

**NEXTOR Asilomar 2004**

---

# **Flexibility and Predictability in Management of Convective Weather Impacts on the NAS**

**Jim Evans**

**Senior Staff**

**MIT Lincoln Laboratory**

**Visiting Industrial Fellow**

**University of California, Berkeley**



# Outline

---

- **Why do we care?**
  - Delays
  - Metrics implications
- **Overall FAA/airline weather impact mitigation process**
  - Ability to predict weather impact with sufficient lead time is poor
- **Insights from the CIWS benefits assessment**
- **How can we achieve a higher degree of predictability through increasing flexibility in ATM during adverse weather**
- **Metrics and system design implications**





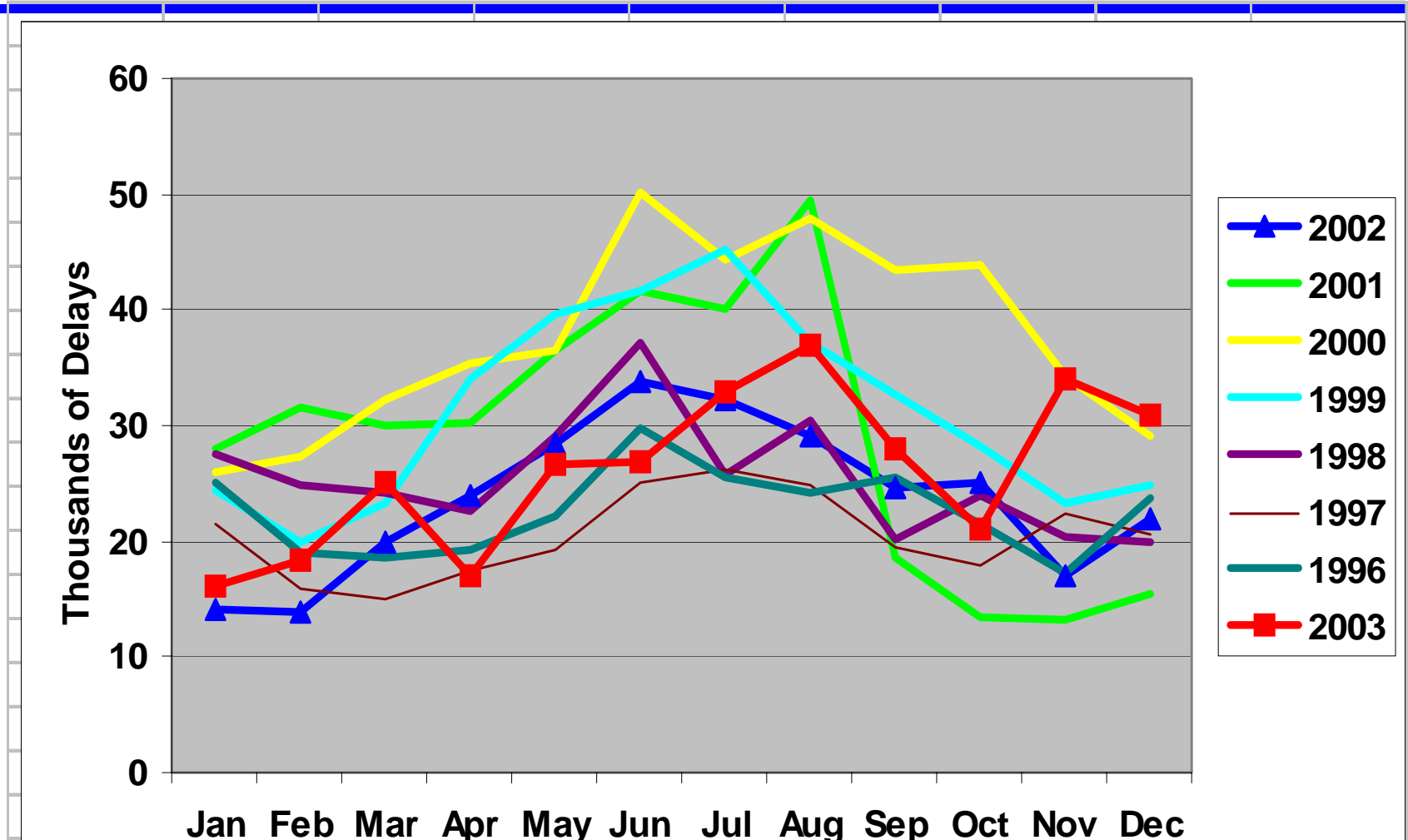
# Why of Interest and Concern

---

- **Airlines seek to reliably and economically deliver the desired product**
  - **Predictability is essential to airline network design and operation**
  - **Want flexibility to make adjustments to address problems and handle flight specific issues (e.g., high value connections)**
  - **Use of off ATC-preferred routes as a key flexibility index**
- **Initiatives underway to improve information transfer and navigation capability seek to provide a more predictable system for scheduling and increase flexibility**
  - **But predictability and flexibility are very hard to achieve when major capacity losses occur “randomly”**
- **Need to improve system design and develop better metrics capabilities**



# Trends in Aviation Delays

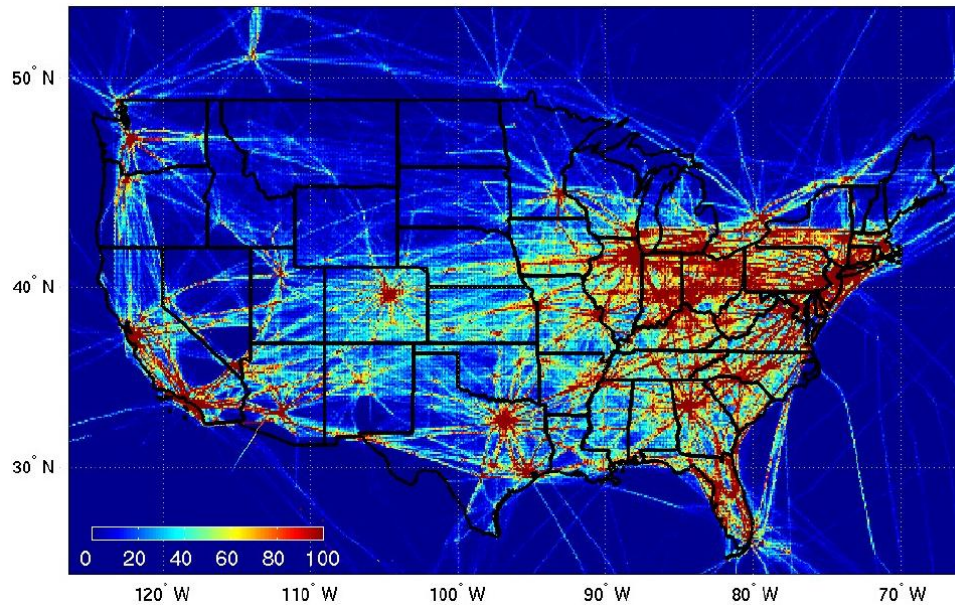


- Peak delays – summer thunderstorms → Delay reduction as metric

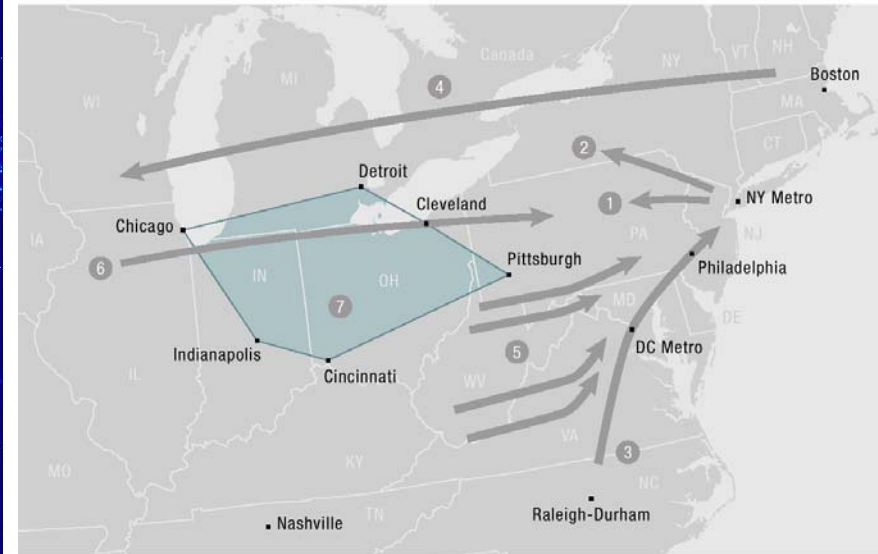


# Air Traffic Congestion

**Air Traffic 09/12/02 1000 UTC – 09/13/02  
1000 UTC**

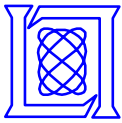


**ATC chokepoints**

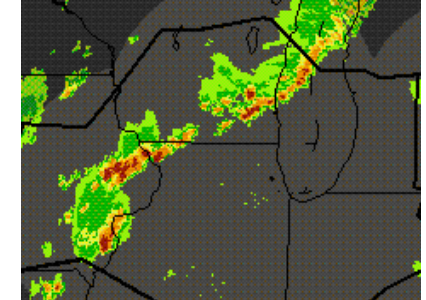
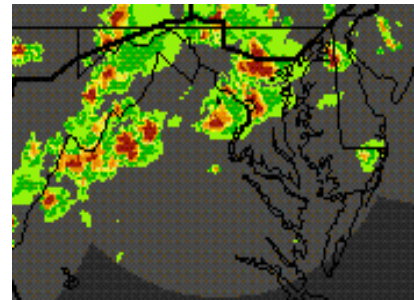
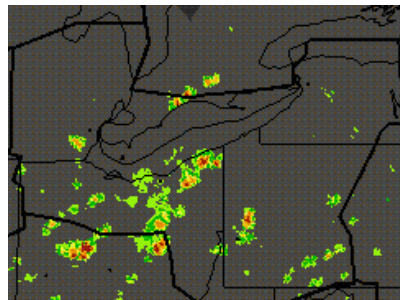
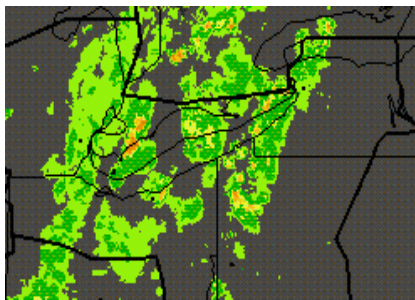
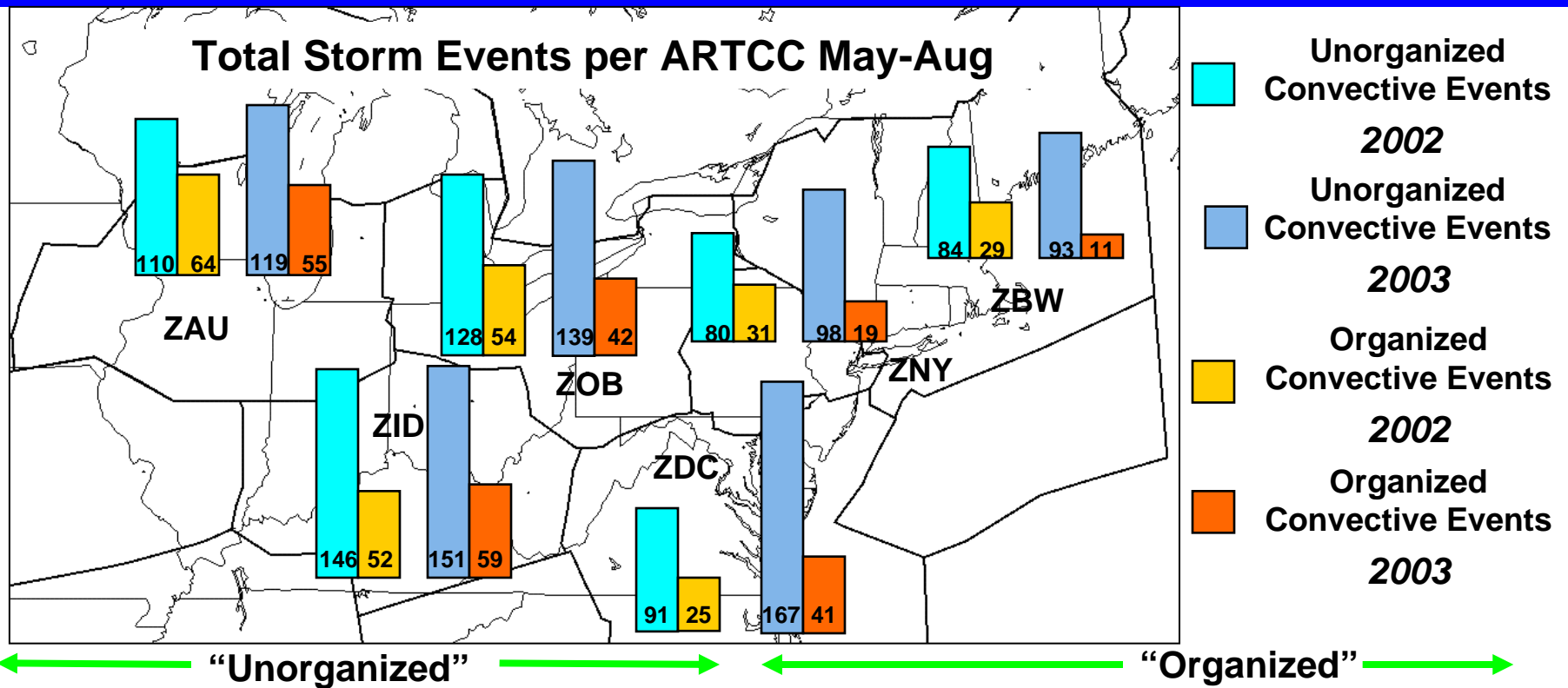


[ from FAA 2002 Airport Capacity Enhancement (ACE) Plan ]

**Increased use of point-to-point flights (versus hubs) and use of alternative airports increases en route congestion and hence, difficulty in providing flexibility and predictability when adverse weather occurs**




# Frequency of Convective Storm Impacts

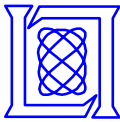




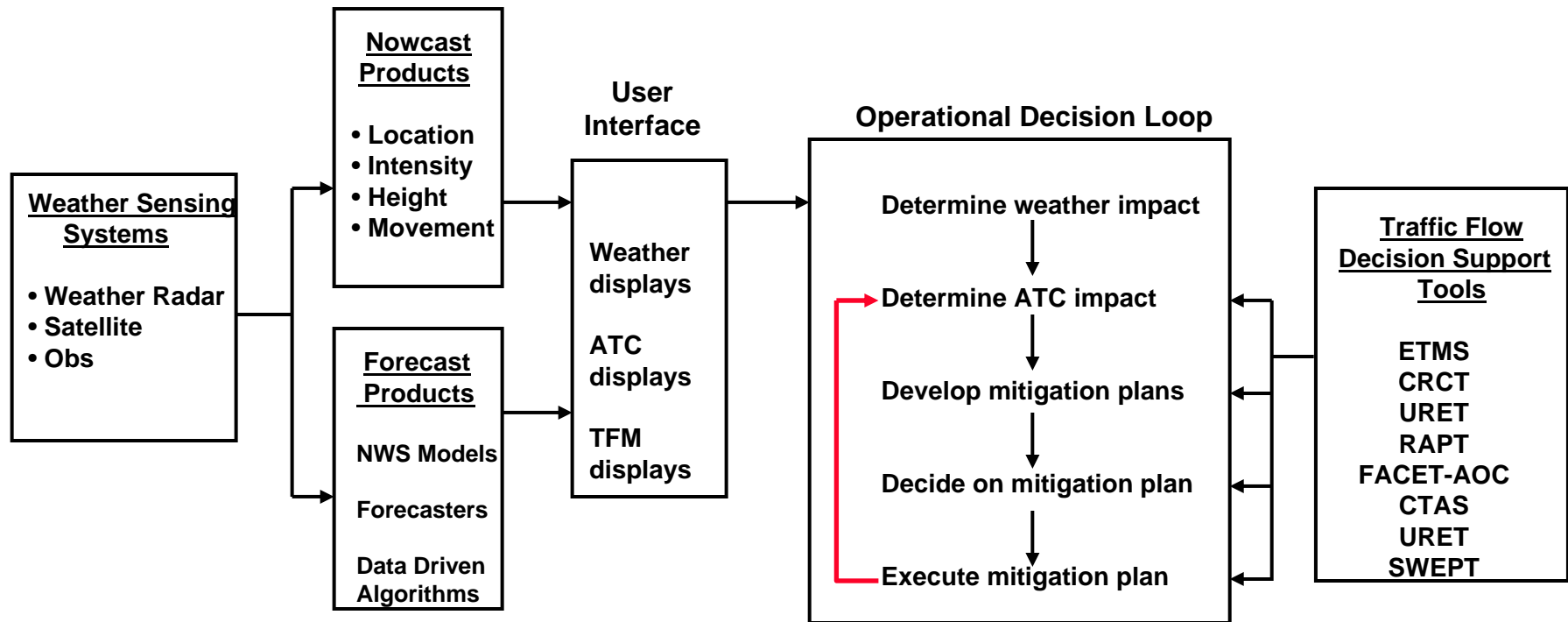
# Outline

---

- **Why do we care?**
  - Delays
- **Overall FAA/airline weather impact mitigation process** 
  - Ability to predict weather impact with sufficient lead time is poor
- **Insights from the CIWS benefits assessment**
- **How can we achieve a higher degree of predictability through increasing flexibility in ATM during adverse weather**
- **Metrics and system design implications**

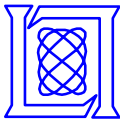


# Weather Impact Mitigation Paradigm



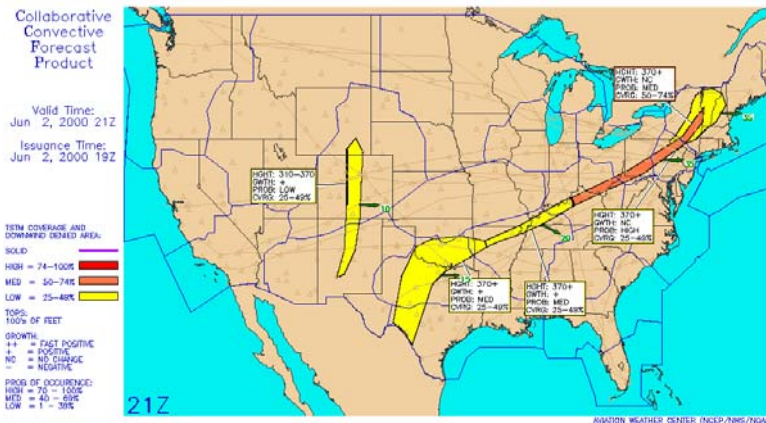
**“Success” in FAA/airline context = executed an appropriate weather impact mitigation plan**

**Must execute the decision loop on a time scale compatible with lead time for accurate forecasts**

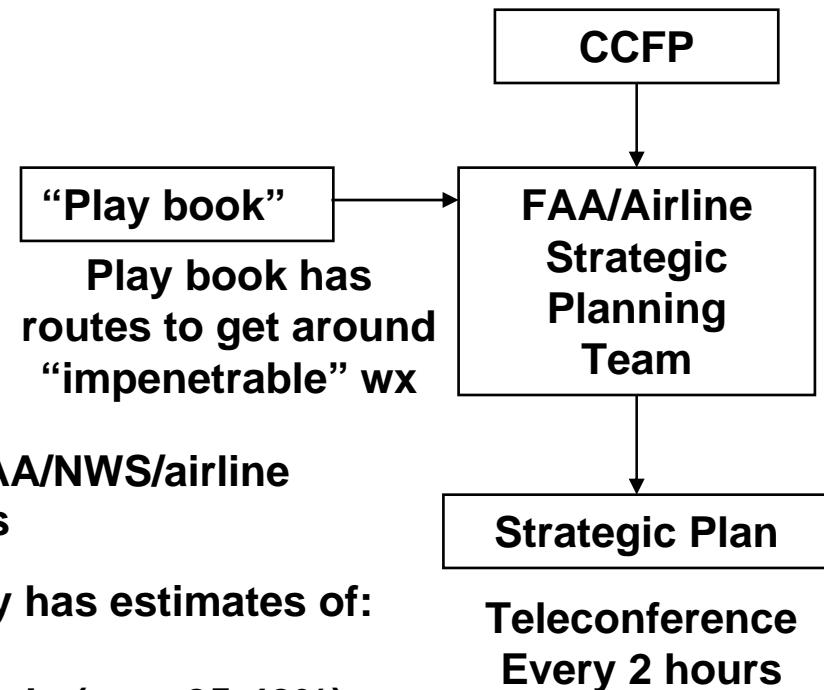


# FAA/Airline “Spring 2K” Planning

## Collaborative Convective Forecast Product (CCFP)



## Strategic Planning



2, 4 and 6 hour predictions generated by FAA/NWS/airline meteorologist collaboration every 2-4 hours

Each region of predicted convective activity has estimates of:

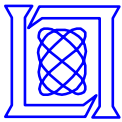
Thunderstorm coverage – three\* intervals (e.g., 25-49%)

Confidence in forecast= low, medium, high

\* To become two intervals

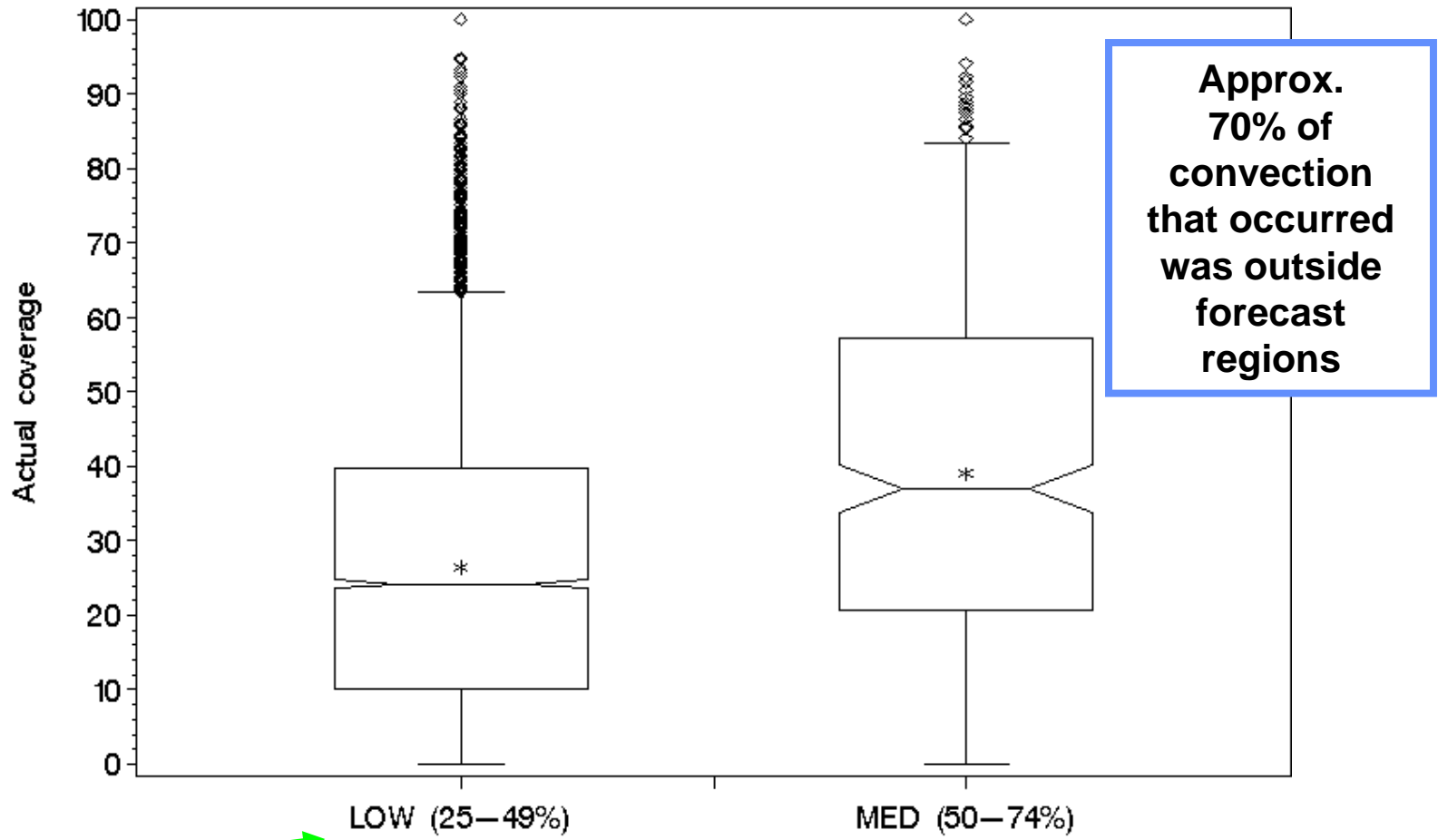
**Delays that occur reflect forecasts plus plans plus actual wx**

MIT Lincoln Laboratory



# CCFP Coverage vs Actual Coverage

CCFP — 2002, Lead = 4 hr (statistics for 2003 are similar)



Approx. 70% of convection that occurred was outside forecast regions


95% of forecasts issued

Forecast Coverage



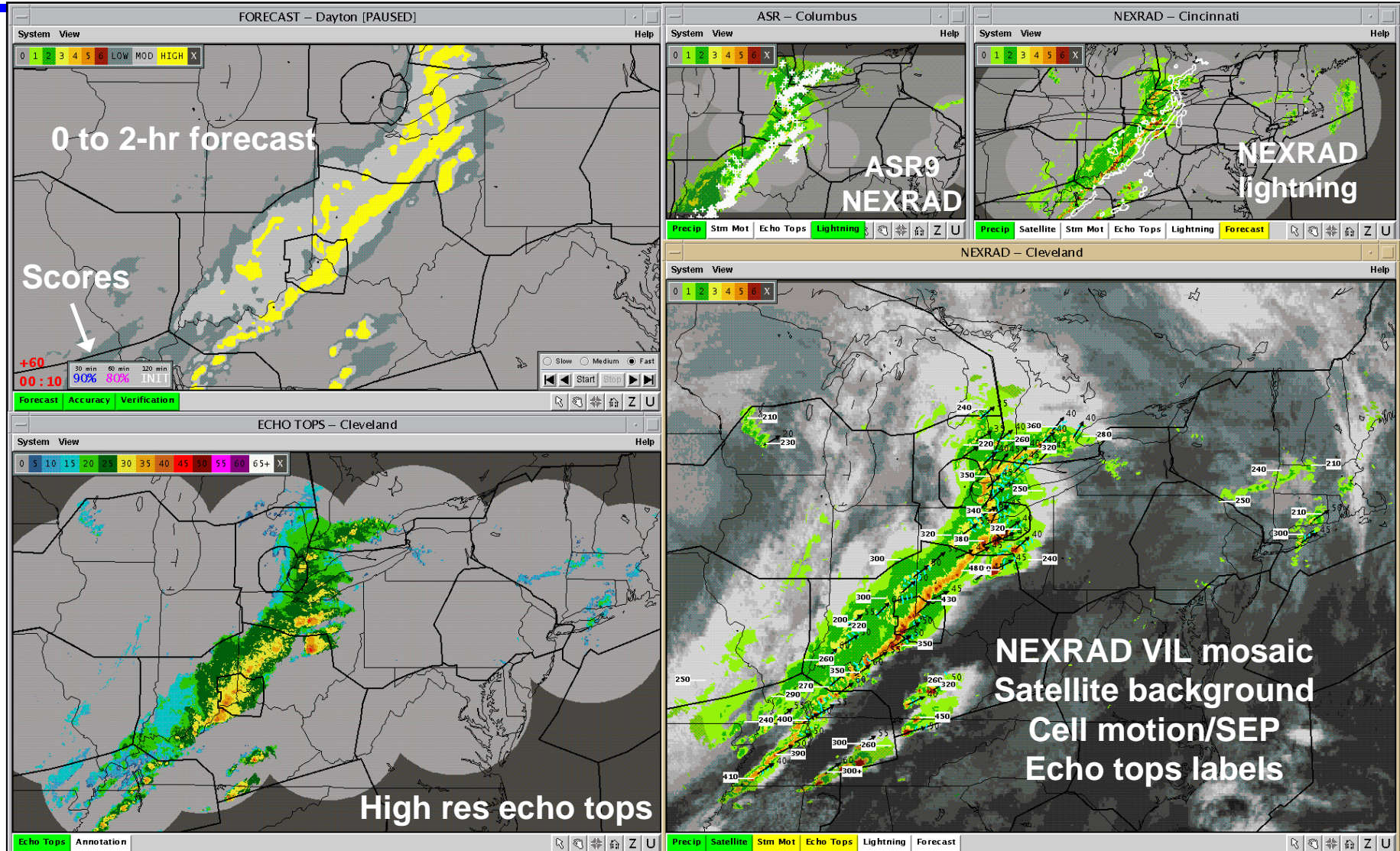
# Outline

---

- **Why do we care?**
  - Delays
- **Overall FAA/airline weather impact mitigation process**
  - Ability to predict weather impact with sufficient lead time is poor
- **Insights from the CIWS benefits assessment** 
- **How can we achieve a higher degree of predictability through increasing flexibility in ATM during adverse weather**
- **Metrics and system design implications**

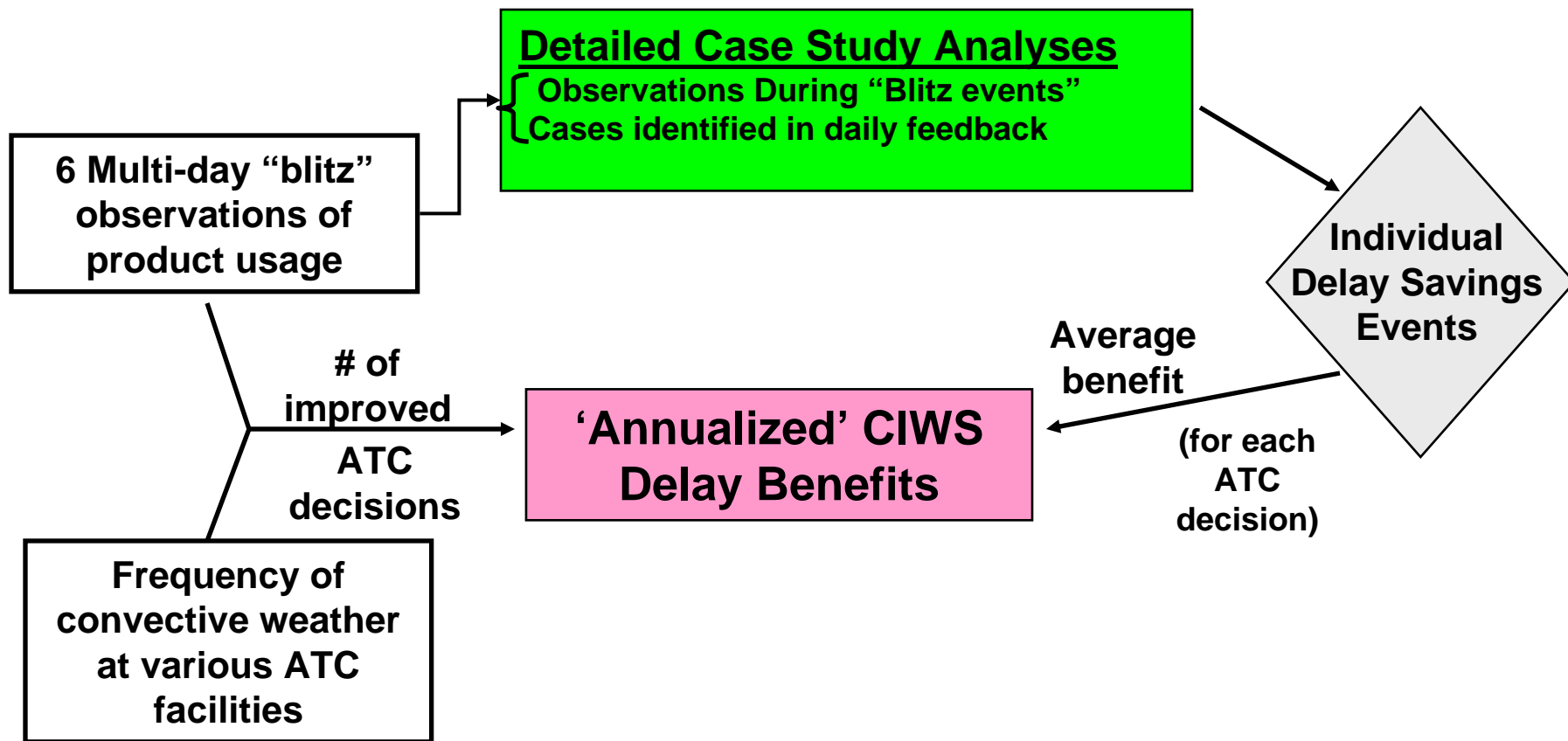


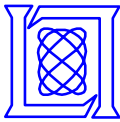
# Corridor Integrated Weather System (CIWS) Products





# CIWS Benefits Assessment



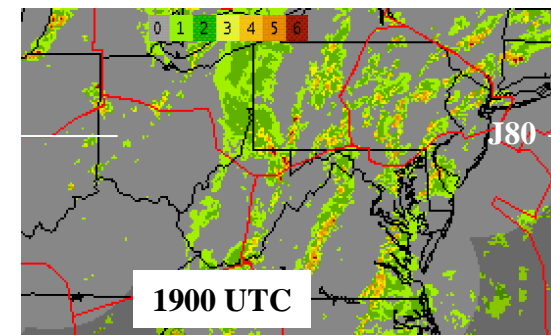
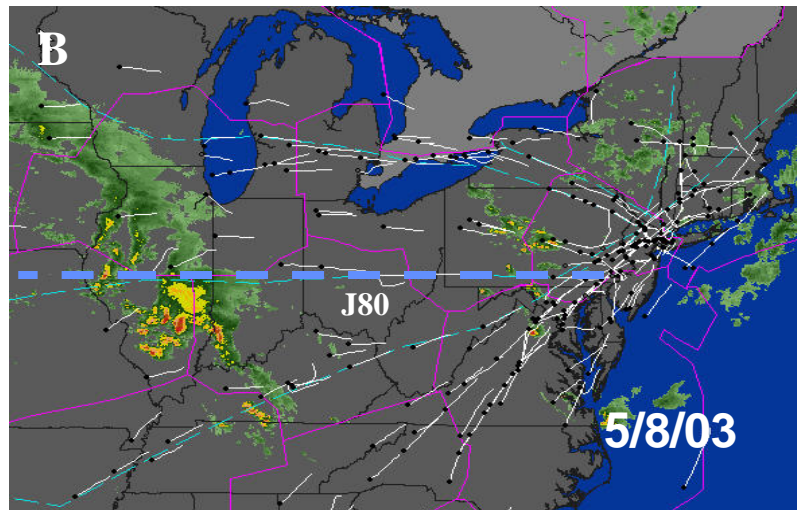
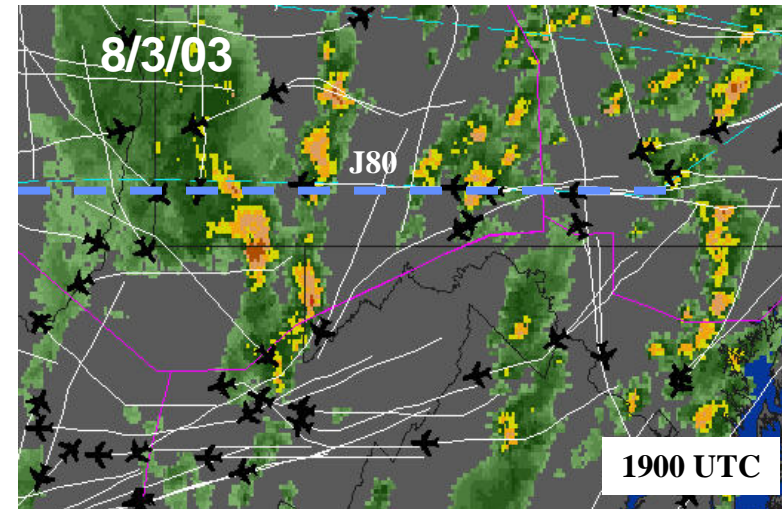
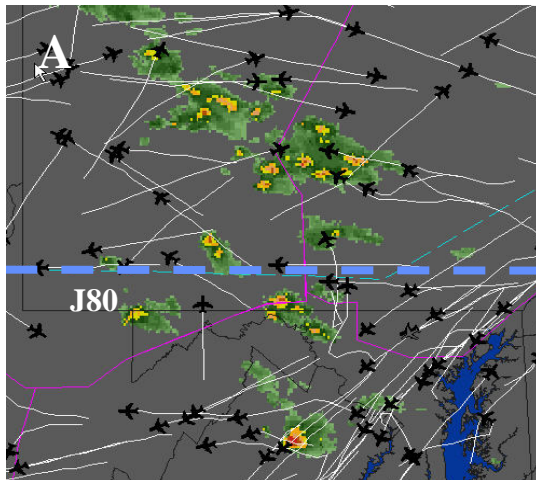


# CIWS 2003 Operational Benefits

Route Impacts / Traffic Flow Management		Benefits from Randomly Chosen Instances of Routes Kept Open		
<b>CIWS Benefit</b>	<b>Times/year</b>	<b>Facility</b>	<b>Dates</b>	<b><u>Direct Delay (Hrs)</u></b>
• Jet routes kept open or reopened earlier	699	ZAU	4/30 6/26	14 106
• Proactive, efficient reroutes	501	ZID	6/10 7/10 7/23	1 70 5
• Directing pathfinders	300	ZOB	5/8 7/6 8/3	4 18 189
• Identifying opportunities to fly over storms	109	ZDC	7/22 7/23 9/3	8 3 29
		ZBW	6/11 8/5	3 7
		ZNY	6/12 8/5	2 49
<b>Delay savings &gt; \$ 110 M per year</b>				
<b>Other uses being quantified:</b>				
Better use of delay programs				
More departures during severe wx				
Reduced MIT restrictions				
				<b>Annual benefit using above instances to estimate mean benefits:</b>
				42,457 hours
				~ \$ 178 M (including passenger time)



# Examples of Different Cases



Low benefit – J80 blocked in IL

High benefit: few other usable E-W routes



# Understandings from CIWS Study

---

- **Delays and benefits varied greatly for nominally similar “local” convective situations due to queues and overall network context**
  - Queue delay is very sensitive to demand, fair and bad weather capacity, and time duration of bad weather
  - Need a very detailed knowledge of weather locations and 3D structure to accurately assess impact of weather
- **System design implications**
  - Predictions of ATC impact of storms hours in advance are likely to have a very wide range of possibilities for ATC impact
  - Need to focus on options for maximizing flexibility to respond to rapidly changing situations
- **Metrics implication:** will be very hard to normalize for weather effects of different weather (and forecasts) in delay comparison

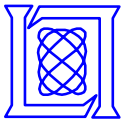


# Outline

---

- **Why do we care?**
  - Delays
- **Overall FAA/airline weather impact mitigation process**
  - Ability to predict weather impact with sufficient lead time is poor
- **Insights from the CIWS benefits assessment**
- **How can we achieve a higher degree of predictability through increasing flexibility in ATM during adverse weather**
- **Metrics and system design implications**

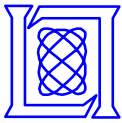




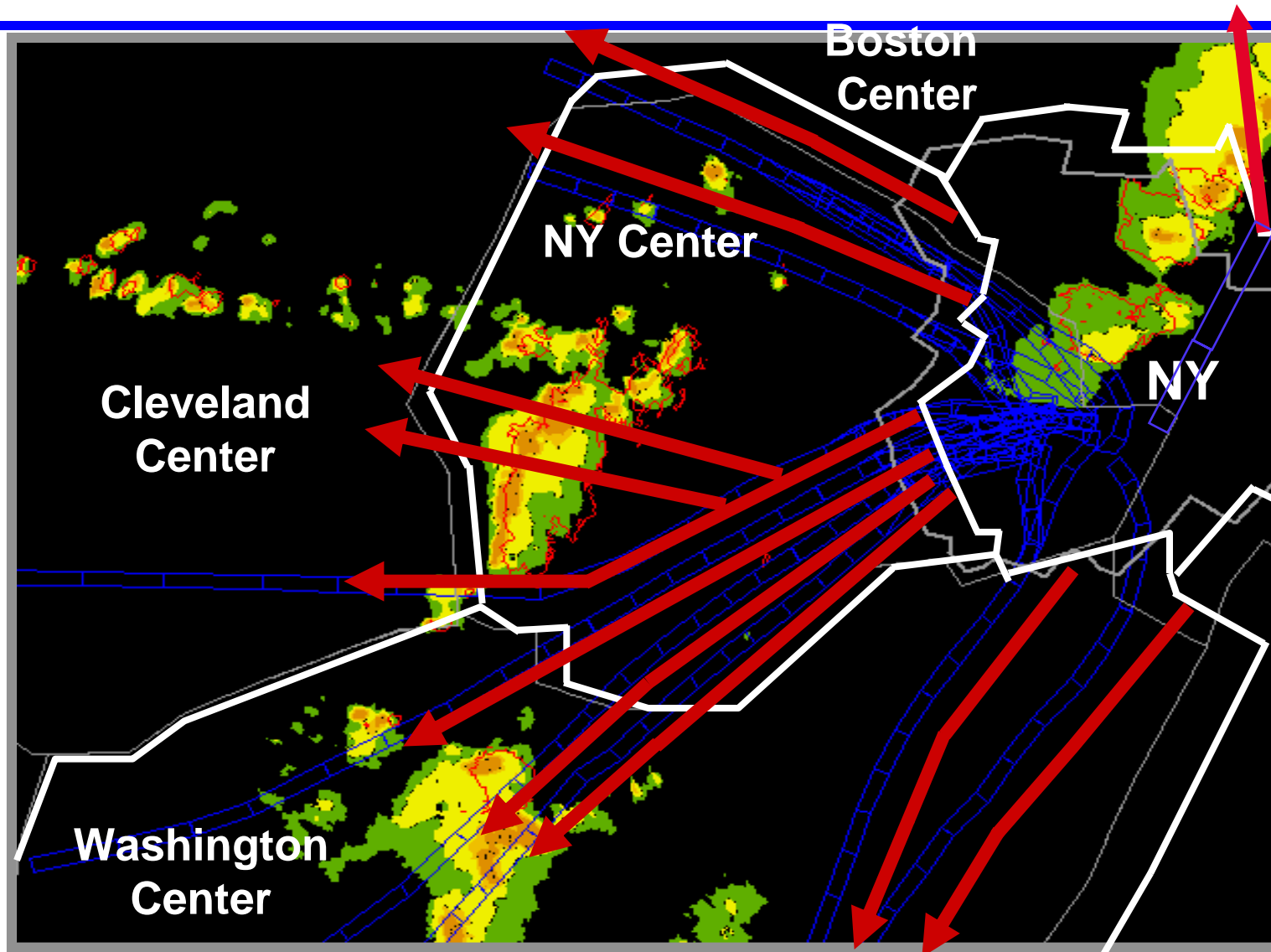
# Flexibility in Transcon Routing

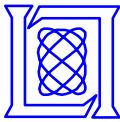


Proposal  
By UA at  
Dec 03  
CDM mtg

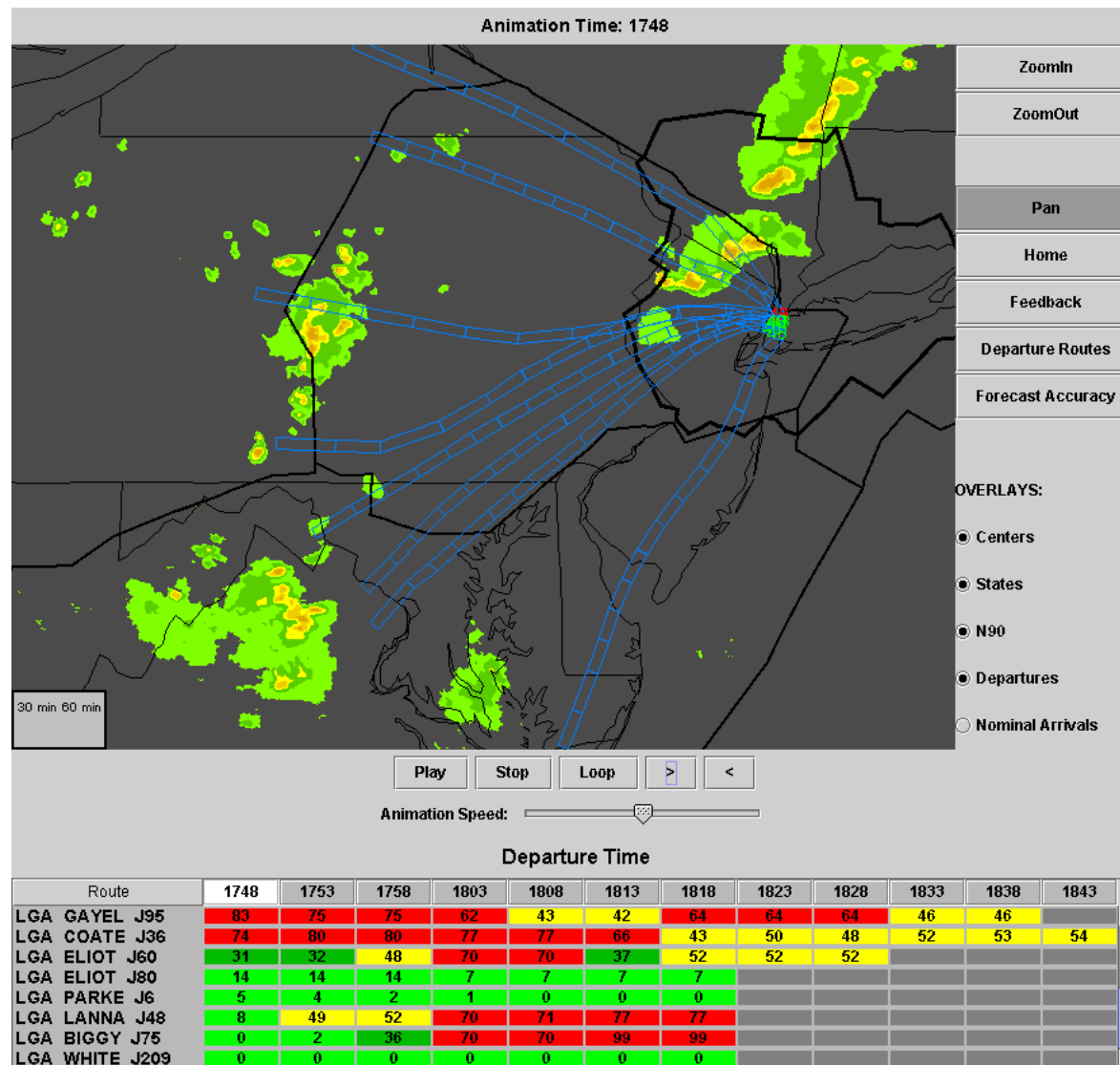


# Multi-facility Coordination for Departures





# Route Availability Planning Tool (RAPT)



Takes advantage of short lived opportunities for departures

## To be added:

- Aircraft specific 3D guidance

- Better support for assessing alternative routes if filed route is blocked

- Pilot/dispatch CDM



# Summary

---

- **Convective weather impacts on congested airspace will continue to be a major problem for the NAS**
  - Capacity impacts cannot be accurately predicted with the desired lead time
  - Classic “free flight” flexibility and predictability objectives will be hard to achieve
- **Will need to consider developing a flexible, agile system that facilitates coping with rapidly changing problems**
- **Metrics implications**
  - Reassessing system operations effectiveness metrics in context of flexible response to changing conditions
  - Normalization for weather and forecast differences between different time periods will require very detailed analysis + new tools