ACI World Safety Seminar
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ILS Replacement

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Contents:

- Ground-Based Navigation
- ILS Approach
- GNSS/SBAS Approach
- Comparisons between ILS and GNSS
- Example: Cost Analysis Between LAAS and ILS
- FAA NextGen
- Milestone of ILS Replacement
Ground-Based Navigation
ILS Approach

Equipment Requirements:

   Localizer: Horizontal Guidance
   Glideslope: Vertical Guidance

Field Requirements:

   Critical Areas for both Equipment
Category I, II, & III Localizer Critical Area

Notes:
1. Critical area is indicated by shaded zones.
2. Hold lines/signs indicate the position beyond which aircraft/vehicles will require ATCT authorization before proceeding on or across runway.
3. Area B is deleted from the critical area when a unidirectional localizer antenna is installed. The standard log-periodic dipole antenna array is in this category.
4. For 8-element localizer array with course widths less than 4 degrees and runways which operate B-747 size and larger aircraft, the Y dimension shall be 600 feet.
5. These dimensions apply where aircraft size is equal to or less than 135 feet in length or 42 feet in height, e.g., B-727.
6. Critical areas for LDA, SDF, and Offset Localizer facilities are the same as for Category I, but are centered about the course line.

Figure 1-2, Category I, II, & III Localizer Critical Area
Image Glide Slope Critical Areas

Figure 1-3. Image Glide Slope Critical Area
ILS Critical Areas (Category II)

Figure 2-6. Category II Critical Areas

1. Location of hold lines when operations are permitted on a 400-foot parallel taxiway.
2. Or to the end of the runway, whichever is greater.
ICAO and US Glide Path Critical Area Size

Large Aircraft (747), Category III (lowest visibility) operation

ICAO CA

$X = 800'$

$Y = 100'$

US CA

$X = 1300'$

$Y = 200'$

ICAO Sensitive Area

$X = 3200'$

$Y = 300'$
GNSS Approach

Global Navigation Satellite System (GNSS)

- WAAS: Wide Area Augmentation System
- LAAS: Local Area Augmentation System
- RNAV: Area Navigation
- ADS-B: Automatic Dependent Surveillance – Broadcast

...
GNSS Approach

WAAS: Wide Area Augmentation System
The WAAS will allow GPS to be used as a primary means of navigation from takeoff through Category I precision approach. Other modes of transportation also benefit from the increased accuracy, availability, and integrity that WAAS delivers. The WAAS broadcast message improves GPS signal accuracy from 100 meters to approximately 7 meters.

The benefits of WAAS to civil aviation will be substantial. WAAS improves the efficiency of aviation operations due to:

- Greater runway capability
- More direct enroute flight paths
- New precision approach services
- Reduced and simplified equipment on board aircraft
- Significant government cost savings due to the elimination of maintenance costs associated with older, more expensive ground-based navigation aids (to include NDBs, VORs, DMEs, and most Category 1 ILSs)
GNSS Approach

LAAS: Local Area Augmentation System
GNSS Approach

Local Area Augmentation System - Benefits

Capacity Benefits:

- LAAS will support complex procedures and terminal area paths.
- De-conflict airspace through extended PVT ranges and obstacle clearance requirements through more precise ground track paths.
- LAAS will provide the ability to change or create approach procedures without infrastructure changes.
- Provide the ability to implement multiple, segmented, or variable glide slopes.
- A single LAAS system supports approaches at multiple runway ends.
Local Area Augmentation System - Benefits

Efficiency Benefits

• Reduced air traffic controller workloads through reduced communications and radar vectoring.
• Reduced time and distance in the terminal area, leading to fuel savings which is a huge cost savings to operators.
• Increase in IFR availability, complex rollouts, and extended arrival procedures (50-160nm).
Local Area Augmentation System - Benefits

User Benefits:

- LAAS terminal area path (TAP) procedures will be uplinked to the aircraft, which eliminates the need for an in-aircraft procedure database.
  - LAAS will eventually support low-powered continuous descent arrivals.
  - Uplinking the LAAS TAP procedures ahead of time allows the aircrew additional time to prepare the aircraft for landing and do it all in an optimal sequence will be truly beneficial to end users. Exacting aircraft locations and approximate times of arrival at key points along the TAP are critical to improving their operations in the terminal area and offer the user significant benefits.
Airport and Community Benefits:

- Noise generation remains a problem for many airports.
- More precise navigation offered by LAAS in the terminal area may provide an opportunity to greatly reduce the impact of aviation-related noise by restricting aircraft to defined three-dimensional routes designed to reduce the noise effects.
- Through the flexibility offered by LAAS to construct complex, defined, highly repeatable flight paths that can be used during all weather conditions, the current costs associated with noise mitigation and noise abatement may be reduced.
GNSS Approach (continued)

Airports with WAAS Approaches (LPV and/or LNAV/VNAV minima)
Comparisons between ILS and GNSS

Approach/Departure path
- Narrow lateral linear segments
- Guided, narrower missed approaches

Incremental capabilities
- Precision Approach and Guidance to Multiple Runway Ends From a Single LAAS Ground Facility
- Greater Siting Flexibility
- Multiple Glideslopes For Aircraft Simultaneously Approaching the Same Runway
- Displaced Threshold Without Physical Relocation of the Ground Facility Components
- Complex Guidance For Approach, Missed Approach, or Departure Segments
- Enables closer route spacing => Capacity benefit
- Facilitates access into airports in complex environments – e.g. high terrain
Comparisons between ILS and GNSS

Efficiency Benefits

• Elimination of ILS Critical Areas
• Closely Spaced Parallel Approaches

Safety Benefits

• Reduced Accidents and Incidents Because of Greater Precision Approach Coverage;
• Positive Surface Guidance in Reduced Visibility;
Comparisons between ILS and GNSS

Societal Benefits

- Ability to Use Common Avionics/Procedures Worldwide For Seamless and Simplified Navigation
- Noise Abatement and Mitigation
- Reduced Impact on Environmentally Sensitive Areas

Economy

- Potential for lower minima (CAT II/III)
- More fuel efficient profiles
- Reduces costs for operators
Questions of GNSS Approach

Q: How much will it cost to design approach paths for ILS, GPS…?

Cost is about the same to develop and test approach procedures regardless of the type of navigation aid used for the approach; roughly $20K per approach path.

Q: How does the FAA plan to use GPS in the future?

These packages can range anywhere from approximately $3,000 (US) for a basic general aviation IFR GPS receiver installation and certification, to $10,000 (US) for a more sophisticated GPS receiver installation/certification on a commercial aircraft. When comparing prices of GPS avionics versus existing ground.
Example: Cost Analysis Between LAAS and ILS By Tetra Tech, Inc.

- 118 US airports selected for the study
- LAAS/ILS Cost Model Scenarios
- LAAS Cost
- ILS Cost
- Summary

Note: All the tables and figures listed here are from Tetra Tech, Inc. internal analysis report.
LAAS/ILS Cost Model Scenarios

- Baseline, which is ILSs are installed (new qualifiers) or maintained
- LAAS Installation based on First ILS Expiration, Divest 100% of ILSs Immediately
- LAAS Installation based on First ILS Expiration, Divest 75% of ILSs
- LAAS Installation based on First ILS Expiration, Divest All But Two ILSs if an Airport Operates More than Two ILSs; Divest All ILSs Elsewhere (All OEP Airports Keep At Least 1 ILS)
- LAAS Installation based on First ILS Expiration, 50% ILSs Divested at the OEP Airports; Remaining Airports Retain 1 ILS
- LAAS Installation based on First ILS Expiration, Divest Two ILSs; at the OEP Airports At Least 1 ILS is Retained
Baseline Number of ILSs per Airport

Number of ILSs Operating (Baseline Scenario)

- Number of Airports with an ILS
- Number of ILSs at an Airport
- Number of ILSs Operating
  - OEP 35 Airports
  - Non-OEP 35 Airports

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LAAS Cost Estimate

- Procedures and Flight Inspection Costs

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Per Runway End</th>
<th>Four Runway Ends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure Development</td>
<td>$9,710</td>
<td>$38,840</td>
</tr>
<tr>
<td>Publication</td>
<td>$640</td>
<td>$2,560</td>
</tr>
<tr>
<td>Flight Inspection</td>
<td>$4,000 for commissioning, 1k per runway end</td>
<td>$16,000 including commissioning and 3 flight checks per runway end</td>
</tr>
</tbody>
</table>
LAAS Cost Estimate

- Procedures and Flight Inspection Costs

Table 2  Annual Procedure Maintenance, Flight Check and Publication Change Costs

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Per Runway End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure Maintenance</td>
<td>$1,000</td>
</tr>
<tr>
<td>Flight Check</td>
<td>$1,000</td>
</tr>
<tr>
<td>Publication Changes</td>
<td>$220</td>
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ILS Cost Analysis

- Equipment and Installation Costs
- Annual Operations and Maintenance Costs
- Equipment Replacement Costs
### ILS Cost Analysis

**Table 3** ILS Costs by Equipment Model ($K)

<table>
<thead>
<tr>
<th>ILS Equipment Model</th>
<th>CAT Capability</th>
<th>Equipment Installation</th>
<th>O&amp;M</th>
<th>Equipment Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark 1</td>
<td>CAT I</td>
<td>N/A</td>
<td>95</td>
<td>N/A</td>
</tr>
<tr>
<td>Mark 1R w/ RMM*</td>
<td>CAT I</td>
<td>N/A</td>
<td>114</td>
<td>N/A</td>
</tr>
<tr>
<td>Mark 20/20A Single</td>
<td>CAT I</td>
<td>1,582</td>
<td>95</td>
<td>357</td>
</tr>
<tr>
<td>Mark 20/20A</td>
<td>CAT II/III</td>
<td>2,293</td>
<td>185</td>
<td>454</td>
</tr>
<tr>
<td>Mark 20/20A Dual w/RMM</td>
<td>CAT I</td>
<td>1,685</td>
<td>114</td>
<td>429</td>
</tr>
<tr>
<td>Mark 20/20A w/RMM</td>
<td>CAT II/III</td>
<td>2,550</td>
<td>116</td>
<td>454</td>
</tr>
<tr>
<td>420 Single</td>
<td>CAT I</td>
<td>1,624</td>
<td>101</td>
<td>409</td>
</tr>
<tr>
<td>420</td>
<td>CAT II/III</td>
<td>2,546</td>
<td>111</td>
<td>491</td>
</tr>
</tbody>
</table>
## Summary

### Table 4  Worst Case Comparative Costs of Removing ILSs

<table>
<thead>
<tr>
<th>Sensitivity Analysis</th>
<th>Total Cost ($M)</th>
<th>Total Cost Savings ($M) (vs. Baseline)</th>
<th>End-State Annual Cost Savings ($M)</th>
<th>Remaining # of ILSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1,582</td>
<td>N/A</td>
<td>N/A</td>
<td>448</td>
</tr>
<tr>
<td>Divest 100% ILSs at LAAS Installation</td>
<td>738</td>
<td>844</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Divest 75% of ALL ILSs (Keep at least 1 ILS per airport)</td>
<td>1,381</td>
<td>201</td>
<td>19</td>
<td>151</td>
</tr>
<tr>
<td>Divest All ILSs if Airport Operates 2 or Fewer, Keep 2 Elsewhere*</td>
<td>1,375</td>
<td>207</td>
<td>19</td>
<td>149</td>
</tr>
<tr>
<td>Keep 50% of ILSs at OEPs, Keep 1 Elsewhere</td>
<td>1,500</td>
<td>82</td>
<td>13</td>
<td>197</td>
</tr>
<tr>
<td>Divest Two ILSs per airport*</td>
<td>1,536</td>
<td>46</td>
<td>14</td>
<td>225</td>
</tr>
</tbody>
</table>
## Summary (cont.)

### Table 5: Most Likely Comparative Costs of Removing ILSs

<table>
<thead>
<tr>
<th>Sensitivity Analysis</th>
<th>Total Cost ($M)</th>
<th>Total Cost Savings ($M) (vs. Baseline)</th>
<th>End-State Annual Cost Savings ($M)</th>
<th>Remaining # of ILSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1,582</td>
<td>N/A</td>
<td>N/A</td>
<td>448</td>
</tr>
<tr>
<td>Divest 100% ILSs at LAAS Installation</td>
<td>645</td>
<td>937</td>
<td>40</td>
<td>0</td>
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<tr>
<td>Divest 75% of ALL ILSs (Keep at least 1 ILS per airport)</td>
<td>1,288</td>
<td>294</td>
<td>21</td>
<td>151</td>
</tr>
<tr>
<td>Divest All ILSs if Airport Operates 2 or Fewer, Keep 2 Elsewhere*</td>
<td>1,283</td>
<td>299</td>
<td>20</td>
<td>149</td>
</tr>
<tr>
<td>Keep 50% of ILSs at OEPs, Keep 1 Elsewhere</td>
<td>1,407</td>
<td>175</td>
<td>15</td>
<td>197</td>
</tr>
<tr>
<td>Divest Two ILSs per airport*</td>
<td>1,443</td>
<td>139</td>
<td>15</td>
<td>225</td>
</tr>
</tbody>
</table>
**Summary (cont.)**

**Cumulative Costs by Year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost ($M)</th>
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</thead>
<tbody>
<tr>
<td>2013</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>200</td>
</tr>
<tr>
<td>2017</td>
<td>400</td>
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<tr>
<td>2019</td>
<td>600</td>
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<tr>
<td>2021</td>
<td>800</td>
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<td>2025</td>
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<td>2029</td>
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</tr>
<tr>
<td>2037</td>
<td>2400</td>
</tr>
<tr>
<td>2039</td>
<td>2600</td>
</tr>
</tbody>
</table>

- Divest Two ILSs (OEPs keep at least One ILS)
- Keep 50% at OEPs, Keep 1 Elsewhere
- Divest 75% of ALL ILSs (Keep at least 1 ILS per airport)
- Divest All ILSs if Airport Operates 2 or Fewer, Keep 2 Elsewhere (All OEPs keep at least One ILS)
- Divest 100% ILSs at LAAS Installation
- Baseline
FAA NextGen - What is NextGen?

• NextGen is a wide ranging transformation of the entire national air transportation system — not just certain pieces of it — to meet future demands and to avoid gridlock in the sky and in the airports while improving safety and protecting the environment.

• NextGen moves away from ground-based surveillance and navigation to new, more dynamic satellite-based systems. These changes are well beyond our legacy modernization programs.

• NextGen will change the way the system operates, reduce congestion, expand capacity, reduce noise and emissions and improve the passenger experience.
FAA NextGen

• NextGen Goal: Performance-Based Navigation (PBN)

ICAO directed regions to develop PBN Implementation Plan by 2009

• PBN includes both Area Navigation (RNAV) and Required Navigation Performance (RNP) specifications

• FAA plans to modernize the National Airspace System (NAS) through 2025
Milestone of ILS Replacement

Very High Frequency Omni Directional Radar (VOR):
- 2007–Decision to begin discontinuance of VOR Service
- 2015 – Decision on further discontinuance

Instrument Landing System (ILS) CAT I:
- 2008–Decision on next generation Cat I landing system
- 2012–Begin ILS Cat I drawdown
- 2020–Mandate execution

ILS CAT II/III
- 2012–Begin drawdown of ILS Cat II/III services
- 2020–Mandate execution
Thanks!