chengdu	China	CAAC
Christchurch	New Zealand	ACNZ
Colombo	Sri Lanka	AASL
Edmonton	Canada	NAV Canada
Gander	Canada	NAV Canada
Guangzhou	China	CAAC
Harbin	China	CAAC
Ho Chi Mihn	Vietnam	VATM
Hong Kong	China	CADHK
Jakarta	Indonesia	AP II
Johannesburg	South Africa	ATNS
Kunming	China	CAAC
Lanzhou	China	CAAC

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World Implementation

Lhasa	China	CAAC
Maastricht	Eurocontrol	Eurocontrol
Madras	India	AAI
Magadan	Russia	Russia FAA
Manila	Philippines	ATO
Mauritius	Mauritius	DCAM
Melbourne (South)	Australia	Airservices Australia
Nadi	Fiji	Airports Fiji Limited
New York	USA	FAA
Oakland	USA	FAA
Papeete	Tahiti	STNA
Reykjavik	Iceland	ICAA
Santa Maria	Portugal	NAV Portugal
Seoul	Korea	KAA
Shanghai	China	CAAC
Shanwick	UK	UKNATS
Singapore	Singapore	CAAS
Tashkent	Uzbekistan	CAA Uzbekistan
Teheran	Iran	CAO – IR
Tokyo	Japan	JCAB
Ulan Bataar	Mongolia	DCA
Urumqi	China	CAAC

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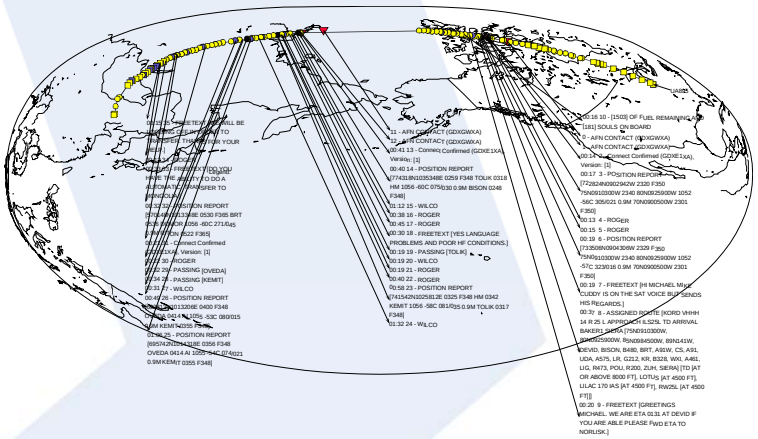
First United Polar Flight
Flight UA895 (N107UA) Chicago-Hong Kong = Jan 20, 1999



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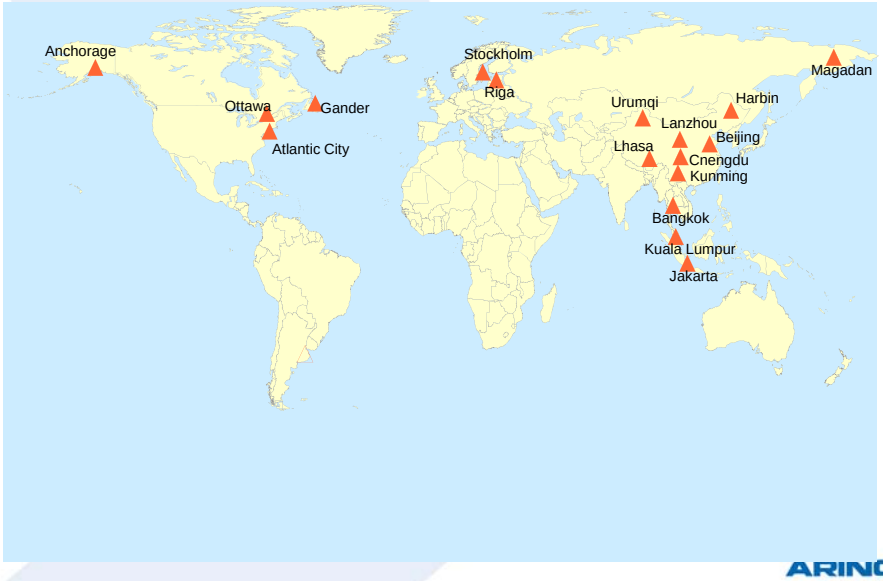
ARINC's CNS/ATM Installations



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Thank you for your attention