A Potential Role for eLoran in Aviation Surveillance

James Carroll, Ph. D.

US DOT/RITA/Volpe Center

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Rationale for Analysis and Selection of a GPS Backup Strategy

- Automatic Dependent Surveillance-Broadcast (ADS-B) has been identified by the FAA as a key element of the Next Generation Air Traffic System (2025)
- ADS-B is a GPS-based surveillance technology that enables equipped aircraft or surface vehicles to broadcast their identification, position, altitude, velocity, and other information
- FAA's Joint Resources Council (JRC) identified a viable backup strategy as a key issue for ADS-B implementation (Sep 05). Backup architecture to be resolved before next JRC meeting (Feb 07)
- ADS-B technical Work Group tasked to select at least one backup strategy that meets proposed rule, and perform trade space & sensitivity analyses (Nov 06)

Technical Team Charter

- **Recommend an approach for mitigating the impact of a loss of GPS on future NAS surveillance (ADS-B)**
- **Methodology entails:** GPS vulnerabilities and fail impacts, evaluation criteria, candidate mitigation strategies, sensitivity analysis, recommendation
- **GPS failure scenario**
  - Focuses on unintentional and planned (testing) interference; SPS L1 <u>only</u>
  - Nominal outage: GPS unusable as a position source for ADS-B within a 40-60nm radius for 3-4 days; outage can occur anywhere in the NAS
  - Must also consider impacts of loss of positioning due to single-aircraft avionics failures and RAIM outages
- **Evaluation Metrics**
  - Operational capability & coverage
  - Technical maturity
  - Independence
  - Flexibility/agility
  - Global interoperability

Assumptions (by 2020)

- General
  - GPS outages (or degradations) due to interference, RAIM holes, or single-aircraft avionics failures must be considered
  - Assumed nominal outage: 40-60nm radius, 3-4 days
- Positioning Infrastructure
  - GPS L5 will be available
  - 21 “healthy” GPS satellites with 0.98 probability
  - Dual frequency WAAS can be available
  - 27 operational Galileo satellites + 3 spares in orbit by 2015, with 3 frequencies for aviation (E5a, E5b, & L1)
  - eLoran ground infrastructure, including database for location-based conductivity factors (ASFs), ***can*** be in place and operational
  - DME/DME navigation capability will be supported at least in en route airspace (24K+ feet, Rockies; 18K+ feet elsewhere), without reverting to inertial
- Surveillance Systems also are addressed

Potential Backup Technologies and Methods (from preliminary Phase)

- Surveillance
  - Secondary Surveillance Radar (SSR)
  - Primary Surveillance Radar
  - Passive multilateration (listen only)
  - Active multilateration (interrogate/reply)
- Navigation
  - DME/DME/IRU
  - DME/DME
  - eLoran
  - IRU only
  - Satellite Navigation (SBAS, L5, Galileo)
  - VOR/DME, LOC/DME, MLS/RNAV
- Procedural Separation

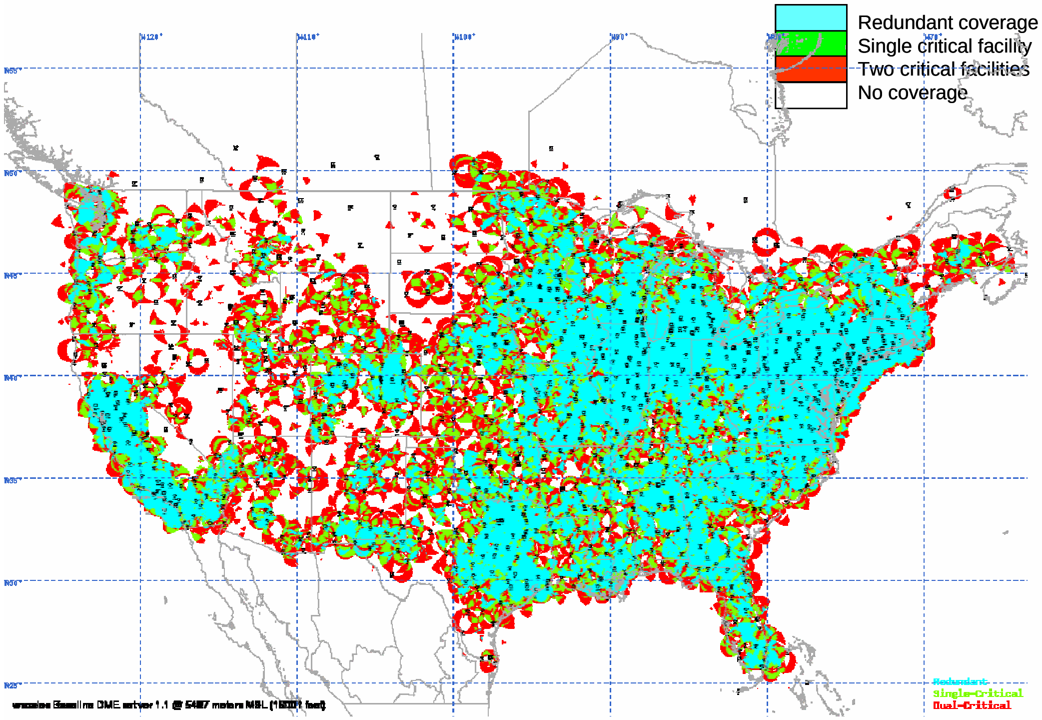
Initial, Qualitative Assessment

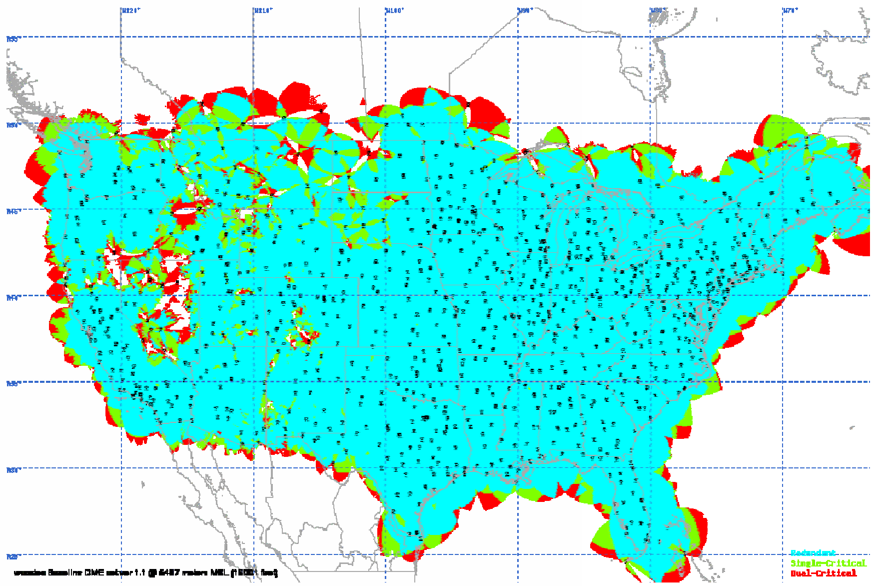
- Technologies/methods fall into one of the following categories:
  - **Meets all minimum criteria for at least one airspace type**
    - Secondary Radar, Primary Radar, Passive and Active Multilateration
  - **Meets most criteria, with uncertainty regarding certain metrics**
    - DME/DME/IRU, SSR, eLoran, Satellite Navigation Only
  - **Does not or will not meet minimum criteria**
    - IRU Only, VOR/DME, LOC/DME, MLS/RNAV, Procedural Separation
- Alternatives assessed to date are based on technologies that fall into the first category
  - **A set of <u>eight</u> "strategies," most involving more than one technology, were postulated**

Strategies Involving SSR, DME/DME/IRU and eLoran

- **Strategy 5**
  - SSR in high density terminal areas and used for all aircraft in event of GPS disruption
  - DME/DME/IRU (AT) and eLoran (GA) provided for medium density areas (Class A airspace, and Class C/D above current CENRAP floor)
  - eLoran (GA) provided for other areas
- **Strategy 6**
  - SSR in high density terminal areas and used for all aircraft in event of GPS disruption
  - DME/DME/IRU with SATNAV (AT) and eLoran (GA) provided for medium density areas
  - SATNAV (AT) and eLoran (GA) provided for low density areas

DME/DME En Route 0.6 NM (95%) Coverage (18000 MSL Altitude)



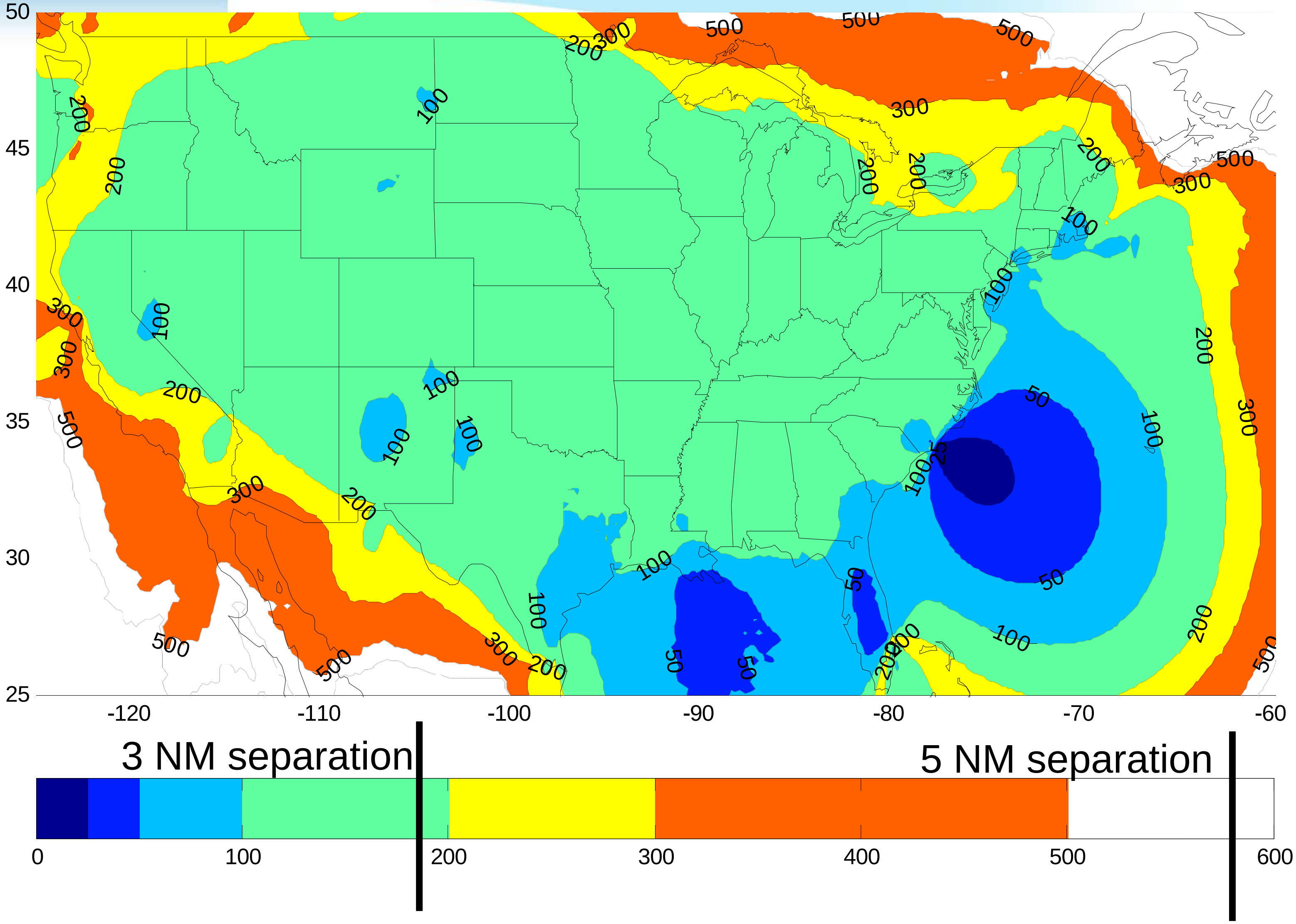


Current coverage (with range dependency)

Current coverage if range dependency eliminated

eLoran Horizontal Accuracy, En Route Altitudes

2DRMS Horizontal Accuracy in meters for all stations available, Clipping Credit of 10dB



eLoran Operational Capability

- Multi-year Congressional-directed program to evaluate Loran capability for aviation
  - 2004 FAA Report of Loran Integrity and Performance Panel concluded RNP-0.3 performance in CONUS is feasible; correction factors (ASFs) needed
  - Variety of flight tests thus far validates report
- Conservative model predictions state RNP 0.3 capability with current infrastructure in 95% of CONUS
- Conductivity correction factors (ASFs) will be needed for 5 nm separation in medium density
  - At least one correction per airport
    - Corrections would be published and maintained in a database
    - May need additional corrections for seasonal variation and effect at different altitudes
  - Correction factor for medium-density terminal surveillance would also enable RNP-0.3 approach capability at affected airports
- Requirements for 9th pulse communications (station ID, integrity, etc.)
  - No augmentation assumed necessary to 9^{th} pulse structure or format

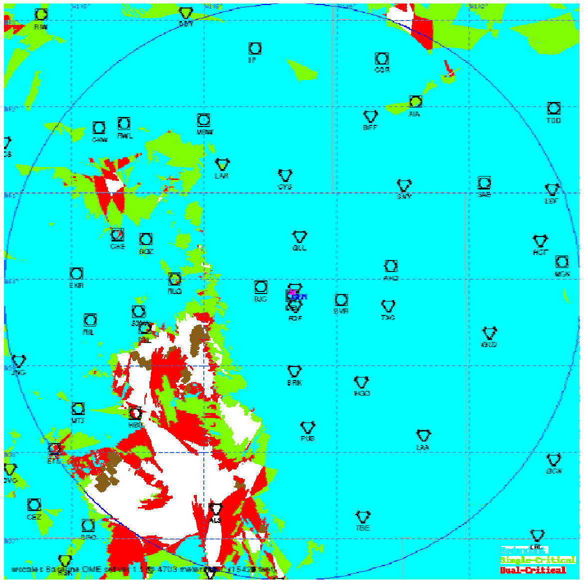
eLoran Evaluation - Other Metrics

- **Technical Maturity**
  - Immature: No standards or avionics equipment available
  - MOPS could be developed in 2 to 3 years, equipment available ~two years after that (2011-2012)
    - Equipment only anticipated if user cost-benefit arises, current market not inclined to invest in new Loran receiver design
- **Flexibility/Agility**
  - USG to decide on continued operation (end CY06)
  - Provides ubiquitous coverage, provides tactical and strategic flexibility within CONUS
    - Provided stations are operational
    - More challenging in Alaska
  - Long-term viability related to other applications (e.g., timing)
    - If retained, multiple Agencies would be involved in system operation and could affect system performance
    - Some degree of performance dependent on Canadian stations
- **International Compatibility**
  - No international standards or ICAO acceptance, but
    - If FAA made decision to retain Loran and recommend it as international standard, may be able to adopt international standards due to other State's interests
    - Coverage unlikely to expand beyond existing (US, Europe, Russia) due to initial infrastructure costs

Cost Implications, DME/DME/IRU

- DME coverage
  - Challenging in western US even to achieve 1.2 nm accuracy
  - Challenging at low altitudes even to achieve 0.6 nm
  - Achieving Final Program Requirement performance is <u>not feasible</u>

DENVER
Coverage
example



Cost Implications, eLoran

- Major recapitalization/modernization of ground system ($160M)
  - 18 U.S. CONUS stations, 6 in AK, 5 Canadian
  - Potential need to add one or more stations to enhance performance
  - Recent atmospheric modeling advances may mitigate this need
  - Canadian stations enhance NAS performance
- Life cycle (incremental) costs TBD
- Would require new avionics once standards are complete
  - Estimates vary significantly depending on integration issues
    - eLoran can be integrated within same unit as GPS
  - Feasibility of common GPS/Loran receiver demonstrated
    - Would affect cabling from antenna to receiver

Scoring Has Just Begun …

Metric	Steering Cmte Weighting
Operational Capability & Coverage	0.3
Technical Maturity	0.25
Independence	0.11
Flexibility/Agility	0.16
Global Interoperability	0.18

Summary

- eLoran has major risks to overcome, under currently approved rules
  - ADS-B business case constraints
  - 50,000 potential “customers” (GA aircraft)
  - Lack of standards and avionics
  - “Rice bowl” mentality
  - Will industry buy in?
- From a purely technical perspective, eLoran can be a cost-beneficial backup