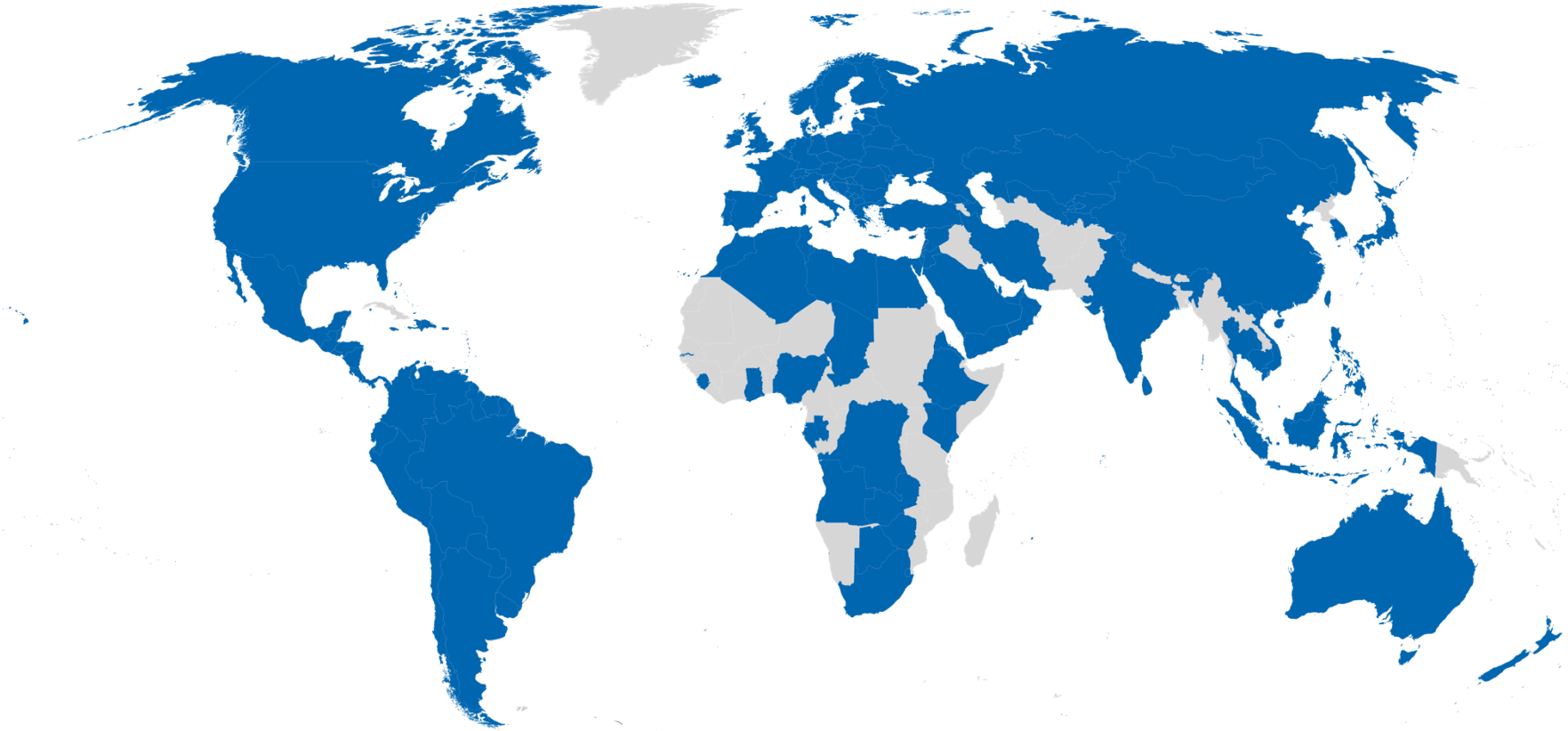
ADS-C/CPDLC

Automation System and Integrated Telecommunications for Air Navigation Services/System-Wide Information Management Workshop (AUTO/SWIM)
Mexico City, Mexico 21 – 24 April, 2014

Manny Gongora

Rockwell Collins
Building trust every day

Our Global Presence



Information Management Services Overview

Extensive Communications, Network Engineering and Systems Integration Capabilities

Market Sectors include—Aviation, Airports, Transportation, Security, Government, Aerospace

Global Headquarters in Annapolis, MD with Regional Headquarters in London and Singapore

Customers in over 140 countries

Focused Expertise. Flexible Capabilities. Sustainable Solutions.

Aviation

The largest Voice & Data Network in the world delivers pole-to-pole coverage for more than 300 Airlines

NextGen DataComm for the FAA

eEnabled DataComm Solutions Modernize Aircraft and Revolutionize Business Processes for Airlines

Comprehensive Suite of Business Aviation Services

Airports

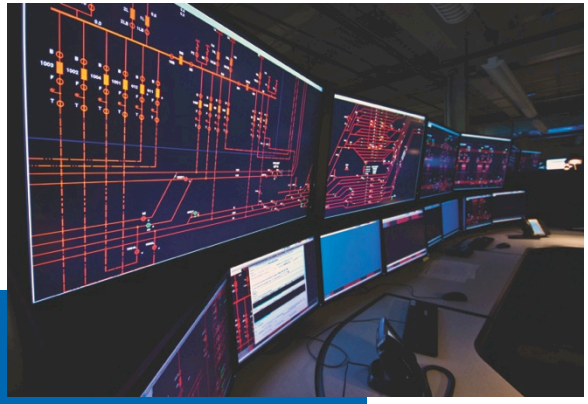
Industry-defining Passenger Processing Solutions at more than 100 Airports Worldwide

Master Systems Integration

First-of-their-kind Self-Serve Technology, Security Innovations, and Cloud Solutions

Aviation and Airports – Curb to Curb

Transportation



North American Leader in Command and Control Centers for Railroads

Information Management and Supervisory Control Systems used by more than 200 trains

8 million passengers in 16 major metropolitan areas utilize ARINC transportation technology

Uniquely positioned to deliver federally mandated Positive Train Control systems in the next decade

Security

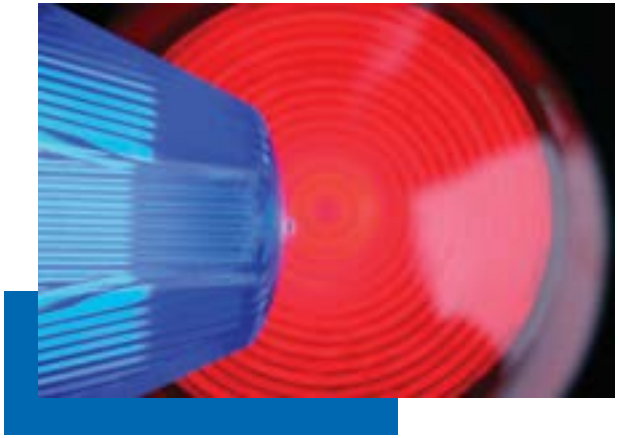
Integrated Systems for Critical National Infrastructure

Command and Control Systems at
more than half of the Nuclear Plants in the U.S.

Advanced Airport and Border Control Security Solutions

Global Network Security Solutions

Government



Radio Interoperability Solutions for Police, Fire and EMS personnel

Military Aviation Support

FAA Support

Electronic Border Control Solutions

DATA LINK MEDIA

ARINC Data Link Media

Truly Worldwide coverage

VDL Mode 2

VHF ACARS

HF Data Link

INMARSAT

Iridium

Delivering over 1.5 million messages per day

Serving 200+ customers

ARINC HF/VHF Communications Media

VHF ACARS

- 1100 ground stations around the globe

VDL Mode 2

- 428 stations in 19 countries

HFDL

- 15 HF Ground stations using multiple frequencies
- Double, even triple redundancy in geographic coverage, including polar regions
- The FAA has accepted PARC CWG's recommendations to approve FANS Over HFDL for RCP/400 Operations as defined in GOLD

ARINC Satellite Communications Media

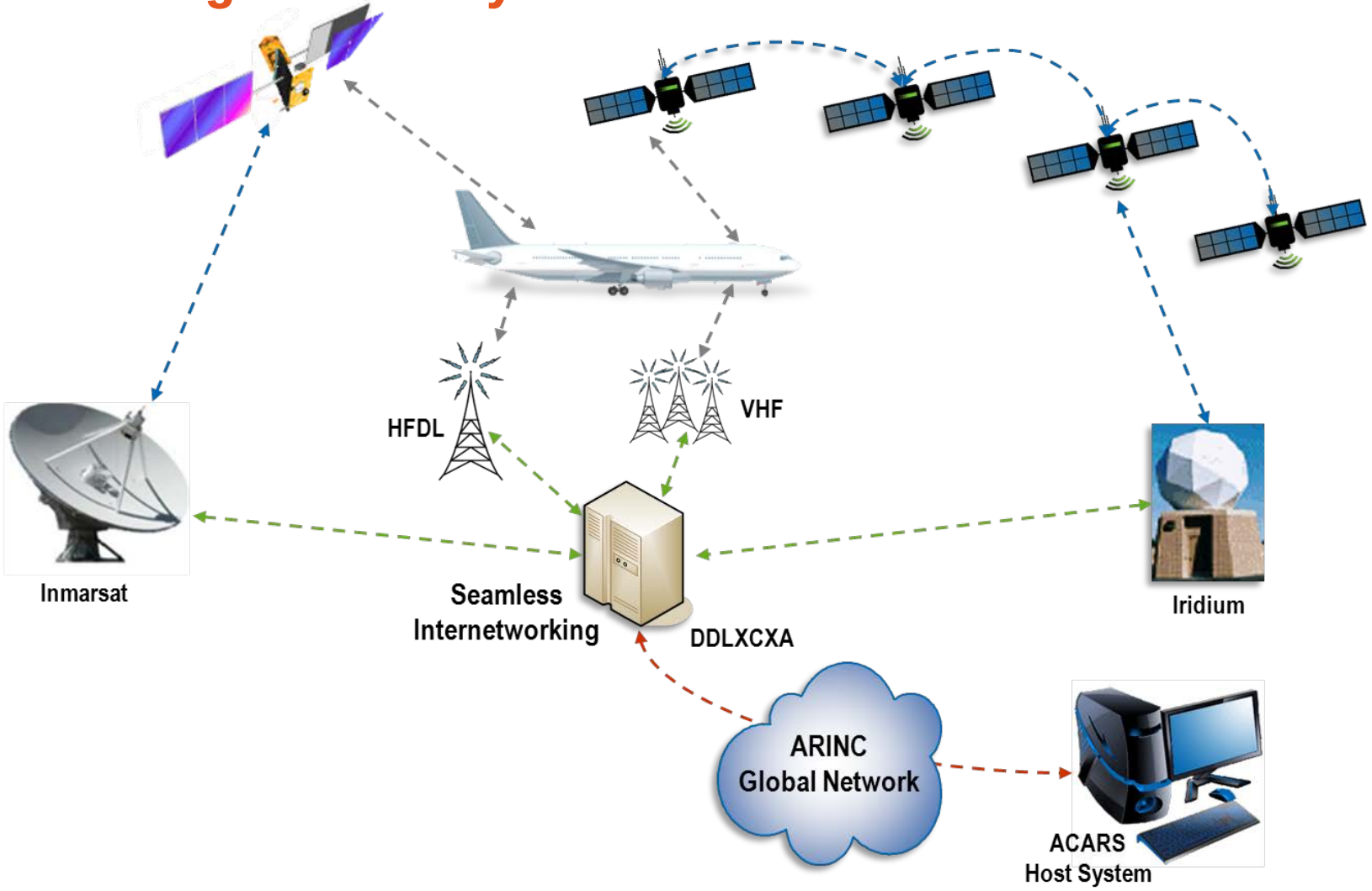
Inmarsat

- Continuing to offer Classic Aero services over the I-3 and I-4 satellite networks
- ARINC was named Distribution Partner (DP) by Inmarsat for SwiftBroadband service

Iridium

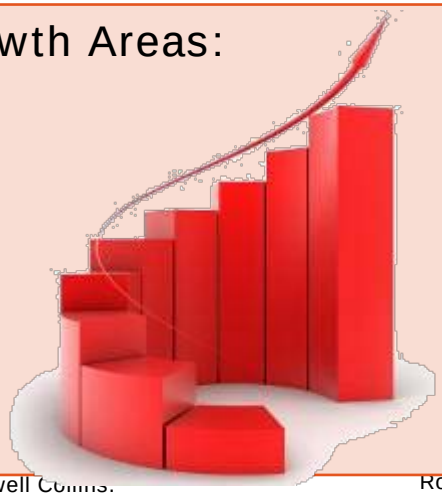
- 66 low-earth orbit (LEO) satellites providing global coverage
- Iridium NEXT Service life extension to 2025 and beyond is planned
- Currently supporting ~400 aircraft

Message Delivery in a Multi-Media Environment

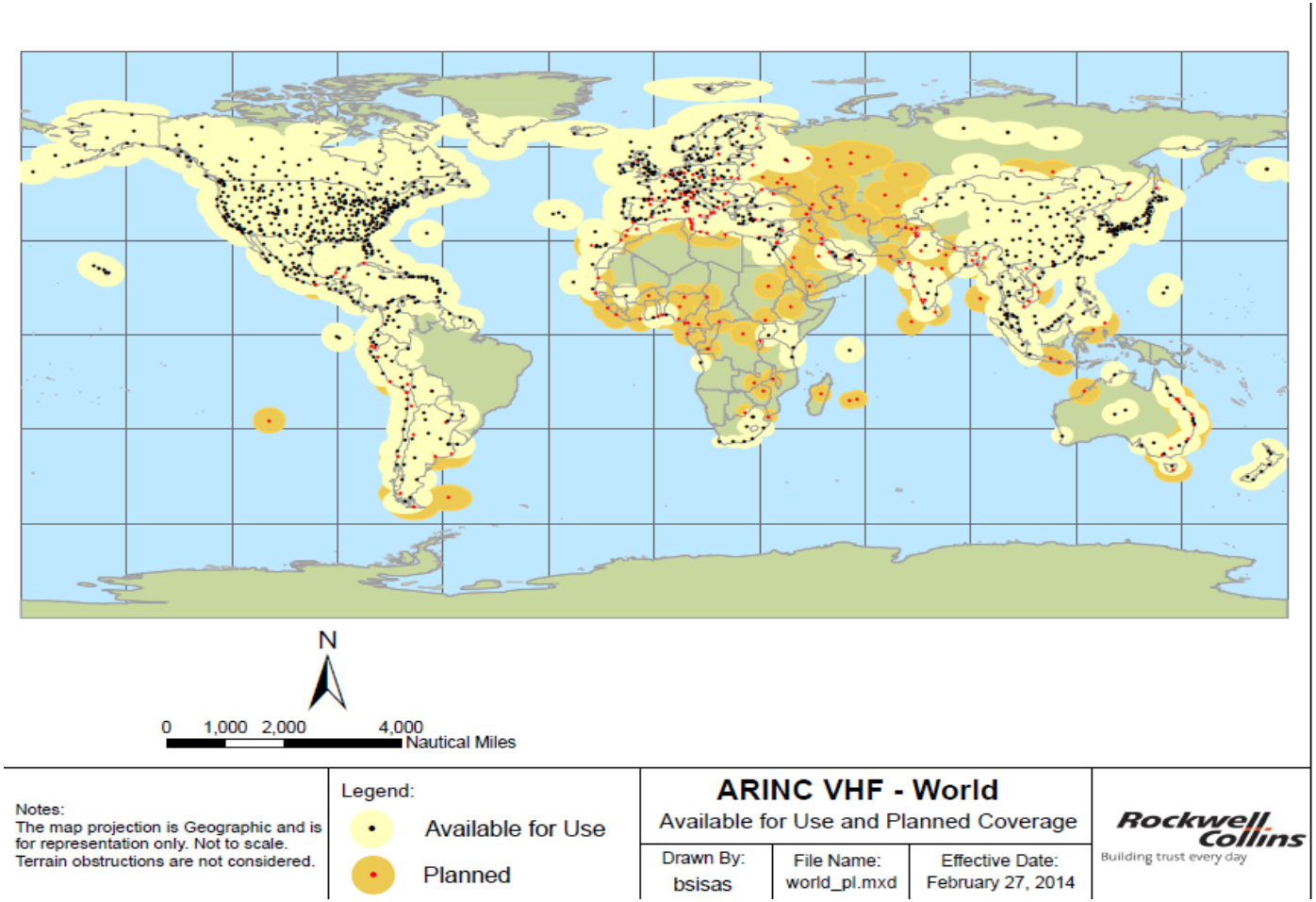


ACARS DATA Link Coverage

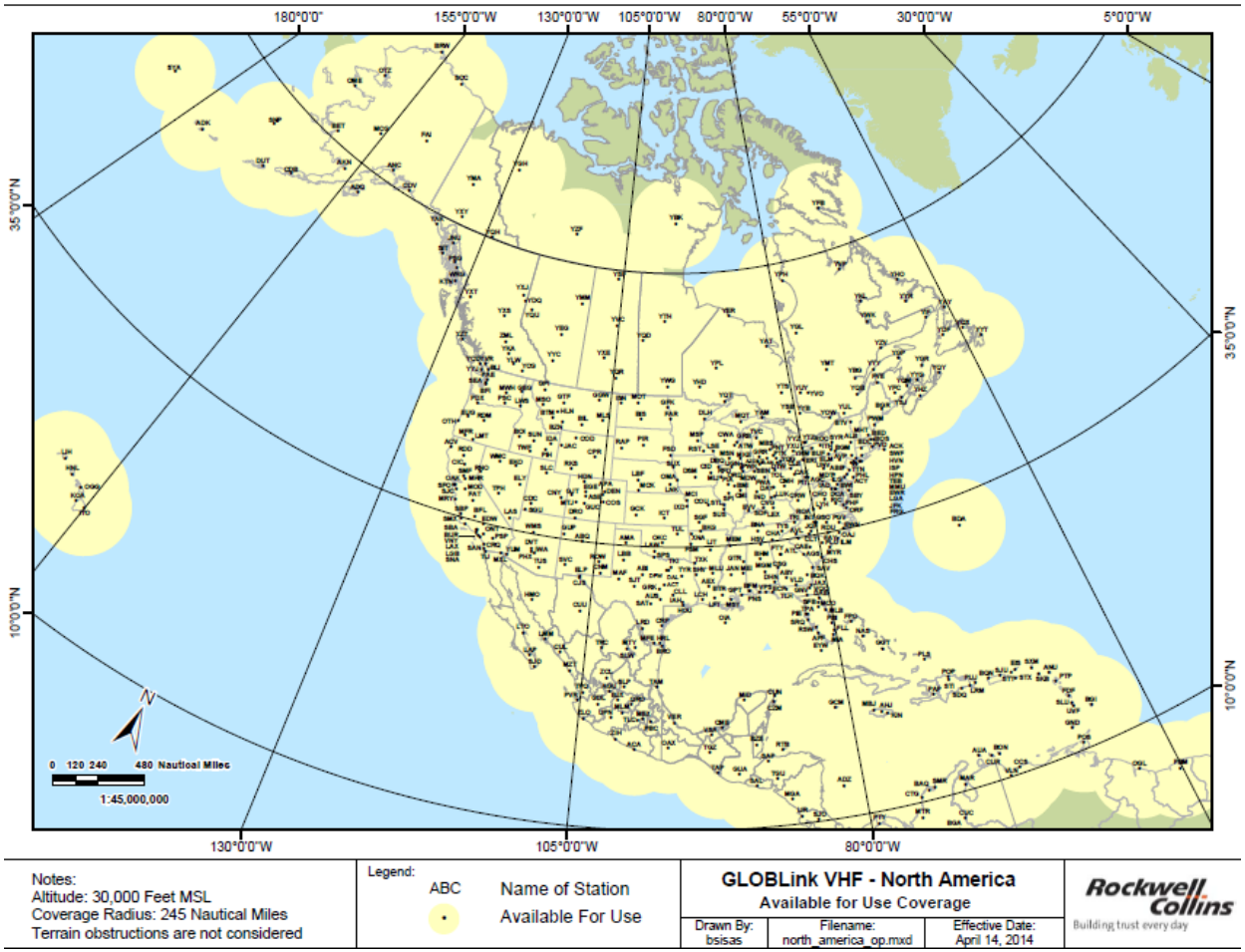
GLOBALink Service Statistics

Messages per Month:	47 Million >1 Billion VHF Kbits in 2011
Monthly Aircraft	17,000+ globally
Classic VHF Stations	1,100+ stations
VDL Mode2 Stations	400+ stations
2012 YTD Uplink Message Success:	98.9% (POA) / 99.0 (AOA)
VDL Block End-to-End Transit (Ave):	1.9 seconds
Major Growth Areas: 	Latin America; South Pacific; India, Malaysia; Eastern-Europe/Middle-East 162 Stations in South/Central America Adding 40+ VDL RGSs in Europe in 2012

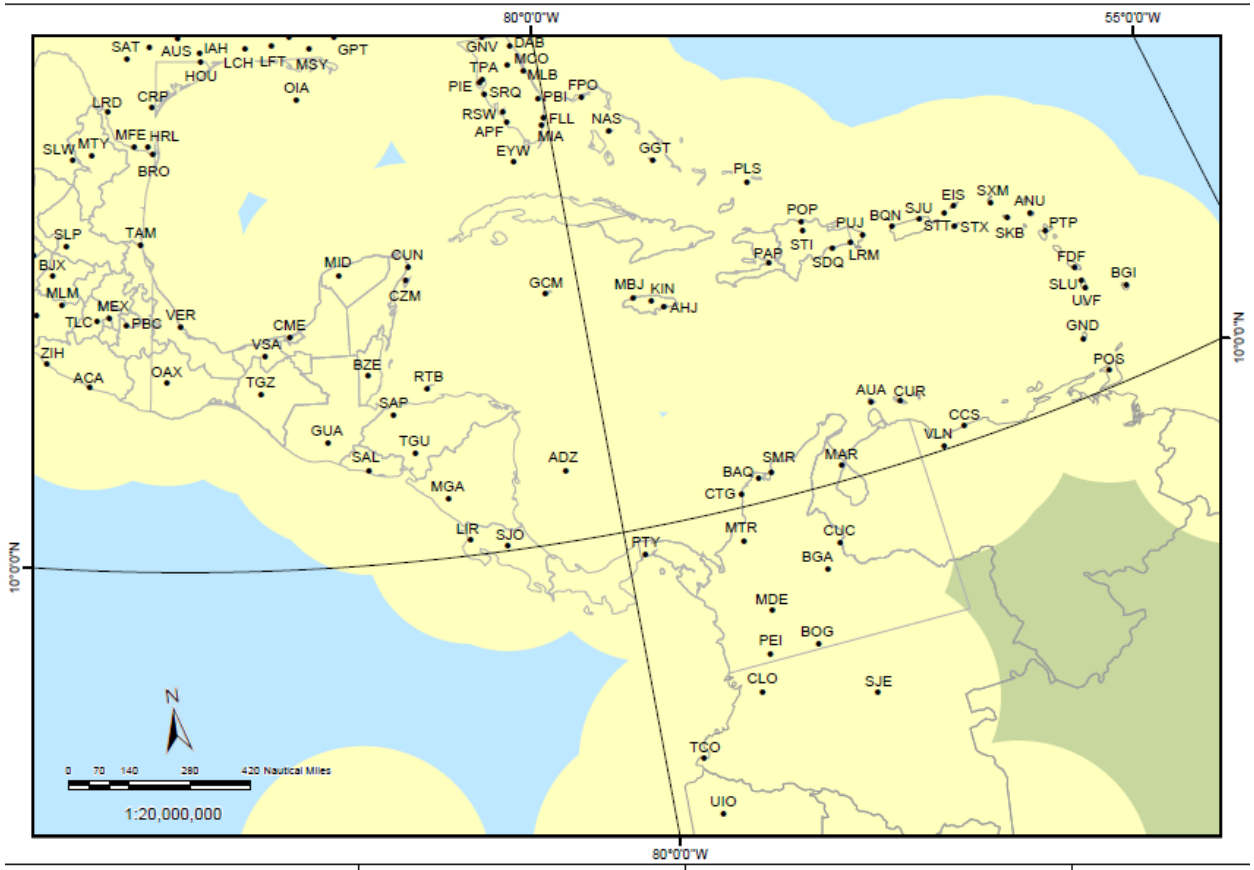
GLOBALink VHF Coverage



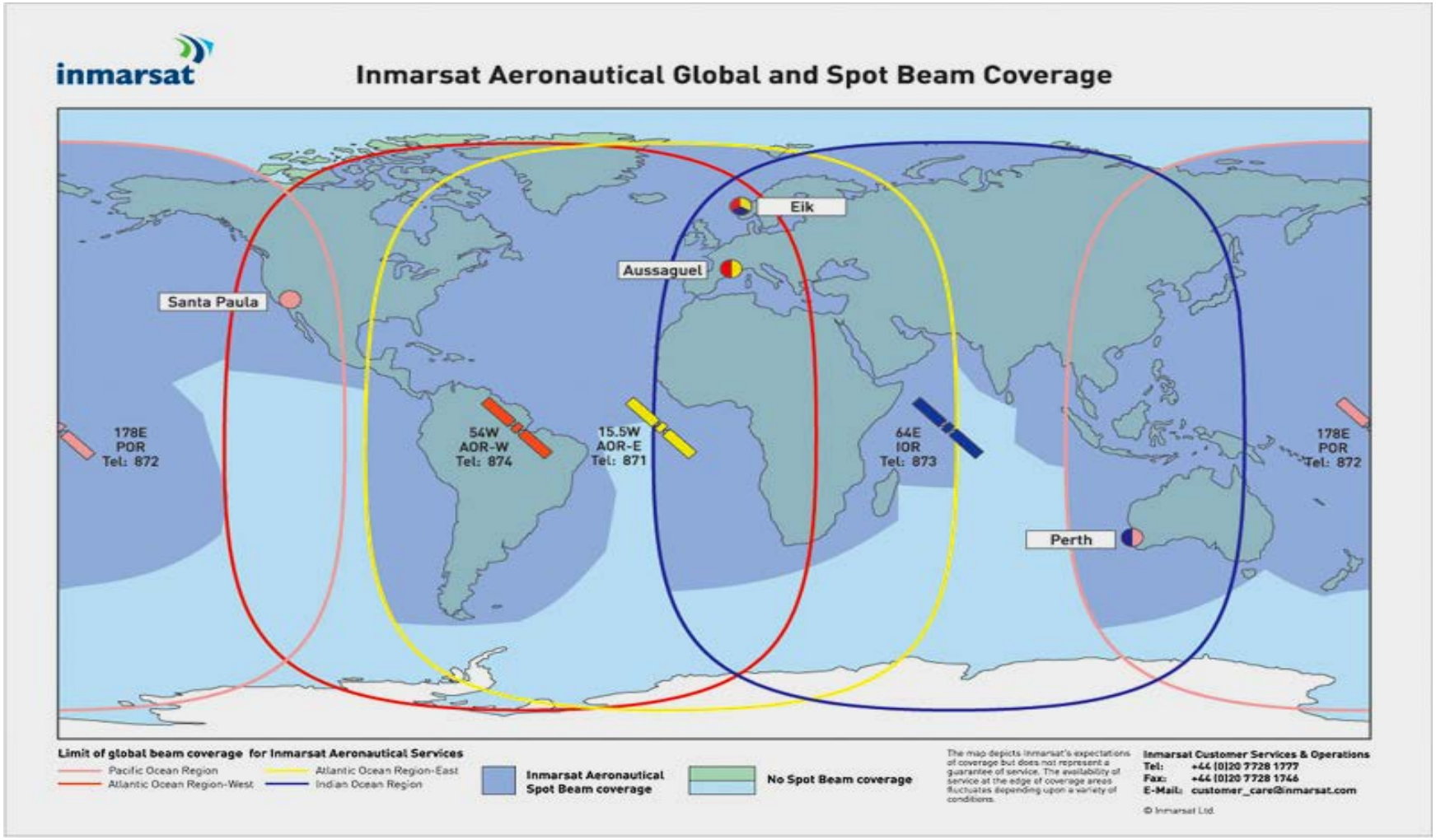
GLOBALink / VHF Coverage Map – North / Central America



GLOBALink / VHF Coverage Map – Caribbean

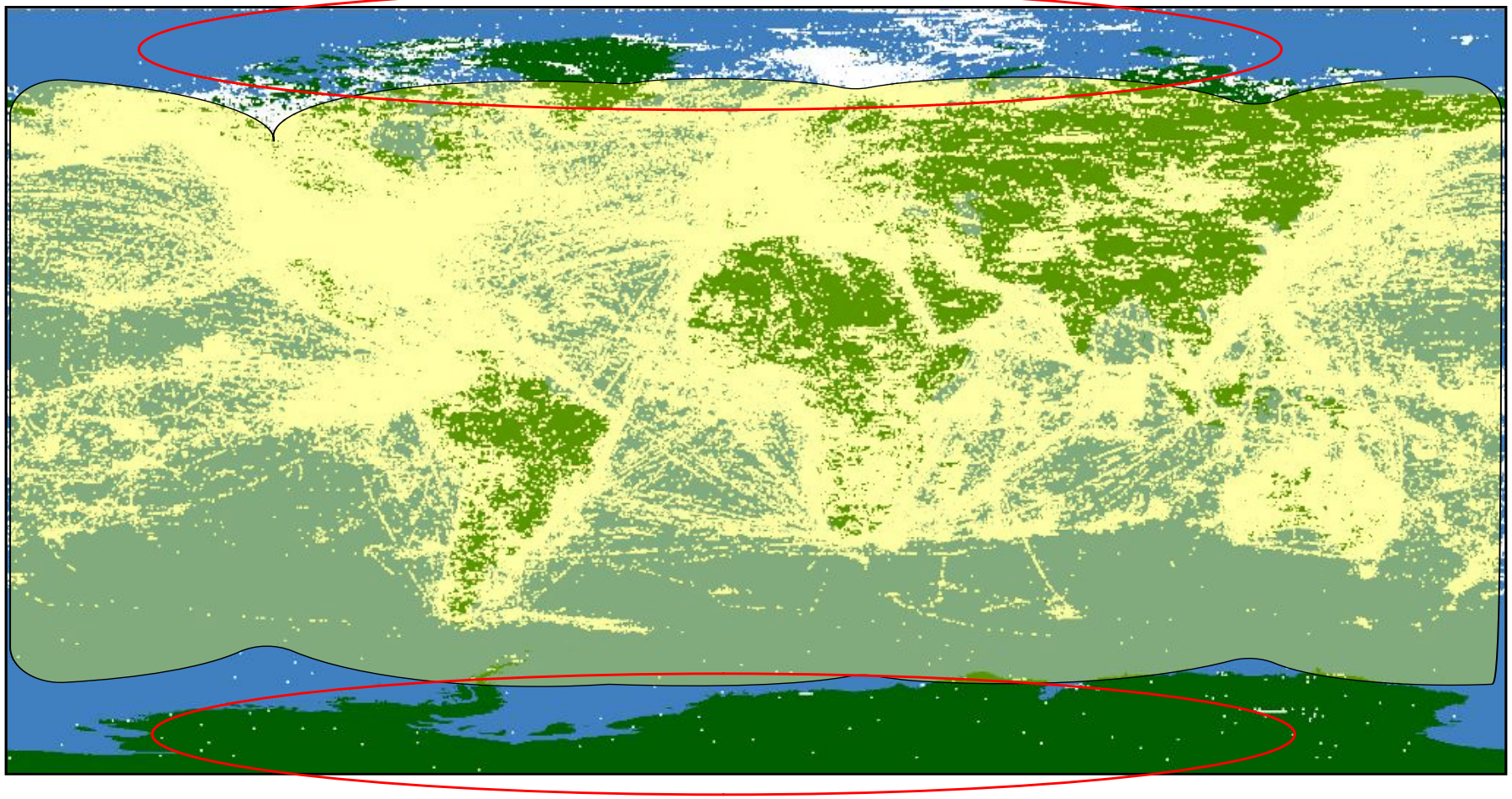


Inmarsat Coverage Map

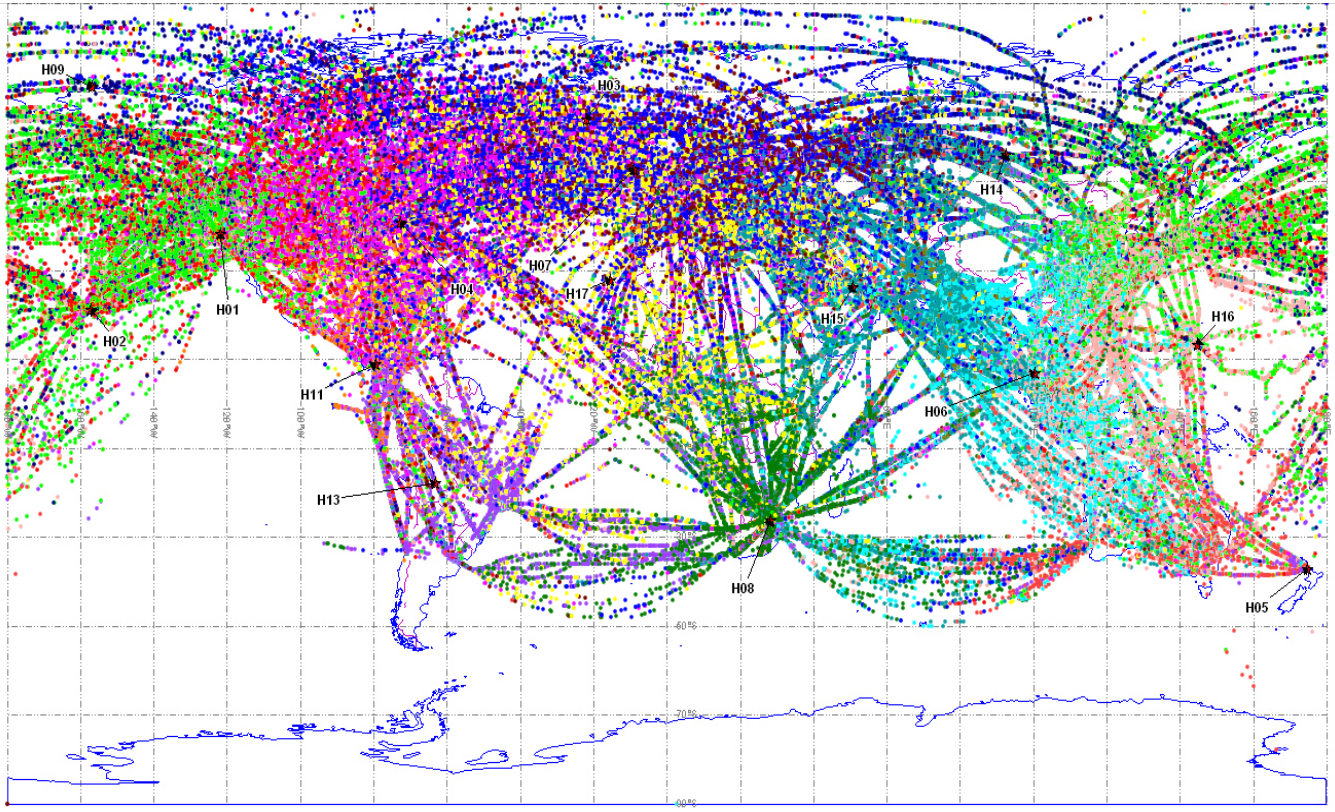


Iridium Coverage

Iridium complements HFDL in GLOBALink coverage



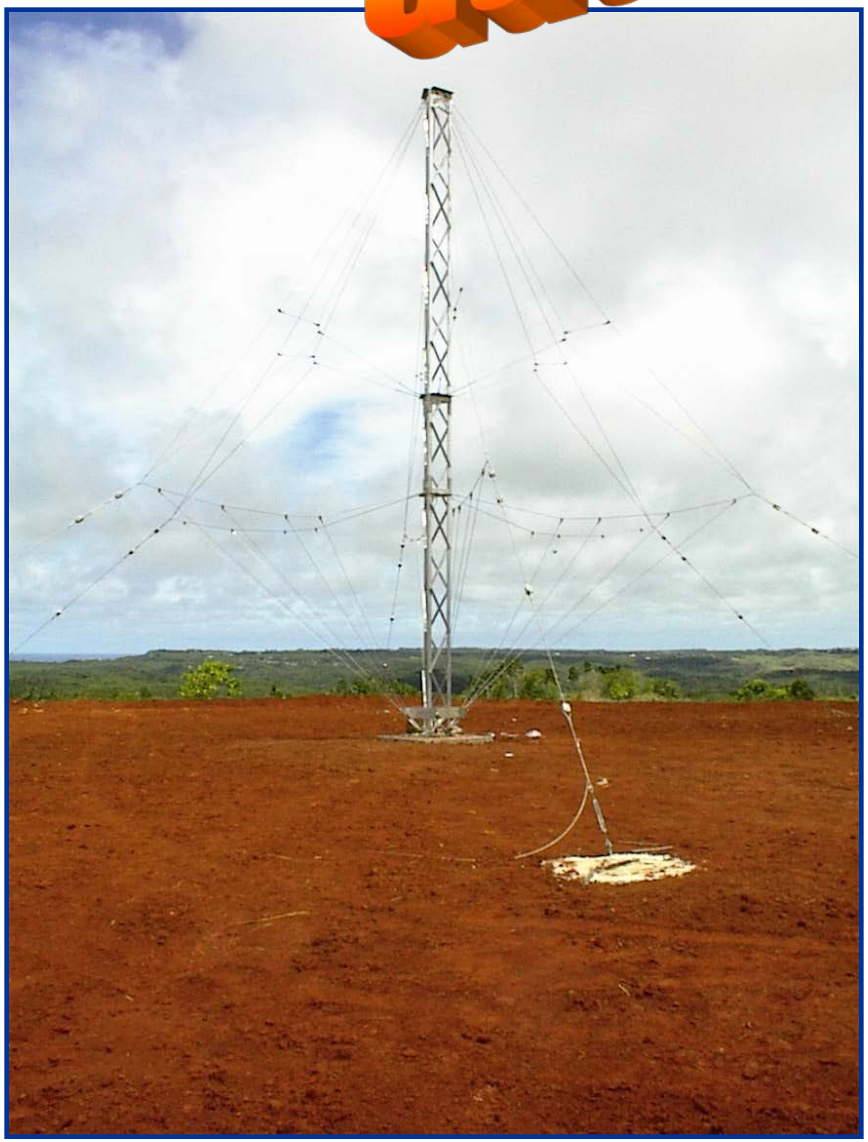
HFDL Coverage / Usage

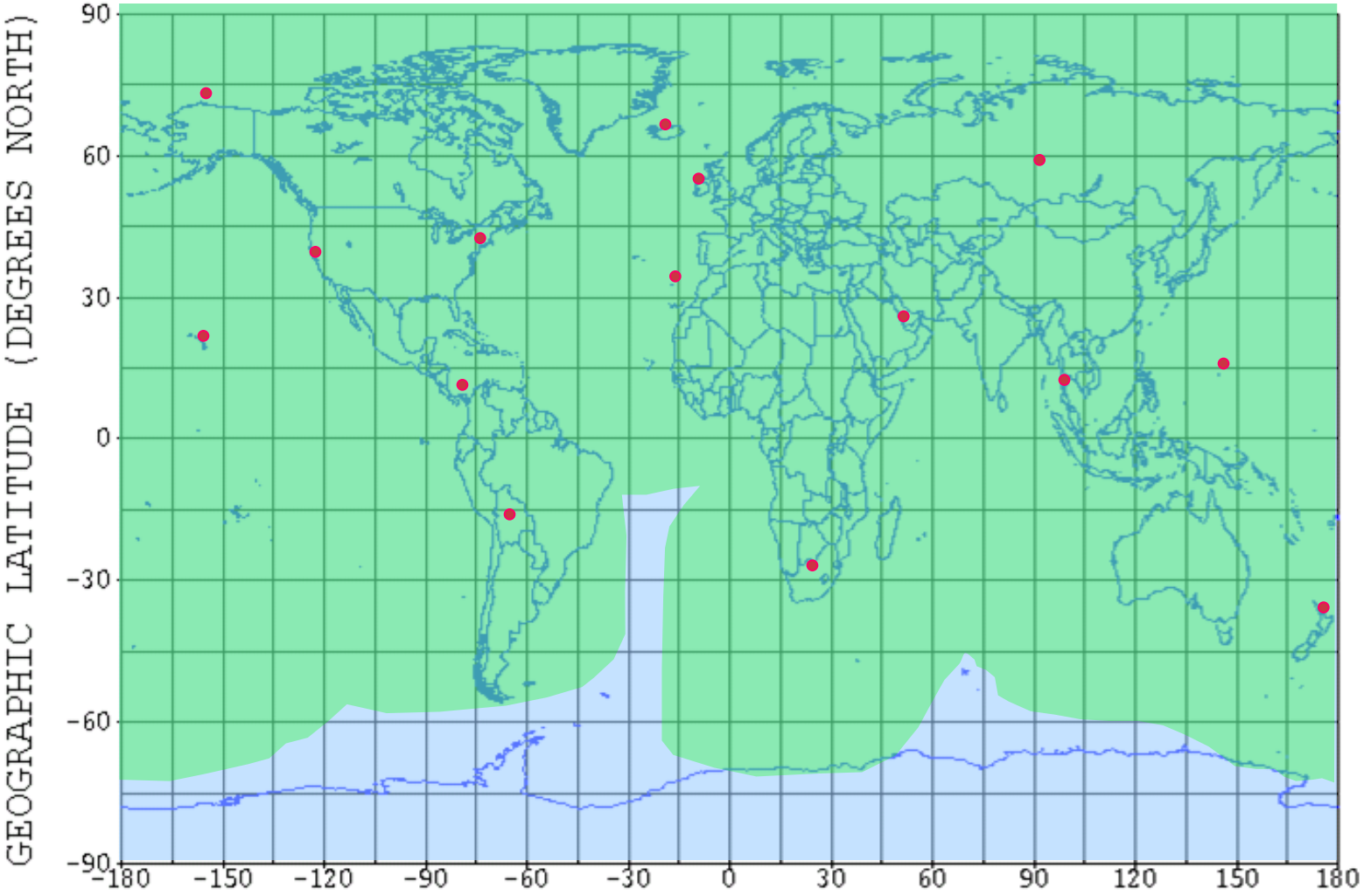


GLOBALink HFDL

HFDL Ground Stations

San Francisco, CA, U.S.A (H01)
Molokai, HI, U.S.A. (H02)
Reykjavik, Iceland (H03)
Riverhead, NY, U.S.A. (H04)
Auckland, New Zealand (H05)
Hat Yai, Thailand (H06)
Shannon, Ireland (H07)
Johannesburg, South Africa (H08)
Barrow, AK, U.S.A. (H09)
Panama City, Panama (H11)
Santa Cruz, Bolivia (H13)
Krasnoyarsk, Russia (H14)
Al Muharraq, Bahrain (H15)
Yona, Guam (H16)
Telde, Canary Islands (H17)





HF Ground Stations

Alaska
Bahrain
Bolivia
California
Canary Islands
Guam
Hawaii
Iceland
Ireland
New York
New Zealand
Panama
Russia
South Africa
Thailand

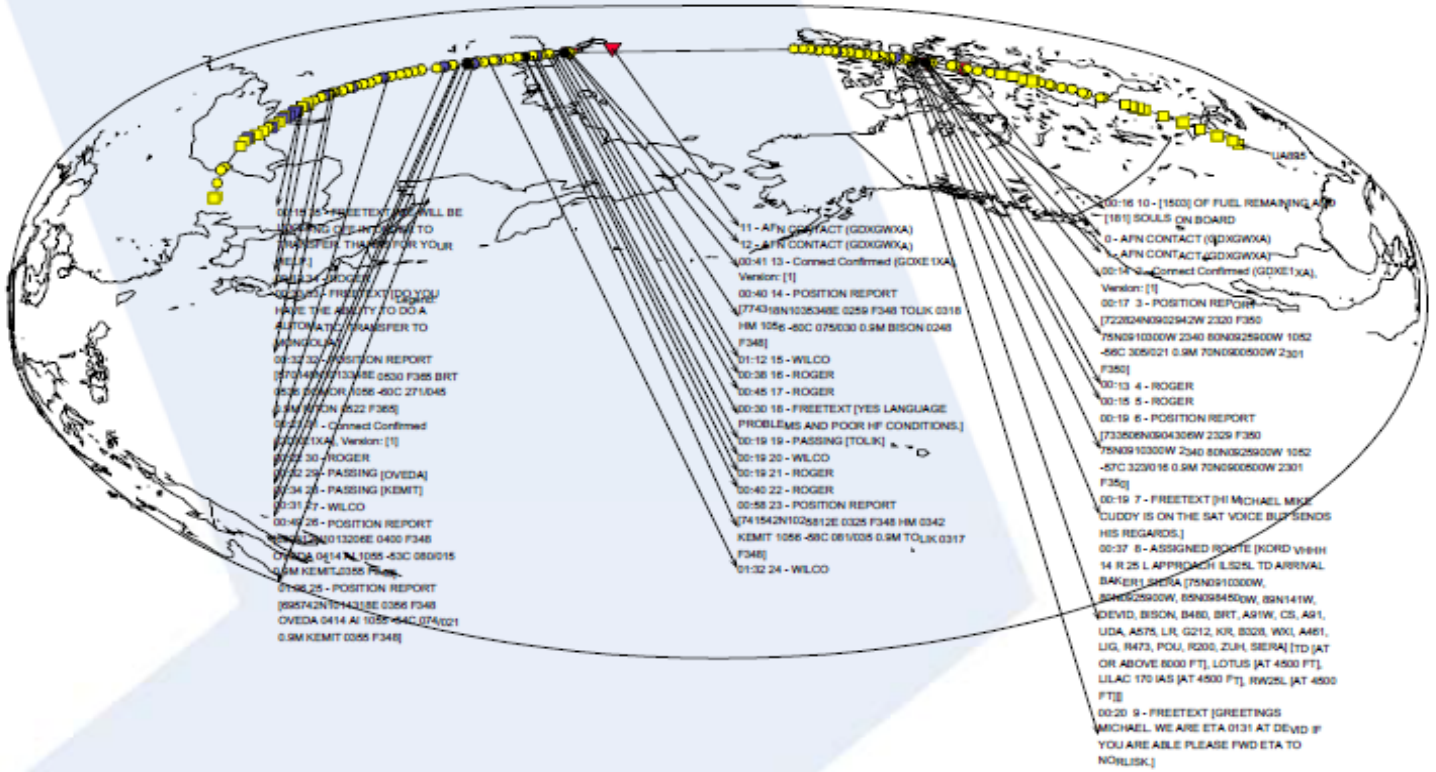
Legend

- HFDL ground station

Rockwell Collins

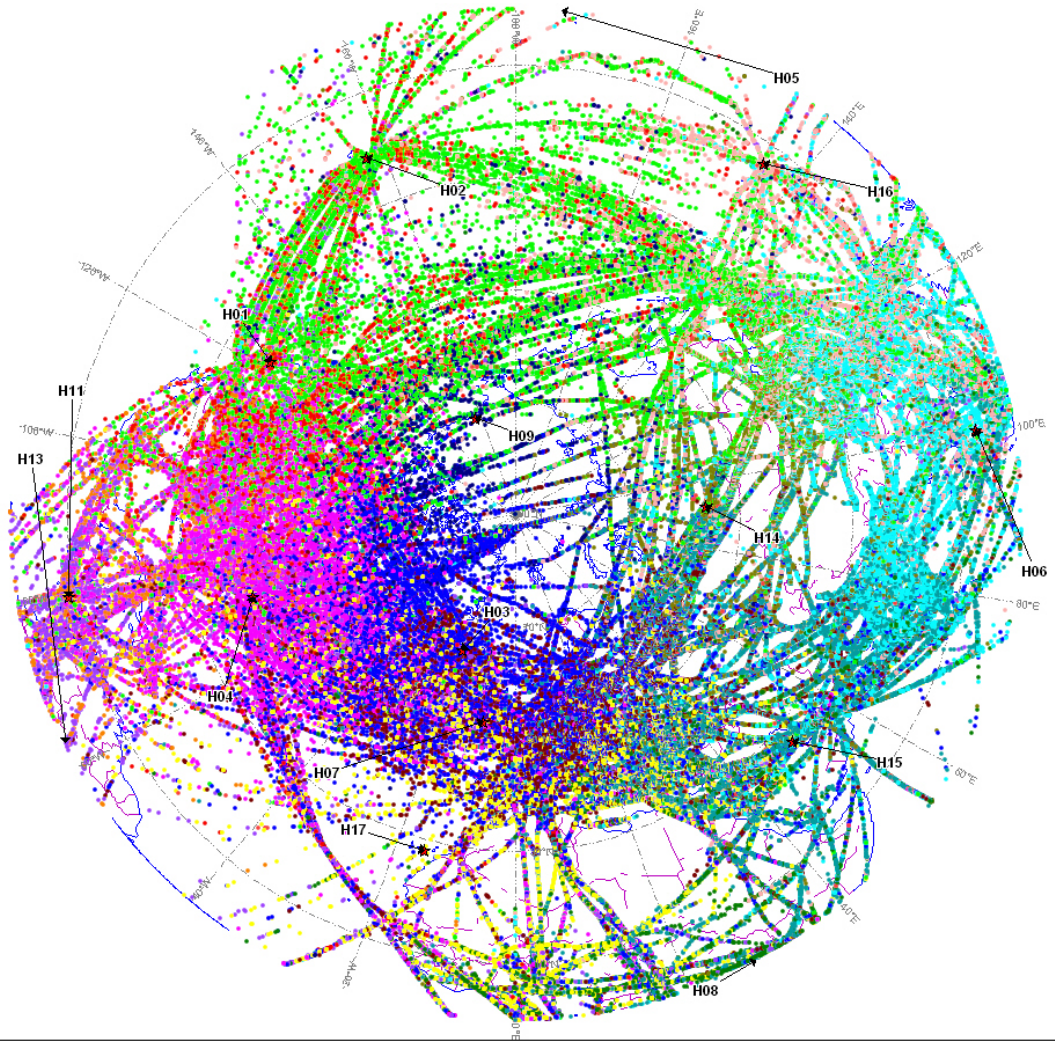
First United Polar Flight

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

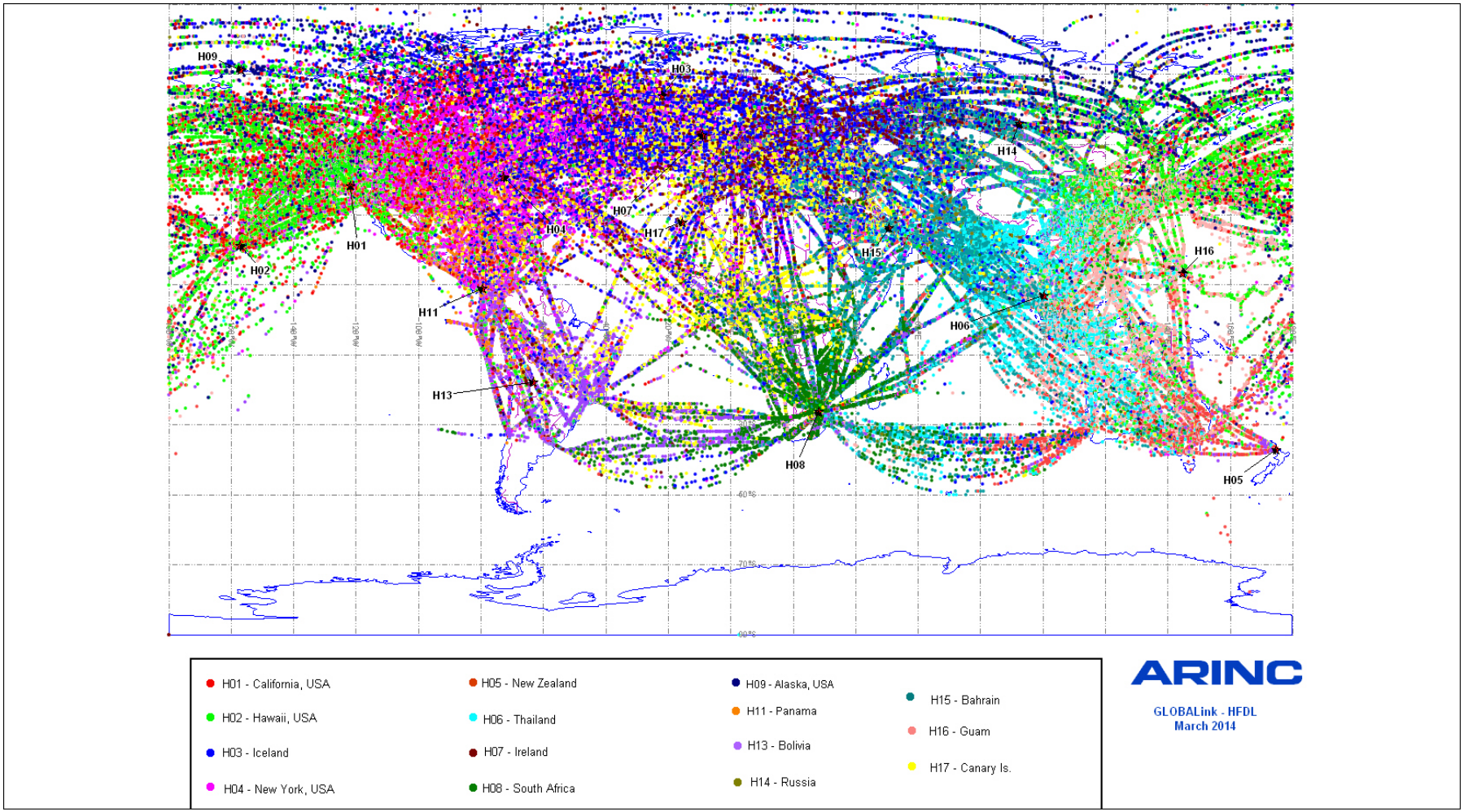


ARINC
arinc.com

HFDL Polar flights – September 2011

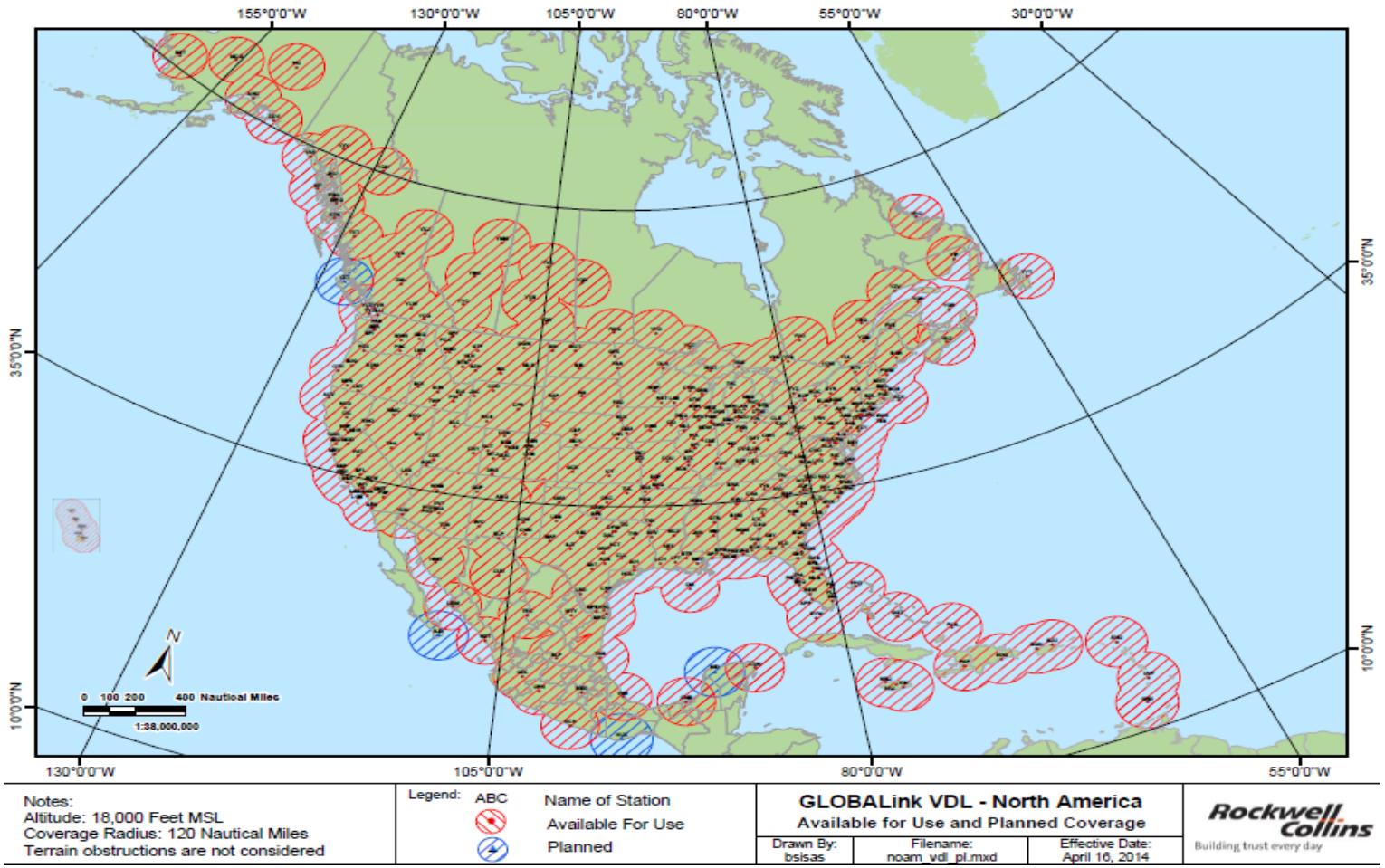


HFDL Flights – March 2014

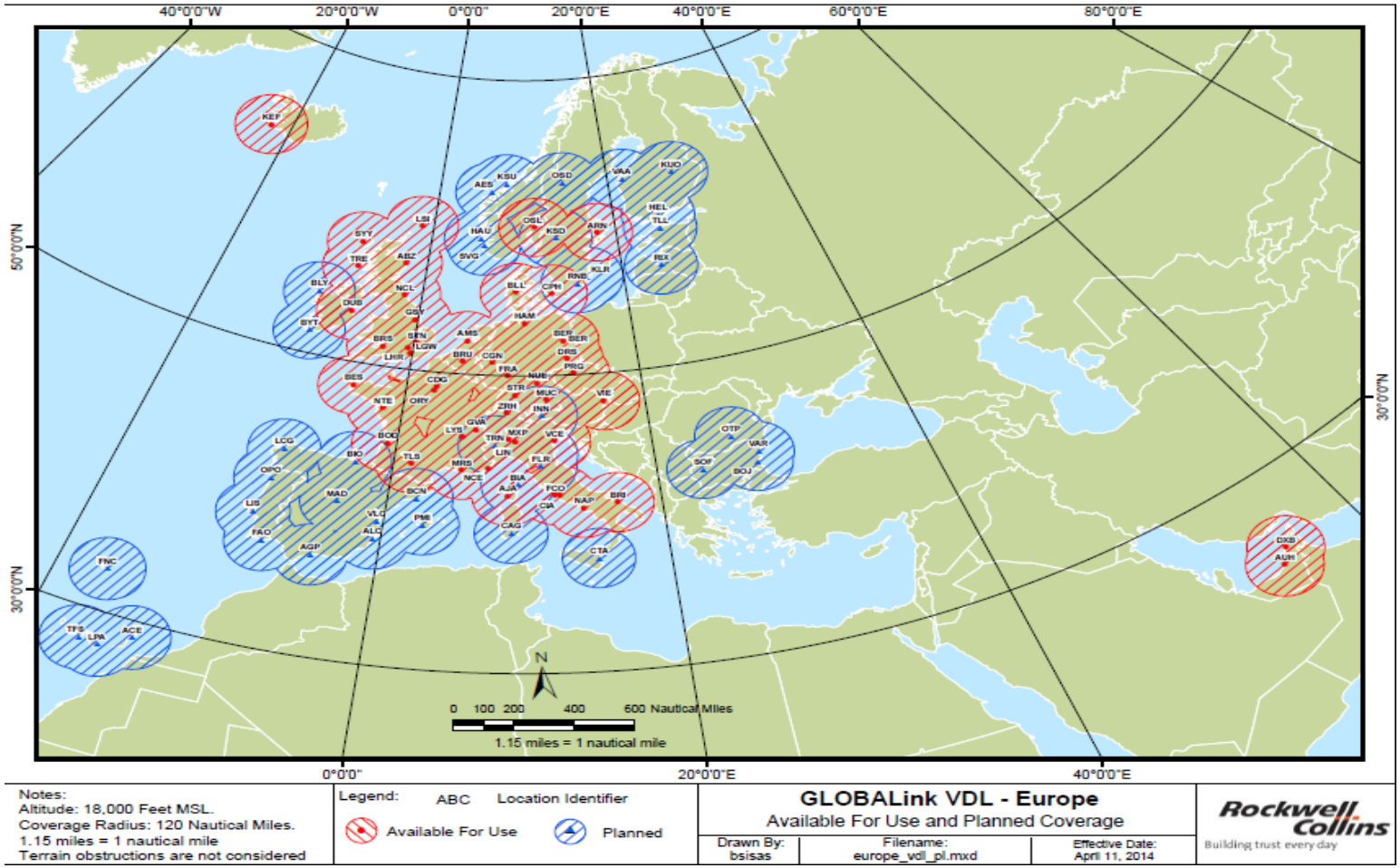


VDL MODE 2 - AOA/ATN

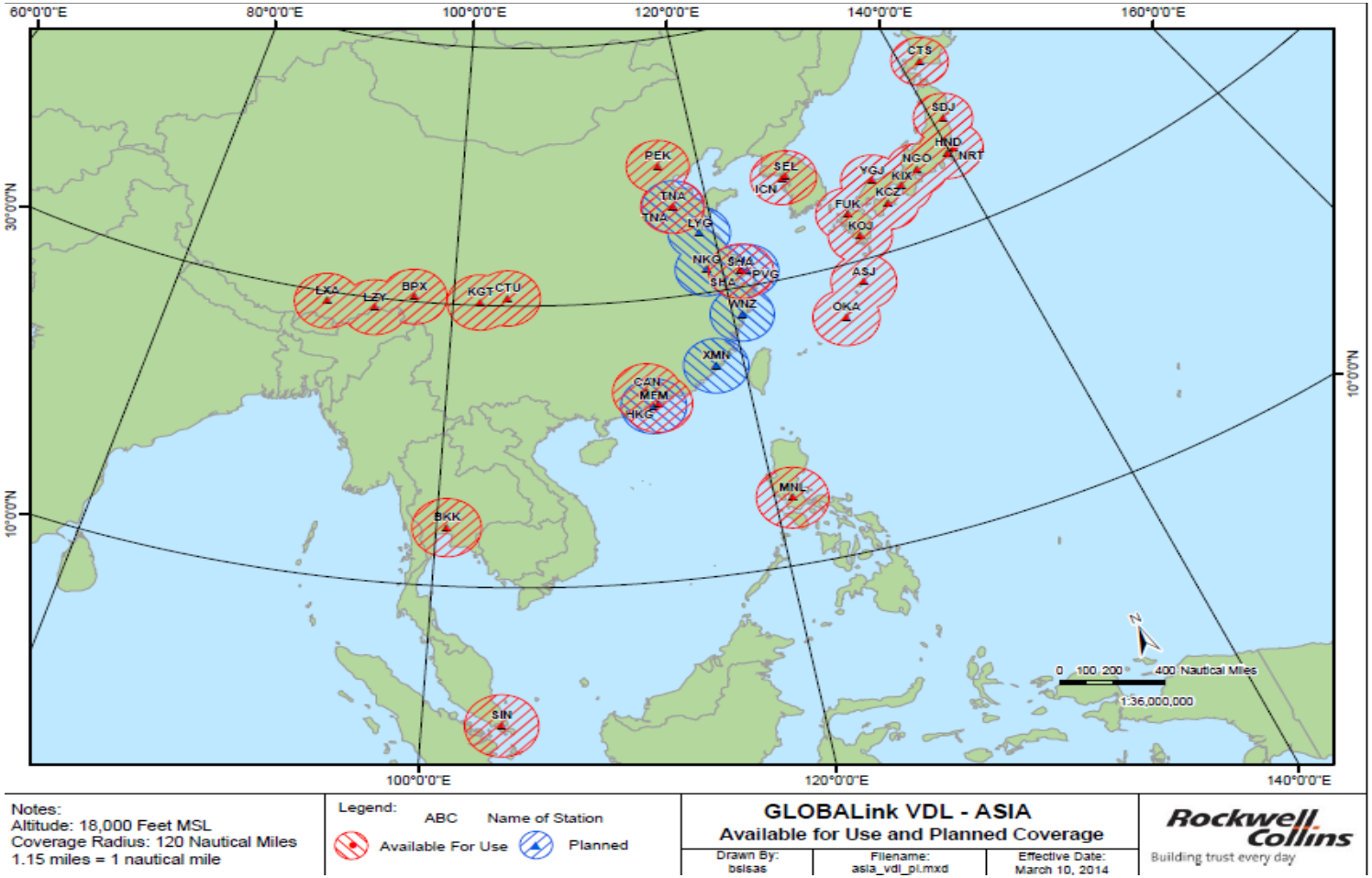
VDL Mode 2 Coverage: North and Central America



VDL Mode 2 AOA / ATN Coverage in Europe



VDL Mode 2 AOA/ATN Coverage in Asia



GLOBALink ATS Services

CNS/ATM Functions

AFN – ATS Facility Notification

CPDLC – Controller Pilot Data Link Communications

ADS-C – Automatic Dependent Surveillance – Contract

CADS/CFRS – Data link position reporting in the North Atlantic

PDC – Pre-Departure Clearance in U.S. and Canada

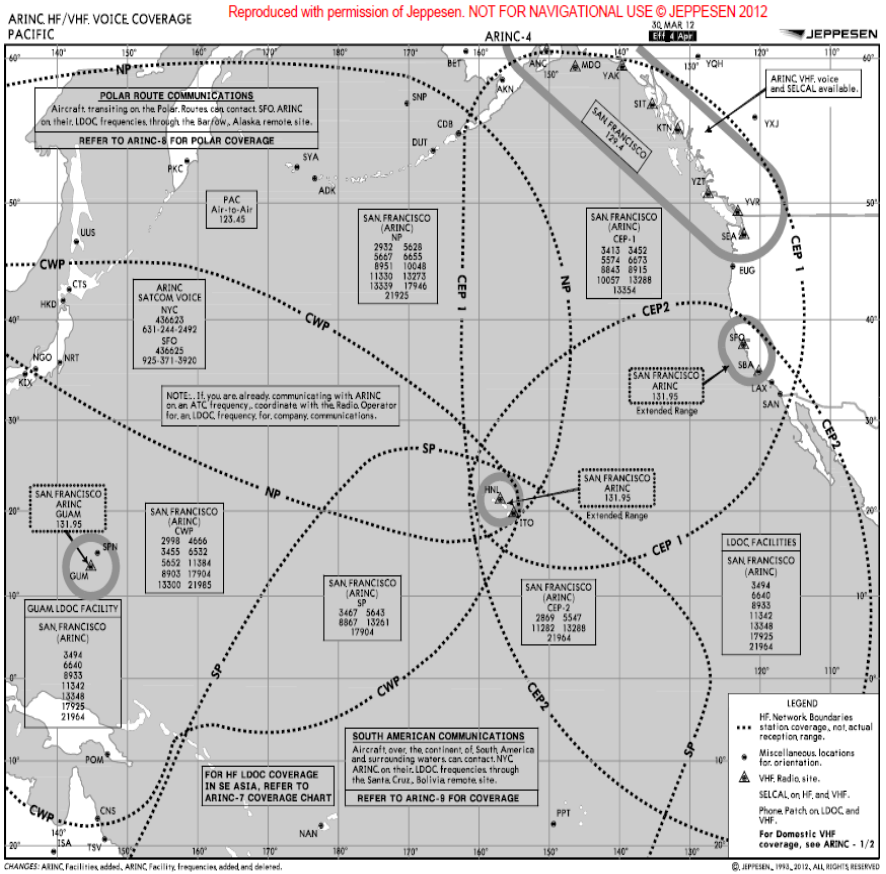
DCL – ARINC 623 Departure Clearance, Worldwide

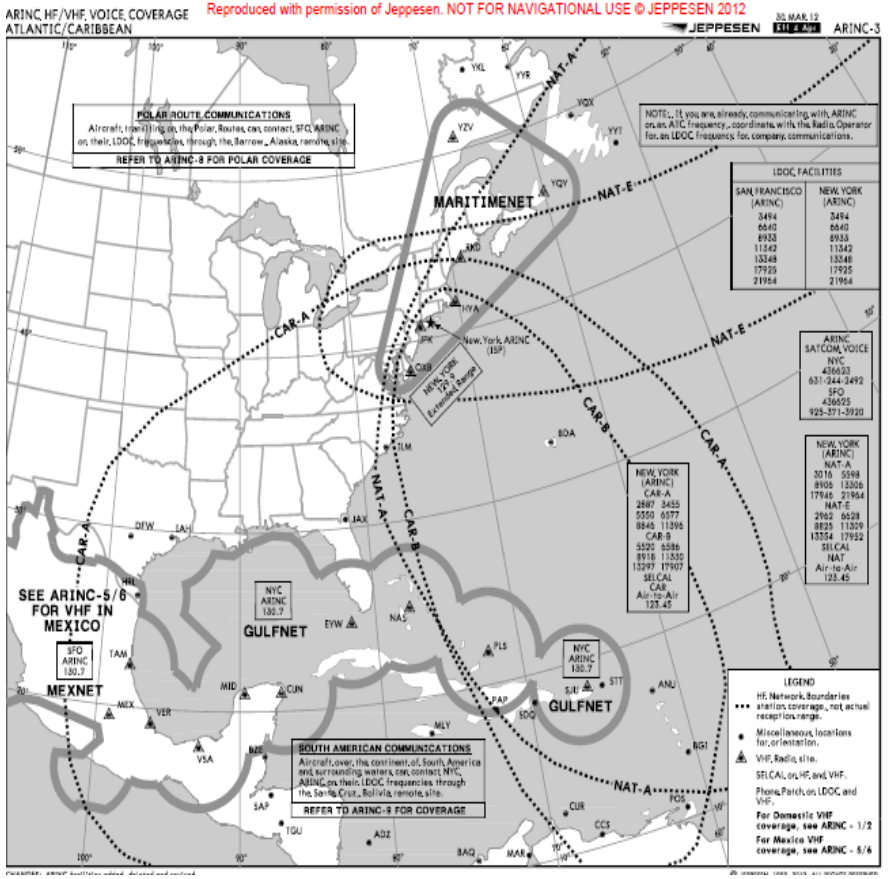
D-ATIS – Digital Automatic Terminal Information Service

GLOBALink FAA / Airline Operation Center Communications

- Air/Ground International HF Voice Service
- New York and San Francisco Long-Distance Operational Control Facilities
- Atlantic, Caribbean, Central and South America, Pacific Oceanic Canadian and Arctic Region, Gulf of Mexico
- Airline Operations Centers messaging

GLOBALink FAA / AOC HF / VHF Voice Coverage (NYC / SFO)





FANS Service Overview

First FANS 1 Flight in South America

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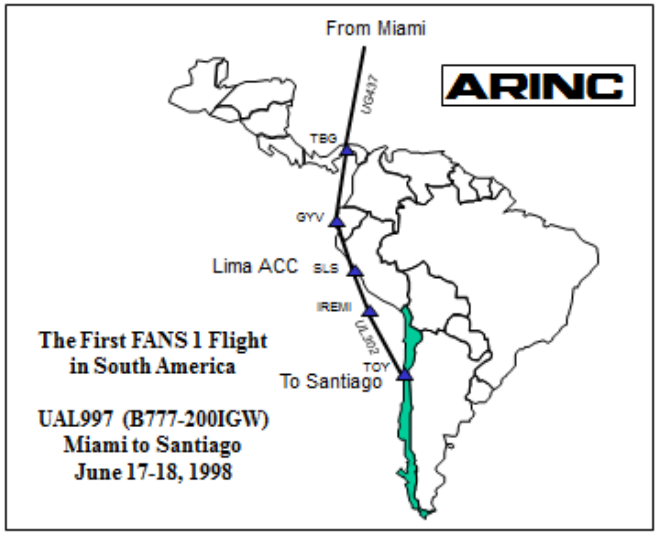

History in the Making

On June 17, 1998 UAL997, a Boeing 777 became the first FANS-1 flight to fly a route over South America from Miami to Santiago, Chile. The flight was tracked using ADS contracts from Annapolis and Lima, Peru. Controller to Pilot Data Link Communications (CPDLC) was established by ARINC from Annapolis and a handoff was made to CORPAC's, Air Traffic Control facility in Lima. Captain Phil Irwin, onboard UAL997, communicated with the Peruvian air traffic controller in the Lima ACC.

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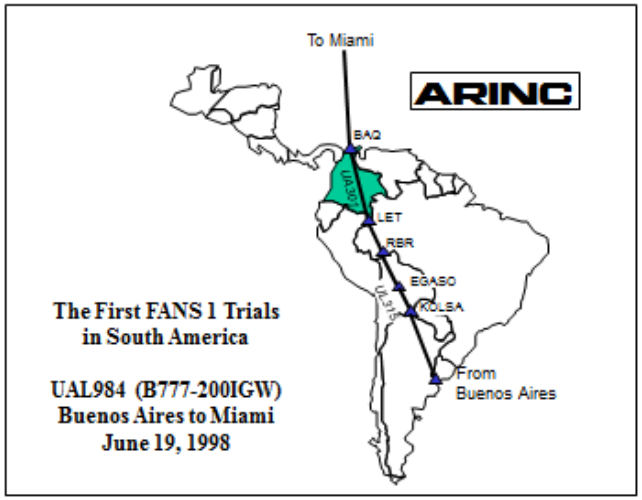
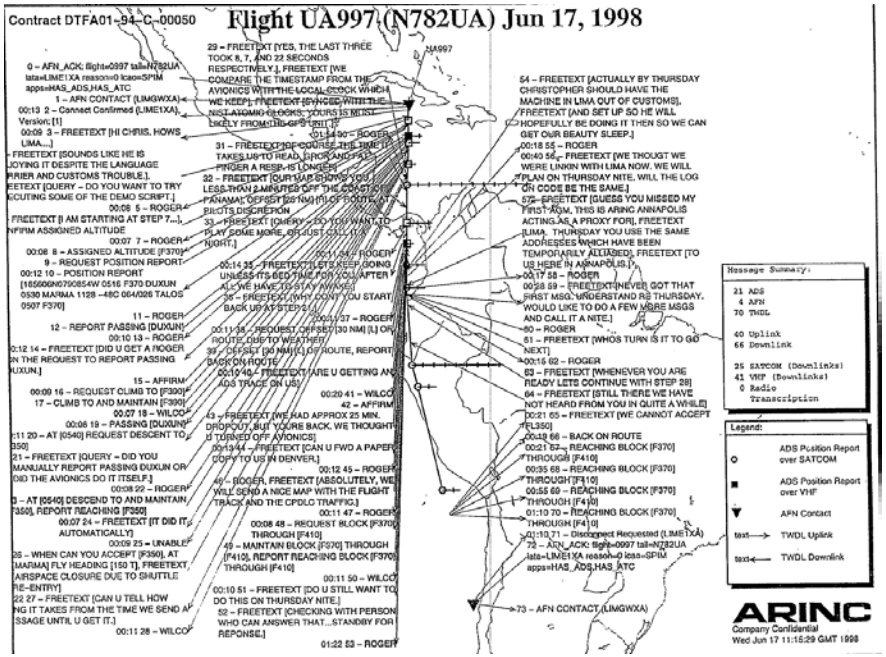
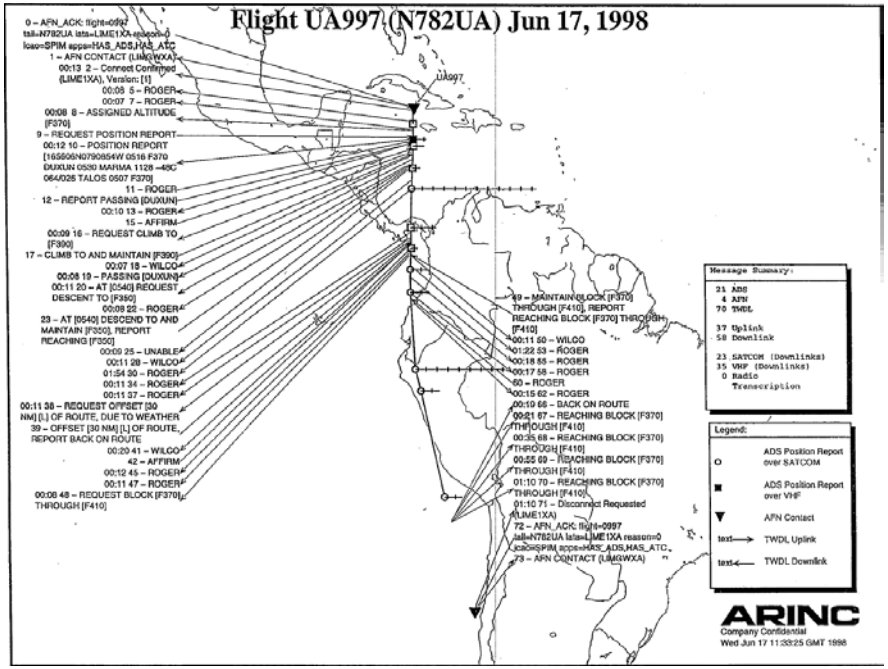


History in the Making

On June 19, 1998 UAL984, a Boeing 777 became the first FANS-1 flight to fly a route from Buenos Aires, Argentina to Miami. The flight was tracked using ADS contracts from Annapolis and Lima, Peru. Controller to Pilot Data Link Communications (CPDLC) was established by ARINC from the CORPAC Air Traffic Control facility in Lima, by Peruvian air traffic controllers. Captain Steve Forte was in command of the flight.

First ADS/CPDLC - Latin America FANS Trials in Cooperation with CORPAC and United Airlines MIA - SCL





Definitions

CNS/ATM – Communications Navigation Surveillance/Air Traffic Management

FANS - Future Air Navigation System

AFN - ATS Facilities Notification

ADS-C – Automatic Dependent Surveillance (aircraft automatically sending position reports according to a “contract”)

CPDLC - Controller-Pilot Data Link Communications

CADS – Centralized ADS

CFRS - Centralized Flight Management Computer (FMC) Waypoint Reporting Service

WPR – Waypoint Position Reporting

ATS – Air Traffic Service

CAA – Civil Aviation Authority

Specifications and Documents

ARINC 620 – Datalink Ground System and Interface Specification

ARINC 622 – ATS Data Link Applications Over ACARS Air-Ground Network

ARINC 623 – Character-Oriented Air Traffic Service (ATS) Applications

ARINC 745 – Automatic Dependent Surveillance (ADS)

RTCA DO 219 – Minimum Operational Performance Standards for ATC Two-Way Data Link Communications

RTCA DO 258 – Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications

GOLD – Global Operational Data Link Document

Guidance Material for ATS Data Link Services in North Atlantic Airspace

ICAO CNS/ATM

Concept developed by ICAO Future Air Navigation Systems (FANS) Committee

Major Elements

- Satellite Navigation and Communications
- Air/Ground Data Link Communications
- Common airborne and ground message sets
- Air Traffic Management

FANS 1 / A

First CNS/ATM Application

- FANS 1 - Boeing aircraft certified June 1995
- FANS A - Airbus aircraft

Three ATC data link applications

- ATS Facilities Notification
- ADS
- CPDLC

Uses existing ACARS data link

ARINC and FANS

FANS Service for the Federal Aviation Administration (FAA)

ARINC was integral in developing the early ground network infrastructure that enabled FANS technology for airlines and the FAA

ARINC's CNS/ATM Workstation in Magadan, Russia

On September 2, 1995 ARINC's CNS/ATM Workstation supported United Airlines flight UAL881 from Chicago O'Hare to Tokyo Narita – one of the first FANS-1 flights over the Russian Far East

China CNS/ATM Project

ARINC's CNS/ATM Workstations were installed at seven ATC centers to support FANS Route L888

FANS Service Provider

ARINC is currently providing FANS 1/A service to Civil Aviation Authorities (CAAs) worldwide, including NAV CANADA, Airways New Zealand, UKNATS, China, Russia, EROTHAI, and Vietnam

ARINC and FANS (Continued)

FANS Satellite Improvement Team (FANS SIT)

ARINC, as an initial organizer and developer, participated in the implementation of the FANS Satellite Improvement Team

FANS over Iridium trials in the North Atlantic

ARINC provided technical support for the FANS over Iridium trials in the North Atlantic and Pacific Ocean regions

Safety Services over SwiftBroadband

ARINC is currently working with Inmarsat and industry to develop the capability which will enable FANS capability for this technology

FANS 1/A Applications

ATS Facilities Notification

- Allows aircraft/ground to exchange information

Automatic Dependent Surveillance (ADS)

- Aircraft automatically sends ID and current position/speed/intent/etc as contracted for by ground system

Controller-Pilot Data Link Communications (CPDLC)

- ATC message exchange between controller and pilot

ADS

Purpose: Aircraft surveillance by controller

Responsibility: Ground initiated ADS contracts

Major Functions:

- Contracts issues by ground system(s)
  - 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.
- Periodic position reports
- Event position reports
- Emergency mode, high-rate position reports
- Optional information may be requested; intent, weather, etc

CPDLC

Purpose: ATC exchange between controller and pilot

Responsibility:

- A single Current Data Authority (CDA) for exchange of operational ATC messages
- A Next Data Authority (NDA) for transfer of comm

Major Functions:

- Exchange of ATC messages, pilot-CDA
- Transfer of data authority, CDA to NDA
- Delivery of downstream clearances, DDA

Centralized Automatic Dependent Surveillance (CADS)

ARINC created CADS to allow CAAs to implement FANS ADS service while the CAAs were preparing their initial FANS CPDLC systems

CADS allows all CAAs in the NAT to utilize the ARINC CADS server enabling ADS capability

The aircraft simply send their FANS ADS reports to CADS instead of the individual CAAs

- CADS provides the required “FANS” routing

The CAAs benefited from the early adoption of this datalink service with lessons learned; the airlines benefited by a reduction in voice communications

CFRS

Centralized Flight Management Computer (FMC) Waypoint Reporting Service (CFRS)

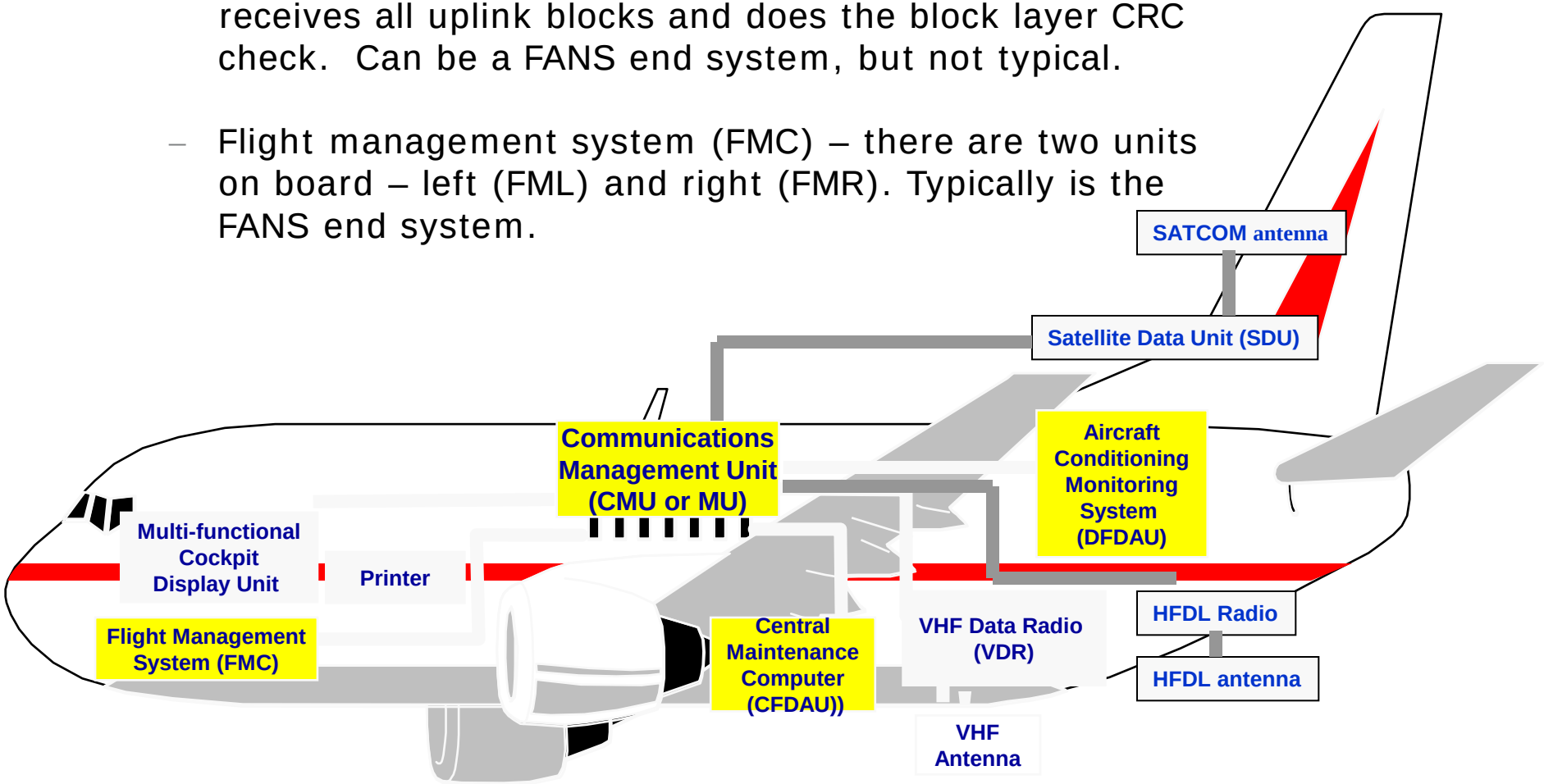
- Allows non-FANS-equipped aircraft to send position reports in a manner similar to CADS
- Honeywell PIP (Product Improvement Package) or Pegasus avionics required
  - Boeing 757-200, Boeing 767-300, Airbus 310, Airbus 319

CAAs supporting CFRS in the North Atlantic

- Nav Canada, Gander
- UKNATS, Shanwick
- Icelandic CAA
- Norway Avinor

Avionics - ACARS Key Components

- 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.



What avionics equipment does FANS?

FANS traffic can be handled either by the MU (management unit) or by the FMC (flight management computer). Which unit processes the traffic is determined by the software on the aircraft (which unit has the software) and which 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 FMD will go to the active FMC unit. Otherwise, the SMI will tell you which FMC computer is sending/receiving.

Basics

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

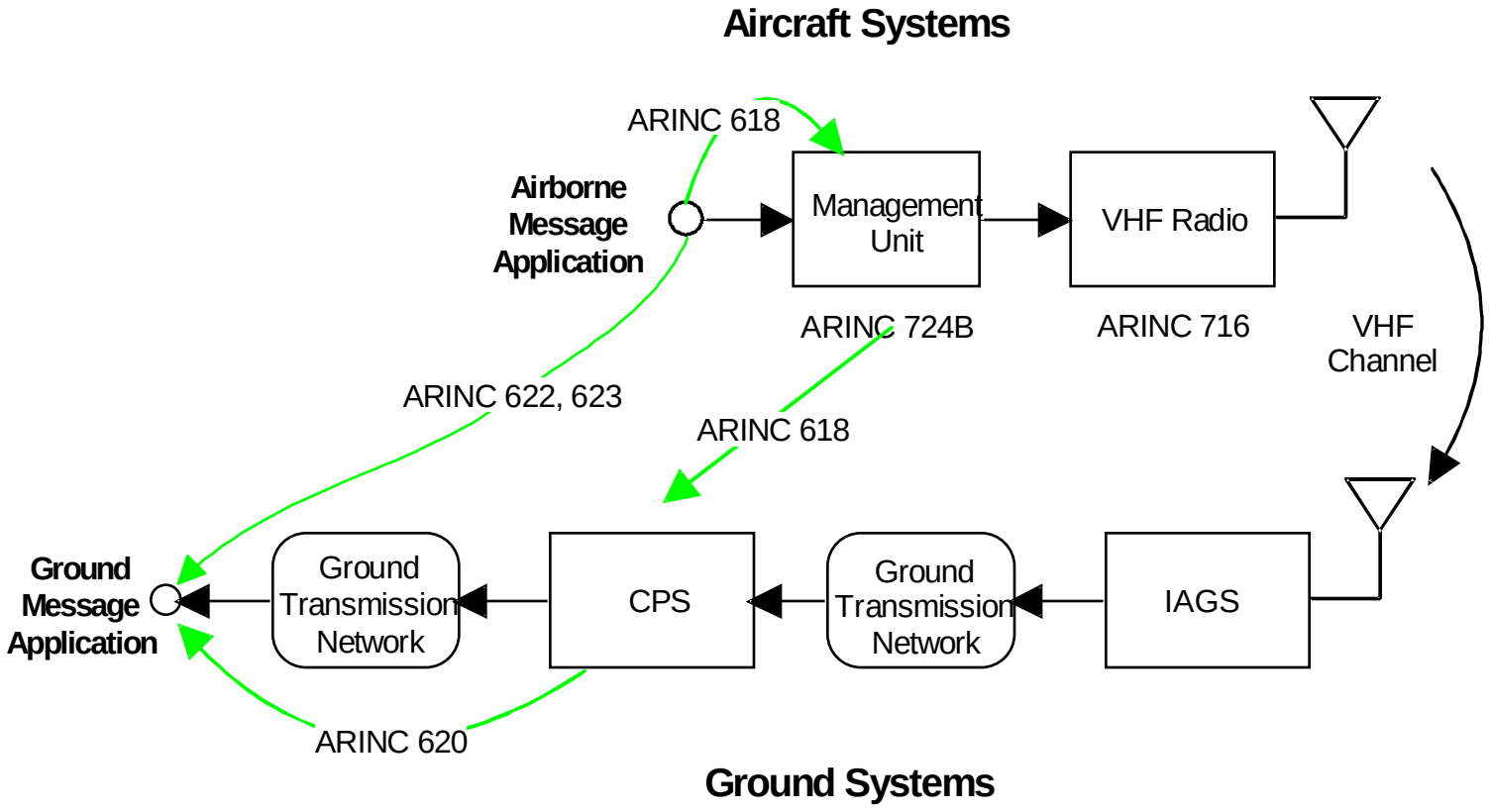
FANS messages bit-oriented within the ATS systems and the converted to characters for transport over ACARS protocols.

- Called ACARS-Convergence-Function (See ARINC 622)
- ATS text not human readable during transport

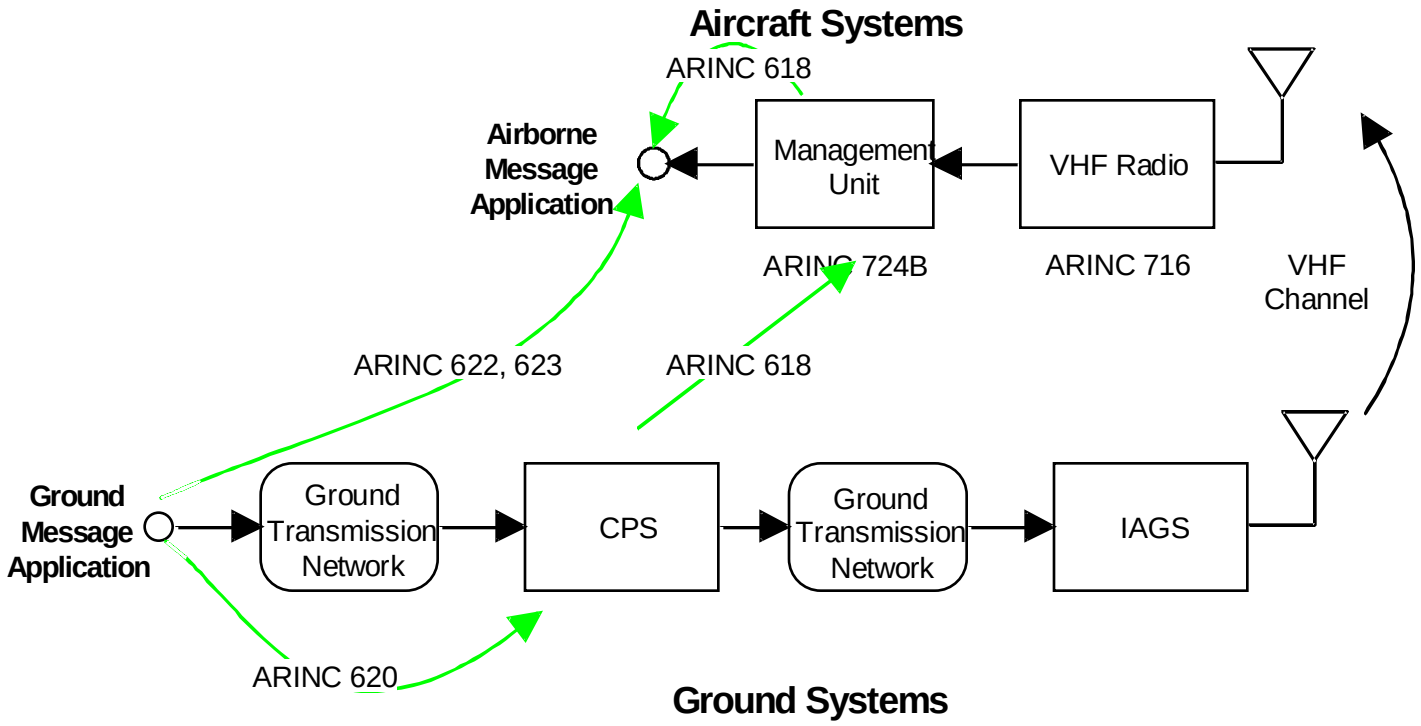
FANS messages have an application layer (32 bit) CRC and contain the tail in the message itself to assure that the ATC traffic reaches the correct aircraft gets the message and that the message content is uncorrupted.

FANS messages to the MU must be hand entered by the pilot into the FMC. Messages to the FMC can automatically update the avionics flight information.

Overall Downlink Message Flow



Overall Uplink Message Flow



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 log-on.
- During a handoff, the ATC might initiate the log-on.
- 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 end system.
- If the ATC initiates the connection, it will use the 7 letter code and the aircraft will respond with the 7 letter code.
- Once the aircraft has responded to the ATC, it will use the 7 character address for the ATC in all downlinks directed to the ATC end system.

ADS – Automatic Dependent Surveillance

Possible Settings (events)

Periodic

- The guideline is the controlling ATC have a 5 minute reporting period, adjacent ATC should have a 15 minute reporting period.
- Default setting 304 seconds (5 minutes)
- Default emergency report timer is 64 seconds

Event mode

- Waypoint change (change in next or next + 1)
- Rate of climb/descent is wrong
- Altitude > ceiling, altitude <floor
- Lateral deviation

Demand

- Used when expected report is not on time

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.

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

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.

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

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

FANS Capable Airlines seen on ARINC's Network (1)

Aeroflot Russian Airlines	American Airlines	Delta Air Lines (USA)
Aerologic (Alliance of European Air Cargo Carries)	Asiana Airlines (South Korea)	DHL AIR LTD
Aeromexico	Atlas Air (USA)	Dragonair (Hong Kong)
Air Asia X (Malaysia)	Boeing (USA)	Emirates (United Arab Emirates)
Air Canada	British Midland	Etihad Airways
Air China	Cargolux (Luxembourg)	EVA Air (Taiwan)
Air France	Cathay Pacific (China-Hong Kong)	Federal Express (USA)
Air Japan	China Airlines (Taiwan)	Finnair
Air New Zealand	China Eastern Airlines	Gulf Air (Bahrain/UAE/Oman/Qatar)
Air Transat (Canada)	China Southern Airlines	Hainan Airlines (China)
All-Nippon Airways (Japan)	Continental Airlines (USA)	Hawaiian Airlines (USA)

FANS Capable Airlines seen on ARINC's Network (2)

Hong Kong Airlines	Nippon Cargo Airlines (Japan)	Southern Air (USA)
Orbest (Portugal)	Northwest Airlines (USA)	TAP Air Portugal
Japan Airlines	Qantas (Australia)	Thai Airways (Thailand)
Jetstar Airways (Australia)	Qatar Airways	Thomas Cook Airlines (UK)
Kenya Airways	Royal Brunei Airlines Brunei	Tianjin Airlines (China Dragon) (China)
Korean Air	Royal Thai Air Force	United Airlines (USA)
LAN (Chile)	Scandinavian Airlines (Denmark/Norway/Sweden)	UPS (USA)
Lufthansa (Germany)	SilkAir (Singapore)	US Airways (USA)
Malaysia Airlines	Singapore Airlines	Vietnam Airlines
Meridiana (Italy)	South African Airways	Virgin Atlantic Airways (UK)

Sample messages and translations

<SOH>QU RURDLXA OAKODYA DPADUUA RTNBOCR <CR><LF>
.DDLXCXA 220000<CR><LF>
<STX>AFD<CR><LF>
FI U????N N????A<CR><LF>
DT DDL HNL 220000 L51A<CR><LF>
- **AFN**/FMHUAL82,.N????A,583548,000012/FPON21147W157322,1/FCOAD<TSTRET>
S,01/FCOATC,0120A8<CR><LF>
<ETX><EOT>
 # AFN_CONTACT, latitude=21.252778 longitude=-157.538889

<SOH>QU DDLXCXA<CR><LF>
.FANS1XA 220000<CR><LF>
<STX>ATC<CR><LF>
AN N????W/MA 486A<CR><LF>
- /YQXE2YA.**CR1**.N802NW0051C3B546C0390B<CR><LF>
<ETX><EOT>
#contract request

<SOH>QU RURDLXA YQXE2YA MSPXONW <CR><LF>
.DDLXCXA 220000<CR><LF>
<STX>ATC<CR><LF>
FI N????N N????W<CR><LF>
DT DDL YQX 220000 J19A<CR><LF>
- **CC1**.N802NW6000000349108662<CR><LF>
<ETX><EOT>
 # id=0 ref=0 timestamp=3, [1]

<SOH>QU RURDLXA YQXE2YA MSPXONW <CR><LF>
.DDLXCXA 220005<CR><LF>
<STX>PAR<CR><LF>
FI N????N N????W<CR><LF>
DT DDL YQX 220005 J20A<CR><LF>
- **ADS**.N802NW03010723BFCED39DC9C4056C1D102C245E922E4F<CR><LF>
<ETX><EOT>
 # A745_ACKNOWLEDGEMENT, contract_request_number=1, A745_BASIC_REPORT, latitude=5
0.272236 longitude=-52.801838 altitude=40000 merit=0x1D, timestamp=347.000000

Sample messages and translations

<SOH>QU RURDLXA QXSCDXS MSPXONW <CR><LF>
.DDLXCXA 220019<CR><LF>
<STX>PAR<CR><LF>
FI N????N N????W<CR><LF>
DT DDL YQX 220019 J22A<CR><LF>
- **ADS**.N802NW1424450EE3A8C9C3D2601D0D25B05F1C71C9C40AEE26666F5<TSTRET>
55549C4002300<CR><LF>
<ETX><EOT>
 # A745_WAYPOINT_CHANGE, latitude=51.004200 longitude=-49.981785 altitude=39996 m
erit=0x1D, timestamp=1176.000000, A745_PREDICTED_ROUTE

<SOH>QU RURDLXA OAKODYA DPADUUA RTNBOCR <CR><LF>
.DDLXCXA 220004<CR><LF>
<STX>ATC<CR><LF>
FI U????AN N????A<CR><LF>
DT DDL XXC 220004 L02A<CR><LF>
- **AT1**.N????A208046427244200B<CR><LF>
<ETX><EOT>
 # id=1 ref=-1 timestamp=265, REQUEST CLIMB TO [F320]

<SOH>QU RURDLXA OAKODYA DPADUUA RTNBOCR <CR><LF>
.DDLXCXA 220005<CR><LF>
<STX>ATC<CR><LF>
FI U????AN N????A<CR><LF>
DT DDL XXC 220005 L03A<CR><LF>
- **AT1**.N793UA6122014200B2A1<CR><LF>
<ETX><EOT>
 # id=2 ref=17 timestamp=302, WILCO

<SOH>QU DDLXCXA<CR><LF>
.ATSXCXA 220013<CR><LF>
<STX>FMD<CR><LF>
AN .N????5/MA 721A<CR><LF>
- AA FUKJJYA.**AT1**.N760652300D02840BB69<CR><LF>
<ETX><EOT>
 # id=6 ref=-1, END SERVICE

<SOH>QU RURDLXA FUKJJYA DPCACCO <CR><LF>
.DDLXCXA 220013<CR><LF>
<STX>FMR<CR><LF>
FI C????N N????5<CR><LF>
DT DDL XXC 220013 F47A<CR><LF>
- **DR1**.N????5D041<CR><LF>
<ETX><EOT>
 # Empty Disconnect

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