How to Modernize Airline Avionics Affordably

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Presentation Topics

- **Overview and Summary**
- **Findings about ADS-B from around the world**
- **Reality Check**
- **Equipage Case Studies:**
  - Low-end: Simple ADS-B upgrade for helicopters in GOMEX
  - High-end: Adding ADS-B, P-RNAV, etc to an AT with older IRS-FMS
- **Conclusion**

Caveats

- This presentation is not intended to be provocative; just informative
- Content is based on our findings across a broad range of aircraft types and geographies
- Plenty of aircraft and configurations, however, haven’t yet been assessed
- Nonetheless, we have a reasonable basis for drawing some general conclusions

Summary

- **ADS-B needs to happen and will happen, sooner or later**
- **Added safety, along with NextGen efficiencies, will come sooner via early, worldwide adoption of ADS-B**
- **Adoption rate is tied to each operator's own cost/benefit analysis**
  - Better cost/benefit means greater likelihood of early adoption
- **ADS-B component costs vary from several thousand to several tens of thousands, depending on overall capability (power, diversity, etc.)**
  - Smaller aircraft for < $10,000
  - Larger aircraft: perhaps $100,000 +
- **Regardless of cost, two key ingredients for optimizing cost/benefit**
  - Buy equipment with the right TSO that includes pre-testing; STC costs minimized (but avionics manufacturers must do their share)
  - Get double-duty out of ADS-B components (i.e., more bang for the buck!)

From *Confused People-Who-Should-Know-Better*

From recent visits...

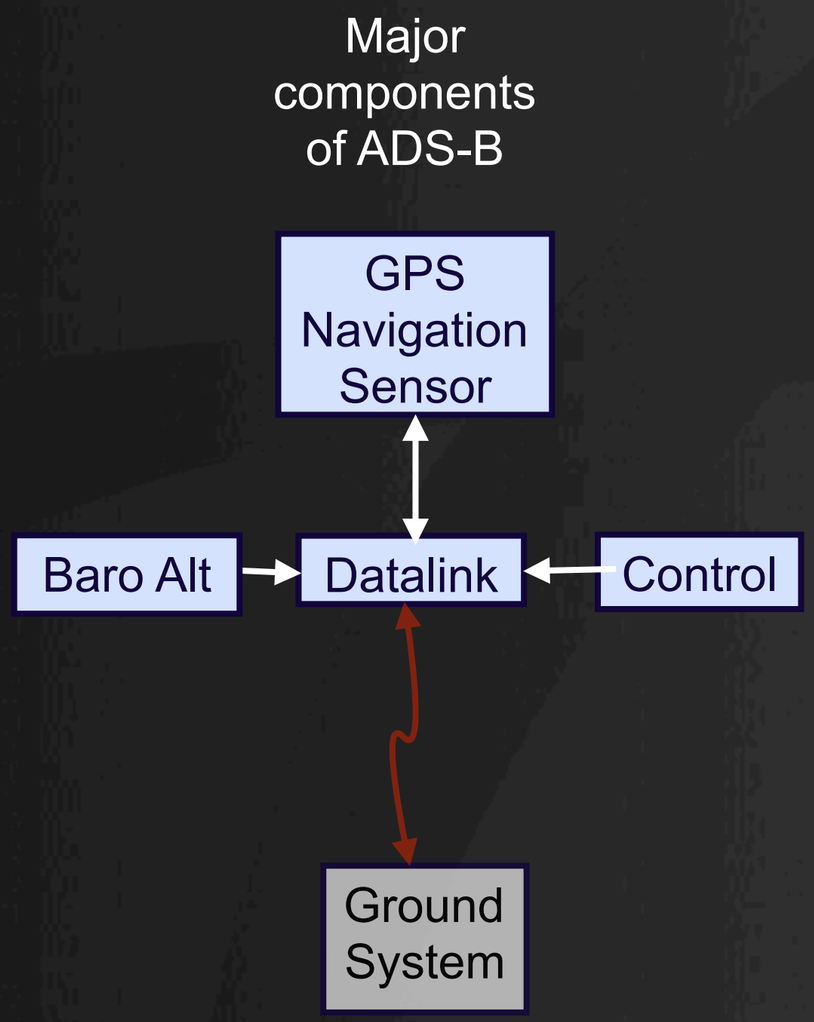
- "ADS-B has already been made obsolete by Galileo. Anyway, there's no equipment available for ADS-B" - Senior Executive at major airline
- "We're just waiting for all this talk about ADS-B to blow over. It's way too expensive for us." - Fleet operator
- "We barely understand what the $&%€* they're saying about ADS-B most of the time. They keep changing their minds" - Technical VP at major airframe OEM
- "We'd like to sell ADS-B to our customers, but they probably can't afford it right now" - Executive at major airframe OEM
- "We're opposed to requiring WAAS for ADS-B. Why? Um... I'm not sure" - Senior executive at major airframe OEM

ADS-B is happening

- **It appears the people who control airspace are going to make it happen.**
- **Recent comments from air traffic operations managers, here and abroad:**
  - "If the politicians don't make up their minds pretty quickly about ADS-B, there are going to be fatalities. Sooner rather than later."
  - "We can't wait for someone to finalize the rules. If one of my controllers has traffic equipped for ADS-B and traffic not equipped, we make the guy without it pay dearly. Sooner or later, they'll get the message."
  - "It's not perfect, but the existing technologies work and are more than good-enough for what we need."

Equipping for ADS-B

ADS-B Avionics 101. Here's what is needed:



- On-board sensor to provide positional information
- Datalink to transmit/receive info from all other aircraft and ground
- Control Head to provide on/off, data entry, and display of ADS-B In
- Ground System to manage and broadcast air traffic and other data

Current regulations: Australia

- Lower airspace
  - No mandate yet, but preferential clearances provided by AirServices Australia
- Upper airspace (29,000 ft and above)
  - Starting 12 December 2013, CASA-compliant ADS-B equipage is mandatory
- CASA permits C129 GPS as data source, as well as all C145a, through 28 June 2012

Current and draft regulations: Europe

- EASA rule in place for non-radar airspace (NRA)
  - Both TSO-C129 and TSO-C145a are acceptable
- Rulings for radar airspace (RAD) and airborne separation (ASAS) available later in 2009
- ETSO-2C166a for 1090 MHz ADS-B
- New aircraft built after 1 January 2012 must be equipped with ADS-B
  - Older aircraft must be equipped with ADS-B by 5 February 2015
  - Aircraft weighing more than 5700 kg or with cruising speed > 250 kts held to higher standard
- “State aircraft” equipage by 5 February 2015

Current regulations: US

- TSO authority via TSO-C166a for 1090 MHz solution (all altitudes)
- TSO authority via TSO-C154b for 978 Mhz/UAT solution (only for < 24,000 feet)
- Existing NPRM stipulates GPS WAAS required for all ADS-B applications
- Final rule-making not expected until April 2010
- GOMEX IFR helicopter ADS-B equipage:
  - Voluntary equipage through March 2010
  - Mandatory equipage from May 2010 through 2020

How to equip for ADS-B

GPS	Have compliant Transponder?	Don't have compliant Transponder?
None	Add a GPS. Connect to transponder.	Upgrade or replace existing transponder. Add a GPS. Connect GPS to transponder.
C129	Maybe upgrade to WAAS. Connect to transponder.	Upgrade or replace existing transponder. Connect GPS to transponder. Maybe upgrade to WAAS.
WAAS	Connect to transponder	Upgrade or replace existing transponder. Connect WAAS to transponder.

ADS-B Equipage 201: Advanced concepts

- **No GPS?**
  - Buy a stand-alone WAAS sensor and install in the equipment bay
  - If aircraft lacks an FMS, buy GPS navigation management system (NMS) and mount in the panel or console
  - If equipped with a non-GPS FMS, buy a WAAS sensor, install in the equipment bay, and consider spoofing the FMS into using it for added benefit.
    - More on this later
- **Have a transponder not fully compliant with ADS-B?**
  - Throw it out and replace with one of the five or six ADS-B compliant transponders currently available
  - If available, purchase transponder upgrade to achieve compliance
- **Flying low-altitude in US airspace only?**
  - Buy one of the two brands of UAT transmitter available, or soon available
- **Want vertical guidance?**
  - For best capability, ensure your WAAS GPS is Class 3 compliant

Avionics for basic 1090 MHz ADS-B Out

TSO-C145 GPS Sensor (FFS 1201)

Enables ADS-B for most aircraft in nearly all air traffic jurisdictions
(Antenna "diversity" needs an up-market transponder and 2nd antenna)

Aircraft State and Time Data

DO 260A Mode S

GPS Antenna

Existing C74c or C112 Antenna

Existing Altitude Encoder

Reality Check

- ✓ **The technology exists and works. Someday, the technology and regulations will be polished to perfection. But right now, an aircraft can efficiently and safely fly - and traffic can be managed - using existing technology.**
- ✓ **Current ADS-B technology is affordable and fairly straightforward. Future technology might be more capable; it will likely be more complex and expensive.**
- ✓ **Flying ADS-B provides numerous economic, safety and environmental advantages.**
- ✓ **Money these days is somewhere between tight and non-existent.**
- ✓ **Suggestion: Install ADS-B now and enjoy the advantages it confers. When the economy recovers, you can buy the future technology - or a whole new airplane. In the meantime, save money and learn how to operate in the future airspace.**

Equipage: How to do it and how much does it cost?

- **Equipping for ADS-B: Two examples**

- **Case 1: Helicopter Fleet**
  - Mixed fleet
  - Flying low and slow in Gulf of Mexico
  - Requires simple operation, low weight

- **Case 2: Fokker 100 ADS-B/Navigation Upgrade**
  - Air transport aircraft with old inertial navigation unit and old FMS lacking a GPS
  - Want to fly aircraft for another 5 years, but need to be compliant with requirements of modern navigation and surveillance
  - Dual system required

- **In both cases, total installed cost is a major consideration**

Case 1: GOMEX Helicopter Fleet ADS-B

- **Gulf of Mexico (GOMEX) is non-radar airspace (NRA)**
- **Fleet of nearly 600 helicopters servicing over 5,000 offshore oil platforms**
  - About 20% are IFR; the rest VFR
  - Several thousand missions flown daily (weather and daylight permitting)
- **During IMC, procedural separation used**
  - Highly inefficient
- **ADS-B is considered KEY to obtaining efficiencies comparable to radar airspace**
- **Challenge:**
  - Mixed fleets (Agusta, Bell, Eurocopter, Sikorsky, etc.)
  - Current transponder equipage not easily upgradeable to ADS-B conformance in a timely manner
  - Regulations constrain solution choices
    - Ex: Using ADS-B Non-Transponder Device combined with a Mode S Extended Squitter transponder

Case 1: GOMEX Helicopter Fleet ADS-B

- **Ex: Helicopter with old Mode A/C transponder and old GPS**
- **Recommended approach:**
  - Upgrade transponder to a panel-mount Mode S Extended Squitter possessing both transponder and ADS-B TSOs.
    - Control head included
  - Consider upgrade to GPS/WAAS to guarantee full compliance with ADS-B MOPS; connect to transponder
    - Otherwise, connect original GPS to transponder
    - Need GPS output signals other than position; e.g., velocity
  - Installation ranges from simple to complex
  - STC simplified with equipment having the right TSOs
  - Train flight crews for new equipage

Case 1: GOMEX Helicopter Fleet ADS-B

- **<u>Economics (ROM, per aircraft)</u>**
  - Avionics (w/antennas) $ 6,000
  - Installation ~$ 4,000
  - <u>STC (no amortization) $ 5,000</u>
  - TOTAL $15,000

- **If amortization + simple installation:**
  - Cost per aircraft < $10,000

- **In this case:**
  - Component costs ~40% of total
  - Non-diversity (single) antenna
  - GPS/WAAS is Class Beta-1
  - Basic ADS-B Out provided

Case 1: GOMEX Helicopter Fleet ADS-B

- **ADS-B Out benefits:**
  - Communication with Houston Air Traffic Control
  - Separation from Houston Air Traffic Control based on ADS-B Out
  - IMC flight comparable to or better than radar airspace

Case 2: Modernizing a Fokker F100

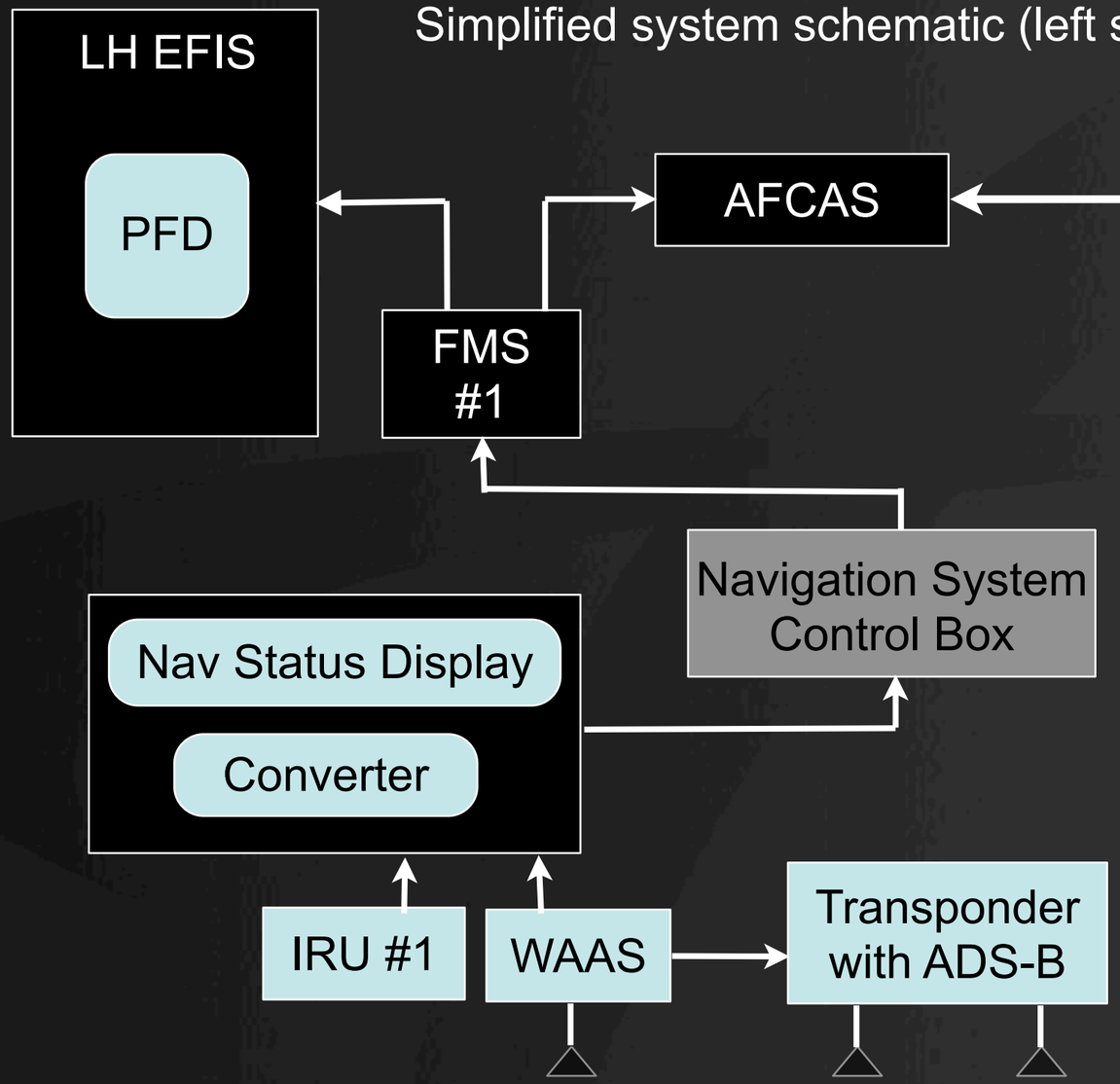
- **Original problem:**
  - Aircraft has old Inertial Reference Unit and old FMS
  - No software or hardware upgrades offered by avionics OEMs
  - Needs ability to fly RNAV 0.3, GPS NPA, P-RNAV, RNAV-1 SID/STAR, RNAV-2 en-route, remote and oceanic... in short, fly in modern airspace
  - Financial situation dictates need to actively fly aircraft for at least another 5-7 years
- **Ideal solution also provides ADS-B capability**

Case 2: Modernizing a Fokker F100

Recommended approach? Add:

- Two LRUs consisting of
  - Navigation status display
  - Converter to combine IRS and GPS data
- Two GPS/WAAS receivers and antennas
- GPS/WAAS connection to Mode S ES transponder
- Control panel

Case 2: Modernizing a Fokker F100



Time and Cost?

- Full system (left & right) and all certifications ~€100K
  - Or, ~$140,000
- Aircraft downtime - 100 hours

Case 2: Modernizing a Fokker F100

- **Benefits:**
  - Able to fly GPS-based RNAV for entire flight (SID, en route, STAR)
  - GPS NPA capability
  - ADS-B Out
  - Approved for operation in Remote and Oceanic regions
  - Positional accuracy enhancement over radio navigation aids
  - No hardware or software change to FMS, EFIS and AFCAS
  - B-RNAV and P-RNAV approved for ECAC airspace
  - APV: Vertical guidance based on Barometric VNAV
  - A costly new FMS is not required

- **Rocky Stone (UAL):**
  - “There are other reasons for GPS equipage, and ADS-B shouldn’t bear the entire burden of cost justification for a GPS upgrade.”

Conclusion: What to take away...

- **A variety of ADS-B Out equipment is out there already, but total cost varies:**
  - With functional capability and performance of ADS-B
  - With type of aircraft: Installation difficulty and how it's flown
  - With national airspace; different countries have different requirements
  - With certifications of existing equipage (e.g., Mode S transponder)
  - "Per aircraft" cost ranges from < $10,000 to > $100,000 (non-certified even less)

- **Choice of data link frequency sometimes required, but choices constrained**
  - 1090 MHz vs. 978 MHz (UAT) vs. VDL Mode 4

- **Recommended path forward to improve cost/benefit:**
  - "Get in the game" early - Reap operational benefits by equipping for basic ADS-B
  - Get equipment with "the right" TSOs to minimize STC costs
  - Get dual use from ADS-B components while further modernizing cockpit