En Route Merging and Spacing Preparation

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Objective

- Develop a concept of operations that utilizes advanced surveillance information and enhanced speed control to increase efficiency and capacity of merging and spacing
  - Facilitate Continuous Descent Arrivals (CDA)
  - An initial implementation of this concept of operations shall be implementable over the next few years (2010)
  - Concept shall also be consistent with operational evolution over longer term (2014 – 2018)
  - Per request of FAA Surveillance and Broadcast Services office
# Development Plan

<table>
<thead>
<tr>
<th>Phase</th>
<th>Summary Description</th>
<th>Performers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AOC establishes spacing (ABESS)</td>
<td>Single Airline</td>
</tr>
<tr>
<td>2</td>
<td>AOC performs ABESS and then transitions flights into FDMS</td>
<td>Single Airline</td>
</tr>
<tr>
<td>3</td>
<td>AOC performs ABESS and FDMS for multiple merge streams and then transitions flights to FDMS</td>
<td>Single Airline</td>
</tr>
<tr>
<td>4</td>
<td>ATC implements a master schedule: En Route Merging and Spacing Preparation (EMSP) and then transitions flights to FDMS (optional)</td>
<td>Multiple Airlines &amp; ATC</td>
</tr>
<tr>
<td></td>
<td>• Step I – Single Merge Stream</td>
<td></td>
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<tr>
<td></td>
<td>• Step II – Multiple Merge Streams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Step III – Automated Resolutions</td>
<td></td>
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<tr>
<td>5</td>
<td>ATC implements a collaborative master schedule with multiple airlines and then transitions flights to FDMS (optional)</td>
<td>Multiple Airlines &amp; ATC</td>
</tr>
<tr>
<td>6</td>
<td>Operations are expanded to all major airports and implemented in NAS</td>
<td>Multiple Airlines &amp; ATC</td>
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</tbody>
</table>

Current demonstrations and testing

Focus of this briefing

EMSP becomes fully operational

EMSP becomes fully operational
Overview of EMSP

Pre-Freeze Metering Schedule for Airline

Frozen Master Metering Schedule for ATC

TFM - EMSP
• Speed Advisories issued to aircraft
• Indicated Air Speeds

AOC - ABESS
• Speed Advisories during en route phase of flight
• Instructions for FDMS transition (initial implementation only)

ATC - EMSP
• Clearances
• Instructions for FDMS transition (full implementation)

Flight Crew

FDMS Initiation

Speed Advisories

FDMS
Overview of EMSP (concluded)

AOC actions to meet Meter Point Time (MPT) constraints at meter point

ATC actions to meet MPT constraints at meter point

- Aircraft prior to EMSP spacing
- Preconditioned Aircraft
- Non-preconditioned aircraft

Speed Advisories

FDMS transition

Clearances

Meter Point

Arrival Airport

Preconditioning is complete, no speed advisories from ground needed
Reasons for AOC involvement

• Early speed advisories should remove requirement of later path-lengthening
  – Expected reduction in fuel burn
  – Expected reduction in controller workload for merge
• Increase TMA effectiveness by improving flow fluidity
  – Flights are preconditioned, requiring less severe adjustments by ATC
• Utilize readily available “indicated airspeed” information via ACARS for speed advisories
• Facilitate early ADS-B benefits without intended changes in TMA and controller responsibility
• Could be conducted in single-airline environment / low traffic environment without need for TMA
  – Facilitate CDA conduct that frequently requires different spacing prior to initiation than “conventional” approaches
## EMSP Steps

<table>
<thead>
<tr>
<th></th>
<th>Step I –Single Merge Stream</th>
<th>Step II –Multiple Merge Streams</th>
<th>Step III – Automated Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TFM</strong></td>
<td>Develops metering schedule for traffic in single Center</td>
<td>Develops metering schedule for traffic in multiple Centers</td>
<td></td>
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<tr>
<td><strong>ATC</strong></td>
<td>Controller defines and communicates maneuvers to meet metering schedule (shorter lead-times)</td>
<td>Automation generates resolutions and transitions flights into FDMS</td>
<td></td>
</tr>
<tr>
<td><strong>AOC</strong></td>
<td>Defines and uplinks speed advisories to meet metering schedule for their own fleet (longer lead-times) and transitions flights to FDMS</td>
<td>May still uplink advisories in single airline environments</td>
<td></td>
</tr>
<tr>
<td><strong>Flight Deck</strong></td>
<td>Follows spacing guidance and transition to FDMS as needed</td>
<td>Advanced FDMS capability for multiple merge streams</td>
<td></td>
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<tr>
<td><strong>TMA</strong></td>
<td>En Route Departure Capability</td>
<td>Adjacent Center Metering</td>
<td>Additional requirements</td>
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<tr>
<td><strong>Est. Time</strong></td>
<td>2010</td>
<td>2014</td>
<td>2015 - 2018</td>
</tr>
</tbody>
</table>
Range of Control Actions – Step I

Range of Trajectory Modifications with EMSP + ABESS II

AOC pre-freeze horizon

Range of Trajectory Modifications with single center EMSP

Metering point

ANSP freeze horizon

AOC

ATC
Range of Control Actions – Step II

Range of Trajectory Modifications with EMSP + ABESS II

Range of Trajectory Modifications with adjacent center EMSP

Range of Trajectory Modifications with single center EMSP

Metering point

AOC pre-freeze horizon

ANSP Outer freeze horizon

ANSP Inner freeze horizon

AOC

ATC
Range of Control Actions – Step III

Range of Trajectory Modifications with EMSP with Automated Resolutions

Range of Trajectory Modifications with adjacent center EMSP

Range of Trajectory Modifications with single center EMSP

Metering point

ANSP freeze horizon

AOC

ATC
ANSP Metering Capability

• The EMSP concept requires a time-based metering capability
  – ANSP makes pre-freeze metering times available to the AOCs who may calculate speed advisories to prepare spacing at meter point
  – Long distance trajectory predictions

• Traffic Management Advisor (TMA) is tool of choice
  – Implemented at all ANSP facilities
  – Currently provides functionality similar to EMSP

• For later EMSP steps, modifications will be required
TMA Overview

- TMA provides a common situational view among ANSP organizations: ARTCC, TRACON, and Tower

TMA - Time-Based Metering

- Enables controllers to apply metering times to manage the flow of aircraft through congested areas.

- Controllers maneuver aircraft to meet TMA-assigned Scheduled Times of Arrival using the time info displayed in the Meter List (shown in green in the middle of the scope).

TMA Timeline

- TMA depicts suggested schedules on a timeline display which can show Estimated Time of Departure and Scheduled Time of Departure. It also displays Estimated Time of Arrival and Scheduled Time of Arrival to assigned Meter Points and associated arcs.
TMA Deployment Status (as of 2007)

## Main Research Issues

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Approach to resolve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EMSP pre-freeze horizons for the AOC significantly extend current TMA freeze-horizons. Is this extension feasible, what are the drawbacks?</td>
<td>Analysis, literature review</td>
</tr>
<tr>
<td>2</td>
<td>What are ATC information requirements about AOC speed advisories?</td>
<td>Operational experts, HITL* simulation</td>
</tr>
<tr>
<td>3</td>
<td>What are the benefits of early AOC speed advisories (e.g., reduced controller workload, customer flight benefits)?</td>
<td>Benefits analysis</td>
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<tr>
<td>4</td>
<td>What are ATC display requirements for EMSP Steps I, II, and III?</td>
<td>Design</td>
</tr>
<tr>
<td>5</td>
<td>Establish feasibility and develop algorithm for multi merge stream FDMS</td>
<td>Design, simulation</td>
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</tbody>
</table>

* Human-in-the-Loop
## Main Implementation Issues

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Approach to resolve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Determine feasibility of bi-directional data-feed between TMA and AOC.</td>
<td>FAA / CSC TMA development groups</td>
</tr>
<tr>
<td>2</td>
<td>Considerations and strategies for merging ABESS traffic with other traffic.</td>
<td>Operational experts, HITL simulation</td>
</tr>
<tr>
<td>3</td>
<td>At what field-site should EMSP Step I test be conducted?</td>
<td>Operational experts, FAA / CSC TMA development groups</td>
</tr>
<tr>
<td>4</td>
<td>What are the adaptation requirements for TMA?</td>
<td>FAA / CSC TMA development groups</td>
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EMSP Phase 4
Concept Development Plan

- **Meetings**
  - EMSP focus group
  - FAA SBS

- **Draft concept**
  - Focus group review
  - Peer/management review
  - Draft available to FAA SBS for review

- **Revised concept**
  - Focus group review
  - Peer/management review
  - Coordination draft delivered

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Next Meeting Schedule
Proposed

- November 18 - 19: Visit of ATL TMA
- December 16 – EMSP focus group meeting
- January 21 – EMSP – FAA SBS meeting
Next Steps

• Goal: Field-demonstration of EMSP Step I in FY 2010
  – Likely candidate: ZKC-center
• Mature concept of operations document
• Develop collection of research issues
• Develop methodology to address research issues (e.g. human-in-the-loop and fast-time simulations)
• Work with ANSP facilities to implement required ground-infrastructure
EMSP Step I

SAMPLE SCENARIO
## Operating Environment Assumptions

<table>
<thead>
<tr>
<th></th>
<th>EMSP Step I</th>
<th>EMSP Step II</th>
<th>EMSP Step III</th>
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</thead>
<tbody>
<tr>
<td><strong>Airspace</strong></td>
<td>Single stream in en route and terminal airspace for arrival flows (e.g. SDF?)</td>
<td>Multiple streams in en route and terminal airspace for arrival flows</td>
<td></td>
</tr>
<tr>
<td><strong>Communications</strong></td>
<td>AOC-to-pilot – Aircraft Communications Addressing and Reporting System (ACARS) and voice</td>
<td>Controller/pilot – air-ground data communications and voice</td>
<td>AOC-to-ATC – ground-ground data communications and voice</td>
</tr>
<tr>
<td></td>
<td>Controller-to-pilot – voice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AOC-to-ATC – voice (or fax/electronic mail)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Navigation</strong></td>
<td>Some aircraft Area Navigation (RNAV) capable</td>
<td></td>
<td>Most aircraft RNAV capable • Required at or above FL 180 • Required for OEP airport arrivals/departures</td>
</tr>
<tr>
<td></td>
<td>Few aircraft Required Navigation Performance (RNP) capable</td>
<td></td>
<td>Some aircraft RNP capable • RNP-2 required at and above FL 290</td>
</tr>
<tr>
<td><strong>Surveillance</strong></td>
<td>Automatic Dependent Surveillance-Broadcast (ADS-B) required for FDMS operations</td>
<td></td>
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</tbody>
</table>
EMSP Step I
Pre-departure

Flight Deck
- Pushback
  - Request for pushback
- Departure clearance
- Load departure clearance into FMS if available
- Depart

AOC
- File and update flight plan

TFM
- Flight plan

En Route ATC
- Flight plan

Terminal ATC
- Issue departure clearance
EMSP Step I
En Route – Pre-Freeze

Flight Deck
- Cross pre-freeze horizon

AOC
- Calculate Speed Advisories to meet MPT constraints
- Monitor MPT constraints for pre-freeze horizon
- AOC-specific MPT constraints for aircraft inside pre-freeze horizon

TFM
- Update metering schedule

En Route ATC
- Flight plans, trajectories, and ETAs

Terminal ATC

Pre-freeze horizon
Freeze horizon
CDA conduct
Terminal

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**EMSP Step I**
En Route – Freeze

**Flight Deck**
- Cross freeze horizon
- Transition to FDMS

**AOC**
- Identify FDMS information for capable aircraft
- FDMS information

**TFM**
- Update metering schedule
- Flight plans, trajectories, and ETAs
- All MPT constraints for aircraft inside freeze horizon
- If needed: Maneuver aircraft to maintain separation

**En Route ATC**
- Maneuver other flights into preconditioned arrival stream

**Terminal ATC**
- CDA conduct
- Metering Point
- Free horizon
**EMSP Step I**

Descent

- **Flight Deck**
  - Identify flight as FDMS
  - Cross into terminal

- **AOC**
  - FDMS identification

- **TFM**
  - Issues TOD clearance

- **En Route ATC**
  - Maneuver other flights into preconditioned arrival stream

- **Terminal ATC**
  - Maneuver non-CDA aircraft to fit into CDA’s
Create and Distribute Metering Schedule

ANSP: Air Navigation Service Provider
AOC: Airline Operations Center
A-ANSP: ANSP Automation
A-AOC: Automation AOC
FC: Flight Crew
AA: Air Automation

1. **ANSP:** Develop/Maintain Master Metering Schedule
2. **A-ANSP:** Distribute Frozen Metering List(s) to Center(s)
3. **A-ANSP:** Distribute pre-frozen Metering List(s) to AOC(s)

**Updates:**
- Flight Plan data, ETAs
- Arrival constraints
- En route constraints
- Predicted wind data
- Aircraft position data (radar, ADS-B)
- Pre-/Frozen Metering List(s)

**ANSP Maneuver Selection**
**AOC Maneuver Selection**
ANSP Maneuver Selection

ANSP (controller): Consider first/next applicable aircraft in Metering List

ANSP Frozen Metering List

first aircraft

next aircraft

YES

NO

Aircraft ETA is within +/- 30 sec of STA at meter point?

YES

NO

Metering Resolution Automation Available?

YES

A-ANSP: Generate Resolution(s) to meet Meter Point Time

NO

ANSP (controller): Determine maneuver(s) to meet Meter Point Time

ANSP (controller): Select Maneuver to meet Meter Point Time

Modify metering list if needed

ANSP: Air Navigation Service Provider
AOC: Airline Operations Center
A-ANSP: ANSP Automation
A-AOC: Automation AOC
FC: Flight Crew
AA: Air Automation

YES

Operational solution found?

YES

ANSP: Communicate maneuver to FC

propose maneuver (as clearance)

NO

Flight Deck Maneuver Implementation

ANSP: Update flight plan in A-ANSP
AOC Maneuver Selection

AOC: Consider first/next applicable aircraft in Metering List

- **First aircraft**: Pre-frozen Metering List

  - **Aircraft ETA is within +/- 30 sec of STA at meter point?**
    - **YES**: Speed Advisory Automation Available?
      - **YES**: A-AOC: Calculate Speed Advisory to meet Meter Point Time
      - **NO**: AOC: Determine speed to meet Meter Point Time
    - **NO**: AOC: Consider first/next applicable aircraft in Metering List

  - **NO**: Next aircraft

- **Next aircraft**

  - **Operational solution found?**
    - **YES**: AOC: Communicate maneuver to FC
      - **proposed maneuver (as speed advisory)**
    - **NO**: AOC: Communicate speed advisory to A-ANSP

ANSP: Air Navigation Service Provider
AOC: Airline Operations Center
A-ANSP: ANSP Automation
A-AOC: AutomationAOC
FC: Flight Crew
AA: Air Automation

Flight Deck Maneuver Implementation
Flight Deck Maneuver Implementation

Proposed maneuver (AOC, ANSP, or Flight-deck based)

- Maneuver Feasible for FC+AA?
  - Yes
  - OR
  - No
    - FC: Follow ANSP/AOC instructions
  - FC: Enable FDMS

- Aircraft position data updates

- FC+AA: Change Flight Behavior

ANSP: Air Navigation Service Provider
AOC: Airline Operations Center
A-ANSP: ANSP Automation
A-AOC: Automation AOC
FC: Flight Crew
AA: Air Automation