Alternative Positioning, Navigation & Timing (APNT) Study Update

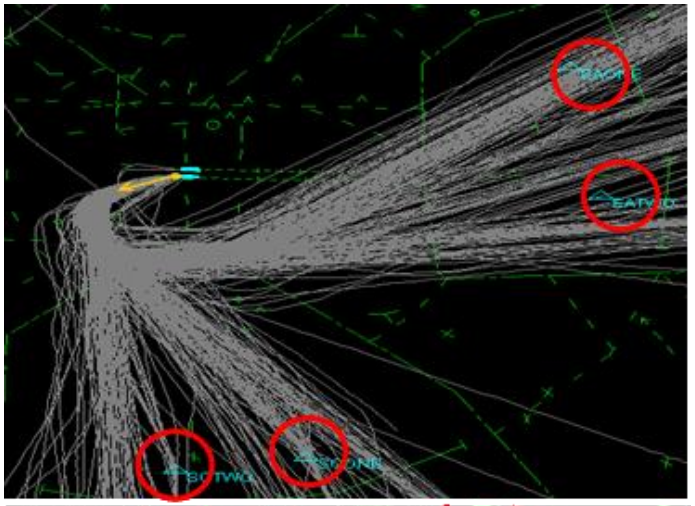
November 9, 2011

Why APNT?

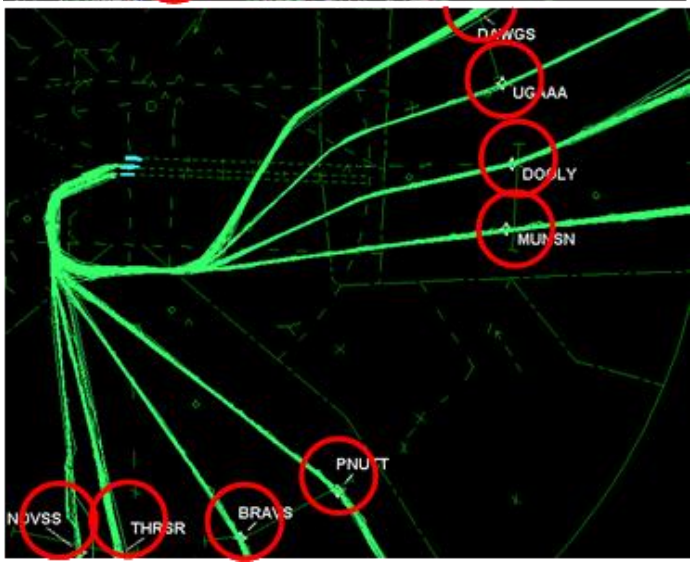
- **The transformation of the National Airspace System (NAS) to the Next Generation Air Transportation System (NextGen) relies on GPS-Based PNT services and suitable alternate PNT services**
  - Current ATC system cannot be scaled up to handle 2X traffic
  - 2X traffic is more than a controller can handle 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

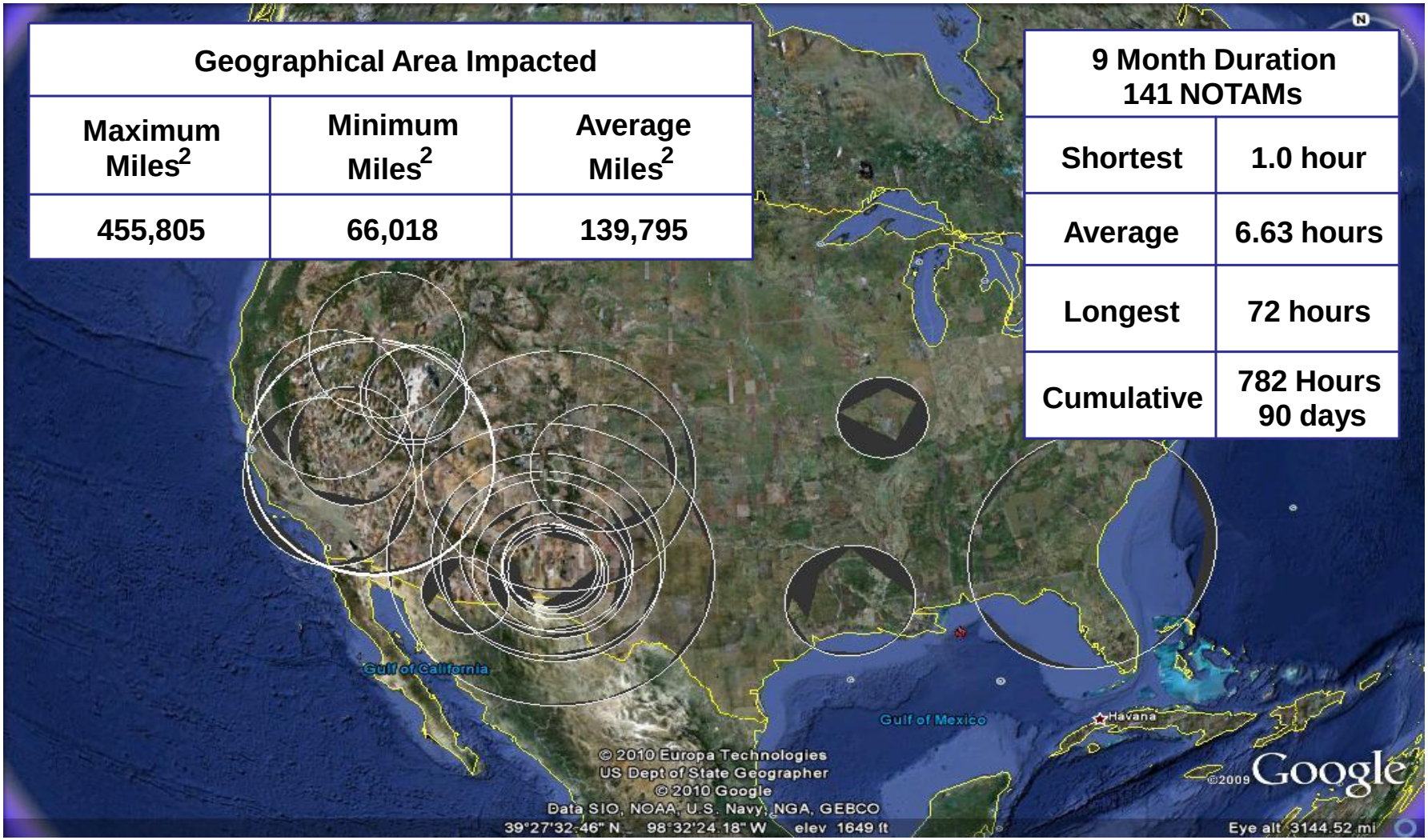
- **Radar vectors are less efficient use of the airspace**



- **Use of RNAV departures enable nearly two fold increase in capacity.**



GNSS Challenges: GPS Testing by DOD

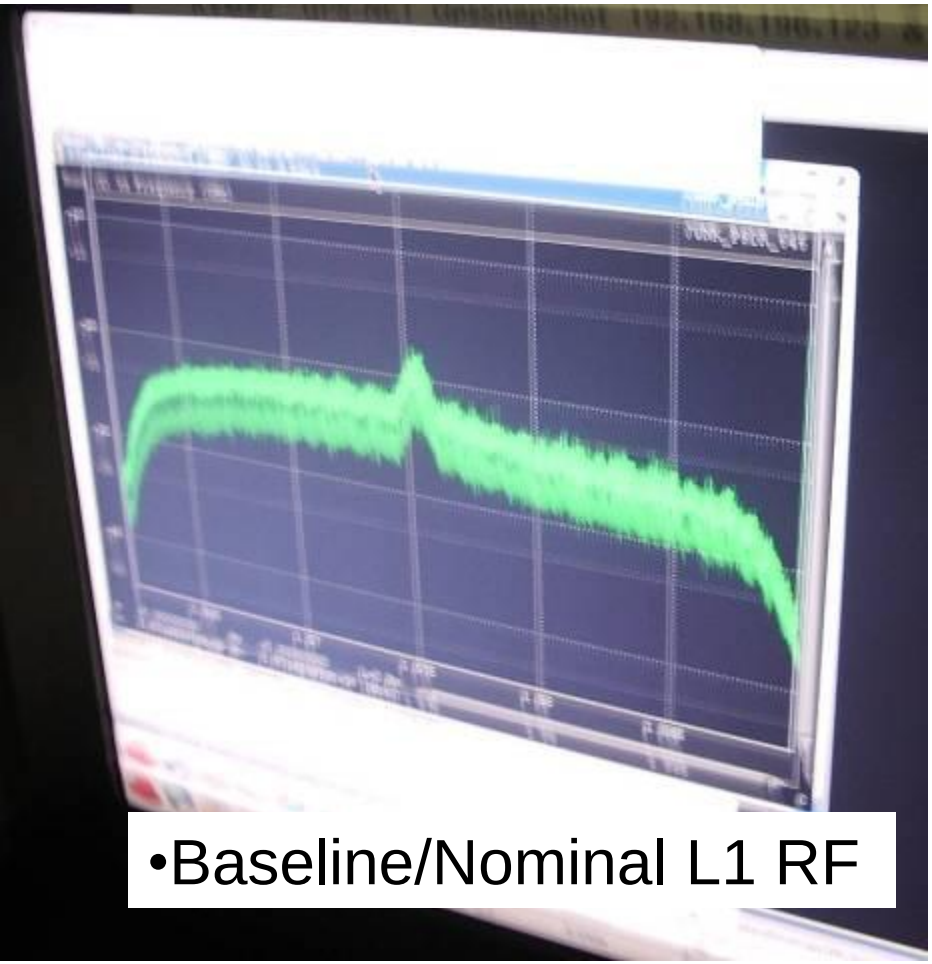


Geographical Area Impacted		
Maximum Miles^2	Minimum Miles^2	Average Miles^2
455,805	66,018	139,795

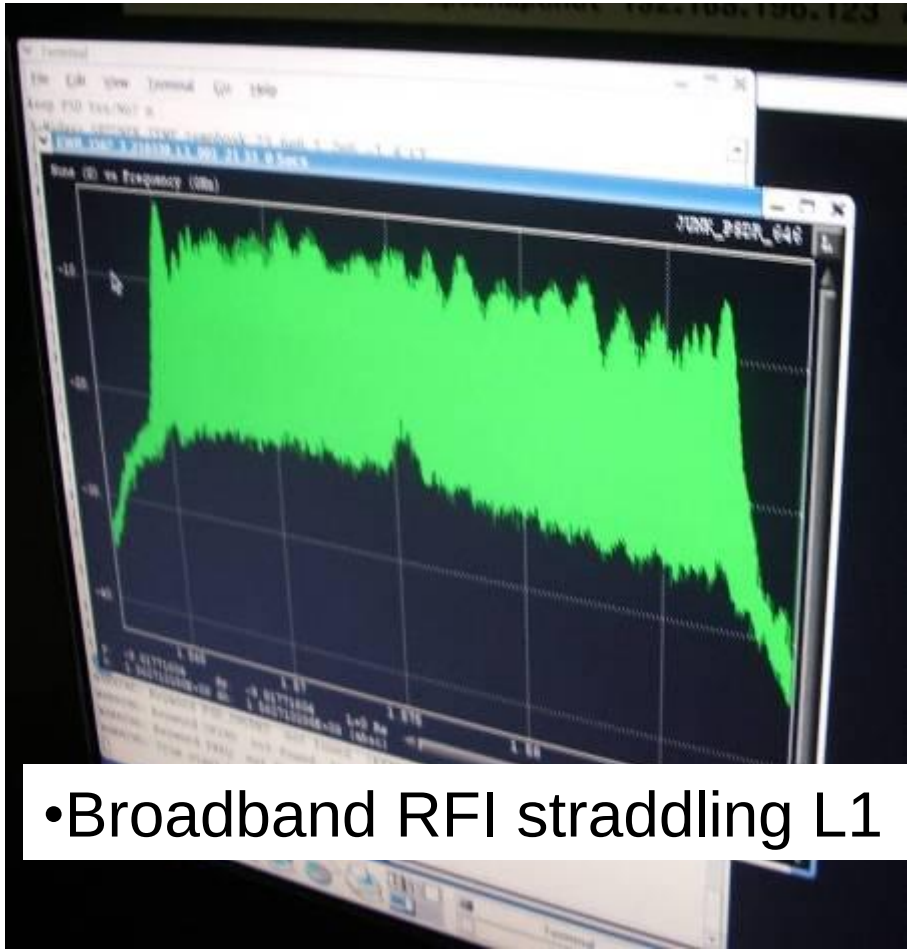
9 Month Duration 141 NOTAMs	
Shortest	1.0 hour
Average	6.63 hours
Longest	72 hours
Cumulative	782 Hours 90 days

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:

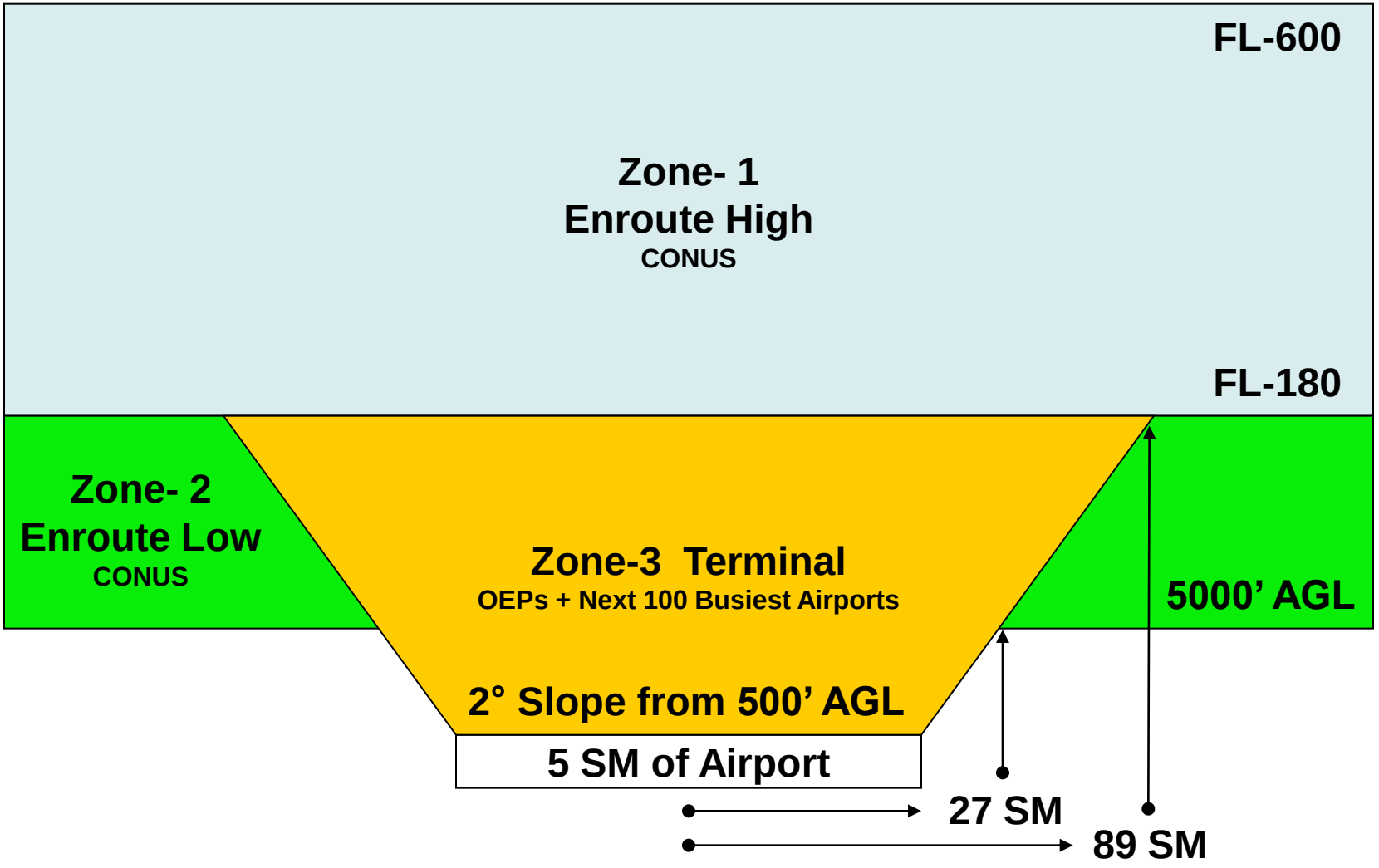
- **Distance Measuring Equipment (DME)**

  Expansion of the DME network, and improve the performance of the DME systems to enable RNAV-0.3 operations without avioncs changes
- **Wide Area Multilateration (WAM)**

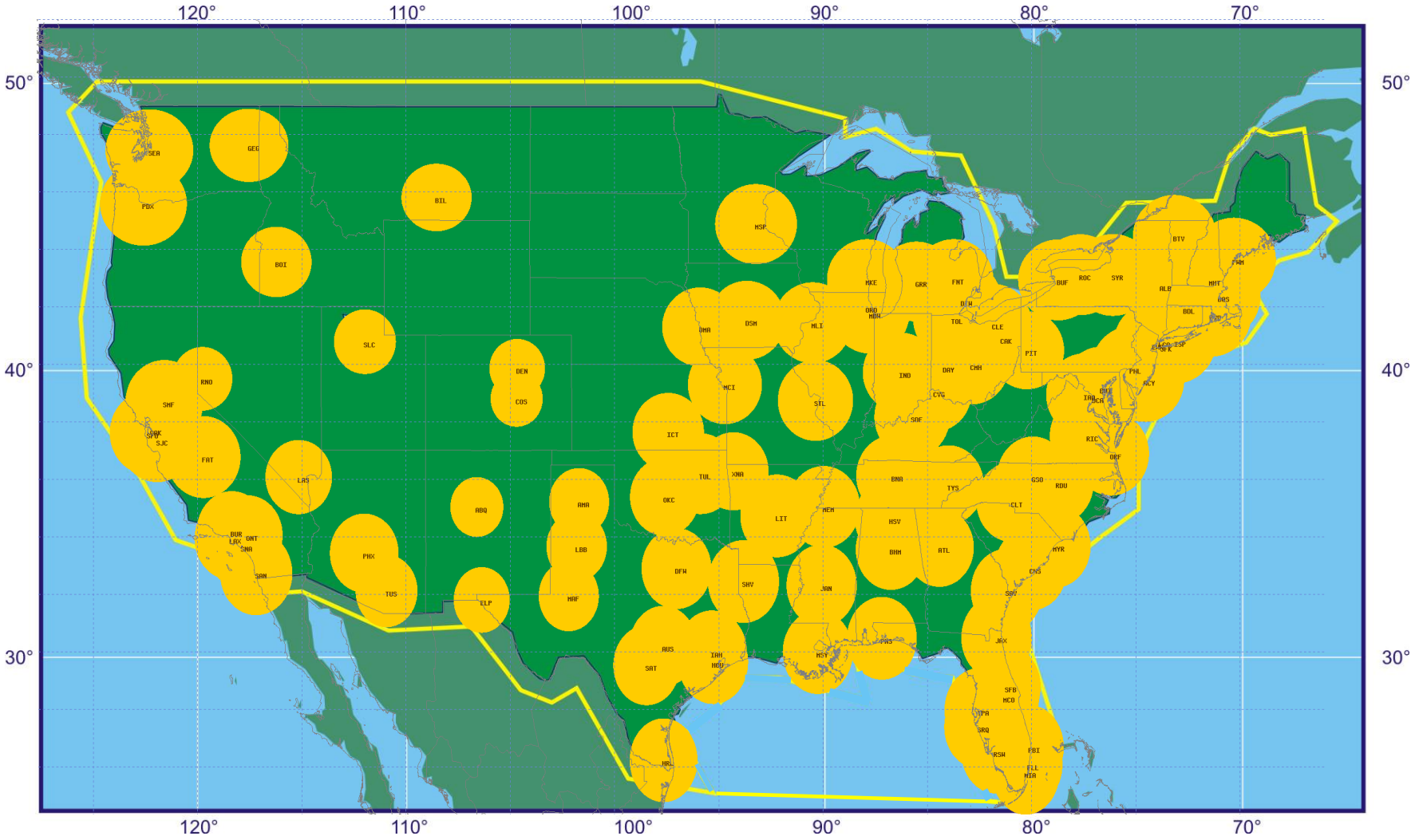
  Use WAM systems to compute aircraft position and send this information to the aircraft. This alternative would leverage ADS-B In avionics, which the standards are still being developed
- **Pseudolite (PDL)**

  The DME and possibly GBT facilities would be modified to also transmit a pseudolite signal that aircraft would use to computes its position. It would require new equipment in the aircraft and on the ground.

PNT Performance Zones



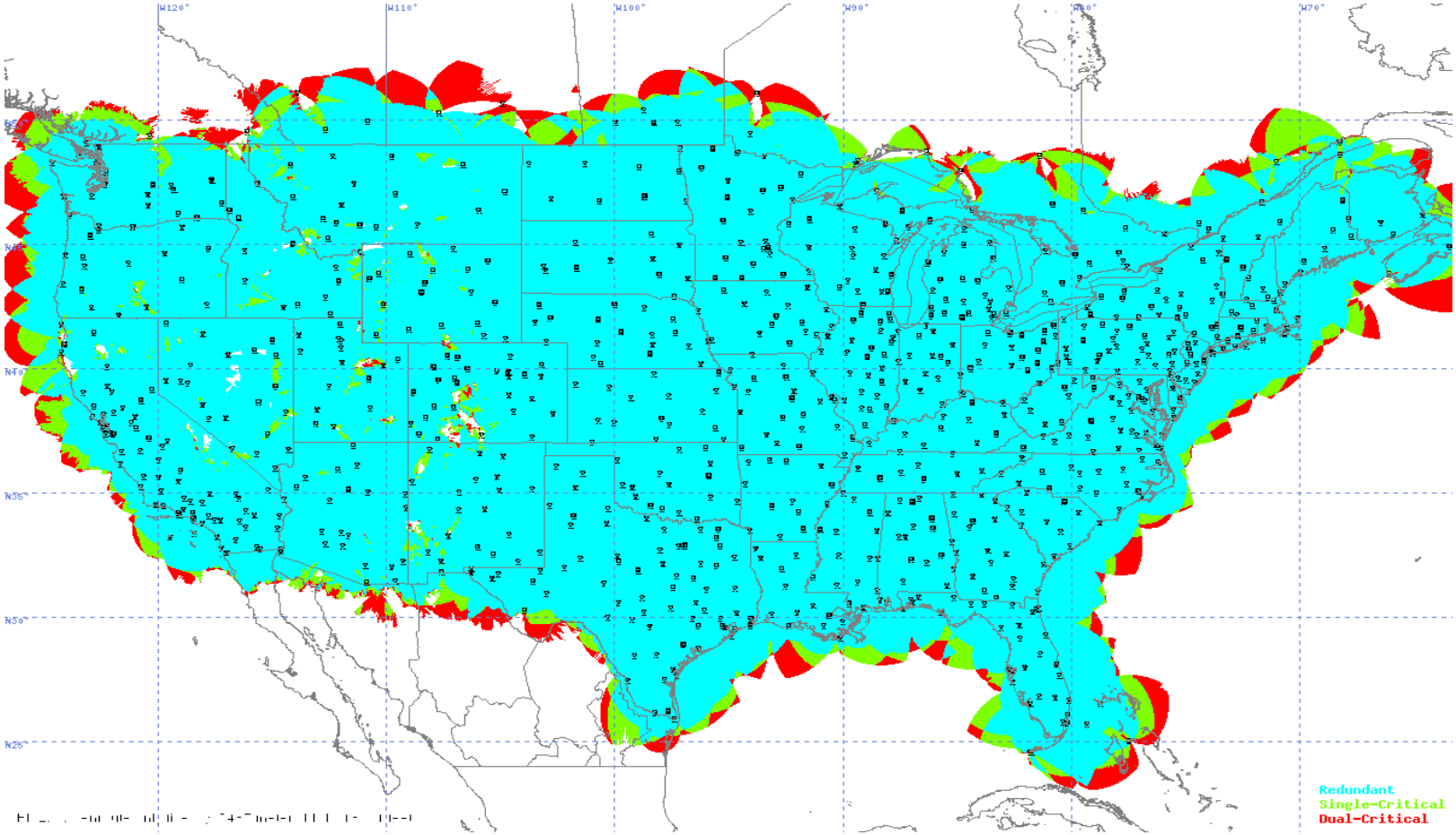
Zone 1, 2, and 3 Geographic Areas



APNT Alternative 1
Optimized DME Network

1100 DMEs in Current Nework

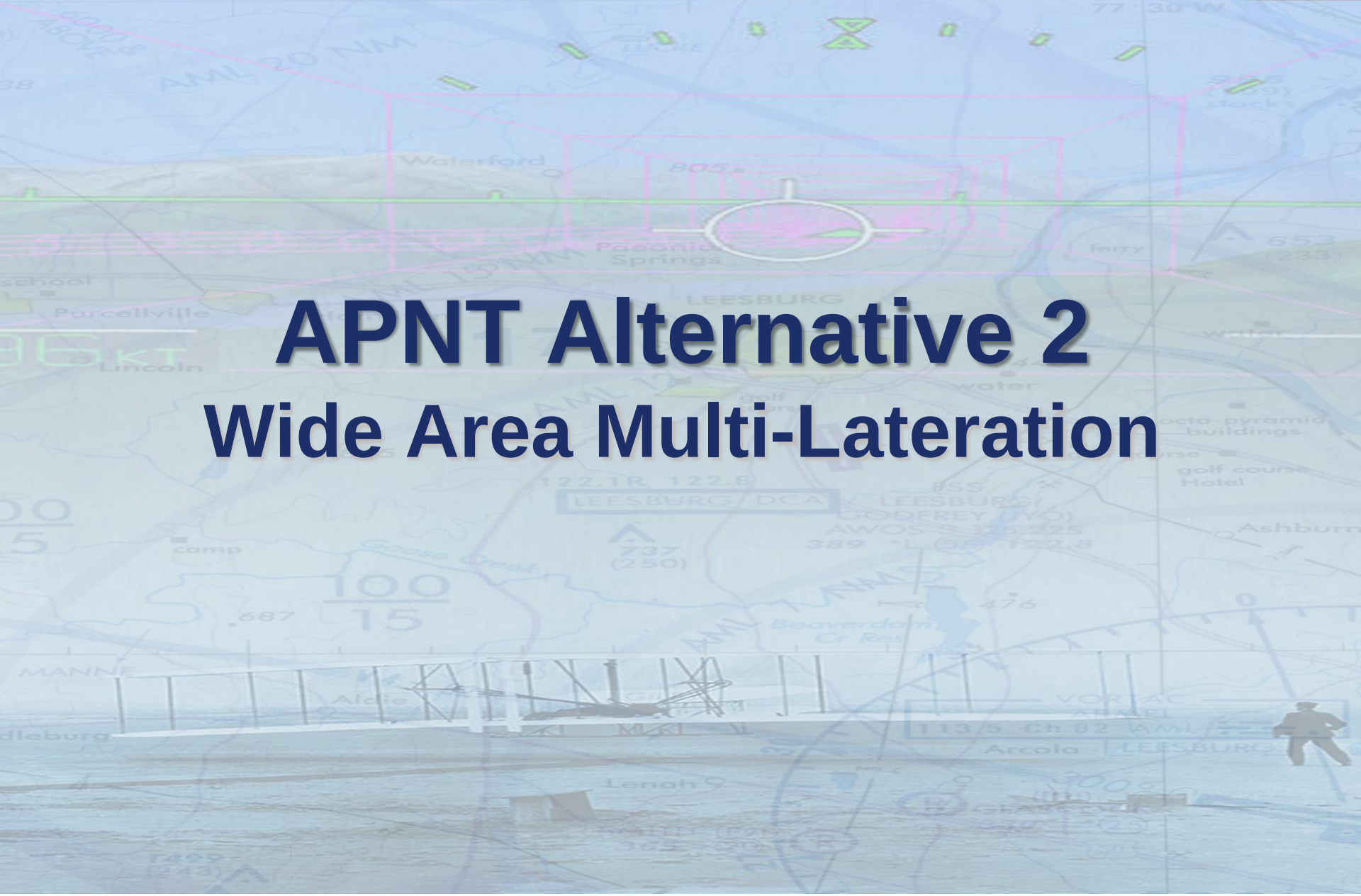
Assumed Upgraded DME-DME Coverage 18,000 ft MSL



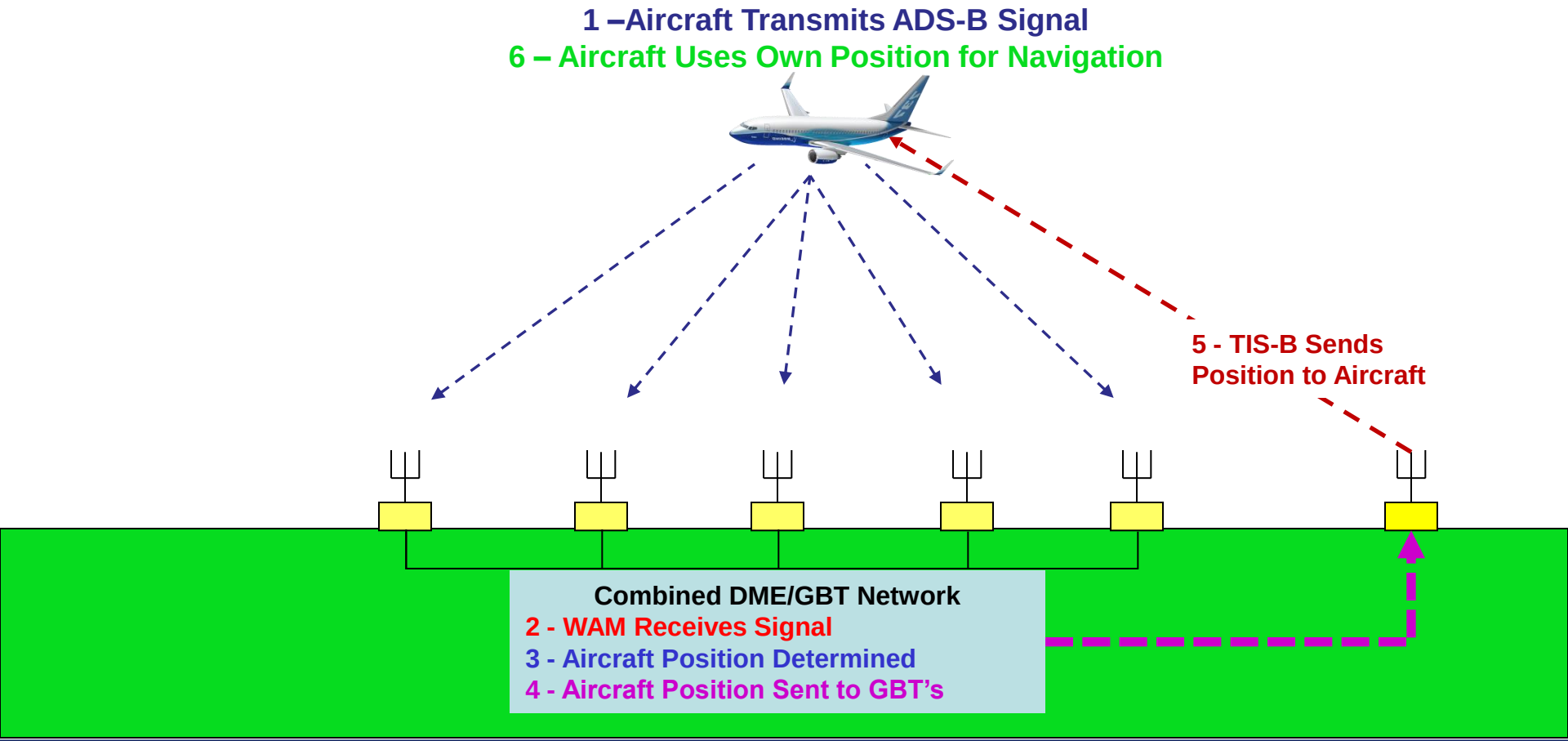
DME Next Steps

- **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

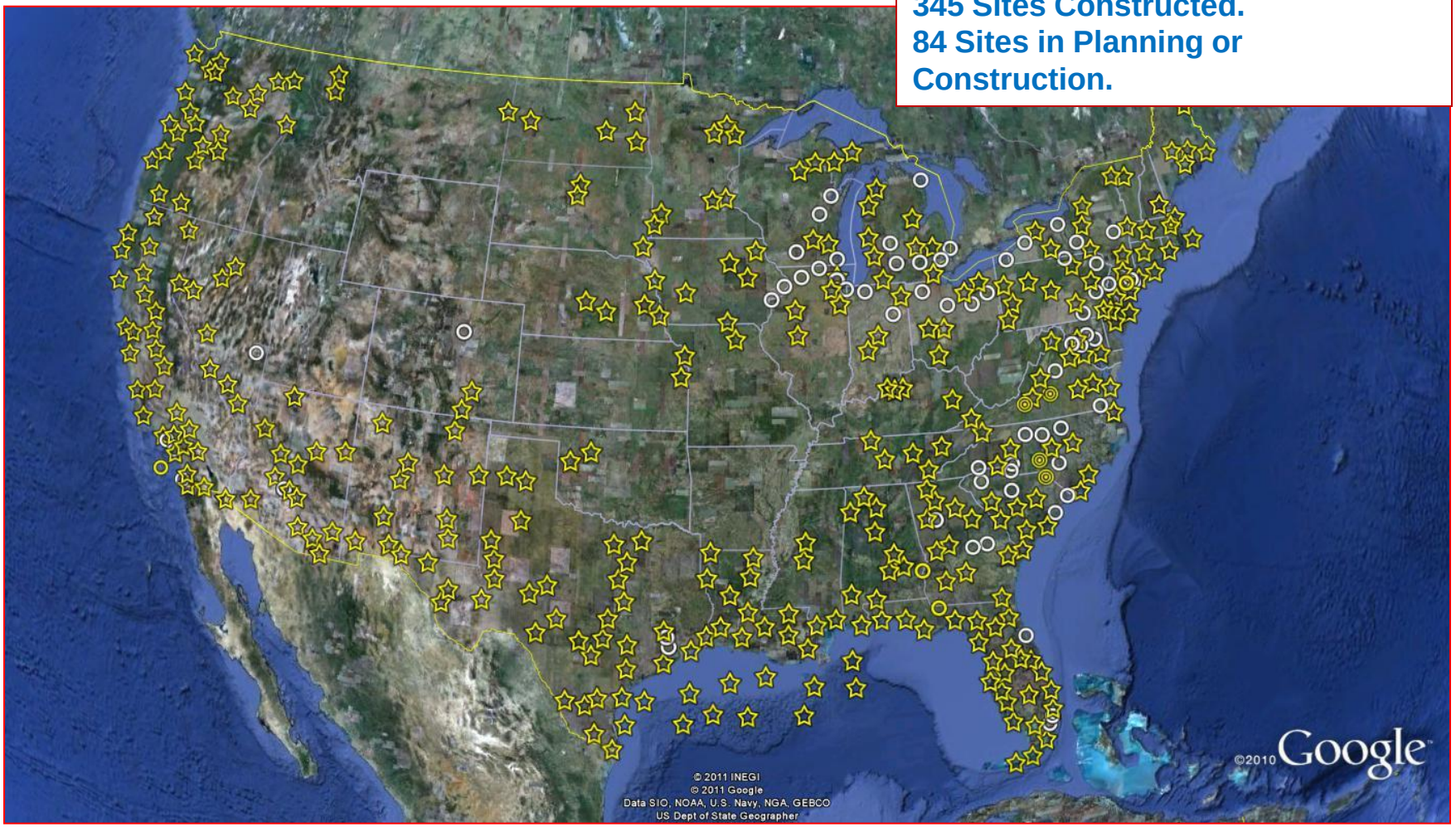


Passive Wide-Area Multi-Lateration (WAM)

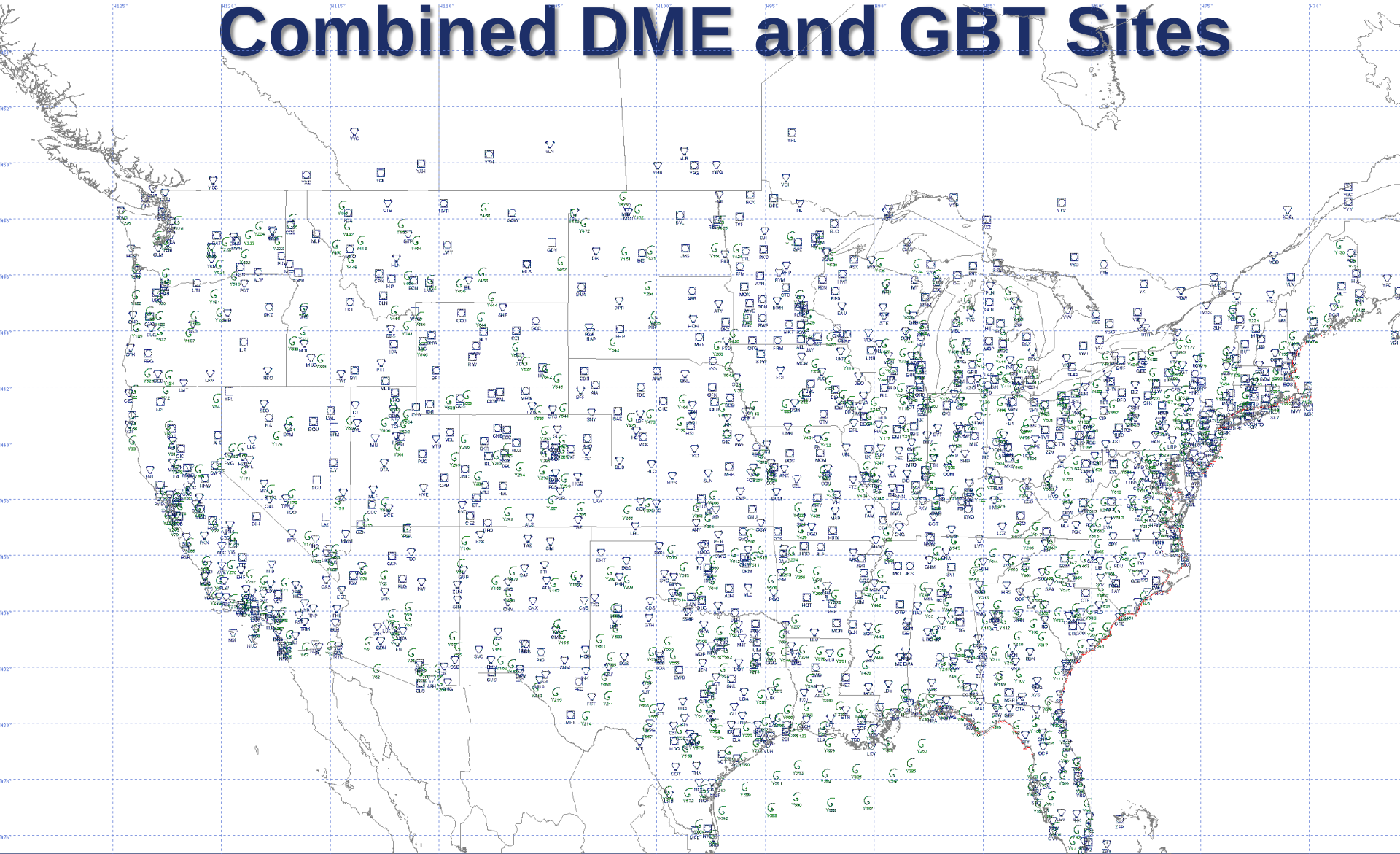


SBS Site Locations

335 Sites Reporting on Network.
345 Sites Constructed.
84 Sites in Planning or Construction.



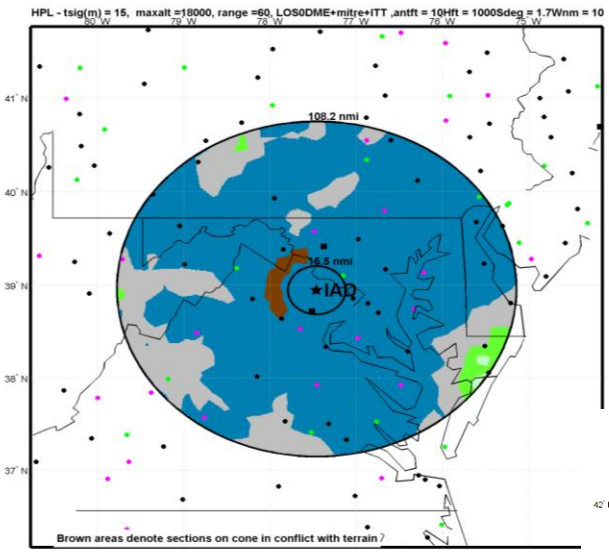
Combined DME and GBT Sites



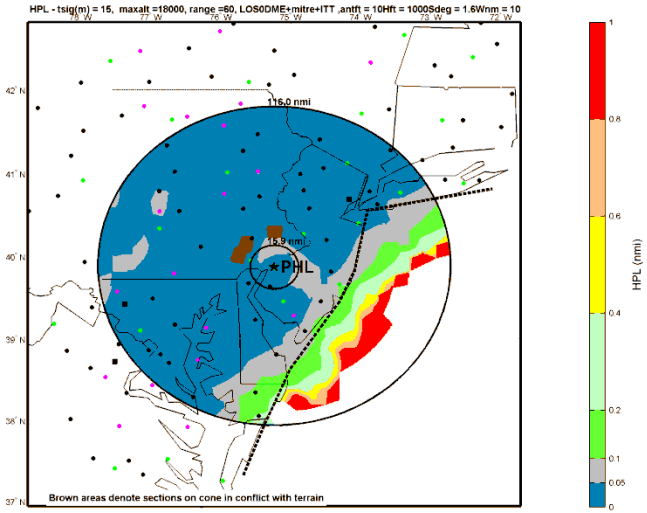
Compatibility of DME/GBT

- **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**

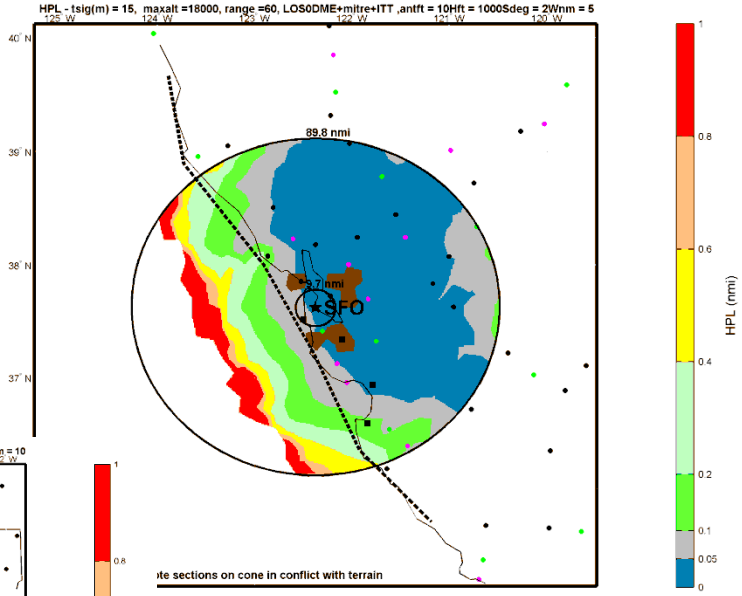
WAM - Initial Analysis Data



Washington Dulles



Philadelphia



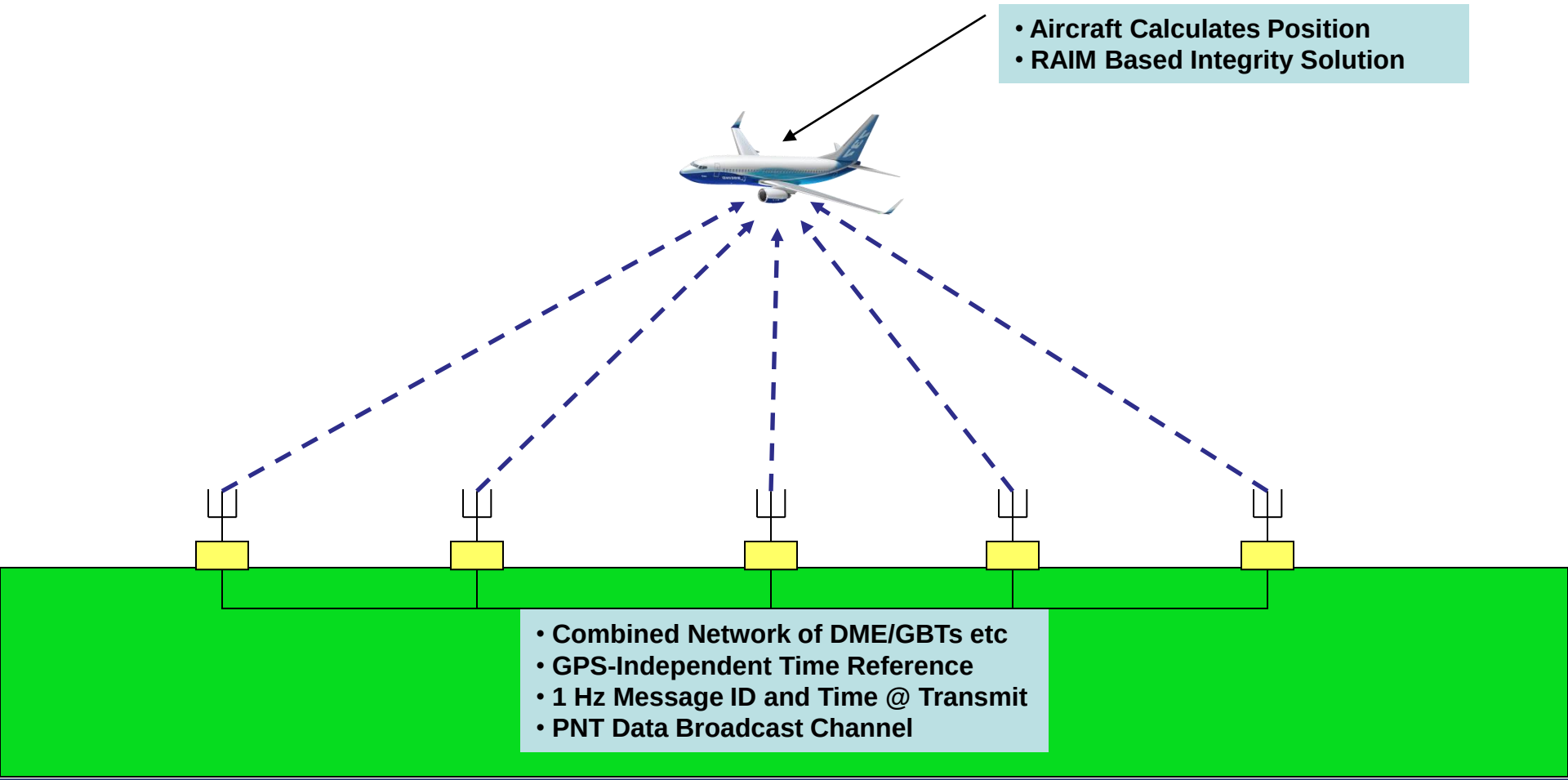
San Francisco

WAM Next Steps

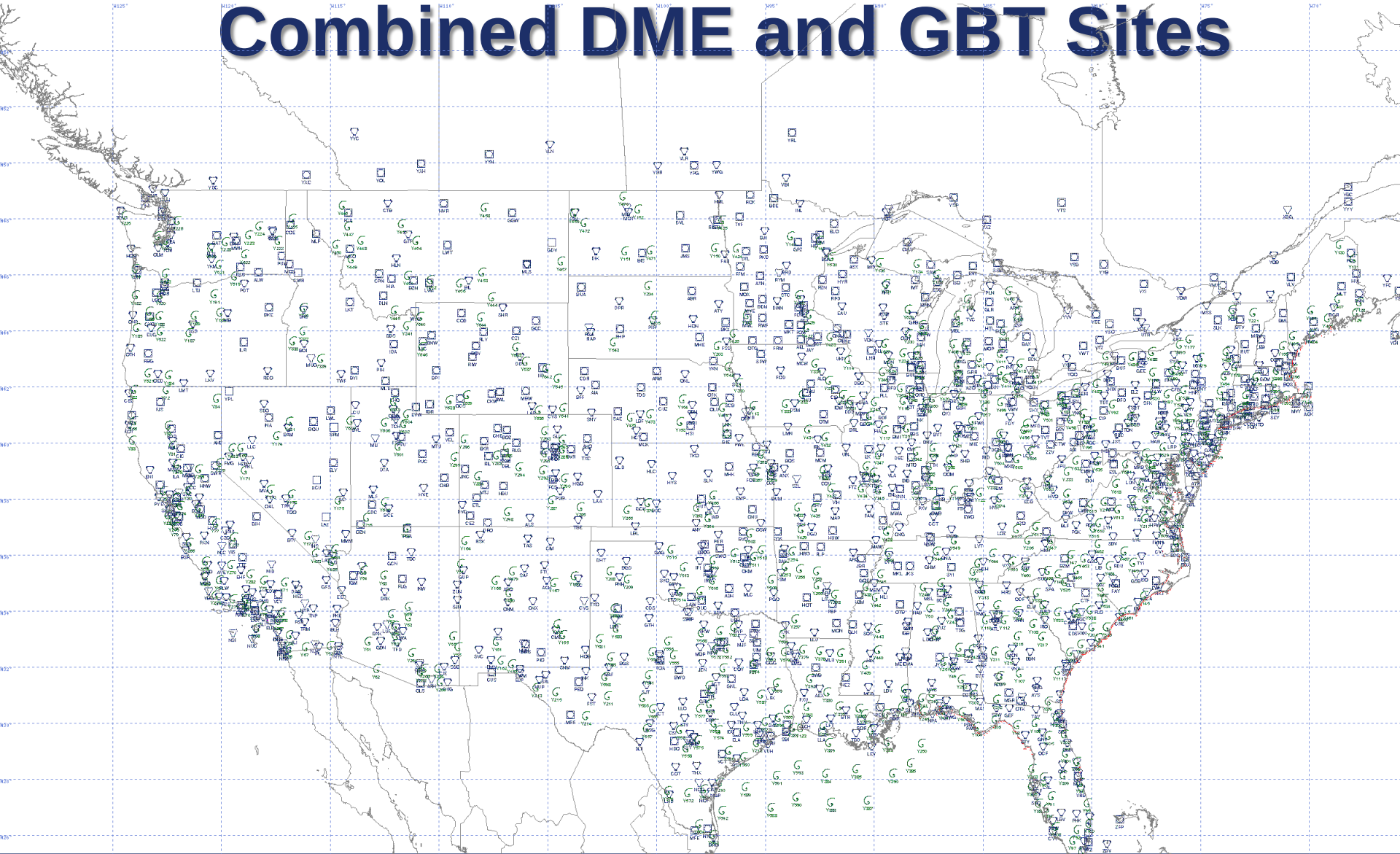
- **Industry resources are needed to fully investigate this alternative**
- **APNT team has prepared a statement of work and IGCE for an Industry Study Contract**
  - Use of ITT contract under SBS program

APNT Alternative 3
DME Pseudolites (DMPL)

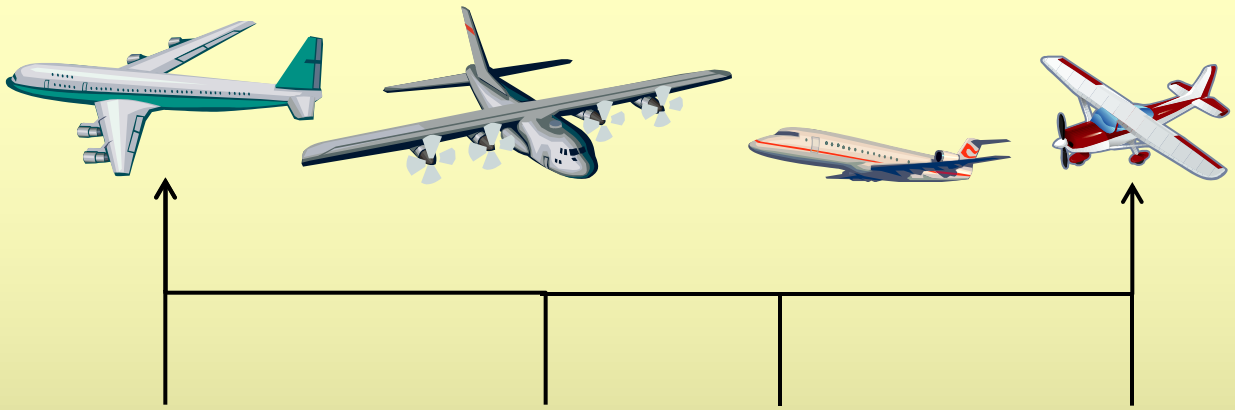
Pseudolite Alternative Concept



Combined DME and GBT Sites



Pseudolite Technologies

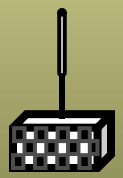


DME (RNAV)
Enhanced
978-1215 MHz

DME PL
978-1215 MHz

SM PL
960-977 MHz

UAT (PL)
978 MHz



DME

Ground Based Transceivers

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

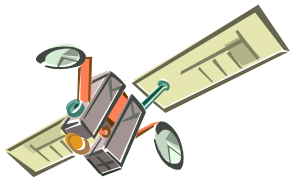
One possibility
1. Commercial uses DME and/or DME PL + UAT PL
2. GA uses DME PL + UAT PL
3. Legacy user can still use DME

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

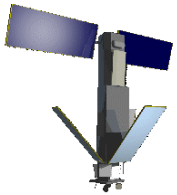
APNT Timing Service

Ground-to-Ground Time Synchronization



GEO: WAAS L5

MEO: GNSS

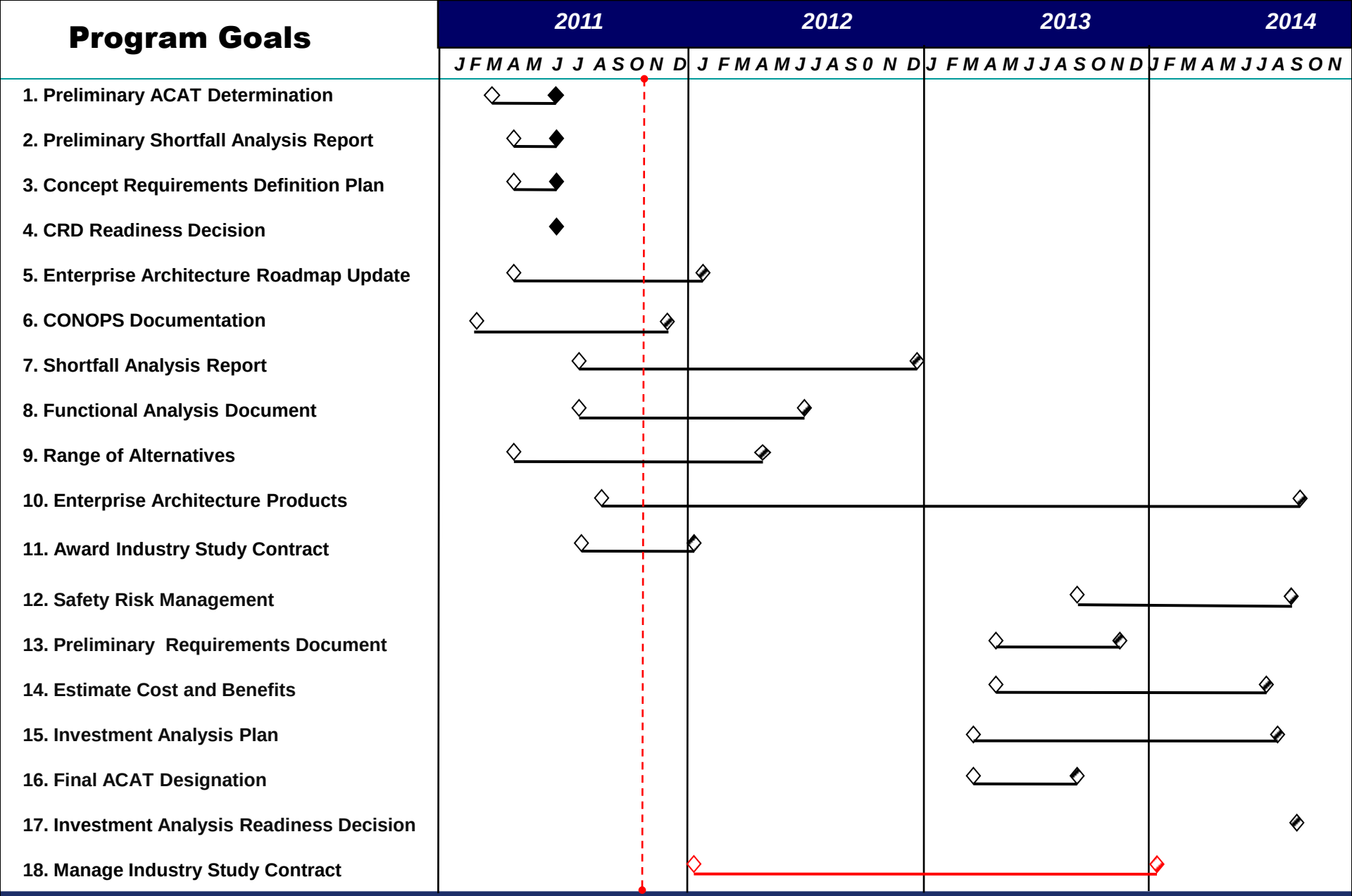


LEO: MSS

30 dB of processing gain

DMEs + Planned DMEs + GBTs

Program Goals



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