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Local Area Augmentation System (LAAS)

Benefits Analysis

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Background

- Original Contract Established With PwC – June 2002
  - Identify and Quantify Safety and Efficiency Benefits
  - Analyze Potential Savings Through LAAS Commissioning
- Contract Modified – August 2003
  - Expanded to Include Comparison of Incremental Benefits to Navigation Baseline
- Draft Report – September 2004
- Final Report – October 2004

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Why An Independent Analysis?

- **To Conduct An Objective Assessment of the Benefits That LAAS May Provide to Aviation System Users**
- **To Provide Fact-Based Support For Government and Industry Decisions**
- **Credibility and Transparency With Industry Stakeholders**
  - Validate Data Through Discussions with Airlines and Airports
  - Validate Findings Through Site Visits
    - Memphis, Seattle, Bradley, Newark, Chicago
    - FedEx, Alaska, United, Continental, Southwest
    - Boeing
  - Update Industry Stakeholders Through Regular Communication
    - Formal Conference Calls to Review Methods and Results
    - Airline User Group Meetings (Dec 03 through Jun 04)
    - Informal Discussions, Conversations
- **NOT a Formal Business Case or Alternatives Analysis**

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Scope

- **Potential Users**
  - Major and Regional Air Carriers
    - Passenger and Cargo
  - Corporate Operations
- **LAAS Applications**
  - LAAS as a Precision Guidance System
  - LAAS as a Complement to Other Systems
- **Operations**
  - Precision Approach and Landing System
  - Precision Takeoff and Departure Guidance
  - Terminal Area Navigation
  - Surface Navigation
- **Timeframe**
  - 2009-2028

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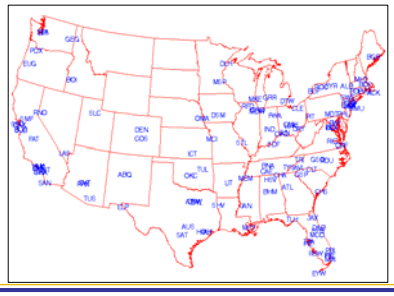
Assumptions

- LAAS Benefits Accrue Only When Capabilities Are Provided Above and Beyond Those Provided by Other Systems
- Assumes No Decommissioning of Any Existing Systems
  - Current ILS's Retained
  - No New ILS's Installed After LAAS IOC (FY2009)
  - Benefits For Continuing ILS In Lieu of LAAS Are Not Analyzed
- Analysis Includes Both 100% and 0% WAAS Equipage Scenarios
- Study Limited to Top 121 NAS Airports
  - Major Airlines' Top Airports (88)
  - NBAA Top 10 Airports
  - RAA Top 50 Airports
  - LAAS LRIP Sites (6)
  - OEP Airports (35)
  - Current Cat II/III ILS (79)
  - Qualifier Cat II/III ILS (2)



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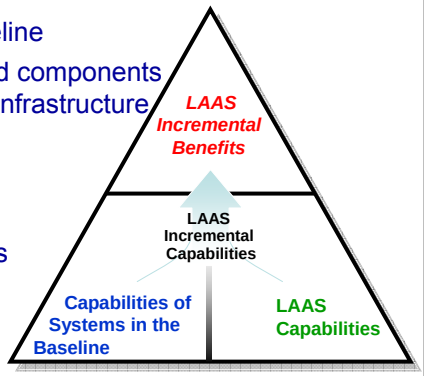
Approach

Hypothesis: LAAS provides benefit to National Airspace System (NAS) operations

1. Establish the navigation capabilities baseline
   - NAS baseline: ground & space-based components
     - Existing and planned navigation infrastructure
   - User baseline: airborne components
     - Existing and planned avionics
2. Estimate incremental LAAS capabilities
   - Relative to the capabilities of systems in the baseline
3. Estimate incremental LAAS benefits



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Navigation Capabilities Baseline

- **NAS Baseline**
  - Existing Navigation Systems Deployed in the NAS
  - Navigation Systems Planned to be Deployed in the NAS During the Twenty Year Time Horizon (2009-2028)
- **User Baseline**
  - Existing Navigation Equipage of Avionics Systems Available
  - Newer Technologies Expected to be Available During the Twenty Year Time Horizon (2009-2028)
  - Users Include
    - Major and Regional Air Carriers
      - Cargo and Passenger
      - Domestic Operations
    - Corporate
    - GA (Alaska Only)
- **Baseline Does Not Include Systems in the R&D Stage That Have Not Been Through Proof of Concept**
- **Baseline Does Not Include the Impact of Installing ILS at Every Runway End**

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Categories of LAAS Benefits

Efficiency

- Straight-in approaches
- Elimination of ILS critical areas
- Takeoff guidance in low visibility conditions
- Complex approaches
- Simultaneous independent parallel approaches

Safety

- Avoided accidents, incidents, fatalities and injuries

Societal

- Only Qualitative discussion of benefits

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LAAS Efficiency Benefits

- Benefits of LAAS Capabilities on Disruptions and Efficiency Above and Beyond the Existing Baseline
  - Reduced Disruptions for Straight-In Precision Approaches
    - LAAS will reduce the landing minima at runways without CAT I service
      - CAT I benefits account for $195.4M in savings
    - LAAS CAT II/III will reduce minima at runways without corresponding ILS CAT II or III capability
      - CAT II/III Benefits Account for 56%of the total Direct Operating Cost Benefits (118 airports with a benefit of $815.7M)
  - Elimination of ILS Critical Areas
    - ILS signal protected during IMC
      - Arrival delay
      - Taxi time delay
      - Elimination of CAT I holds/delays at 13 Airports ($56.9M)
      - Elimination of CAT II/III holds/delays at 8 Airports ($13.2M)

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LAAS Efficiency Benefits

  - Reduced Flight Disruptions with LAAS Precision Takeoff Guidance
    - Departure operations during low visibility conditions
    - 74 Airports Benefit from LAAS Take Off Guidance ($94.5M)
  - LAAS-Based Complex Procedures
    - LAAS Capability for Terminal RNAV Operations Including Approach to CAT I/II/III Minimums at Runways Without ILS
    - Use of a Single System for Terminal Area Navigation Through Final Approach and Landing
    - Benefits were Identified at 14 Runway Ends (CAT I $205.3M, CAT III $13.5M)

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LAAS Efficiency Benefits

- Closely Spaced Simultaneous Independent Parallel Approaches
  - Combination of Improved Navigation System Accuracy and Reduced Flight Technical Error Could Lead to a Reduction of Runway Separation Distances
  - 11 Airports (Reduction of Separation from 4300 feet to 3100 feet)
  - Potential LAAS Benefit Shared with other Systems (.5 Factor Applied / Benefit Total $10,600,000)

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LAAS Safety Benefits

Flight Safety Foundation

- **Conducted by Flight Safety Foundation**
- **Incremental Safety Benefits LAAS Provides Above and Beyond the Baseline**
- **Safety Benefits Include:**
  - Reduced Accidents and Incidents Because of Greater Precision Approach Coverage
  - Positive Surface Guidance in Reduced Visibility
- **Current Level of Safety is Maintained or Improved During the Transition**
- **LAAS Benefits Are Calculated to be $58,299,500 / $14,876,000**
  - Hull Loss/Damage, Fatal/Serious Injuries

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LAAS Societal Benefits

- International
  - Ability to Use Common Avionics/Procedures Worldwide For Seamless and Simplified Navigation
- Reduced Impact on Environmentally Sensitive Areas
- Noise Abatement and Mitigation
- LAAS – JPALS Compatibility
- Economic Impact of Increased Reliability of Air Service
- Proximate Airports
- The Societal Benefits are Not Included in the Total Benefits Numbers

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Sensitivity Analysis & Issues

- **IBM Conducted a Sensitivity Analysis to Address Concerns Raised During the Study Period**
  - Airline Direct Operating Cost of a Flight Disruption
    - Based on research, published estimates, and interviews with airline representatives. The range for major carriers is $782-$4,269 with $1,983 being most likely
  - LAAS Avionics Installed Over a 6 Year Period, Beginning at IOC
    - Range is 5 years to 8 years with most likely being 6 years with 80% of fleet equipped
  - Downstream Effect Factor
    - Range was 1.0-2.6 with the most likely being 1.8
  - Average Duration of Delay
    - For the major airlines the range was 13-41 minutes and the most likely average delay was 25 minutes

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Summary of LAAS Benefits
(121 Airports 2009-2028)

	Efficiency		Safety	Total
	Direct Operating Cost Savings	Passenger Time Savings		
LAAS Benefits (Assuming 0% WAAS equipage)	$638,900,000	$795,800,000	$58,300,000	$1,493,000,000
LAAS Benefits (Assuming 100% WAAS equipage)	$429,300,000	$542,100,000	$14,900,000	$986,300,000

Societal Benefits	Not Included in Totals Above
0% WAAS equipage	$120,000,000
100% WAAS equipage	$46,000,000

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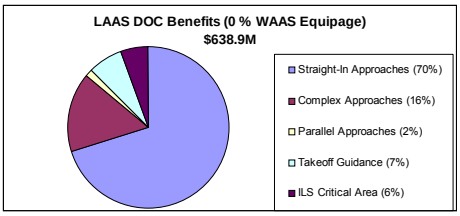
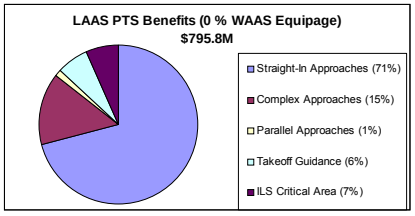
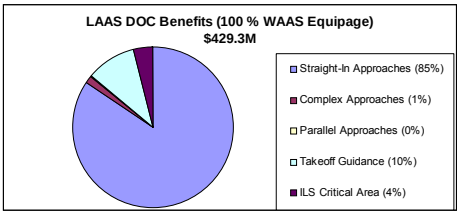
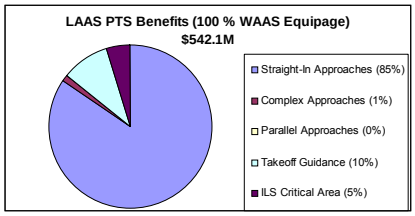
Proportion Discounted 20 Year LAAS Best Estimate Benefits









- The largest benefit is achieved for straight-in approaches, with the largest portion of that being due to LAAS Cat II/III

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Questions?

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Approach – Terms included in the Straight-in Arrivals Benefit Calculation

- Number of airport arrivals per year (scheduled, unscheduled)
- Runway usage based on wind direction and aircraft type
- Probability that weather conditions are above LAAS minima
- Probability that weather conditions are above Baseline system minima
- Availability of LAAS and the Baseline systems
- Avionics equipage level for LAAS and the Baseline systems
- Cost of each disruption
- Discount rate

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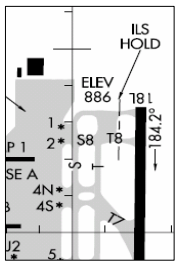
Approach – Elimination of ILS Critical Areas



- Issue: Protection of ILS critical area leads to,
  - Reduced runway capacity
  - Increased taxi time for departing and crossing traffic
- LAAS Benefit: Elimination of ILS critical area allows,
  - Decreased arrival delays
  - Decreased taxi delay
- Method: Identify ILS holds where critical area protection reduces capacity
  - Collect scheduled and observed arrival and departure data
  - Estimate theoretical airport capacity based on arrival and departure sequences
  - Estimate average delay based on differential capacity
    1. with ILS critical area protection
    2. with LAAS and no need for ILS critical area protection

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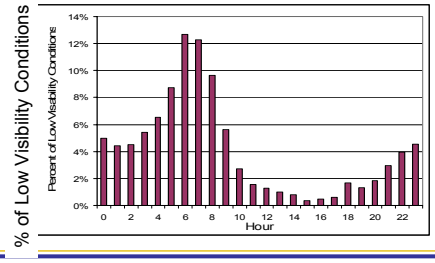
Approach – Takeoff Guidance

- Issue: Departures are restricted or prohibited during low visibility conditions
  - Rare occurrence, but large impact on air carriers
- LAAS Benefit: Permitting takeoff operations in low visibility conditions can reduce departure delay for properly equipped aircraft
  - LAAS as input to a Takeoff Guidance System (*e.g.*, LAAS + HUD)
- Method: Identify runways where LAAS may increase low visibility takeoff capability
  - Without required lighting, markings
  - Without current Cat-III localizer
  - Estimate average delay during low visibility conditions
    1. Without LAAS-guided takeoff
    2. With LAAS-guided takeoff



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Approach – Complex Approaches*

Benefits from Complex Approaches are not included in current Preliminary Benefits totals.
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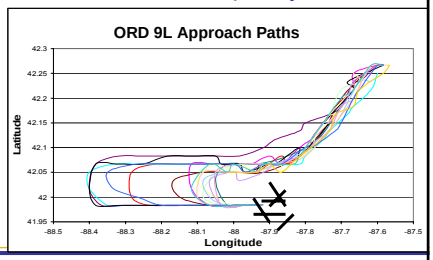
- Issue: Airport capacity is reduced in IMC
- LAAS Benefit: Provide precision guidance for terminal area operations
  - Maintain VMC/MVMC airport operations in IMC
  - Reduce pilot-controller communications workload
  - Improve predictability of time and distance through terminal area
- Method: Identify airports where LAAS may significantly increase IMC capacity
  - Hypothesis: LAAS can help an airport maintain MVMC capacity in IMC
  - Estimate average delay during IMC
    - with current IMC capacity
    - with MVMC capacity
- Benefit depends on the role of LAAS in RNAV and RNP operations
  - Avionics on recent and future aircraft are capable of RNP-0.3 or better without LAAS



* Complex approaches include everything except straight-in approaches

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Approach – Simultaneous Independent Parallel Approaches

Benefits from Parallel Approaches are not included in current Preliminary Benefits totals.

- Issue: Airport capacity is reduced in IMC
- LAAS Benefit: Research, flight tests[1] suggest that LAAS may contribute to reducing the required spacing for parallel arrival operations in IMC to 3100 feet
  - However, surveillance, flight technical error, and reaction time are the primary drivers of required runway separation distance
  - Navigation error plays a smaller role in determining runway spacing
- Method: Identify airports where LAAS may improve IMC parallel arrival operations
  - Parallel runway spacing between 3100 and 4300 feet
  - Estimate average delay improvement
    - For optimal vs. reduced arrival rate
    - Approximate the potential improvement achievable by LAAS
- Several questions must be addressed:
  - Need for backup system if LAAS is the primary landing guidance
  - Complementary systems in addition to LAAS are required to achieve benefit
  - The need for LAAS (*e.g.*, *versus* WAAS) must be established

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Approach – LAAS Safety Benefits

- Issue: Lack of vertical guidance continues to be a source of aircraft accidents
- LAAS Benefit: Reduced risk due to increased availability of vertical guidance
- Method: Estimate the change in risk with LAAS installed at the 120 airports
  - Review past accident and incident data (1993 – 2002)
  - Select events that may have been prevented if LAAS had been operational
  - Estimate future potential safety impact of LAAS based on historical data
  - Adjust estimate for the impact of existing and planned Baseline systems
  - Adjust estimate for the anticipated LAAS implementation schedule

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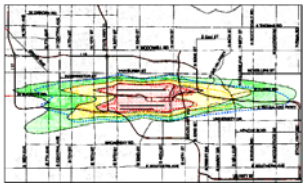
Approach – LAAS Societal Benefits

Societal benefits are not included in current Preliminary Benefits totals. Benefits from this category are qualitative.

- LAAS societal benefits are qualitative, for example:
  - Reduced noise and environmental impact
    - through reliable, repeatable paths in all weather conditions
    - includes reduced noise mitigation and abatement costs
  - Increased reliability and predictability of air travel
    - increases the value of air travel to all passengers
    - potential economic benefits
  - Many of these benefits depend on the role of LAAS in RNAV and RNP operations

Noise signature at Phoenix



http://phoenix.gov/AVIATION/community/contour.html

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DAL Example

- **Current Operation**
  - Cat I ILS on four runways
    - 13 L/R
    - 31 L/R
  - No Cat II/III system
    - 0.4% of DAL weather is Cat II/III per year
  - Actual Annual Cat II/III Disruptions (Major Airlines):
    - Delays = 362
    - Cancellations = 56
    - Diversions = 23

- **LAAS Incremental Benefits**
  - Cat II/III landing guidance
    - LAAS Cat II/III approach operations on 13L & 31L
  - Estimated Annual Cat II/III Disruptions With LAAS (Major Airlines):
    - Delays = 168
    - Cancellations = 15
    - Diversions = 18

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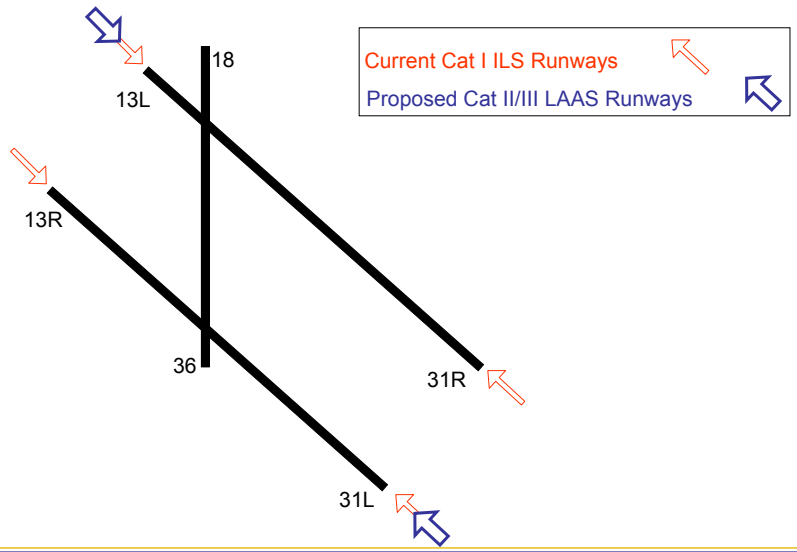
Dallas Love Field



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Example - DAL Inputs Used in the Straight-in Analysis

Apt ID	Runway ID	Runway Length	Arrival Runway?	IMC Runway Priority	IMC Utilization	Best System	Best Hat / Visibility	Any LAAS Cat I Benefit?	Any LAAS Cat III Benefit?	Probability that wx is between Best System and Cat I LAAS Minima	Probability that wx is between Best System and Cat III LAAS Minima
DAL	DAL 13L	7753	Yes	Primary	51%	ILS Cat I	200 / 1800	No	Yes	--	0.0036
DAL	DAL 13R	8800	//		0%	ILS Cat I	200 / 3960	No	No	--	--
DAL	DAL 18	6149	No		0%	N/A	N/A	No	No	--	--
DAL	DAL 31L	8800	Yes	Primary	49%	ILS Cat I	200 / 1800	No	Yes	--	0.0036
DAL	DAL 31R	7753	//		0%	ILS Cat I	200 / 2400	No	No	--	--
DAL	DAL 36	6149	No		0%	N/A	N/A	No	No	--	--

Straight-in Benefit Example: DAL -- Runway 13L -- Year 2001 -- No WAAS Equipage Scenario

User Group	Disruption Cost	Discount Rate	# of Arrivals	IMC Runway Utilization	LAAS Availability	LAAS Equipage	Probability that wx is between Best System and Cat III LAAS Minima	ILS Availability	ILS Cat I Equipage	# of Disruptions Avoided with LAAS	LAAS Cat III Benefit $ (Operating Cost)
Major Carriers	$ 3,360	1.00	49,572	51%	0.999	100%	0.0036	0.995	100%	90	$ 303,974
Regional Carriers	$ 1,100	1.00	7,206	51%	0.999	100%	0.0036	0.995	100%	13	$ 14,466
Cargo Carriers	$ 2,250	1.00	1,313	51%	0.999	100%	0.0036	0.995	100%	2	$ 5,391
Corporate	$ 1,270	1.00	42,852	51%	0.999	100%	0.0036	0.995	100%	78	$ 99,320
											$ 423,152

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Additional Tasks/Deliverables

- Generic Airlines LAAS Benefits Spreadsheets
  - Provides an Estimate of Direct Operating Cost Savings by Benefits Category by Airport
- LAAS Avionics Cost Estimator
  - Developed to Help Airlines Calculate Cost to Forward Fit and Retro Fit Aircraft
- ILS Replacement Cost Analysis
- Equipment Comparative Analysis