



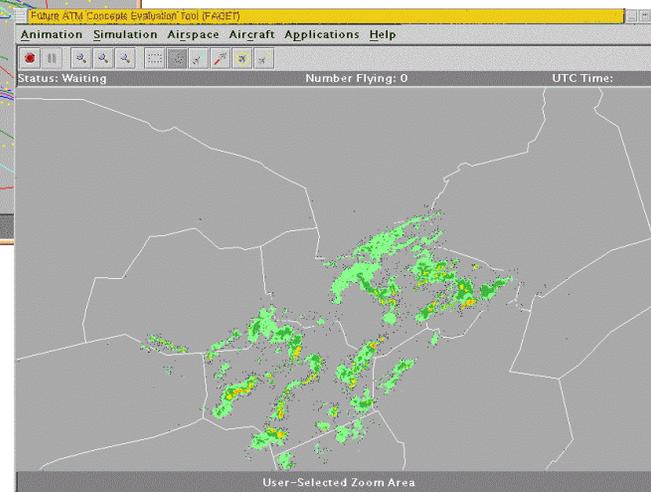
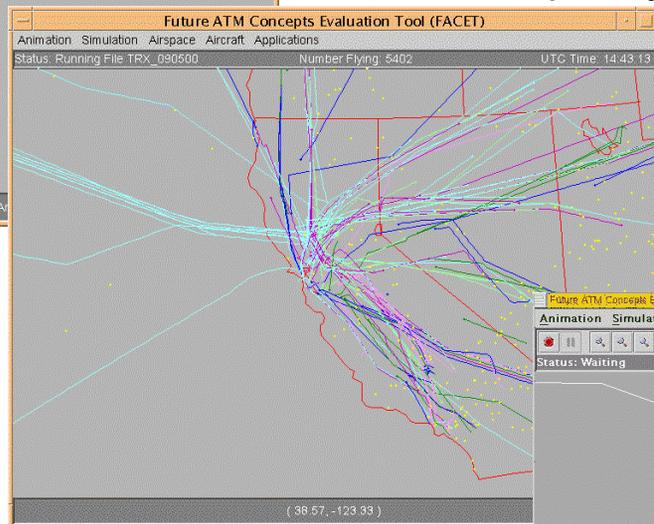
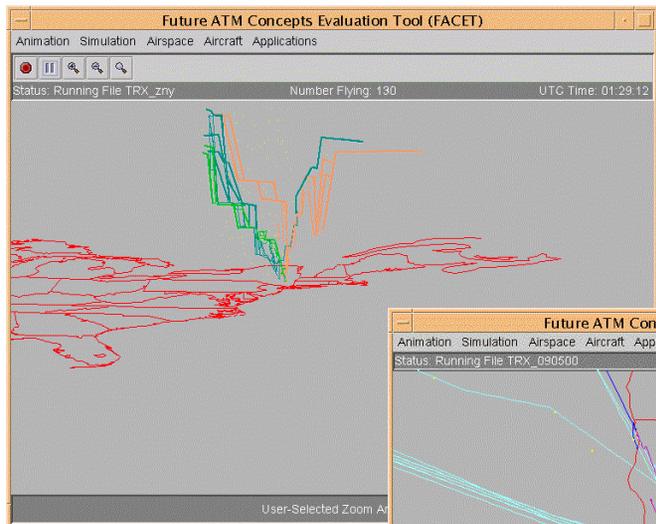
Recent Developments in the Future ATM Concepts Evaluation Tool (FACET)

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"Future ATM Concepts Evaluation Tool (FACET)

- **Simulation tool for exploring advanced ATM concepts**
 - Flexible environment for rapid prototyping of new ATM concepts
 - Can be integrated with other tools of varying complexity and fidelity

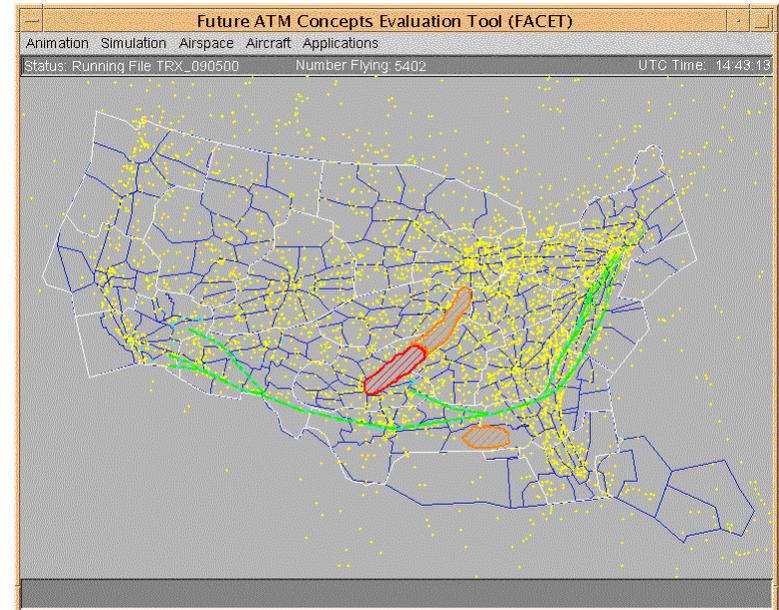




Introduction to FACET

- **Balance between fidelity and flexibility**

- Model airspace operations at U.S. national level (over 5,000 aircraft)
- Modular architecture for flexibility
- Software written in "C" and "Java" programming languages
- Can be used for both off-line analysis and real-time applications

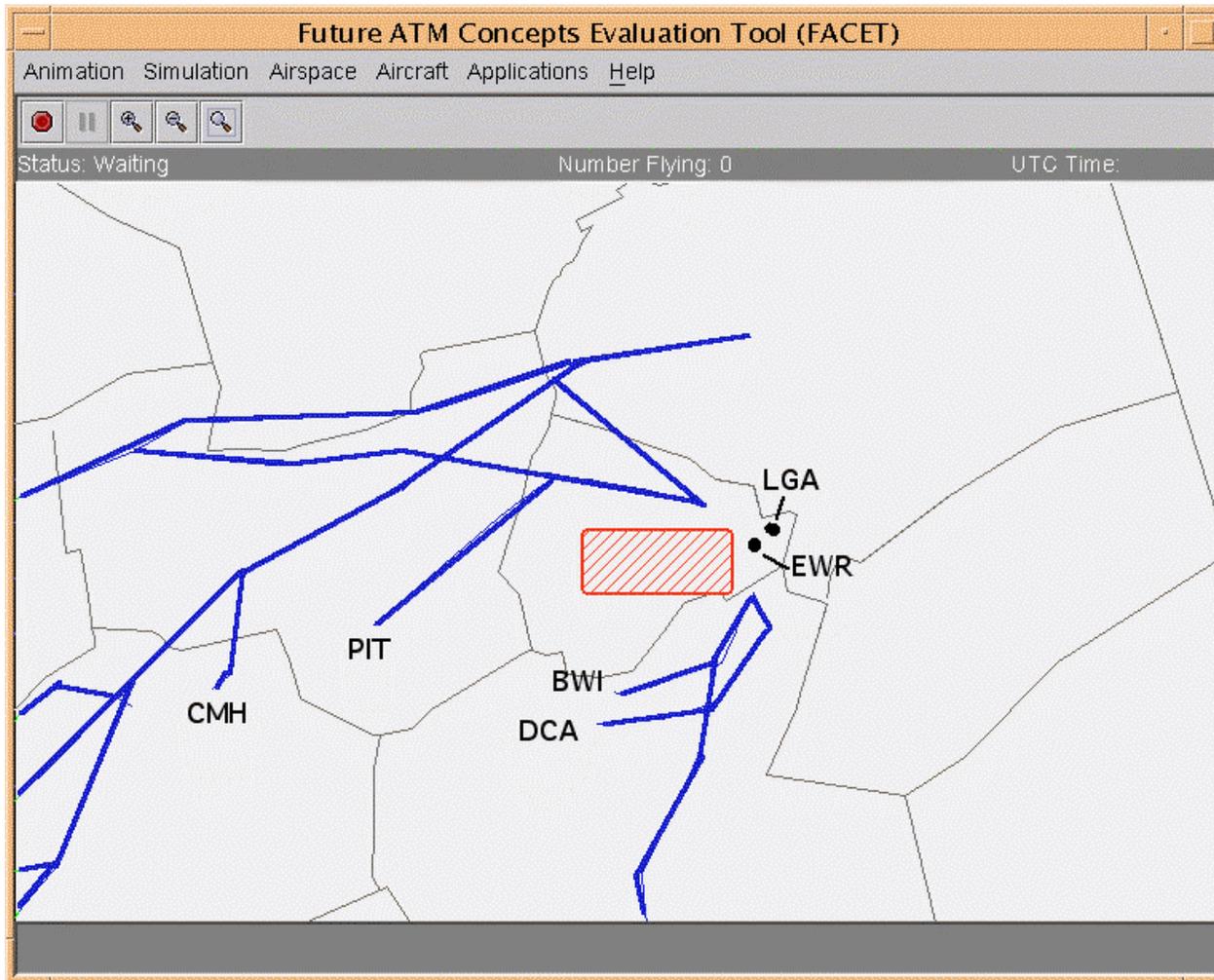


- **Recent Additions to FACET**

- Integrated Assessment of Traffic Flow Management Initiatives
- Distributed Air-Ground Separation Methods
- Probabilistic Sector Demand Forecasting
- Wind Optimal Rerouting



Integrated Assessment of Traffic Flow Management Initiatives



(NO WESTGATES/RBV Playbook Plan)



Alternative TFM Initiatives During Severe Weather

Time	ZNY34	ZNY10
Cap	17	17
13:06	13	14
13:21	11	18
13:36	10	18
13:51	13	14
14:06	10	14
14:21	8	9
14:36	9	14
14:51	7	18

Nominal Sector Counts

Time	ZNY34	ZNY10
Cap	17	17
13:06	20	9
13:21	20	12
13:36	13	15
13:51	15	10
14:06	14	10
14:21	10	8
14:36	13	11
14:51	10	16

Weather Reroute
(NO_WESTGATES)

Time	ZNY34	ZNY10
Cap	17	17
13:06	15	9
13:21	14	12
13:36	13	14
13:51	12	10
14:06	11	11
14:21	9	8
14:36	12	11
14:51	11	16

[A] Rerouting +
Nominal Departure
Rates

Time	ZNY34	ZNY10
Cap	17	17
13:06	16	9
13:21	15	12
13:36	13	14
13:51	13	11
14:06	13	10
14:21	13	8
14:36	15	11
14:51	8	16

[B] Rerouting +
Optimal Departure
Rates

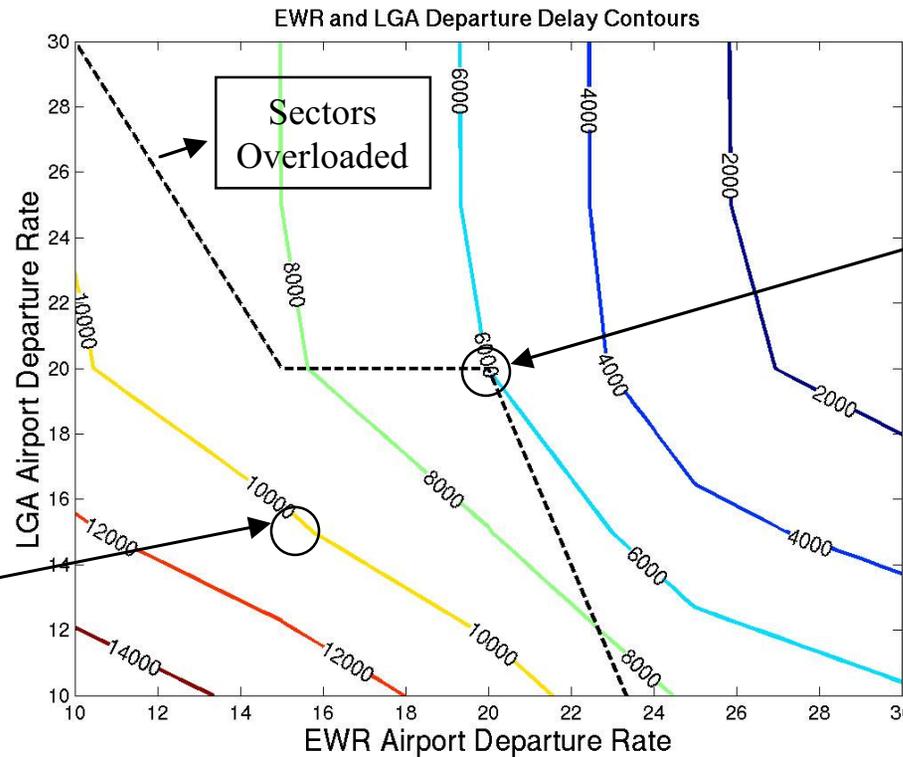
Rerouting results in Sector overloading and requires additional TFM initiatives.



Delays Associated with TFM Initiatives

Sector ()		
File	Edit	Table
Time	ZNY34	ZNY10
Cap	17	17
13:06	15	9
13:21	14	12
13:36	13	14
13:51	12	10
14:06	11	11
14:21	9	8
14:36	12	11
14:51	11	16

[A] Rerouting + Nominal
Departure Rates
Total Delay = 10361 sec.



[B] Rerouting + Optimal
Departure Rates
Total Delay = 5986 sec.

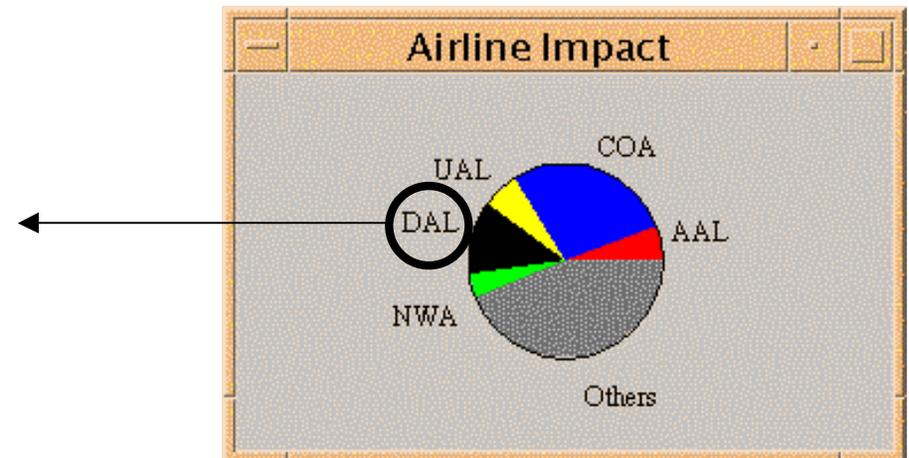
Sector ()		
File	Edit	Table
Time	ZNY34	ZNY10
Cap	17	17
13:06	16	9
13:21	15	12
13:36	13	14
13:51	13	11
14:06	13	10
14:21	13	8
14:36	15	11
14:51	8	16

Using FACET, total system demand is met (increase in capacity) with minimum delay



Airline Impact of Rerouting and Departure Delays

Acid	Rerouted	GDP/GS
DAL1745	X	
DAL1747		X
DAL1749	X	X
DAL1826	X	X
DAL217		X
DAL2293		X
DAL2475	X	X
DAL270		X
DAL305	X	
DAL339		X
DAL631	X	
DAL847	X	
DAL999	X	



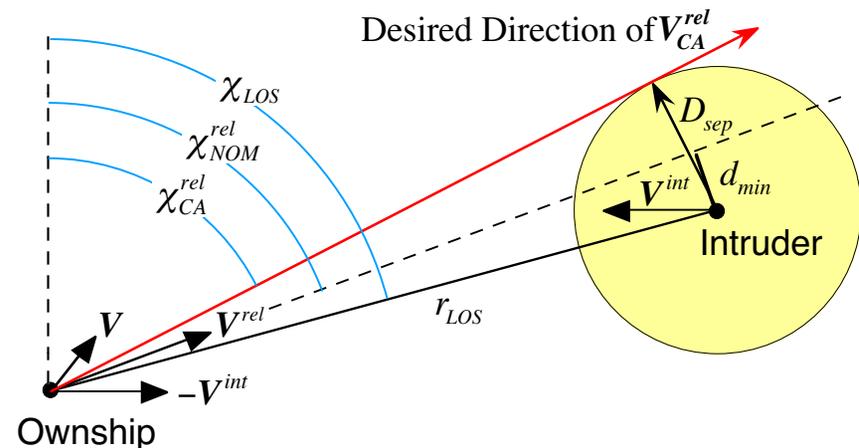
Red: Active Flights

Yellow: Proposed Flights



Conflict Detection and Resolution

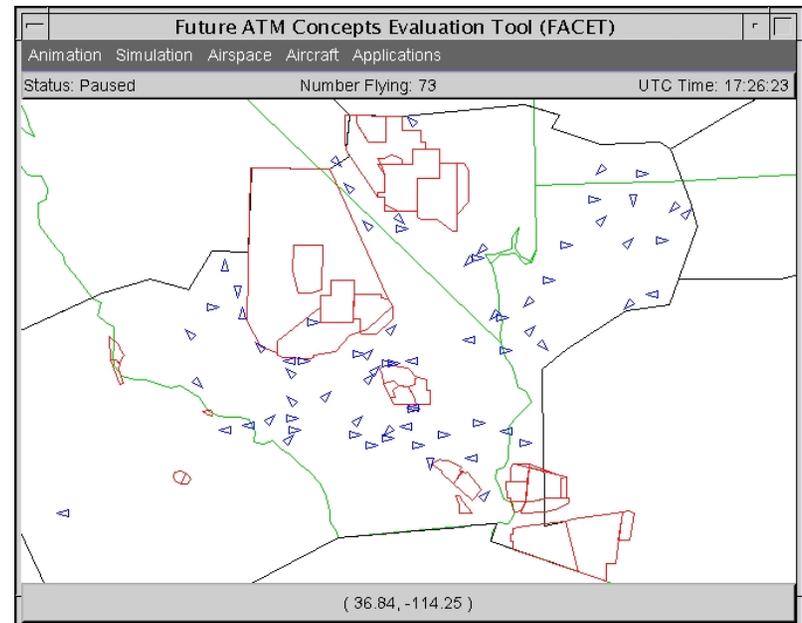
- **Two qualitatively different Conflict Detection and Resolution (CD&R) schemes are currently available in FACET**
 - Geometric Optimization approach (developed at NASA Ames)
 - Modified Potential Field approach (developed at MIT Lincoln Lab)
 - CD&R capabilities utilized for DAG-TM studies on airborne self-separation
- **Geometric Optimization approach**
 - Seeks to minimize deviations from nominal trajectory
 - Geometric characteristics of aircraft trajectories are utilized to derive closed-form analytical expressions for efficient conflict avoidance
 - » Best heading-speed combination
 - » Heading only
 - » Speed only
 - » Altitude-rate only





Studies on Self-Separation for DAG-TM

- **Free Maneuvering is a key element of DAG-TM**
 - Airborne self-separation is necessary to enable Free Maneuvering
- **Initial feasibility evaluation of airborne self-separation**
 - Focus on system-level performance characteristics and issues
 - Conducted simulation studies in FACET
- **FACET-based studies**
 - Performance evaluation of airborne separation assurance for free flight
 - Agent-based approach to conflict resolution with spatial constraints
 - Properties of air traffic conflicts for free and structured routing

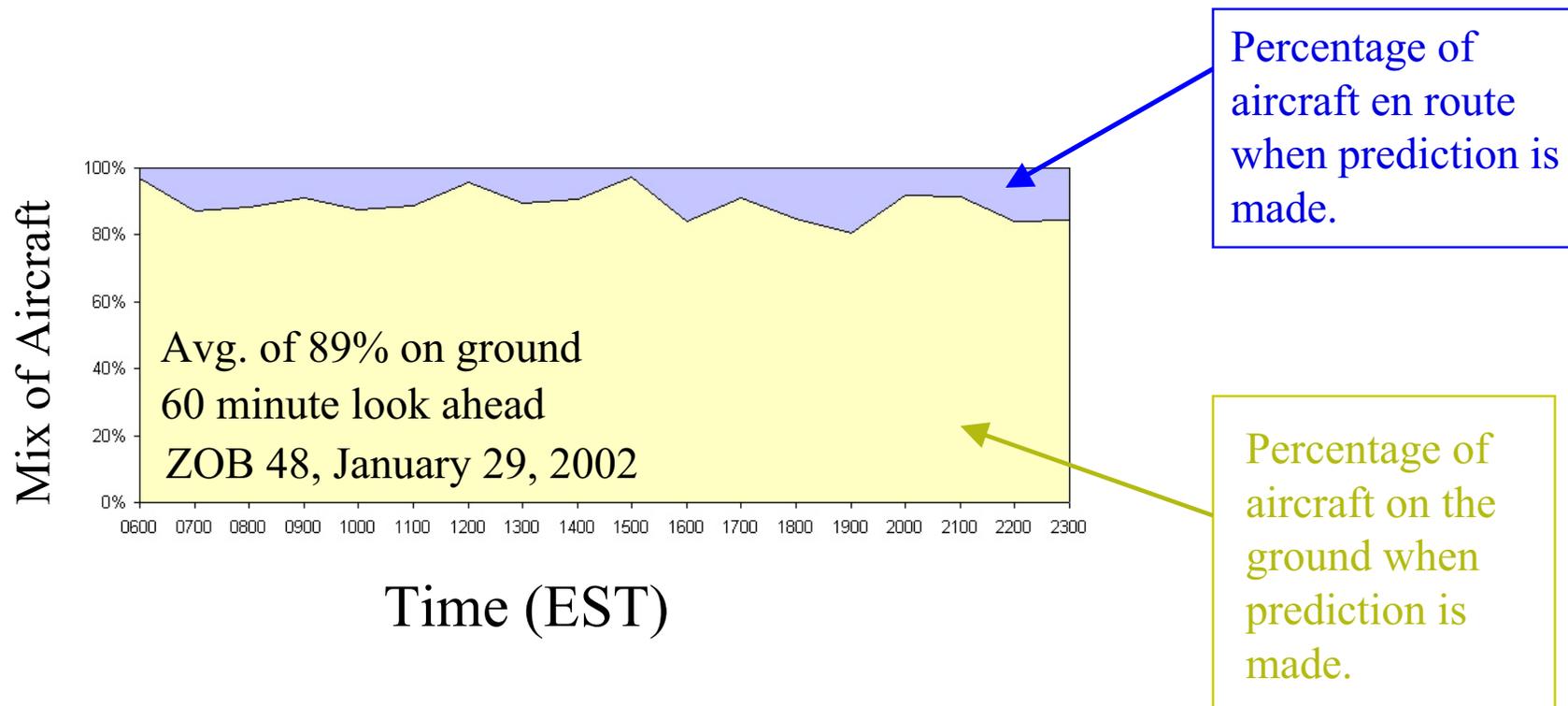


- **Results support feasibility of airborne self-separation**



Probabilistic Sector Demand Forecasting

- Departure time prediction accuracy is a key factor in terms of long term trajectory prediction accuracy.



(Metron Aviation Inc., NAS2-98005, Task Order 66)



Probabilistic Sector Demand Forecasting

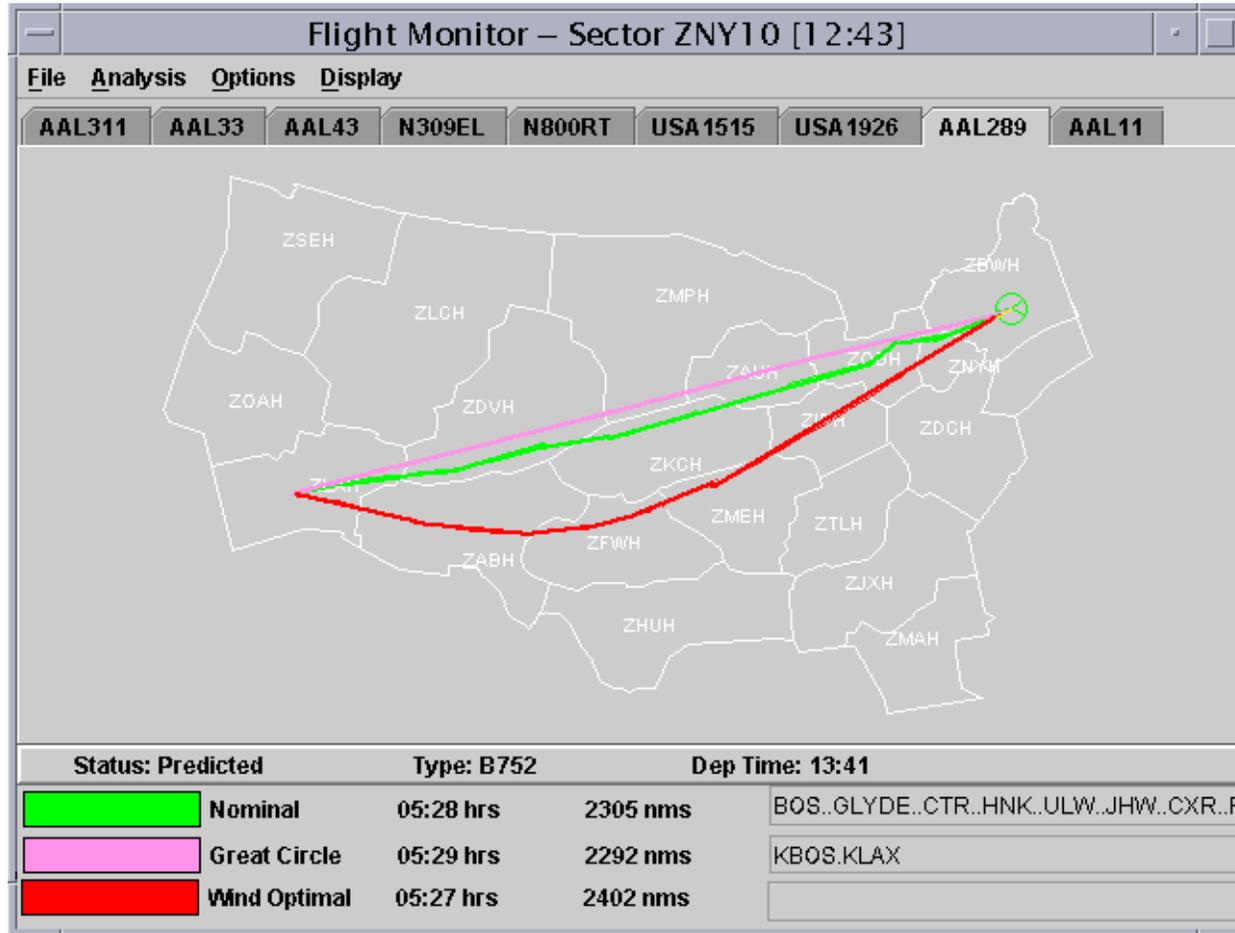
- Departure time uncertainty has been modeled as Gaussian distributions for major airports with means and standard deviations derived from historical delay data.
- Departure delay distributions are used with the trajectory prediction process to forecast the probability of exceeding the monitor alert levels by specified number of aircraft.
- Probabilistic demand forecasting is being compared with deterministic demand forecasting to assess the benefit for decision making.

Time	ZOB29	ZKC84	ZLA30	ZNY42	ZDC12
Cap	18	15	13	15	16
19:00	19	9	14	16	12
19:15	21	21	13	17	18
19:30	17	20	14	20	14
19:45	22	10	11	18	18
20:00	22	10	9	22	23
20:15	12	13	15	16	19
20:30	10	13	11	18	12
20:45	14	9	8	9	11

Time	ZOB29	ZKC84	ZLA30	ZNY42	ZDC12
Cap	18	15	13	15	16
19:00	100	0	100	100	0
19:15	100	100	22	92	100
19:30	28	100	51	100	19
19:45	53	1	0	65	89
20:00	36	1	0	100	100
20:15	0	1	41	84	69
20:30	0	3	3	6	15
20:45	0	0	0	0	0



Wind Optimal Rerouting



More details will be provided tomorrow by Matt Jardin.