ADS-B and WFP Operators
Safety Advantages Security Concerns

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ADS-B

• How can ADS-B be useful for Humanitarian Air Operation? Are there security concerns?
• Evolution of ADS-B
• Begin with RADAR
RADAR
Radio Direction and Range
IFF

- Identification Friend or Foe
- Predecessor to transponder
- Simple response signal when interrogated
- No response meant Foe
- Security innovation
- Led to safety feature
- Mode A identify individual aircraft

Primary Radar
Secondary Surveillance Radar
Transponder Mode A, Mode C

- Military IFF became civil transponders
- Mode A transponder squawk codes allow discrete aircraft identification
- Requires pilot to dial in the assigned transponder code
- Mode C – Aircraft altitude from altimeter
Radar ATC Information Displayed

Transponder Mode A, Mode C
Mode S Transponder

- Mode S can **select** a single transponder code to interrogate
- Avoids over-interrogation in busy terminal areas
- Enables airborne collision avoidance systems TCAS
- Message is addressed to 24 bit ICAO hex code permanently assigned to the aircraft
- **Upon interrogation transmits to ATC SSR, other aircraft with TCAS, and ADS-B**
Air Traffic Control Radar

Ground-based

TCAS

- Traffic Collision Avoidance System
- Aircraft to aircraft system
- Next step to a non-ground based system
- Ground-based implies a large, expensive infrastructure
HOW TCAS WORKS

- TCAS operates similar as Secondary Surveillance Radar (SSR), but in air to air role.

[Diagram showing the workings of TCAS]

Transponder

Secondary Surveillance Radar

Mode A/C
- Altitude
- 4096 Code

Elementary Mode S
- ACFT Addr
- Flight ID
- Surveillance ID

Enhanced Mode S
- Selected Alt
- TAS
- Mach No
- IAS
- Mag Hdg
- GS
- Roll Angle
- VS
- Track Angle
- Track Angle Rate

Extended Squitter
- Position
- Velocity
- Fit ID, etc

+ GPS

TCAS / Traffic Computer

ADS-B Out

+ ADS-B In

ADS-B In Applications
- Receive
- Merge TCAS & ADS-B Targets
- Surface Ops
- In Trail Climb Procedures
- Visual Separation on Approach
- Sequencing & Merging
- Etc.
Evolution to ADS-B

- The next step toward ADS-B is GPS

GPS – Global Positioning Satellite System

1. Each satellite broadcasts radio signals with three location databases and precise time information.
2. GPS does signal travel at speed of light – 300,000 km/s.
3. GPS device receives radio signals, noting that each time of arrival and uses these to calculate its distance from each satellite it can view.
4. Once a GPS receiver knows its distance from at least 4 satellites, it uses geometry to determine its exact location on Earth in 3D.
GPS

• It is the GPS satellite system that makes ADS-B navigation possible
• It is a space based system that communicates directly with the aircraft
• The information from GPS signal is transmitted out via ADS-B to ATC and other aircraft

Automatic Dependent Surveillance-Broadcast  ADS-B

• Airplane automatically transmits accurate position, its velocity (both vertically and horizontally), its altitude, heading and other information to controllers and other ADS-B equipped aircraft.
• It is dependent upon the broadcast of information from the aircraft not transponder interrogation from ATC
• Aircraft equipped with ADS-B Out broadcast the information 1x per second.
ADS-B

- Advantages:
  - Does not require an extensive ground based infrastructure of radar transmitters and receivers that must connect with each other.
  - Is not limited by line of sight issues between radar antenna and the target.
Automatic Dependent Surveillance Broadcast (ADS-B)
Aircraft broadcast position, altitude, speed etc

Secondary Surveillance Rader (SSR) Mode-S Surveillance
Altitude and identity data available

Mode-S Transponder
Selective Interrogation
ICAO 24 bit Aircraft Address

Operational Radio Stations
Current as of March 2014

USC Viterbi
School of Engineering
University of Southern California
Five days of ADS-B Data B737 only LAX

American Airlines
Delta Airlines

Southwest Airlines
United Airlines

American Airlines
Delta Airlines

Southwest Airlines
United Airlines

All Airlines Vertical Rate
All Airlines Vertical Rate
Equipment needed to collect and record ADS-B data:

- Antenna tuned for 1090 mHz, purchased or homemade
- Coaxial cable to recording computer
- Software Defined Radio (SDR) USB stick
- Decoding software, options include (all free):
  - Modesdeco2
  - Dump1090
  - ADSB Spy
  - RTL 1090
  - Plane Plotter
  - Many more
  - All free, most open source (open source = anyone can inspect how software works = can’t hind malicious code)
- Lines of data created by decoding software:
  - Hexadecimal Data
  - Comma Separated Data
- Data can then be saved into database, options include:
  - SQL (Structured Query Language, pronounced sequel)
  - Text Files
  - Comma Separated Variable (CSV) files
  - Any other database format
- Collection range depends on line-of-sight and sensitivity of receiver:
  - USC can reach cruise-altitude aircraft 250 miles away
  - Multiple receivers can be connected via internet to expand range
  - All data is timestamped – networking delays do not corrupt data
- The following organizations will provide professional-grade ADS-B receivers if you have a good location that they want more coverage in (non-exhaustive list):
  - Planefinder (ours)
  - FlightAware
  - Flightrader24 (used by Andrew Walton at Liberty University)
- Harder to find software that will automatically record data into local database:
  - Will require at least a basic understanding of programming
  - But ADS-B is popular with amateur radio and programming communities
  - Can likely find support locally or through the FlightAware support forum

FlightAware Pro Stick Plus ADS-B USB Receiver Built-in Filter

No FlightAware

Price: $190.95

Drink: $3.49 (FFP in CA)

Note: FlightAware and Plane Plotter are two of the leading providers of ADS-B data.
The Final Take-Aways

- Investment of $500
- Ground-based system
- Observe ADS-B equipped aircraft
- Range line of sight
- Initiate an initial flight data system

- Anyone with $500 and computer capability can see the information as well.

For Advice

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Thank You from USC
GPWS - EGPWS

- Aircraft based
- Not an ATC system
- Aircraft to aircraft

Enhanced Ground Proximity Warning System

GPWS – EGPWS

USC Viterbi
School of Engineering
University of Southern California
GPWS - EGPWS

• GPWS works on radar altimeter information; it looks down.
• EGPWS compares radar altimeter data with GPS location and terrain elevation data base. Via the software it looks forward as well as down.
• 4300 MHz civil radar altimeter frequency
GPWS – EGPWS
Enhanced Ground Proximity Warning System

B777 Antenna Locations