Convective Weather Impact On NEXTGEN

NextGen Benefits

Weather causes 70% of delays. NextGen will reduce delays and increase safety while improving efficiency, capacity and environmental performance.

Jim Evans
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NEXTOR NAS Performance Workshop
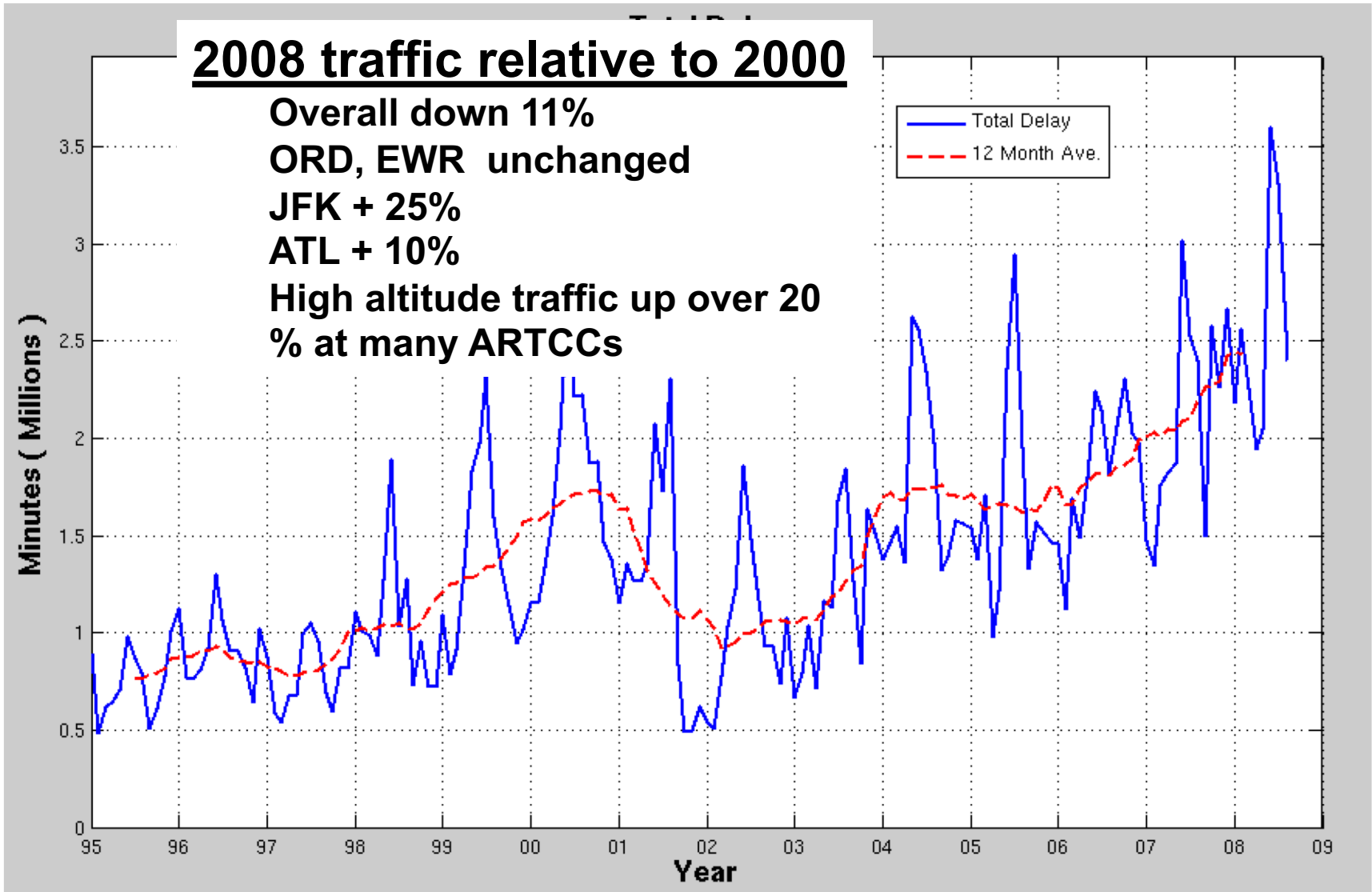
15 April 2009

Outline

- **Delays**
- **Principal NextGen solution sets that are germane**
    1. **Reduce weather impact**
    2. **Improve collaborative ATM**
    3. **Increase arrival/departure (A/D) rates at high-density airports**
    4. **Increase flexibility in the terminal environment**
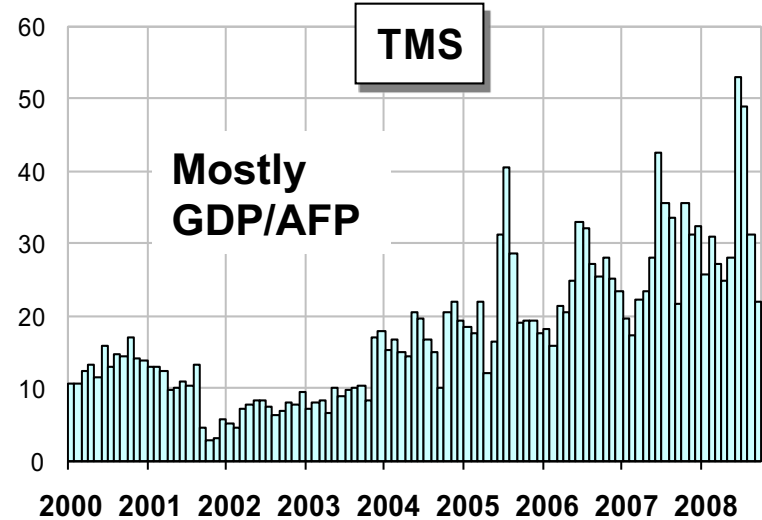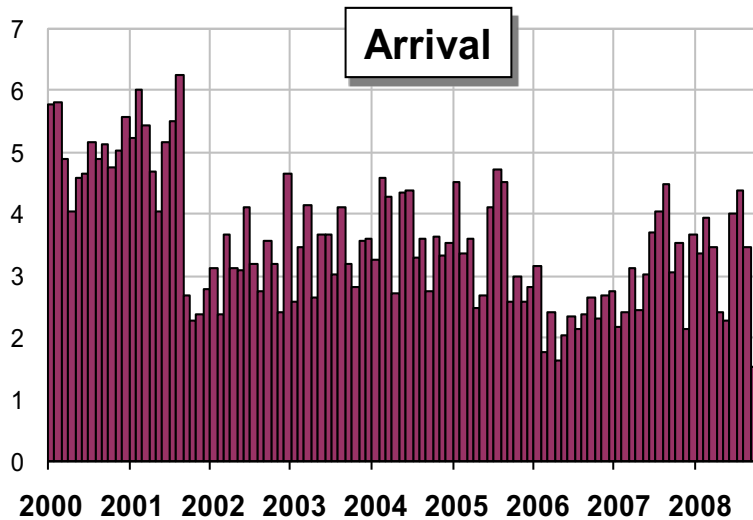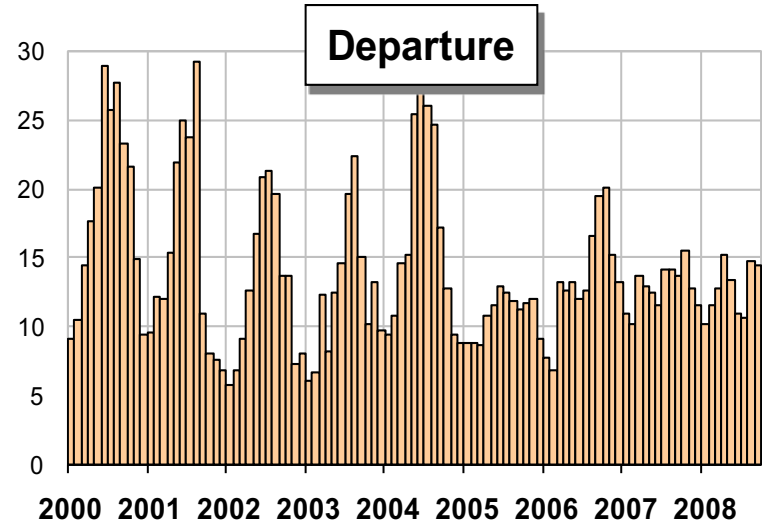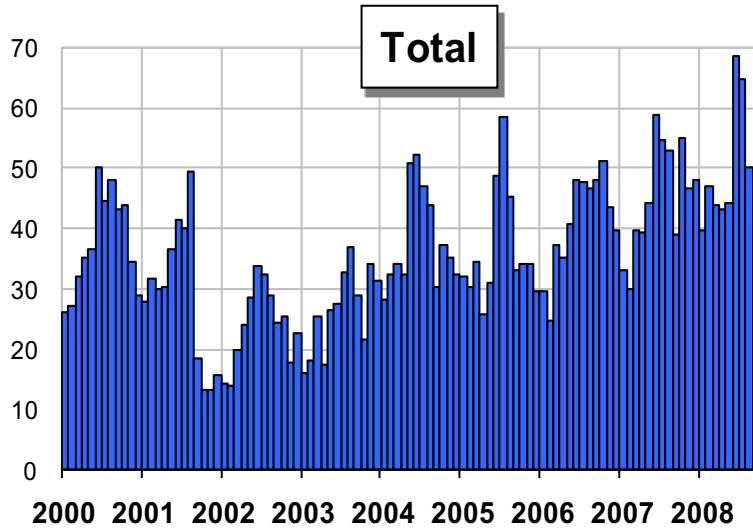- **Important issues not addressed in current plan**
- **Summary**

Total Air Traffic Delay 1995 - 2008

2008 traffic relative to 2000

Overall down 11%

ORD, EWR unchanged

JFK + 25%

ATL + 10%

High altitude traffic up over 20 % at many ARTCCs

Legend:
- Total Delay
- 12 Month Ave.

Y-axis: Minutes (Millions)

X-axis: Year (95, 96, 97, 98, 99, 00, 01, 02, 03, 04, 05, 06, 07, 08, 09)

OPSNET Delays By Category

Preliminary Data as of 10/02/08

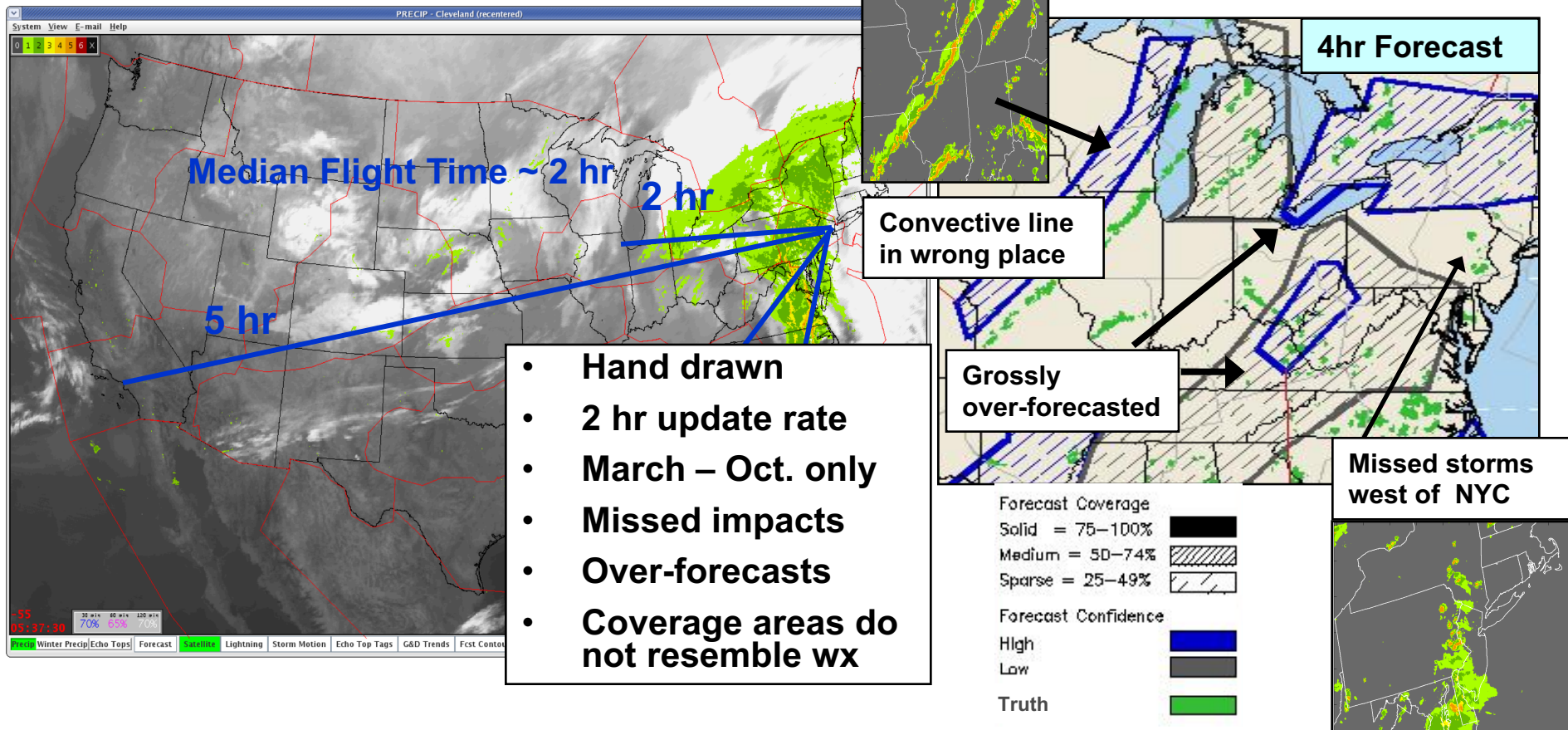All Facilities, January 2000 - September 2008, thousands;
Notes: Calculation of GDP and GS delays automated on 10/01/07; AFPs began being used on 06/29/06

"Strategic Planning" for Convective Weather

- **Strategic planning seeks to manage number of planes that flow through congested regions**
- **Airlines require 90 min window prior to takeoff**

Current 2-6 hr Forecast Technology

Median Flight Time ~ 2 hr

2 hr

5 hr

4hr Forecast

Convective line in wrong place

Grossly over-forecasted

Missed storms west of NYC

- **Hand drawn**
- **2 hr update rate**
- **March – Oct. only**
- **Missed impacts**
- **Over-forecasts**
- **Coverage areas do not resemble wx**

Forecast Coverage
Solid = 75–100%
Medium = 50–74%
Sparse = 25–49%

Forecast Confidence
High
Low
Truth

NextGEN Reduce Weather Impact (RWI)

- **4 D "data cube" weather database accessed using service-oriented architecture (SOA)**

- **Improved forecasts (0 - 8 hour) by NextGEN Weather Processor (NWP)**

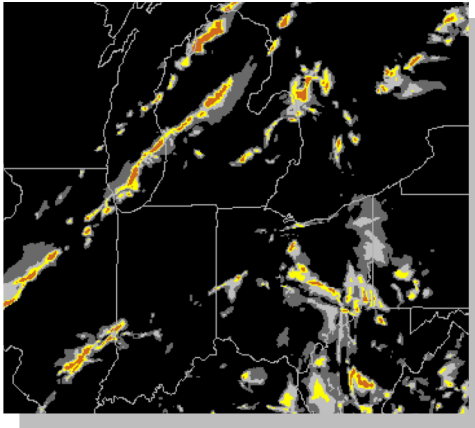- **"Single authoritative source" for strategic planning weather information**

"CoSPA" 0-8 hr Forecasts

Collaborative Storm Prediction for Aviation
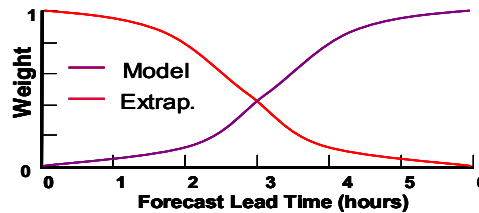
LINCOLN LABORATORY
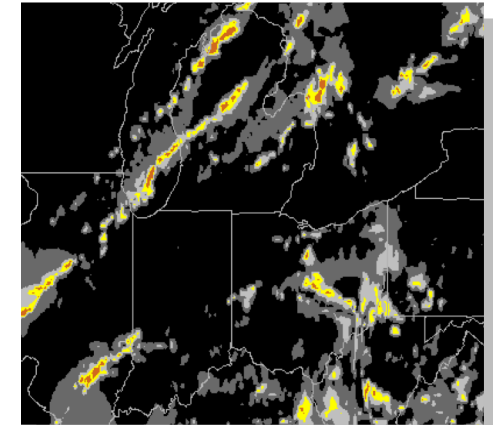MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Extrapolation

The National Center for Atmospheric Research
NCAR sponsored by NSF

Blended Forecast

- **Motion correction**
- **Intensity correction**
- **Blend using statistical performance weights**
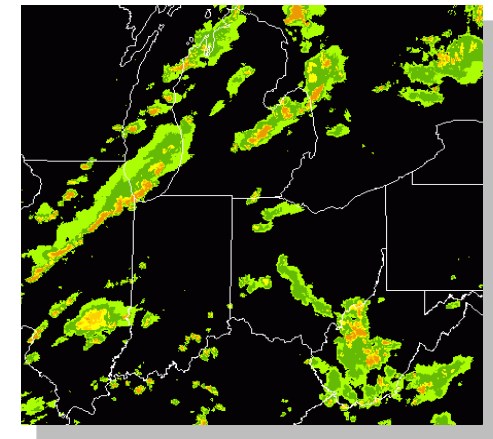

Blended Forecast

Truth 23Z

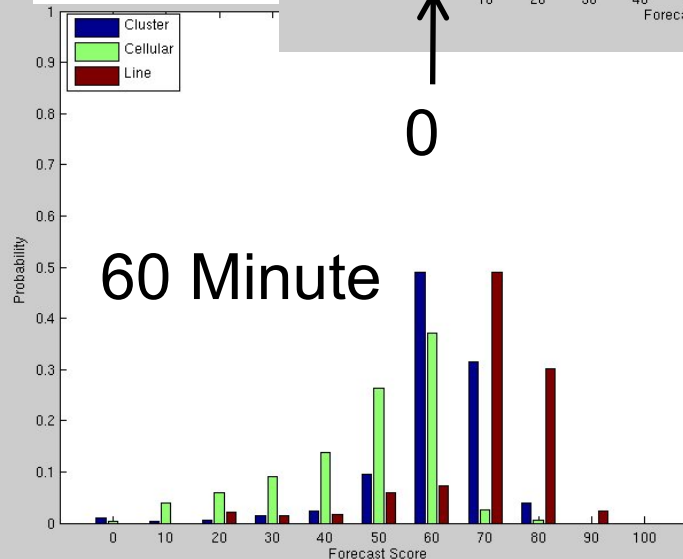**Earth System Research Laboratory**
Serving Society through Science

Numerical Model
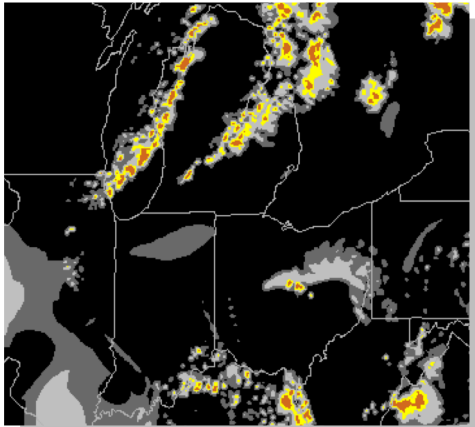
10 July 2007   3 hour forecasts issued at 20Z

Forecast Score for Various Types of Convective Weather Near NYC

30 Minute

120 Minute

60 Minute

0

100
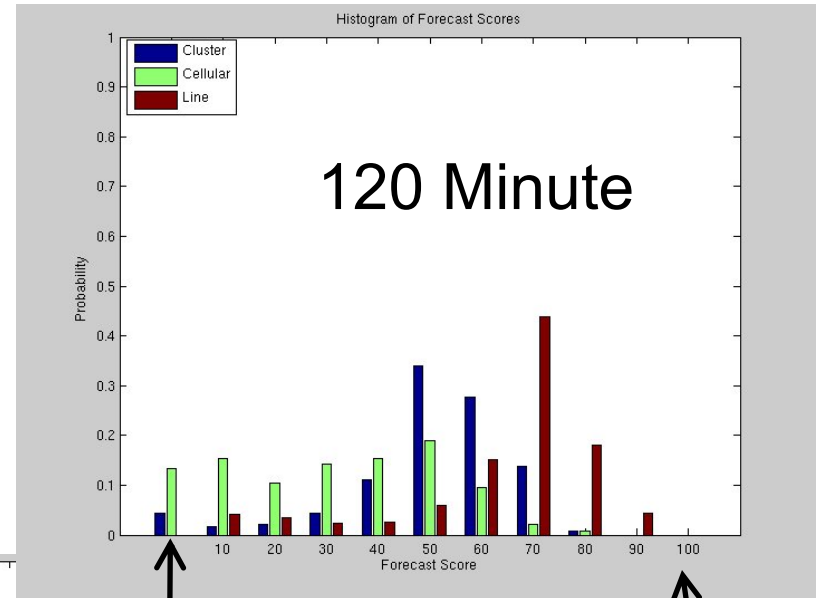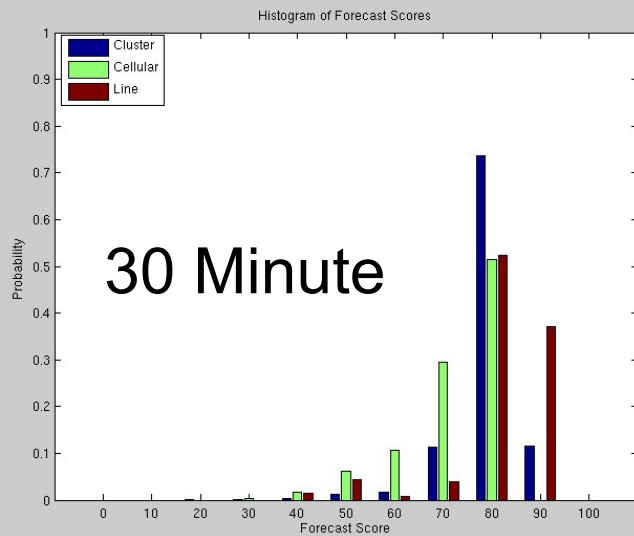
Blue= cluster
Green= cellular
Brown=squall line

Spatial patterns of 120 minute forecast and actual weather

Cellular
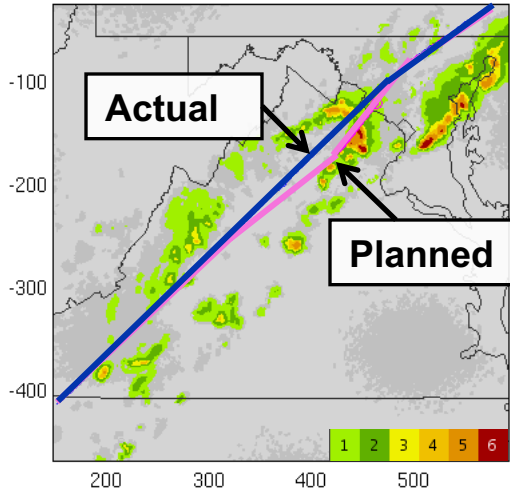
Cluster

Line

Score = 40%

Score = 70 %
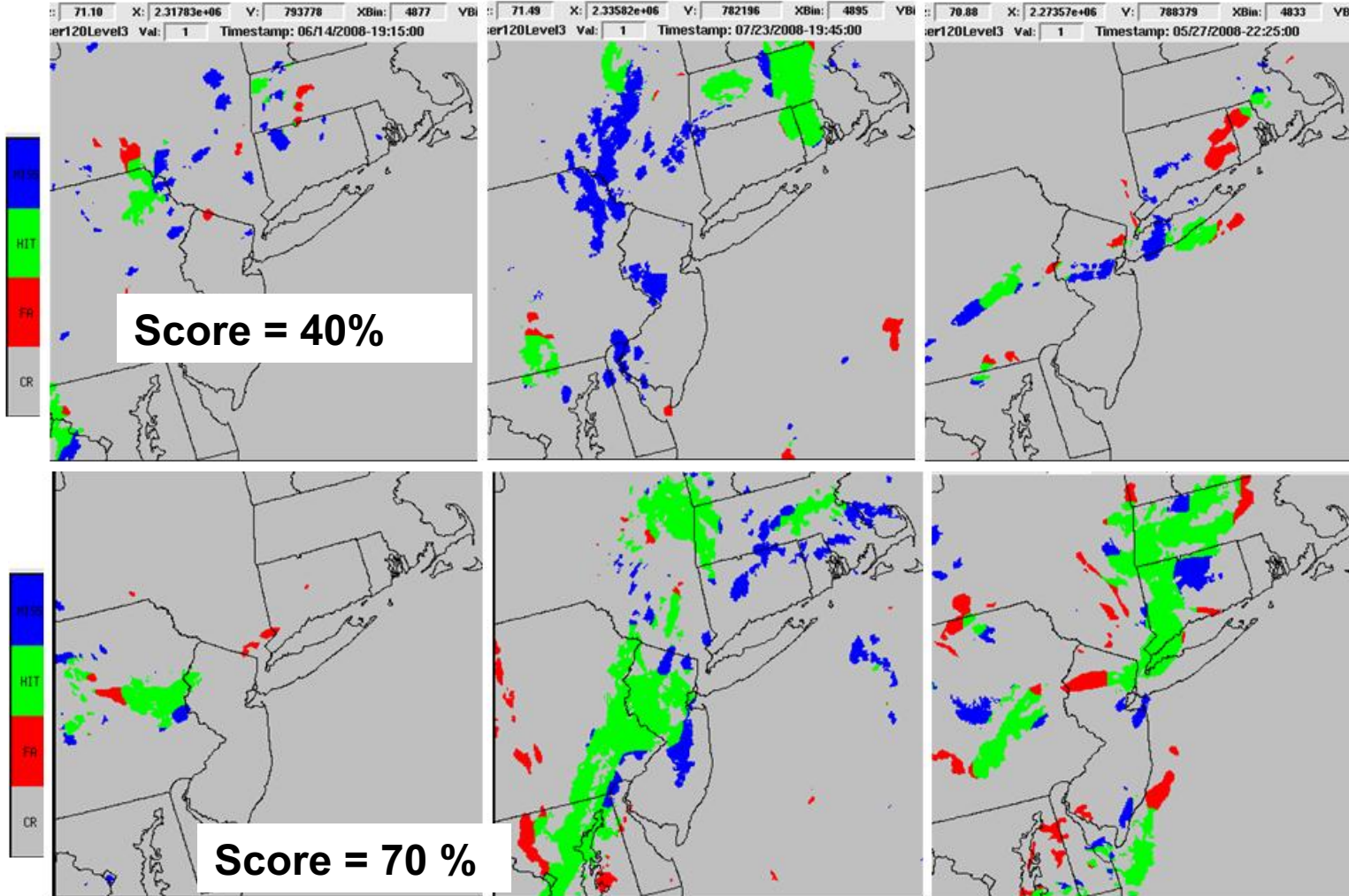
Implications of Inaccurate "Strategic" Forecasts

- **Much of time, strategic plan alone will not suffice**

- **Need to make tactical adjustments**

- **Time pressure and complexity of solving network flow problems necessitates higher level of decision support**
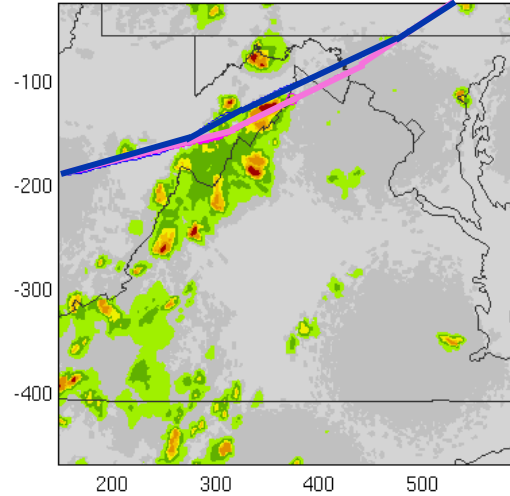
Storm Deviations Increase Flight Time and Workload (i.e., impact TBO and capacity)
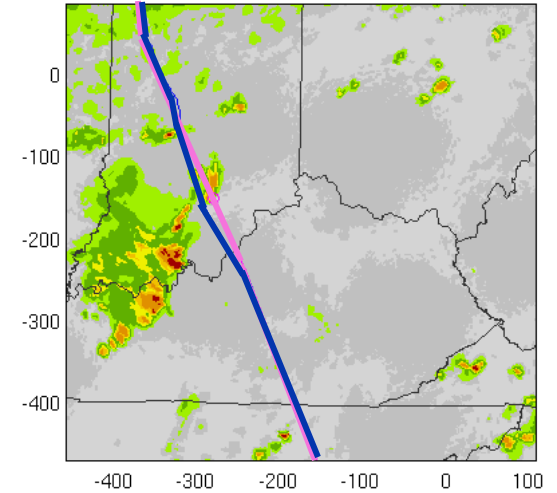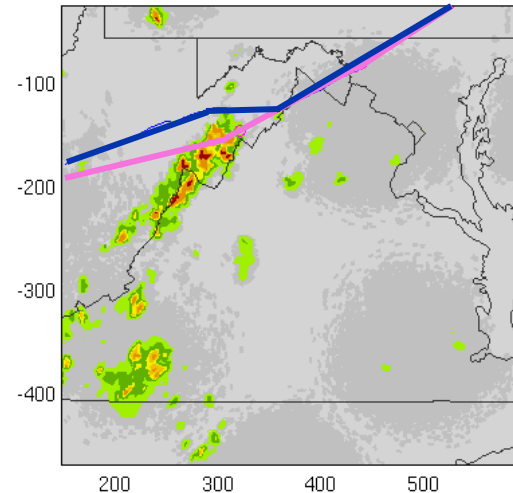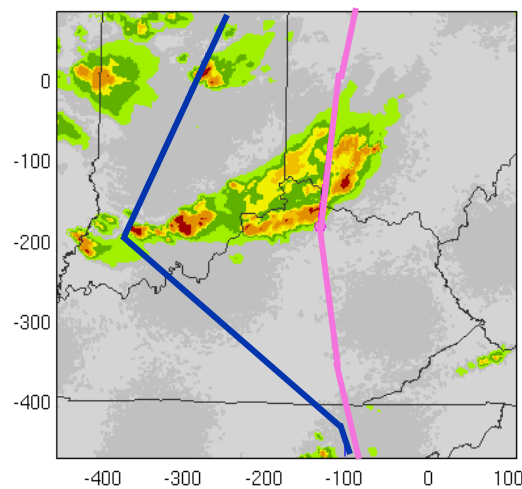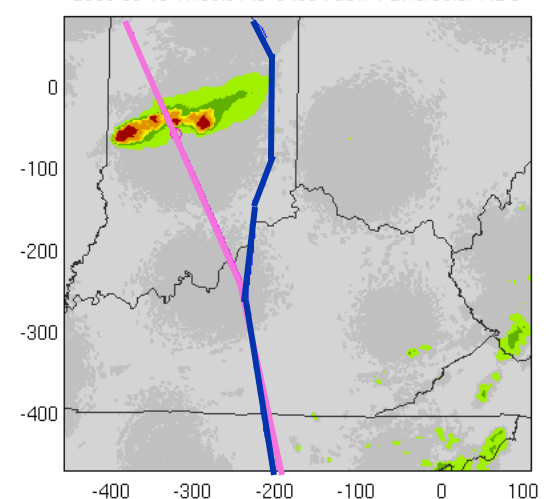
Decision Making Framework

4-D Weather Forecast

Precipitation

Echo Tops

Wx – ATM Integration

Pilot Model

TRANSLATION

Probability of Deviation

Capacity Models

Route Impacts

Effective Response Strategies

Route Availability Planning Tool

Demand

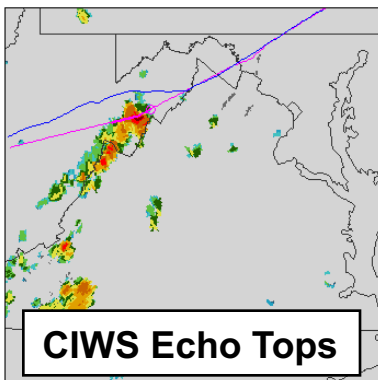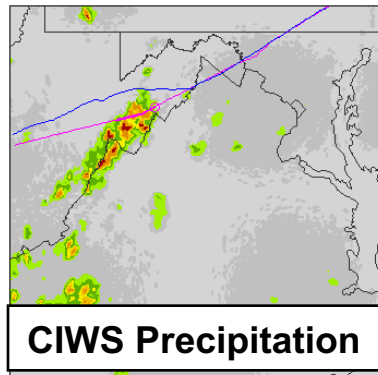## Air Traffic Management Decision Making and Execution
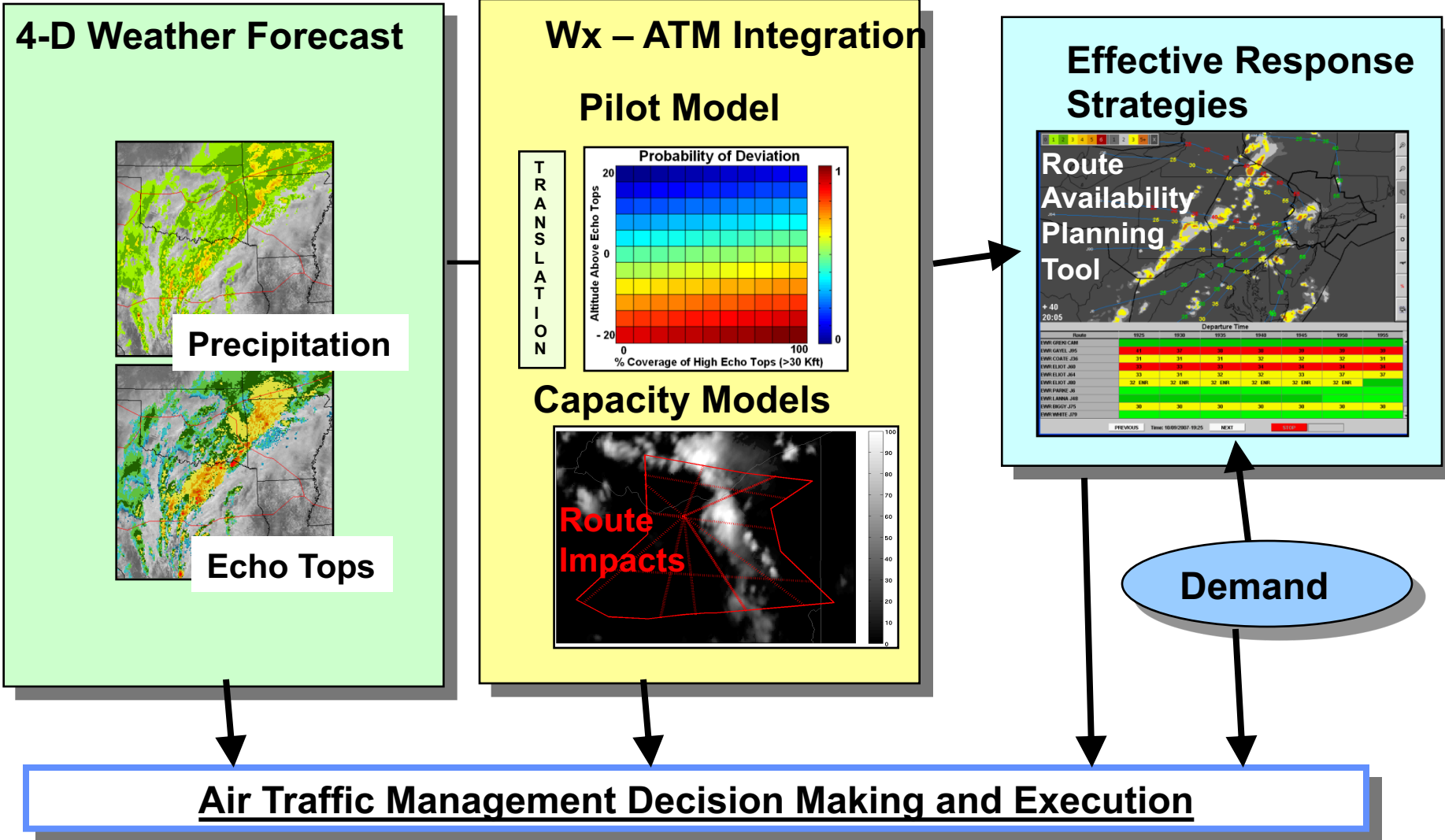
Issues That Arise With Integration

- **Pilot response**

- **What is "capacity" and, can it be predicted from weather products**
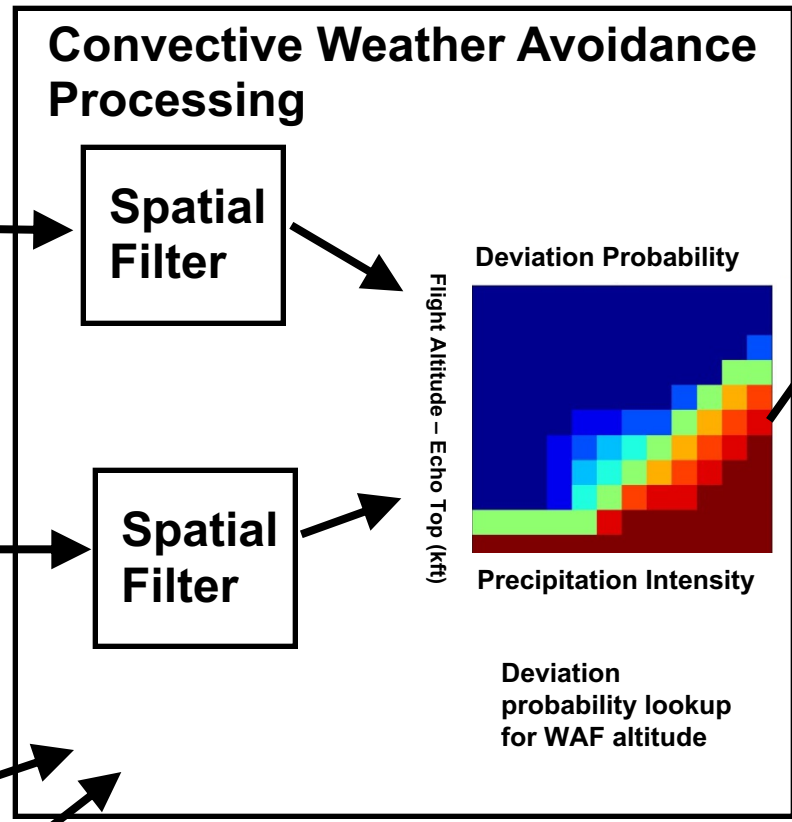
- **"Human factors"**

Convective Weather Avoidance Modeling

- **The Weather Avoidance Field (WAF) uses the model to predict the probability a pilot will avoid a region of convective weather**
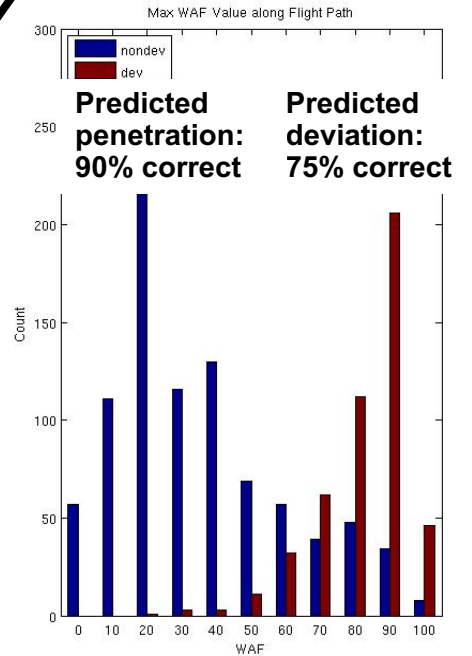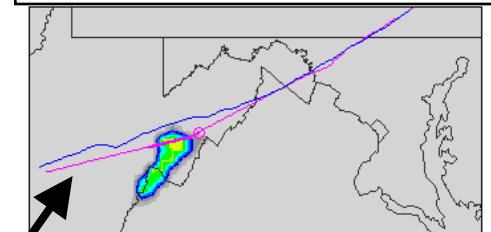

CIWS Precipitation

CIWS Echo Tops

Turbulence

Visual Cloud Indicators

Convective Weather Avoidance Processing

Spatial Filter

Spatial Filter

Deviation Probability

Flight Altitude – Echo Top (kft)

Precipitation Intensity

Deviation probability lookup for WAF altitude

Weather Avoidance Field

Max WAF Value along Flight Path

nondev
dev

Predicted penetration: 90% correct
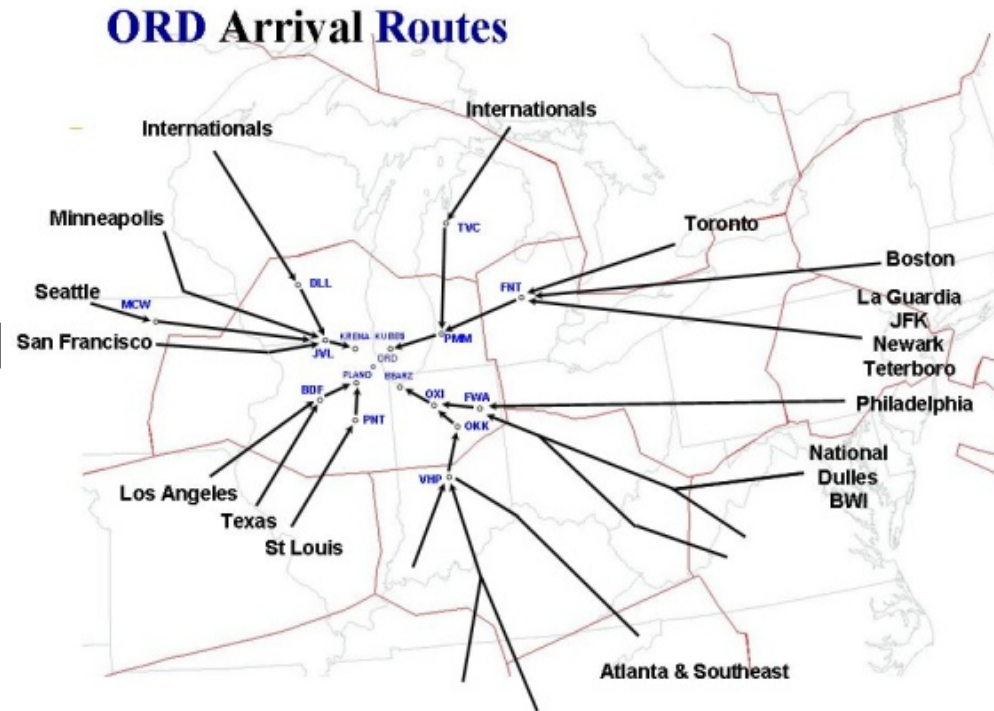
Predicted deviation: 75% correct

"Capacity" In Convective Weather

- **Sector occupancy versus flows as the control mechanism in convective weather**

- **Does controller workload need to be considered for NextGEN "mid-term" applications?**
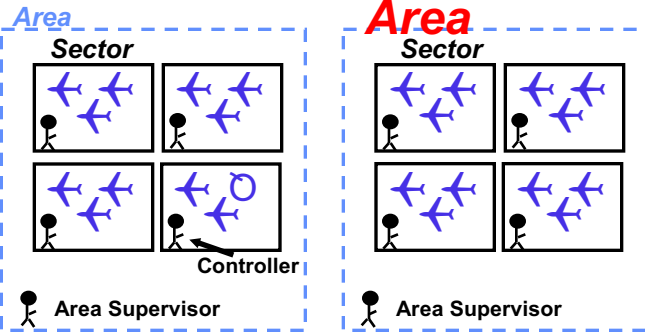
Best reported agreement to date between predicted and actual airspace usage has been with models that consider normal route blockage

ORD Arrival Routes

RAPT 2008 Field-Assessment

Facilities

Area

Sector

Area

Sector

Controller

Area Supervisor

Area Supervisor

ZNY **ARTCC**   *TMU*

ZOB, ZDC, ZBW

Towers
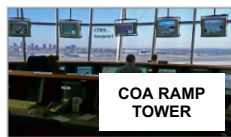
LGA

JFK

EWR

TEB

N90 TRACON

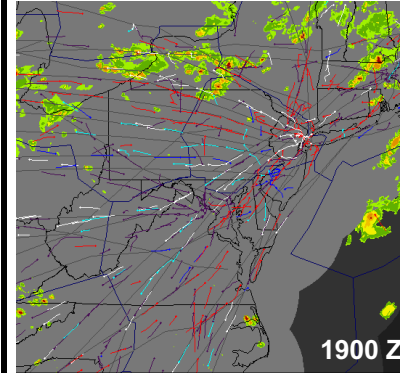Traffic Management Coordinators (TMC)

Airlines

COA RAMP TOWER

ATCSCC

11 Total Facilities; 39 hours of observations

Weather

Day 1: 21 July   **Day 2: 22 July**

1900 Z   1830 Z
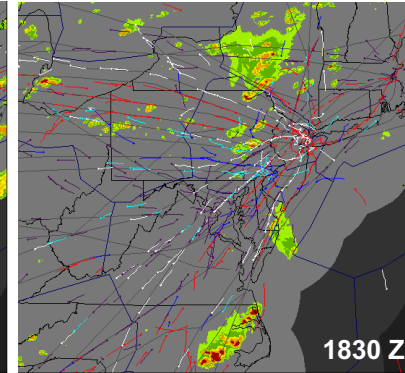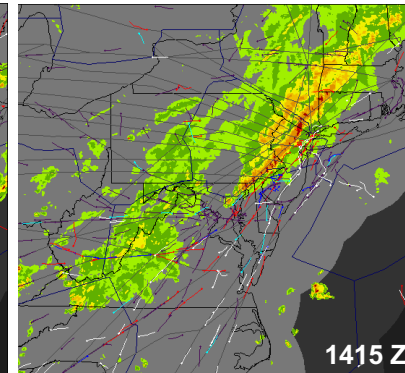
Day 3: 15 August   **Day 4: 09 September**
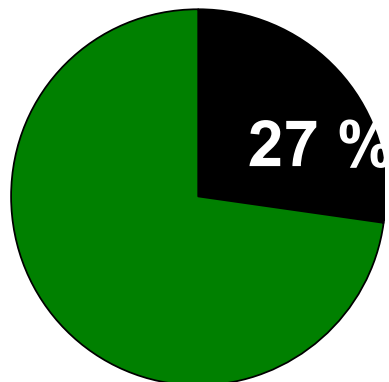
2130 Z   1415 Z
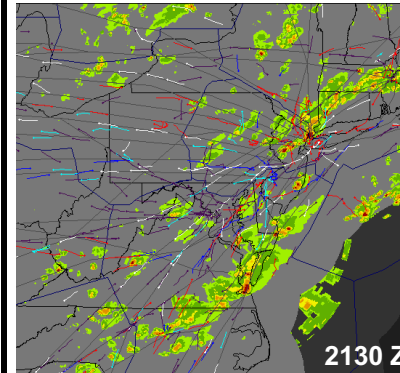
Achieved benefits in 2008 were << potential benefits due to user acceptance, inter- and intra-facility coordination and, situational awareness problems
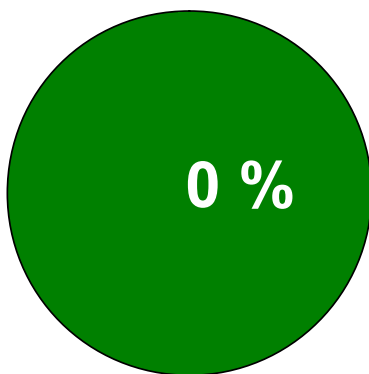
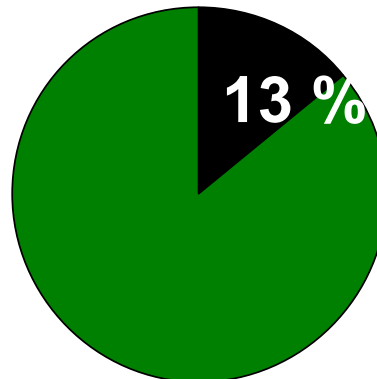# % Route Reopening Missed Opportunities per "Route"

1. COATE/GAYEL
J36 / J95
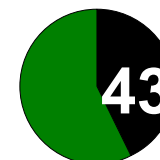
27 %

22 cases

2. ELIOT
J60 / J64 / J80

0 %

20 cases

3. J6 / J48 / J75

13 %

22 cases

4. WAVEY

43

7 cases

11 SWAP Case Days

Total cases = 113
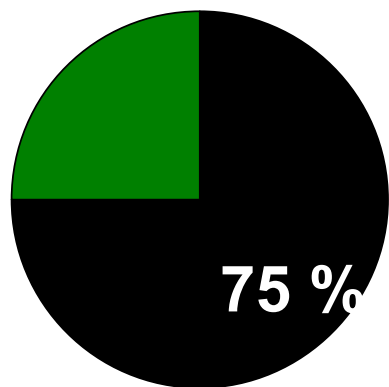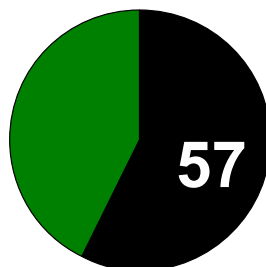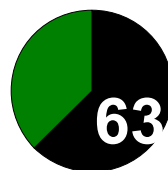
🟩 Route reopens – no missed opportunity (73)
⬛ Route reopen missed opportunities (40) – 35%

5. RBV
J60 / J64

75 %

20 cases

6. RBV
J80 / J6

57

14 cases

7. RBV
J48 / J75

63

8 cases
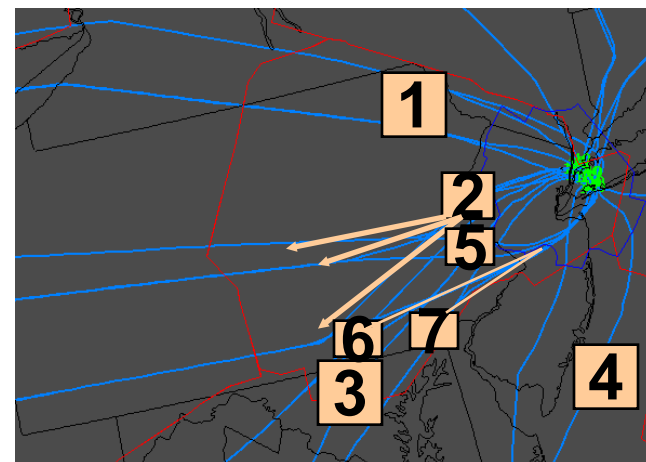
Business Case for Investment

- **Objectives**
  - **Quantify benefits of improving convective weather forecasts and ATM**
  - **NEXTGEN "mid term" opportunities**

- **Approach**
  - **Given time-varying capacities computed from weather products, produce wide-area ATM plan which minimizes total delay by flight routing plus air and ground holding.**
  - **Compare capacity usage by optimized plan with actual capacity usage**
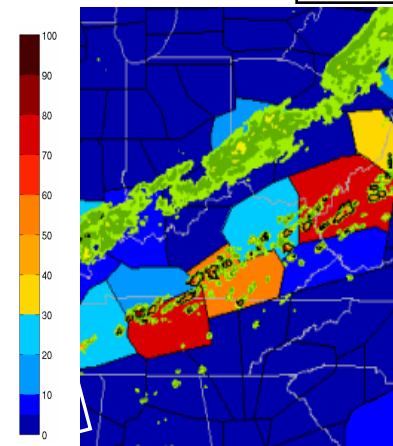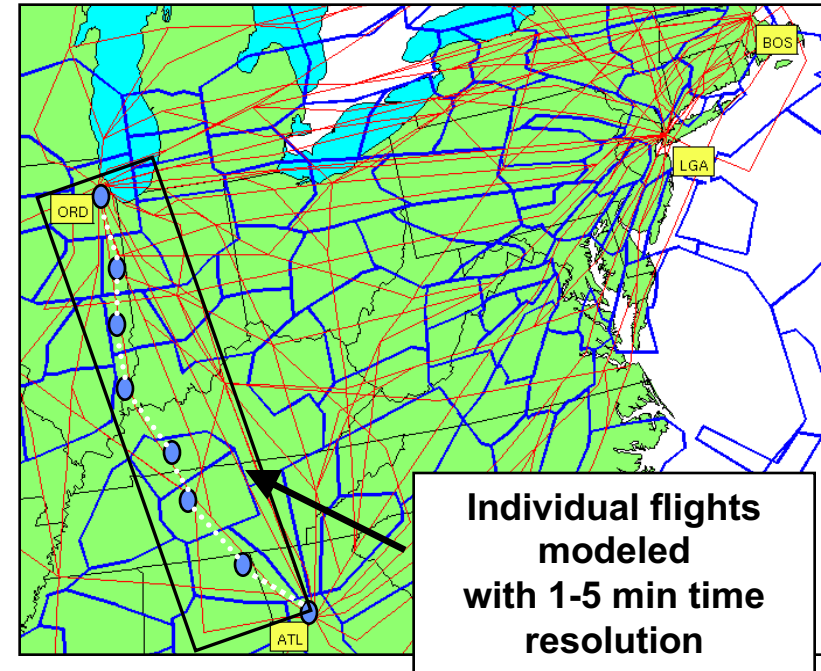
Results for 3 days from 2005:

- **75% of delay was avoidable;**
- **Missed opportunities were consistent with RAPT real time observations**

Individual flights modeled with 1-5 min time resolution

Summary

- **Convective weather** ⟹

    High delays, fuel consumption and emissions today due to en route <u>and</u> terminal congestion

    Major challenge for NEXTGEN 4D trajectories and high density ops

- **Improvements coming in forecasts > 2 hrs, but will not be able to provide highly accurate forecasts for many types of convective storms**

- **Weather-ATM integration essential, but need**
    1. **"Foundational studies" (pilot storm avoidance, "capacity", human factors)**
    2. **<u>Design</u> of adaptive "tactical" TFM***
    3. **Evolutionary development with "rapid prototyping"**
    4. **Effective way to couple weather and ATM communities**

*CATM will significantly improve ability to reroute planes in en route airspace