Outline

• Operational overview of wake turbulence effect management in the United States

• Evolution of operational programs designed to manage wake turbulence effect

• Current and planned deployments

• Next Steps
Overview of Wake Turbulence Management

• The Federal Aviation Administration (FAA) and Europe continue to have a successful collaboration to manage wake turbulence effects

• Continued collaboration will bring positive results
  – Partners
    • Federal Aviation Administration (FAA)
      – Wake Turbulence Program
      – Flight Standards
      – Terminal Operations
  – Supporting Organizations
    • DOT Volpe,
    • MITLL (MIT Lincoln Labs),
    • CAASD (MITRE’s Center for Advanced Aviation System Development)
    • NASA
Overview of Wake Turbulence Management (cont’d)

- Capacity demand in the US is projected to increase by 64 percent between 2007 and 2020.
- Wake turbulence management will have the most impact on airport capacity.
- Prior wake turbulence separation
  - Based on 30-year old research
Overview of Wake Turbulence Management (cont’d)

• New wake turbulence management proposals
  – Current research shows closer spacing is possible with potential for increased runway capacity
    • A one mile reduction of in-trail separation in approaches to closely spaced parallels can increase runway capacity by 20 percent.
  – Wake turbulence management will come in increments over a multi-year period.
    • Each proposal can be implemented as it is approved, bringing small but measurable capacity increases
    • Operational changes have been made incrementally over the past 14 years
Wake Turbulence Management Progress in the United States (cont’d)

• Status
  – A sequence of programs underway to change wake turbulence standards one step at a time.
  – Initial work completed:
    • In-Trail Spacing Tool for Final Approach – Terminal Proximity Alert (TPA) & Automated Terminal Proximity Alert (ATPA)
    • Closely Spaced Parallel Runway (CSPR) operations – ATPA Phase 2
    • Wake Re-categorization (RECAT)
    • Wake Turbulence Mitigation for Departures (WTMD)
Wake Turbulence Management Progress in the United States (cont’d)

– The way forward to dynamic wake separation standards
  • Combine multiple wake standard changes with automation tools
    – ATPA, RECAT & WTMD
– The Wake Turbulence Program incorporates a planned progression to:
  • Reduce wake turbulence delays
  • Increase throughput
  • Maintain safety
US Wake Turbulence Programs

- Current and future programs described in this presentation:
  - Terminal Proximity Alert (TPA)
    - Enhanced Terminal Proximity Alert (ETPA)
    - Automated Terminal Proximity Alert (ATPA)
  - Wake Turbulence Re categorization (RECAT)
  - Wake Turbulence Mitigation - Departures (WTMD)
Terminal Proximity Alert (TPA)
Terminal Proximity Alert (TPA)

• Decision support tool
  – TPA graphic aids in maintaining precise separation along the Final Approach Course (FAC)
  – Aids in reducing operational errors attributed to compression

• Operational in all STARS and CARTS facilities with color displays
  – STARS: Phase 1 Final, March 2008
  – CARTS: Phase 1 Final, May 2009
  – FAA transitioning to single automation platform for terminal services

• Sites requested automation of TPA to reduce controller workload
  – A TPA Work Group defined requirements for Automated Terminal Proximity Alert (ATPA)
Examples of TPA Graphics (cont’d)
Enhanced Terminal Proximity Alert (ETPA)
Enhanced Terminal Proximity Alert (ETPA)

- ETPA is an enhancement to the TPA function originally implemented and based on feedback from operational sites.
- Enhancements include:
  - Flexibility in defining the sizes of the TPA J-Ring and Cone
    - 1, 1.1 – 9.9 (tenths of a nm inclusive), 10 – 30 NM
    - Sizes of the TPA J-Ring and Cone are displayed
  - New keyboard entries to enable or inhibit the display of the TPA graphics size (per track and per display)
  - Distance from the primary extent to any point on the Cone’s arc is identical
    - Results in a thinner-looking TPA Cone with a less “bowed” arc
Examples of ETPA Graphics
Examples of ETPA Graphics (cont’d)

Enhanced Cone
Automated Terminal Proximity Alert (ATPA)
Automated Terminal Proximity Alert (ATPA)

- Sites requested automation of the Terminal Proximity Alert to reduce controller workload
  - A TPA Work Group defined requirements for Automated Terminal Proximity Alert (ATPA)
Objectives of ATPA

• Provide controllers with the same information that Traffic Analysis Review Program (TARP) uses to detect losses of aircraft separation at terminal facilities

• Aid controllers in avoiding compression errors along the FAC

• Improve situational awareness
  – Situational awareness: "the ability to maintain a constant, clear mental picture of relevant information and the tactical situation…” (Dostal, 2007)
  – Critical part of the decision-making process
Automated Terminal Proximity Alert (ATPA)

- Automatically determines the separation minima between associated IFR aircraft
- Automatically displays a visual alert when a potential loss of separation is detected
  - Warning (Yellow) or Alert (Orange) Cone
- Automatically displays the required separation from the preceding aircraft on Final Approach Course (FAC)
- Reduces manual keyboard entries
- A Three Phase program
Examples of ATPA Phase 1 Graphics
ATPA Phase 1 Graphics (cont’d)

Blue Monitor Cones
ATPA Phase 1 Graphics (cont’d)

Warning Cones (45 second look-ahead time)
ATPA Phase 1 Graphics (cont’d)

Alert Cones (24 second look-ahead time)
ATPA Phase 1 Operational Dates

- Operational dates into CARTS facilities
  - Minneapolis, MN TRACON (M98)  May 2011
  - St. Louis, MO TRACON (T75)  July 2011
  - Chicago O’Hare TRACON (C90)  Oct  2011
  - SoCal TRACON (SCT)  May 2012
  - Denver, CO. TRACON (D01)  Aug  2012
  - Atlanta, GA. TRACON (A80)  TBD

- Operational dates into STARS facilities
  - Miami TRACON (KMIA)  June 2013
  - Charlotte TRACON (KCLT)  June 2013
ATPA Phase I Survey Findings

• C90 (Chicago TRACON) findings
  – General impressions were favorable
    • 89-100% of participants reported that they sometimes or always used ATPA
    • 68-80% of participants reported that ATPA always provides a benefit to the final control position
  – 3rd line distance information is useful
    • 81-87% of participants reported that they sometimes or always used the 3rd line distance information
  – Participants said they wanted ATPA mileage information to be displayed only on the owner’s display
  – Airport arrival efficiency rate at ORD increased by an average of 3%
ATPA Phase I Survey Findings

• T75 (St Louis TRACON) findings
  – General impressions were mostly favorable
    • 70-100% of participants reported that they sometimes or always used ATPA
    • 50-75% of participants reported that ATPA always provides a benefit to the final control position
  – 3\textsuperscript{rd} line distance information is useful
    • 70-100% of participants reported that the 3\textsuperscript{rd} line distance information was sometimes or always useful
  – A few controllers reported that ATPA added “clutter” to their display
  – Airport arrival efficiency rate at STL increased by an average of 0.87%
ATPA Phase I Survey Findings

• M98 (Minneapolis TRACON) findings
  – General impressions were favorable
    • 100% of participants reported that they sometimes or always used ATPA
    • 92-85% of participants reported that ATPA always provides a benefit to the final control position
  – 3rd line distance information is useful
    • 100% of participants reported that they sometimes or always used the 3rd line distance information
  – Cone orientation toward the lead aircraft in a pair can be misinterpreted as indicating the aircraft heading
  – Airport arrival efficiency rate at MSP increased by an average of ~1%
ATPA Phase I Survey Findings

- Operational assessment limitations
  - Feedback collected from volunteers from questionnaires are self-reported and are subject to biases
  - Airport arrival rate data is dependent on facility-specific factors other than ATPA use at the TRACON
  - Findings must be considered tentative
  - Findings cannot be generalized to the entire TRACON controller workforce
    - Sample size too small to represent the entire workforce reliably
ATPA Phase 2

- Monitors the diagonal separation between associated IFR aircraft executing parallel dependent instrument landing system (ILS) approaches.
The in-trail distance from the preceding aircraft is displayed on the left side of line 3 in the Full Data Block (FDB).

The diagonal distance from the preceding aircraft is displayed on the right side of line 3.
ATPA Phase 2

• ATPA Phase 2 uses FAA Joint Order 7110.65, Paragraph 5-9-6 wake separation requirements

• Although not required for air traffic operations, ATPA Phase 2 supports the 1.5-Nautical Mile minimum separation requirement of FAA Order 7110.308 when executing parallel dependent ILS approaches to Closely Spaced Parallel Runways.
5-9-6 PARALLEL DEPENDENT ILS APPROACHES

TERMINAL

a. Apply the following minimum separation when conducting parallel dependent ILS, MLS (Microwave Landing System), or ILS and MLS approaches:

1. Provide a minimum of 1,000 feet vertical or a minimum of 3 miles radar separation between aircraft during turn on.

2. Provide a minimum of 1.5 miles radar separation diagonally between successive aircraft on adjacent localizer/azimuth courses when runway centerlines are at least 2,500 feet but no more than 4,300 feet apart.

3. Provide a minimum of 2 miles radar separation diagonally between successive aircraft on adjacent localizer/azimuth courses where runway centerlines are more than 4,300 feet but no more than 9,000 feet apart.
ATPA Phase 2 Video
ATPA Phase 3

• Phase 3 (Future)
  – Site-specific separation
  – Integration with Wake Turbulence Mitigation – Arrivals (WTMA)

• Possible future ATPA enhancements
  – Display the visual notifications for departures
  – Include:
    • Miles-in-trail (MIT)
    • Metering
Wake Turbulence Recategorization (RECAT)
RECAT

- The FAA recently approved a re categorization of wake turbulence separation minima from the previous standard to a new standard (RECAT Phase I).
  - Based on years of joint research and development by the FAA, EUROCONTROL, scientific experts in wake, and experts in safety and risk analysis.
  - Categories are now based on weight, approach speeds, and wing span.
  - RECAT places aircraft into six categories (labeled A-F) for both departure and arrival separation.
    - Data have shown the six categories to be as safe as or safer than, today’s separation standards
    - Provides the opportunity for increased efficiency for NAS operations by reducing wake turbulence delays.
RECAT Phase 1

• Revises the ICAO single runway wake separation that addresses both capacity and safety improvements
• Establishes six (6) aircraft categories (labeled A-F)
• Applies to both departure and arrival separation
• In preparation for future phases, automation decision support tool is adaptable to support growth of aircraft categories up to twenty.
RECAT Phase 2

- Static pairwise separation
- Airport-specific program
  - Customize wake turbulence categories based on the mix of aircraft types of each airport
  - Automation decision support tool is also adaptable to support customized categories.
RECAT Phase 3

- Dynamic pair-wise separation
  - Weather-based
  - Aircraft configuration
- Maps directly to FAA NextGen ultimate dynamic pair-wise separation
Aircraft Assignments Under Current US Weight Classes and Under RECAT

Current U.S. Weight Classes

RECAT Wake Categories

Aircraft Type (Decreasing Wingspan ➔)
### RECAT Separation for Departures

#### Wake Turbulence Separation Table for "Directly Behind"

<table>
<thead>
<tr>
<th>Leader</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<tr>
<td>C</td>
<td></td>
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<td></td>
<td>3.5NM</td>
<td>5NM</td>
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<tr>
<td>D</td>
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# RECAT Separation for Approaches

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<th>C</th>
<th>D</th>
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<td>6NM</td>
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<td>D</td>
<td>3.5 NM</td>
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<td>4NM</td>
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</table>

*Wake Turbulence Separation Table for "On Approach"*
RECAT Deployments

• KMEM was the first site for permanent RECAT implementation.
  – Implemented November 1, 2012
• RECAT will be incorporated into STARS & CARTS software
• FAA plans to expand RECAT to other airports in 2013-2014
  – Future Key site deployments:
    • KMEM (STARS): November 2012
    • KMIA (STARS): July 2013
    • KPHL (STARS): November 2013
    • KSDF (CARTS): August 2013
    • KIAH (STARS): September 2013
    • KSFO (CARTS): September 2013
Memphis TRACON/Tower RECAT Evaluation

- 2-month Post-Implementation Evaluation @ Memphis
  - CPCs volunteered from TRACON and ATCT
  - CPCs were observed using RECAT
    - Observed for 30-minute intervals
    - Observation results

<table>
<thead>
<tr>
<th></th>
<th>Controller did use RECAT</th>
<th>Controller did NOT use RECAT</th>
<th>Pilot did NOT use RECAT</th>
<th>Total Flights Observed</th>
<th>% of Flights Using RECAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEM Tower - Departures</td>
<td>170</td>
<td>157</td>
<td>18</td>
<td>345</td>
<td>49%</td>
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<tr>
<td>M03 TRACON - Arrivals</td>
<td>9</td>
<td>180</td>
<td>0</td>
<td>189</td>
<td>5%</td>
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RECAT Evaluation (cont’d)

• CPCs (certified professional controllers) answered questionnaire items
  – Scaled-answer items

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<tr>
<th>Scale Labels</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<td>Rating</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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WakeNet Europe  May 2013
RECAT Evaluation (cont’d)

- Questionnaire Items with High Agreement (≥4)

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<thead>
<tr>
<th>Question</th>
<th>TRACON N=9</th>
<th>ATCT N=11</th>
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<tbody>
<tr>
<td>The RECAT wake categories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased my workload for arrivals</td>
<td>4.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Caused me to use different strategies for spacing aircraft</td>
<td>3.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Increased arrival efficiency</td>
<td>4.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Increased departure efficiency</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Were easy to understand</td>
<td>4.6</td>
<td>3.8</td>
</tr>
<tr>
<td>The wake category indicator in the data block</td>
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<td></td>
</tr>
<tr>
<td>Was meaningful</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Was easy to find</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Did not conflict with other indicators in the data block</td>
<td>3.7</td>
<td>4.5</td>
</tr>
</tbody>
</table>
RECAT Evaluation (cont’d)

• 6-month post-implementation evaluation to be conducted at Memphis TRACON/Tower June 3-6, 2013

  – Item of interest: the % of arrivals in which radar controllers utilize RECAT procedures
Questions