A Potential Role for eLoran in Aviation Surveillance

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Presented at the
International Loran Association
35th Annual Convention and Technical Symposium
Mystic Marriott Hotel and Spa, Groton, CT

October 24, 2006
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 only
  - 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 eight “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)

- Redundant coverage (no critical facilities)
- Single critical facility
- Two critical facilities
- No coverage

Current coverage (with range dependency)

Current coverage if range dependency eliminated

ILA-35, 10/24/06
eLoran Horizontal Accuracy, En Route Altitudes

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

3 NM separation

5 NM separation

U.S. Department of Transportation
Research and Innovative Technology Administration

ILA-35, 10/24/06
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 9th 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 not feasible

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
<table>
<thead>
<tr>
<th>Metric</th>
<th>Steering Cmte Weighting</th>
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<tbody>
<tr>
<td>Operational Capability &amp; Coverage</td>
<td>0.3</td>
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<tr>
<td>Technical Maturity</td>
<td>0.25</td>
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<tr>
<td>Independence</td>
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<td>Flexibility/Agility</td>
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<td>Global Interoperability</td>
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Scoring Has Just Begun …
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