Denver PBN Project

An Integrated Airspace Concept

CCO and CDO Implementation

Presented By: James Arrighi,
FAA PBN Policy and Support Group

Objectives

- General
  - Mission Statement
  - Scope of Project
- Denver International Airport PBN Project
  - Background
  - Preliminary Activities
  - Design Activities
  - Pre-implementation Activities
  - Implementation and Post-implementation Analysis
- Conclusions

MISSION STATEMENT

Build an appropriate airspace structure in the Denver area that will allow development of a NextGen System centered on RNAV technology that will meet the needs of the front range aviation community.

Denver PBN System January 2010 – March 2013

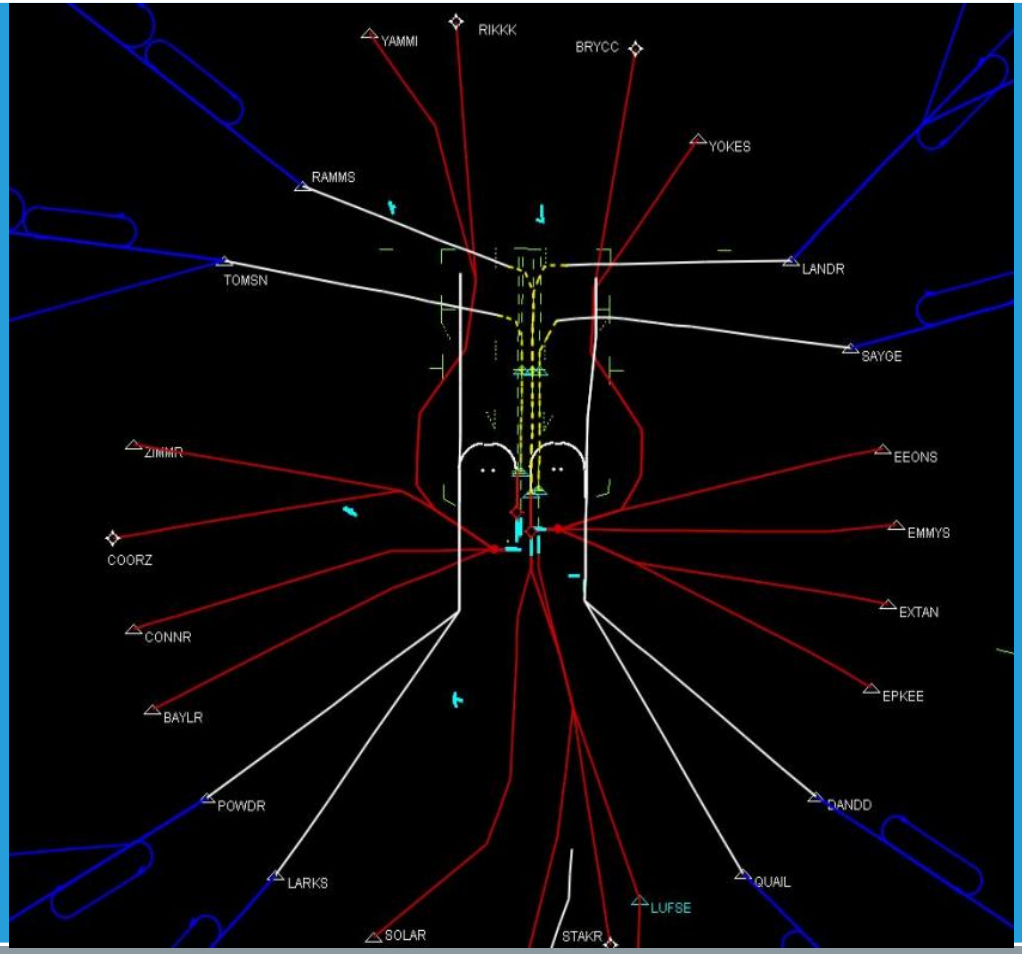
Planned and implemented a network of 49 New procedures

21 arrivals (STARs) with Optimized Profile Descent (OPD) – 16 Denver Intl; 4 satellite airports, 1 COS

16 departures (SIDS) CCO or minimal level-off

12 RNP-AR *operational June 2013*

ILS approach transitions from STARs



The Key to a Successful PBN Project:

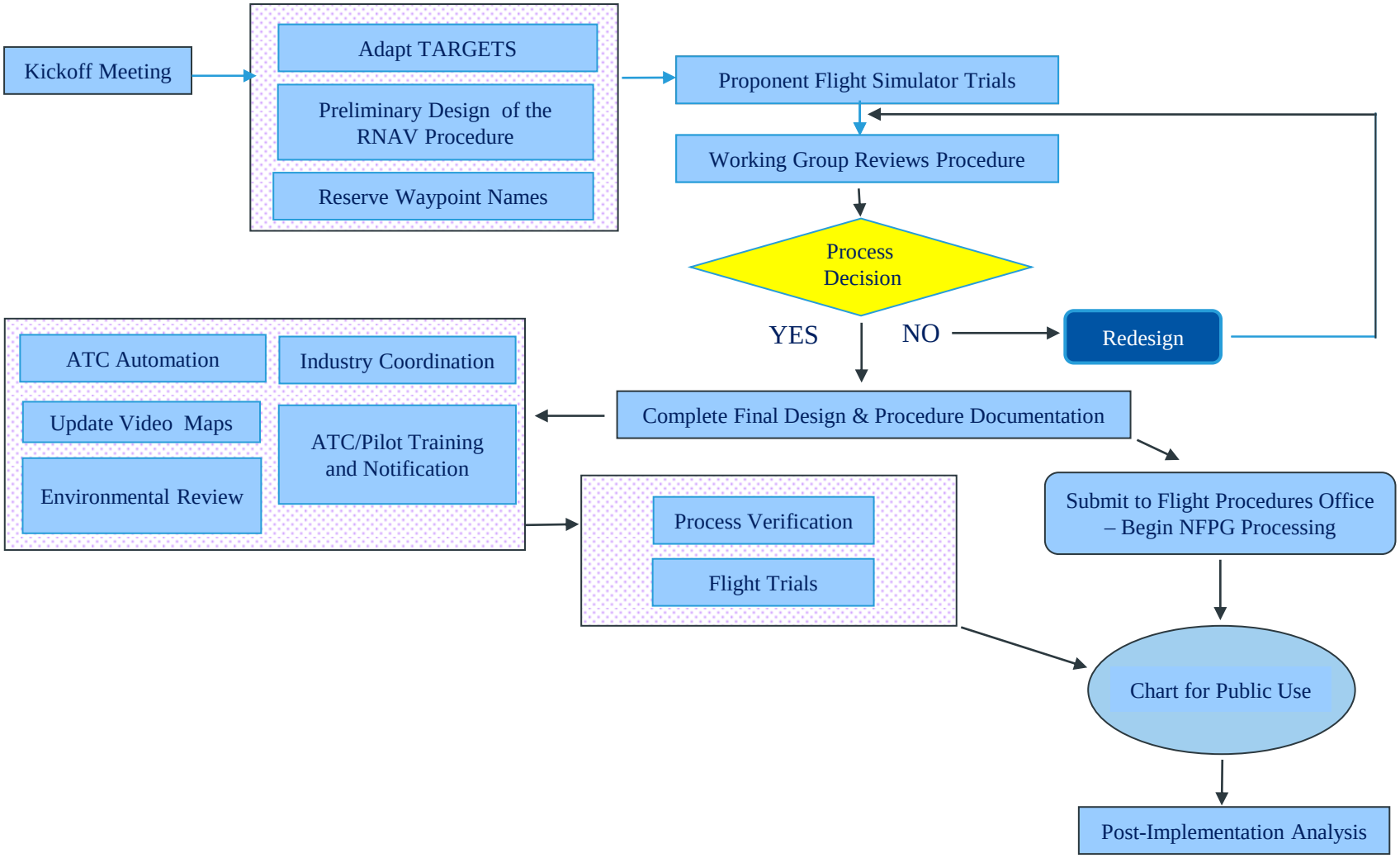
Plans are nothing; Planning is everything

Dwight D. Eisenhower

The Planning *Team*

Figure 4.— Airspace design team

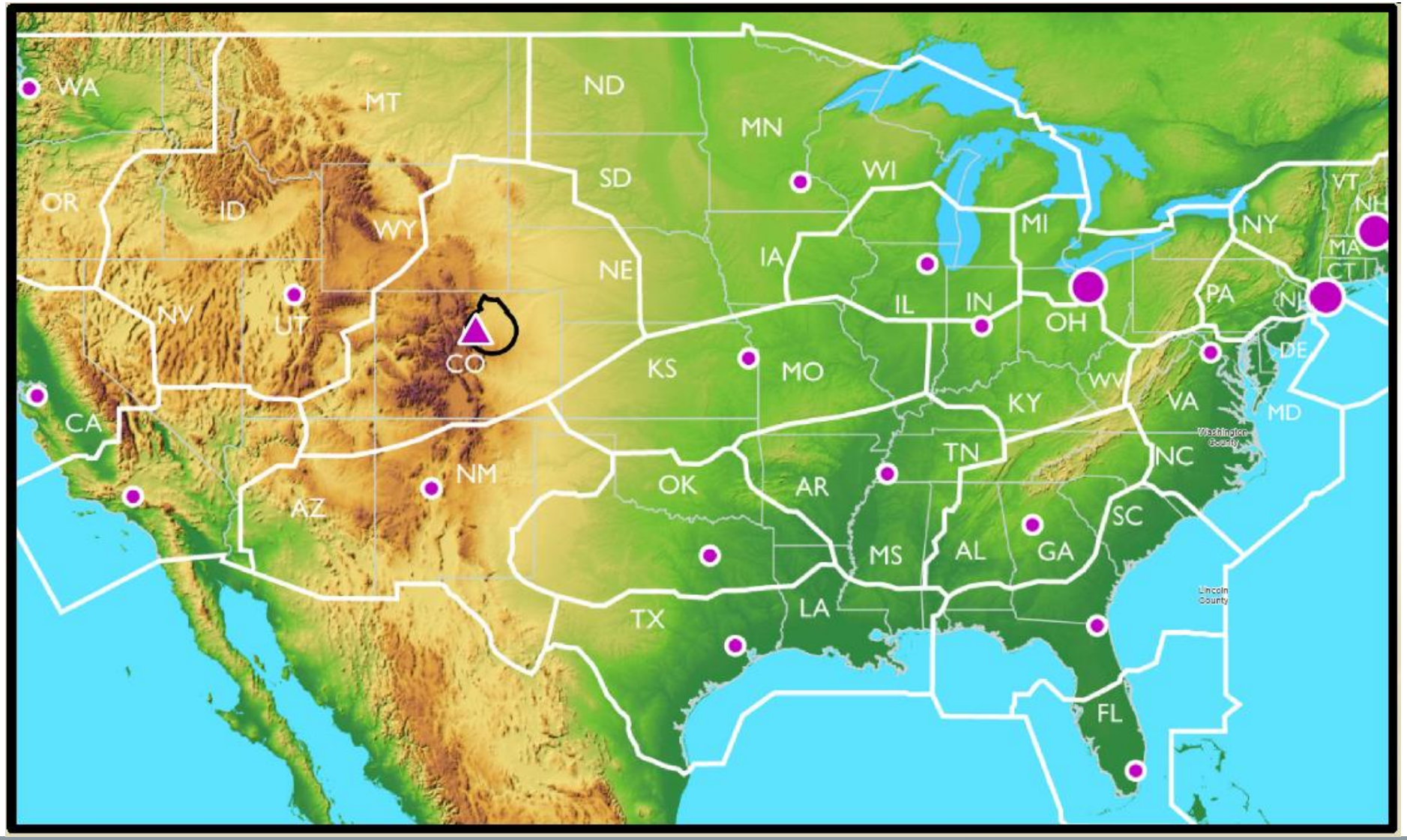
18-Step Guidelines for RNAV Procedure Implementation



Denver International Airport PBN Project

Background Information

Denver PBN Project Area



Changing Airport Configuration

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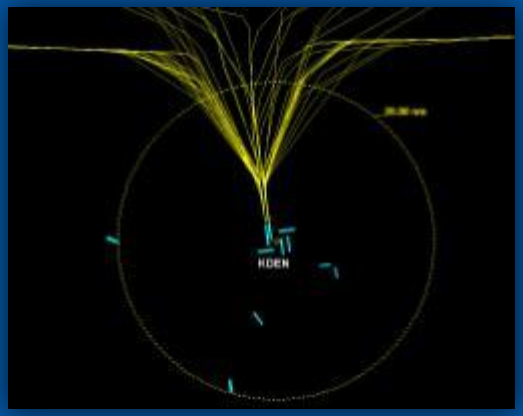

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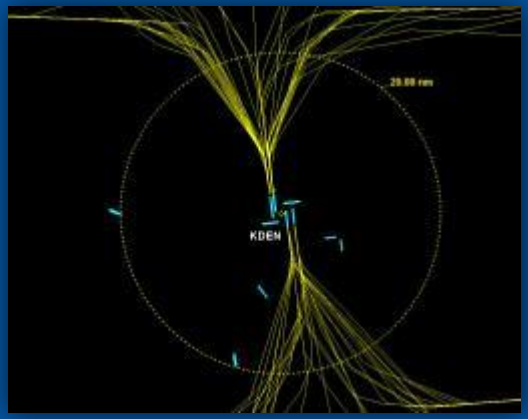

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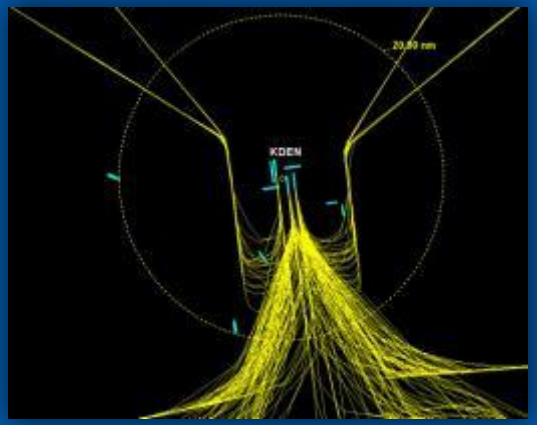

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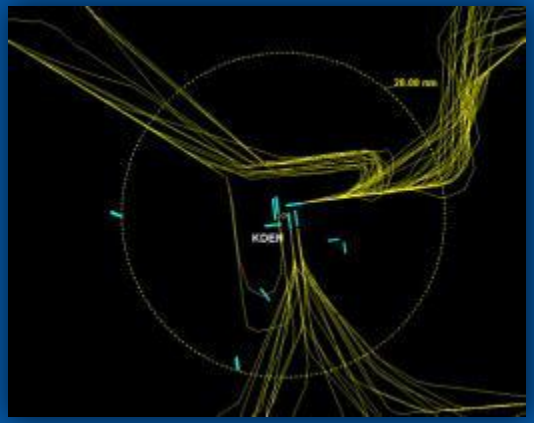

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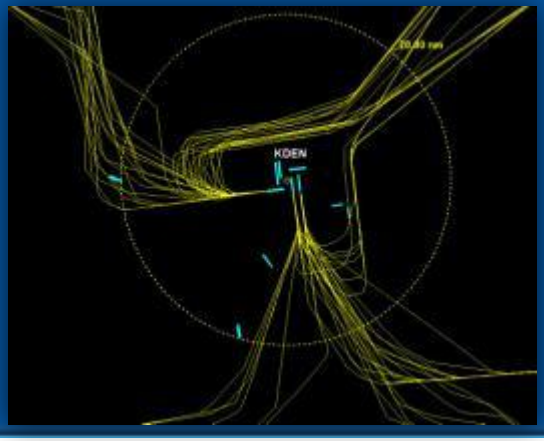
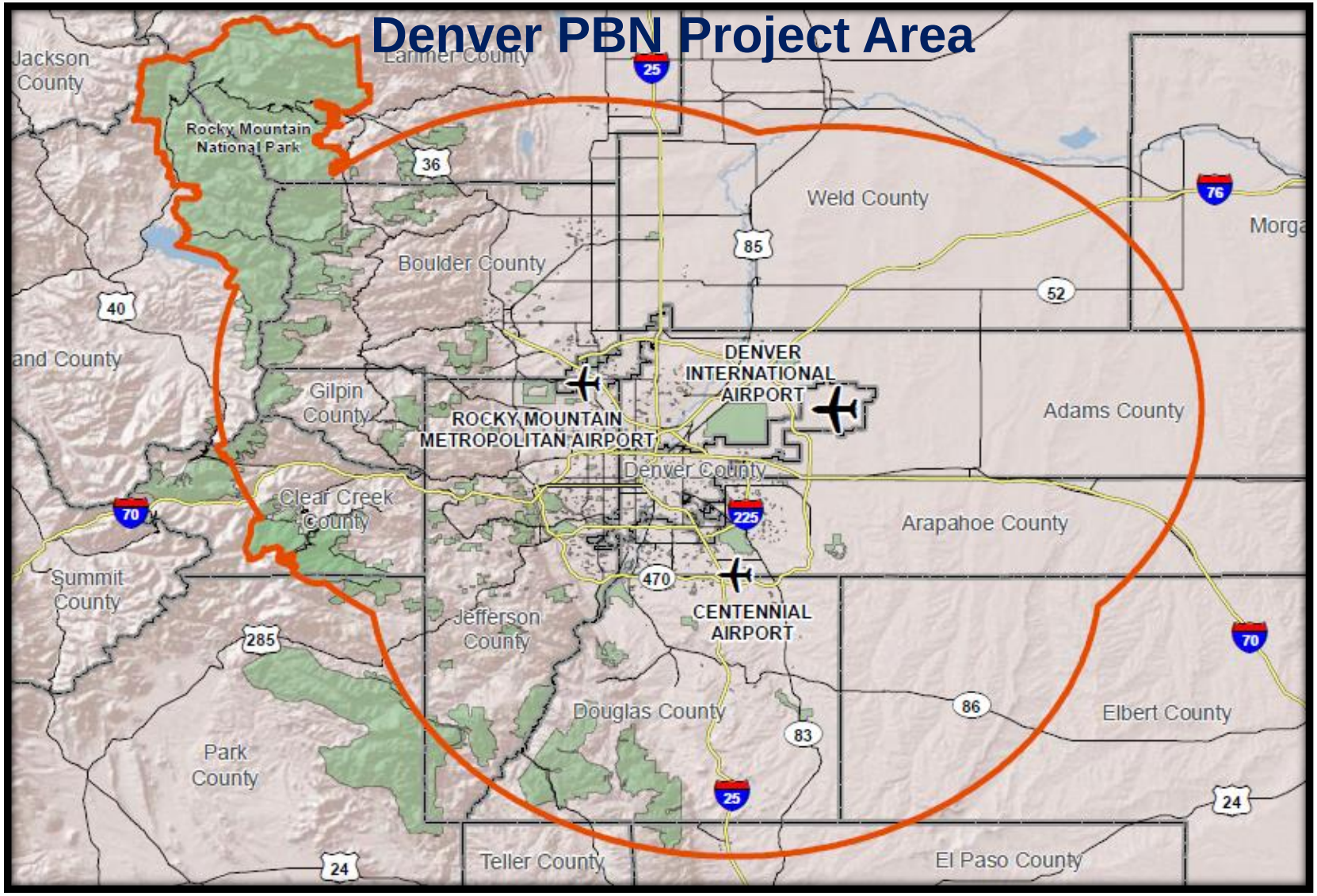


Denver PBN Project Area



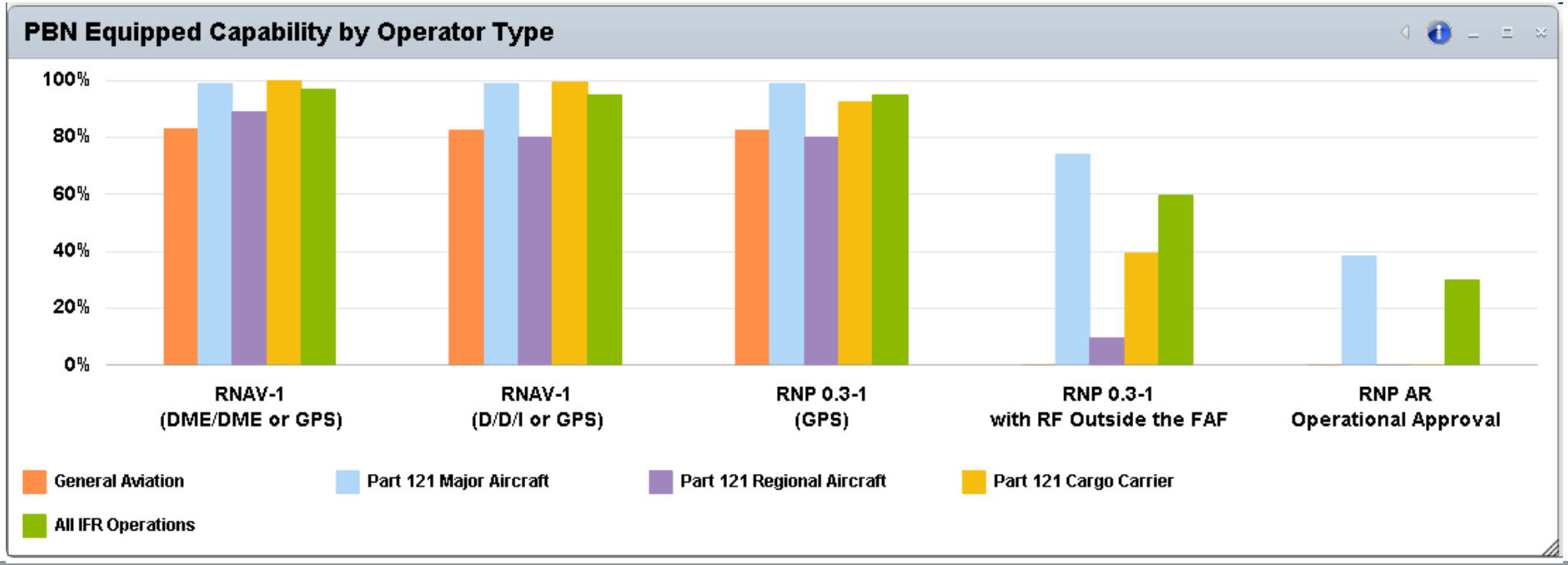
Denver International Airport PBN Project

Preliminary Activities

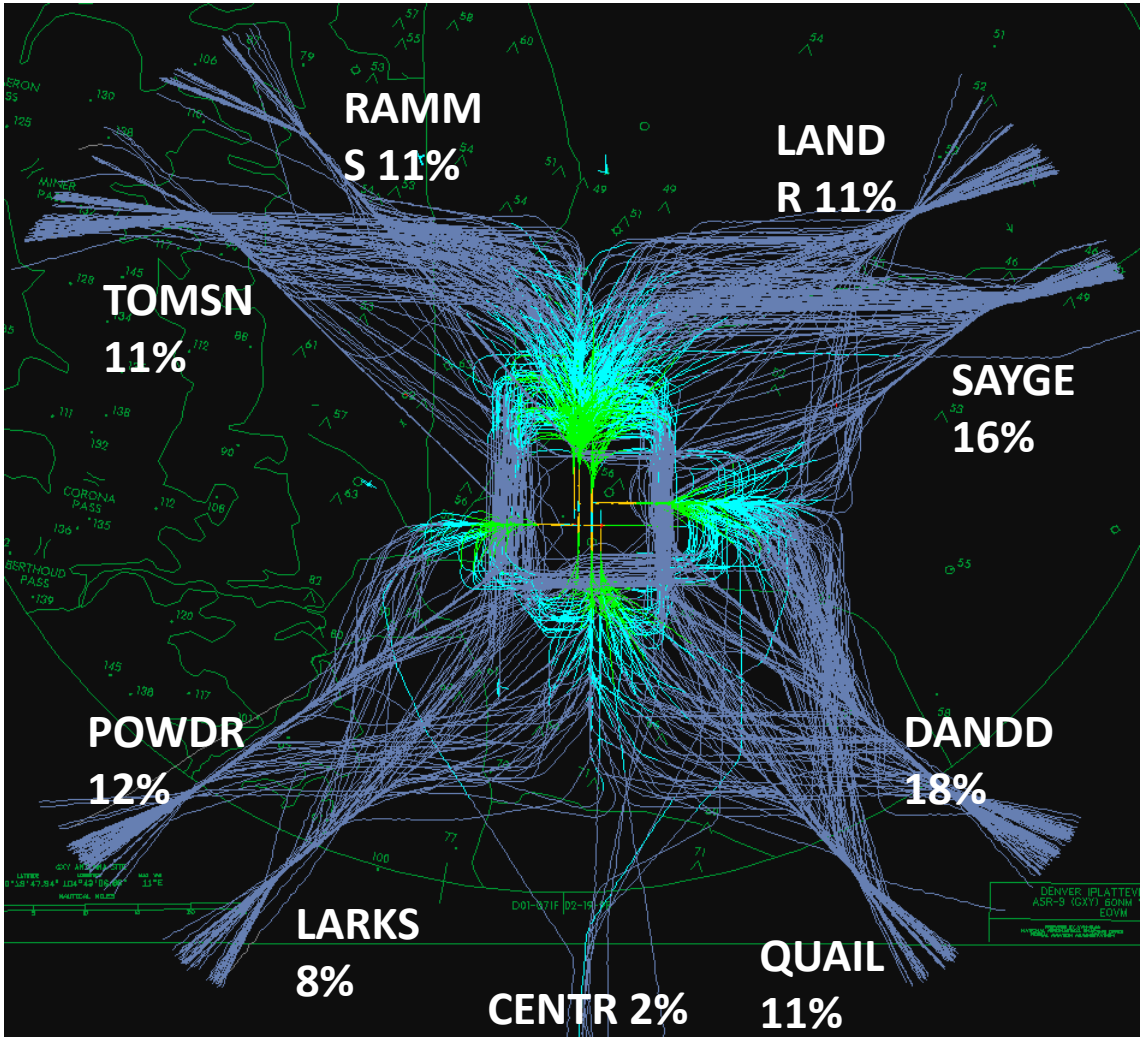
Denver Baseline Analysis

PBN Dashboard

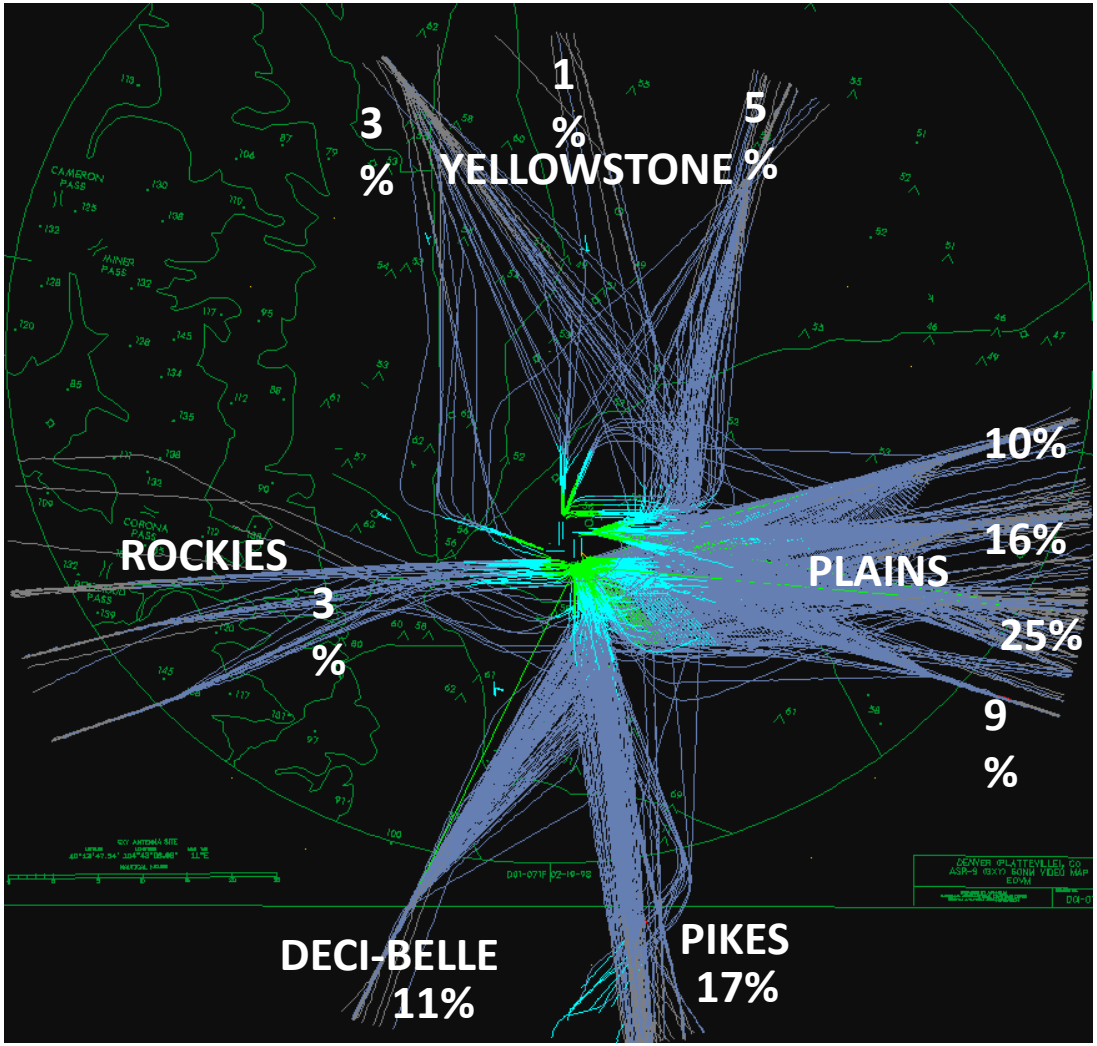
Info	Data
Total Air Carrier & Air Taxi Operations	655,521
Total GA Operations	421,960
Total Military Operations	9,310
Total Metroplex Operations	1,086,791



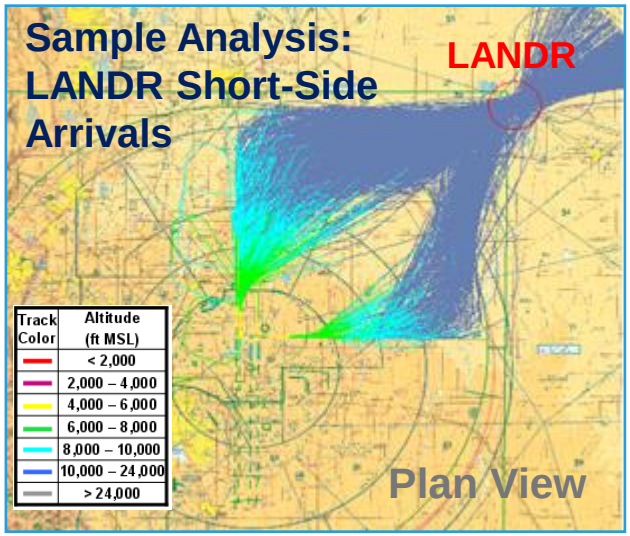
Denver Jet Arrival Fix Loading



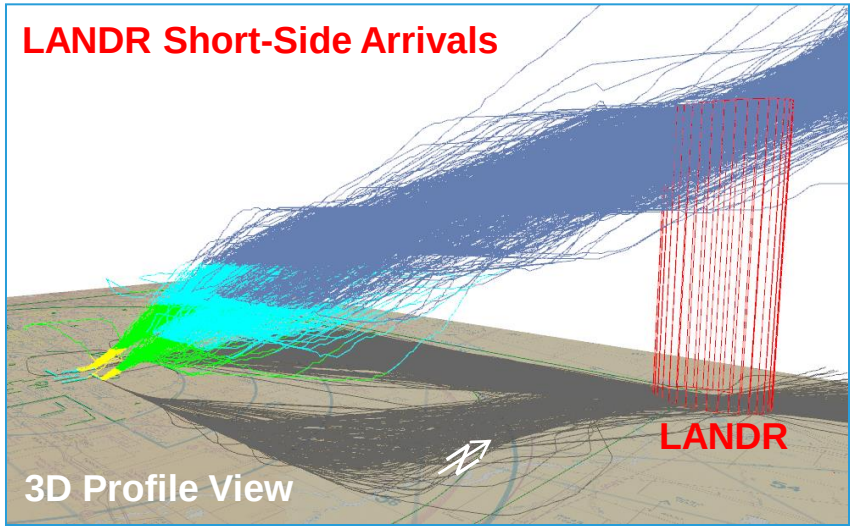
Denver Jet Departures

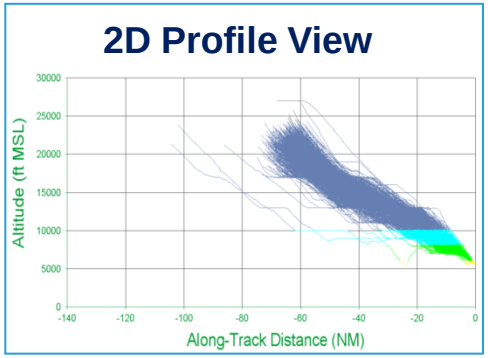


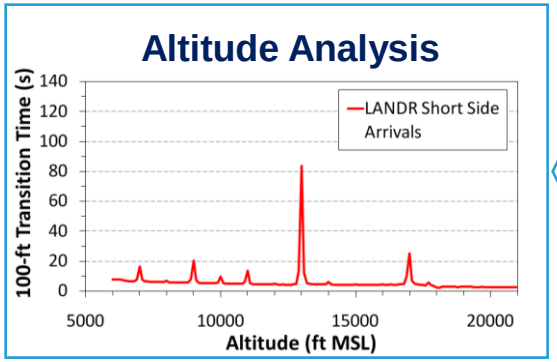
Short-Side Arrival Descent Profile Analysis



Track Color	Altitude (ft MSL)
	< 2,000
	2,000 – 4,000
	4,000 – 6,000
	6,000 – 8,000
	8,000 – 10,000
	10,000 – 24,000
	> 24,000





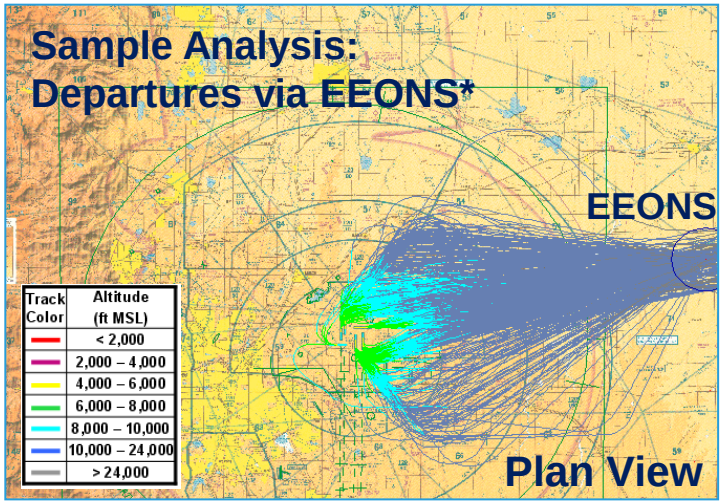


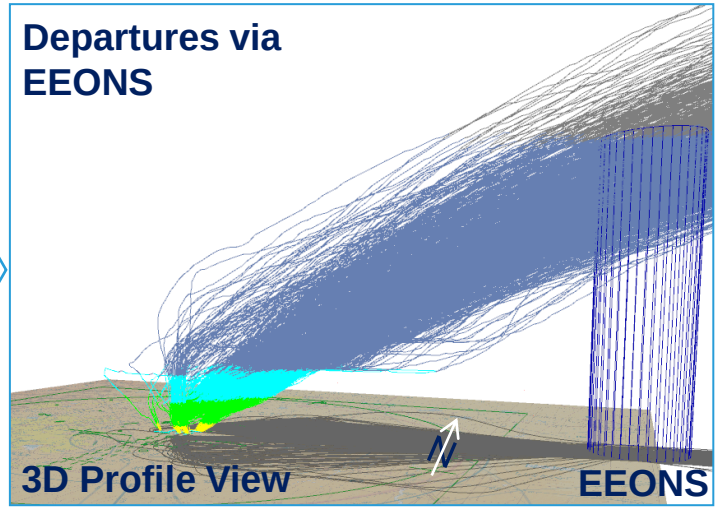
Benefit Estimation

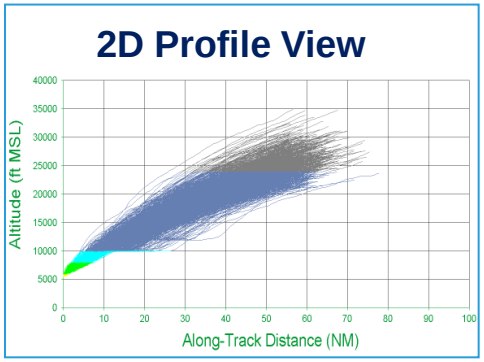
Altitude (ft MSL)	Average Time in Level Flight per Arrival (s)	Potential Fuel Burn Benefit per Arrival (gal)	Potential Flight Time Benefit per Arrival (min)
6000			
7000	12	1.2	0.11
8000			
9000	19	1.3	0.15
10000	5	0.4	0.04
11000	11	0.5	0.07
12000			
13000	95	4.7	0.56
14000	2	0.1	0.01
15000			
16000			
17000	27	0.8	0.08
18000			
19000			
20000			
Total	171	9	1.02

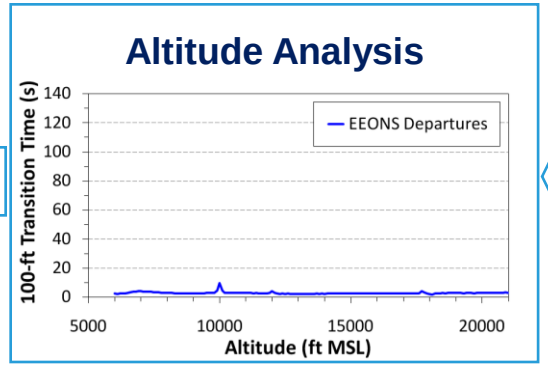
* Radar tracks selected from 20 days of recorded DEN operations

Departure Climb Profile Analysis







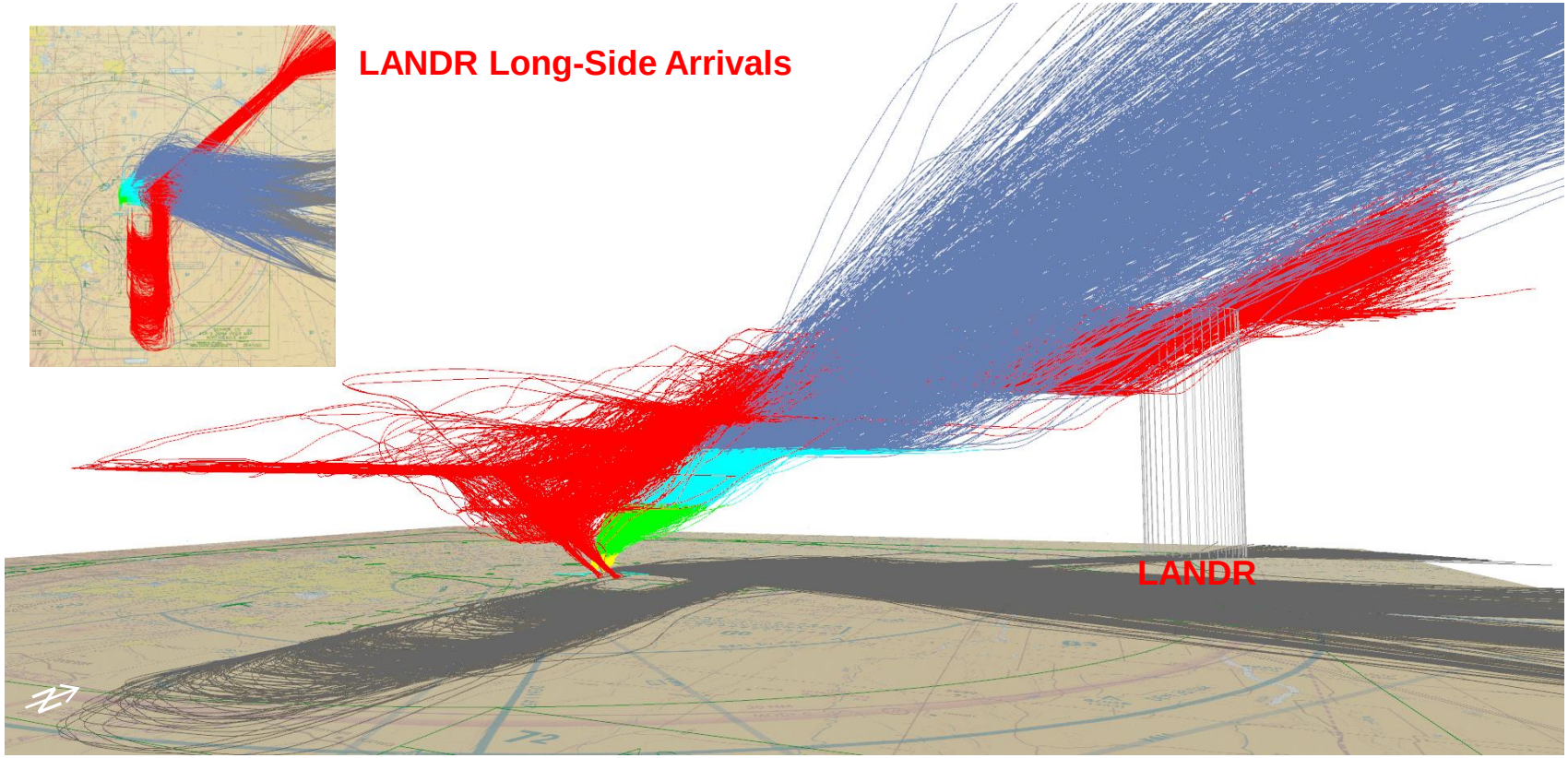


Benefit Estimation

Altitude (ft MSL)	Average Time in Level Flight per Departure (s)	Potential Fuel Burn Benefit per Departure (gal)	Potential Time Benefit per Departure (min)
6000			
7000			
8000			
9000			
10000	10	0.7	0.06
11000			
12000	2	0.2	0.01
13000			
14000			
15000			
16000			
17000			
18000			
19000			
20000			
Total	12	0.9	0.7

* Radar tracks selected from 20 days of recorded DEN operations.

Arrival-Departure Interaction:



LANDR Long-Side Arrivals	Average time in level flight: 517 seconds per arrival
Rwy 08 East-bound Departures	Average time in level flight: 6 seconds per departure
Rwy 34L/R East-bound Departures	Average time in level flight: 22 seconds per departure

Denver International Airport PBN Project

Procedure Design Activities

Problem Areas:

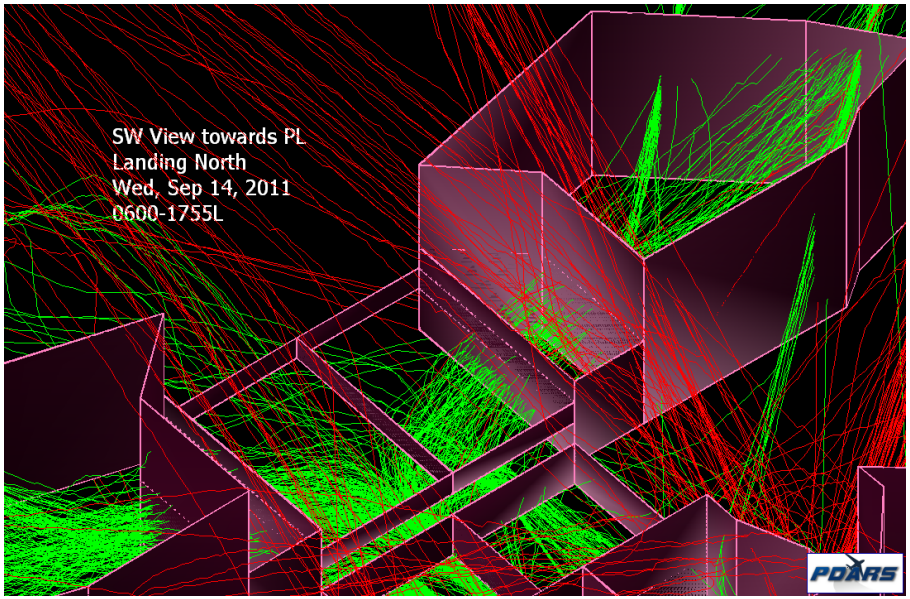
- Complexity
  - Controllers merge 8 (16) streams of traffic into 2 or 3 final approach courses within 35 miles of the airport
- Excessive radio communication
  - Altitude/Speed issued by controllers; routine/repetitive
  - Frequency congestion and read-back/hear-back errors
- Lack of predictability
  - Situational problem solving and variances due to human factors
- Resulting in: Higher Operating Costs

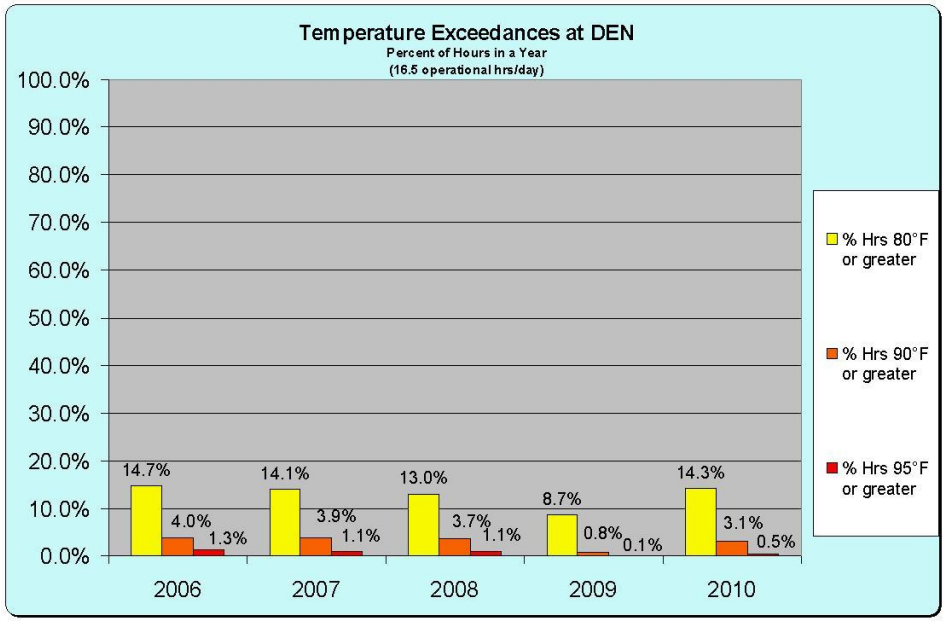
Procedure Design Objectives:

- Arrivals descend unrestricted (CDO/OPD)
  - Create closed-loop STAR to RNP/ILS designs
- Departures climb unrestricted (CCO)
- Procedurally separated arrivals/departures
- Incorporate satellite arrivals
- Avoid or mitigate noise over environmentally sensitive areas

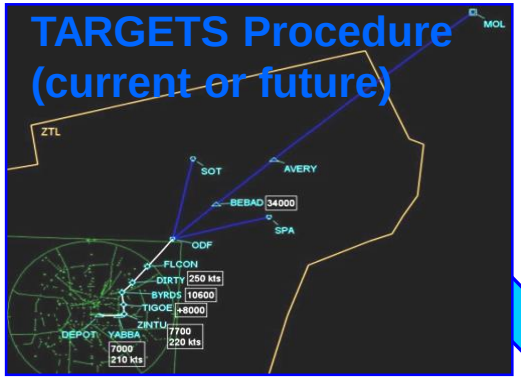
Data Driven Decision Making

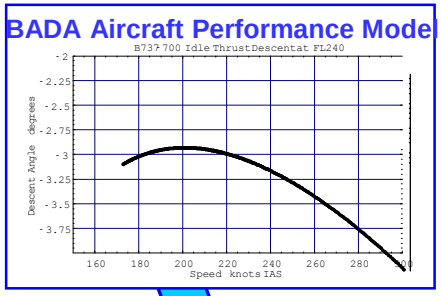
- Focus on analysis to drive designs
- Use of modeling to assess designs
- Extensive simulation by ATC and industry stakeholders

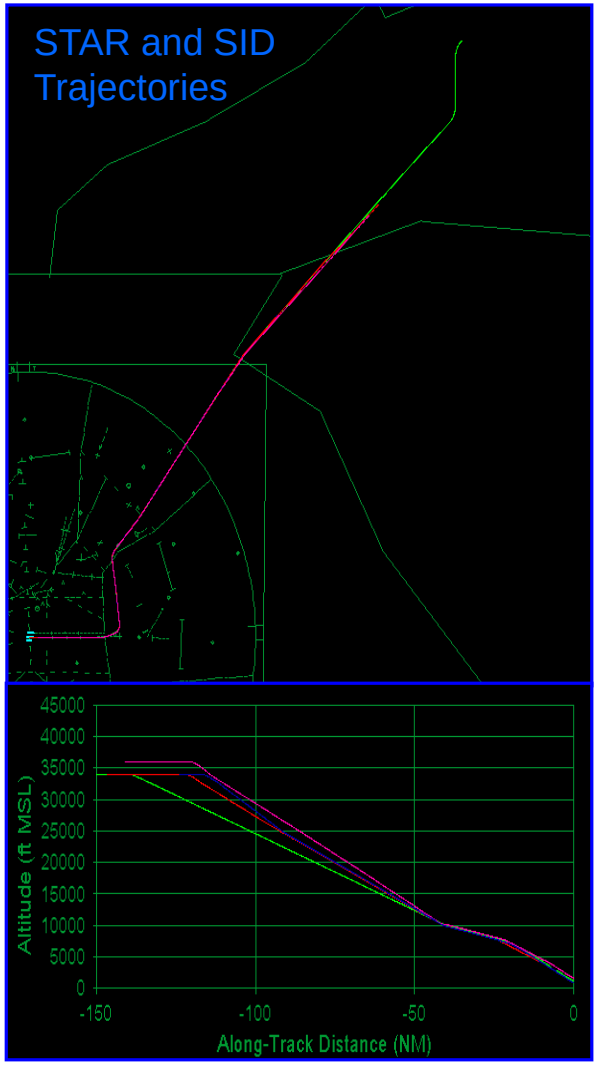


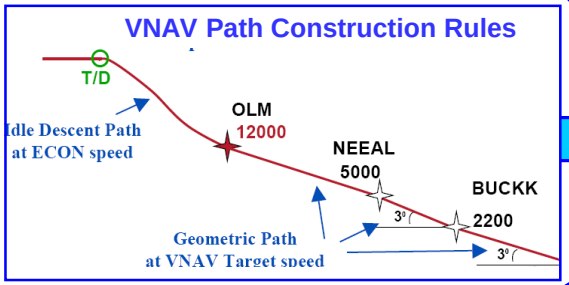


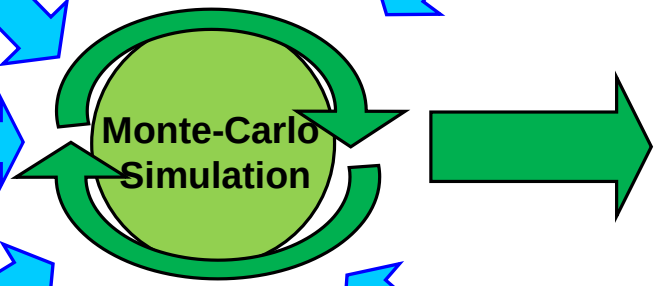
Procedure Modeling - MFAST

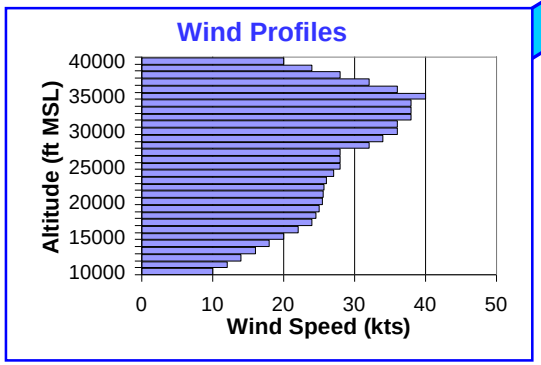


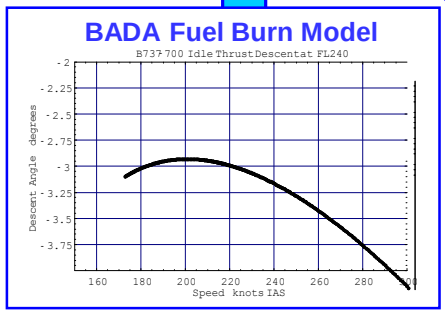






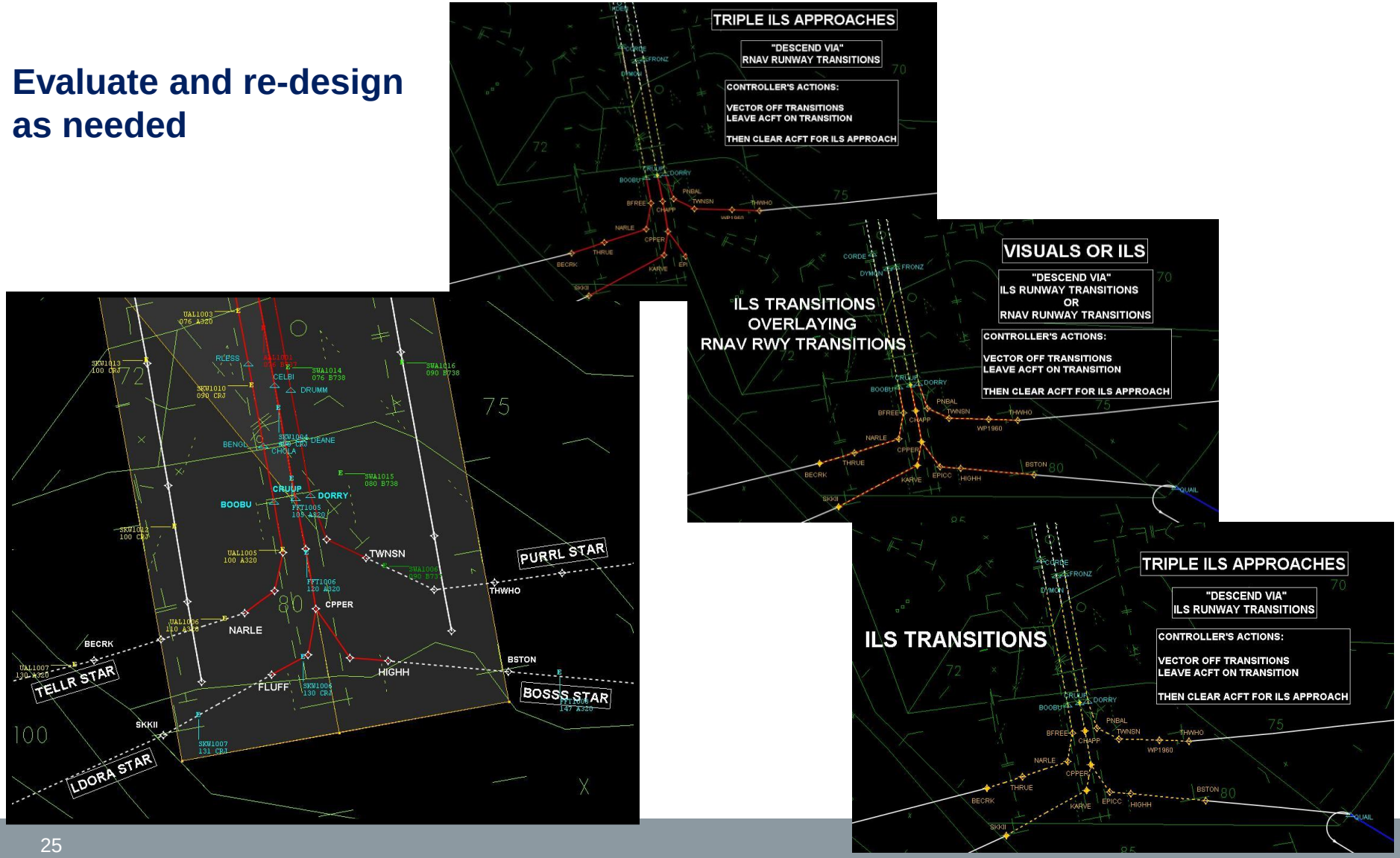






Assess Design Options

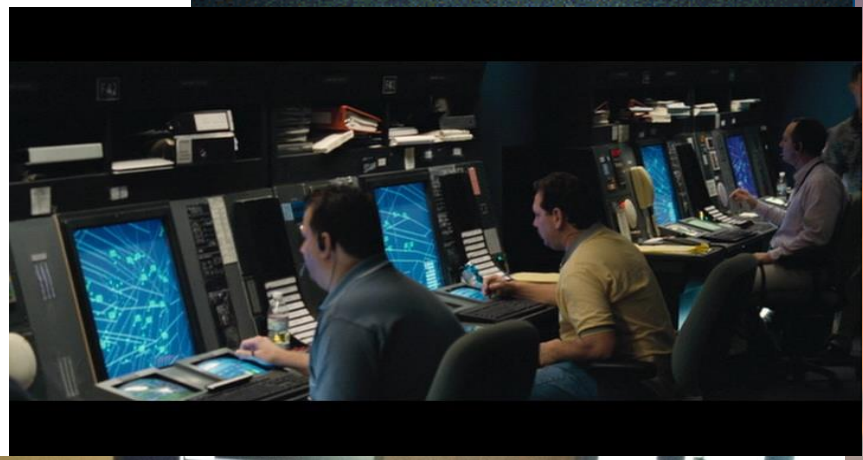
Evaluate and re-design as needed



Aircraft Simulator Sessions With ATC

February 20, 2011	United Airlines A320
March 20, 2011	Frontier Airlines A320
June 16 & 17, 2011	United Airlines A320
July 7, 2011	Southwest Airlines B737-700
July 28, 2011	United Airlines A320
August 1, 2011	United & Frontier Airlines A320
August 30-31, 2011	Skywest Airlines CRJ-2
September 1-2, 2011	Southwest Airlines B737-700
September 12, 2011	United & Frontier Airlines A320
October 19, 2011	Skywest Airlines CRJ-2
February 4, 2012	United & Frontier A320
April 19, 2012	Southwest B737-700
April 24, 2012	United and Frontier A320
May 28, 2012	Skywest Airlines CRJ-2
June 7, 2012	ExpressJet CRJ-2
August 28, 2012	United B787
August 28, 2012	ExpressJet E45
September 12-13, 2012	Flight Standards A320
October 1-5, 2012*	AFS-440 A330/A340
October 1-5, 2012*	AFS-440 B737-800
November 11-14, 2012	Flight Standards B777
November 21-23, 2012	Flight Standards B747

Human in the Loop (HITL) Simulations TRACON and En Route



MITRE HITLs
January 12-16, 2009
July 27-31, 2009
September 27-30, 2010

'In-House' HITLs
March 21-23, 2011
May 19, 2011
June 27, 2011
July 23, 2011
August 13, 2011
August 23-24, 2011
September 19, 2011
October 22, 2011
November 18, 2011
December 09, 2011
February 13, 2012
March 23, 2012

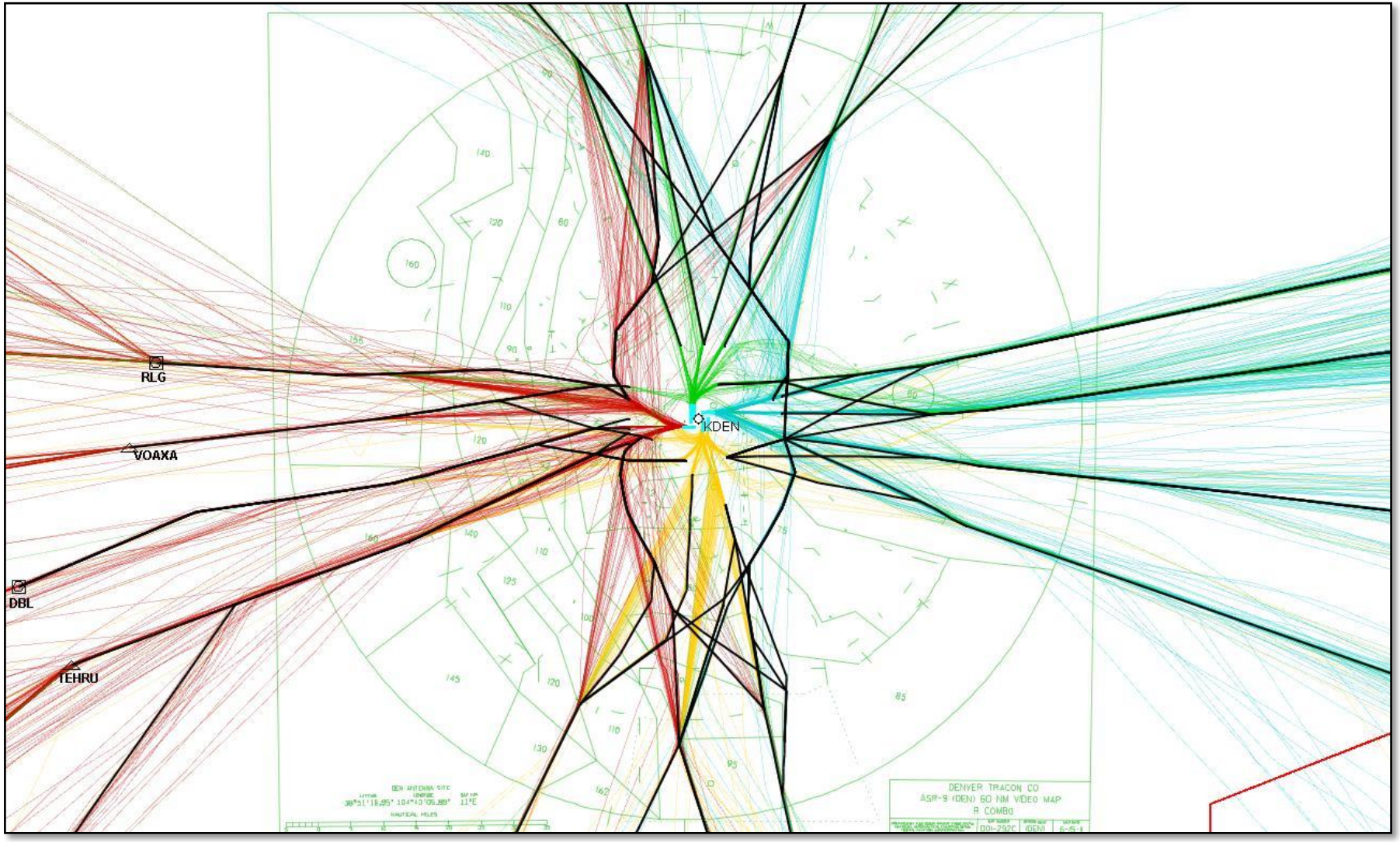
AFS-440 / ATSI HITL
April 4-6, 2012

Tower Human in the Loop (HITL) Simulations ‘Expediting Departures’

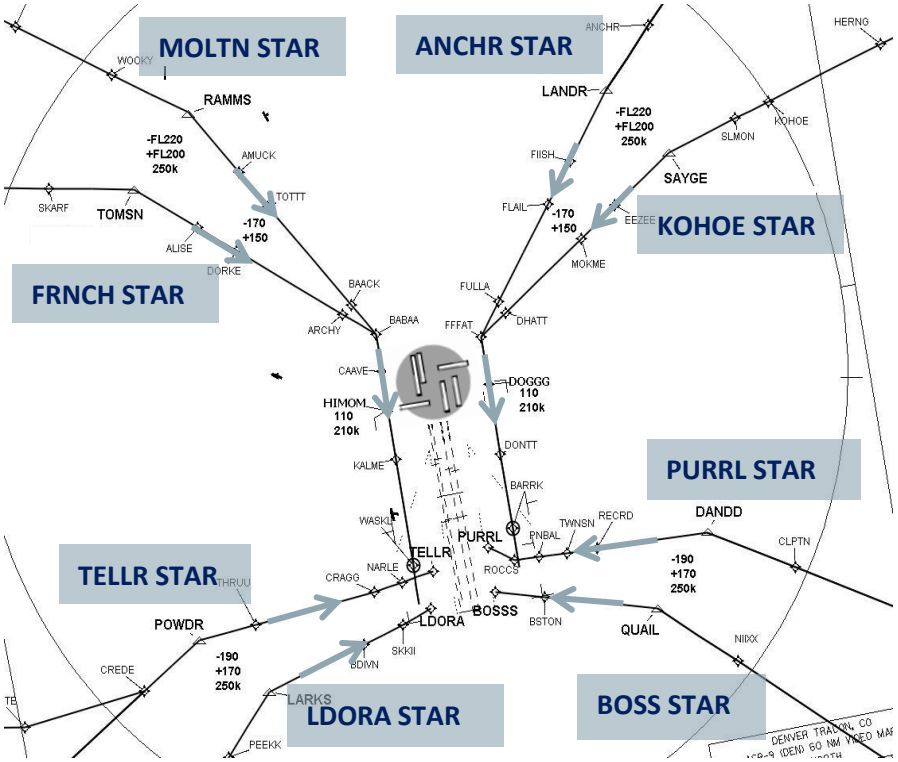
Denver ATCT Simulator

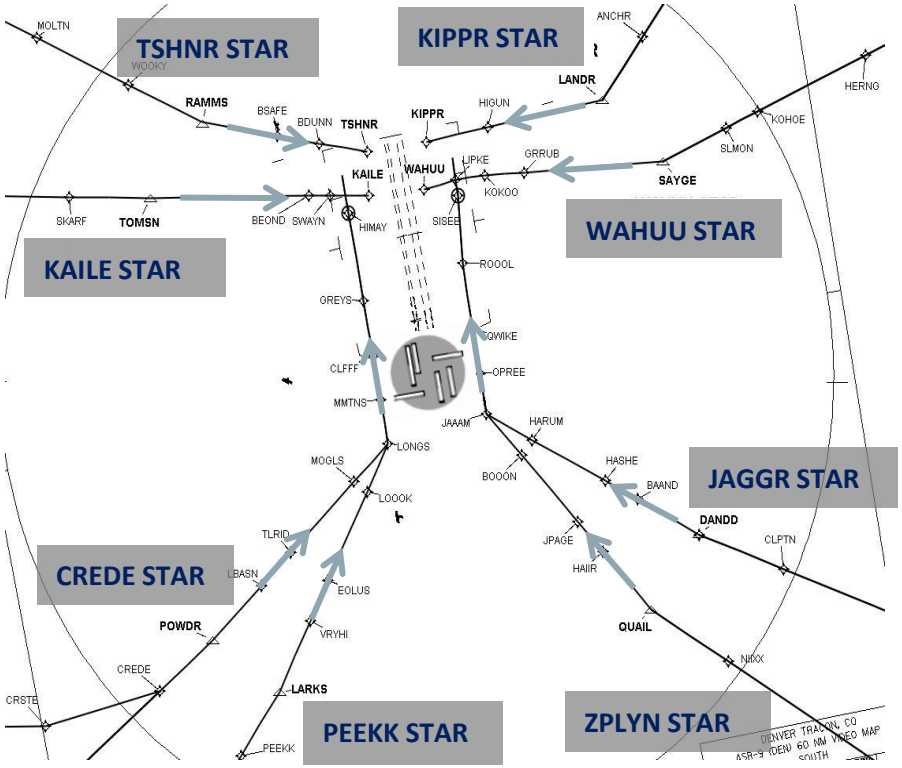
72 Problem Solving Sessions with the focus on expediting Departures in the RNAV SID System.

New DEN RNAV SID System



New DEN RNAV STAR System





STARs used for Landing North

STARs used for Landing South

North/South STARs Share Inbound Waypoints but diverge inside TRACON Airspace
STARs may be re-assigned by ATC for
airport configuration changes or traffic management

Denver International Airport PBN Project

Pre-Implementation

Pre-implementation Activities

- Final WG review. Review and complete all procedure forms
- Submit procedures for processing
- Develop implementation plan
- Review ATC automation plan
- Review/resolve database issues
- Review draft charts
- Complete Environmental Assessment
- Review process
- Advise/coordinate with aviation community and ATC agencies
- Flight plan filing requirements/coordination
- Plan/coordinate Flight Inspection/validation
- Order/review new ATC video maps
- Develop and execute ATC training plan
- Develop post-implementation plan

ATC TRAINING REQUIREMENTS

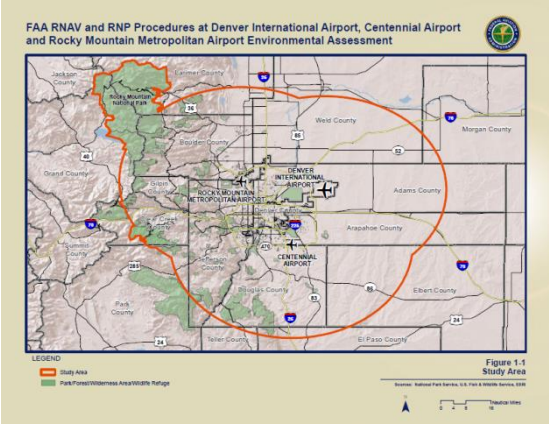
- Qualification (Certification Required) Training or Supplemental Training Decision
- CPC Requirements
- Developmental Requirements
- ATA Requirements
- TMC Requirements
- FLM Requirements
- OM Requirements

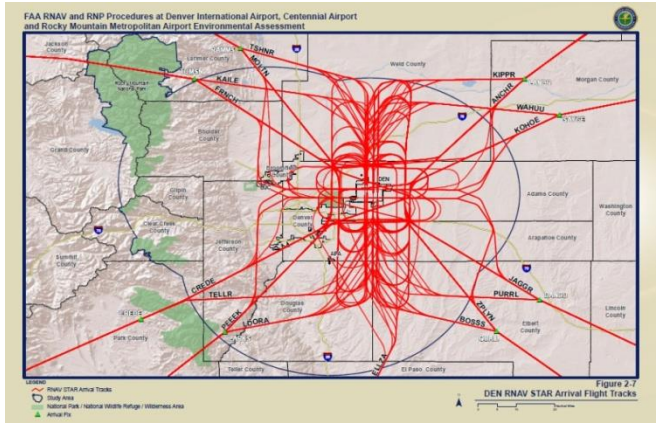
Denver developed a basic 5 step process.
Separate plans were developed for various specialties.

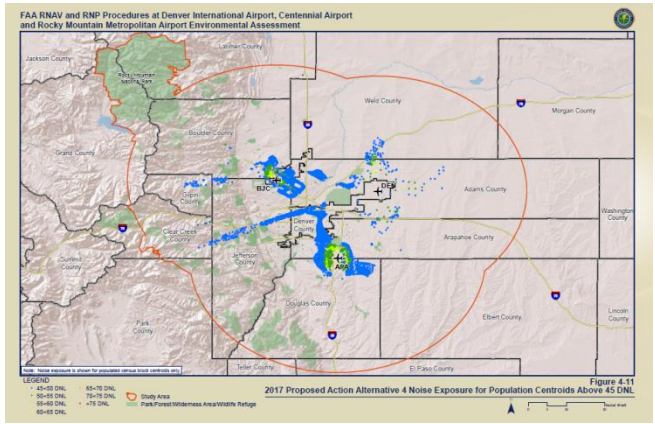
The Segmented RNAV Training Process Provides Increasing levels of Specificity….

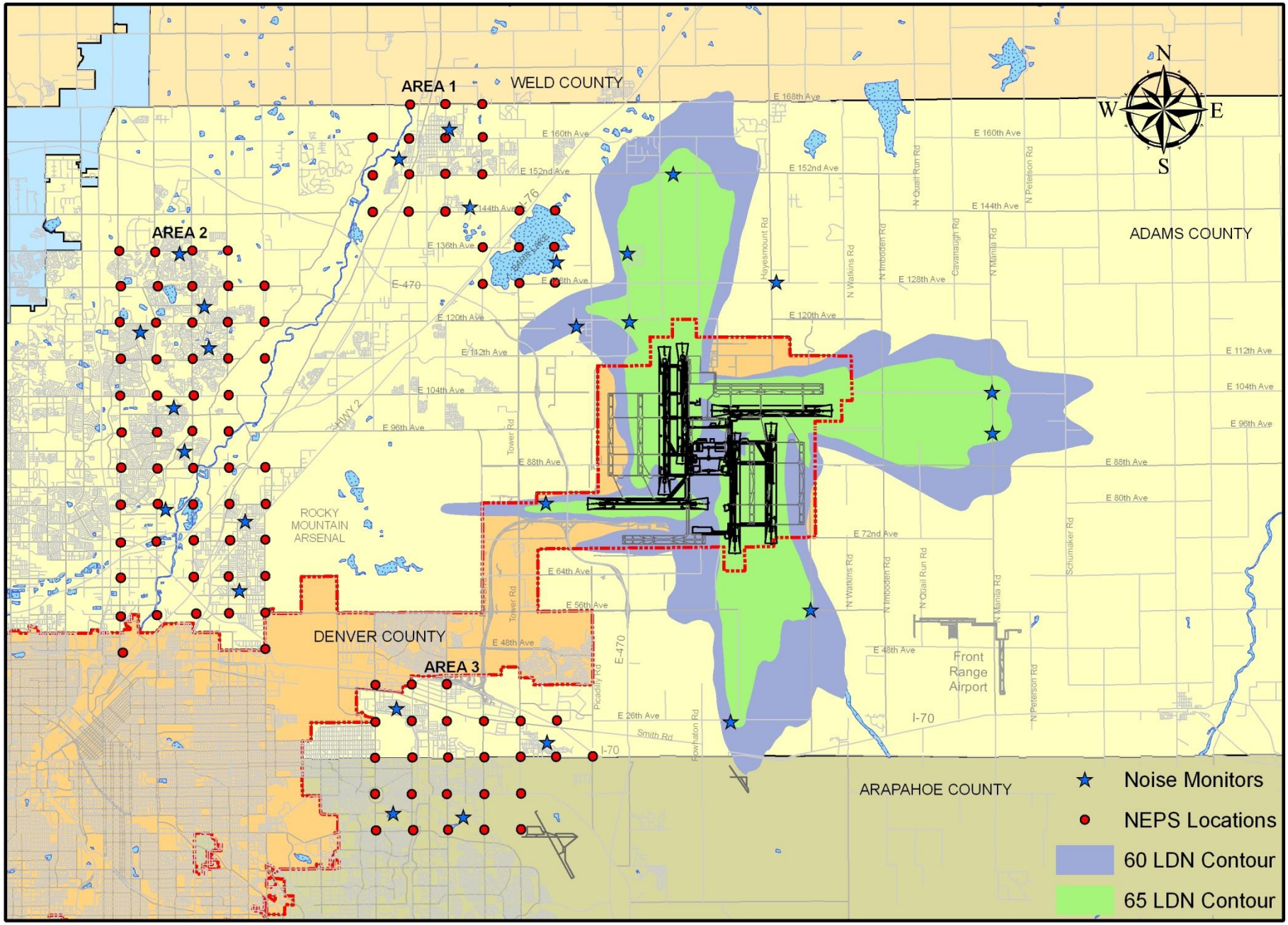
Environmental Assessment

- Meet with State & National Parks to Obtain Basic Agreements on Route Structure
- Meet with Local Community Noise Related Groups
- Schedule Meetings with Denver International Noise Office, CDOT and others
- Environmental Assessment Support – Help the Contractor Understand the Project and its Needs
- Determine Alternatives (Critical that the Facility is Involved)
- Attend EA Scoping Meetings and DRAFT EA Meetings
- Choose Favored Alternative from EA and Provide Support for the Decision









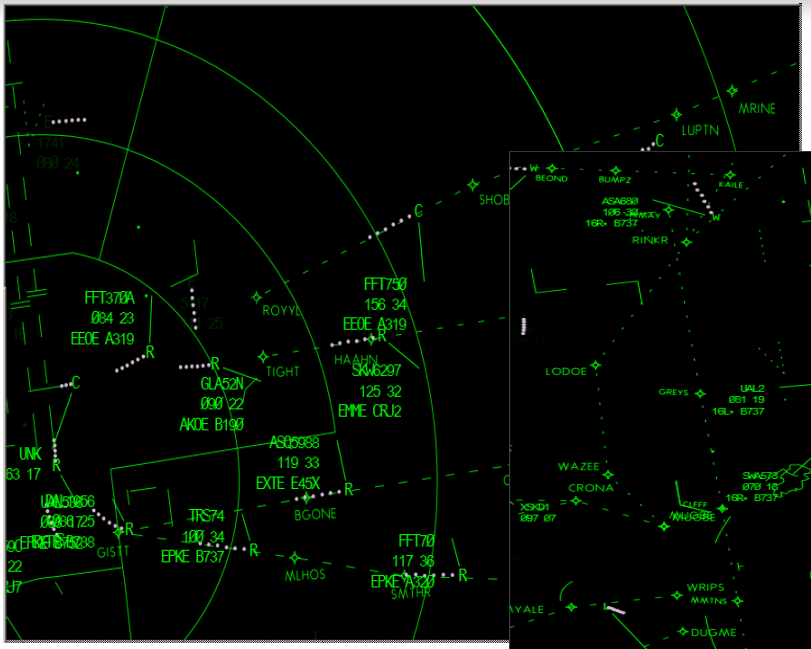
DEN NOISE EXPOSURE PERFORMANCE STANDARDS (NEPS)

Prepared By Annie Christensen, DEN Noise Officer 11/2010

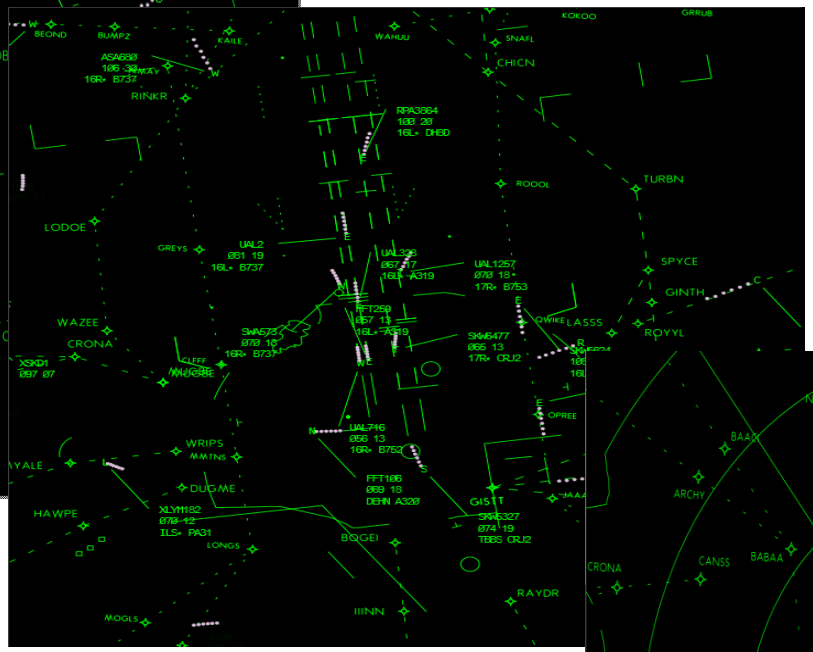
Denver International Airport PBN Project

Implementation

Denver PBN Implementation

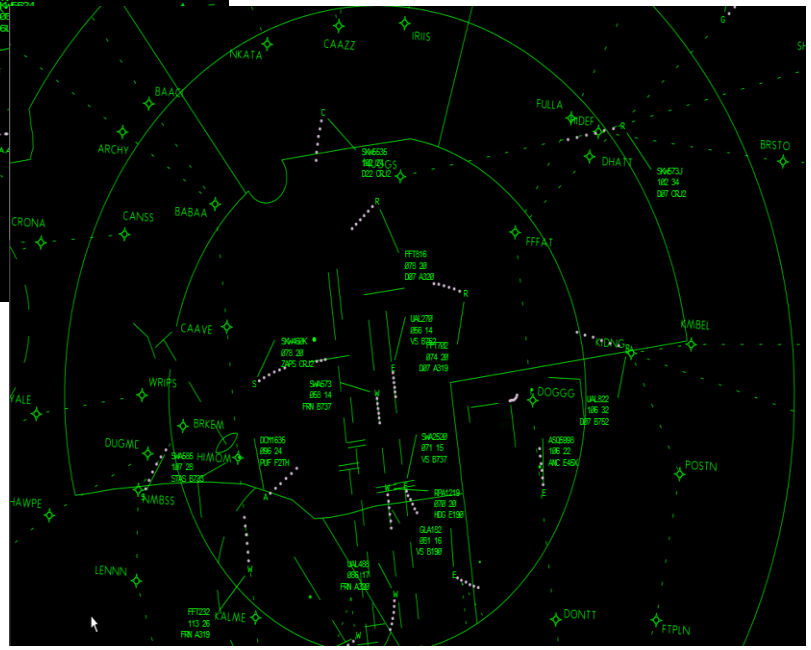


East SIDs



Land South

- Final Readiness review
- Test ATC Automation
- Conduct Flight Trials
- ATC/Industry response teams on site

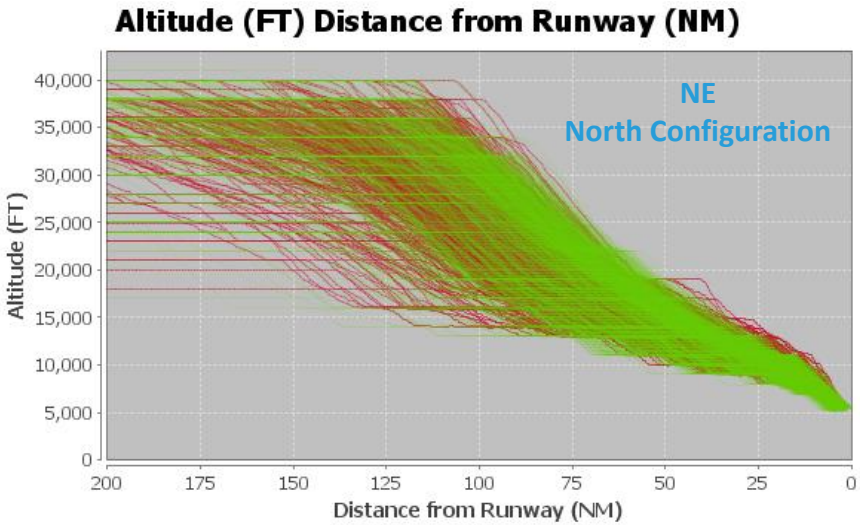


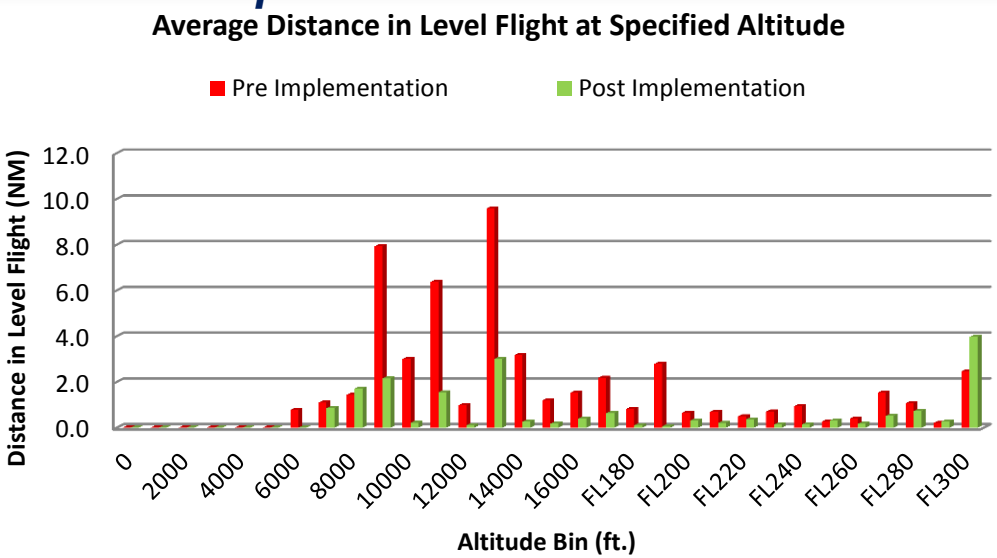
Land North

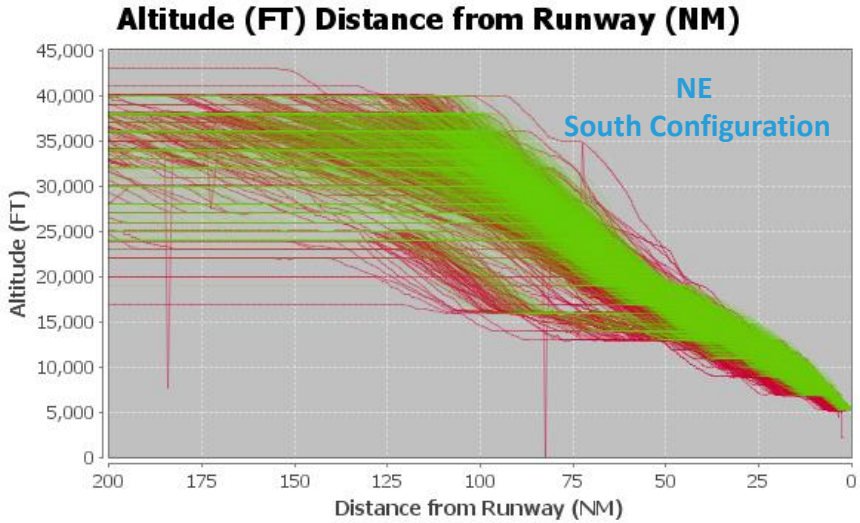
Denver International Airport PBN Project

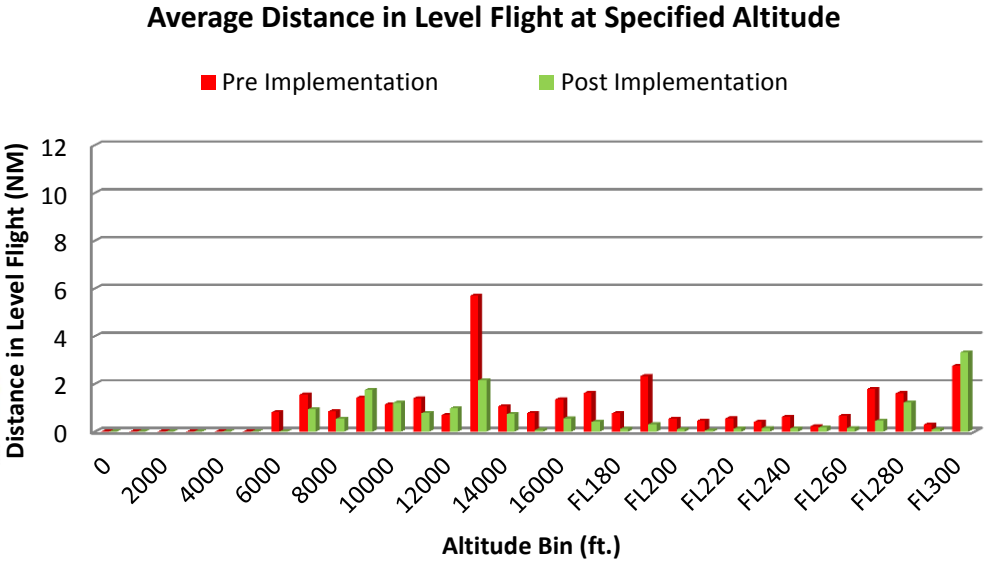
Post-Implementation

Quick-Look Level-Off Analysis *Northeast Corner-post Arrivals*



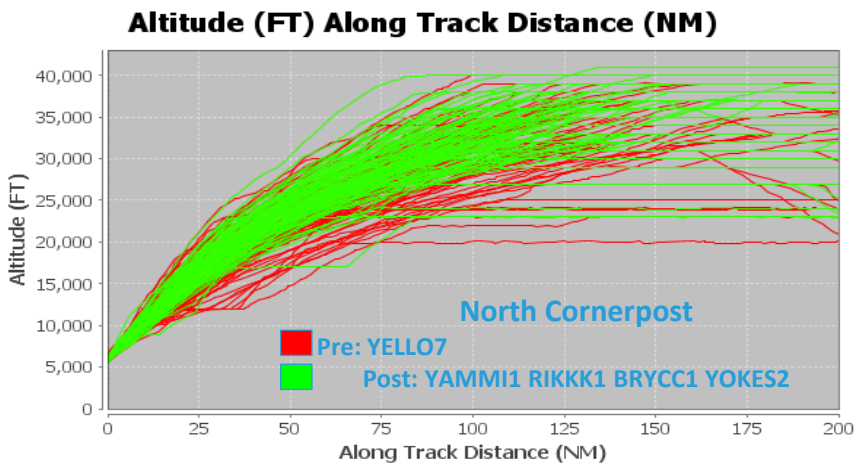


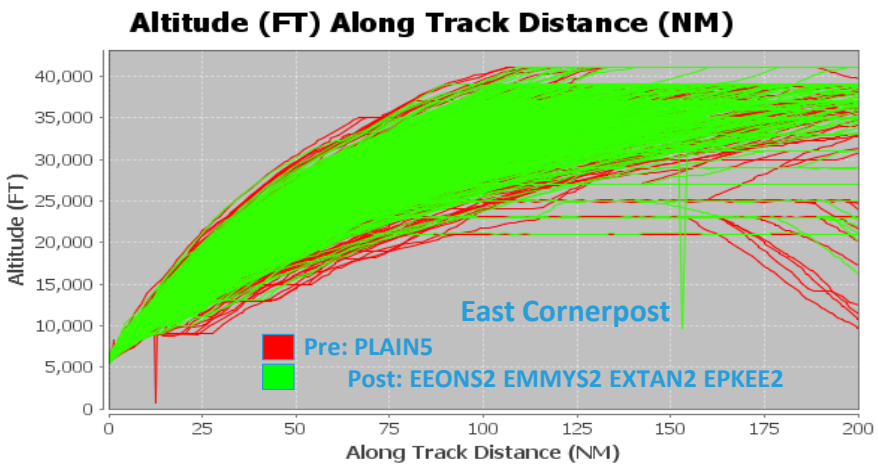


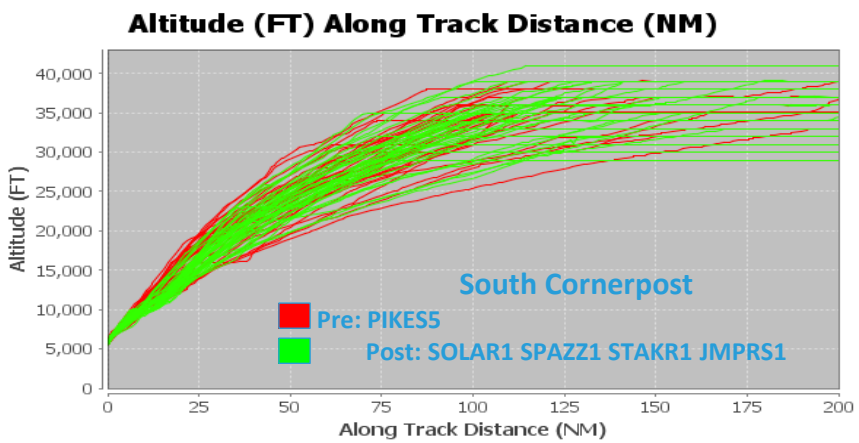


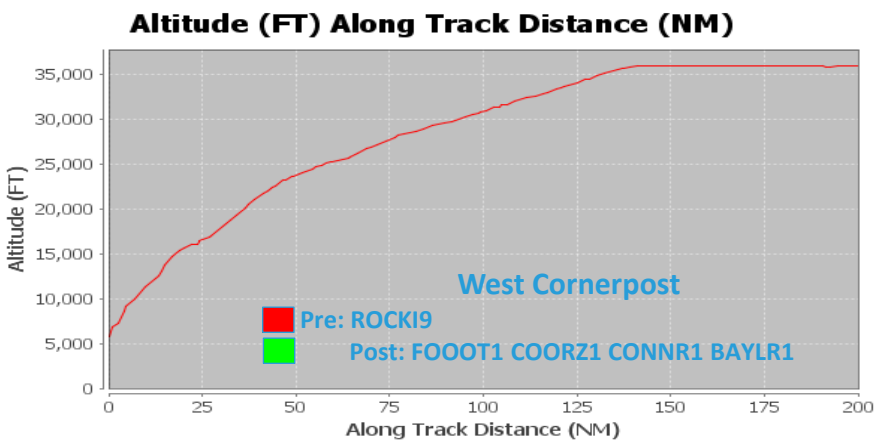
Quick-Look Level-Off Analysis *East-flow Departures*

- No significant observed level-off changes in the 3 day data sample. Conclusions should not be drawn from level-off results as more data is needed.









*** Level-Off results depict all aircraft that departed from each respective corner-post.**

Denver Post-Implementation Analysis Plan

- Data Gathering in Progress
- Analysis will have three main topics
  - Impacts to flight time, flight distance, and fuel burn
    - Level flight & overall
    - By flowtube and airport-wide
  - Utilization of RNAV procedures
    - Segment-level conformance
    - Comparison of flight paths to expected vectoring
  - Impacts to tunneling by departure operations in high temperatures

Denver International Airport PBN Project

Conclusions

Conclusions

- ***Planning is everything***
  - Complex systems require time, multi-discipline expertise and detailed planning
  - Less complex systems still require detailed planning
- The law of unintended consequences
  - Constantly evaluate for potential problems…Then re-evaluate again!
- Change is hard work!
  - Be prepared to adjust or change your plan

BONUS SLIDES!!!

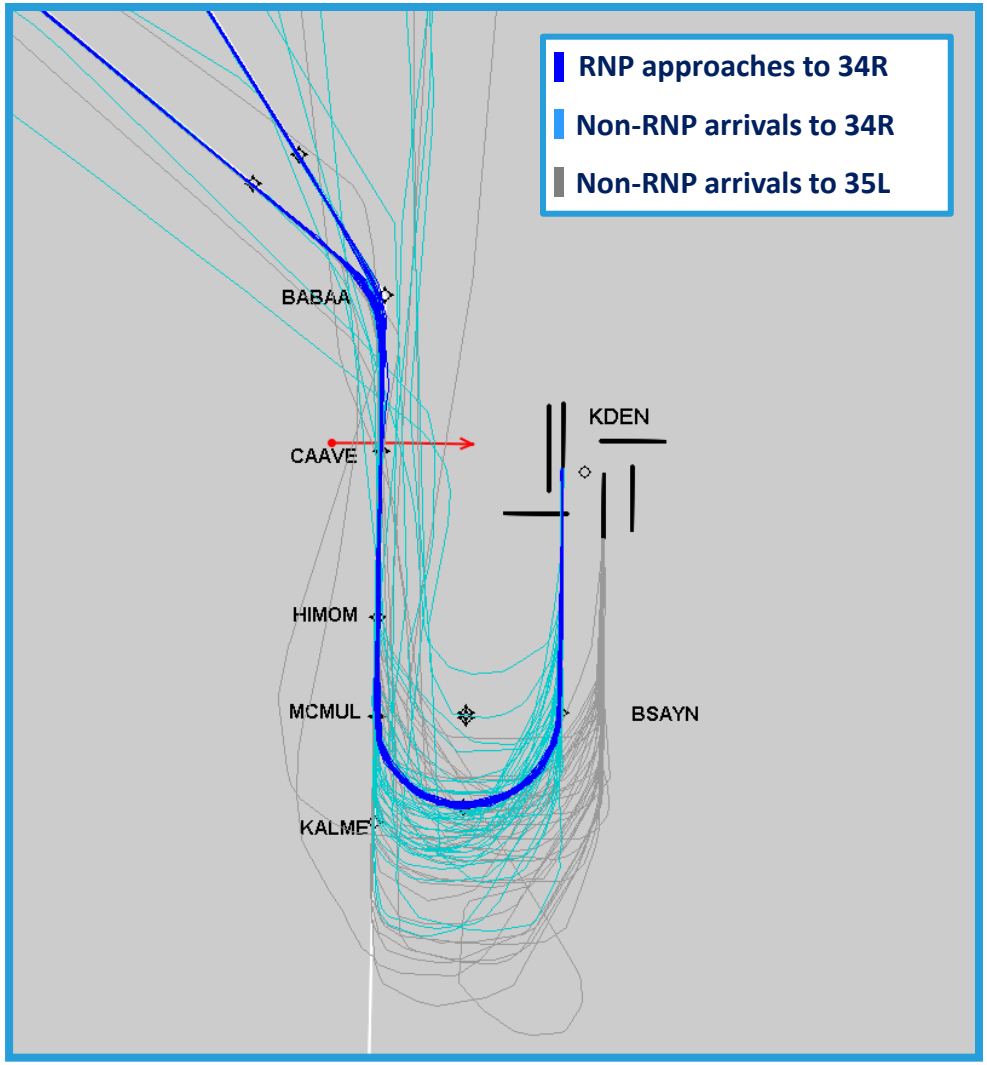
Denver Dedicated Runway for RNP AR

- RNP AR to 34R Initiative began on 7 October 2013
  - Northwest gate RNP-capable aircraft are assigned to RNP for 34R
    - When landing north in visual approach operations
    - From 7:00 to 22:00 only
  - Assigned RNP AR everyday since they have been in North flow
- D01 estimates that roughly 325 flights were assigned the RNP between 7 October and 4 November 2013
  - Largest number of flights were assigned on 16 October (50)
  - As able ATC is also using RNP approaches to other runways

Dedicated RNP AR Runway Quick-look Assessment

- Along track distance measured from CAAVE to runway thresholds
- Averaged track length savings of:
  - 1.0 NM between RNP to 34R and vectors to 34R
  - 2.2 NM between RNP to 34R and vectors to 35L

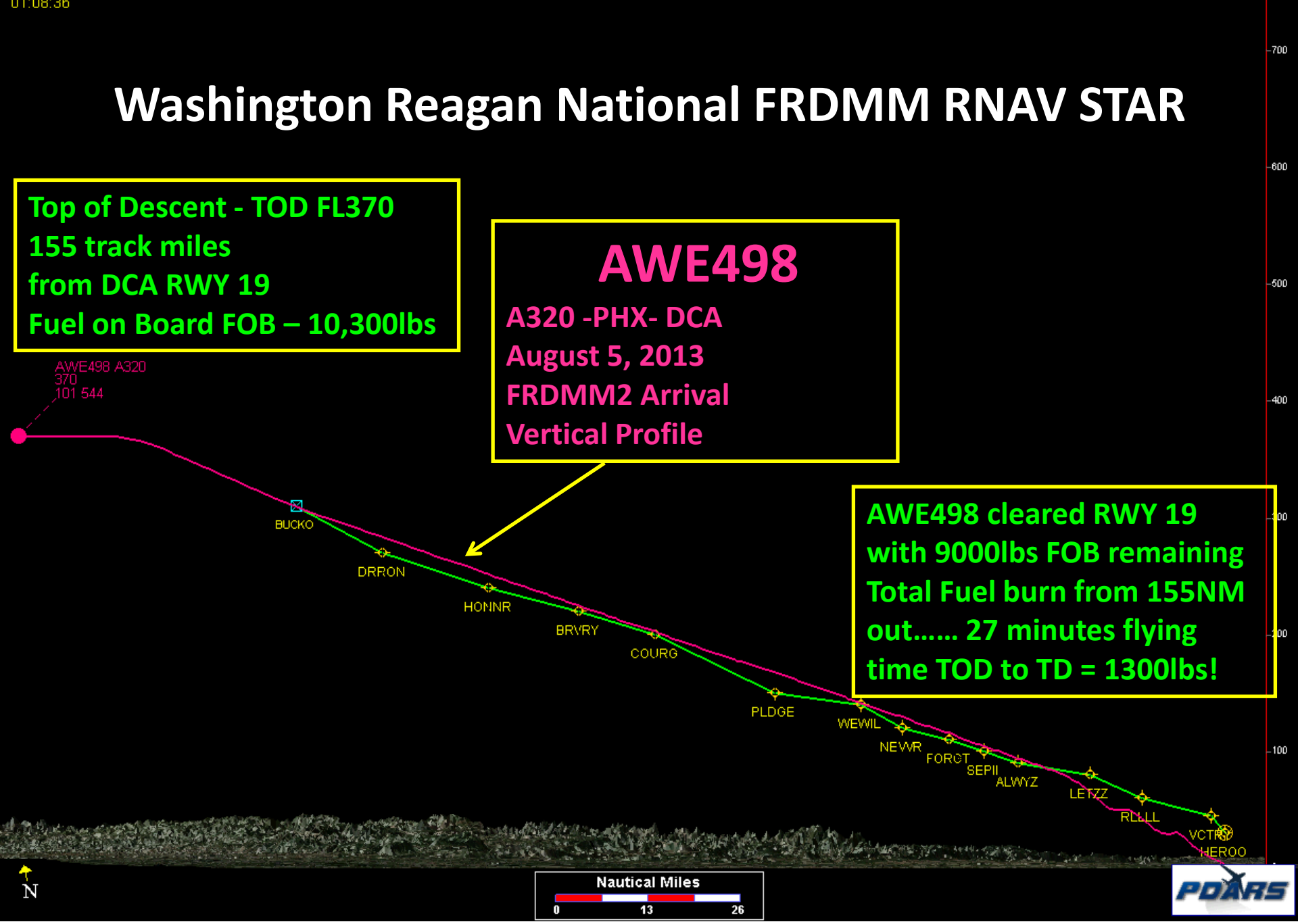
16 October 2013 Flight Length Comparison Northwest arrivals to North Flow RNP34R vs. Vector to 34R or 35L		
Approach/Runway	Average Track Length (NM)	Track Count
RNP34R	24.5	33
Vector to 34R	25.5	39
Vector to 35L	26.7	38



Washington Reagan National FRDMM RNAV STAR

Top of Descent - TOD FL370
155 track miles
from DCA RWY 19
Fuel on Board FOB – 10,300lbs

AWE498

A320 -PHX- DCA
August 5, 2013
FRDMM2 Arrival
Vertical Profile

AWE498 cleared RWY 19 with 9000lbs FOB remaining Total Fuel burn from 155NM out…… 27 minutes flying time TOD to TD = 1300lbs!