

# R&D and the Operational Improvement Plan

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Friends/Partners of Aviation Weather  
Vision Forum  
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# General Wx Thrust

- **Provide a consistent, common operating picture**
  - Currently, between FAA and NWS legacy systems, there are about 15 different thunderstorm products at any given time
- **Reduce weather impact on trajectory-based and performance-driven operations**
- **Enhance capacity and improve safety**
- **Make weather transparent to the user**



# Three Problem Areas

- 1. Weather Information Integrated into Decision Support Tools**
- 2. Common Situational Awareness for weather**
- 3. Observation and Forecast Quality**



# Problem 1: Weather Information Integrated into Decision Support Tools

- Today the FAA and airlines use Collaborative Decision Making to manage a weather day
- Many users say that the outcome of such days are often determined by who is on duty at the command center
- Ineffective weather decision-making is unacceptable when weather is a factor in 70% of delays



# Problem 1: Weather Information Integrated into Decision Support Tools

- A multitude of inconsistent weather products that are manually applied result in inefficient, inconsistent, and unpredictable decisions
- ATM does not consistently evaluate and plan for weather, producing unpredictable results and ineffective resource utilization
- **Every NAS day is a weather delay day!**



# Solution 1: Weather Information Integrated into Decision Support Tools

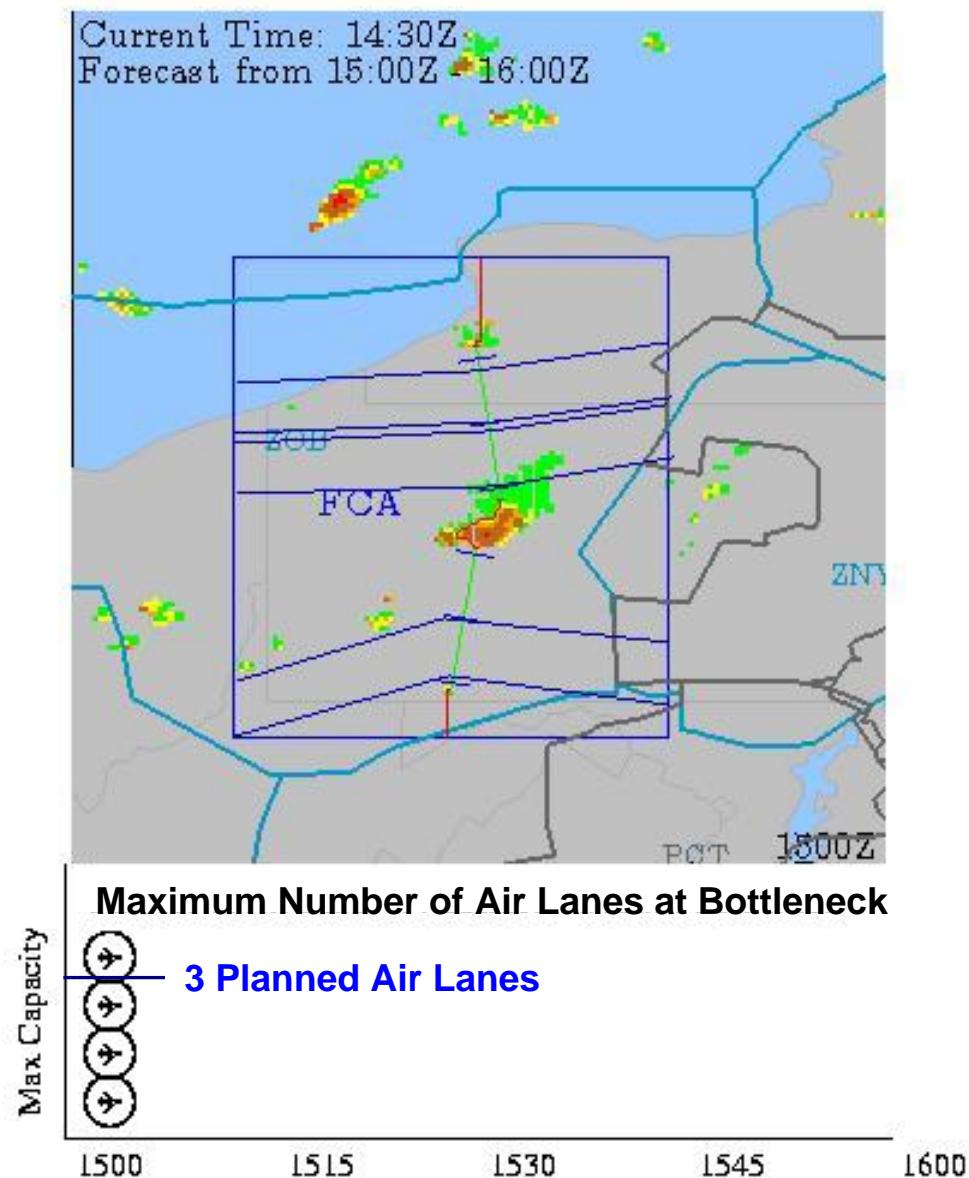
- Increase resource predictability and availability by:
  - Wx information translated into ATM constraints and delivered to aviation stakeholders as an integrated part of Decision Support Systems (DSS)
  - Aircraft- and trajectory-specific evaluation of weather provided to decision-makers and DSS
  - Tailored, probabilistic, authoritative, network-enabled weather information incorporated into automated DSS tools that consider Wx uncertainties

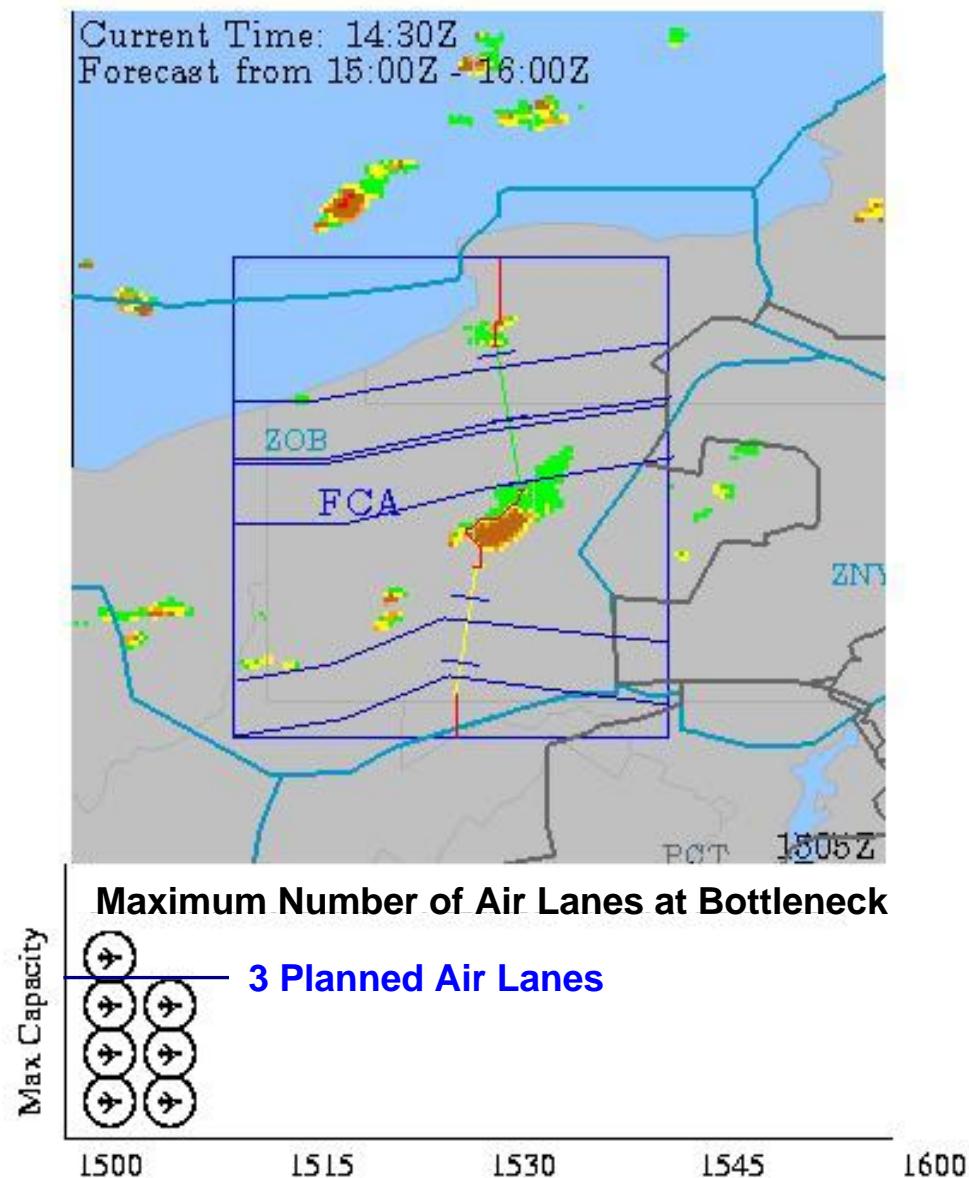


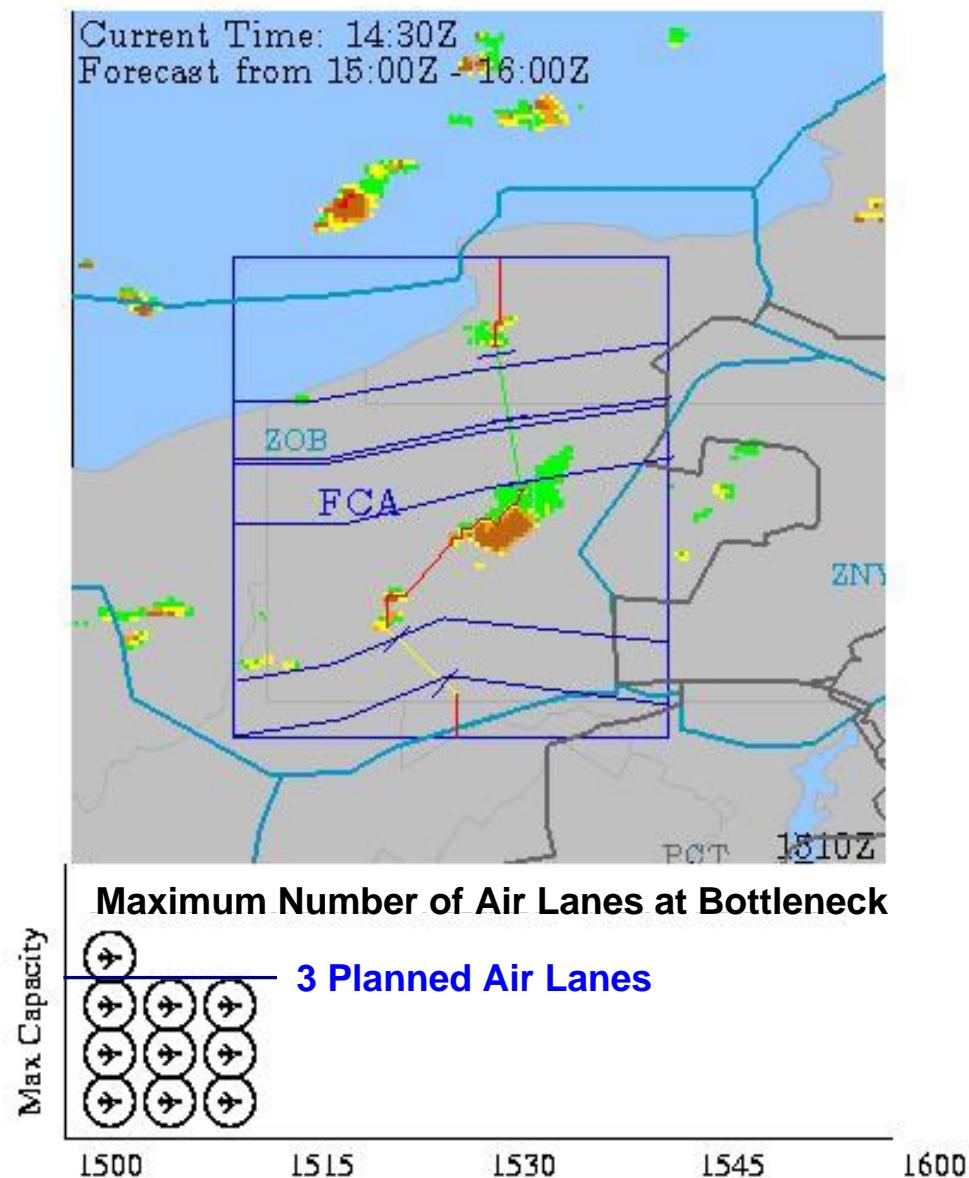
# Examples of ATM Weather Research

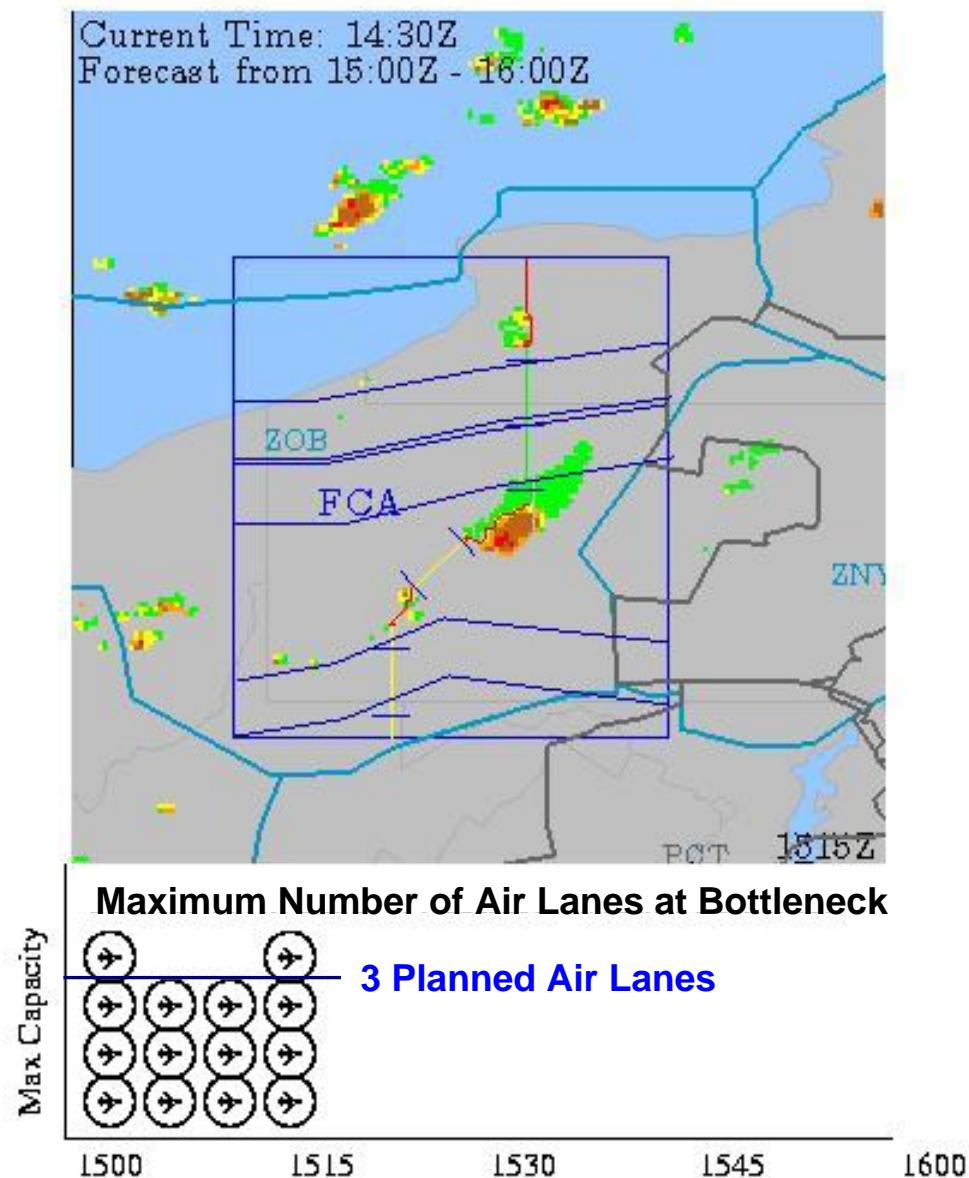
- NASA Ames Weather ATM Integration Research  
Jimmy Krozel, Metron
- MITRE/CAASD by Craig Wanke

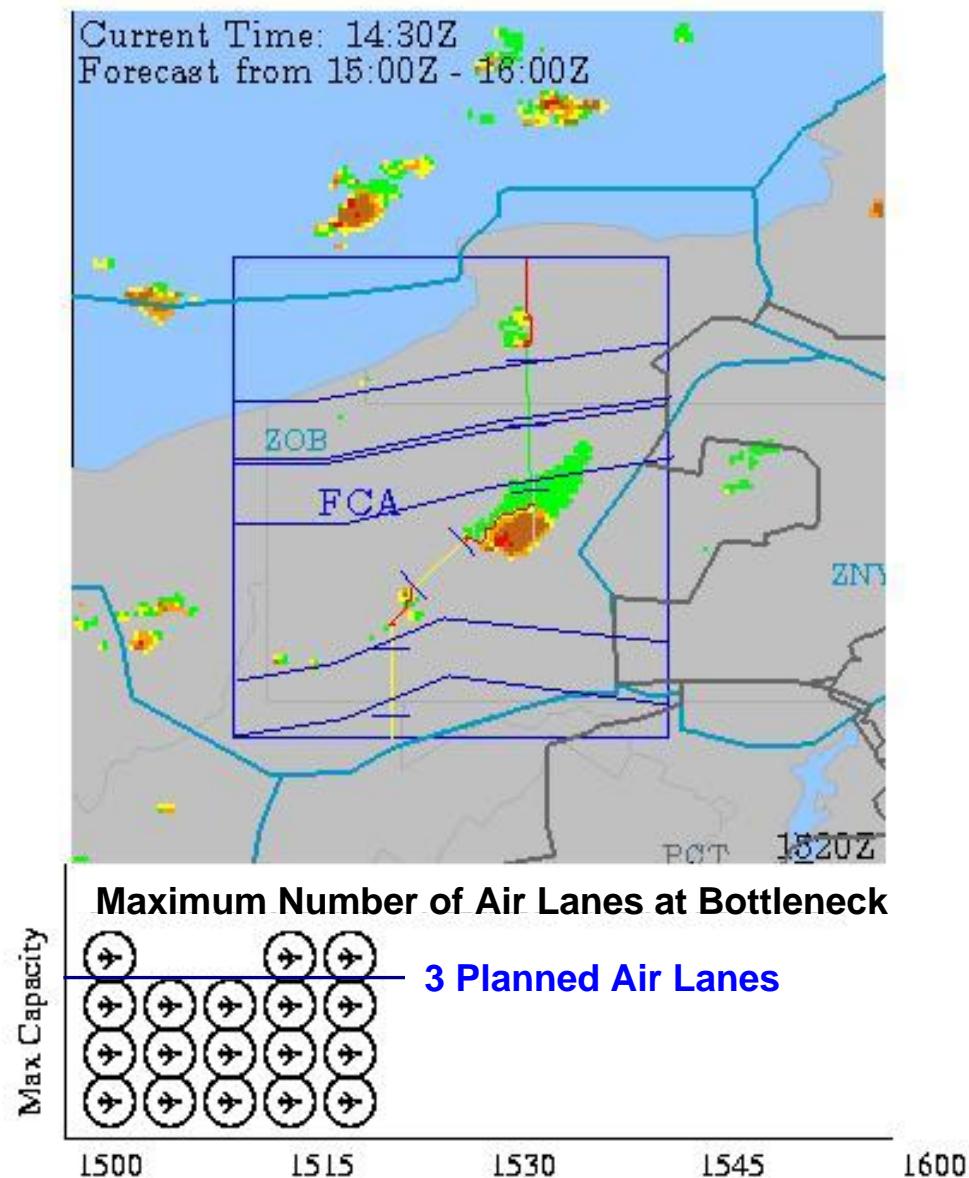


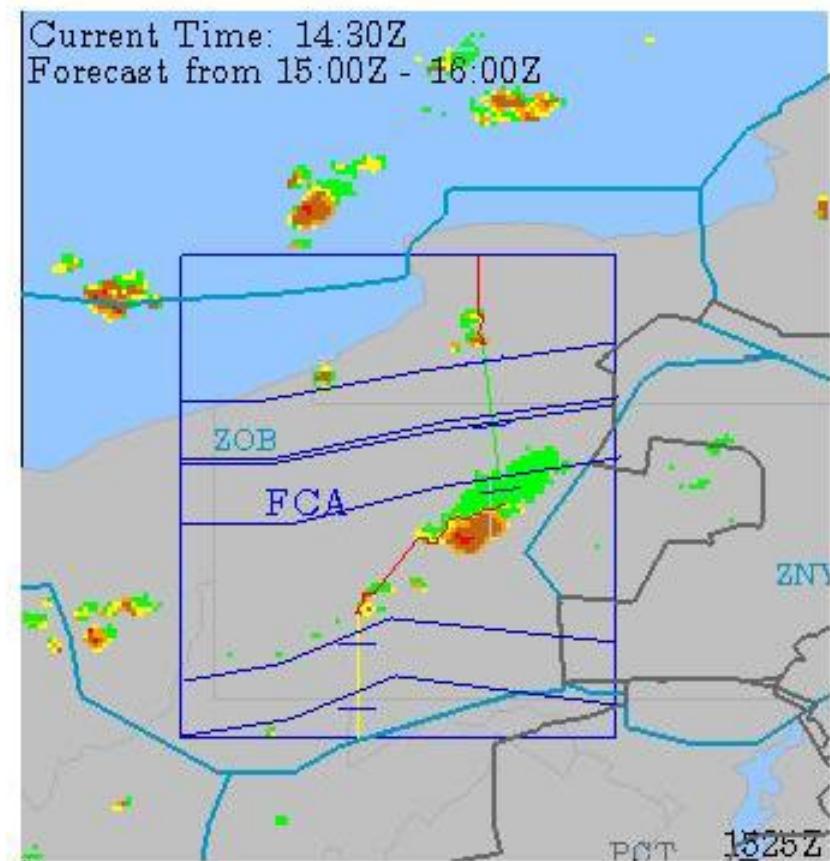








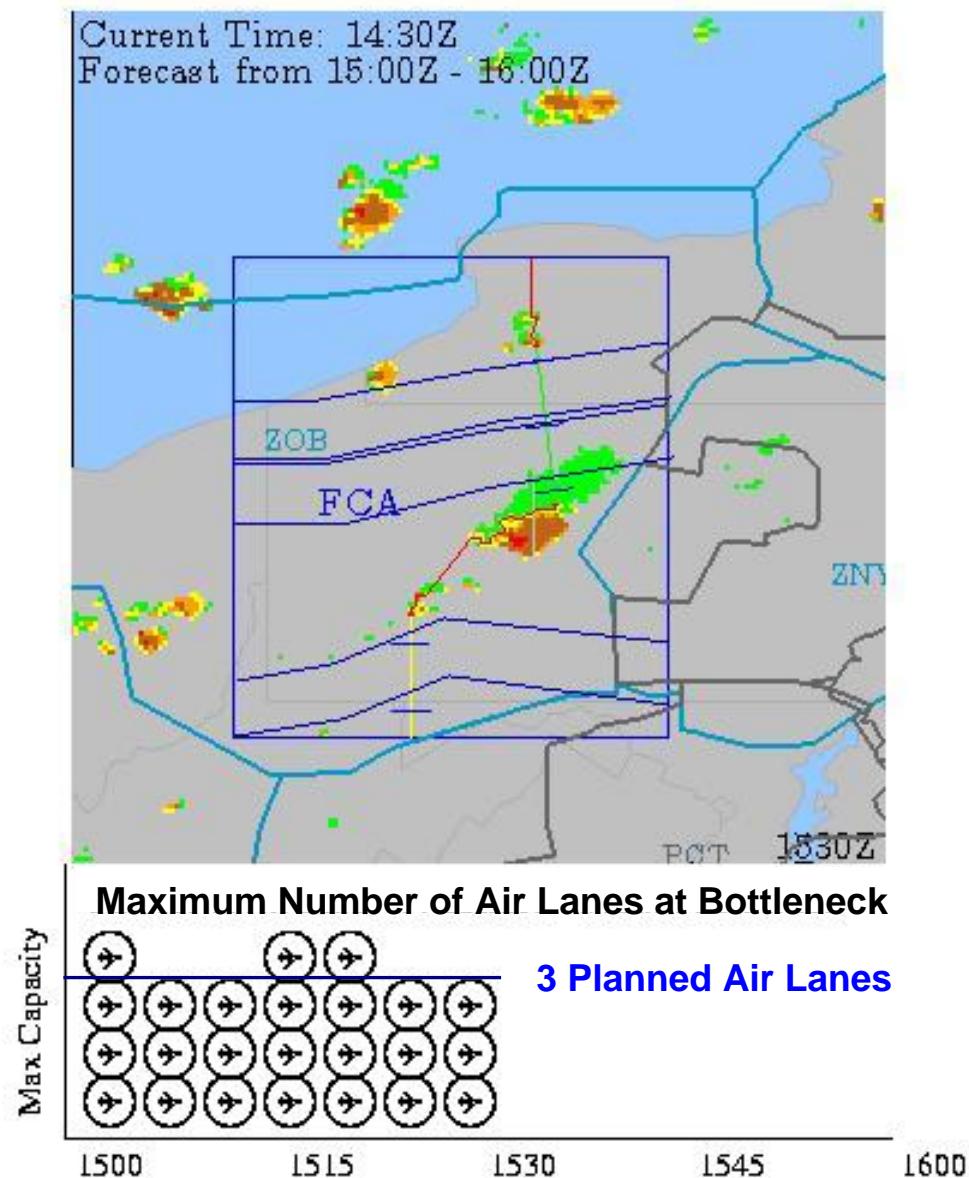


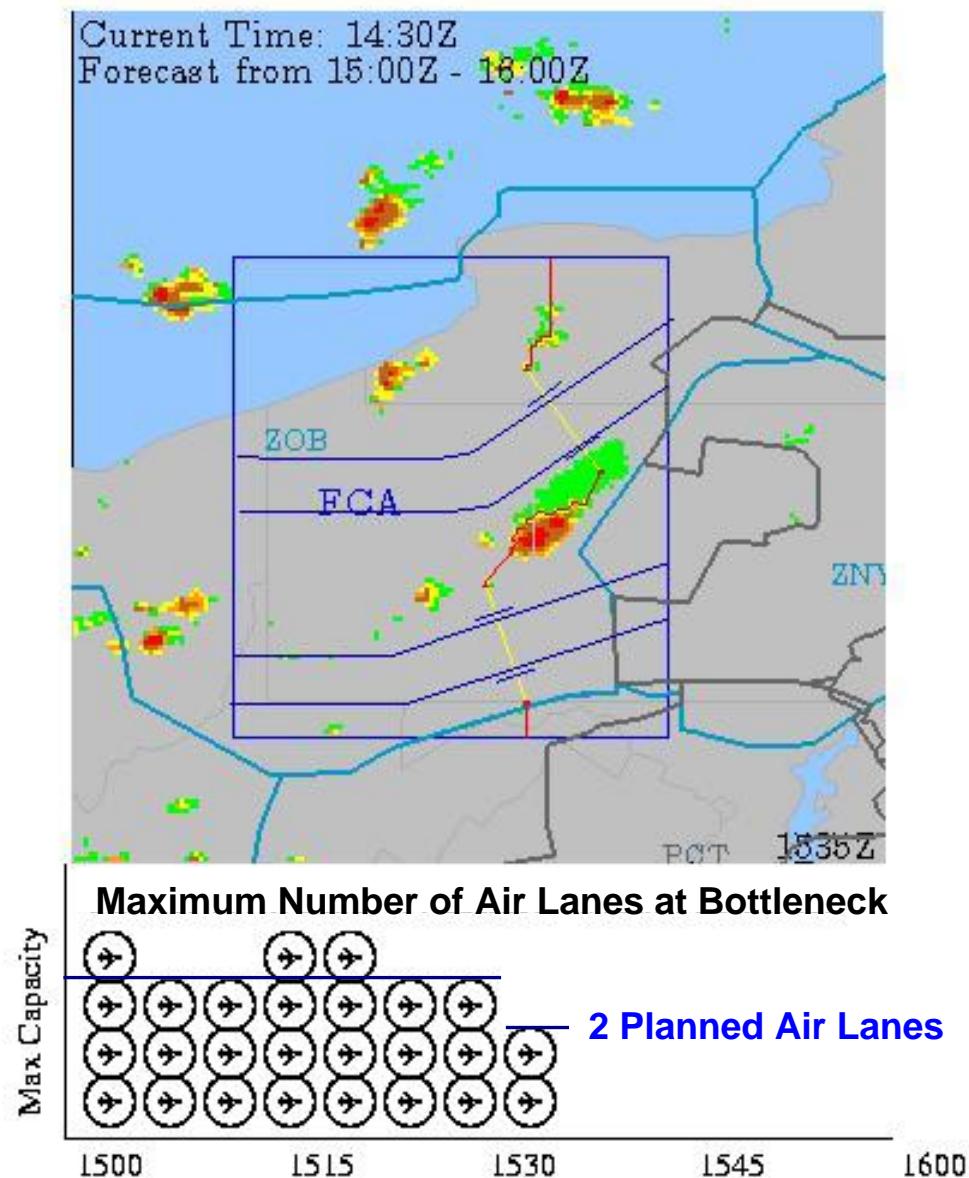


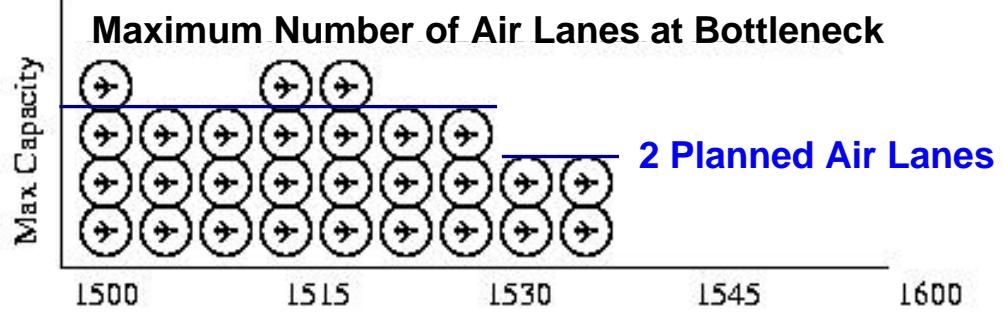
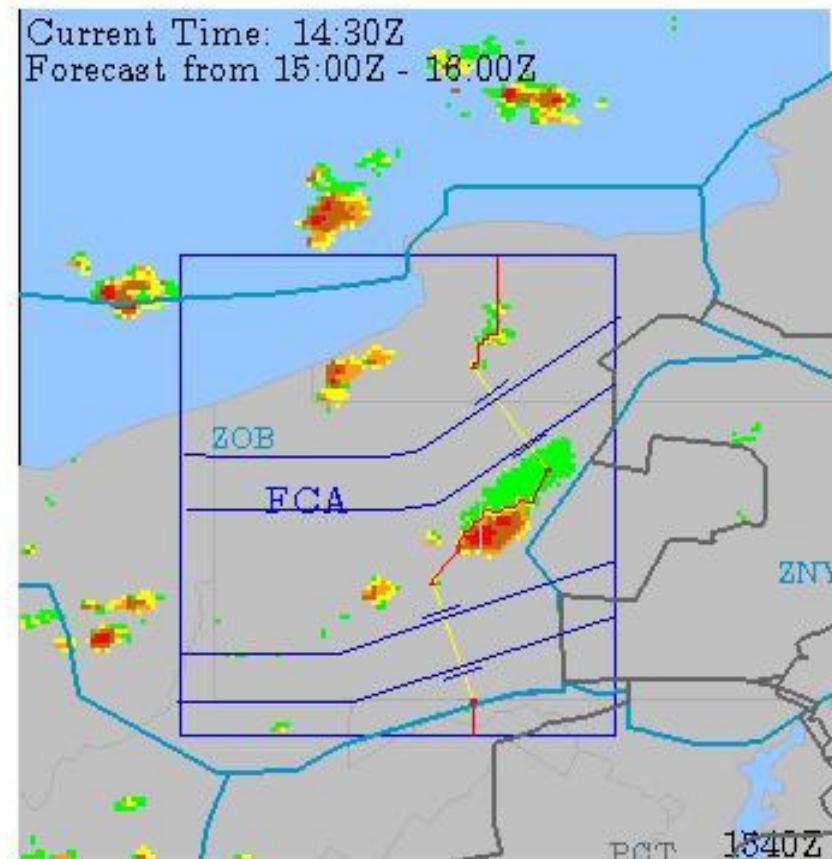
Max Capacity

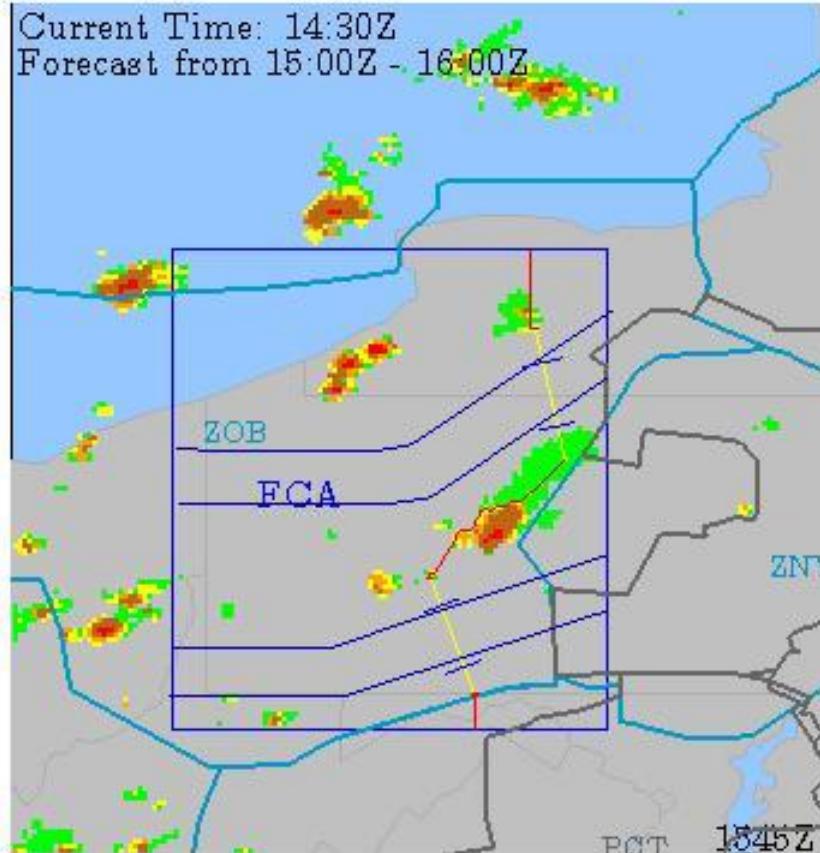
3 Planned Air Lanes

1500 1515 1530 1545 1600

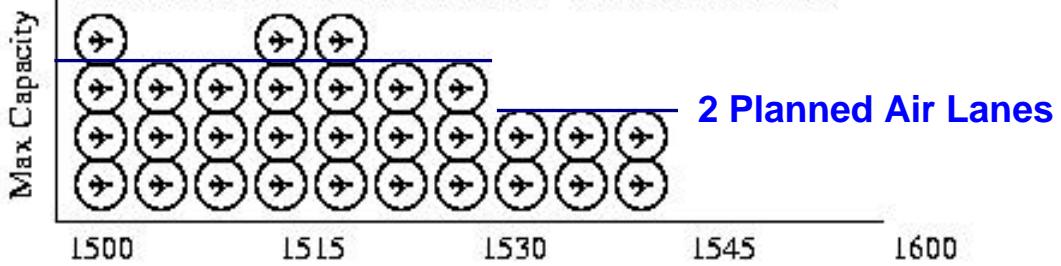


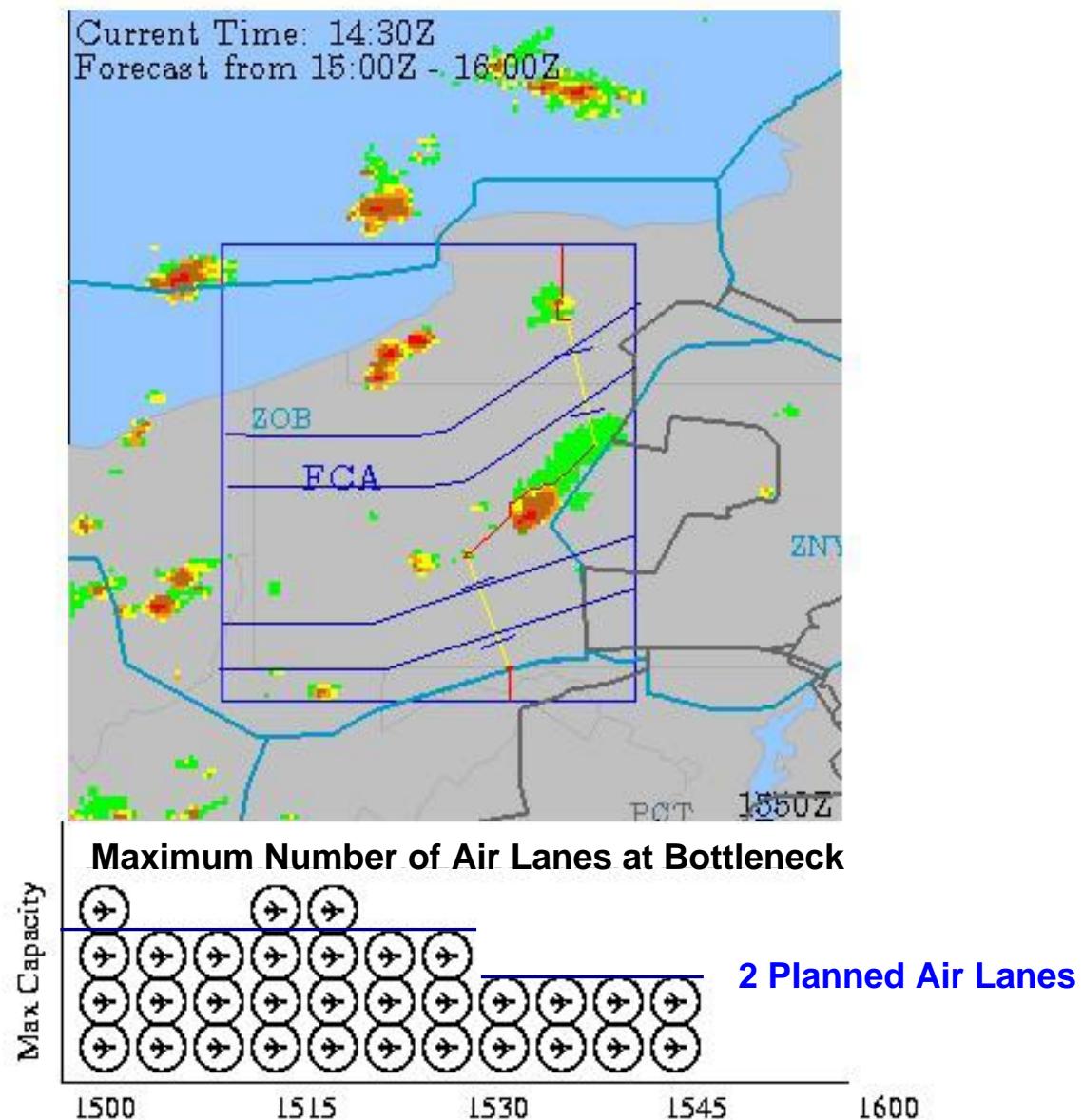


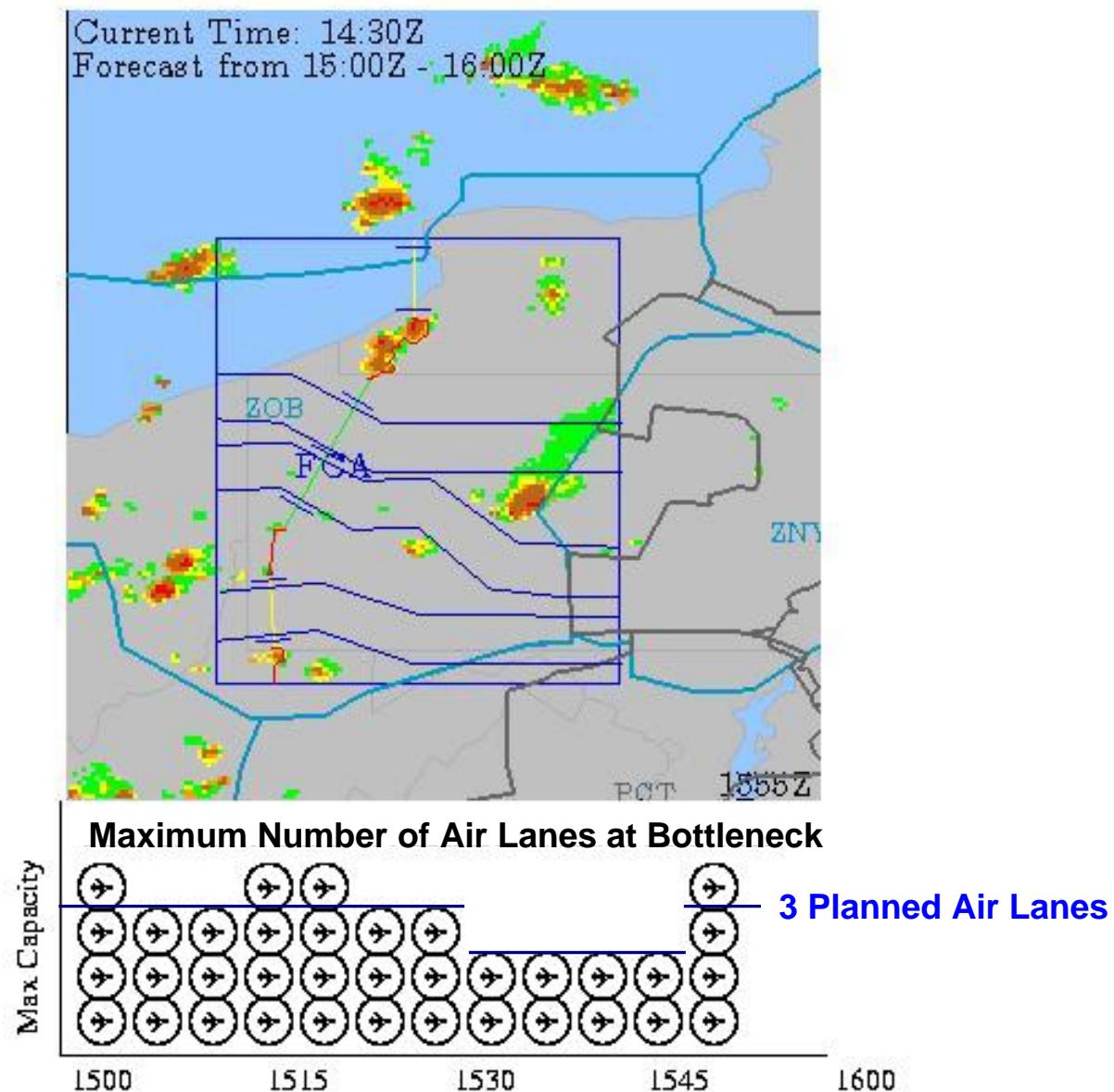


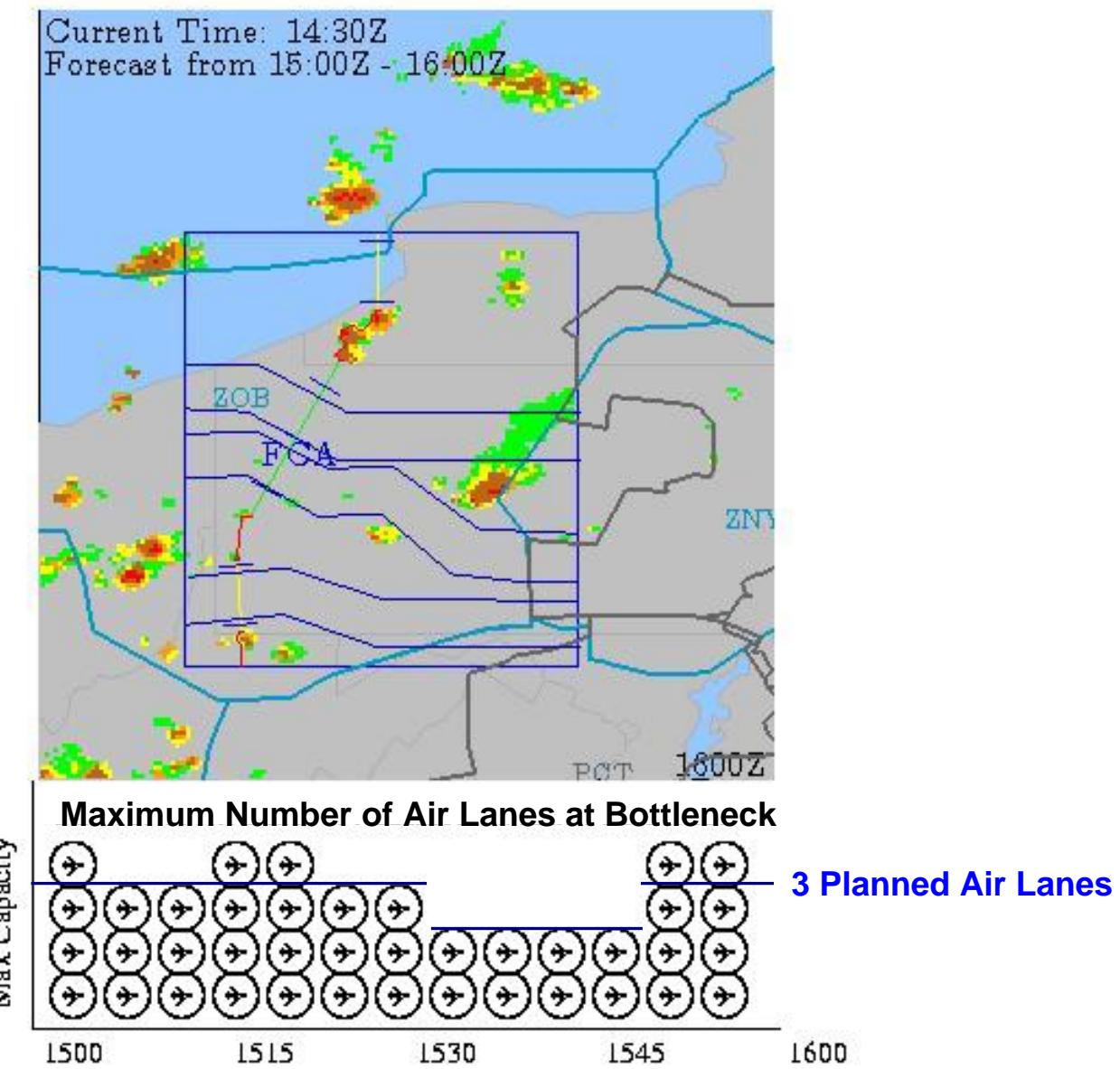


### Maximum Number of Air Lanes at Bottleneck

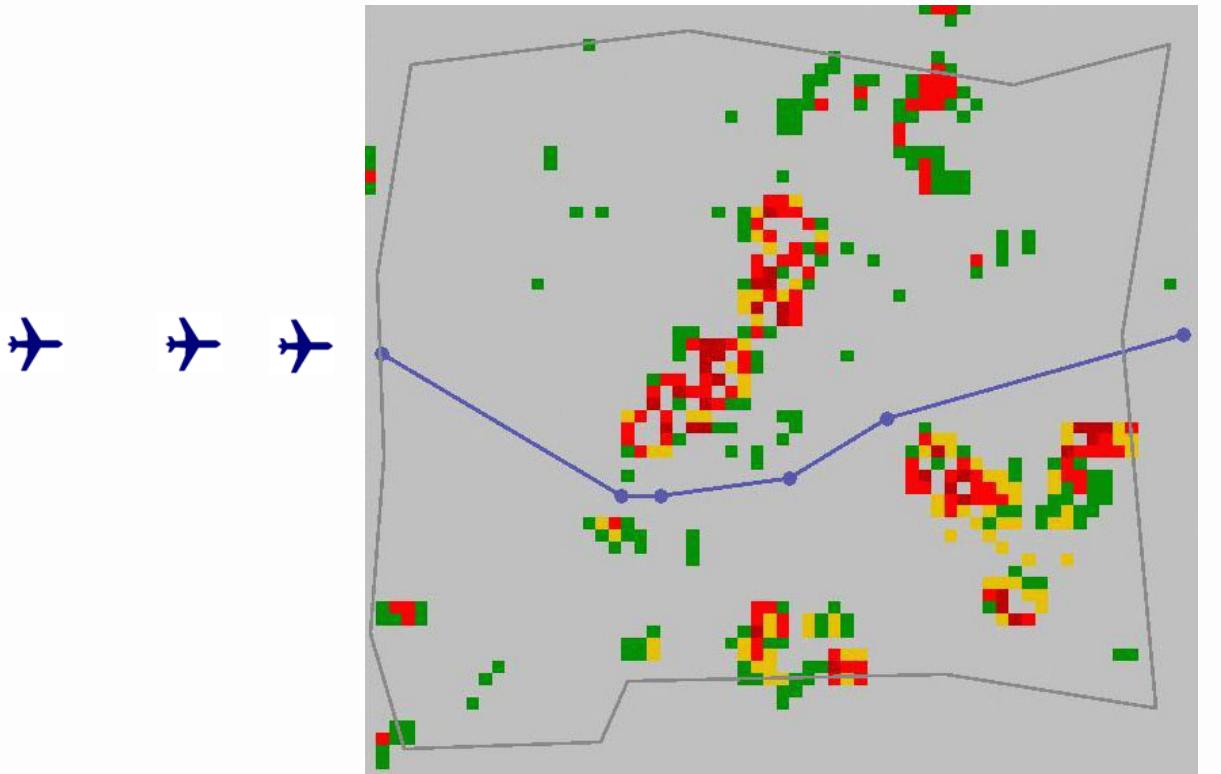








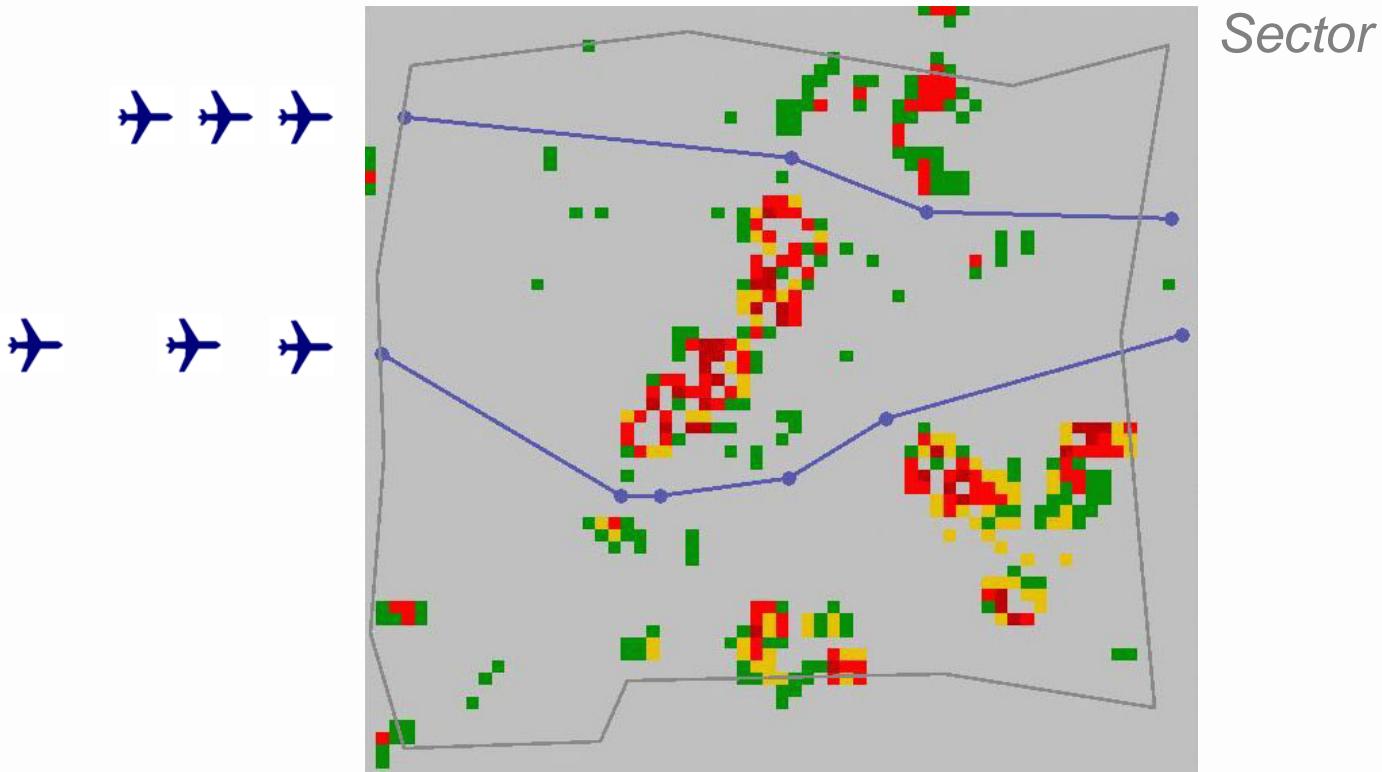
# Weather Avoidance Algorithms for En Route Aircraft



1 Flow



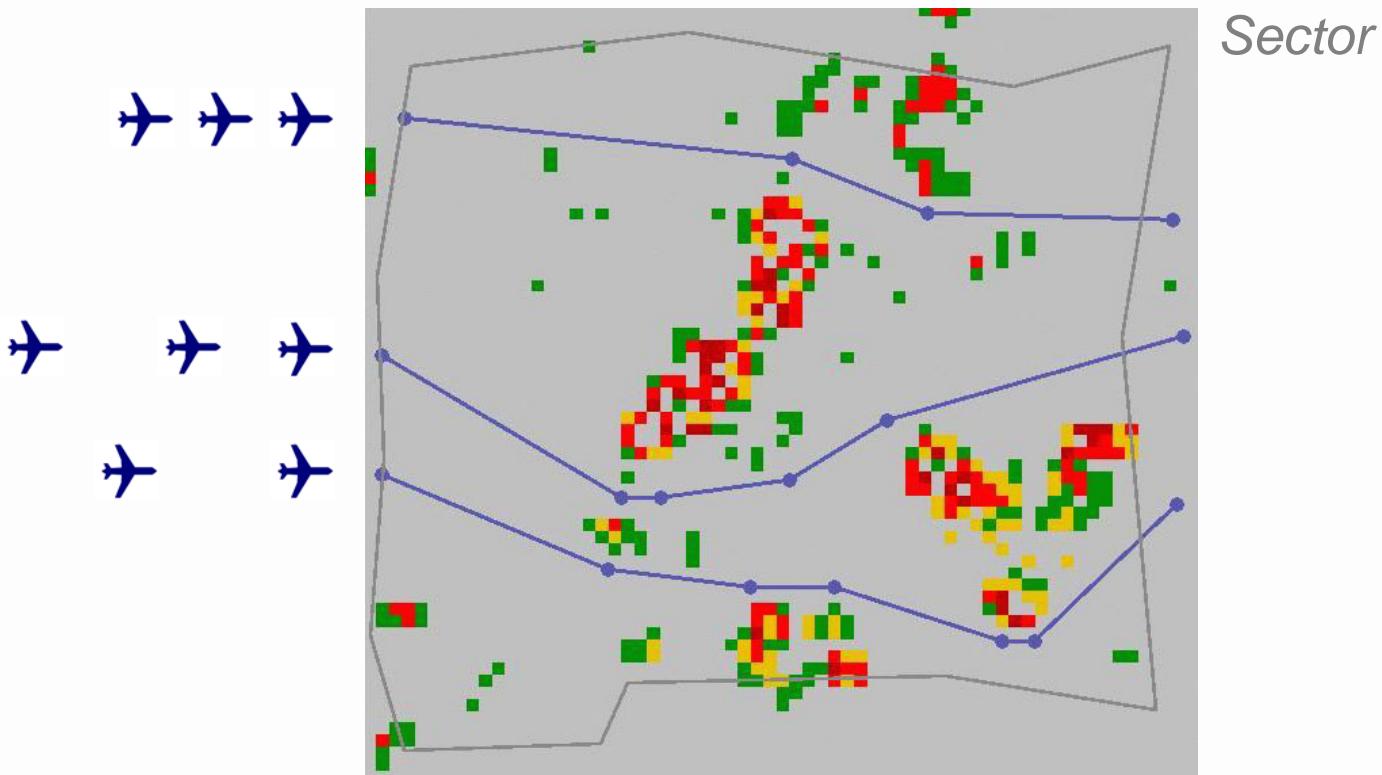
# Weather Avoidance Algorithms for En Route Aircraft



2 Flows



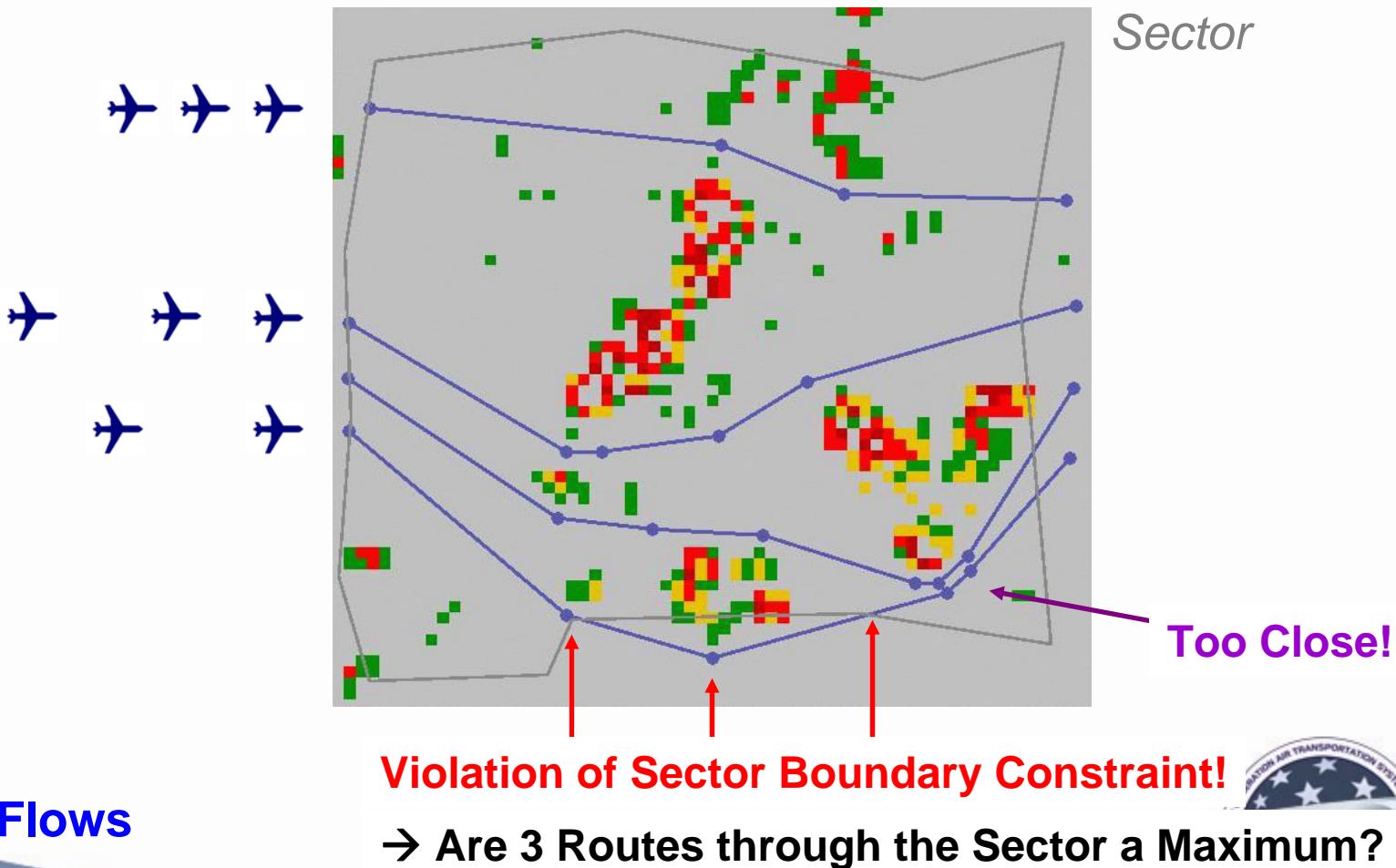
# Weather Avoidance Algorithms for En Route Aircraft



3 Flows

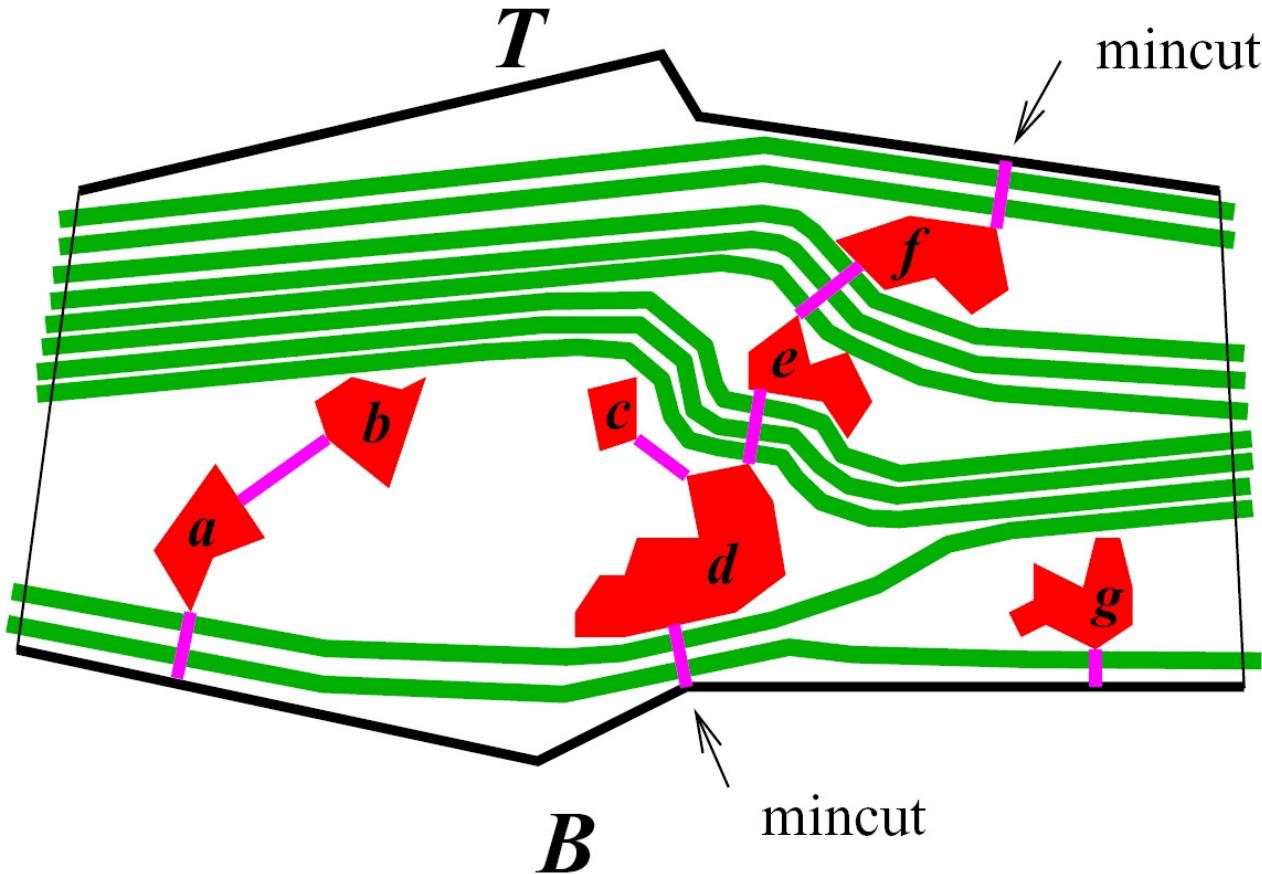


# Weather Avoidance Algorithms for En Route Aircraft

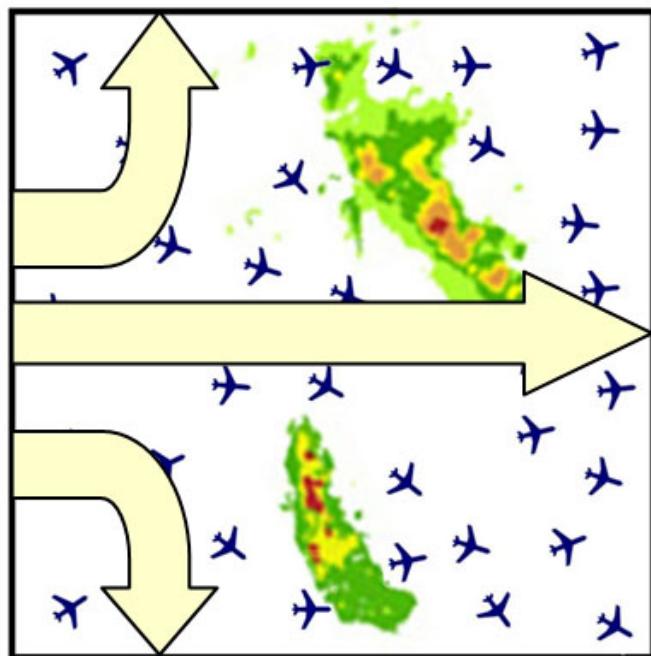


## Algorithm: Mincut (Deterministic)

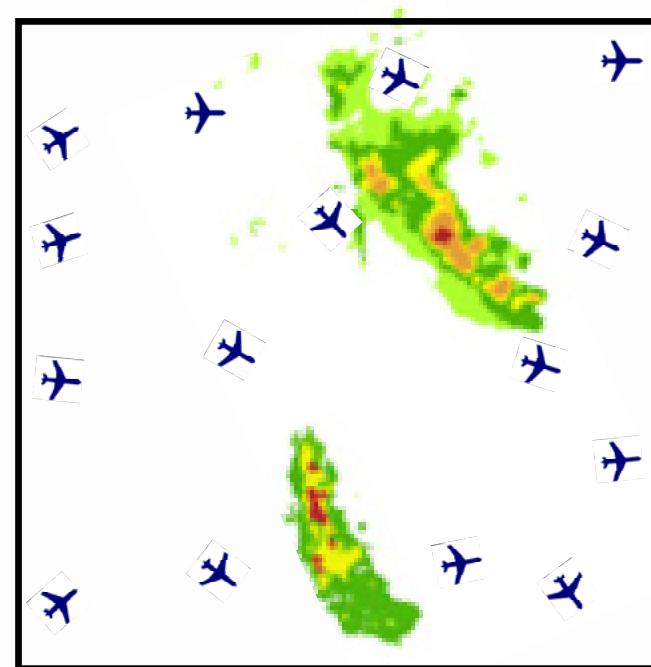
5. Find maximum number of air lanes through the mincut



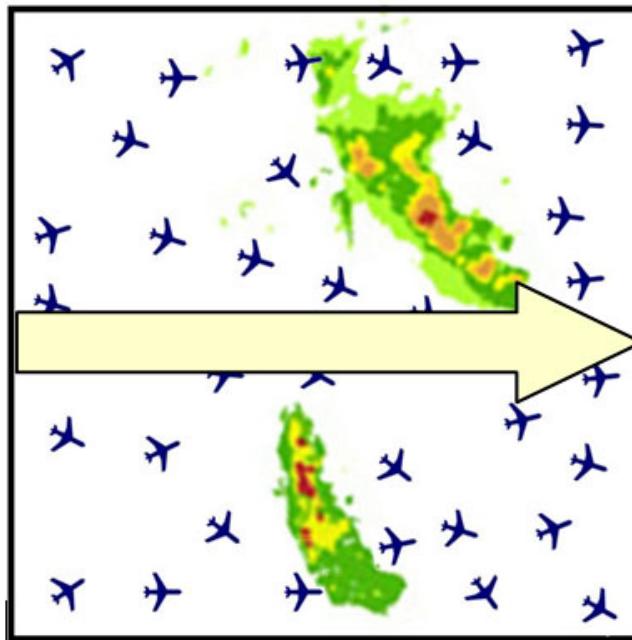
# Unidirectional Flows



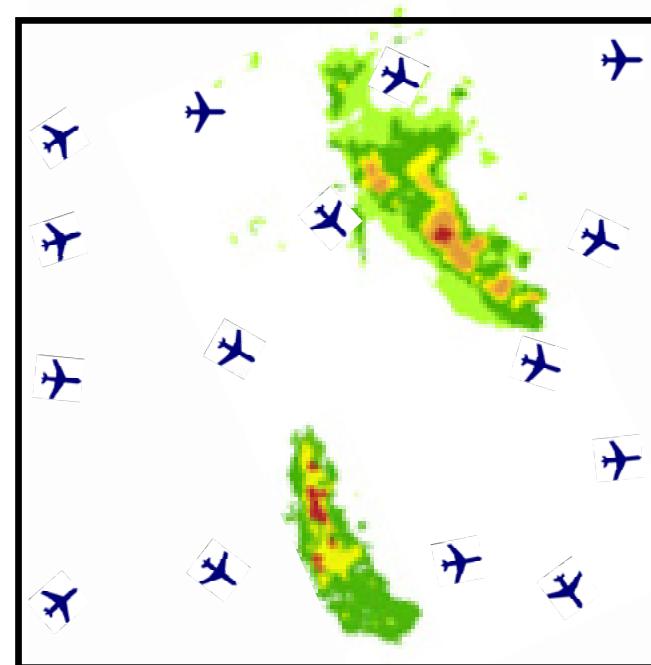
Free Flight (Monotonic Rule)



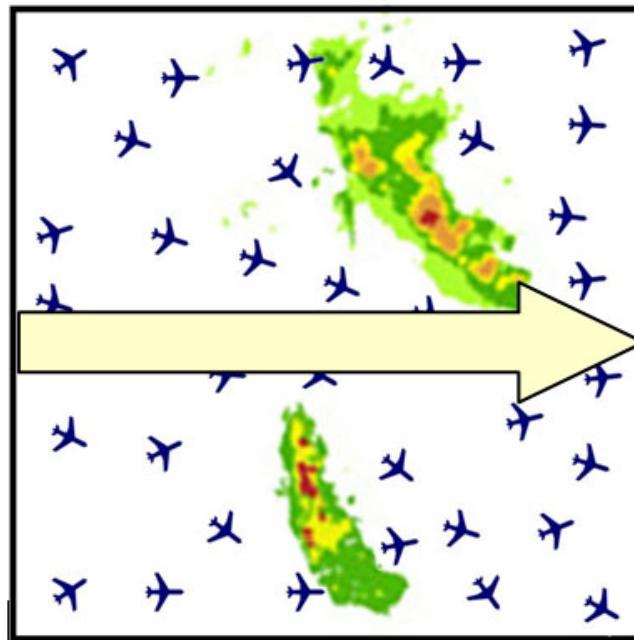
# Platooning of 1



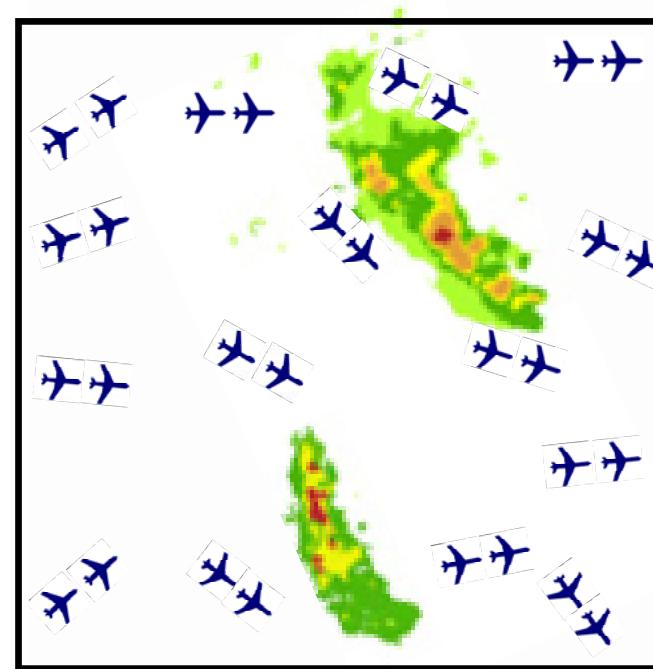
Free Flight (Unidirectional Rule)



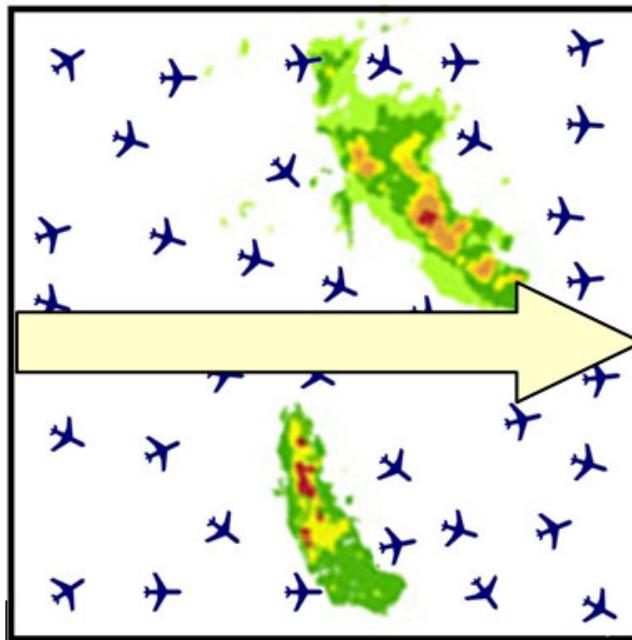
## Platooning of 2



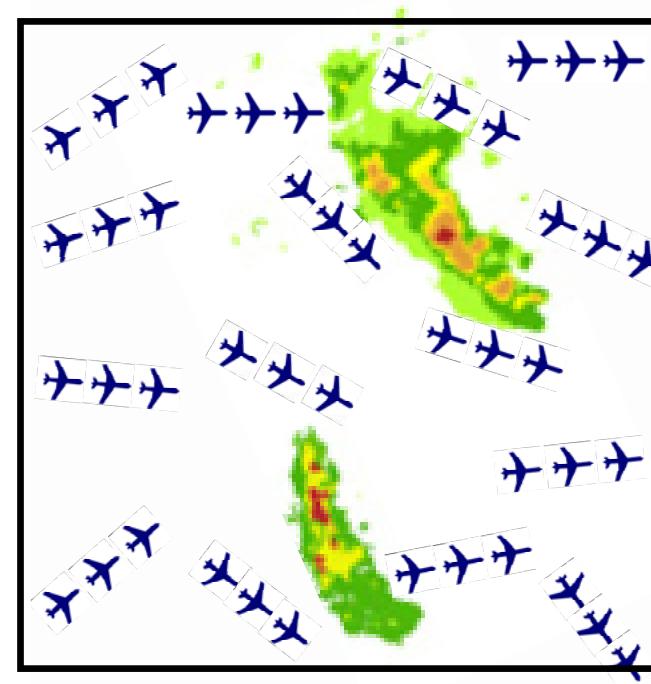
Free Flight (Unidirectional Rule)



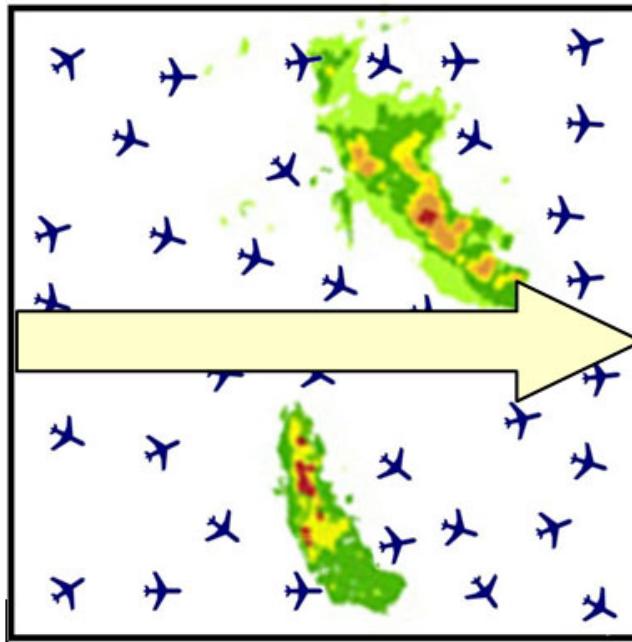
## Platooning of 3



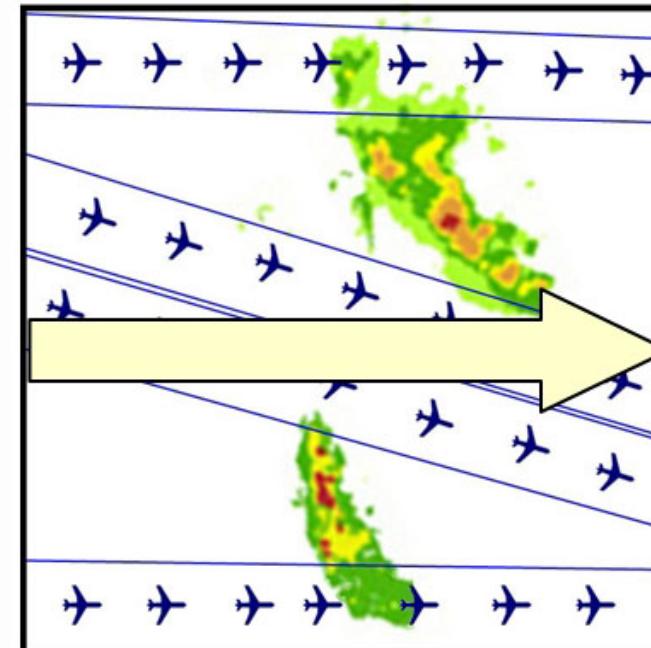
Free Flight (Unidirectional Rule)



# Platooning of N → Flow-Based Route Planning



Free Flight (Unidirectional Rule)



Packed Unidirectional Flow

Difference between platoon 1 and 4 is a 300%  
Increase in traffic (2D, simple concept)

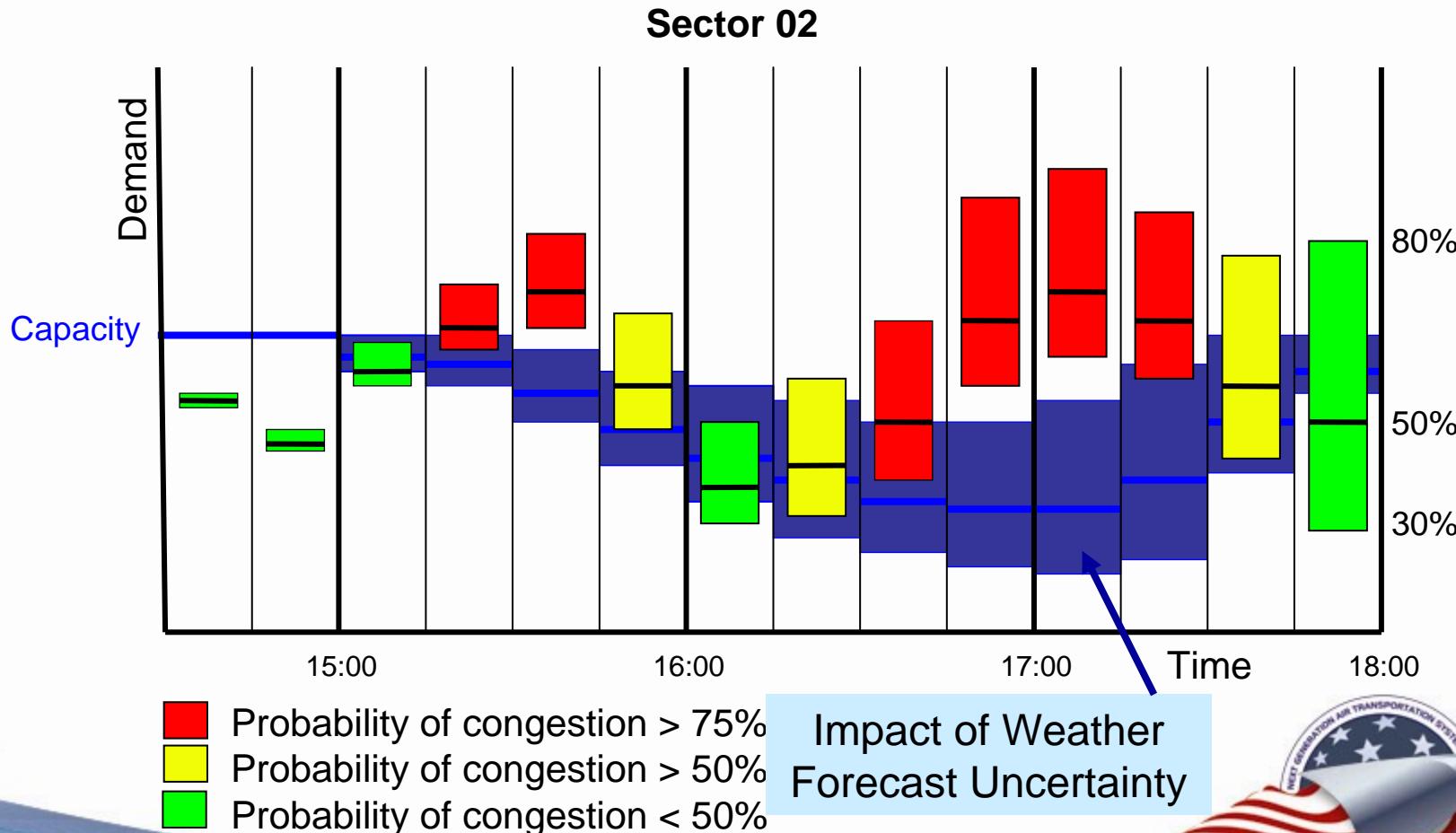


# Operational Focus (CAASD Wanke)

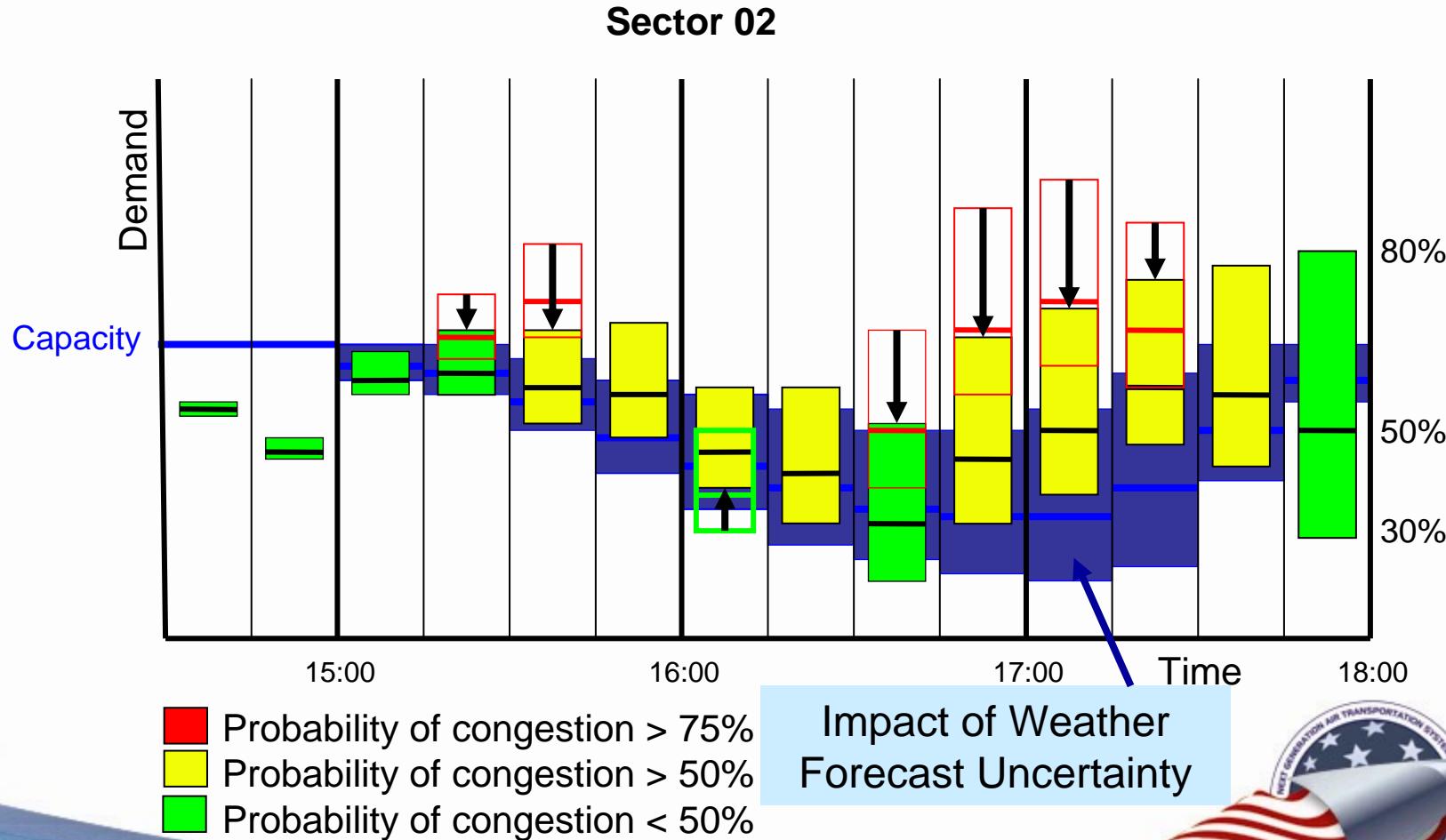
- An automated process to estimate weather impacts on sector capacity and develop resolution strategies:
  - Reduce TFM workload and increase efficiency
  - Reduce numbers of flights affected, magnitude of delays, delays on unininvolved flights
    - Provide more opportunities for customer participation
    - Maintain safe controller workload
- Highly relevant to the NextGen concept of operations:
  - Factor weather impact explicitly into operational planning
  - A natural path to trajectory-based operations
  - An automated feedback service for NAS customers for distributed (and automated) decision making
  - Better, faster tactical congestion management means a more robust and flexible NAS



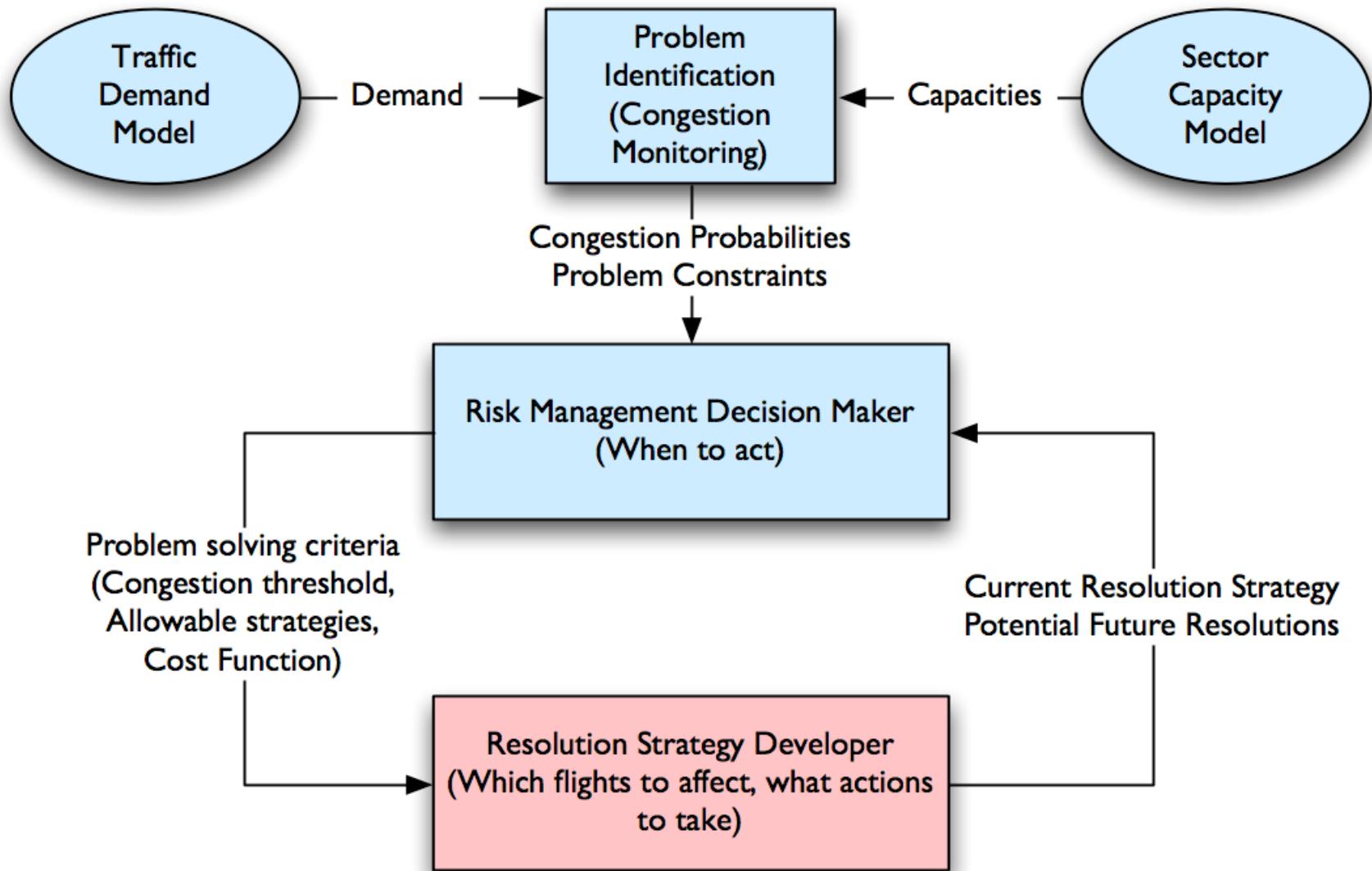
# Probabilistic Future Sector Demand and Capacity Graph



# Managing Congestion to an Acceptable Level of Risk (Probability)



# Risk Management Decision Loop



# Good Examples of Weather Integration into Automated Decision Support Tools

- Researchers are making progress on many elements of decision support for incremental, probabilistic traffic management.
  - A step towards “TFM by exception”
  - Congestion management is only one application
  - This work is consistent with NextGen TFM concepts, may provide key technology elements



# Problem 2: Common Situational Awareness for Weather

- Weather information is used for a variety of purposes in the air transportation system
- Much of this information is inconsistent, and is not standardized across the operational system
- Legacy systems often do not communicate critical weather information with each other
- Uncoordinated and inconsistent decision-making result from a lack of definitive weather information



# Solution 2: Common Weather Situational Awareness

- Reduce weather's impact on safety and air transportation system predictability
- Share common weather situational awareness among NextGen stakeholders
- Develop a single authoritative (common) source for weather information and a network enabled (similar but more in-depth web-based) dissemination system to provide users with consistent weather information tailored to respective needs
- Develop an affordable capability to provide weather information to/from the cockpit



# Problem 3: Observation and Forecast Quality

- Today's weather observations and forecasts provide generalized information, which often is not useful at the geographic or time scale appropriate to the decision being made
- Current weather capabilities are not tailored to specific decision-making needs, being insufficient in terms of accuracy, timeliness, and resolution



# Solution 3: Observation and Forecast Qualities

- Significantly reduce delays attributed to weather and ATM reaction to weather forecasts by:

Providing observations and forecast information with qualities tailored to NextGen procedures, safety, and capacity needs

Implementing nested forecasting systems that are probabilistic and use 4D cube concepts



# Weather & Air Traffic Management

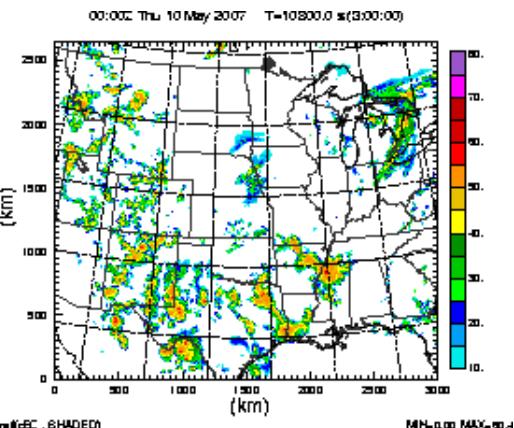
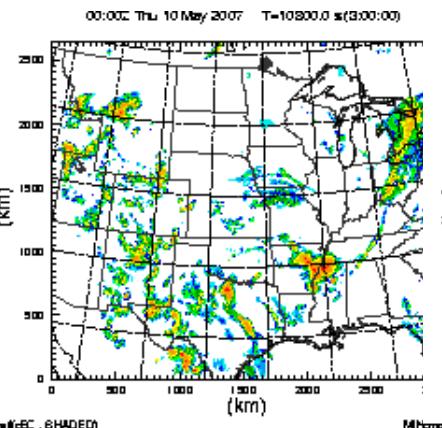
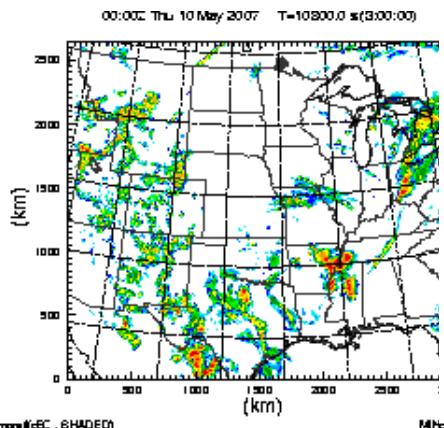
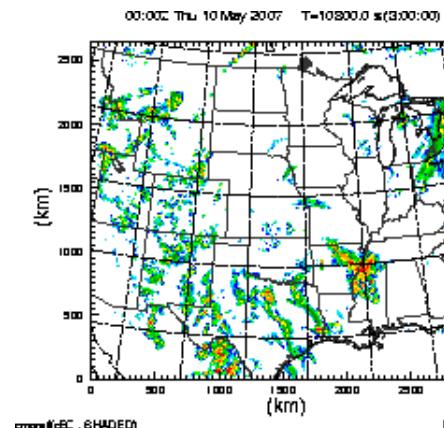
## Aviation

- hazardous areas
- storm intensity, structure & organization
- weather uncertainty

## Weather

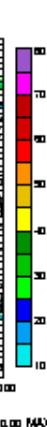
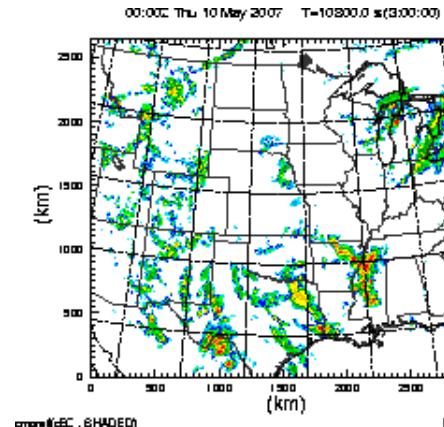
- convective storms, turbulence, icing, visibility
- high-resolution forecasts
- probabilistic forecasts, ensemble modeling



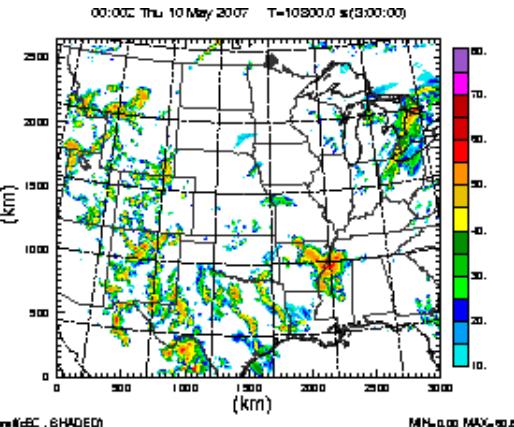


MIN 0.00 MAX 80.0

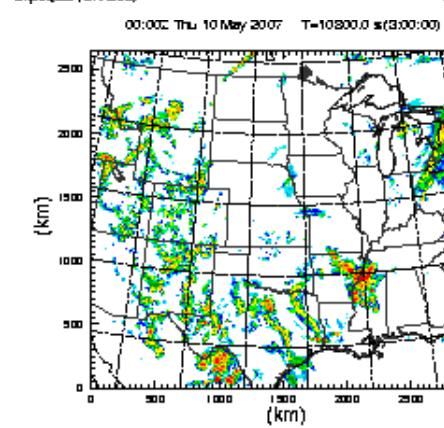
10 member, 4 km resolution,  
3 hour WRF ensemble forecast  
valid for 10 May 2007 at 00 Z



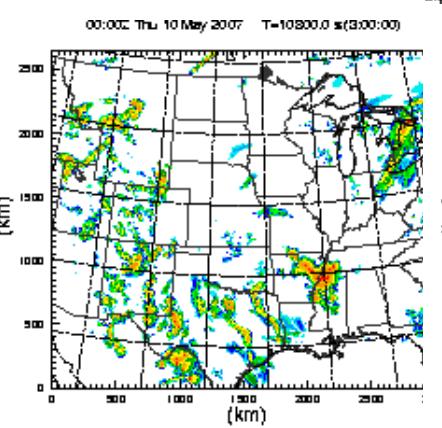
MIN 0.00 MAX 80.0



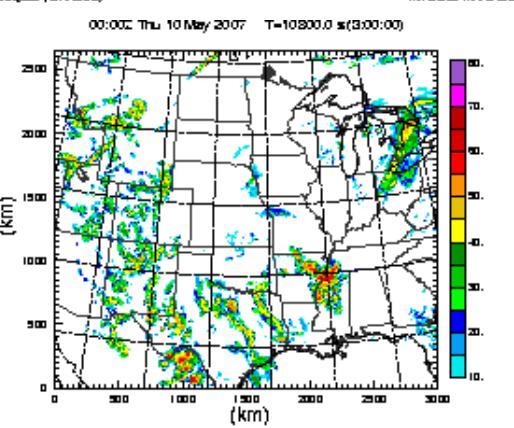
MIN 0.00 MAX 80.0



MIN 0.00 MAX 80.0

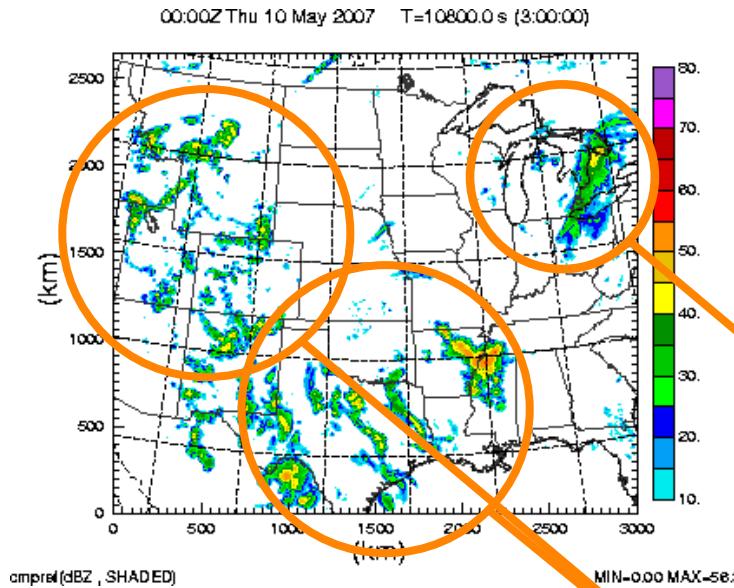


MIN 0.00 MAX 80.0

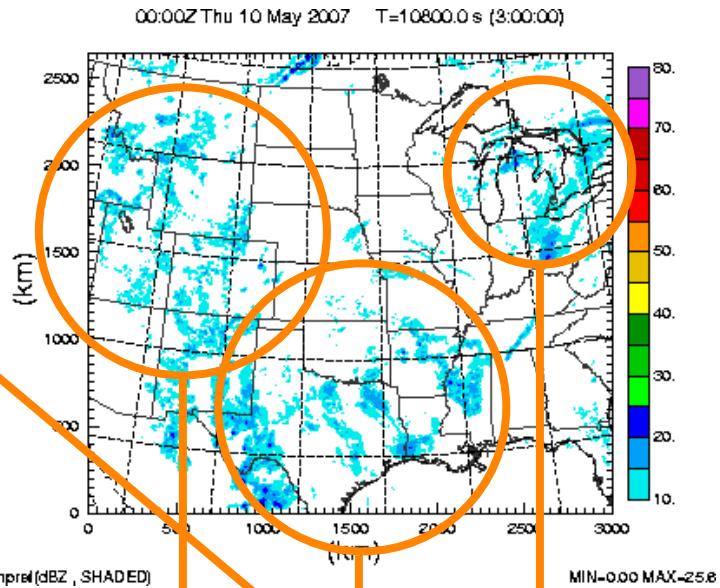


MIN 0.00 MAX 80.0

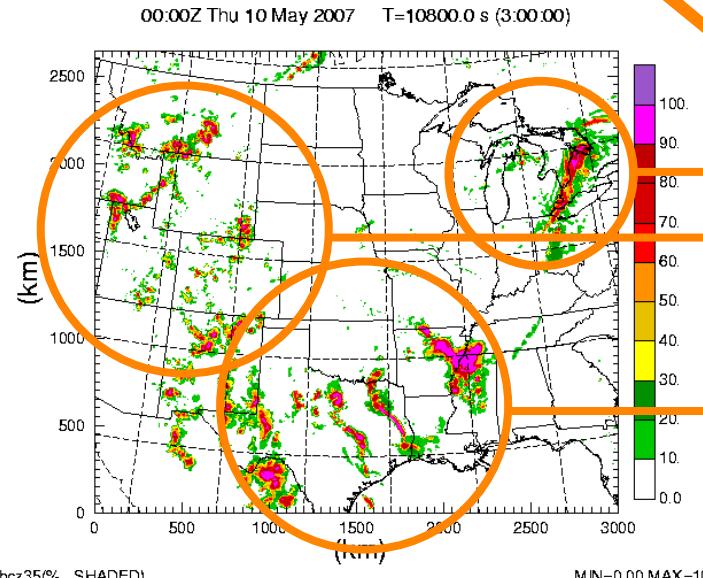
## Ensemble Mean



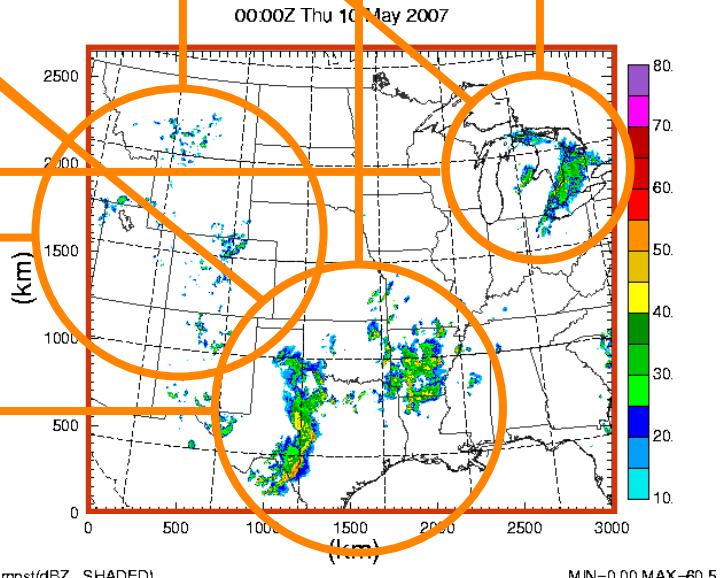
## Ensemble Spread



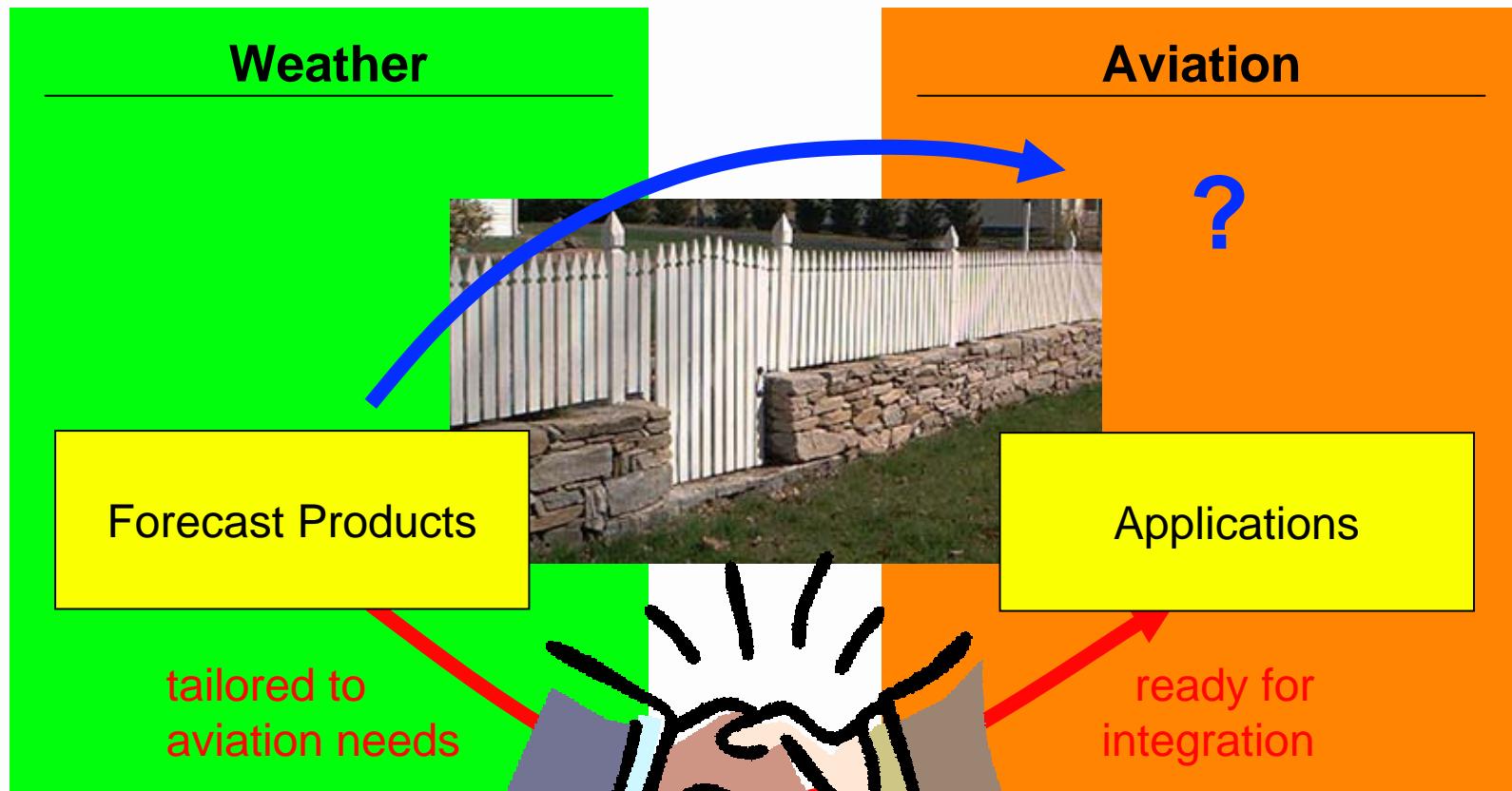
## Ensemble Probability > 35 dBZ



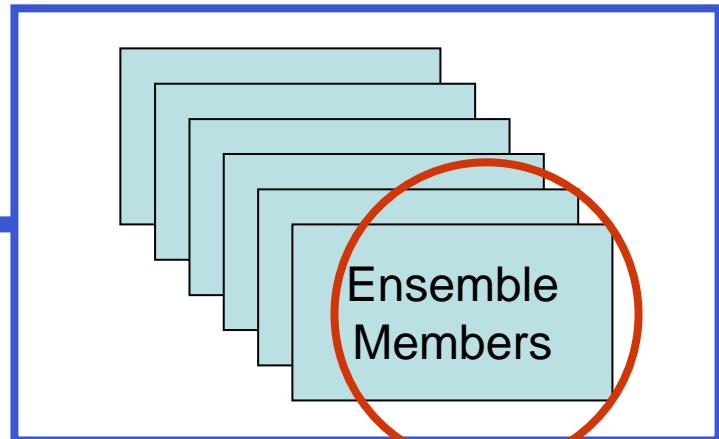
## Verification



# Weather Integration — Old & New



Forecast System

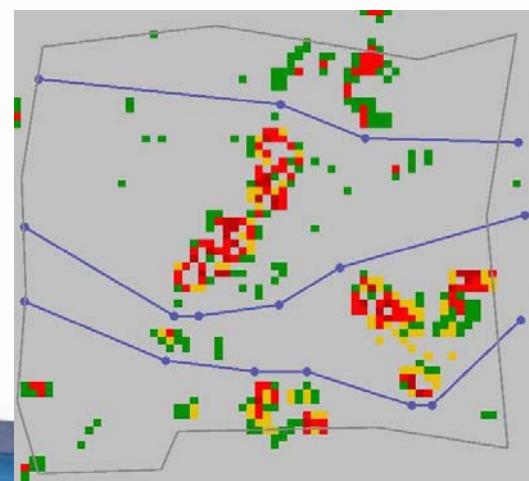


Probabilistic Weather Forecast

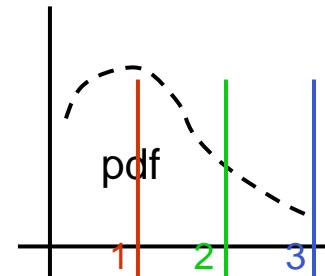
for each member  
over some airspace

Weather Pattern Analysis from an Aviation Perspective

permeability, MinCuts, etc.

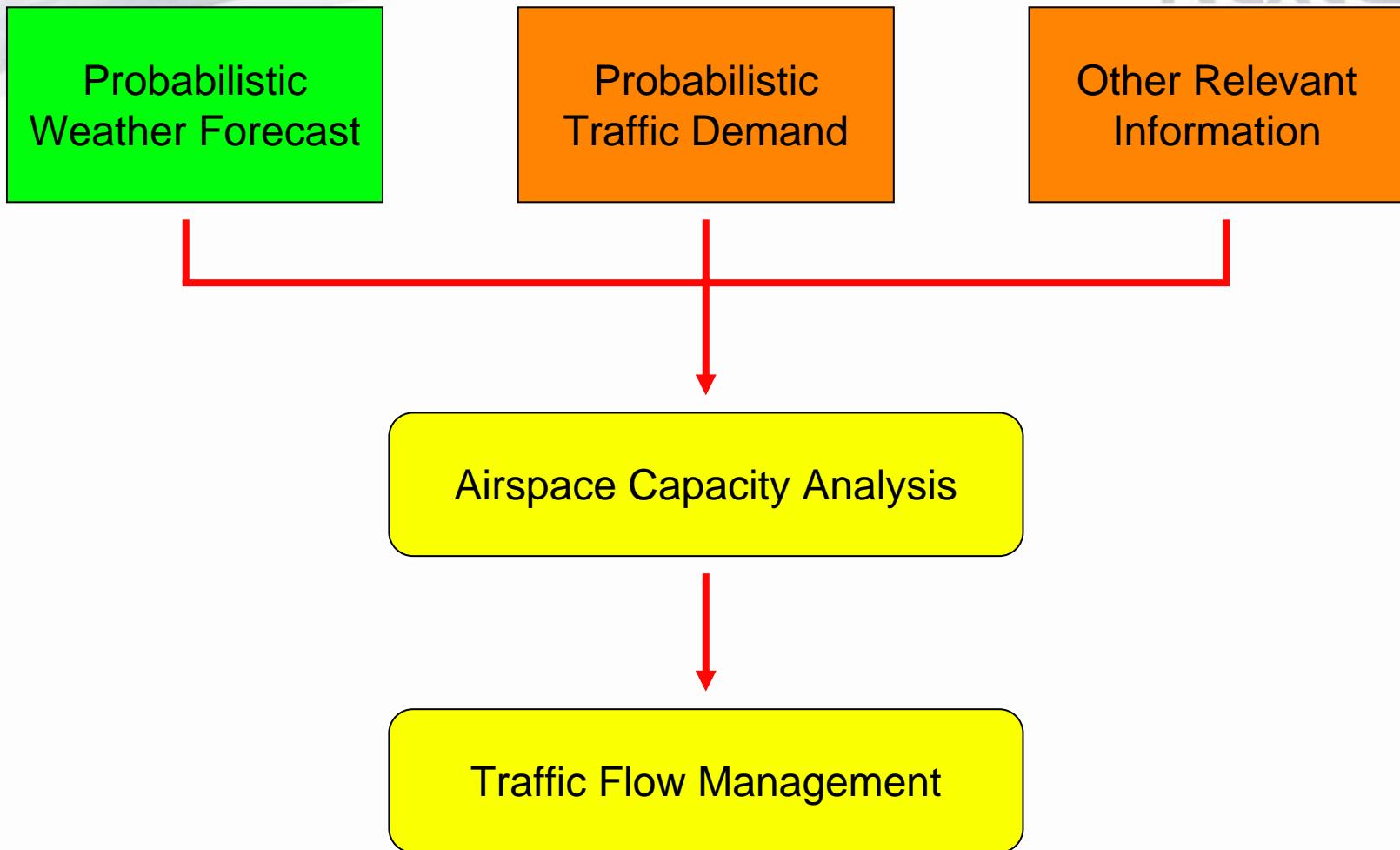


How many air lanes fit through  
evolving precipitation patterns?



for each airspace based  
on all ensemble members

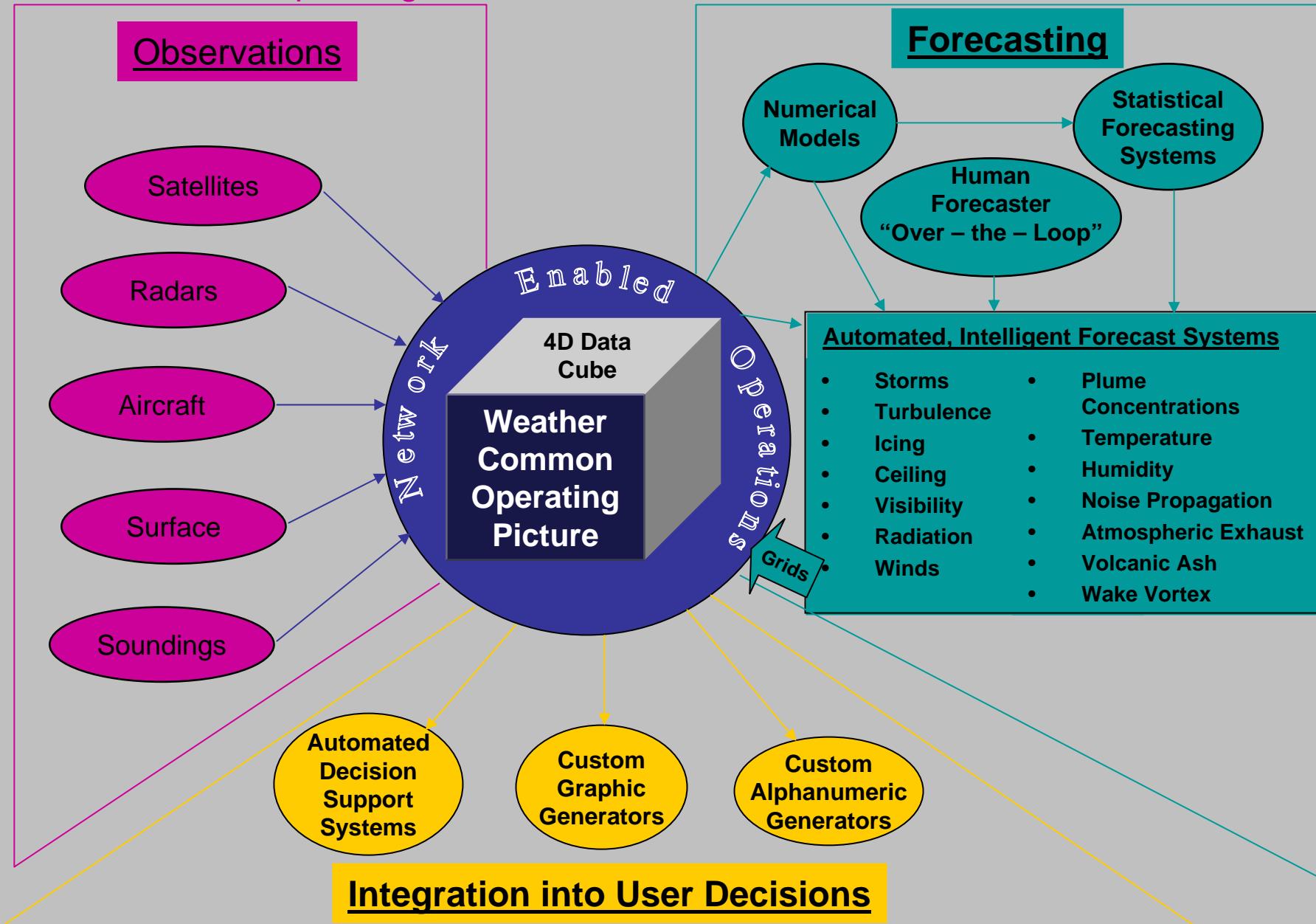




In collaboration with



# Observations and Forecasting: Populating the NextGen Weather Data Cube



# Thank You!

## Questions? Comments?

