An Overview of Louisville Merging and Spacing Activities

CDA Workshop June 7, 2007

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Outline

• Participants
• Overview
• M&S concept
• Approach
• Calendar
• Roadmap
M&S Working Groups

• Two Groups:
  – Airline-Based En route Sequencing and Spacing (ABESS)
  – Flight-Deck based Merging and Spacing (FDMS)
• “ABESS” working group:
  – Ground-side tools for AOC
  – Concept and procedures for ABESS operator, dispatchers and pilots (including AOC-pilot and AOC-ATC interactions)
• “FDMS” working group:
  – Flight deck-based merging and spacing concept development
  – Development and testing of flight deck algorithms, tools and procedures
  – Pilot-controller phraseology
  – Pilot and controller human in the loop simulations
  – Coordination with external groups (EUROCONTROL, ASAS RFG)
• Participants and roles:
  – UPS, MITRE, EUROCONTROL, ACSS, NASA, FAA
Merging and Spacing Overview

• The (Louisville) Merging and Spacing concept of operations utilizes enhanced technologies and procedures to support merging and spacing from en route airspace into the terminal domain.

• Concept consists of three elements, to be described in this briefing:
  – Airline-Based En route Sequencing and Spacing (ABESS)
  – Flight-Deck based Merging and Spacing (FDMS)
  – Continuous Descent Arrivals (CDA)

• Approach: phased development and deployment of new air and ground technologies and procedures
  – Outline of phases
  – Description of past and current activities
General Description of Merging & Spacing

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<td>Merge Fix</td>
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<td>Final Approach Fix (FAF)</td>
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- **Set-Up**
  - Airline or ATC Based En-route Sequencing and Spacing (ABESS)
  - Flight deck-based M&S (FDMS)

- **Conduct**
  - Merge Fix
  - Remain Behind
  - Conduct

- **Termination**
CHERI CDA from 2004
ABESS

• In M&S phase 1 the AOC provides speed advisories to flights to establish spacing over a single en route merge fix

• Participants
  – Single airline, ground operator, flight crews

• Environment, Traffic
  – UPS late-night west coast inbounds
  – Filed over a single merge fix

• ABEss Ground Tool:
  – Provides speed advisories
FDMS

- Concept, display, and safety and performance requirements are currently being assessed
  - Application Description version 1.5 was released in April 2007
  - Safety analysis version 2 is to be released June 2007
- Simulations and demonstrations for human factors evaluation
  - Three Human-in-the-loop (HITL) simulations have been completed
  - Pending MITRE-Langley HITL simulation to evaluate algorithms and pilot procedures (late FY07)
- Algorithm performance testing is ongoing
- Flight-deck procedures
  - Being examined in simulations
- Training requirements
  - Under development by UPS
- Avionics procurement and installation
  - On-going with UPS and ACSS
2007 CDAs for SDF 17L and 17R

Vertical Navigation Planning Information:
- M & S Trial aircraft will follow AGO command speed until FAF.
- All aircraft must be at 179 knots or less at FAF.
- Arrival must be flown using FMS UNAV and VNAV guidance.
- A300: Use the appropriate vertical mode for compliance with altitude/airspeed constraints.

Arrival:
- Calks One: Expected ILS 17L
- CBSKT One: Expected ILS 17R

CDA North Arrival Pilot Notes:
1. Load the ILS prior to starting the arrival. Verify speed/altitude constraints for the arrival and approach. Do not put the final approach speed in either the runway or FAF waypoint.
2. Set the FMS descent speed to 80/810.
3. Set the altitude window to the lowest assigned ATC altitude.
4. D135/768/763/760: Use VNAV.
5. Maintain speed at 10 knots IAS of published speeds.
6. Select final approach speed no later than BASMIN or BRYDL to ensure speed reduction. Select next fsp setting no later than RACRR or SLEW.
7. Arm the ILS, after receiving ILS approach clearance.
8. If backtracking the ILS, fly path or glide slope to the FAF.
9. No later than 1 mile prior to the final approach fix, select gear down and approach flaps.

ATC Clearance Information:
1. Clearance from Kansas City or Indianapolis Center will be "cleared as filed" with a pilot discretion descent to 11000 feet.
2. Louisville Approach will clear with a pilot discretion descent; expect the ILS 35 Left or Right.
2007 CDAs for SDF 35L and 35R

VERTICAL NAVIGATION PLANNING INFORMATION

M & S trail aircraft will follow AGL command speeds until FAF. All aircraft must be at 170 Kts or less at FAF.

B757/767/777-400:
Arrival must be flown using FMS LNAV and VNAV guidance.

A300:
Use the appropriate vertical mode for compliance with altitude/airspeed constraints.

ARRIVAL
BGEST ONE - Expect ILS 35L
PXV ONE - Expect ILS 35R

POCKET CITY ONE ARRIVAL (PXV1)

Valid for West Coast arrivals
5000 to 8000

POCKET CITY
N38 01.3 W085 41.7

Cross at or above 4400’ and at 220 Kts.

BASKT
N37 59.0 W085 40.0

Cross at 3000’ and at 175 Kts.

UPSCO
N37 54.8 W085 40.9

Cross at 4000’ and at 180 Kts.

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M&S Phase 2:  
*Flights transition from ABESS to FDMS*

- In M&S phase 2, the ABESS participating AOC develops an arrival sequence for arrival streams from a single direction.
- As flights reach the FDMS transition zone, the AOC transitions flights into FDMS.
- Using their onboard equipment, flights follow onboard speed guidance to achieve the AOC identified target spacing over a merge fix.
- Once they are in ADS-B range, flights follow relative spacing guidance.
- Flights merge in enroute airspace.
- After top of descent, flights fly a company specific CDA.
**Flights transition from ABESS to FDMS**

**Traffic**
- Single Airline
- Late night, UPS aircraft from the West coast
- Single merge stream
- Company specific CDA
- Flights follow common lateral path from en route merge fix to the runway
- CDAs may be flown “open loop” if no lead a/c is identified

**AOC**
- AOC manages sequence and spacing of aircraft for an en route merge fix
- AOC provides speed advisories to deliver flights at the desired fix crossing time
- AOC identifies lead aircraft and interval for self-spacing aircraft (FDMS)
- AOC transitions flights from ABESS to FDMS

**Flight Deck**
- Uses on-board tool for speed guidance to achieve the assigned spacing
- Speed guidance is based on state vector (non-trajectory) based spacing algorithm (Cospace 2003)
- Advisory Guidance Display of speeds in primary field of vision
- Speed guidance is initiated and administered on an electronic flight bag
M&S Activities: 2004-2006

• 2004: development and testing of CDAs at Louisville
• 2005:
  – concepts developed for M&S ABESS (“Phase 1”) and FDMS (“Phase 2”)
  – Selection, development and evaluation of algorithms for FDMS
• 2006:
  – *Initial flight tests of “FDMS-phase 1” algorithm by ACSS*…
    • 2 tools were tested in “shadow mode” at UPS AOC, then refined for fall evaluation
  – ABESS field evaluation, October 2006
    • 2 week test of ABESS operations at UPS AOC
    • 2 tools were used to develop sequence and speed advisories for late night, “west coast” inbound fleet of 14-20 aircraft
  – Analysis of results: November 2006-January 2007
M&S Activities: 2007

• February – June, 2007:
  – Refinement of ABESS tool, combining features from both tools tested in October 2006
  – Acquisition of improved data feed for ABESS based as a result of Oct 2006 performance

• June:
  – ABESS Shadow test, June 25\(^{th}\) – 29\(^{th}\), 2007

• July:
  – Hazard and safety analyses
  – CDA approval for UPS operations, July 5\(^{th}\), 2007

• August:
  – ABESS field evaluation, Aug 6 – 17\(^{th}\), 2007
  – Demonstration to FAA administrator, Aug 28\(^{th}\), 2007
“Roadmap”

1st Phase: Airline Operations Center (AOC) establishes spacing during en route flight over a single merge fix
2nd Phase: AOC performs ABESS and then transitions flights into FDMS
3rd Phase: AOC performs ABESS for multiple merge streams
4th Phase: ATC implements a master schedule during periods of lower traffic complexity
5th Phase: ATC implements a collaborative schedule for multi-airline operations
6th Phase: Operations are expanded to multiple airports and guidance for NAS implementation is provided
END
BACKUP

- TOOWiLD CDA (for Dave Williams’ talk)
- Phase 2-3 material from roadmap draft
1. KSDF ATIS indicates when CDA procedures are in effect for B757/767 arrivals.
2. Load CDA 17R with filed transitions and ILS approach. Close any discontinuities between the arrival and the ILS final approach.
4. Verify FMS cruise/descent speed based on the GOC arrival uplink message. MCP altitude should be set based on ATC assigned altitude. To maintain a constant descent during arrival request lower altitude well in advance of any Top Of Descent.
5. Enter any ATC speed or route changes in the FMS and use power or speed brakes to re-acquire VNAV path. Flight level change or vertical speed should not be required.
6. For best VNAV path performance enter spacing algorithms speed into FMS prior to descent.
7. ARM approach after receiving ATC clearance for the ILS approach. NOTE: The altitude constraints at individual waypoints are not ATC restrictions – they are point to initiate the speed slowdowns.

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M&S Phase 3: 
*Sequence Aircraft from Multiple Directions*

- In M&S phase 3, the ABESS participating AOC develops an arrival sequence for arrival streams from multiple directions.
- As flights reach the FDMS transition zone, the AOC transitions flights into FDMS.
- Flights follow speed guidance to meet an absolute time using their onboard equipment until they come into ADS-B range of their lead-aircraft.
- Once they are in ADS-B range, flights follow relative spacing guidance.
- After top of descent, flights fly a company specific CDA that allows them to merge during CDA conduct.
M&S Phase 3: Sequence Aircraft from Multiple Directions

Traffic
- Traffic merges from multiple directions
- Company specific CDAs allow merge in terminal airspace

AOC
- AOC manages order and spacing of aircraft arriving at a common final merge fix from multiple fixes
- Establishes sequence and arrival times for the runway threshold
- Computes en route fix time and speed advisories to achieve scheduled times
- Identifies lead aircraft and interval for self-spacing aircraft

Flight Deck
In addition to Phase 2:
- In addition to a relative spacing mode (phase 2), an absolute spacing mode is used
- Trajectory based spacing algorithm