



# **FAA Technical Center's**

## ***Airborne Networking***

### ***Multi-Aircraft Network***

#### ***Capability***

##### ***Demonstration***



# FAATC Airborne Networking Multi-Aircraft Network Capability Demonstration: *Purpose*

- Facilitate the early adoption of NGATS Netcentric aviation capability into the present National Airspace System
- Demonstrate that Netcentric capability for aviation can begin in 2006
- Advance the basic Netcentric capability for aviation



# Impact of Air-to-Air Link Performance Assumptions Made for Internet Links Do Not Apply to AN Links

Link Attribute	Terrestrial Internet	Airborne Network	Networking Impacts
Bandwidth	Infinite – can add more fiber and routers as needed	Constrained by available spectrum in a geographic region Function of distance, antenna gain, power levels, interference	Routing performance
Bit Error Rate	$10^{-9}$ to $10^{-12}$ , fairly constant	$10^{-5}$ to $10^{-7}$ , highly variable due to distance, fading, EMI	End-to-end reliable transport
Stability	Generally long periods (days) of availability	Short periods (minutes, seconds) of availability the norm	Routing performance (convergence)
Threat	Generally few (e.g., backhoe)	Highly exposed to EMI and intentional jamming	Network capacity
Directionality	Bidirectional	May be unidirectional (e.g., different power levels) Receive-only nodes	Protocol algorithms
Latency	Constant based upon link length	Variable over time as link length changes	Synchronized applications



# FAA Tech Center's New Test Aircraft Bombardier Global 5000



N47 FLYING LABORATORY



**FAA**  
Air Traffic Organization



# FAA Tech Center R&D Fleet

- **Boeing B727 – N40**
- Sikorsky S76 -
- Convair 580 – N39
- Convair 580 – N49
- King Air – N35
- Aerocommander –
- **Bombardier – N47**



(Will lose the Boeing  
B727 in June after the  
Airborne Internet Demo)



# FAATC Airborne Networking Multi-Aircraft Network Capability Demonstration: *Aircraft Flight Scenario*

- Three similarly equipped aircraft will fly from Nantucket to Atlantic City at 37,000 feet in a “cluster”
  - Tech Center’s Bombardier Global 5000 (N47)
  - Tech Center’s Boeing B727 (N40)
  - AVN’s Bombardier Challenger 604 (N88)
- Transiting Special Use Airspace
- Other aircraft may participate, TBD

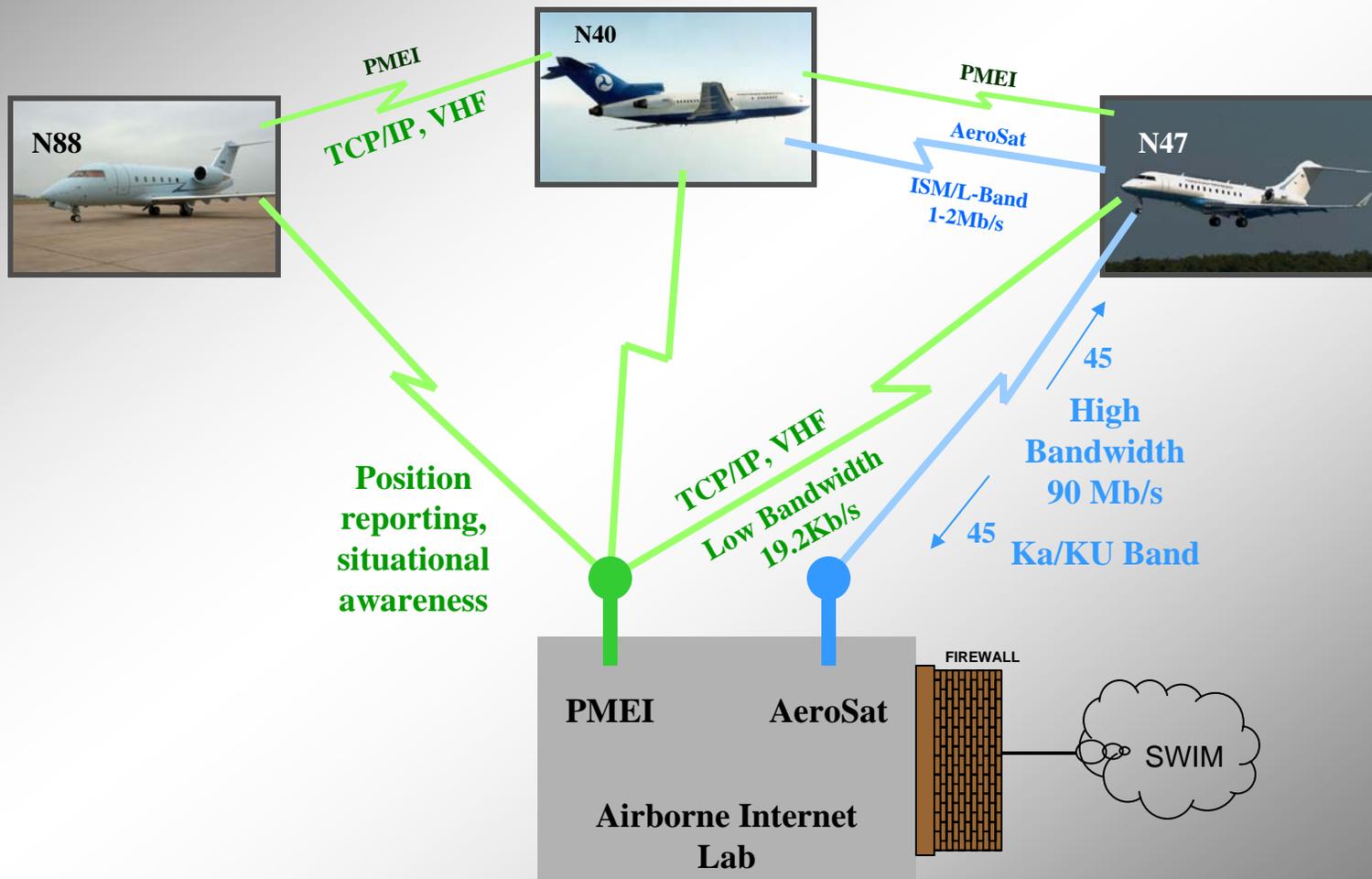


# FAATC Airborne Networking Multi-Aircraft Network Capability Demonstration: *Aircraft Flight Demo Applications*

- Airborne networked aircraft position reporting will be displayed on EFB
- Airborne Network
  - 4-D Trajectory Flight Plan to be sent from ground to aircraft; aircraft acknowledges and accepts
  - Weather
  - Various text messaging, email
  - Web services, white board, VoIP
  - TCAS advisory is sent to the ground
  - Live video images telemetered to the Tech Center
- Security: Add in VPN, encryption, etc.
  - Pico cell: use of special encrypted cell phones



# FAATC Airborne Networking Multi-Aircraft Network Capability Demonstration: *Two* Airborne Networking Systems





# The Systems

- Each company has similar ideas about air-to-air networking
- But are implementing them in completely different ways



# PMEI Approach: Applications supported

- Autonomous peer-to-peer position location and network discovery
- Low latency direct peer-to-peer messaging (automated chat)
- Assured uplink broadcast services (multiple applications)
- Surface movement monitoring (local and remote) with integrated voice and text-to-voice advisory services
- COTS network connectivity to ATC, AOC and APC (Pax) networks (with firewall and encryption as required)
- IP ground based network management for DNS and aircraft domain address resolution
- Airborne Global Routing Information Protocol (GRIP) provides over-the-horizon and Beyond Line of Sight (BLoS) connection management to any discovered peer or ground center
- APC (Pax) and AOC support via out-of-band signaling
- Back-up surveillance (position reporting) with dynamically modifiable report rate
- Security and authentication services



# PMEI System: Future Airborne Network



Satellite Datalink Service Provider  
(Iridium or similar)

Satcom interconnect to be completed  
(est. 1 month effort)



Air-to-air routing AND  
Air-to-ground via satellite gateway  
(gateway on-board for test/demo)

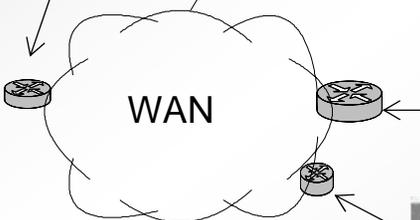
Multiple routing algorithms available  
Min\_Time\_Max\_Performance presently implemented  
(single assured route)



Air-to-air routing and  
Air-to-ground comm.



Remote  
Ground Station



WAN



Ground Station



Surface Networks



## Beyond line-of-sight performance based mobile net routing

# PMEI's Global Routing Information Protocol (GRIP)

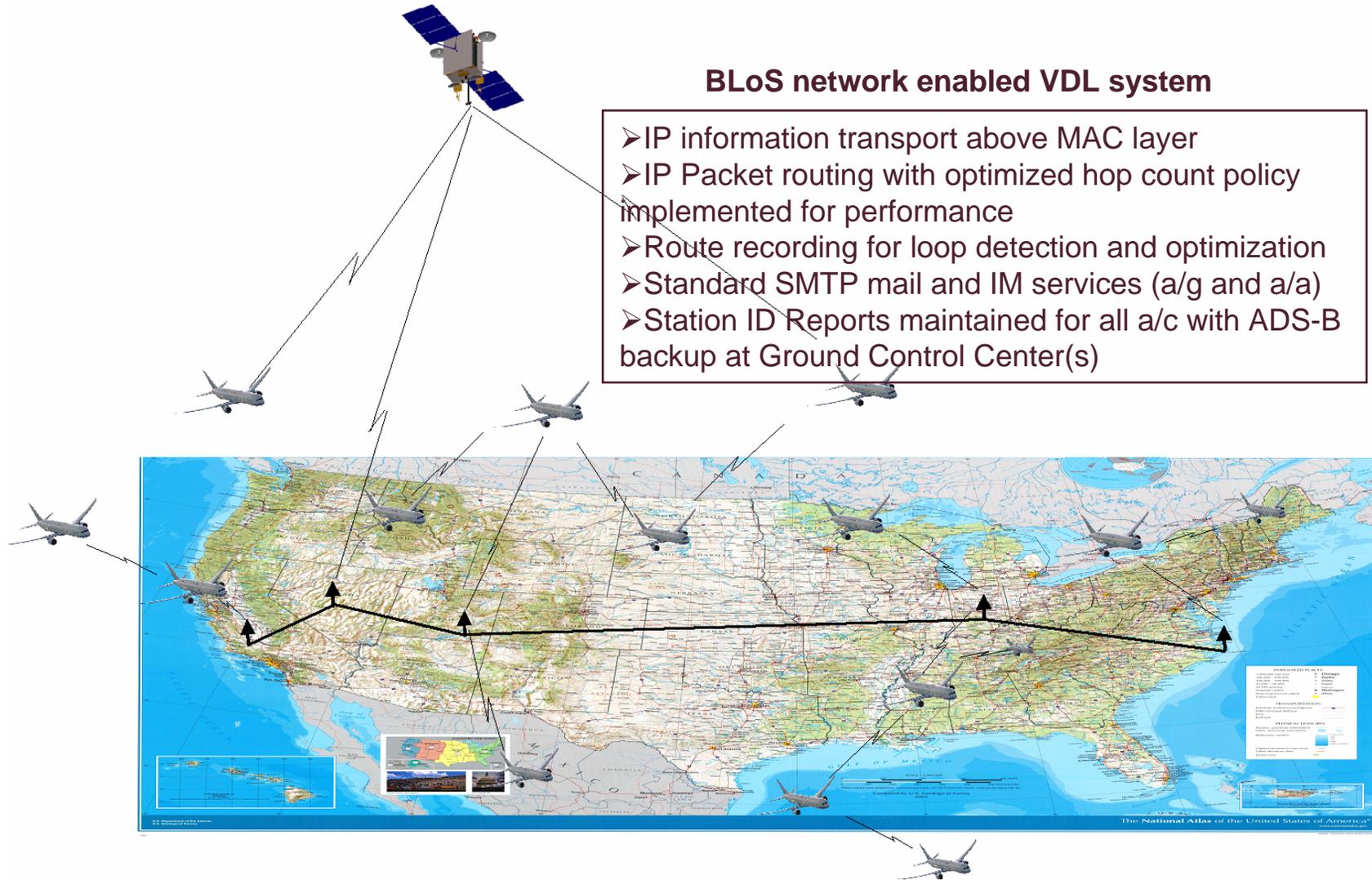
- *Near ground station operation*
  - Positive rapid and assured failure recovery - RF propagation can force temporary outages (Obstacle shielding/blocking e.g., baggage cart blocking the antenna). GRIP enables immediate seamless graceful backup (effectively make-while-break)
  - Ground station failures can be bypassed with a hop via another aircraft to another ground station without the need for super-redundancy at every airport
- *Remote ground station operations*
  - Extends the range of point-to-point air/ground data comms arbitrarily (range limited only by the maximum hop count policy and worst-case aircraft density)
  - Enables beyond-line-of-sight flight following
  - Enables 0 AGL (ground level) coverage at every airport w/o requiring a ground station at every airport
- *Remote air-to-air operations*
  - Permits air-to-air operations with full CNS functionality among all participants (e.g., passing maneuver, climbing thru SUA airspace, etc.)
- *Other benefits*
  - Full 16 level ATN priority management for all packet routing
  - Ad hoc discovery, network establishment and relay functions in a peer-to-peer community
  - No additional cost to install on aircraft (no additional hardware [today a laptop is required] or frequency assignment required)
  - Inexpensive to deploy (requires few ground stations for wide-area coverage)
  - Can be continuously and dynamically tailored to performance needs and support a wide range of traffic densities
  - Automatically re-configures based upon system state of connectivity – NO ROUTING SET\_UP!
  - Network protocol agnostic (can support multiple protocols including ACARS, ATN, IPv4 and IPv6)



# PMEI's Example NAS GRIP network lay-down for enroute and terminal operations (proof-of-concept)

## BLoS network enabled VDL system

- IP information transport above MAC layer
- IP Packet routing with optimized hop count policy implemented for performance
- Route recording for loop detection and optimization
- Standard SMTP mail and IM services (a/g and a/a)
- Station ID Reports maintained for all a/c with ADS-B backup at Ground Control Center(s)

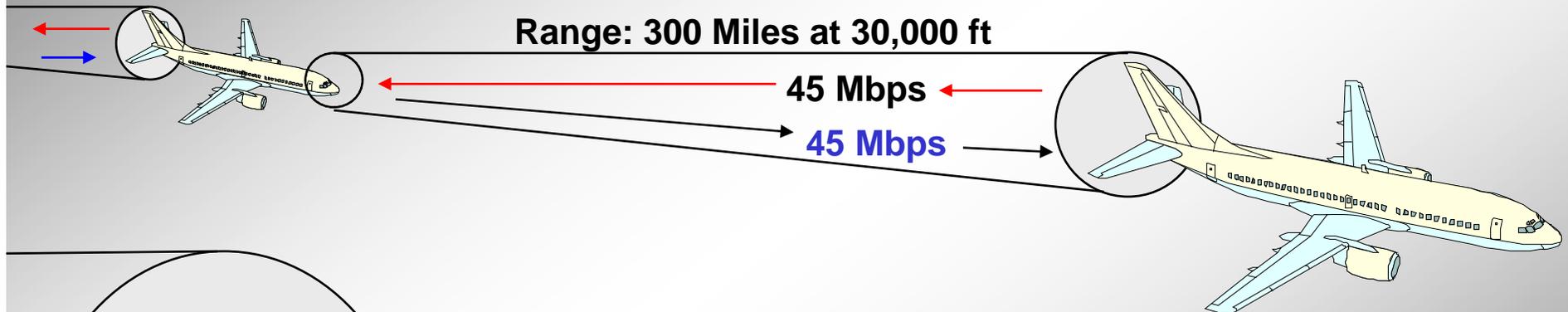


Oceanic approach/ departure services and gulf operation monitoring<sup>13</sup>



# AeroSat Airborne Network Demonstration

Broadband communications over 1000 times as fast as standard 64K satellite service, operating at a small fraction of the cost.



## Applications

### Operations and Maintenance:

- Engine Monitoring
- Crew Communications
- Fault Reporting
- Diversion Management

### Cabin Services:

- Internet Access
- Programming Distribution

### Air Traffic Management:

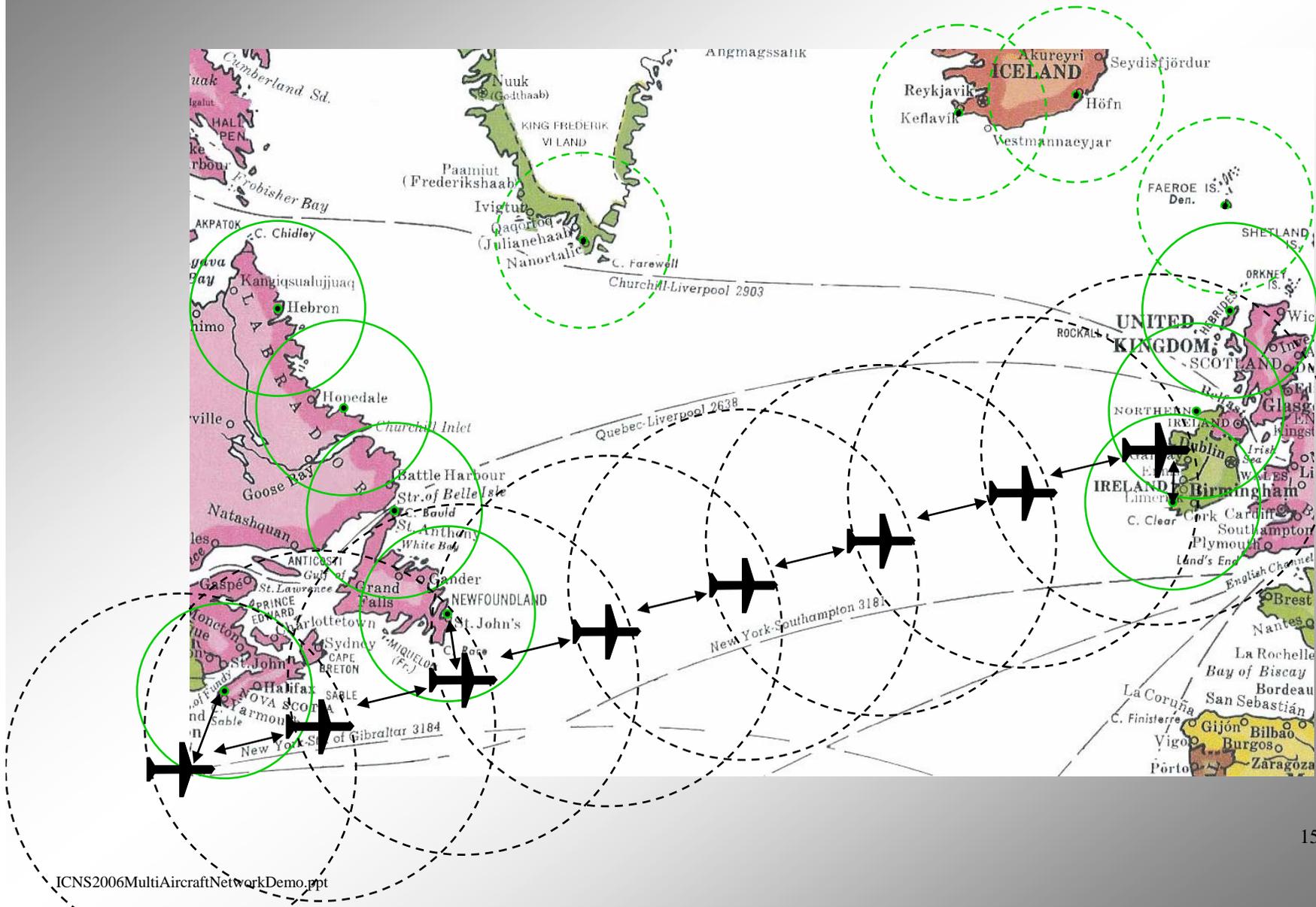
- System Capacity (separation)
- Hazardous Weather Avoidance
- Collaborative Decision Making
- Position reporting

### Safety & Security:

- Transportation Security
- Real Time Black Box Transmission
- Telemedicine



# Aerosat Airborne Network Concept





# *Network In the Sky*

## *Every aircraft is a network node*

*For more information:*

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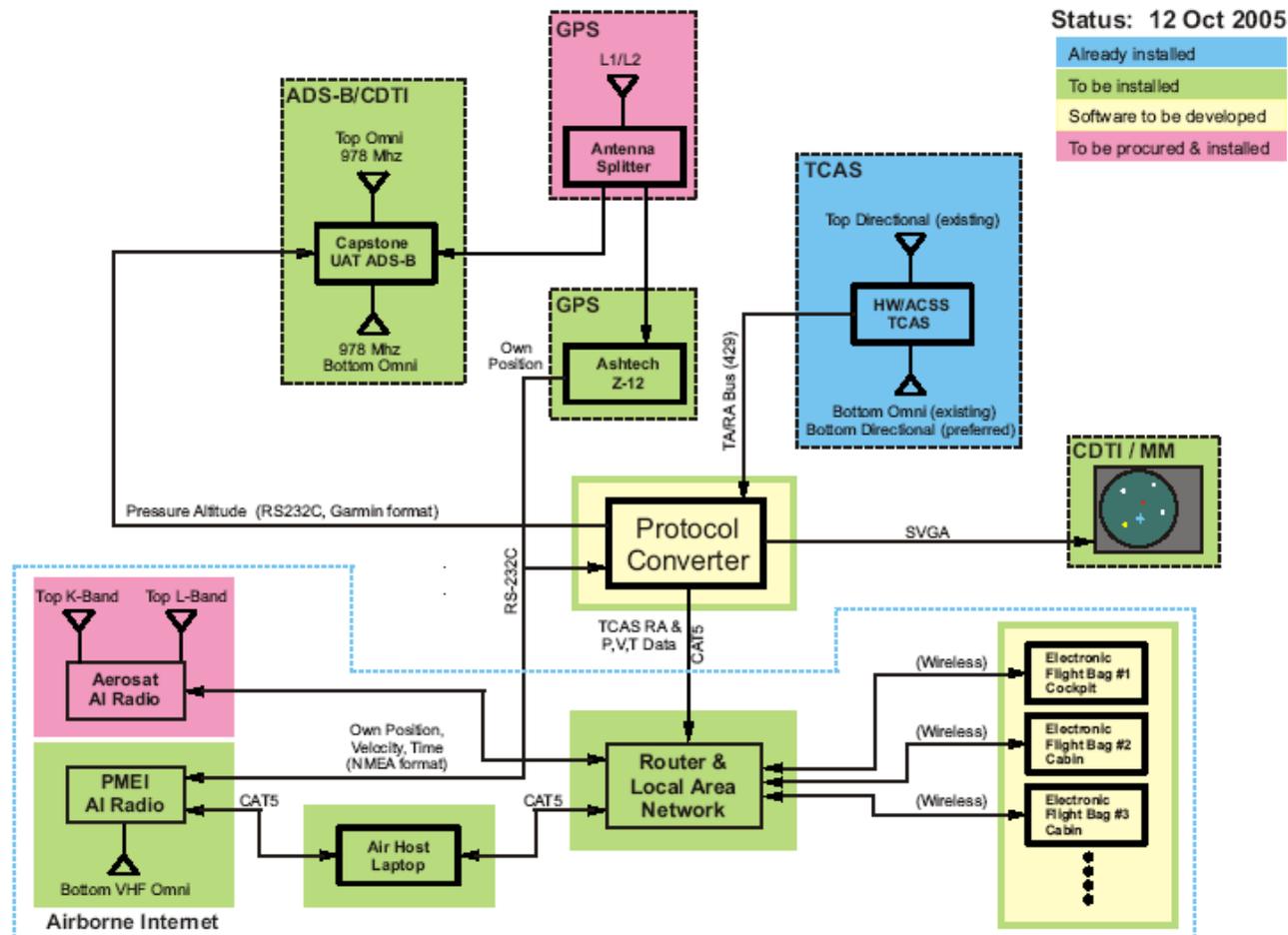
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**<http://www.AirborneInternet.com>**

**<http://www.airborneinternet.net>**



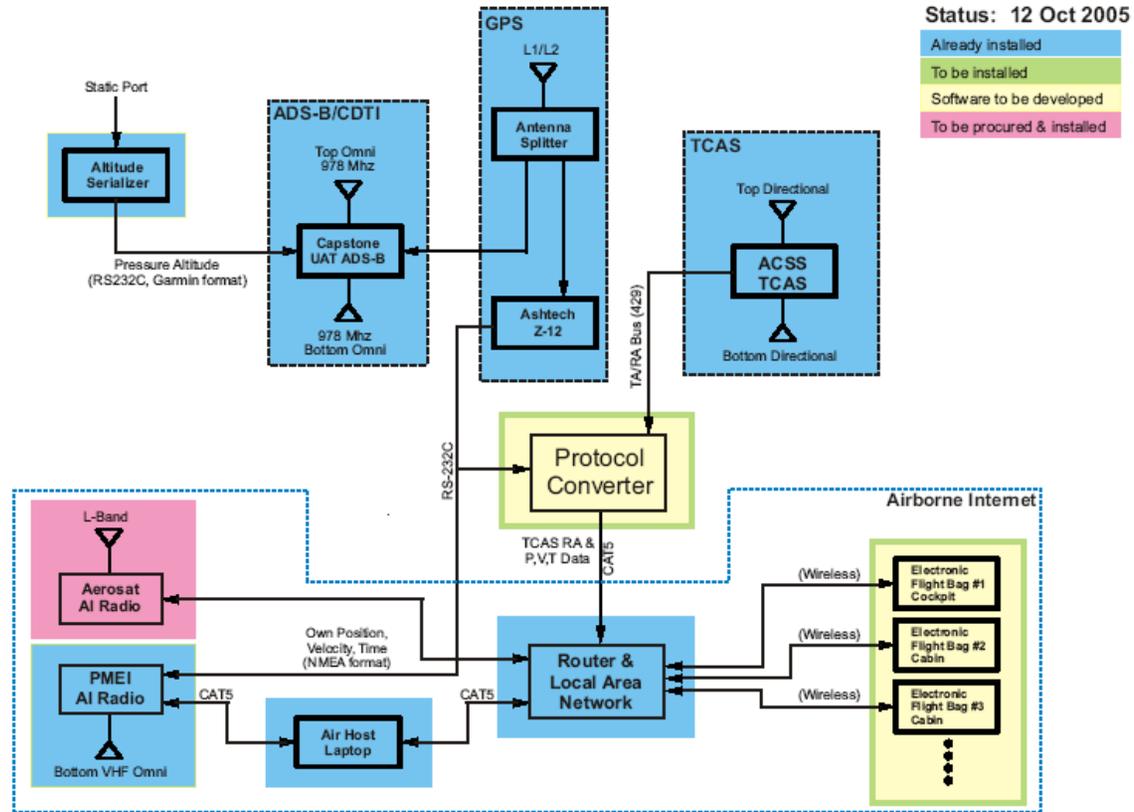
# N47 Aircraft Configuration



## N47 NGATS Demonstration Project Avionics Configuration



# N40 Aircraft Configuration



N40 NGATS Demonstration Project Avionics Configuration



# N88 Aircraft Configuration

