GPS – Backbone of ADS-B
ADS-B – Backbone of NGATS

Briefing to Colorado Springs ION

December 11, 2009
Overview

• Introduction
• ADS-B “essential” and “critical” services
• Navigation accuracy, integrity, & probability of non-detected integrity error
• Data links and spectrum
• ADS-B ground infrastructure deployment
• Summary
What does ADS-B stand for?

- **Automatic** – aircraft & ground-based ADS-B equipment automatically broadcasts ADS-B information
- **Dependent** – ADS-B depends on GNSS signals, possibly with Flight Management System, for state vector
- **Surveillance** – unprecedented situational awareness of air traffic for ADS-B aircraft and ATC
- **Broadcast** – ADS-B ground stations and aircraft periodically broadcast navigation data and other flight information

GPS is backbone of ADS-B → ADS-B is backbone of the Next Generation Air Transportation System (NGATS)
ADS-B Operational View

http://www.itt.com/adsb/adsb-explained.html
Why use ADS-B?

- Enables air traffic control procedures for more effective, efficient – increased capacity and better routing
- Unprecedented pilot situational awareness with cockpit safety services; expands safe air traffic control services to cockpit
- Lower cost (estimated to be 10% of the cost of radar as well as air traffic efficiency time/money savings)
- More accurate (3-meters) and more frequent surveillance infrastructure (1 second vs up to 12 seconds for en route radar)
- Allows surveillance where previously not possible, e.g. Gulf of Mexico, mountains of Alaska

<table>
<thead>
<tr>
<th>Ground radar-based system</th>
<th>ADS-B system</th>
</tr>
</thead>
<tbody>
<tr>
<td>On the ground, dependent on human participation</td>
<td>On the aircraft, providing automatic flow of ID &amp; location data</td>
</tr>
<tr>
<td>Coverage gaps exist in some areas</td>
<td>ADS-B ground stations placed anywhere (e.g., mountains, oil rigs)</td>
</tr>
<tr>
<td>Positions updated by aircraft every 12 seconds</td>
<td>Positions updated by aircraft every second</td>
</tr>
<tr>
<td>Costly to install and maintain</td>
<td>Significantly less costly to install and maintain</td>
</tr>
</tbody>
</table>

Safety, cost/time savings, accuracy, expanded surveillance
Lower cost, more accurate & more frequent surveillance: ADS-B aircraft landing at Orlando
Lower cost, more accurate & more frequent surveillance:

A/C on down wind phase

A/C on final approach

SSR delay
What are “critical” ADS-B services?

- **ADS-B**: Aircraft broadcasts ADS-B messages, other ADS-B equipped aircraft receive these messages as well as the ground radio infrastructure for data delivery to ATC facilities.
- **ADS-R (Automatic Dependant Surveillance-Rebroadcast)**: translates for both ADS-B broadcast links
  - 1090 MHz for air transport, military & high-end GA aircraft
  - 978 MHz Universal Access Transceiver (UAT) for lower cost airborne avionics on aircraft flying below 24,000 feet

What are “essential” ADS-B services?

- **Traffic Information Services Broadcasts (TIS-B):** provides air traffic situational awareness of non-ADS-B aircraft to ADS-B equipped aircraft

- **Flight Information Service - Broadcast (FIS-B):** provides current weather information and awareness of meteorological conditions that might impact flight

What is the TIS-B service?

- Traffic Information Services Broadcasts (TIS-B)
- ADS-B ground infrastructure ingests:
  - All ADS-B broadcasts from aircraft
  - FAA radar-based surveillance data for non ADS-B equipped aircraft
- TIS-B service broadcasts TIS-B messages on 1090ES & UAT
- Provides ADS-B aircraft with situational awareness by displaying data on all traffic in its proximity on a cockpit display
TIS-B Displays

TIS-B in Anchorage Bowl area, round nosed targets are radar targets, arrow nosed targets are ADS-B equipped aircraft

TIS-B in Anchorage Bowl on Garmin MX20 custom map display
TIS-B: Unprecedented situational awareness with indications/alerts for safe operations in taxi & approach

TIS-B: Enables advanced ATC procedures such as conflict management

Cockpit Display of Traffic Information (CDTI)

What is the FIS-B service?

- Flight Information Service - Broadcast (FIS-B)
- ADS-B ground infrastructure ingests:
  - Weather data
  - Aeronautical data
- FIS-B service broadcasts FIS-B messages on UAT only
- Pilots have an understanding of all weather and aviation system changes that might impact flight
FIS-B display

Moving map display, FIS-B and terrain at Windy Pass, Alaska

http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/surveillance_broadcast/graphics/sample_cockpit_displays/index.cfm
How close can ATC space aircraft based on ADS-B?

- Merging & Spacing: ADS-B provides flight deck spacing for the safest, most efficient interval possible from cruise altitude to runway
- ATC can delegate aircraft separation responsibility to pilots with airspeed commands

Image of SafeRoute-M&S™ (Merging & Spacing) display courtesy of ACSS
GPS Accuracy & Integrity Parameters: NACp, NIC, and SIL

- **Accuracy** reflects nominal GPS performance; needed to avoid collisions and issue associated alerts
  - Navigation Accuracy Category for Position (NACp) specifies the “Estimated Position Uncertainty” (EPU) with a 95% uncertainty bound
- **Integrity** reflects level of trust in GPS data; needed to provide a safe aircraft separation assurance
  - Navigation Integrity Category (NIC) specifies integrity containment region characterized by horizontal radius of integrity containment (Rc or HPL)
- **Probability of non-detected integrity errors**; needed to assess aircraft maneuver risks and mitigate or avoid
  - Surveillance Integrity Limit (SIL) specifies the probability of exceeding the NIC-specified integrity containment region
Navigation Integrity Category (NIC) Parameter

- NIC derived from HIL/HPL $\rightarrow$ Rc
  - GPS-WAAS receiver NIC value function of WAAS differential data
  - GPS-only receiver, RAIM algorithm (depends on mfg.)
    - Older units: fixed accuracy assumption assumes SA “on”
    - Use URA in real-time to scale pseudorange accuracy

<table>
<thead>
<tr>
<th>NIC</th>
<th>Horizontal and Vertical Containment Bounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Unknown</td>
</tr>
<tr>
<td>1</td>
<td>Rc &lt; 37.04 km (20 NM)</td>
</tr>
<tr>
<td>2</td>
<td>Rc &lt; 14.816 km (8 NM)</td>
</tr>
<tr>
<td>3</td>
<td>Rc &lt; 7.408 km (4 NM)</td>
</tr>
<tr>
<td>4</td>
<td>Rc &lt; 3.704 km (2 NM)</td>
</tr>
<tr>
<td>5</td>
<td>Rc &lt; 1852 m (1 NM)</td>
</tr>
<tr>
<td>6</td>
<td>Rc &lt; 1111.2 m (0.6 NM)</td>
</tr>
<tr>
<td>7</td>
<td>Rc &lt; 370.4 m (0.2 NM)</td>
</tr>
<tr>
<td>8</td>
<td>Rc &lt; 185.2 m (0.1 NM)</td>
</tr>
<tr>
<td>9</td>
<td>Rc &lt; 75 m and VPL &lt; 112 m</td>
</tr>
<tr>
<td>10</td>
<td>Rc &lt; 25 m and VPL &lt; 37.5 m</td>
</tr>
<tr>
<td>11</td>
<td>Rc &lt; 7.5 m and VPL &lt; 11 m</td>
</tr>
</tbody>
</table>

NIC value – defines size of integrity region
Surveillance Integrity Limit (SIL) Parameter

- SIL corresponds to the probability of being outside the NIC Rc containment region – higher SIL value is better
- SIL is fixed during equipment installation & certification

<table>
<thead>
<tr>
<th>SIL</th>
<th>Probability of Exceeding the Horizontal Integrity Containment Radius (Rc) Without Indication</th>
<th>Probability of Exceeding the Vertical Integrity Containment Region (VPL) Without Indication</th>
<th>Corresponding Hazard Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No Safety Effect</td>
</tr>
<tr>
<td>1</td>
<td>≤1×10⁻³ per flight hour or per sample</td>
<td>≤1×10⁻³ per flight hour or per sample</td>
<td>Minor</td>
</tr>
<tr>
<td>2</td>
<td>≤1×10⁻⁵ per flight hour or per sample</td>
<td>≤1×10⁻⁵ per flight hour or per sample</td>
<td>Major</td>
</tr>
<tr>
<td>3</td>
<td>≤1×10⁻⁷ per flight hour or per sample</td>
<td>≤2×10⁻⁷ per 150 seconds or per sample</td>
<td>Severe Major/Hazardous</td>
</tr>
</tbody>
</table>

1×10⁻⁷/hr reflects augmented GPS specification for Signal-in-Space integrity

SIL – probability of being outside NIC integrity region
Navigation Accuracy Category for Position (NACp)

- NACp derived from HFOM (95\textsuperscript{th} percentile accuracy) and is a weighted version of HDOP.
- Estimated Position Uncertainty (EPU)
- NACp EPU < NIC Rc for same NACp & NIC values.

<table>
<thead>
<tr>
<th>NACp</th>
<th>95% Containment Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EPU &gt;= 10 NM</td>
</tr>
<tr>
<td>1</td>
<td>EPU &lt; 10 NM</td>
</tr>
<tr>
<td>2</td>
<td>EPU &lt; 4 NM</td>
</tr>
<tr>
<td>3</td>
<td>EPU &lt; 2 NM</td>
</tr>
<tr>
<td>4</td>
<td>EPU &lt; 1 NM</td>
</tr>
<tr>
<td>5</td>
<td>EPU &lt; 0.5 NM</td>
</tr>
<tr>
<td>6</td>
<td>EPU &lt; 0.3 NM</td>
</tr>
<tr>
<td>7</td>
<td>EPU &lt; 0.1 NM</td>
</tr>
<tr>
<td>8</td>
<td>EPU &lt; 0.05 NM</td>
</tr>
<tr>
<td>9</td>
<td>EPU &lt; 30 m</td>
</tr>
<tr>
<td>10</td>
<td>EPU &lt; 10 m</td>
</tr>
<tr>
<td>11</td>
<td>EPU &lt; 3 m</td>
</tr>
</tbody>
</table>

NACp: 95\% bound on position accuracy (0-11)

EPU: NACp – 2\sigma Nav position uncertainty region

NIC: Integrity containment radius (0-11)

SIL: probability actual position is outside NIC circle (0-3)
GNSS position & Required Navigation Performance (RNP)

- RNP specifies the “navigation performance necessary for operation within a defined airspace”
  - Aircraft certification specifies an accuracy level, such as RNP 0.1 or RNP 0.3, at which the aircraft can navigate
  - RNP X conveys that total Nav error ≤X NM 95% of the time
- RNP specifies Nav performance required to fly air routes
  - RNP requires alerts if performance not being met
- GNSS is current, primary navigation system for RNP

GNSS equipment values NACp, NIC-SIL support RNP
## RNP and ADS-B Enabled with GNSS PNT

<table>
<thead>
<tr>
<th></th>
<th>Navigation (≥ 99.0% Availability)</th>
<th>Surveillance (≥ 99.9% Availability)</th>
<th>Positioning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy (95%)</td>
<td>Containment (10⁻⁷)</td>
<td>Separation</td>
</tr>
<tr>
<td>En Route</td>
<td>10 nm</td>
<td>20 nm</td>
<td>5 nm</td>
</tr>
<tr>
<td></td>
<td>4 nm</td>
<td>8 nm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 nm</td>
<td>4 nm</td>
<td></td>
</tr>
<tr>
<td>Terminal</td>
<td>1 nm</td>
<td>2 nm</td>
<td>3 nm</td>
</tr>
<tr>
<td>LNAV</td>
<td>0.3 nm</td>
<td>0.6 nm</td>
<td></td>
</tr>
<tr>
<td>RNP</td>
<td>0.1 nm</td>
<td>0.2 nm</td>
<td>2.5 nm DPA</td>
</tr>
<tr>
<td>LPV</td>
<td>16m/4m</td>
<td>40m/50m</td>
<td>2.5 nm DPA</td>
</tr>
<tr>
<td>LPV-200</td>
<td>16m/4m</td>
<td>40m/35m</td>
<td></td>
</tr>
<tr>
<td>GLS Cat-I</td>
<td>16m/4m</td>
<td>40m/10m</td>
<td>2.0 nm IPA</td>
</tr>
<tr>
<td>GLS Cat-III</td>
<td>16m/2m</td>
<td>40m/10m</td>
<td></td>
</tr>
</tbody>
</table>

**Dependent Parallel Approach (DPA)**

**Independent Parallel Approach (IPA)**

**Surveyance Integrity Level (SIL)**

**Navigation Integrity Category (NIC)**

**Navigation Accuracy Category for Position (NACp)**


11 December 2009
ADS-B surveillance position validation

- ADS-B position ($P_{ADS-B}$) validated using any of three alternate, independent surveillance position sources ($P_{\text{Indep}}$):
  - Radar data (primary, secondary, or both if available)
  - One-way ranging on UAT targets
  - Time difference of arrival (TDOA) when the target is received by more than one radio station

- Surveillance position validation threshold:
  \[
  |\text{Position}_{\text{Aircraft ADS-B report}} - \text{Position}_{\text{Independent source}}| \leq \text{Threshold}
  \]
  - Valid if $\text{Threshold} \leq 1.9$ NM for en route airspace, 36 s data window
  - Valid if $\text{Threshold} \leq 0.56$ NM for terminal airspace, 15 s data window

ADS-B position validation with 99.9% confidence
ADS-B Surveillance: deployed where previously *not* possible

- ADS-B OUT avionics enable closer aircraft spacing
- Reduced Gulf separation from 120 NM to “radar-like” 5 NM

ADS-B position valid for en route

Example NACp, NIC, & SIL values:
- NACp ≥ 7 (EPU ≤ .1 NM)
- NIC ≥ 5 (Rc ≤ 1 NM)
- SIL ≥ 2 (Prob.(Rc ≥ 0.2 NM)) ≤ 10^{-5}

ADS-B, NACp, NIC-SIL GPS data passed to ATC
What are key ADS-B data links?

• **1090 Mode-S Extended Squitter (ES)**
  - ATC stations and TCAS-equipped aircraft already have 1090 Mode S receivers and only require modifications to process ES data
  - Due to data link bandwidth limits, **1090ES doesn’t support FIS-B**
  - 1090 ES messages (120 bits, including 8 bit preamble) at 1 Mbps
  - ES signals from Mode S transponders or non-transponder (NT) devices

<table>
<thead>
<tr>
<th>Bits</th>
<th>1-5</th>
<th>6-8</th>
<th>9-32</th>
<th>33-88</th>
<th>89-112</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF17=transponder</td>
<td>DF #</td>
<td>Indicates ADS-B, TIS-B, etc.</td>
<td>24 bit address</td>
<td>56 bit message</td>
<td>parity</td>
</tr>
<tr>
<td>DF18=non-transponder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• **Universal Access Transceiver (978 MHz UAT)**
  - Designed for ADS-B and has greater bandwidth
  - UAT is bi-directional and can **send real-time Flight Information Services (FIS-B)** such as weather and other data to aircraft
  - UAT Frame (1 UTC second) has 3952 message start opportunities

<table>
<thead>
<tr>
<th>36 bits</th>
<th>144 bits</th>
<th>96 bits</th>
<th>36 bits</th>
<th>272 bits</th>
<th>112 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNCH</td>
<td>Short Message</td>
<td>FEC parity</td>
<td>SYNCH</td>
<td>Long Message</td>
<td>FEC parity</td>
</tr>
</tbody>
</table>
UAT 978 & 1090ES spectrum – Both in the ARNS band (960-1215 MHz)

- 1090 MHz center frequency dedicated to Secondary Surveillance Radar (SSR), Traffic Alert and Collision Avoidance System (TCAS), and Extended Squitter ADS-B systems
- SSR interrogation (1030 MHz) and reply (1090 MHz) channels
- Notches around 1090 MHz for Joint Tactical Information Distribution System/Multifunction Information Distribution System (JTIDS/MIDS) & Directional Measuring Equipment/Tactical Air Navigation (DME/TACAN) ops
- By comparison, UAT 978 MHz spectrum less congested
Ambient Emissions in the 1010-1060 MHz Frequency Band at BWI Airport

MEASURED EMISSIONS DATA FOR USE IN EVALUATING THE ULTRA-WIDEBAND (UWB) EMISSIONS LIMITS IN THE FREQUENCY BANDS USED BY THE GLOBAL POSITIONING SYSTEM (GPS)
Project TRB 02-02 Report, October 22, 2002, Technical Research Branch
Laboratory Division Office of Engineering and Technology Federal Communications Commission
MEASURED EMISSIONS DATA FOR USE IN EVALUATING THE ULTRA-WIDEBAND (UWB) EMISSIONS LIMITS IN THE FREQUENCY BANDS USED BY THE GLOBAL POSITIONING SYSTEM (GPS)

Project TRB 02-02 Report, October 22, 2002, Technical Research Branch
Laboratory Division Office of Engineering and Technology Federal Communications Commission
Ambient Emissions in the 960-1010 MHz Frequency Band at BWI Airport

MEASURED EMISSIONS DATA FOR USE IN EVALUATING THE ULTRA-WIDEBAND (UWB) EMISSIONS LIMITS IN THE FREQUENCY BANDS USED BY THE GLOBAL POSITIONING SYSTEM (GPS)
Project TRB 02-02 Report, October 22, 2002, Technical Research Branch
Laboratory Division Office of Engineering and Technology Federal Communications Commission
ADS-B Ground Infrastructure

• ADS-B requires ground infrastructure to process & disseminate  
  • ADS-B reports to ATC facilities  
  • TIS-B and FIS-B messages
• Nationwide deployment ongoing
A “Typical” GA Airport Site

- 60’ tower
- 4 directional 1090 antennae
- 1 omni-antenna for UAT
- Enclosure with two racks of fully redundant equipment including:
  - radios,
  - data comm. equipment,
  - batteries for short-term blackouts, and
  - engine generators for long-term power outages
Oil Platform Installation – Extends coverage

ADS-B ground states have a small footprint and can be more easily installed in remote areas (i.e., Alaska, coastal oil platforms)
ADS-B Essential Services
Regional service volume deployment

# ADS-B Program Ground Infrastructure Schedule

## Now

### FY 2008 Through FY 2013

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESSENTIAL SERVICES (TIS-B / FIS-B)</strong></td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td></td>
</tr>
<tr>
<td>In-Service Date (ISD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segment 1 Continued Roll-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segment 2 Roll-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CRITICAL SERVICES (ADS-B / ADS-R)</strong></td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td></td>
</tr>
<tr>
<td>Key Sites - Initial Operational Capability (IOC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Service Date (ISD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segment 2 Roll-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WEATHER OBSERVATION</strong></td>
<td>Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
<td>Q1 Q2 Q3 Q4</td>
</tr>
<tr>
<td>Gulf of Mexico Roll-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alaska Roll-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FY 2009 Milestone

<table>
<thead>
<tr>
<th>Event</th>
<th>Projected Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Service Decision (ISD) for Broadcast Services</td>
<td>November 2008</td>
</tr>
<tr>
<td>Louisville Service Acceptance Test (SAT)</td>
<td>April 2009</td>
</tr>
<tr>
<td>Gulf of Mexico Weather SAT</td>
<td>June 2009</td>
</tr>
<tr>
<td>Gulf of Mexico SAT</td>
<td>June 2009</td>
</tr>
<tr>
<td>Philadelphia SAT</td>
<td>August 2009</td>
</tr>
<tr>
<td>Gulf of Mexico Comm. &amp; Weather IOC</td>
<td>September 2009</td>
</tr>
</tbody>
</table>

### FY 2010 Milestone

<table>
<thead>
<tr>
<th>Event</th>
<th>Projected Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juneau SAT</td>
<td>October 2009</td>
</tr>
<tr>
<td>Louisville IOC of Surveillance Services</td>
<td>October 2009</td>
</tr>
<tr>
<td>Gulf of Mexico IOC of Surveillance Services</td>
<td>December 2009</td>
</tr>
<tr>
<td>Philadelphia IOC of Surveillance Services</td>
<td>February 2010</td>
</tr>
<tr>
<td>Juneau IOC of Surveillance Services</td>
<td>April 2010</td>
</tr>
<tr>
<td>Surveillance Services ISD for ADS-B</td>
<td>September 2010</td>
</tr>
</tbody>
</table>
Florida’s 11 ADS-B ground stations
Florida’s 11 ADS-B ground stations – first In Service Decision (ISD) for essential/critical services

Several ADS-B targets (0/1/2 indicates DO260/DO260A/DO260B equipment)
We bring all FAA radar data into the ground control stations

Track the main SSR radar beams to blank ADS-B transmissions when the ground station is in the main beam
Aircraft icons: We put all the data through a multi-sensor tracker so we get a multi-sensor output of radar and ADS-B (GPS-based) data.
Halos indicate TIS-B service area around every ADS-B equipped aircraft (about 22 shown) if there’s another aircraft in that service volume, transmit; otherwise not
Louisville International Airport – morning departures
Conclusion

• GPS/GNSS makes ADS-B possible
• ADS-B is safe, robust, scalable, and secure
• FAA deploying ADS-B infrastructure
  • Essential services complete by 2012 & critical services by 2013
• Deploying ground infrastructure with system ops & maintenance
http://www.faa.gov/air_traffic/technology/ads-b/

http://www.itt.com/adsb/

http://www.rtca.org/

BACKUPS
ADS-B System View

Surveillance and Broadcast Services System (SBSS) is the ground infrastructure including radio stations, central processing facilities, radar/sensor data pickup, weather and aeronautical data pickup and data delivery capabilities.
What is ADS-B IN & ADS-B OUT?

• ADS-B IN – aircraft receives ADS-B info for Cockpit Display of Traffic Information (CDTI) such as “see and avoid” surveillance or flight information such as weather
  • FAA will define strategy for ADS–B IN by 2012

• ADS-B OUT – aircraft transmits its navigation state vector for Air Traffic Control surveillance
  • The Aviation Rulemaking Committee (ARC) supports ADS-B OUT implementation in the NAS by 2020
  • ADS-B OUT aircraft-based 1090ES equipment may eventually replace radar surveillance technology