ATM-Weather Integration

AJP-B, Aviation Weather Office

Federal Aviation Administration

Presented to: FPAW – Vision Forum

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Date: July 22, 2009

Background

- **Research, Engineering & Development Advisory Committee (REDAC, October 3, 2007)**
- **Report of the Weather-ATM Integration Working Group**
  - The objective of ATM/Weather Integration is a seamless and transparent system that accounts for weather effects in all of the ATM algorithms.
  - *Recommendation: Translate weather information and forecasts to parameters relevant to decision support tools.*
  - *Recommendation: Implement Tactical Trajectory Management with integrated weather information.*

Background (continued)

- **The 2009-2013 Flight Plan Objective 1 (Increase capacity to meet projected demand and reduce congestion) has the associated initiative target: "Deliver the Weather Integration Plan version 1.0 to the NEWP by September 30, 2009."**
  - Stand up a cross-disciplinary team to prepare the ATM-Weather Integration Plan

Problem Statement

Most weather support to ATM is manual, with weather displays that must be interpreted by the user

- **Weather products do not have the maturity nor are they translated into impact information required for direct insertion without interpretation ***
- **Rules for interpretation and use of weather data are generally based on the experience of the user**
- **ATM decisions based upon today's weather products are inconsistent from user to user**

*** This aspect of the problem is addressed in the NextGen Weather Plan rather than in the ATM-Weather Integration Plan**

Working Definition

ATM-Weather Integration:

The inclusion of weather information

- into the logic of an ATM decision process or decision aid
- such that weather impacts have already been taken into account when the decision is made or recommended

Conceptual Flow of the Plan

State of the Atmosphere	Translated Impact Parameters	Decision Rules	Decision System
Examples: • Convective wx forecast • Turbulent EDR (Eddy Dissipation Rate) From: weather systems Ownership: wx community with requirements from users Located: 4D Weather Data Cube	Examples: • CWAM (Convective Weather Avoidance Model) • EDR index to aircraft type From: Appendix B Ownership: wx community with user guidance Located: multi-use in network service; unique in user systems	Examples: • Acceptable severity level • SFO (San Francisco Airport) parallel approach From: user community, with support from Appendix B Ownership: Users, with support from weather community Located: multi-use service; unique in user systems	Examples: • TFMS (Traffic Flow Management System) • TBFM (Time-Based Flow Management) From: users, and cataloged in Appendix A Ownership: users Located: user systems

Status

Wx-ATM Integration Plan Status

Bring together two communities

1. Capabilities under development (Sub-team 1)
   - Solution Sets
   - JPDO Working Groups
2. Technologies and methodologies for (Sub-team 2)
   - Translating weather into impacts
   - Dealing with uncertainty

Program management support (Sub-team 3)

Wx-ATM Integration Plan Status (continued)

- **Kick off meeting held November 18, 2008**
- **April 22, 2009 – Draft V 0.7**
  - review & comments
- **July 10, 2009 – Draft V 0.8**
  - August 10, for review & comment
- **On track for V1.0 on September 30, 2009**

Execution Concept

Step process

1. Analysis and team alignment
2. Determine integration opportunity points
3. Identify which impact methodologies apply
4. Support implementation into tools and processes

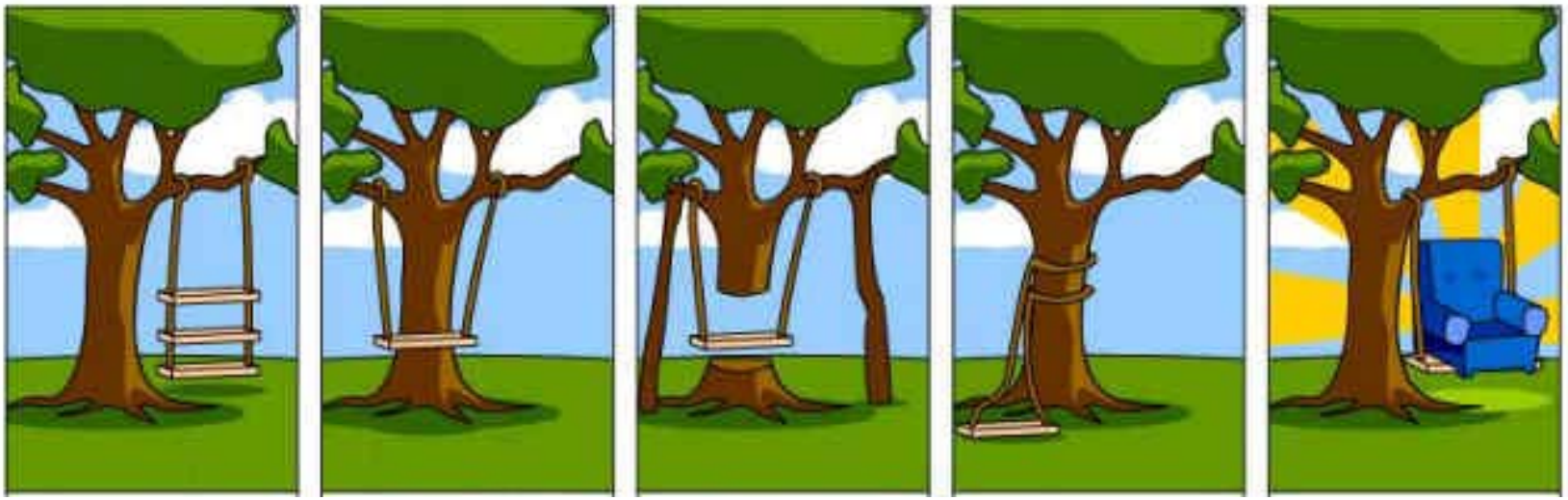
Mature wx translation methodologies

- Development
- Test and evaluation
  - Increase the Technology Readiness Level (TRL)

“Vision Forum”

Keeping an Operational View

Getting the User Requirements Right



How the customer explained it	How the project leader understood it	How the analyst designed it	How the programmer wrote it	How the business consultant described it

Getting the User Requirements Right

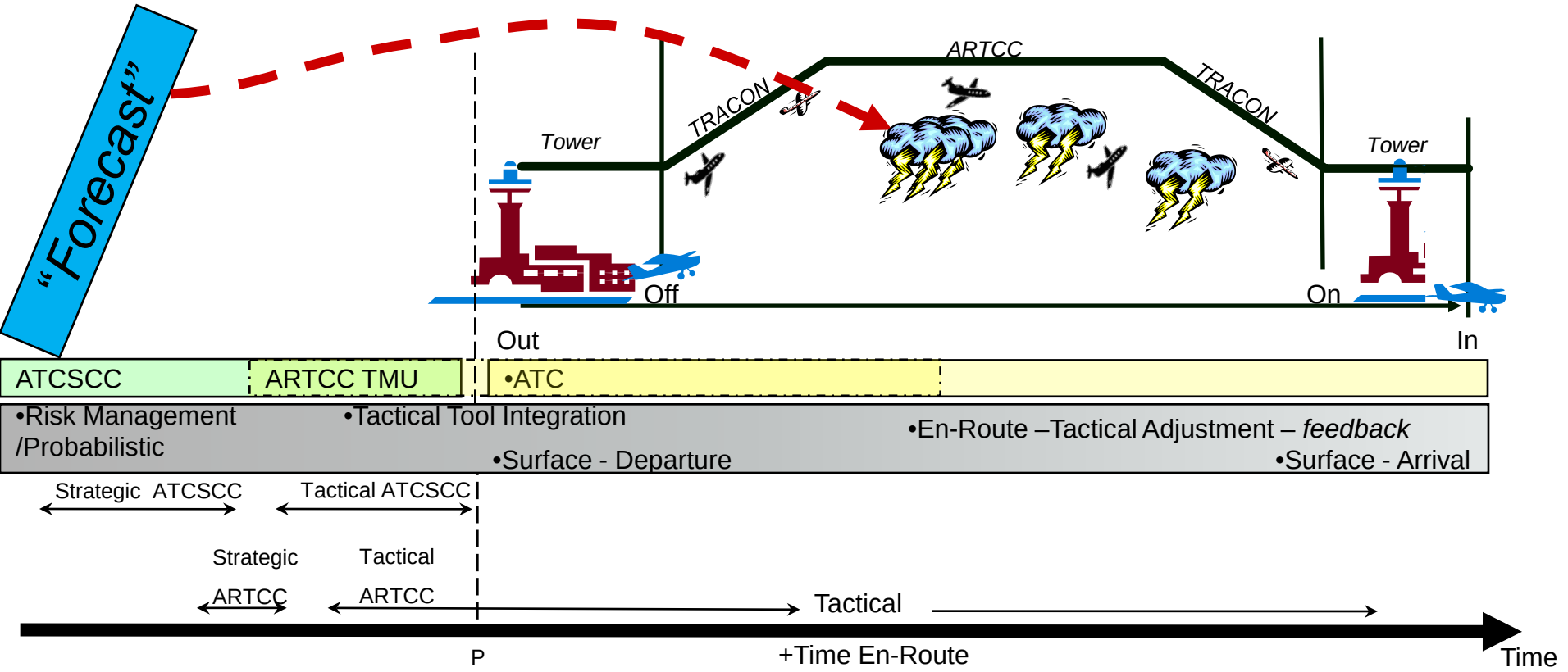
How the project was documented	What Operations installed	How the customer was billed	How it was supported	What the customer <u>really</u> <u>needed</u>

When will the weather materialize/dissipate? *What is the expected coverage?* *In what location?*

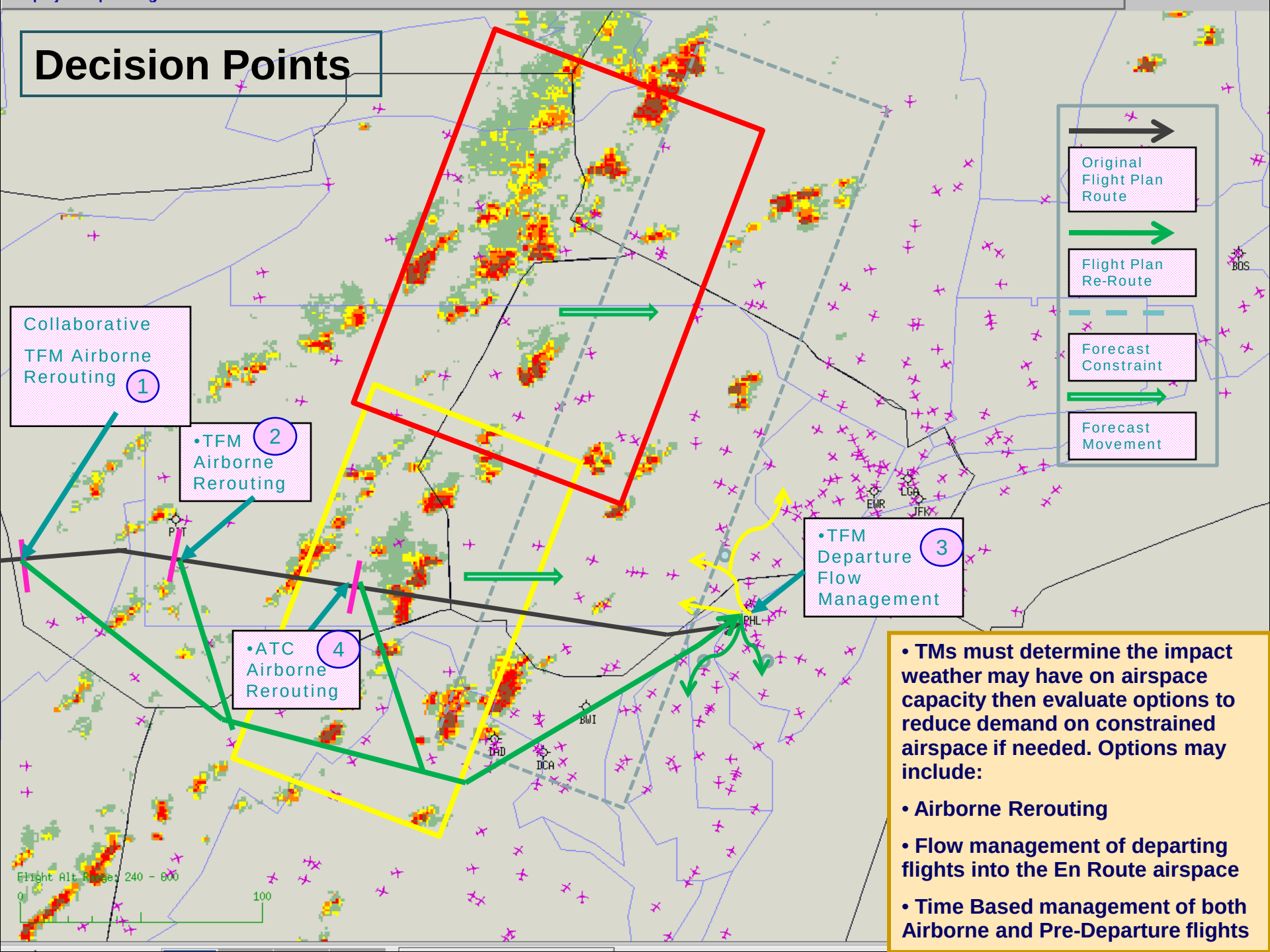
What is the traffic demand at that time? *How much demand will need to be moved (re-routed or delayed)?*

Can the area be over-flown? *What is the risk to today's or tomorrow's operation?*

Post event analysis - how do we assess how well we did?



Decision Points



- **TMs must determine the impact weather may have on airspace capacity then evaluate options to reduce demand on constrained airspace if needed. Options may include:**
- **Airborne Rerouting**
- **Flow management of departing flights into the En Route airspace**
- **Time Based management of both Airborne and Pre-Departure flights**

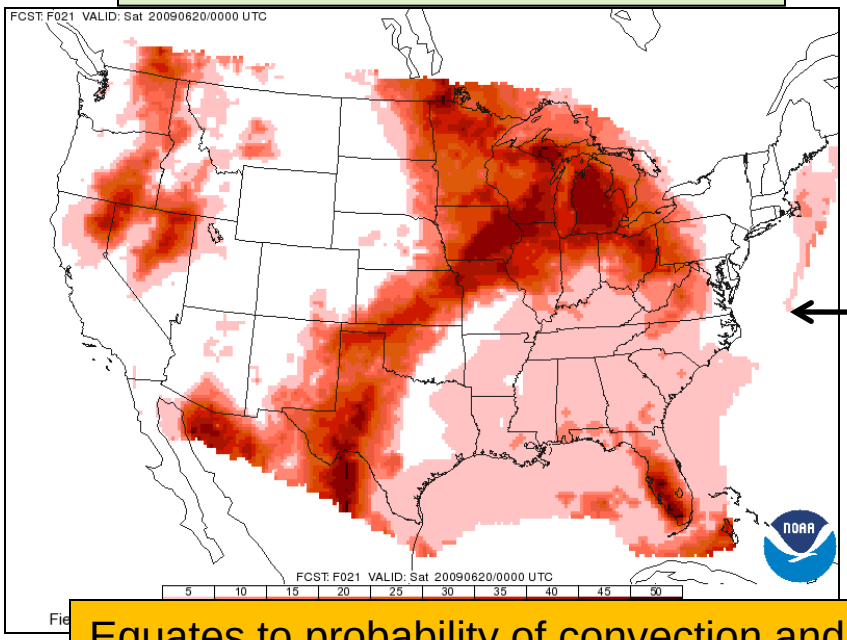
Tackling the Problem

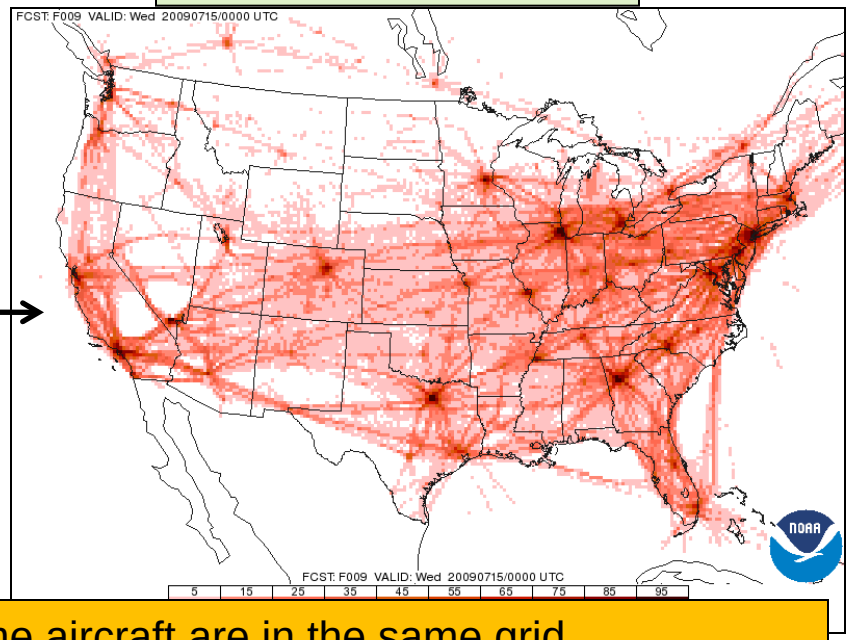
Examples:

- Improved weather detection/prediction integration with TMA, FY08 Demo
- Long Range Strategic Planning - Risk Management
- CDM FCT, System Enhancement for Versatile Electronic Negation (SEVEN) – Planning Options
- Integrated Departure Route Planning (IDRP) - Getting Airborne
- En-route Flow Planning Tool (EFPT) – Airborne Tactical Adjustments
- Turbulence - Eddy Dissipation Rate (EDR)

TFM - Long Range Strategic Planning

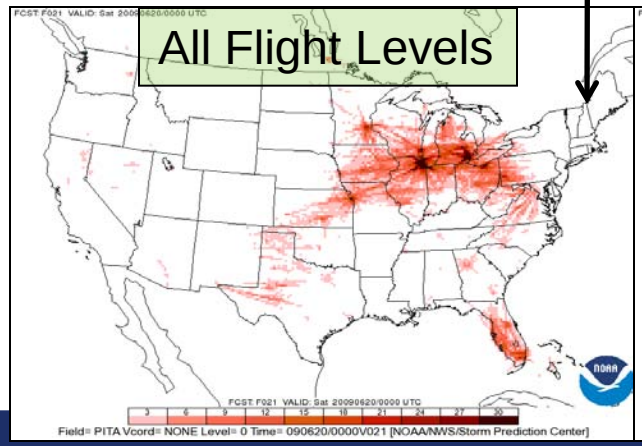
SPC SREF (Wx model data) ⟷ Historical Air Traffic



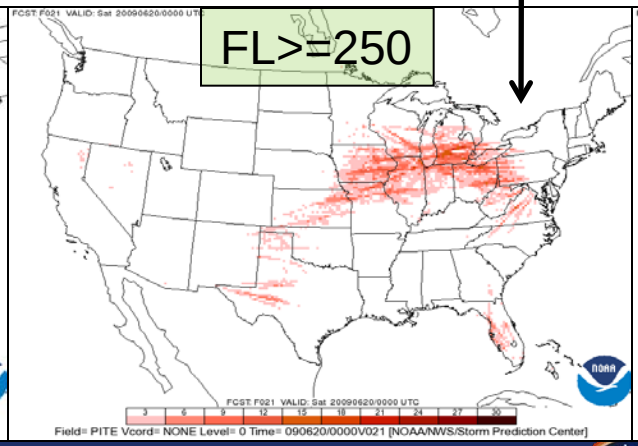


Equates to probability of convection and % time aircraft are in the same grid

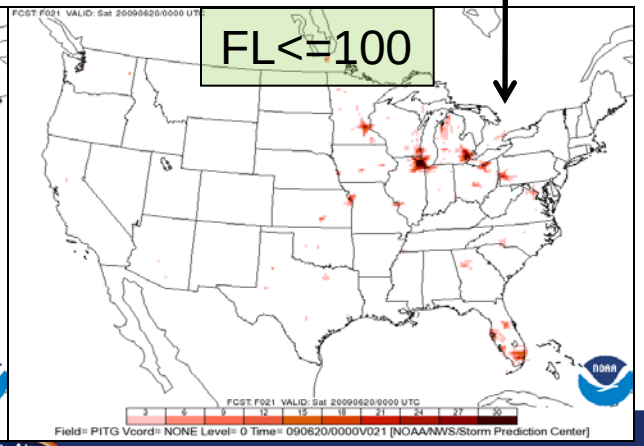
All Flight Levels



FL>=250

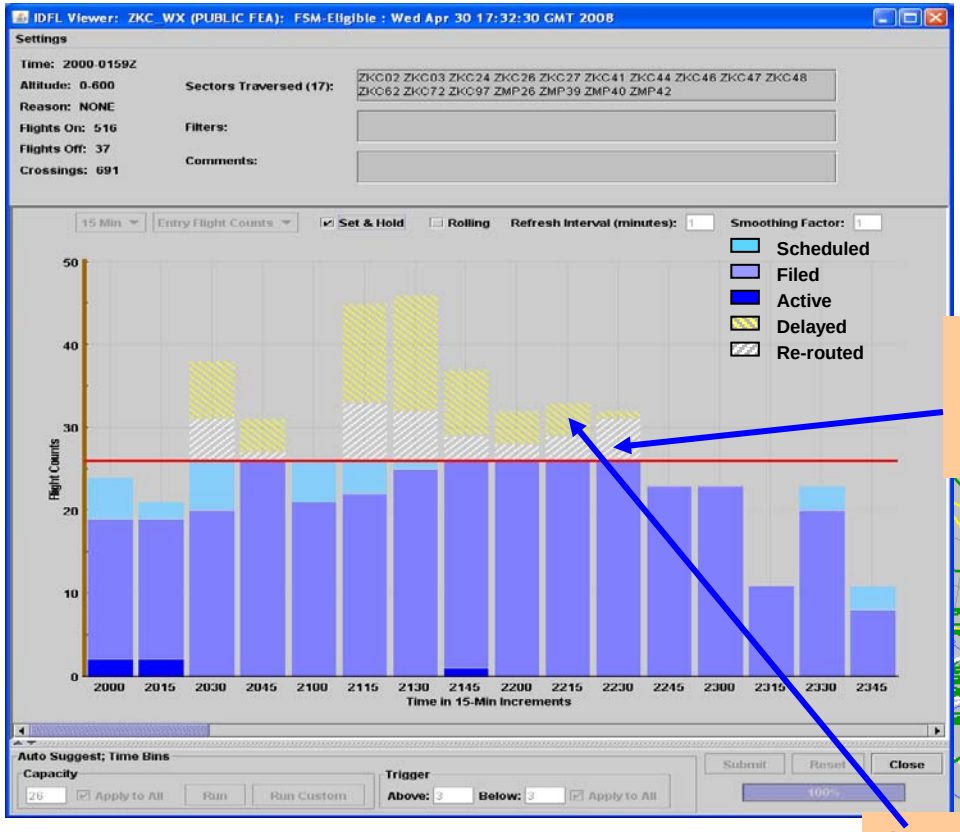


FL<=100

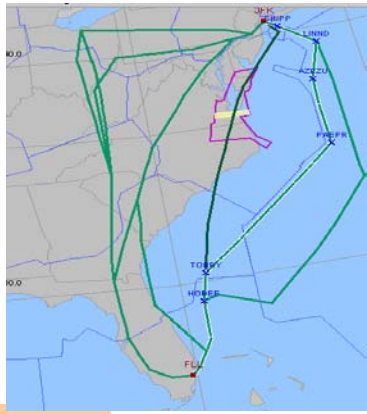


Concept SEVEN 7

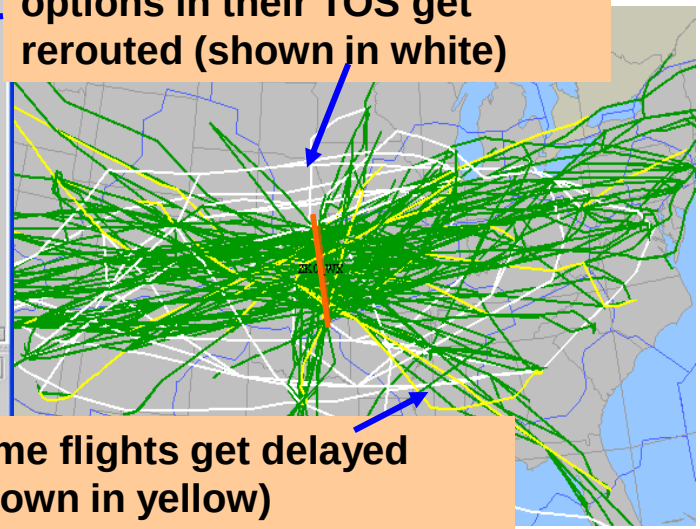
ATCSCC conferences stakeholders. Decides to dial down to 60% capacity.



Trajectory Option Set (TOS)



Flights with valid reroute options in their TOS get rerouted (shown in white)



Some flights get delayed (shown in yellow)

Demand through the ZKC FEA at 17:32z after capacity dial down to 60%

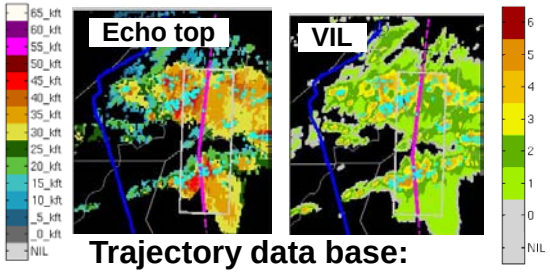
Question:

- **How far do you turn down the “Big Dial” of SEVEN?**

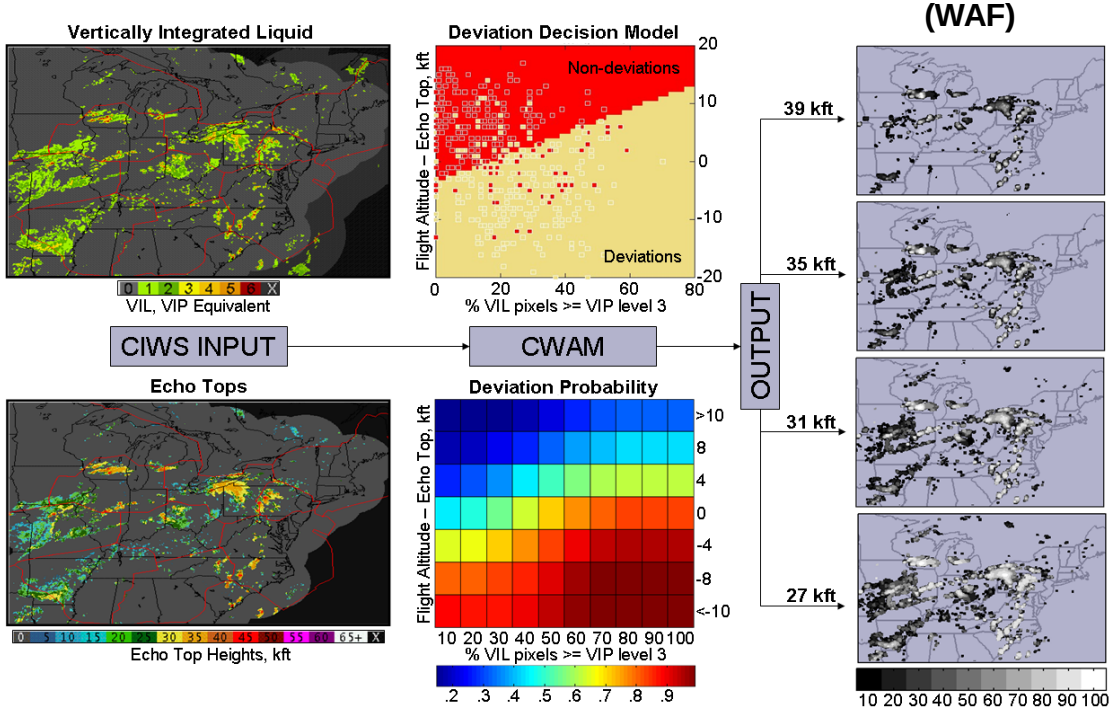
- **Answer: look to the weather translation methodologies**

Weather Avoidance Field (WAF)

Creating the Model



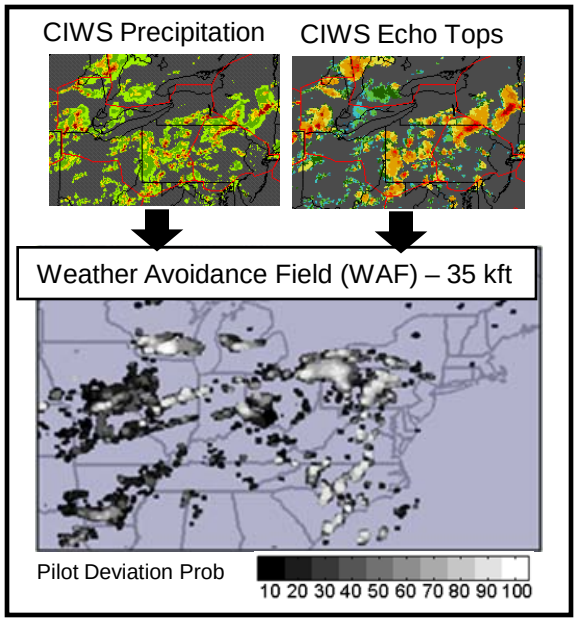
Applying the Model

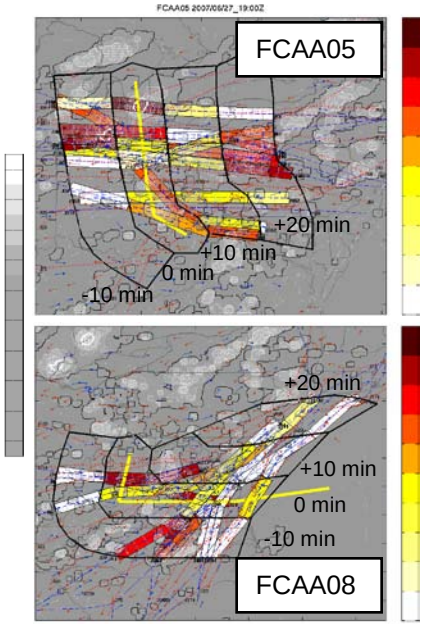


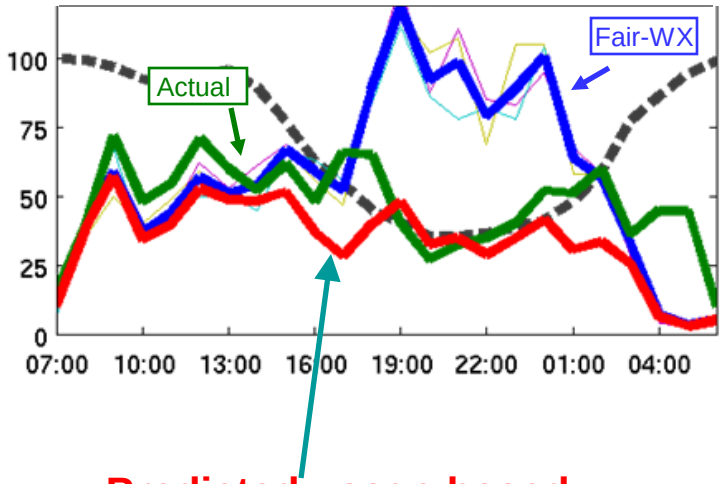
- **WAF gives probability of deviation at each pixel**

Throughput Estimation from WAF / CWAM

Actual Weather → **Estimate AFP Airspace Availability** → **AFP Throughput Estimate**

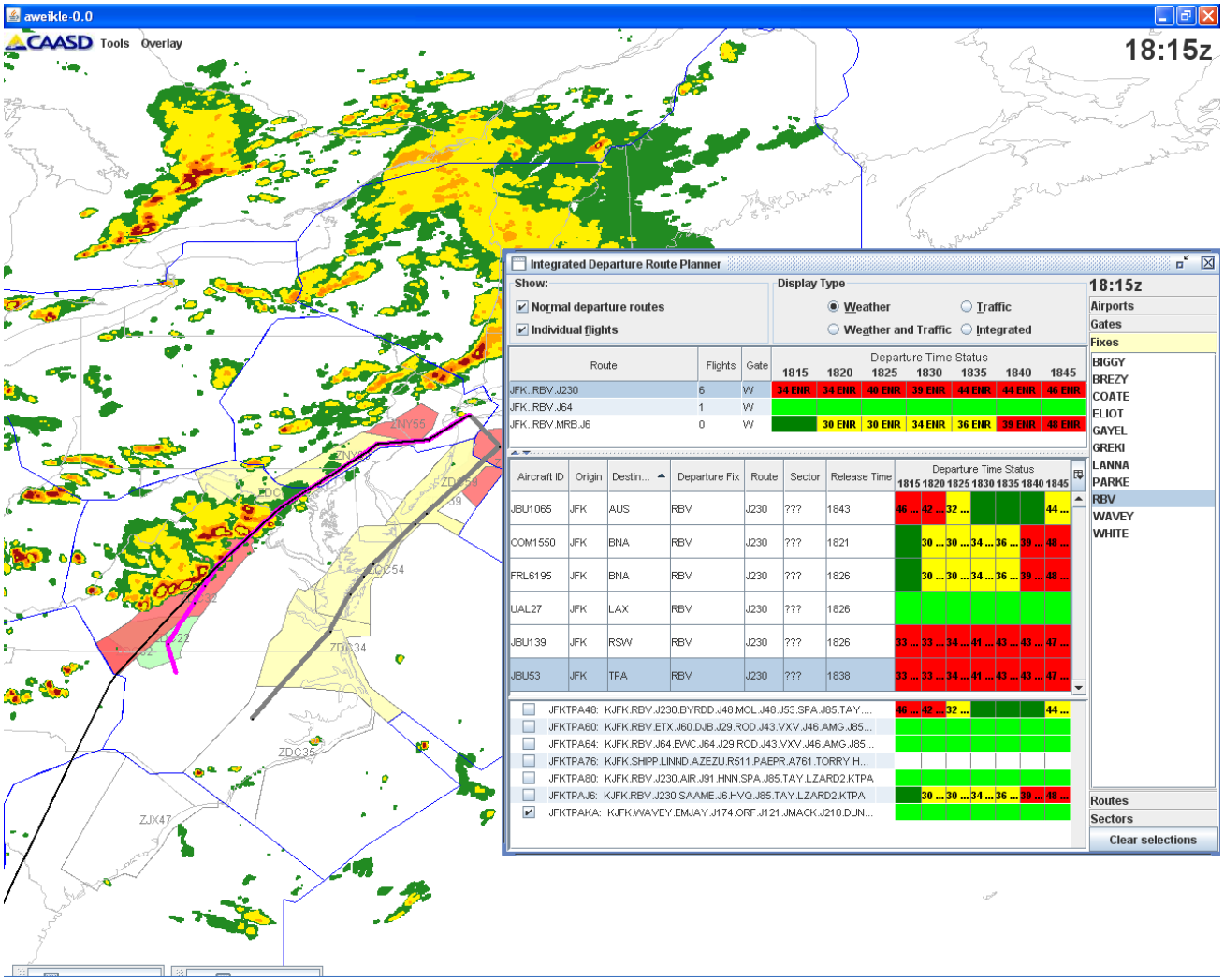




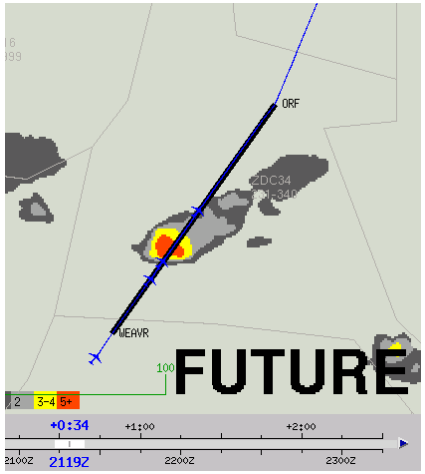


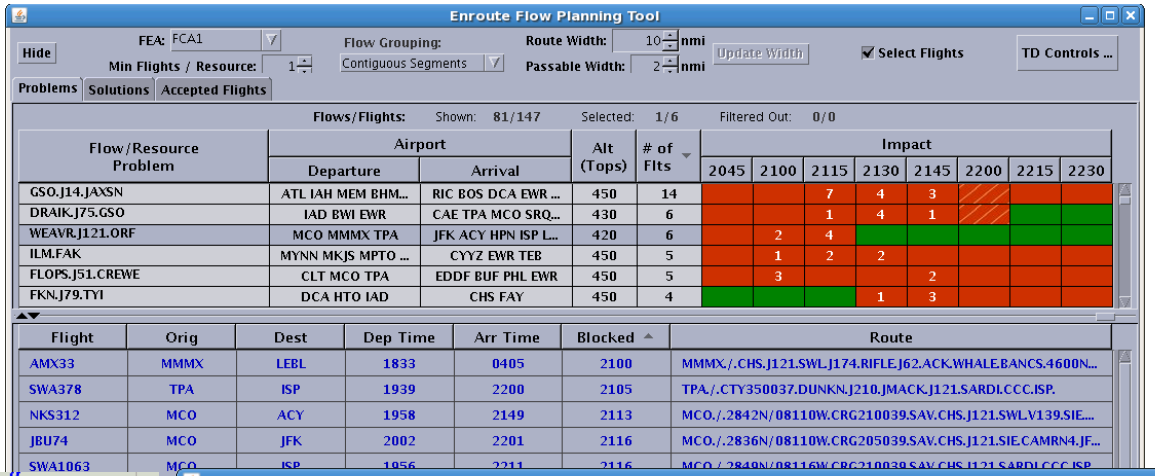
- **Route Blockage Model used to determine individual route availability (RA)**

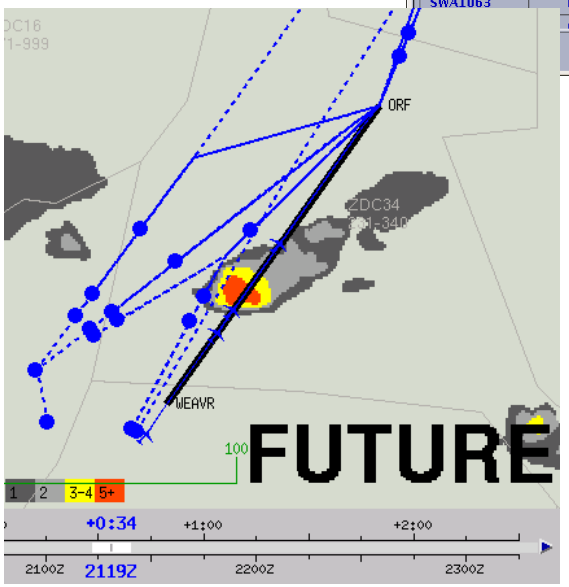
Integrated Departure Route Planning

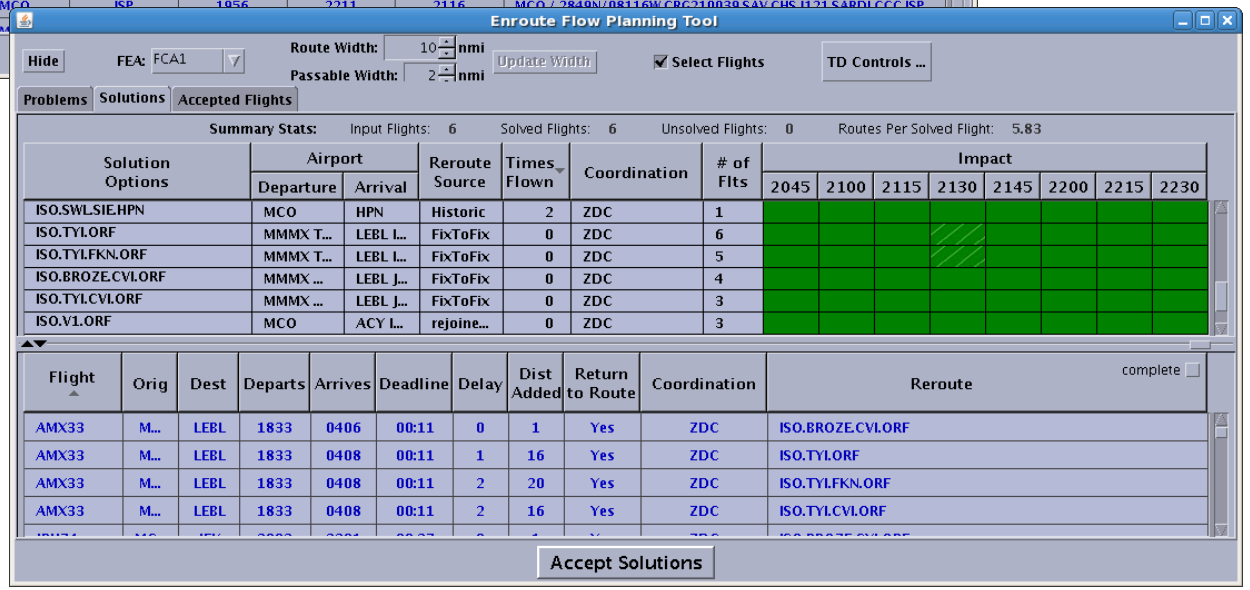


En-Route Flow Planning

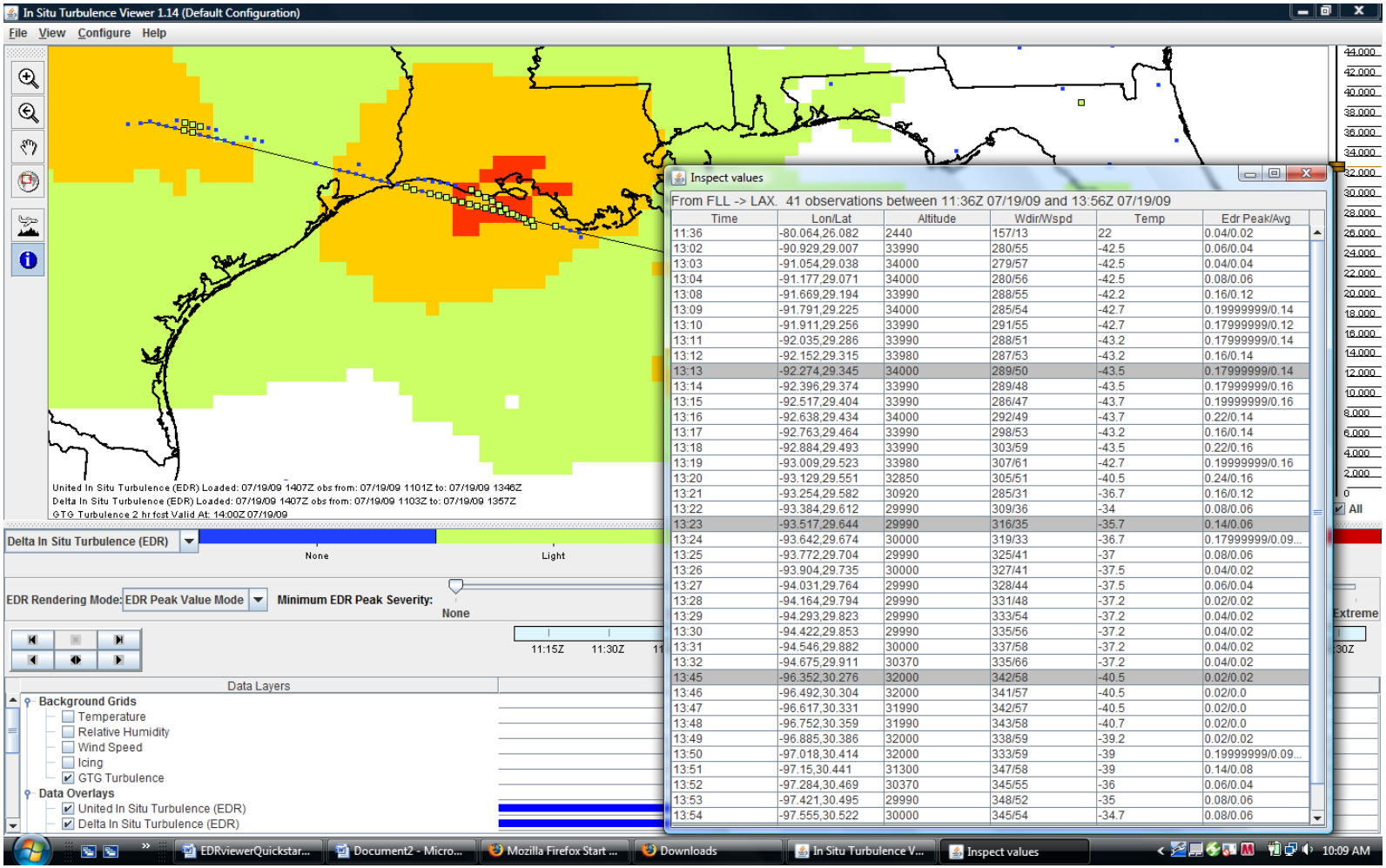








In Situ Turbulence - EDR

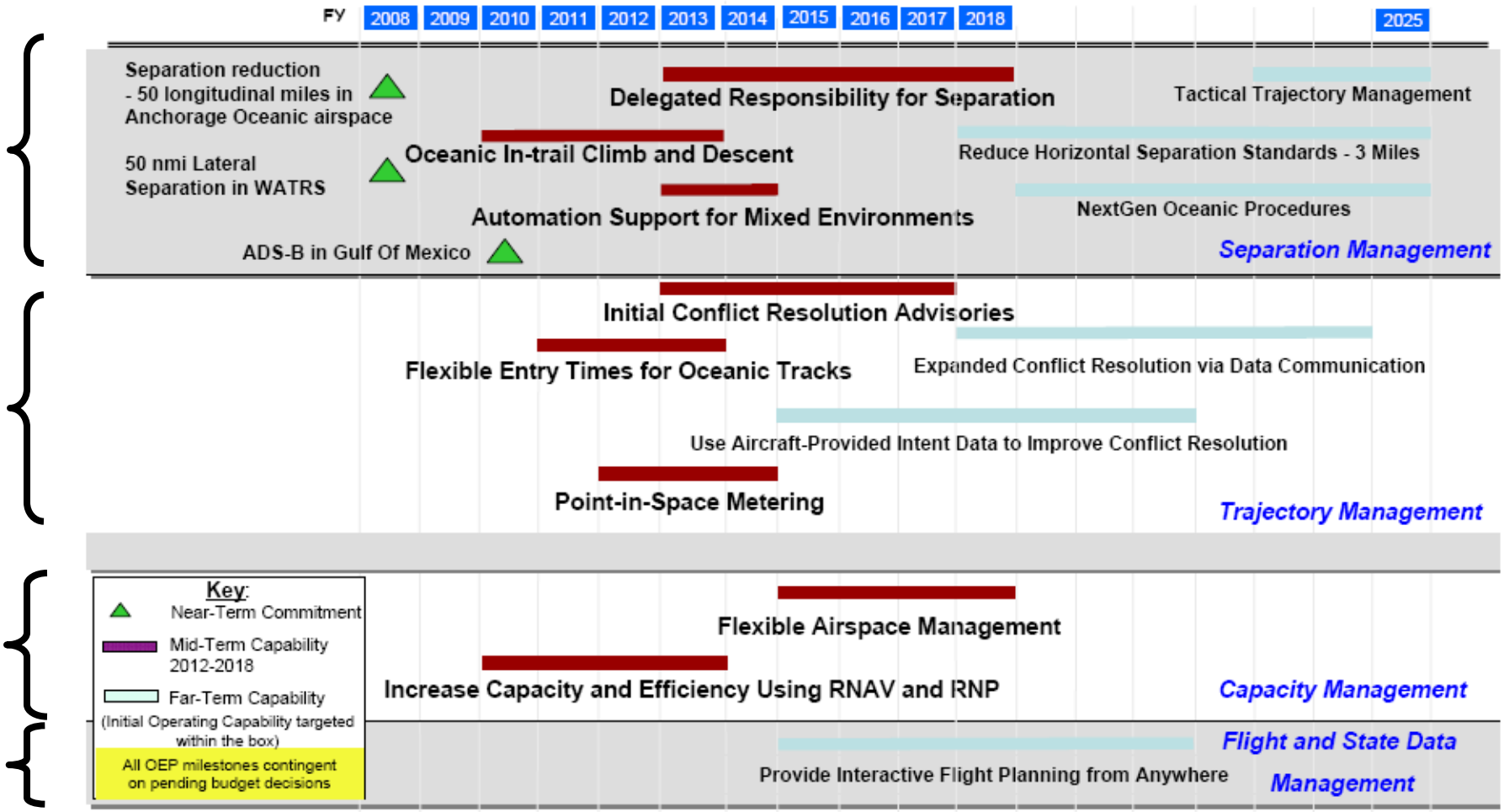


Summary

- The Wx-ATM integration plan brings together improved capabilities and concepts along with the developing methods of translating weather into ATM impacts
- The solution set spans a wide range of User needs, from Risk assessment due to the weather uncertainty to quick tactical- immediate decisions required by the system.
- As we move forward, we can't lose sight of the Operational Requirements and ensure that they are being met.

Back-ups

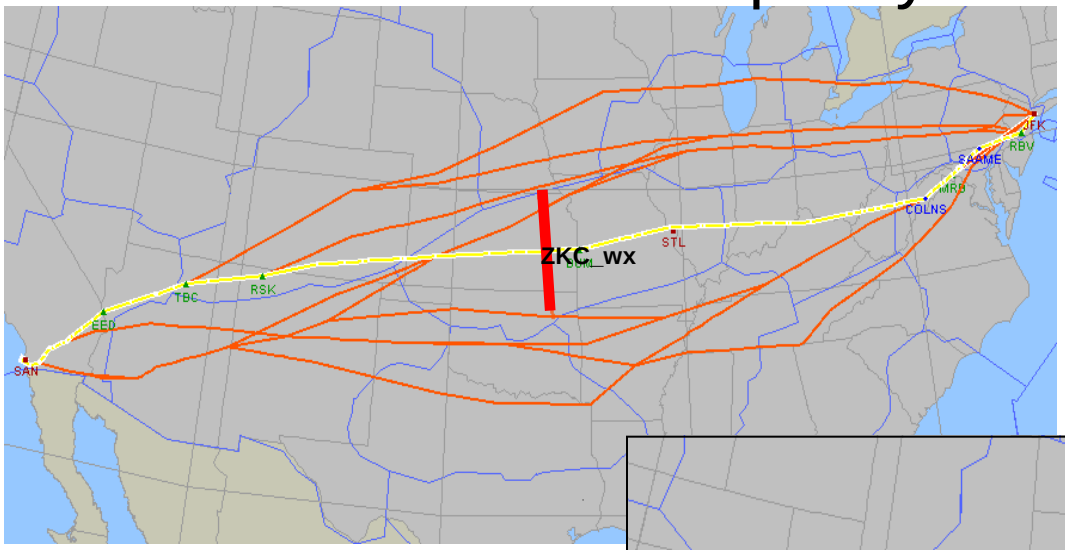
Example of "Swim Lanes" from NGIP



Integration

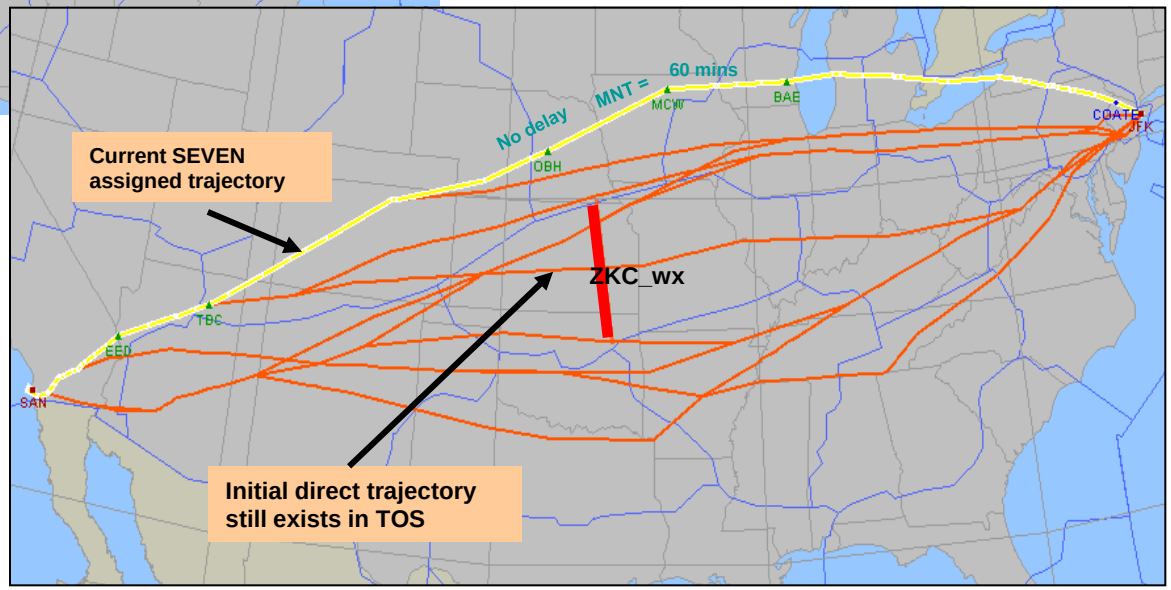
- **Integration refers to the inclusion of weather information into the logic of a decision process or decision aid such that weather impacts have already been taken into account when the decision is made or recommended**
- **Goal: minimize the need for humans to gauge NAS weather impacts or to determine the optimum mitigation**
  - Today, “integration” mostly manual after viewing weather products
  - At NextGen Weather IOC (2013)
    - Some weather flow machine-to-machine with real DST integration
    - Most integration still manual with improved “high glance value” weather
    - Data and displays will be provided to the cockpit for pilot decisions
  - By 2018, mid-term decision support tools and processes to have integrated weather
  - By 2025, weather information to be automatically translated to impacts and ingested into most decision algorithms (ground and cockpit)

ATCSCC dials down capacity –impact on a particular flight.



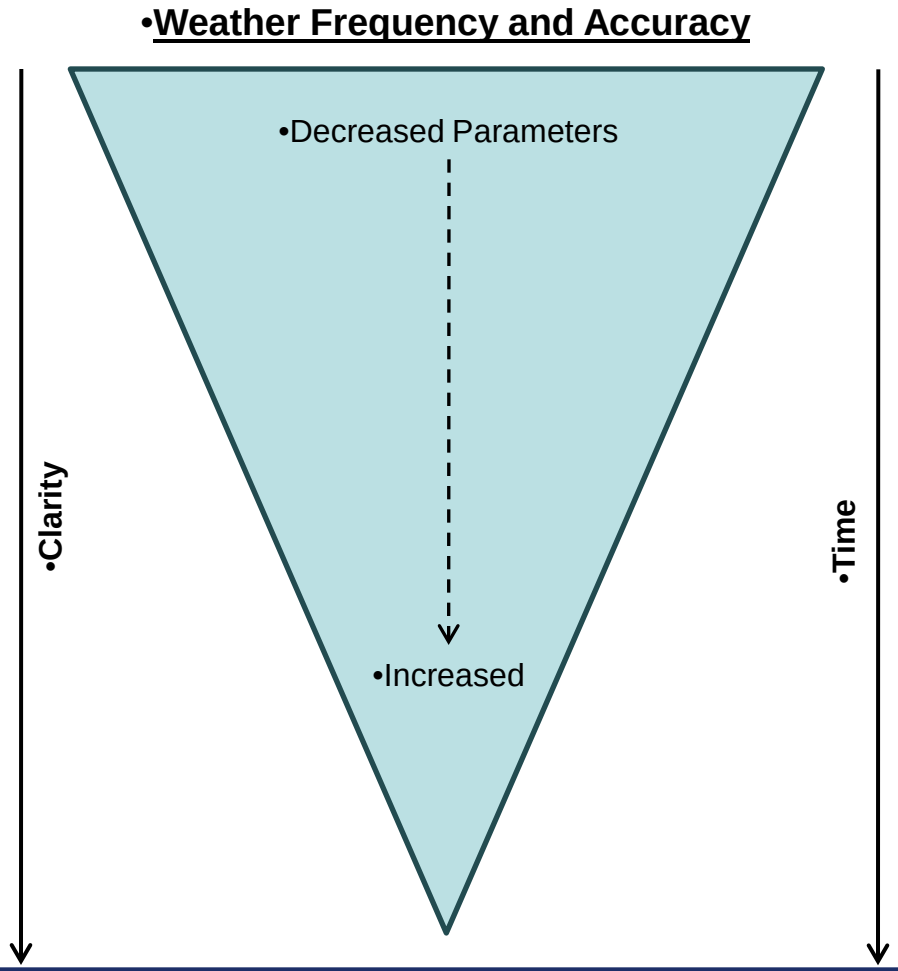
TOS for pre-dial down

post-dial down



RMNT: Route Minimum Notification Time *required by the user to accept the given trajectory*

•How do Wx Needs Change in Different Situations?



Scenario Timeline

- **Strategic Planning/Risk Analysis (i.e. 8+ and greater - Hrs)**
- **Flight Planning &Strategic Operations Plan (i.e. 2-8 Hrs)**
- **Tactical Airborne Reroute – ARTCC (i.e. 1-2 Hrs)**
- **En route Tactical Decisions – Multi-sector, pilot/controller**
  - **i.e. 20-40 min**
  - **i.e. 0-20 Min**
- **Tactical DEP/ARR Fix Blockage**
- **Terminal/Facility Operations**

Process	Examples
Solution Set	• Initiate Trajectory Based Operations (TBO)
Swim Lanes	• Separation Management • Trajectory Management • Capacity Management
Capability (OIs): Near/Mid/Far-term	• ADS-B in Gulf of Mexico (Near-term) • Point-in-Space Metering (Mid-term) • Tactical Trajectory Management (Far-term)
Assessment: What is the weather link? What is currently in development?	• WARP: enhanced forecasts – winds, convection, etc. • ESP Delay Estimation (CE)
Decision Process	• Monitoring/Constraint ID/Analysis/Planning/Execution
Weather Integration Capabilities & Requirements	• Assumptions • Scenario and Use Cases

•We Read the Headlines……

•**Weather delays flights at Newark-area airports**

•by The Associated Press Wednesday December 10, 2008, 7:12 PM

•NEW YORK -- Flights at New York City area airports have been delayed by rainy weather.

•LaGuardia Airport is reporting average flight delays of 3 hours on arriving and departing flights Wednesday evening.

•Thanksgiving Air Travel Foiled by Weather Delays

•**BOTTOM LINE WEATHER POINTS**
– Weather delays significantly slowed airport traffic during Thanksgiving weekend.
– On-time arrivals fell below 50% mark on Sunday, Nov. 30 due to weather delays.
– Snow and rain made 4 hour delays "commonplace" during Sunday air travel.

•THURSDAY, DECEMBER 4, 2008

•**Heavy Rain, Wind Delay Travel as Storm Heads North**

•By Chris Dolmetsch; March 5 (Bloomberg)

•**Airlines Struggle to Weather Summer Storms**

•By Keith L. Alexander; Tuesday, July 11

Background

- **Weather accounts for 70%[1] of all air traffic delays within the U.S. National Airspace System (NAS)**
  - Total cost as much as $41B annually[2]
  - Thus weather portion costs over $28 billion annually
- **Up to two thirds of the weather delays are avoidable[3] implying benefits pool of ~$19B**

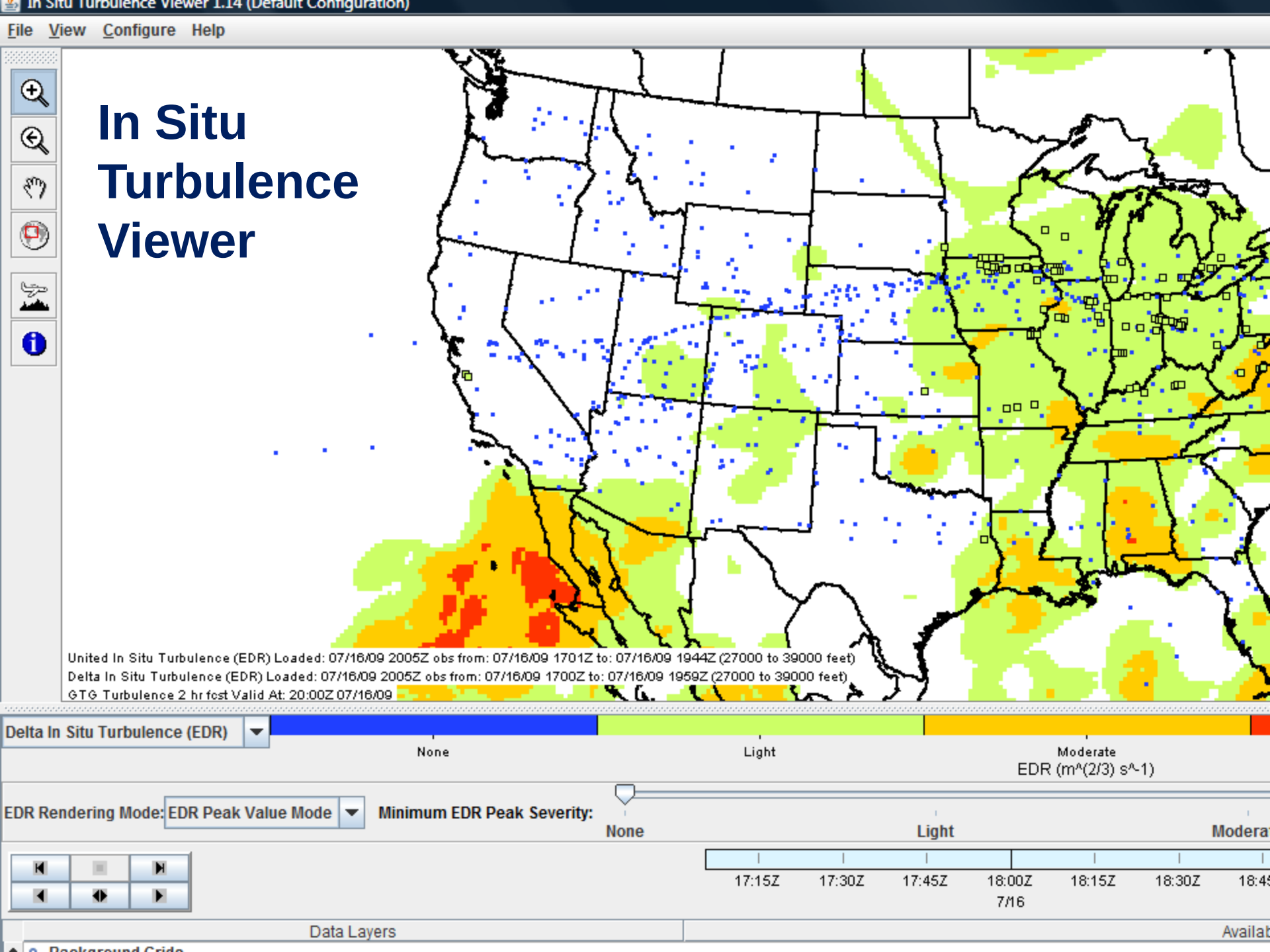
Sources: 1: OPSNET

2: Congressional Joint Economic Committee; May 2008

3: REDAC Weather-ATM Integration Working Group Report; Oct 3, 2007

Wx-ATM Integration Plan Status (continued)

- **Three sub-teams were formed**
  - Weather Integration Sub-Team 1 (WIST1): Operational Capabilities and Requirements
  - Weather Integration Sub-Team 2 (WIST2): Technology and Methodology
  - Weather Integration Sub-Team 3 (WIST3): Program Management and Documentation


In Situ Turbulence Viewer
United In Situ Turbulence (EDR) Loaded: 07/16/09 2005Z obs from: 07/16/09 1701Z to: 07/16/09 1944Z (27000 to 39000 feet)
Delta In Situ Turbulence (EDR) Loaded: 07/16/09 2005Z obs from: 07/16/09 1700Z to: 07/16/09 1959Z (27000 to 39000 feet)
GTG Turbulence 2 hr fcst Valid At: 20:00Z 07/16/09
Delta In Situ Turbulence (EDR)
None
Light
Moderate
EDR (m^(2/3) s^-1)
EDR Rendering Mode:
EDR Peak Value Mode
Minimum EDR Peak Severity:
None
Light
17:15Z
17:30Z
17:45Z
18:00Z
18:15Z
18:30Z
7/16
Data Layers