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# **An Overview of Louisville Merging and Spacing Activities**

**CDA Workshop June 7, 2007**

**James McDaniel, FAA  
Nancy Smith, NASA  
Peter Moertl, MITRE**



# Outline

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- **Participants**
- **Overview**
- **M&S concept**
- **Approach**
- **Calendar**
- **Roadmap**

# M&S Working Groups

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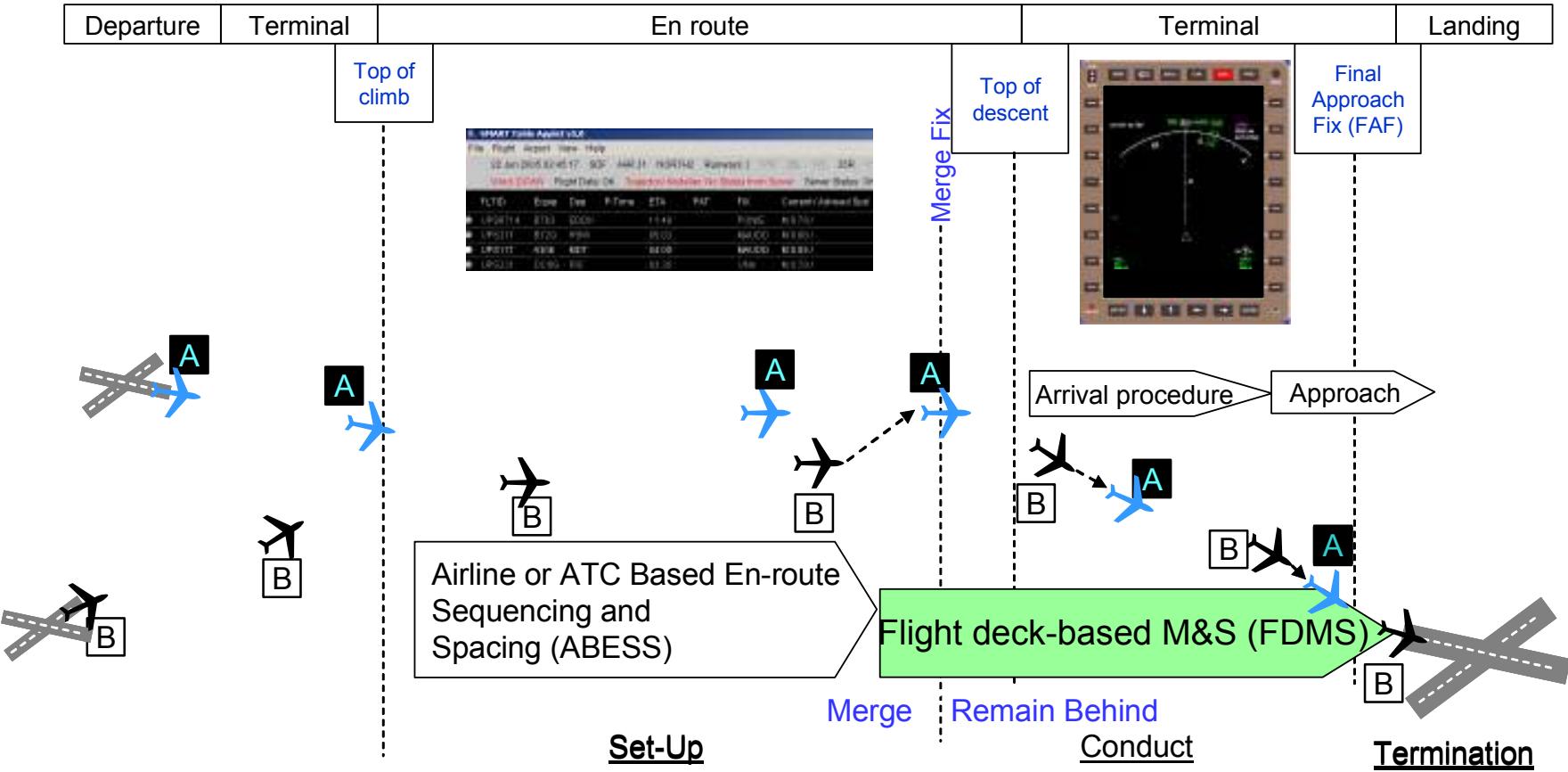
- **Two Groups:**
  - **Airline-Based En route Sequencing and Spacing (ABESS)**
  - **Flight-Deck based Merging and Spacing (FDMS)**
- **“ABESS” working group:**
  - **Ground-side tools for AOC**
  - **Concept and procedures for ABESS operator, dispatchers and pilots (including AOC-pilot and AOC-ATC 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

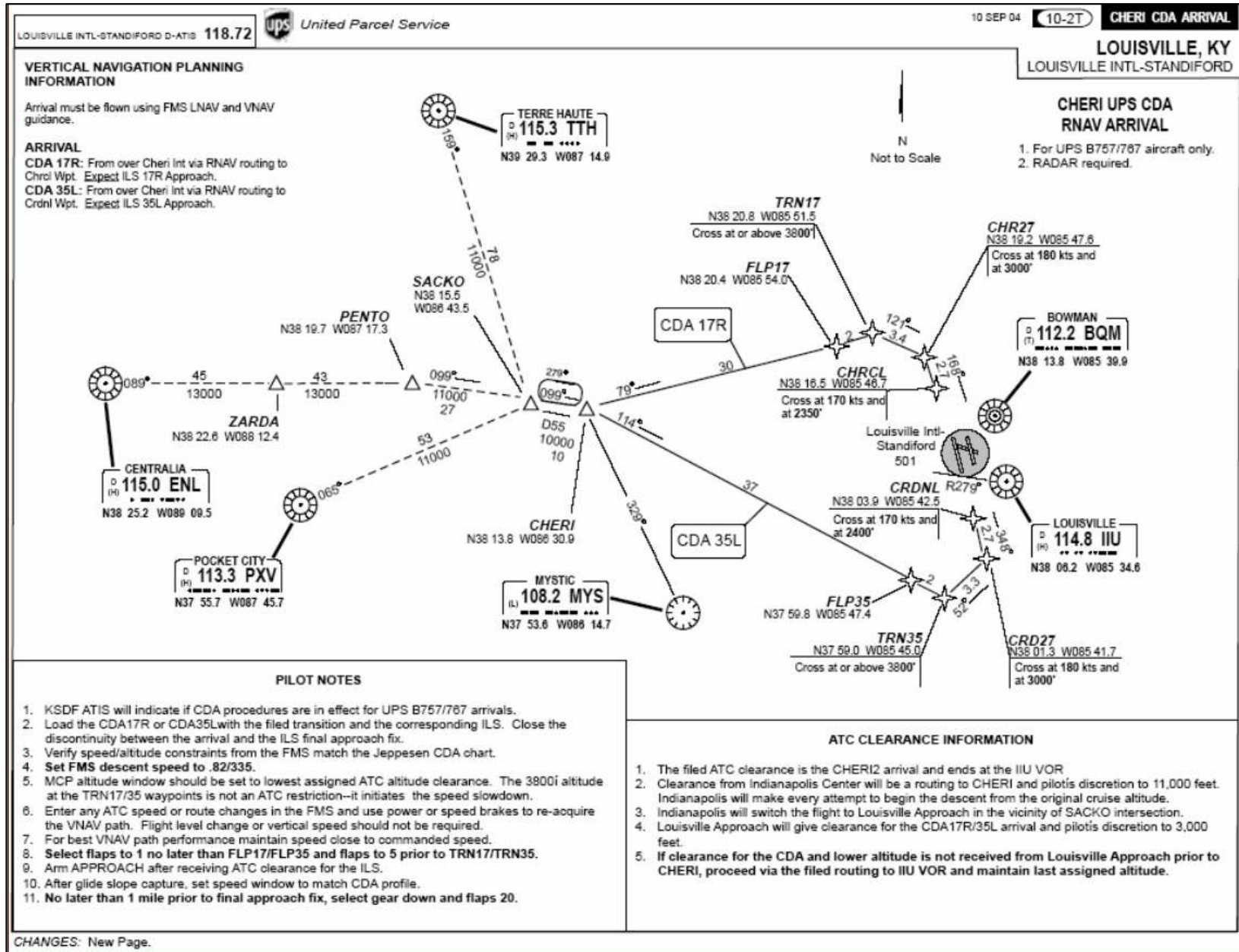
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- **The (Louisville) Merging and Spacing concept of operations utilizes enhanced technologies and procedures to support merging and spacing from en route airspace into the terminal domain**
- **Concept consists of three elements, to be described in 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

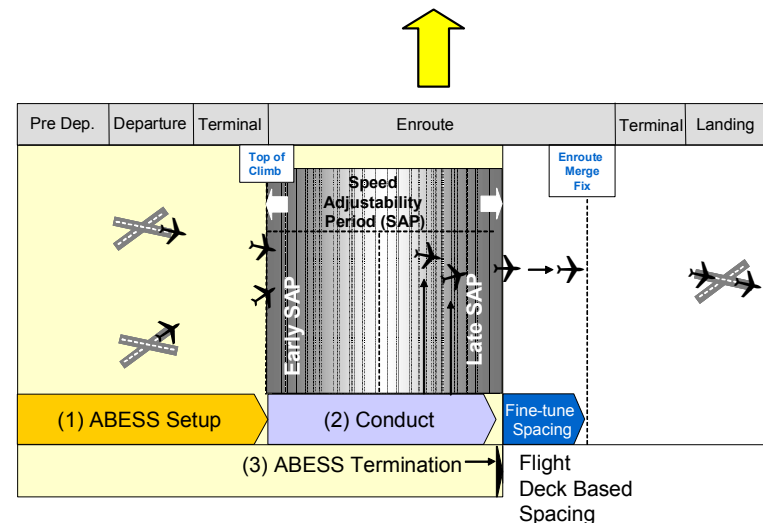
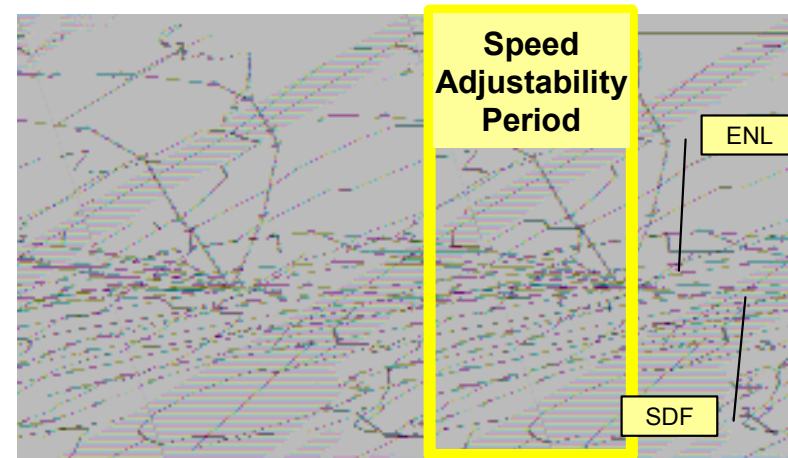


# CHERI CDA from 2004



# 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

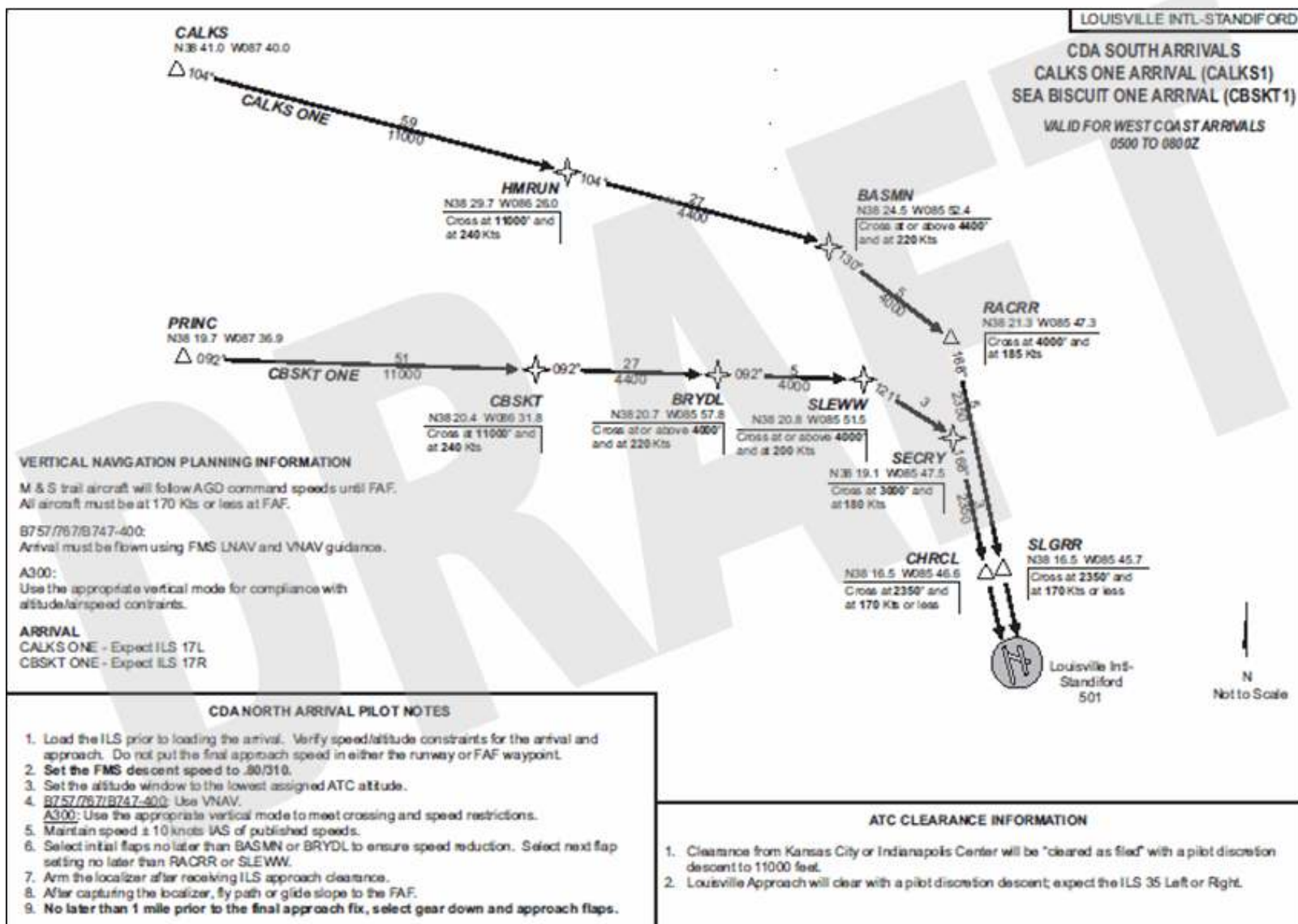


# FDMS

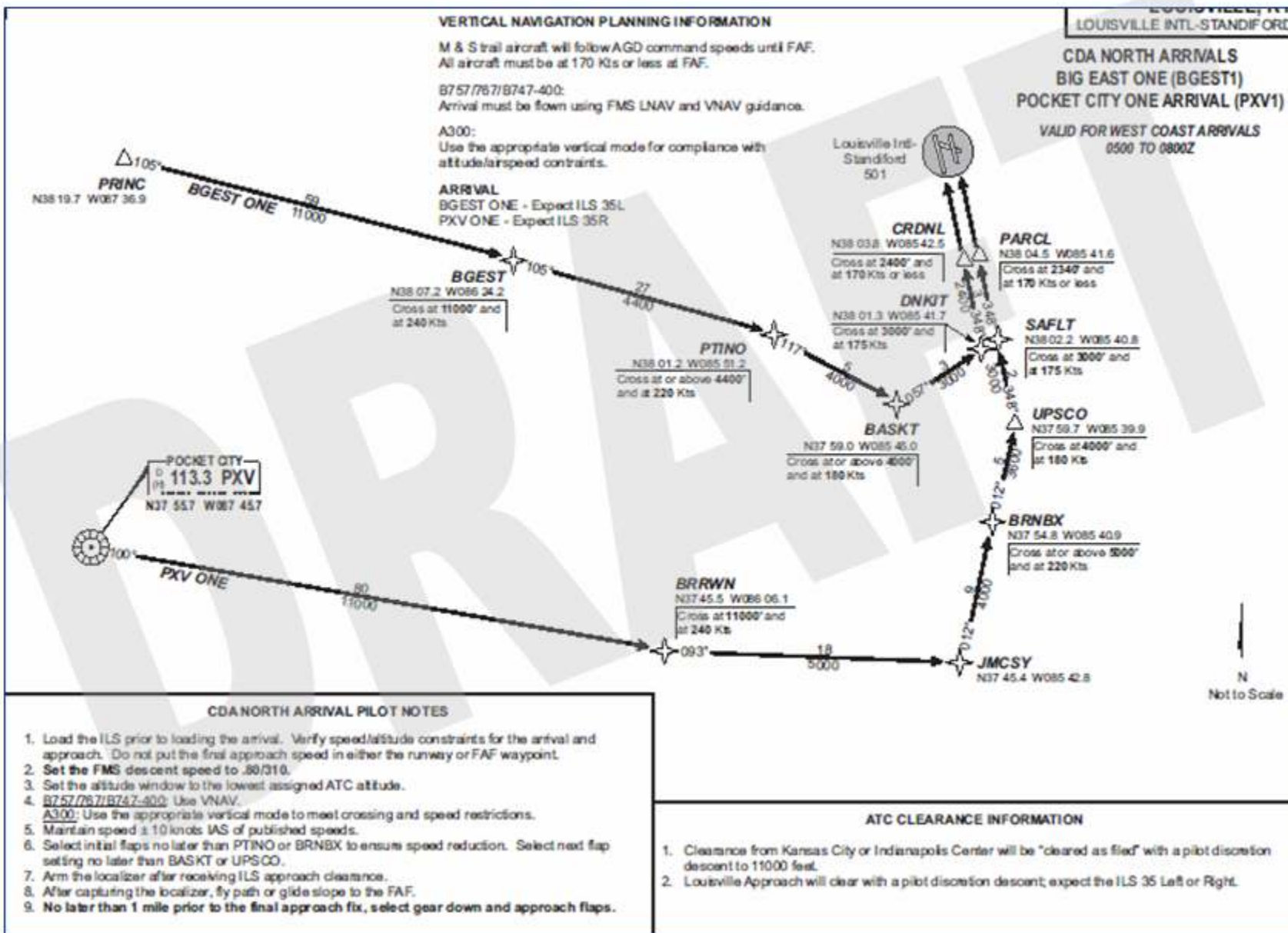
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- **Concept, display, and safety and performance requirements are currently being assessed**
  - Application Description version 1.5 was released in April 2007
  - Safety analysis version 2 is to be released June 2007
- **Simulations and demonstrations 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



# 2007 CDAs for SDF 35L and 35R



## **M&S Phase 2:**

### ***Flights transition from ABESS to FDMS***

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- **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

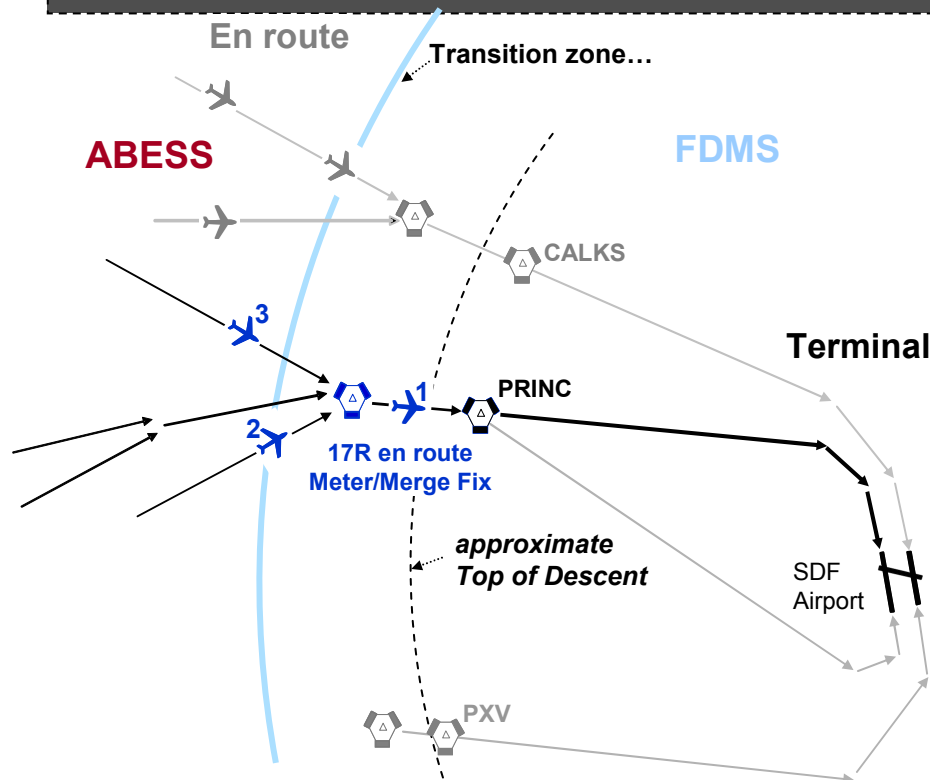
- Single Airline
- Late night, UPS aircraft from the West coast
- Single merge stream
- Company specific CDA
- Flights follow common lateral path from en route merge fix to the runway
- CDAs may be flown “open loop” if no lead a/c is identified

## 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

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- **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...***
  - **ABESS “shadow test,” May 2006**
    - **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

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- **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<sup>th</sup> – 29<sup>th</sup>, 2007
- **July:**
  - Hazard and safety analyses
  - CDA approval for UPS operations, July 5<sup>th</sup>, 2007
- **August:**
  - ABESS field evaluation, Aug 6 – 17<sup>th</sup>, 2007
  - Demonstration to FAA administrator, Aug 28<sup>th</sup>, 2007

# “Roadmap”

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**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**

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# BACKUP

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- **TOOWiLD CDA (for Dave Williams' talk)**
- **Phase 2-3 material from roadmap draft**

LOUISVILLE, KY  
LOUISVILLE INTL-STANDIFORD

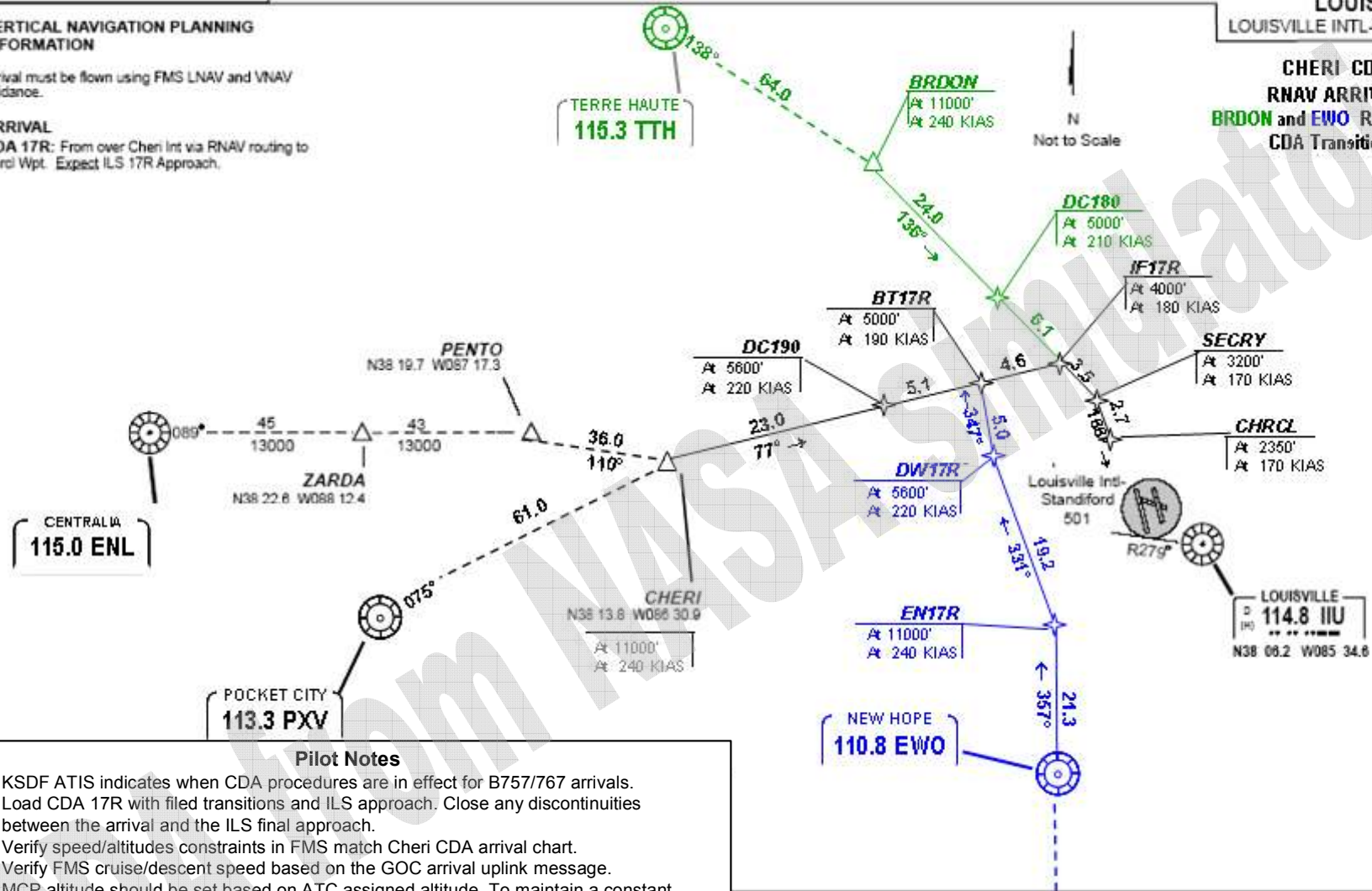
CHERI CDA  
RNAV ARRIVAL  
BRDON and EWO Runway 17R  
CDA Transitions

**VERTICAL NAVIGATION PLANNING INFORMATION**

Arrival must be flown using FMS LNAV and VNAV guidance.

**ARRIVAL**

CDA 17R: From over Cheri Int via RNAV routing to Cheri Wpt. Expect ILS 17R Approach.



**Pilot Notes**

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.
  3. Verify speed/altitudes constraints in FMS match Cheri CDA arrival chart.
  4. Verify FMS cruise/descent speed based on the GOC arrival uplink message.
  5. 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.
  6. 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.
  7. For best VNAV path performance enter spacing algorithms speed into FMS prior to descent.
  8. 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.

**ATC CLEARANCE INFORMATION**

1. The filed ATC clearance is the CHERI arrival and ends at the IIU VOR
2. Clearance from Indianapolis Center will be a routing to CHERI and pilot's discretion to 11,000 feet. Indianapolis will make every attempt to begin the descent from the original cruise altitude.
3. Indianapolis will switch the flight to Louisville Approach in the vicinity of SACKO intersection.
4. Louisville Approach will give clearance for the CDA-17R/35L arrival and pilot's discretion to 3,000 feet
5. If clearance for the CDA and lower altitude is not received from Louisville Approach prior to CHERI, proceed via the filed routing to IIU VOR and maintain last assigned altitude

# M&S Phase 3:

## *Sequence Aircraft from Multiple Directions*

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- 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

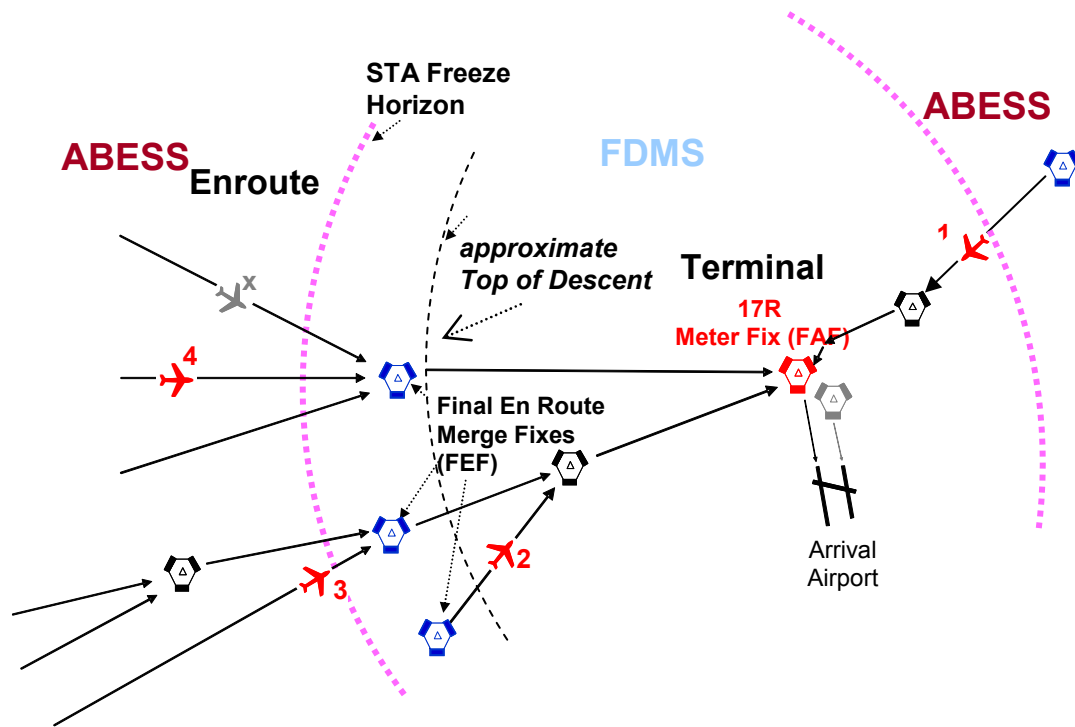
# M&S Phase 3: Sequence Aircraft from Multiple Directions

## 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