Alternative Positioning, Navigation & Timing (APNT) Study Update

November 9, 2011
Why APNT?

- The transformation of the National Airspace System (NAS) to the Next Generation Air Transportation System (NextGen) relies on GPS-Based PNT services and suitable alternate PNT services
  - Current ATC system cannot be scaled up to handle 2X traffic
  - 2X traffic is more than a controller can handle using radar vectors
  - RNAV and RNP procedures for trajectory-based operations (TBO)
  - Automation will separate aircraft performing trajectory-based operations (TBO)
  - Controllers intercede to provide “control by exception”
- TBO Operations may require PNT performance that exceeds DME/DME/IRU
- GPS vulnerability to radio frequency interference (RFI) requires mitigation
  - Waiting for the source of the interference to be located and turned off is not an acceptable alternative
PBN Benefits

- Radar vectors are less efficient use of the airspace

- Use of RNAV departures enable nearly two fold increase in capacity.
## GNSS Challenges: GPS Testing by DOD

### Geographical Area Impacted

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<tr>
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<th>Maximum Miles&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Minimum Miles&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Average Miles&lt;sup&gt;2&lt;/sup&gt;</th>
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<td>455,805</td>
<td>66,018</td>
<td>139,795</td>
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### 9 Month Duration

- 141 NOTAMs
- Cumulative Duration: 782 Hours (90 days)
- Shortest Duration: 1.0 hour
- Average Duration: 6.63 hours
- Longest Duration: 72 hours
Commercially Available GPS Jammer
(so called “Personal Privacy Device”)
Zeta “SnapShot” System Data

- Baseline/Nominal L1 RF
- Broadband RFI straddling L1
... and a few more “Personal Privacy Devices”

- $110 eBay
- $335 eBay
- $92 eBay
- $40 GPS&GSM
  www.chinavasion.com
- $55 eBay
- $83 GPS&GSM
  www.Tayx.co.uk
- $152 eBay
APNT Alternatives Analysis

APNT Study will investigate three alternatives:

- **Distance Measuring Equipment (DME)**
  Expansion of the DME network, and improve the performance of the DME systems to enable RNAV-0.3 operations without avionics changes.

- **Wide Area Multilateration (WAM)**
  Use WAM systems to compute aircraft position and send this information to the aircraft. This alternative would leverage ADS-B In avionics, which the standards are still being developed.

- **Pseudolite (PDL)**
  The DME and possibly GBT facilities would be modified to also transmit a pseudolite signal that aircraft would use to compute its position. It would require new equipment in the aircraft and on the ground.
PNT Performance Zones

Zone-1
Enroute High
CONUS

Zone-2
Enroute Low
CONUS

Zone-3
Terminal
OEPs + Next 100 Busiest Airports

5 SM of Airport

2° Slope from 500’ AGL

5000’ AGL

FL-600

FL-180

5 SM

27 SM

89 SM
APNT Alternative 1

Optimized DME Network
1100 DMEs in Current Network
Assumed Upgraded DME-DME Coverage
18,000 ft MSL
DME Next Steps

• Propose requirements changes for the current DME program
  – Enable RNAV 0.3 accuracy without avionics changes
  – SELEX will require resources to access the impacts

• Prepare a P3I feasibility study for SELEX
  – Potential to achieve ADS-B 92.6 meter accuracy requirement
  – Use of DME stations to receive MLAT signals
  – Potential use of DME stations as combined/MLAT/GBT stations
APNT Alternative 2
Wide Area Multi-Lateration
Passive Wide-Area Multi-Lateration (WAM)

1 – Aircraft Transmits ADS-B Signal
6 – Aircraft Uses Own Position for Navigation

- Aircraft Transmits ADS-B Signal
- WAM Receives Signal
- Aircraft Position Determined
- Aircraft Position Sent to GBT's
- TIS-B Sends Position to Aircraft
- Aircraft Uses Own Position for Navigation
SBS Site Locations

335 Sites Reporting on Network.
345 Sites Constructed.
84 Sites in Planning or Construction.
Compatibility of DME/GBT

- DME’s and ADS-B Ground Stations can add passive MLAT Receivers to existing systems

- ADS-B/MLAT and DME can share the same antenna since they are in the same frequency band

- Independent, precise position of the WAM stations is established and through measuring the time of squitter signal arrival the position of the aircraft is determined

- Backup timing and synchronization method will need to be identified to compensate for loss of GPS time sync

- Distributed receivers in DME and ADS-B GS measures TOA and forwards to WAM master stations where aircraft position and integrity bounds are computed

- Aircraft position information is broadcast back to the user via TIS-B to support determining its navigation solution
WAM - Initial Analysis Data

Washington Dulles

San Francisco

Philadelphia
WAM Next Steps

• Industry resources are needed to fully investigate this alternative

• APNT team has prepared a statement of work and IGCE for an Industry Study Contract
  – Use of ITT contract under SBS program
APNT Alternative 3
DME Pseudolites (DMPL)
Pseudolite Alternative Concept

- Combined Network of DME/GBTs etc
- GPS-Independent Time Reference
- 1 Hz Message ID and Time @ Transmit
- PNT Data Broadcast Channel

- Aircraft Calculates Position
- RAIM Based Integrity Solution
Combined DME and GBT Sites
Pseudolite Technologies

- APNT can use existing systems + new avionics
- DME PL+UAT PL can use single antenna

One possibility
1. Commercial uses DME and/or DME PL + UAT PL
2. GA uses DME PL + UAT PL
3. Legacy user can still use DME
Pseudolite Next Steps

• Investigate expansion of Locata technology for nationwide service
  – Air Force Institute of Technology proposal – $500K
  – Cooperation with 746 Test Squadron, Holloman AFB, NM

• Stanford University continue to research DME – pseudolite concept
  – Modulate heartbeat signal on existing DMEs
  – Use of 960 – 978 Mhz frequency band for PDL broadcast
  – Possible use of nation wide DME channel for PDL
APNT Timing Service
Ground-to-Ground Time Synchronization

GEO: WAAS L5

MEO: GNSS

LEO: MSS

30 dB of processing gain

DMEs + Planned DMEs + GBTs
Program Goals

1. Preliminary ACAT Determination
2. Preliminary Shortfall Analysis Report
3. Concept Requirements Definition Plan
4. CRD Readiness Decision
5. Enterprise Architecture Roadmap Update
6. CONOPS Documentation
7. Shortfall Analysis Report
8. Functional Analysis Document
9. Range of Alternatives
10. Enterprise Architecture Products
11. Award Industry Study Contract
12. Safety Risk Management
13. Preliminary Requirements Document
14. Estimate Cost and Benefits
15. Investment Analysis Plan
16. Final ACAT Designation
17. Investment Analysis Readiness Decision
18. Manage Industry Study Contract

APNT Study Brief to PNTAB
November 9, 2011
Summary

• NextGen Operational Improvements enabled by performance based navigation capabilities increases dependence on GPS and alternate PNT services

• GPS vulnerability to radio frequency interference needs to be addressed for trajectory based operations at some locations

• Alternatives are being studied for further consideration
Questions