HCI Aero '06
Next Generation Air Transportation System Initiative: Methods for the Analysis of Future Operational Concepts

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Outline for Today

- How has JPDO (EAD) gone about evaluating the potential impact of the NGATS plan – and the benefits of transformation?
- What are the issues for automation design and implementation that must be addressed in the future?

It's More Than Just the Movement of People and Goods

- ✓ Big Return on Investment
- ✓ Contributes over $1.3 Trillion/Year in U.S. Output
- ✓ Supports 12+ Million American Jobs
- ✓ Travel and Tourism an Integral Part of This
- ✓ Exports Reduce Balance of Trade Deficit

All Signs Point to Continued Strong Growth

- One Billion+ Passengers in U.S. Skies by 2015
- 2x to 3x Demand by 2025
- New Entrants Such as Very Light Jets
- Global Market Opportunities for U.S. Companies
- U.S. Travel & Tourism to Grow 4.2% Annually

There Are Problems

- Aging, Inefficient, Unreliable and Costly Air Transportation Infrastructure
- Reaching the Limits of Capacity
- Failure to Act Will Cost $40 Billion Annually
- Challenges to American Exports/Balance of Trade
- Unsustainable Security + National Defense Costs

NextGen Tangible Benefits

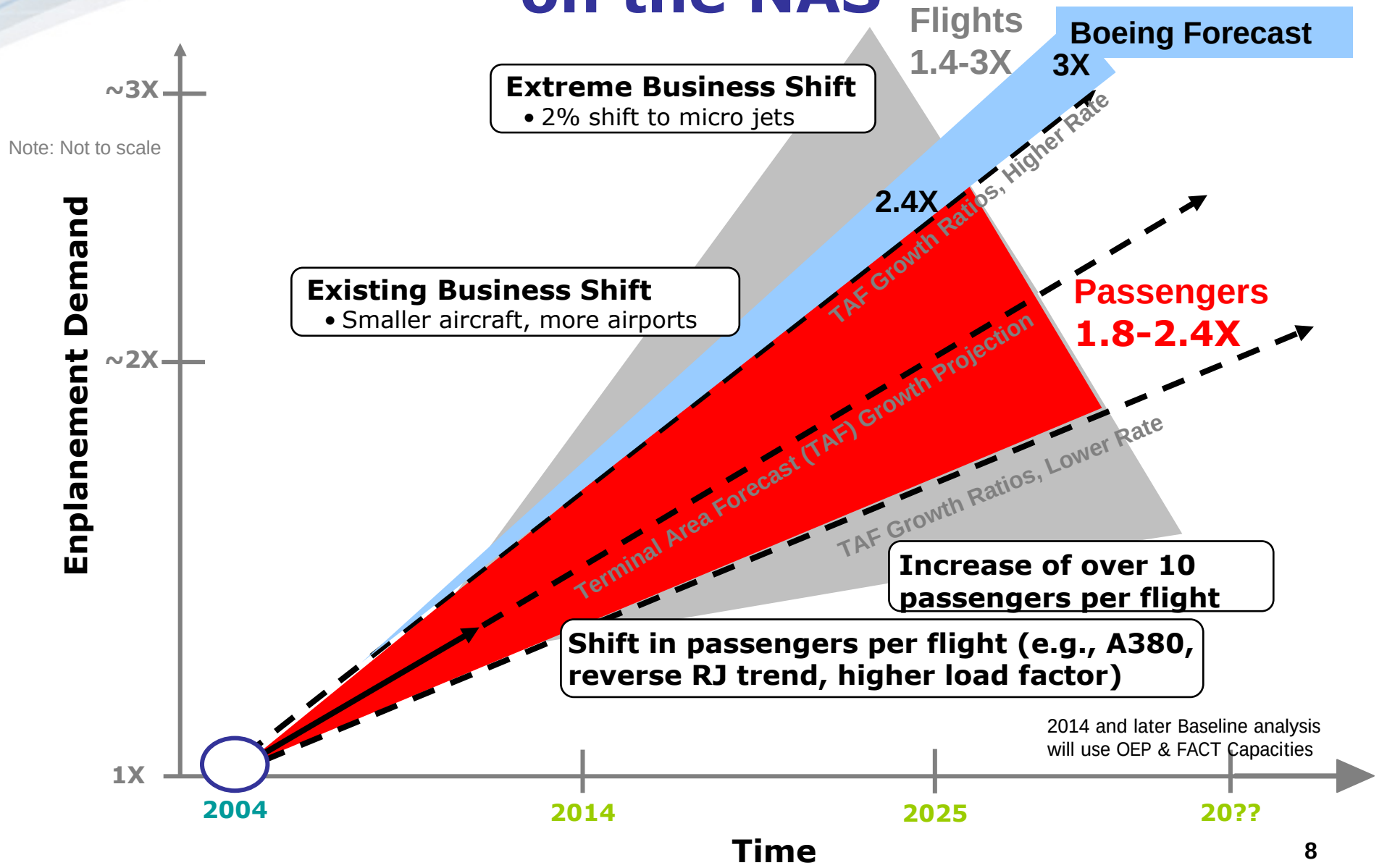
- Meets Greater Demand/Reduces Delays
- Increases Security
- Is Cheaper to Operate and Maintain
- Makes Best Use of the Taxpayer's Dollar
- Fuels Economic Growth
- Brings Aviation's Benefits to Main St. USA
- Bolsters U.S. Global Competitiveness

Transformation Started Yesterday

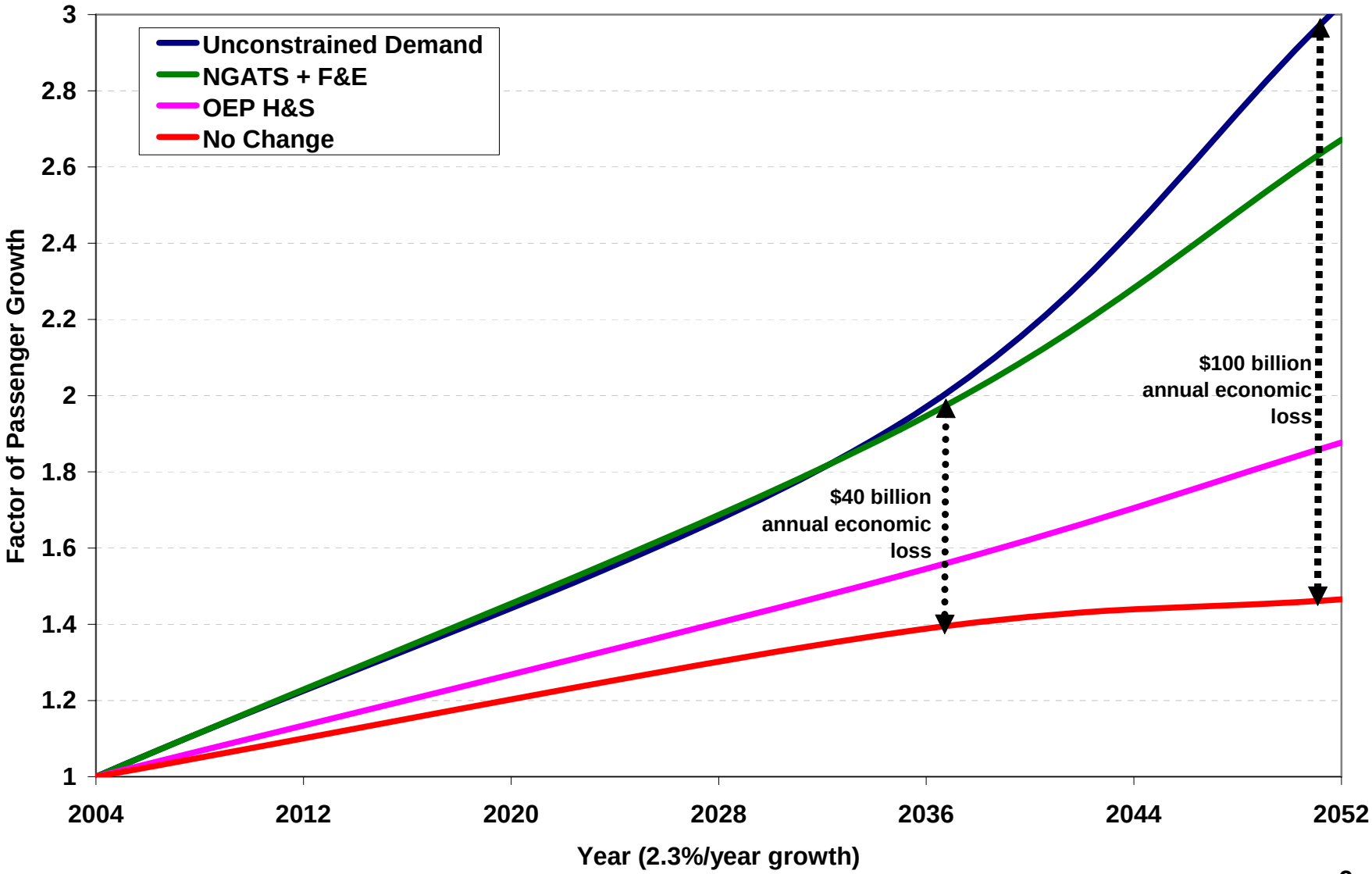
- Real World Improvements Being Delivered Now
- Transformational Building Blocks
- Network Enabled Operations: The Big Picture
- Revolutionizing Air Navigation and Surveillance

Demand Shortfall: The Case for the Investment

Potential Future Demand on the NAS



NGATS Impact on Future Growth



Future Fleet Mix and Business Model Assumptions

A. *Pax/Cargo Demand*	B. *Fleet Mix/ Aircraft Types*	C. *Business Model/ Schedule*
1) Current (1X)	1) Current Scaled	1) Current (mostly Hub & Spoke)
2) TAF Growth to 2014 & 2025 (1.2X, 1.4X)	2) More Regional Jets	2) More Point to Point + Regional Airports
1) 2X TAF Based Constrained Growth	3) New & Modified Vehicles • Microjets • UAVs • E-STOL/RIA • SST • Cleaner/ Quieter	3) Massive Small Airport Utilization
2) 3X TAF		

Future Scenarios

Hub and Spoke:

Current fleet mix and business model (both hub and spoke and low cost carrier point to point)

Bizshift:

Growth beyond OEP airport capacities comes from smaller aircraft (approx 100 passenger) and new flights at under-utilized regional airports near OEP airports

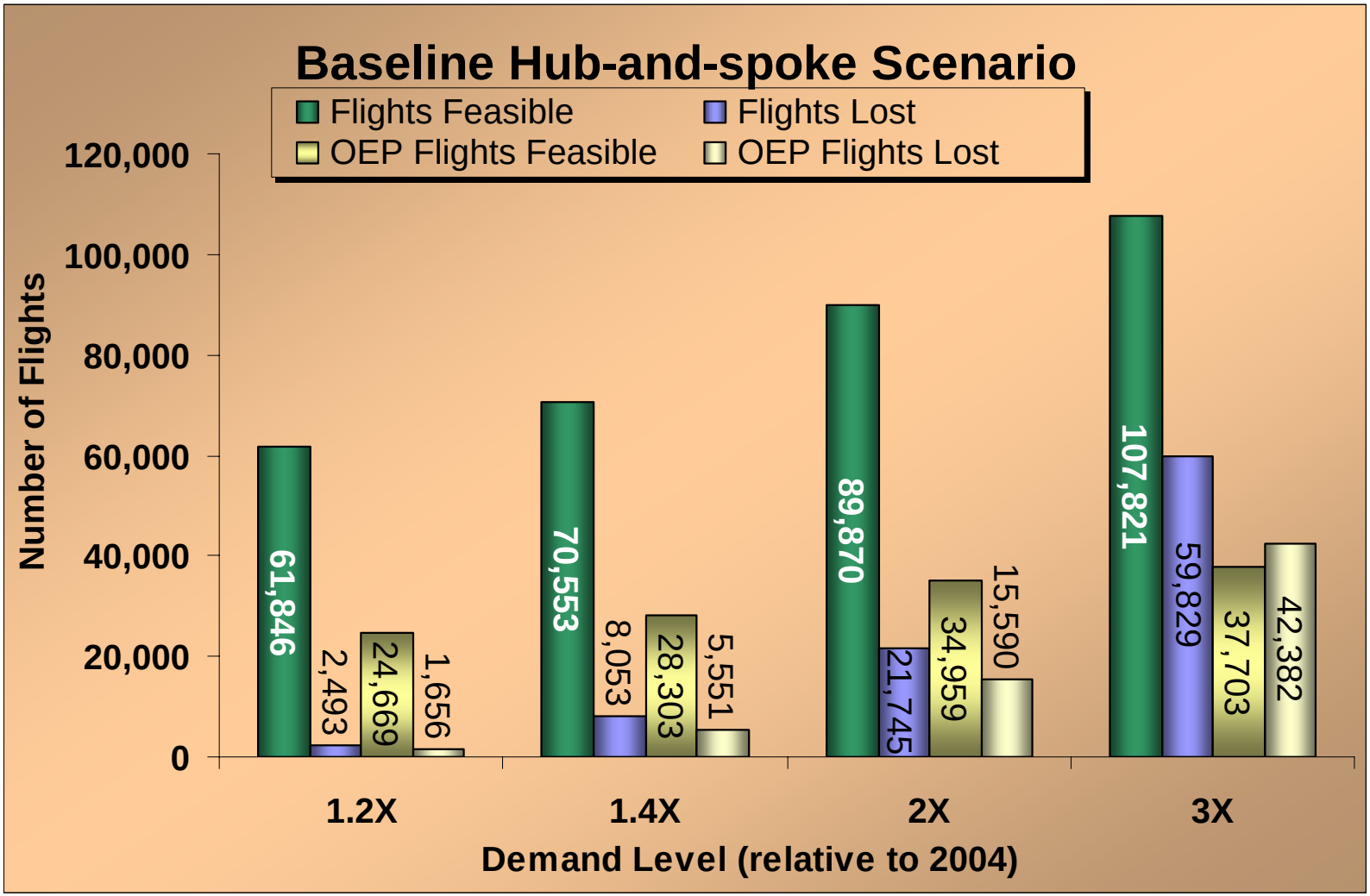
Future Scenarios Operations Growth

Scenarios	Percent Growth by User Class			
	Air Carrier	Commuter/ Air Taxi	General Aviation	Overall NAS Growth
2X Ops TAF	142%	100%	38%	100%
3X Ops TAF	294%	195%	65%	200%

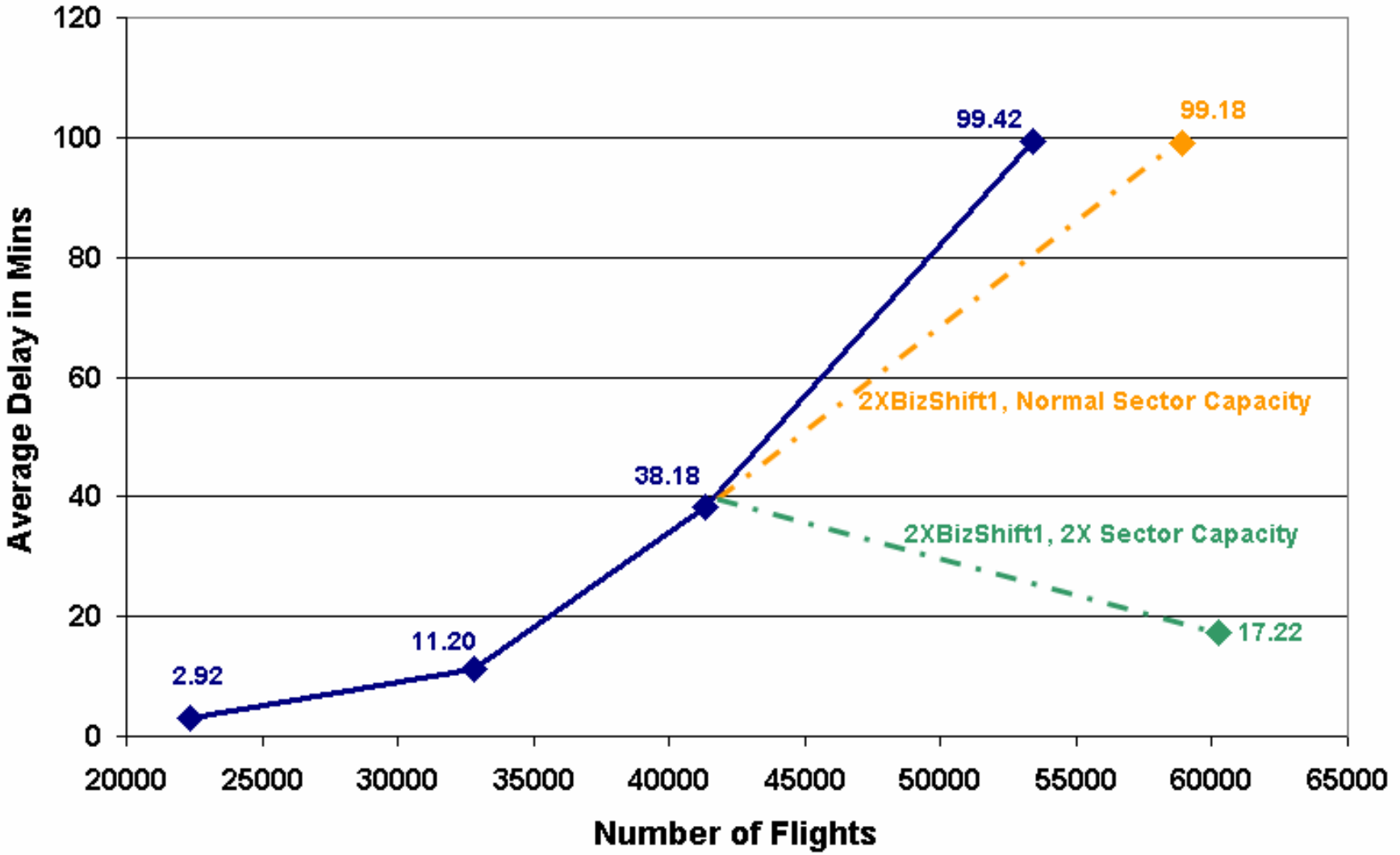
2004 Baseline seed day has a total of ~55K IFR flights

General Aviation (GA) operations only includes IFR itinerant operations

Future Capacity Shortfall by Airport Type



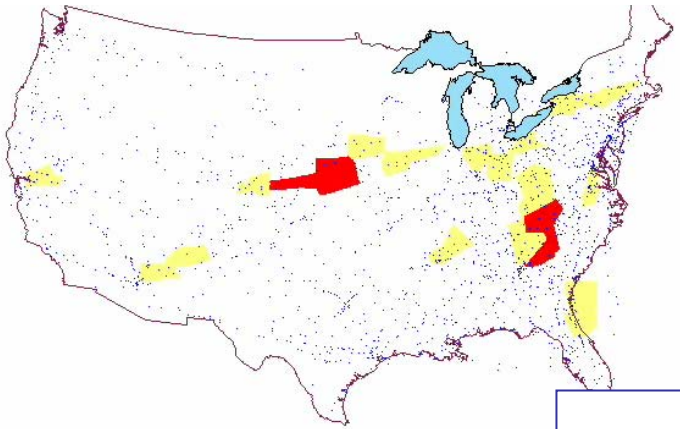
Bizshift1 Increased Regional Airport Utilization

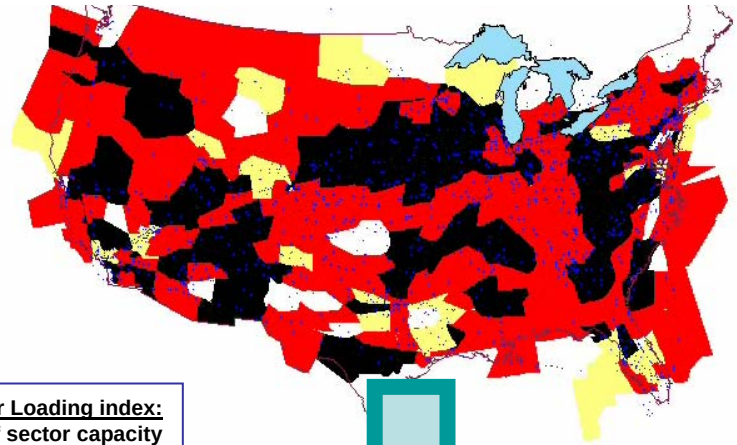


Baseline Demand (2002)
Current Sector Capacities

Snapshot at ~1pm EDT
2X Future Demand

2X Future Demand
Current Sector Capacities



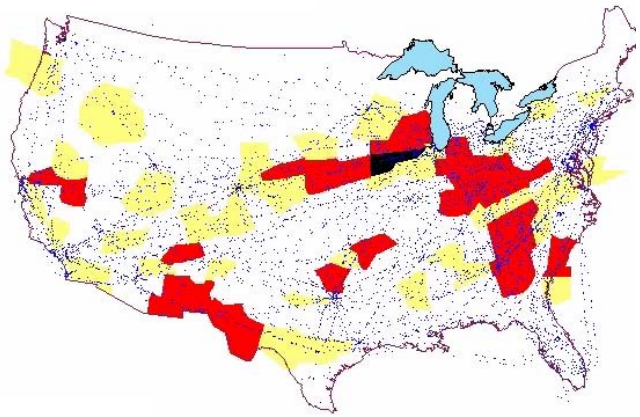


Active Flights : 2289

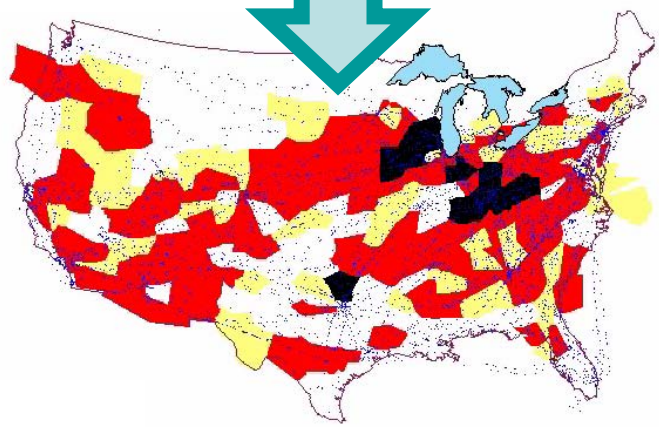
Sector Color Loading index:

Yellow:	80 – 125% of sector capacity
Red:	125 - 200% of sector capacity
Black:	> 200% of sector capacity

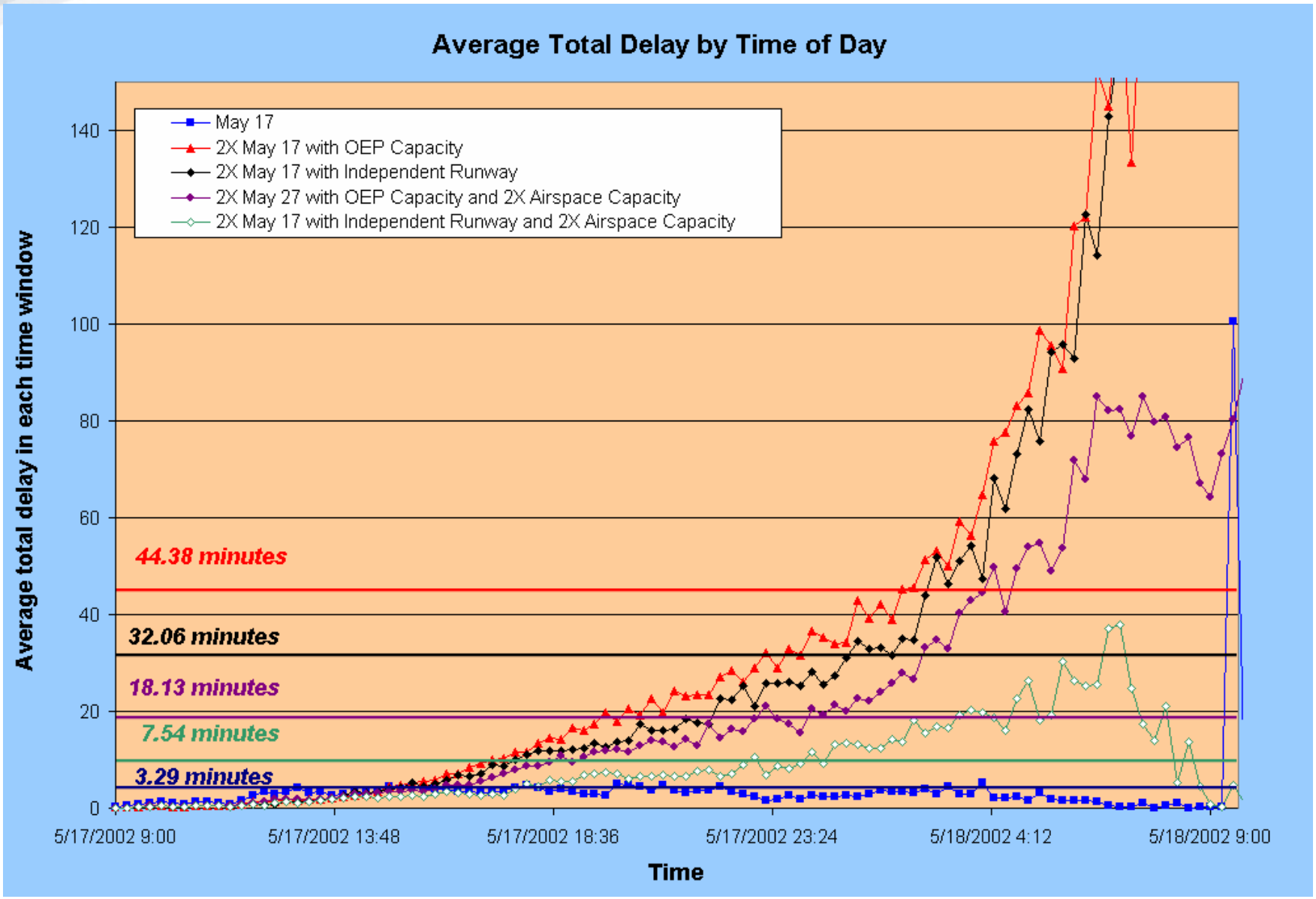
2X Future Demand
3X Current Sector Capacities



2X Future Demand
2X Current Sector Capacities



Time-of-day Delay Distribution Comparison



Capacity Analysis Approach:
from Unconstrained Demand to Feasible Throughput (1 of 2)

- Estimation of "feasible throughput"
  - Flights are eliminated from the future flight schedule after a specified airport delay tolerance or sector capacity is reached
  - Airport constraints are implemented via delay tolerance; maximum allowed delay for future epochs (15-minute windows) is the greater of
    - the maximum delay at each epoch experienced in summer 2000 for the given airport
    - the average of the delays experienced in summer 2000 at the busiest 31 airports
  - Sector capacities are implemented with the Monitor Alert Parameter (MAP)
    - The maximum number of aircraft simultaneously in a sector within a 15-minute window

Capacity Analysis Approach:
Details

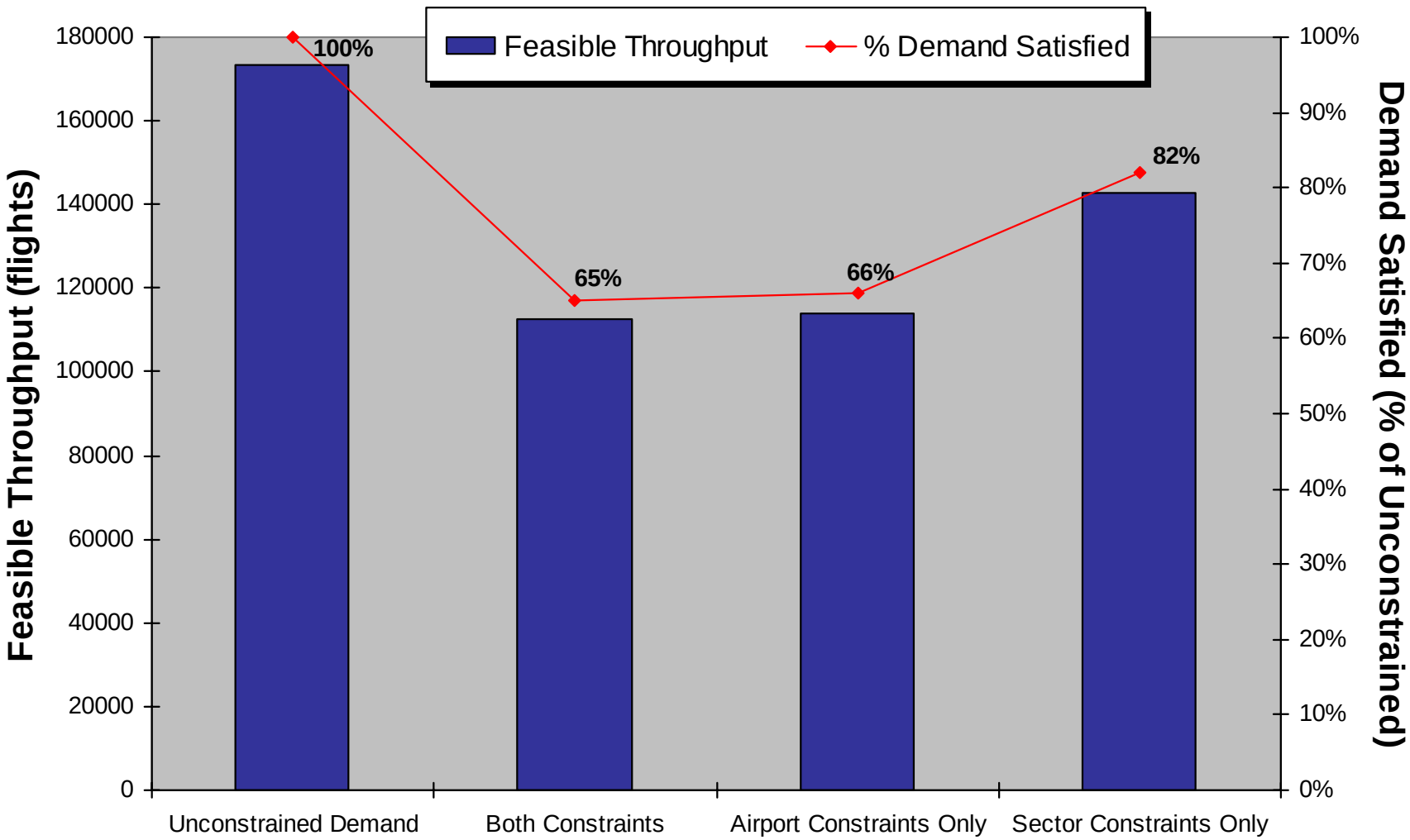
- We looked at a 3X demand scenario
  - This means we took a current (2004) demand set and extrapolated the demand to 3X based on TAF growth rates
  - We preserved the current prevailing business model (hub & spoke), fleet mix, schedule time-of-day patterns, flight trajectories, and other parameters
- We've run our simulation models in three configurations
  1. Both airport and sector constraints are active
  2. Sector constraints are active but airport capacity is assumed to be unlimited
  3. Airport constraints are active but sector capacity is assumed to be unlimited
- We estimated the feasible throughput based on the following capacity constraints
  - Airport capacities are set based on 2014 Operational Evolution Plan (OEP) airport capacities
  - Airspace capacities are set based on current FAA sector capacities; i.e., MAP values
- We analyzed the feasible throughput, including
  - Where must capacity constraints be addressed (specific airports and airspace), by what magnitude, etc.

Summary of Capacity Constraints Analysis

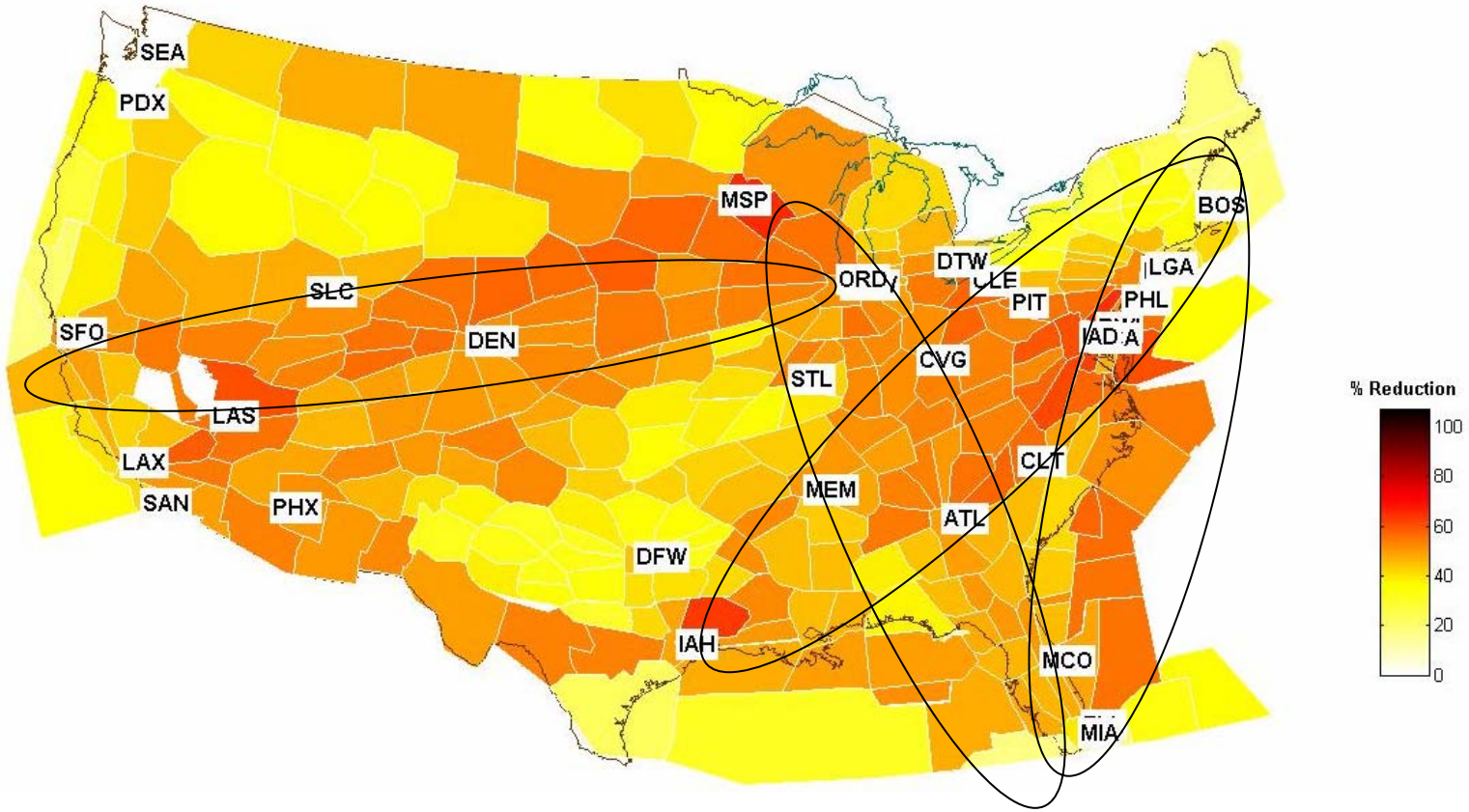
Category	3X Baseline Demand	3X Feasible Throughput (Airports Constrained)	3X Feasible Throughput (Airspace Constrained)	3X Feasible Throughput (Airports and Airspace Constrained)
Flights in NAS	173,980	114,156	142,782	112,595
Number of Flights Trimmed	N/A	59,824	31,198	61,385
% of Flights Trimmed	N/A	34%	18%	35%

- ***Assuming only FAA airport capacity benchmark report airport capacity improvements and no airspace capacity improvements, the portion of demand that cannot be satisfied ranges from 18% to 35%.***
- ***Note that the unsatisfied demand for the Airport Constrained and the Airport/Airspace Constrained cases are almost identical.***

Initial Constraints Analysis Summary Results

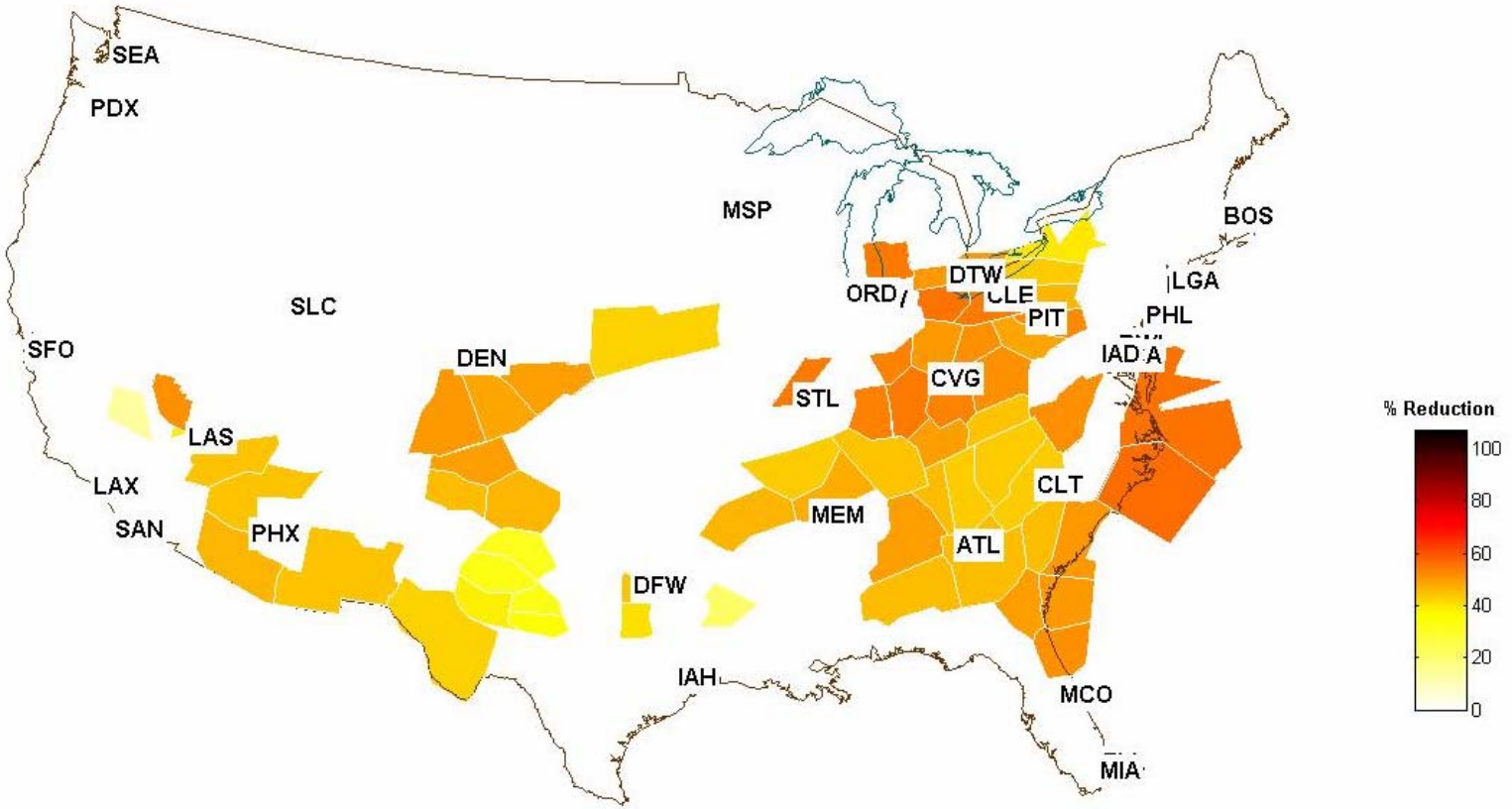


% Flight Reduction in High Sectors – *Airports and Airspace Constrained*



Flight trimming reduces loading in high sectors in heavily-trafficked corridors between major airports.

% Flights Reduction in Super Sectors – *Airports and Airspace Constrained*



Flight trimming reduces loading in super-high sectors in heavily-trafficked areas of the country.

Overall Conclusions

- Airport constraints are more binding, in both scenarios (2025 and 3X)
  - If you only solve the sector constraints, you really haven't done much for the NAS-wide performance
    - Just a 1% improvement in feasible throughput, in both scenarios
  - If you only solve the airport constraints, you reap a lot of NAS-wide performance benefit
    - However, in the 3X scenario, you still have significant sector constraints that keep you from satisfying all the unconstrained demand
- To satisfy 3X demand, both types of constraints must be resolved

Modeling Operational Improvement Performance

A New Portfolio of Programs Needs to Be Funded in FY08 to Meet 2015 Needs

Current Programs

- ERAM
- TFM-M
- STARS/CARTS
- RNP/RNAV
- Initial ADS-B
- Initial SWIM

New Portfolio of Programs

ERAM Enhancements
Automated Problem Resolution
Integrated Controller Suite

TFM-M Enhancements
Time-Based Metering

STARS Enhancements
Merging and Spacing Tools

RNP/RNAV Expansion
Precise Navigation

Data Communications
Automated Complex Clearance Delivery
Flight Intent Downlink

ADS-B
Aircraft Separation

SWIM
Net-Centric Information Sharing

NGATS

- Trajectory-Based Operations
- Aircraft Data Communications
- Performance-Based Operations and Services
- Separation Management
- Collaborative TFM
- Precision Navigation
- Weather Integration
- Surveillance Services
- Network-Centric Information Sharing

•Next Generation Air Transportation System Initiative:

Methods of Analysis of Future Operational Concepts

How do we go about analyzing the impact of Future Operational Concepts?

Questions we really need to address that have not been looked at yet

Outsourcing:

How much should the "skilled" worker do and how much can be outsourced to automation, another element in the system (when it is not busy) etc.

Some important issues that arise are:

how quickly can one come to full situational awareness if a task is outsourced and must be directly managed due to an emergency?

Who is the best owner of authority given varying levels of complexity?

What "must" the automation or oursourced element be able to do to assure safety?

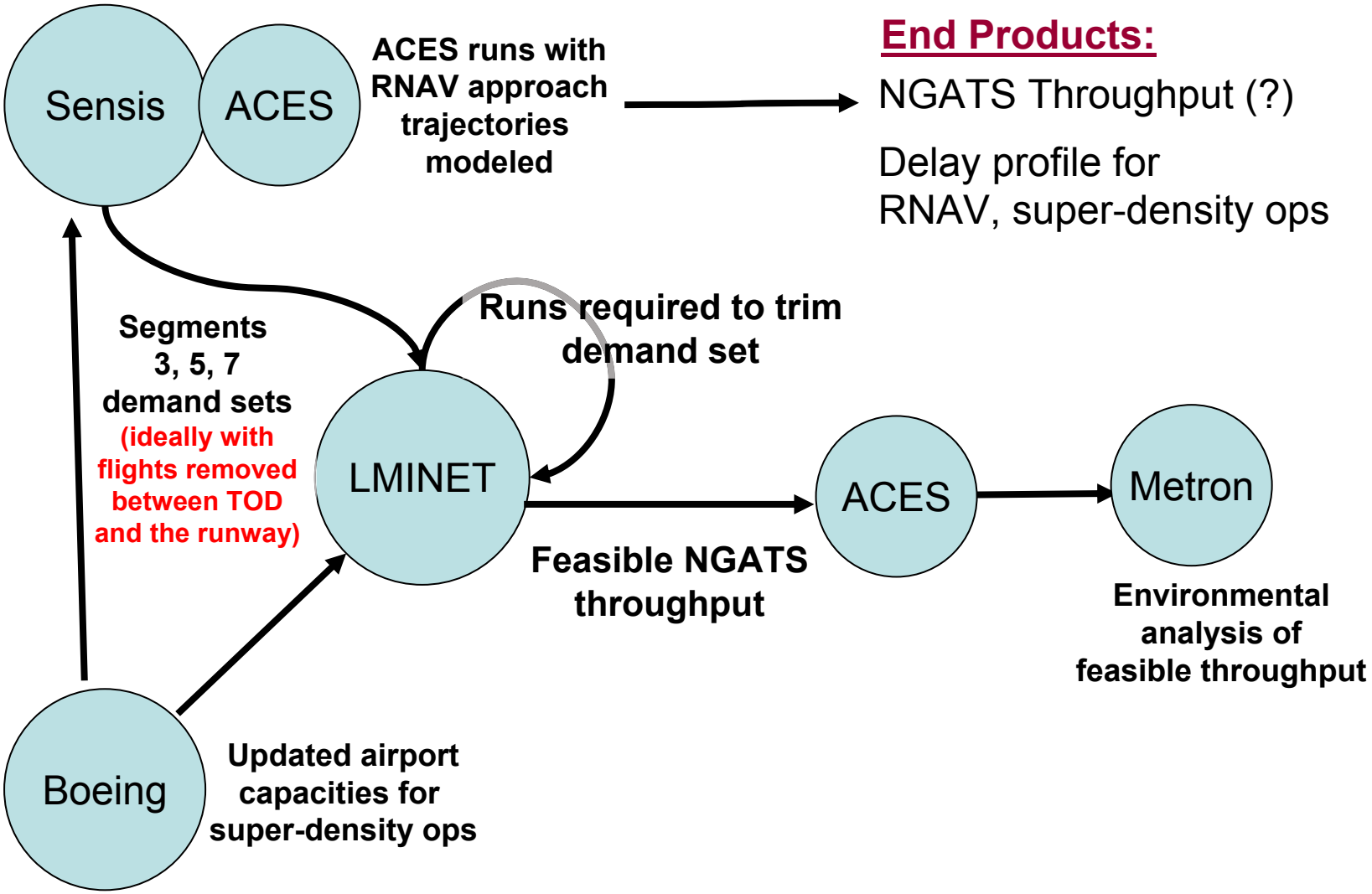
Next Generation Air Transportation System Initiative:
Methods of Analysis of Future Operational Concepts

How do we go about analyzing the impact of Future Operational Concepts?

In the past; we operated in a paradigm of organization – to-organization; whether the entity was the Flight Operations Center talking to an Airport Tower, or a Controller talking to an Individual Aircraft; the operational paradigm was one in which the objectives of the ORGANIZATION took precedence over the objectives of the individual.

In today's environment it is possible for individual pilots to optimize their own environments; for FOCs to optimize for their fleet and for individual controllers to manage the interfaces among many pilots, flight operations centers, and each other, due to the ubiquitous availability of information.

Modeling Process



Next Generation Air Transportation System Initiative:
Methods of Analysis of Future Operational Concepts

How do we go about analyzing the impact of Future Operational Concepts?

Frontiers for Human Factors Analysis and Engineering – The Vital Role of HF analysis in NGATS System Performance Assessment

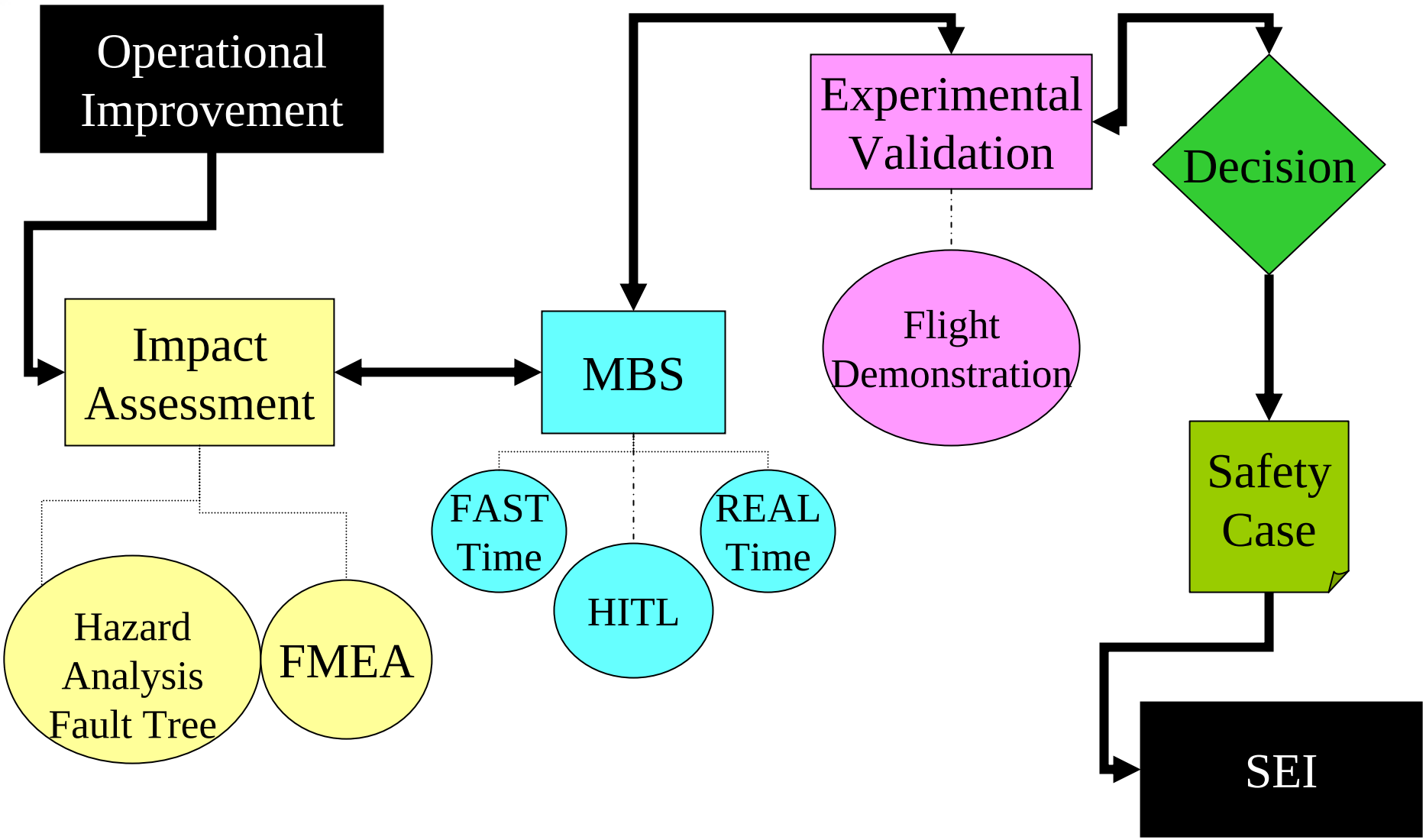
What is the ROLE of Human Factors Analysis in the Next Generation System Evaluation process?

Concept Definition
Safety Analysis (aircraft, airspace, individuals)
Organizational Design and Overview
Workload / work force requirements
During transition to NGATS
At End-state
Substitution of Automation for Humans – Development of Software Design requirements and Certification Criteria

How will EAD attack this problem?

Theoretically
Analytically
Experimentally

How do we go about analyzing the impact of Future Operational Concepts? The



Next Generation Air Transportation System Initiative:
Methods of Analysis of Future Operational Concepts

How do we go about analyzing the impact of Future Operational Concepts?

Understanding the system components
- Airports
- Terminal Area Airspace
- Enroute Airspace

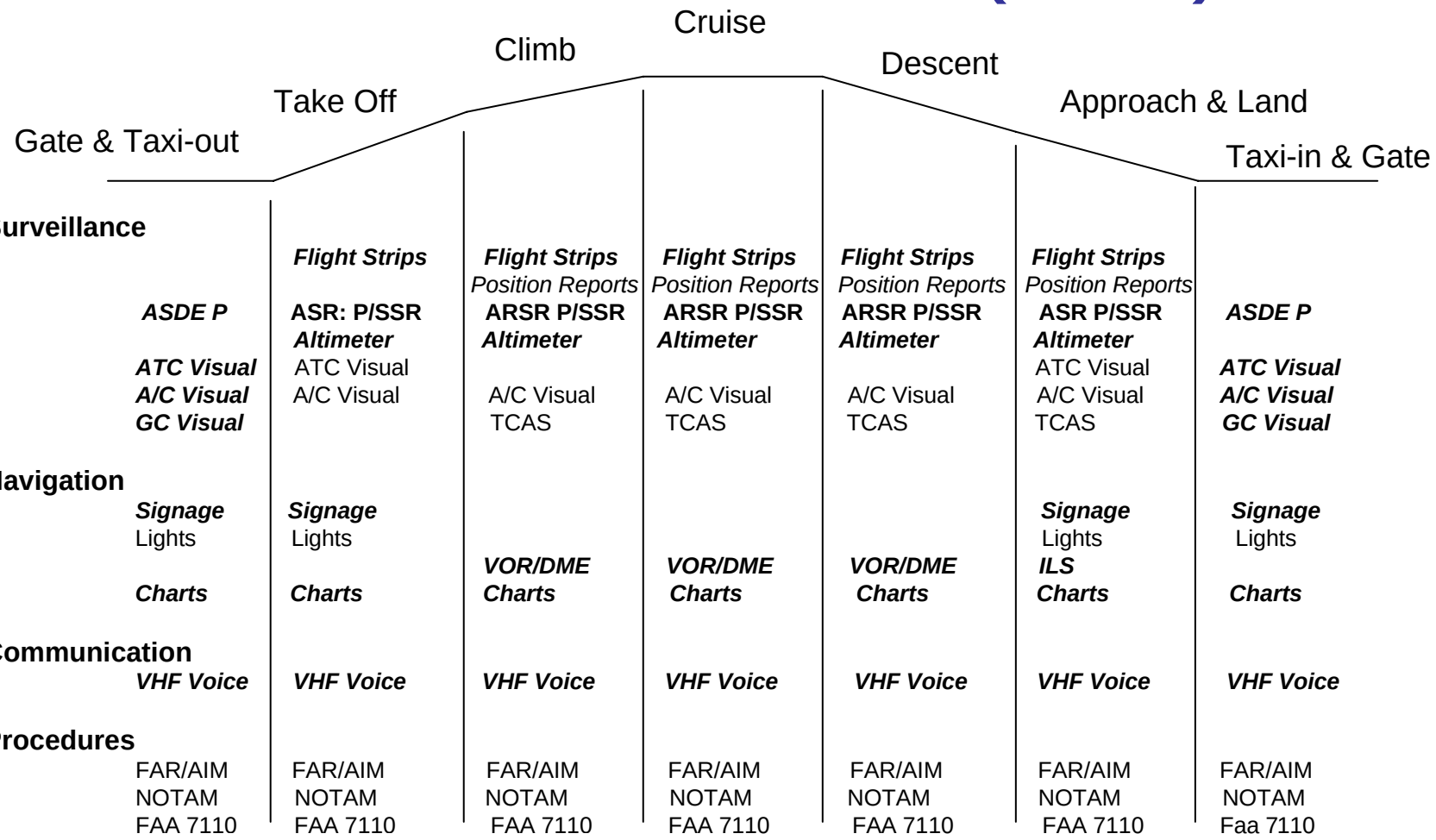
The "Exceptions"
- Weather and weather and more weather

Understanding the impact of the NGATS solutions
- **Things that Enable Improvement**
- ADS-B
- SWIM / NEO
- CDTI

Things that Enhance current performance
- EG CDA's
- RNP/ RNAV
- Wake Vortex Separation Reductions
- **Things that Replace current system elements**
- Dynamic Airspace Allocation
- Required System Performance
- Secondary Airports / Remote and Virtual Towers
- Aircraft to Aircraft Self-Separation
- Aircraft internal health management

THINGS WE CAN'T Know yet!!!

Safety-Related Components Example 1 – *Safe Separation from Aircraft and Vehicles in the Commercial IFR Environment* (Case 6)

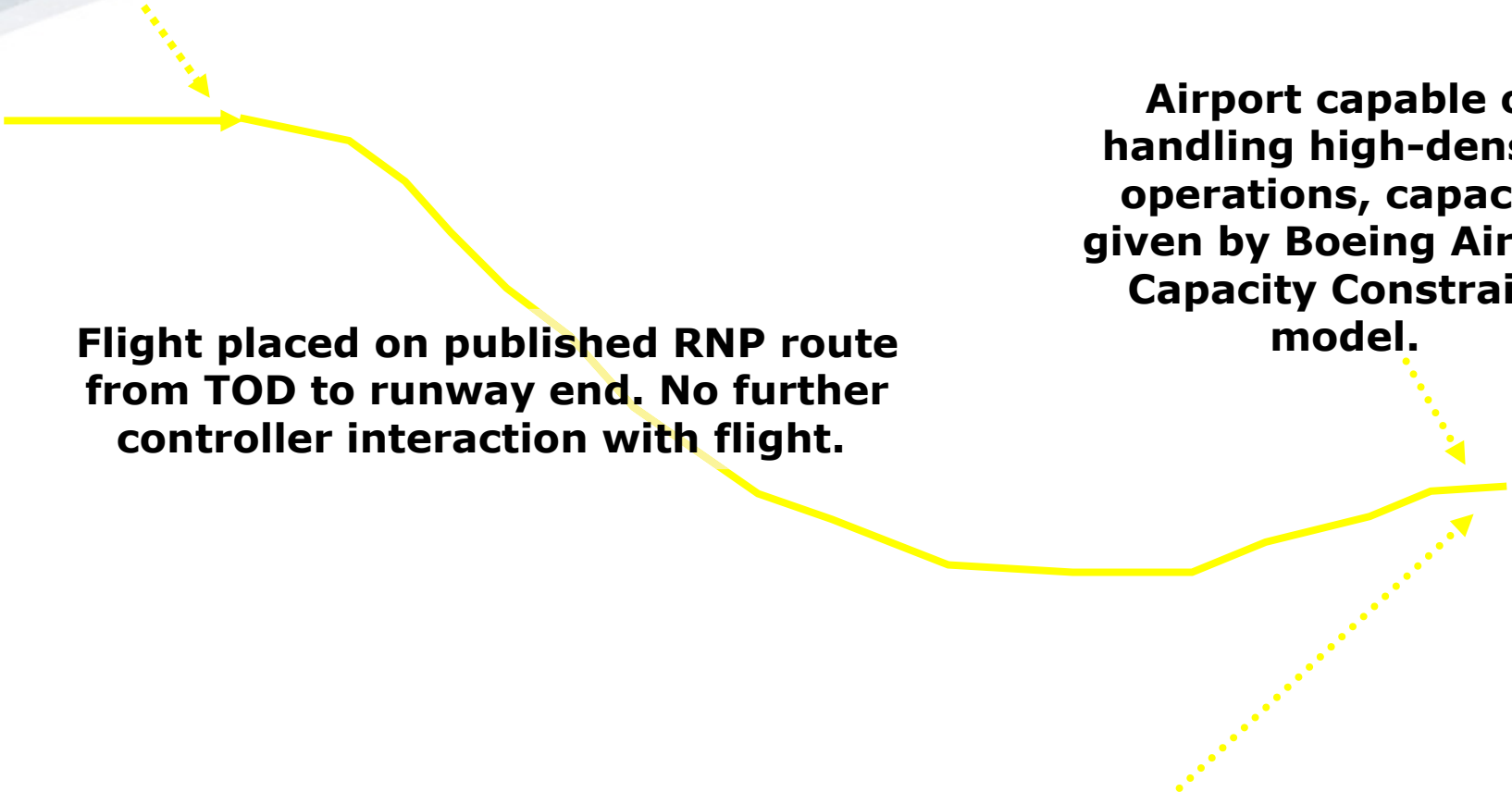


ASDE: Airport Surface Detection Equipment
ASR: Airport Surveillance Radar
ARSR: Air Route Surveillance Radar
P = Primary Radar; SSR = Secondary Surveillance Radar
NOTAM: Notice to Airmen
SID/STAR: Standard Instrument Departure/Standard Terminal Arrival Route

TCAS: Traffic Alert & Collision Avoidance System
VOR: VHR Omnirange
DME: Distance Measuring Equipment
FAR/AIM: Federal Aviation Regulations / Airman's Information Manual
FAA 7110: Air traffic Controller's Handbook

Portfolio Assumptions

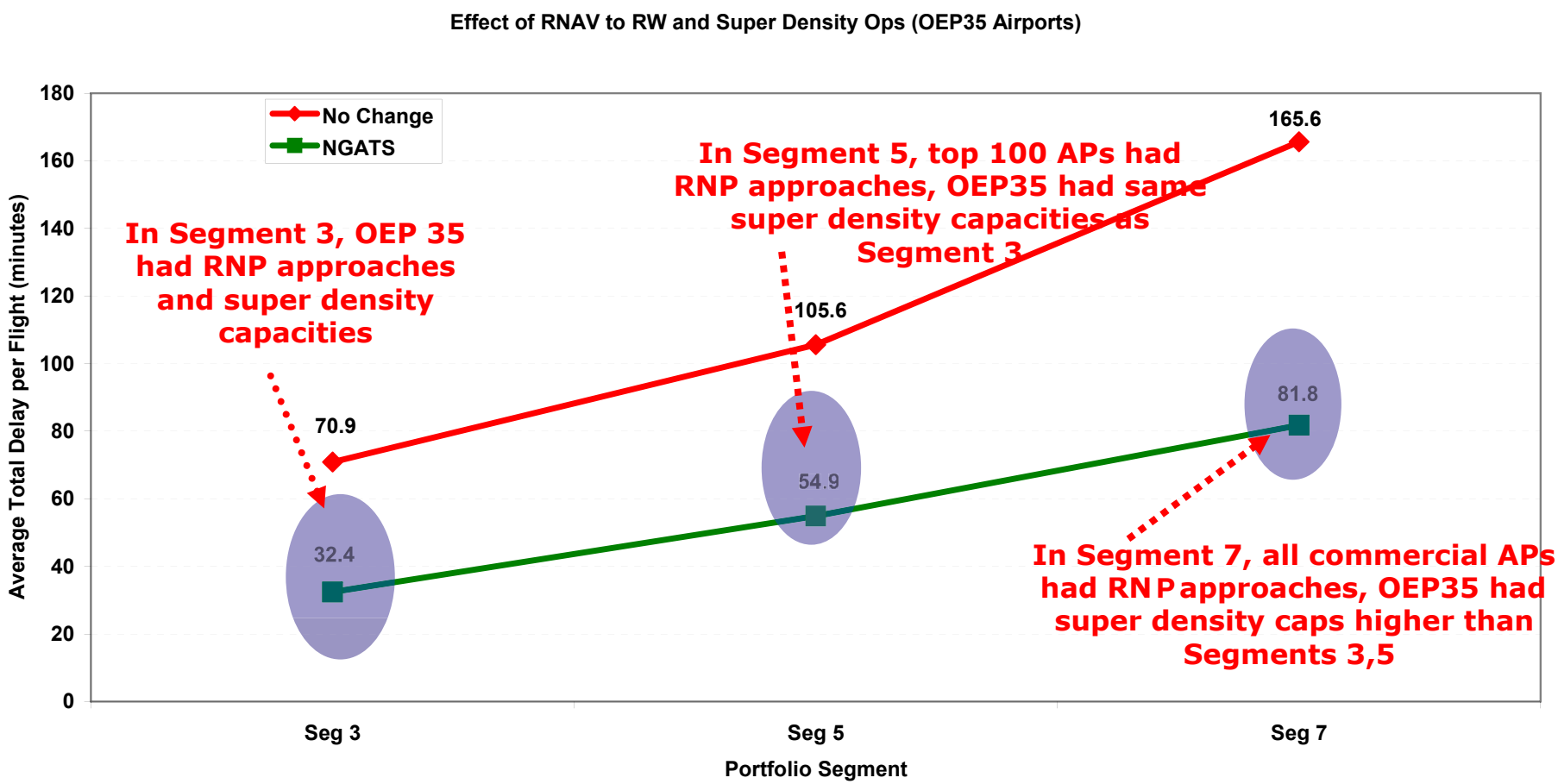
Top of Descent (TOD)



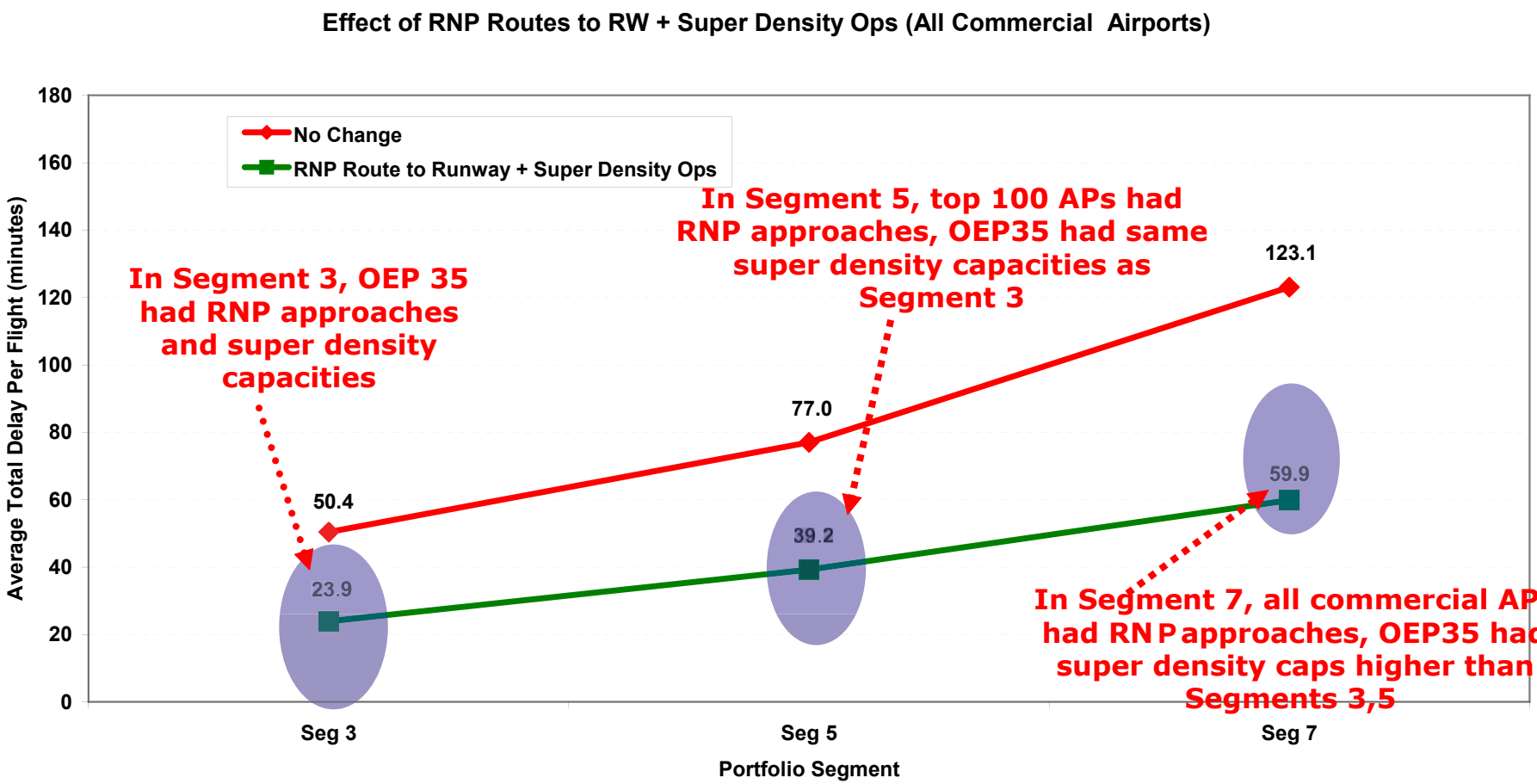
Flight placed on published RNP route from TOD to runway end. No further controller interaction with flight.

Airport capable of handling high-density operations, capacity given by Boeing Airport Capacity Constraint model.

Results: Average delay at OEP airports (unconstrained demand flown)



Results:
Average delay at all commercial airports (unconstrained demand flown)



Next Generation Air Transportation System Initiative: Methods of Analysis of Future Operational Concepts

Next Questions????

- Why are current system designs in place – should they be replicated in the transformed system ? Will they perform as intended?
- How do we certify a system with so many possible failure modes that an exhaustive analysis is impossible?
- What should the performance requirement / criteria be that ensures that the new system delivers its best capability without overtaxing the system managers?
- **Which criteria should be applied to:**
  Decide that dynamic airspace reconfiguration is needed / warranted,
  Aircraft are capable of meeting the minimum RTSP performance level for access,
- Determine that an unsafe situation is emerging,
  Describe and certify the training criteria to allow individuals to provide these services?