MIT Lincoln Laboratory
Technical Support Capability to
Federal Aviation Administration

55th ATCA Conference
National Harbor, MD
24 – 27 October 2010

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Outline

• MIT Lincoln Laboratory
  – Background

• Surveillance and Automation
  – Tower Flight Data Manager (TFDM)
  – Runway Status Lights (RWSL)

• Weather Integration for ATM Decision Making
  – Corridor Integrated Weather System (CIWS)
  – Consolidated Storm Prediction for Aviation (CoSPA)
  – Route Availability Planning Tool (RAPT)
MIT Lincoln Laboratory

<table>
<thead>
<tr>
<th>Mission</th>
<th>Technology in Support of National Security</th>
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<table>
<thead>
<tr>
<th>Staff</th>
<th>Primary Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical: 2370</td>
<td>• System architecture engineering</td>
</tr>
<tr>
<td>Support:  830</td>
<td>• Long-term technology development</td>
</tr>
<tr>
<td>Total:     3200</td>
<td>• Rapid system prototyping and transition</td>
</tr>
</tbody>
</table>

MIT Lincoln Laboratory is a Federally Funded Research and Development Center (FFRDC)
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Air Traffic Control Tower Challenges

- **Objective:** develop the **architecture**, **processing**, and **interfaces** to:
  - Consolidate tower systems
  - Provide electronic data exchange
  - Enable Surface Trajectory-Based Operations (STBO) decision support tools

- **Lead:** AJT Terminal System Engineering
Electronic Data Exchange Elements

- Alternate Route Preferences
- Departure Route Viability
- Expected Pushback Time
- Surface Delay
- Taxi Clearances
- Aircraft Derived Data
- Runway Closure Request
- Runway Demand
- Runway Arrival Time of Arrival
- Planned Config. Change
- Flight Plan Data
- Flight Plan Amendments
- Traffic Management Initiatives
- Surface Delay
- ATCSCC / TFMS
- ARTCC
- TRACON
- ATCA 7
- 24-27 October 2010
Tower Displays

- Adapted / customized / consolidated across several tower user positions
  - Ground, local, supervisor, clearance, flight data

- Tower Information Display System (TIDS)
  - Surface traffic situation, taxi routing, airport status

- Flight Data Manager (FDM) Display
  - Flight strips showing aircraft state data, queues

- Decision Support Tool (DST) Displays
  - Airport configuration control, demand management, weather impacts
Decision Support Tool (DST) Suite
(30” high-resolution display, 2560x1600 pixels)

Components
- Airport configuration
- Runway assignment
- Departure routing

- Sequencing and scheduling
- Taxi routing
- Weather, NOTAMs, …
- Traffic management initiatives
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RWSL Safety Benefit Addresses Runway Incursion Problem

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**RWSL reduces incursions**

“...runway incursions have significantly decreased on the RWSL test runway at DFW (70%)”

- DOT Inspector General, 2007

5 known “saves” at DFW since 2008

- Likely more unreported

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No on-board equipment required or heads-down time in cockpit

Give direct warnings to all pilots and vehicle drivers on the airport surface

**RED THLs prevent takeoff from occupied runway at DFW**

**Pilot** - “…The RWSL worked awesome. I noticed that BEFORE I saw the intruding regional jet.”

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**Diagram**: Runway Incursions Rate Per Million Operations - Category A & B

- FY01: 0.81
- FY02: 0.57
- FY03: 0.51
- FY04: 0.44
- FY05: 0.46
- FY06: 0.51
- FY07: 0.39

**Key**

- Yellow bars: Number of Runway Incursions
- Orange bars: Number of Category A & B Runway Incursions
- Blue line: Rate Per Million Operations - Category A & B
Runway Status Lights (RWSL)

Fused surveillance sources and safety logic automatically illuminate lights to **directly** warn pilots that runway is unsafe.

FAA plans deployment RWSL to 22 U.S. airports
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CIWS Benefits Assessment

**Observed CIWS Product Usage**

<table>
<thead>
<tr>
<th>Product</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>NEXRAD Precip.</td>
<td>900</td>
</tr>
<tr>
<td>8-24 hour</td>
<td>700</td>
</tr>
<tr>
<td>Echo Tops</td>
<td>500</td>
</tr>
<tr>
<td>G&amp;D Trends</td>
<td>400</td>
</tr>
<tr>
<td>Storm Motion</td>
<td>300</td>
</tr>
<tr>
<td>8-24 hour Echo Tops</td>
<td>200</td>
</tr>
<tr>
<td>Lightning</td>
<td>100</td>
</tr>
<tr>
<td>ASR Precip.</td>
<td>90</td>
</tr>
<tr>
<td>Satellite</td>
<td>80</td>
</tr>
<tr>
<td>Forecast Accuracy</td>
<td>70</td>
</tr>
<tr>
<td>Verify Contours</td>
<td>60</td>
</tr>
</tbody>
</table>

**Relative Frequency of Benefits Categories**

- Improved Arrival/Departure Transition Area Management
- Proactive, Efficient Reroutes: $136M
- Reduced Workload
- Improved Inter/Intra-facility coordination
- Improved Situational Awareness
- Keeping Routes Open Longer: $160M

**Location Photos**

- New York Air Route Traffic Control Center
- Traffic Management Unit
- Kennedy tower
- Continental Airlines
- Washington DC Air Route Traffic Control Center
- FAA Air Traffic Control System Command Center
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CoSPA Forecasts

Strategic Decision-Making ↔ Tactical Decision-Making

- High resolution, deterministic 0 – 8 hr Precipitation and Echo Tops Forecast
- Animates in 15 min or 60 min increments
- Forecasts interpreted like radar – show “what radar will look like in the future”
- Updates every 15 min
- Improved forecast of storm organization & evolution
- Can be readily translated to forecast of airspace capacity impact

2 – 8 Hours “National & Planned”

0 – 2 Hours “Local & Dynamic”
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RAPT Display

- Displays RAPT timelines
- Re-Centers / Re-Zooms
- CIWS on NY Region
- Displays NY departure routes & animated dep’s
- CIWS Precip Forecast ON
- Adds N90 TRACON overlay

- RAPT fully integrated into CIWS
- RAPT forecasts update every 5 minutes

Plane location along J95/J36 given a departure time of 05 min past the hour

Blockage Location
- No weather or <= level 1
- Some weather, but passable
- Route partially blocked – use loop and judgement
- Route blocked by storms

RAPT “Post-Impact Green (PIG)” Timer – minutes route has been ALL GREEN after route impact ended

Blockage Location (Route is blocked in N90)

Echo Tops Forecast at location of route blockage

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ATCA 20
24-27 October 2010
<table>
<thead>
<tr>
<th>Observed RAPT Benefit Categories (2008)</th>
</tr>
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<tbody>
<tr>
<td>1. More timely departure route reopenings; eased departure restrictions</td>
</tr>
<tr>
<td>2. More timely reroute planning/implementation; improved route impact planning</td>
</tr>
<tr>
<td>3. Directing pathfinder requests</td>
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<tr>
<td>4. Keeping departure routes open longer</td>
</tr>
<tr>
<td>5. More timely and proactive resumption of arrival flows; decreased airborne holding; potentially saved diversions</td>
</tr>
<tr>
<td>6. Proactive runway sequencing assistance</td>
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<tr>
<td>7. Enhanced decision-making productivity</td>
</tr>
<tr>
<td>8. Enhanced Inter/Intra-facility coordination</td>
</tr>
<tr>
<td>9. Improved safety</td>
</tr>
<tr>
<td>10. Enhanced common situational awareness</td>
</tr>
<tr>
<td>11. Improved awareness of evolving airspace impacts</td>
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<tr>
<td>12. Decision/Plan/Information confirmation or evaluation</td>
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2,600 hrs delay saved
$8.7 M Cost Savings
Summary

✔ Lincoln Laboratory applies its expertise to air traffic control for the Federal Aviation Administration

✔ Principal technical activities provide enhanced Surveillance, Collision Avoidance, Hazardous Weather Detection, Automation, and Safety

✔ Technology in support of NextGen:
  ✔ System architecture and human factors engineering
  ✔ Rapid system prototyping and transition
  ✔ Long-term technology development

✔ RWSL, TFDM, CIWS, CoSPA and RAPT capabilities are being demonstrated in the ATCA Exhibit Hall!
Tower Flight Data Manager (TFDM) System

External Data
- Surveillance
- Flight Plans
- Traffic Flow Management System
  - Integrated Departure / Arrival Capability (IDAC)
- Flight Operations Centers
- Airport Operations
- Weather

Tower Flight Data Manager (TFDM)

TFDM Information Bus

Decision Support Algorithms
- Departure Route Assurance
- Taxi Route Generation
- Runway Assignment
- Airport Configuration
- Sequencing
- Conformance Monitor

Computer-Human Interfaces
- Tower Information Display System (TIDS)
- Flight Data Manager (FDM) Display
- Other Decision Support Displays

Database
TFDM --- Capabilities

**Runway Assignment**
- Efficient arrival / departure balancing to maximize throughput & reduce delays

**Taxi Routing**
- Coordination prevents gridlock
- Enables taxi conformance monitoring for safety

**Airport Configuration**
- Planning tools facilitate timing configuration changes and proactively rerouting traffic

**Sequencing and Scheduling**
- Departure sequence optimized for throughput and flexibility
- Taxi scheduling reduces fuel burn
- Alerts and guidance for aircraft unlikely to meet time constraints

**Data exchange**
- Airline, TRACON, and ARTCC gain visibility into airport status
- Tower uses external data to enhance operational efficiency

**Departure Route Assurance**
- Proactive identification of traffic and weather constraints allows tactical collaborative rerouting
Runway Status Lights Elements

- Runway Entrance Lights (RELs), Takeoff Hold Lights (THLs), and Runway Intersection Lights (RILs) give automatic and direct warnings to all pilots and vehicle drivers on the airport surface.
- No on-board equipment required or heads-down time in cockpit.
RWSL Safety Benefit

**RWSL is best defense in >75% of real incursions**

**RWSL reduces incursions**

“…runway incursions have significantly decreased on the RWSL test runway at DFW (70%)”
- DOT Inspector General, 2007

5 known “saves” at DFW since 2008
- Likely more unreported

**RED THLs prevent takeoff from occupied runway at DFW**

Crossing aircraft

**Pilot** - “…The RWSL worked awesome. I noticed that BEFORE I saw the intruding regional jet.”

Departing aircraft
Final Approach Runway Occupancy Signal (FAROS)

- RWSL infrastructure is flexible to integration of additional safety functionality
- FAROS directly alerts landing pilots that runway is occupied
  - PAPIs that give vertical path guidance on approach FLASH to provide situational awareness (SA) when runway is unsafe for landing
  - Audio alerts in tower enhance SA for air traffic controllers

6 month prototype FAROS test at DFW showed concept improved pilot SA
**Route Availability Planning Tool (RAPT)**

**RAPT ConOps:** Facilitate efficient, proactive, consistent departure management decisions that increase capacity and decrease delay

- **GREEN = GO**
  - Open Route, Keep Open

- **YELLOW = JUDGEMENT**
  - Reopen / Restrict Route Under Guidance

- **RED = REROUTE**
  - Route Blocked, Plan / Maintain Reroute
Strategic and Tactical Planning

2 – 6 Hours
“National & Planned”

- Airspace Flow Programs
- “Playbook” Reroutes
- Ground Delay Programs

0 – 2 Hours
“Local & Dynamic”

- Tactical Decision-Making
  - Managing pilot deviations
  - Safe management of airborne holding
  - Dynamic, locally-coordinated reroutes
  - Implementing local airspace restrictions
  - Balancing airport arrival / departure fixes

Strategic Decision-Making
- Playbook reroutes
- Ground Delay Programs
- Airspace Flow Programs
- Collaborative Decision Making

Good Strategic Planning
Contributes to Successful Strategic Plan

Manageable Tactical Environment
Good Tactical Planning

Good Strategic Planning
Manageable Tactical Environment
Contributes to Successful Strategic Plan

ATCA 32
24-27 October 2010
MIT Lincoln Laboratory
CoSPA Operational Evaluation Status

- Providing 2-8 hr forecasts of VIL and Echo Tops to select facilities
- Collaboration between MIT LL, NCAR and NOAA
- Objective: Evaluate suitability and quantitative benefits of CoSPA for ATM operations
- Duration: June – Oct.

- Very positive response from users
- Improves situational awareness and strategic planning coordination
- High resolution is useful in assessing weather impacts
- Observed decisions in:
  - Airspace flow programs (AFP)
  - Ground delay programs (GDP)
  - “Playbook” reroute initiatives
  - Setting staffing needs

<table>
<thead>
<tr>
<th>Benefits Collection</th>
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<tbody>
<tr>
<td>13-14 June</td>
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<tr>
<td>16 June</td>
</tr>
<tr>
<td>6-8 July</td>
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<tr>
<td>19-21 July</td>
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<tr>
<td>3 Aug.</td>
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<tr>
<td>4-5 Aug.</td>
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<tr>
<td>1-2 Sept.</td>
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<td>16 Sept.</td>
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