



FACET Modeling and Simulation Capability

Banavar Sridhar
NASA Ames Research Center
Moffett Field, CA 94035
bsridhar@mail.arc.nasa.gov
November 7, 2001



Current analysis capability

- **Deeper understanding of current-day operations**
- **New operational concepts**
- **Analysis and benefits study of controller decision support tools**
- **New vehicles/transportation modes**
- **Advanced Traffic Flow Management (TFM) strategies**
- **Airspace design/utilization policy**



What Improvements are needed? NASA AvSTAR Workshop, Sep 20-21, 00

- Provide tools to frequently update strategic planning with and tactical operations decisions
- Develop metrics for Controller workload (Dynamic Density) and feasible capacity of TFM under ATC, user-preferred and actual conditions
- Provide a forecast of the traffic flow conditions to all users and decision makers (AOC, ATCSCC, Regions)
- Move from “reactive” TFM strategies to “proactive” TFM strategies
- Improve the reliability of sector monitor alerts
- Create a unified TFM



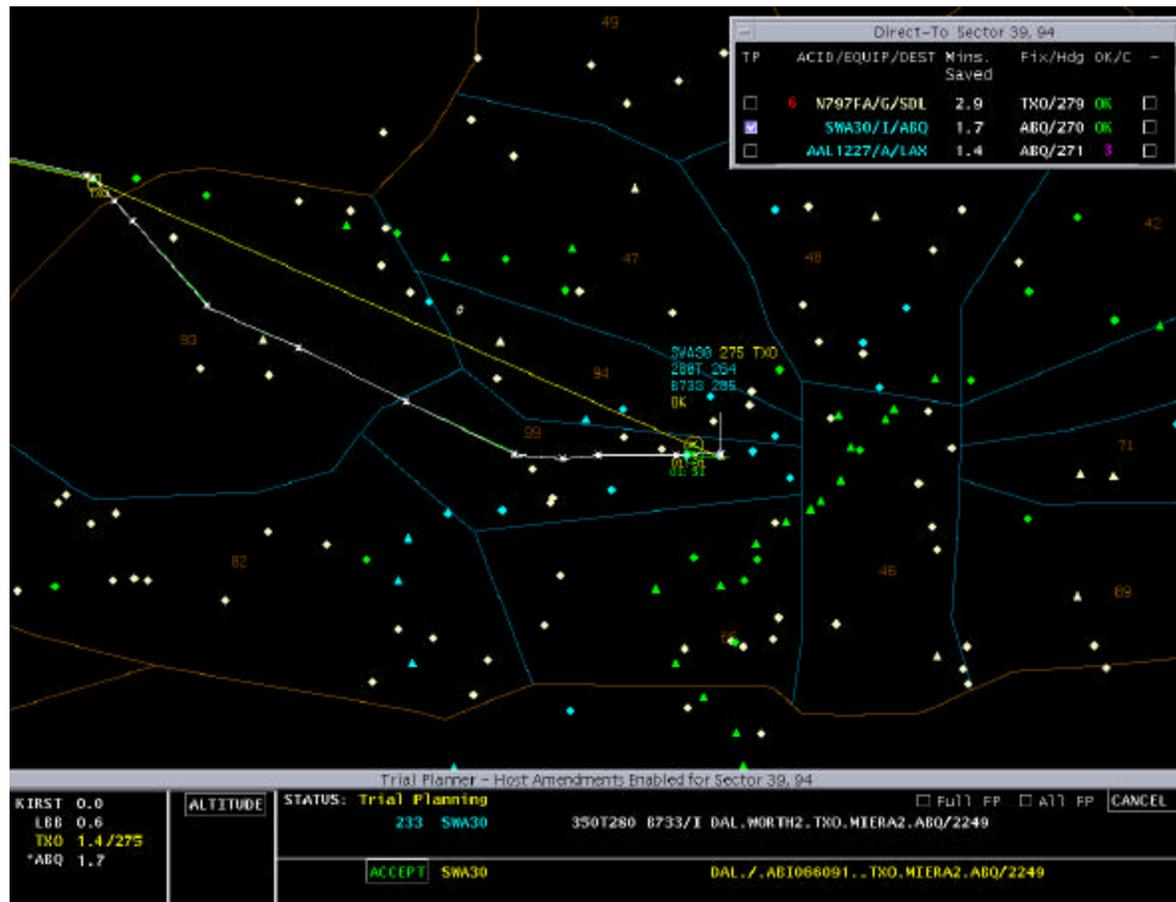
Research and Development in TFM

- **Modeling and Simulation Capability (FACET)**
- **Near-term Tool Development (FACET/SWEPT)**
- **System Level Optimization Methods**



Direct-To Controller Tool

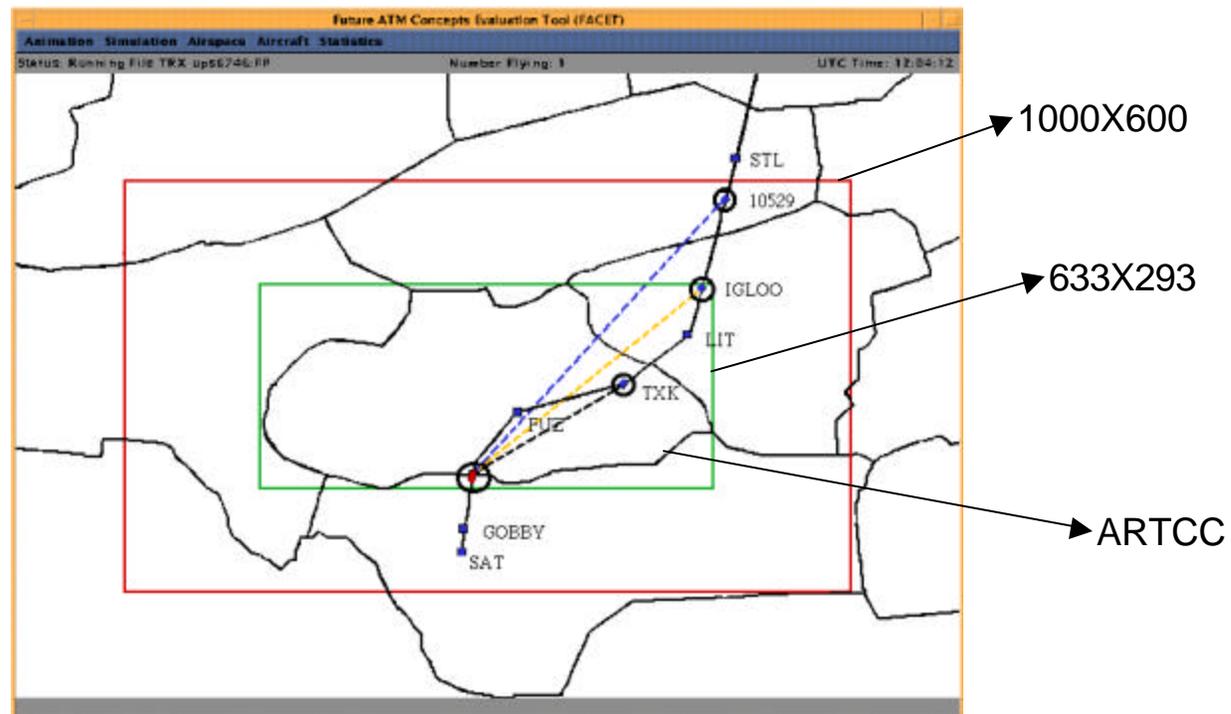
- Optimizes routing of departures and en route traffic to minimize flight time and avoid conflicts (Field Test June 2001)





BENEFITS OF DIRECT-TO TOOL AT FORT WORTH CENTER

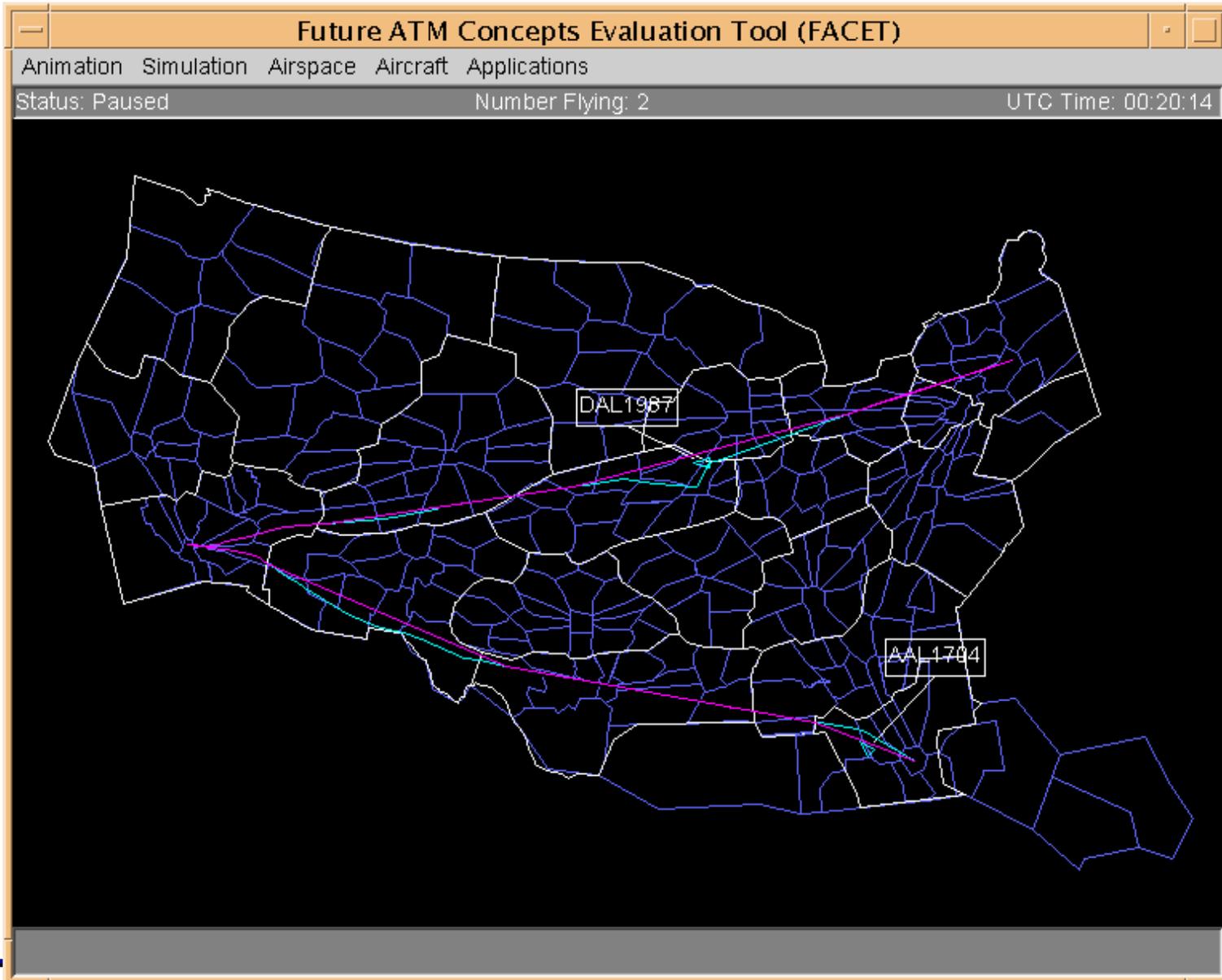
- 24 hours of ETMS data processed in FACET using different windows



SEARCH AREA	NUMBER OF AIRCRAFT	TOTAL SAVINGS (HOURS)	SAVINGS PER AIRCRAFT (MINUTES)
1000 X 600	349	20.6	3.5
633 X 293	139	10.3	4.1
ARTCC	113	7.8	4.4

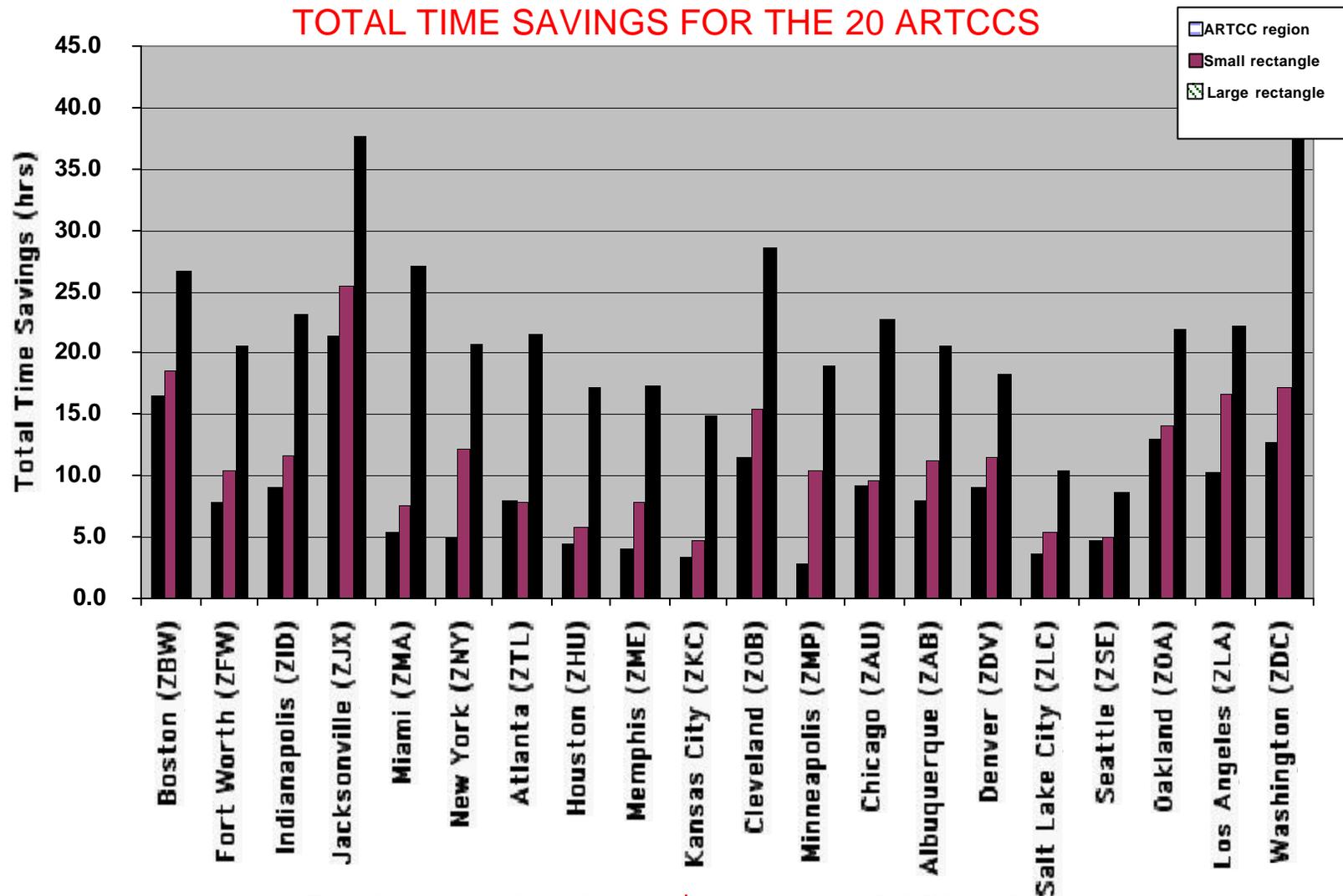


Simulation of D2 concept at all Centers





Does the proposed technology provide benefit ?

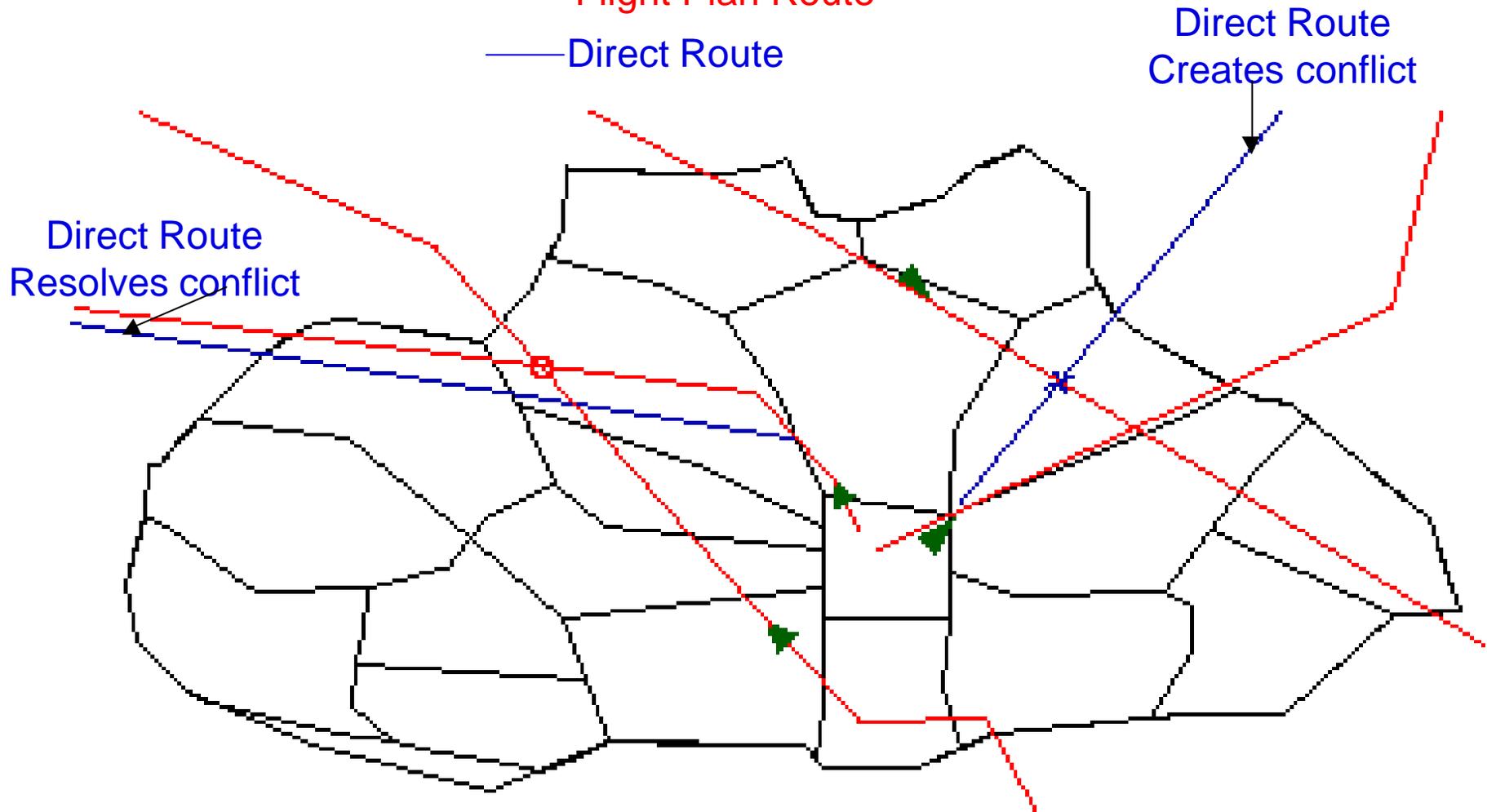


Projected Savings \$150-200 Million/Year



LOCATION OF CONFLICTS

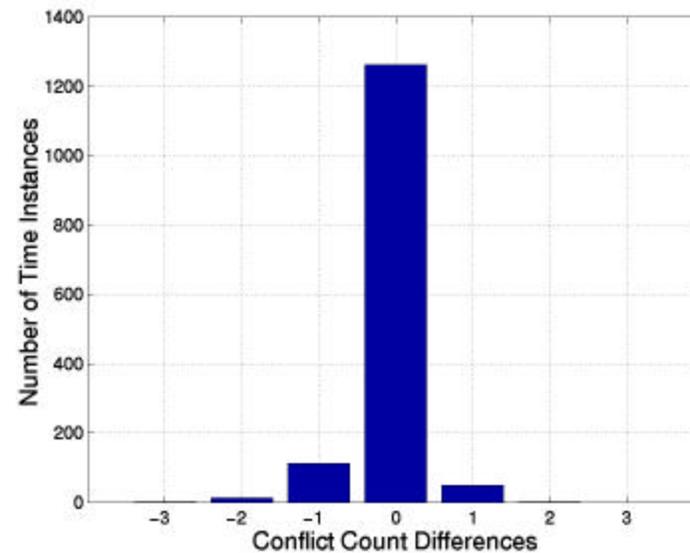
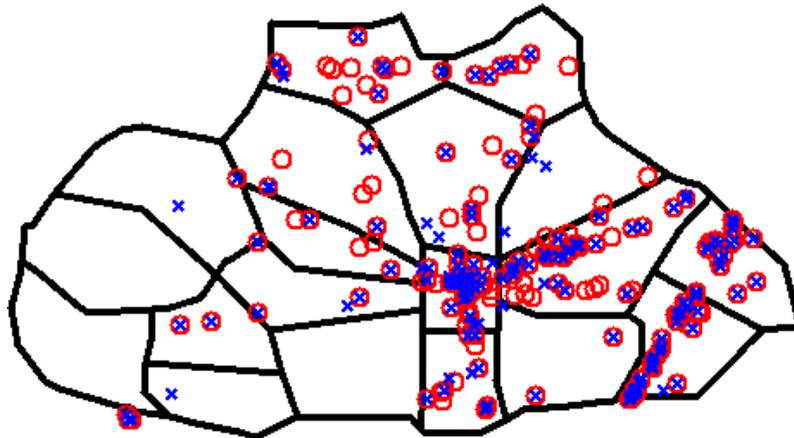
- Flight Plan Route
- Direct Route





Does D2 affect Controller's situation awareness?

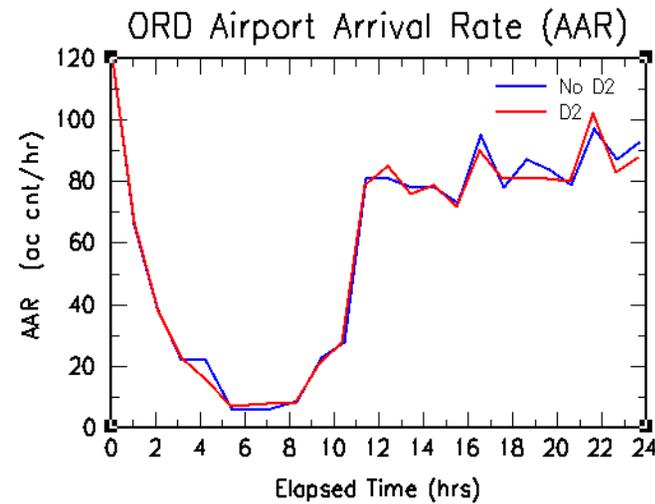
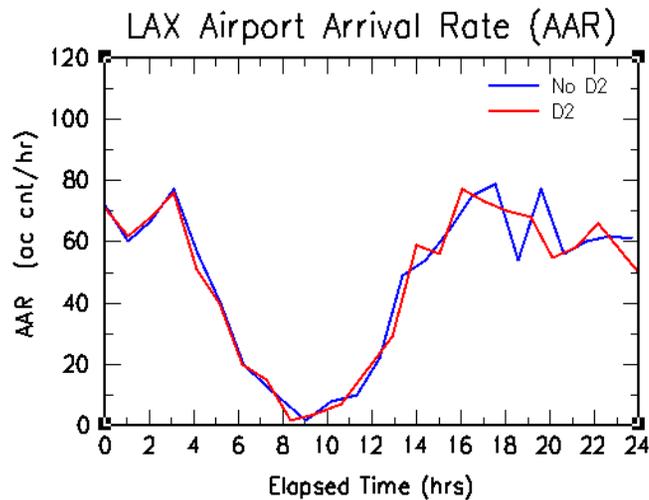
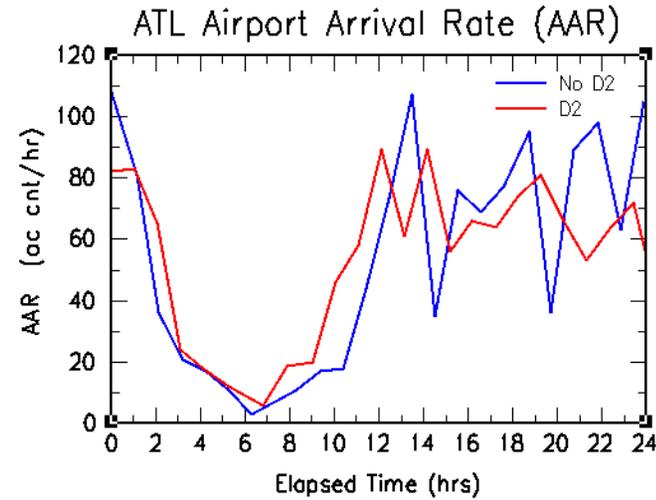
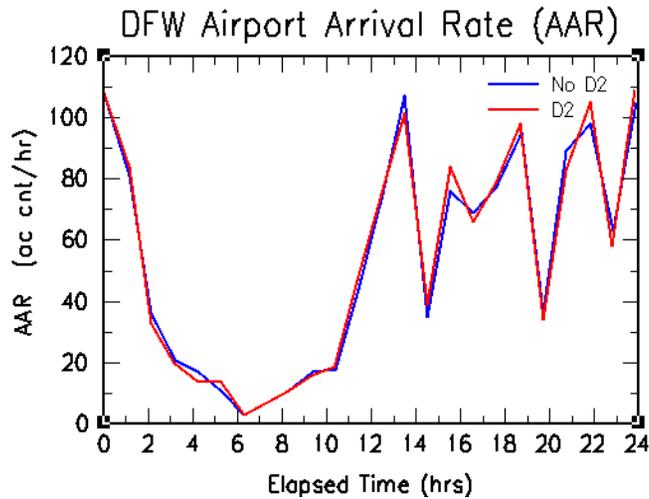
- Conflicts with Flight Plan Routing
- X Conflicts with Direct Routing



Direct-TO does not significantly affect the controller's situation awareness_ The number of conflicts and the location of conflicts are approximately same for both Direct routing and Flight Plan Routing



Does the technology have adverse impact?

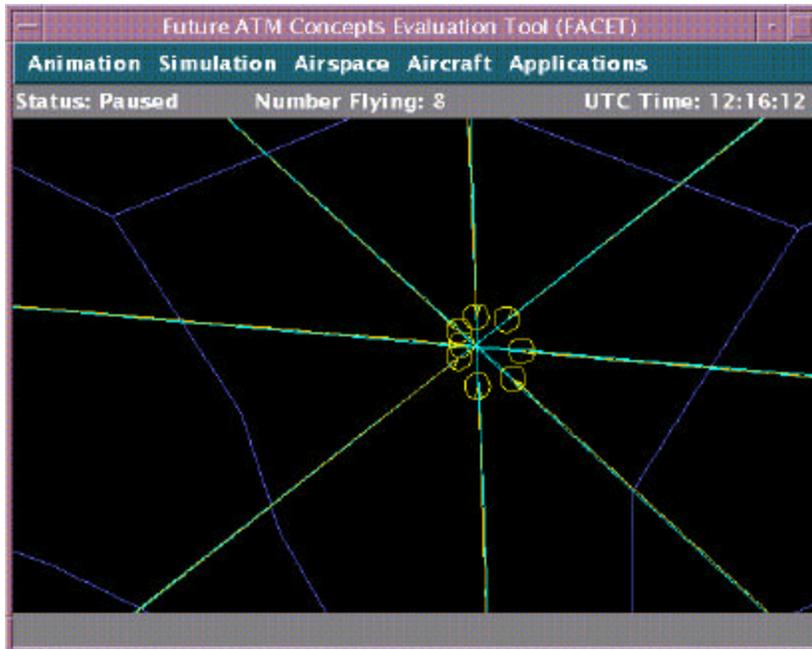


Direct-TO has no adverse effect on Airport Arrival Rates

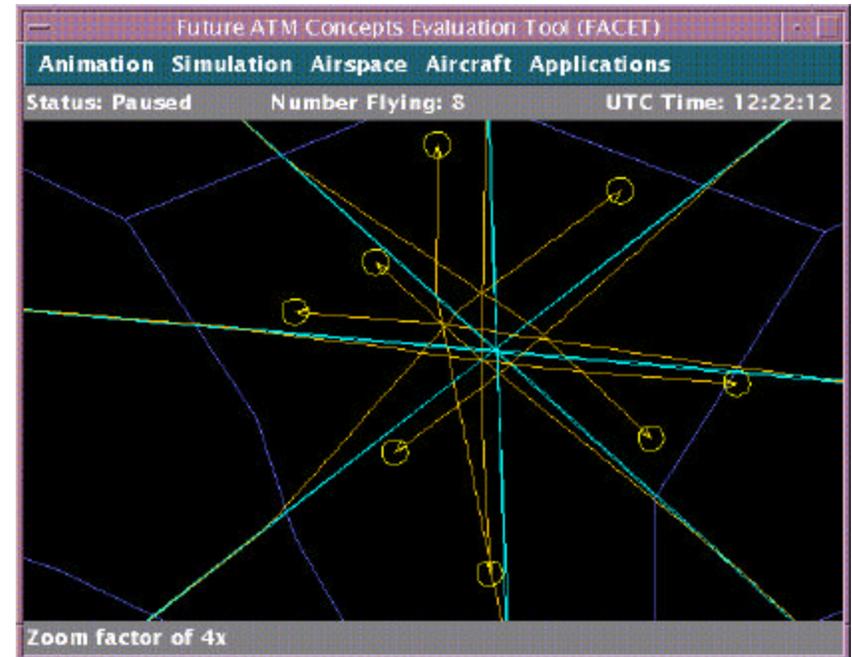


Airborne Self-Separation

- Airborne Conflict Detection and Resolution (CD&R) is necessary to enable the “Free Maneuvering” aspect of Distributed Air/Ground Traffic Management (DAG-TM)
- Two CD&R schemes implemented in FACET: Geometric Optimization and Modified Potential Field approach



Test Scenario without CD&R

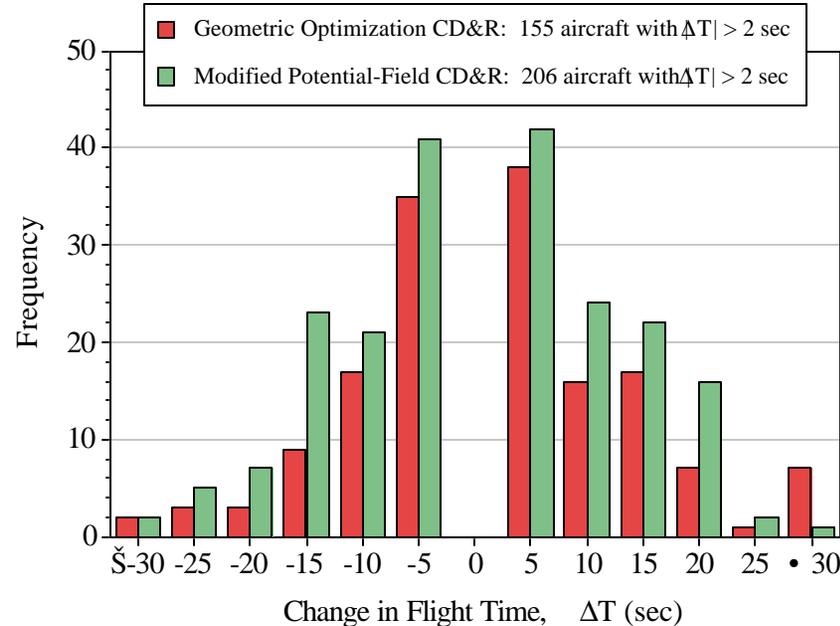


**Test Scenario with CD&R
(Geometric Optimization)**



Is Airborne Self-Separation Feasible?

- **Conducted a simulation evaluation in FACET, based on real traffic data**
 - 3 hrs of ETMS data for Denver Center**
 - 955 A/C flown direct to destination**
 - 209 A/C in 129 conflicts (no CD&R)**



Airborne Self-Separation resolved all conflicts with minimal deviation from nominal trajectories

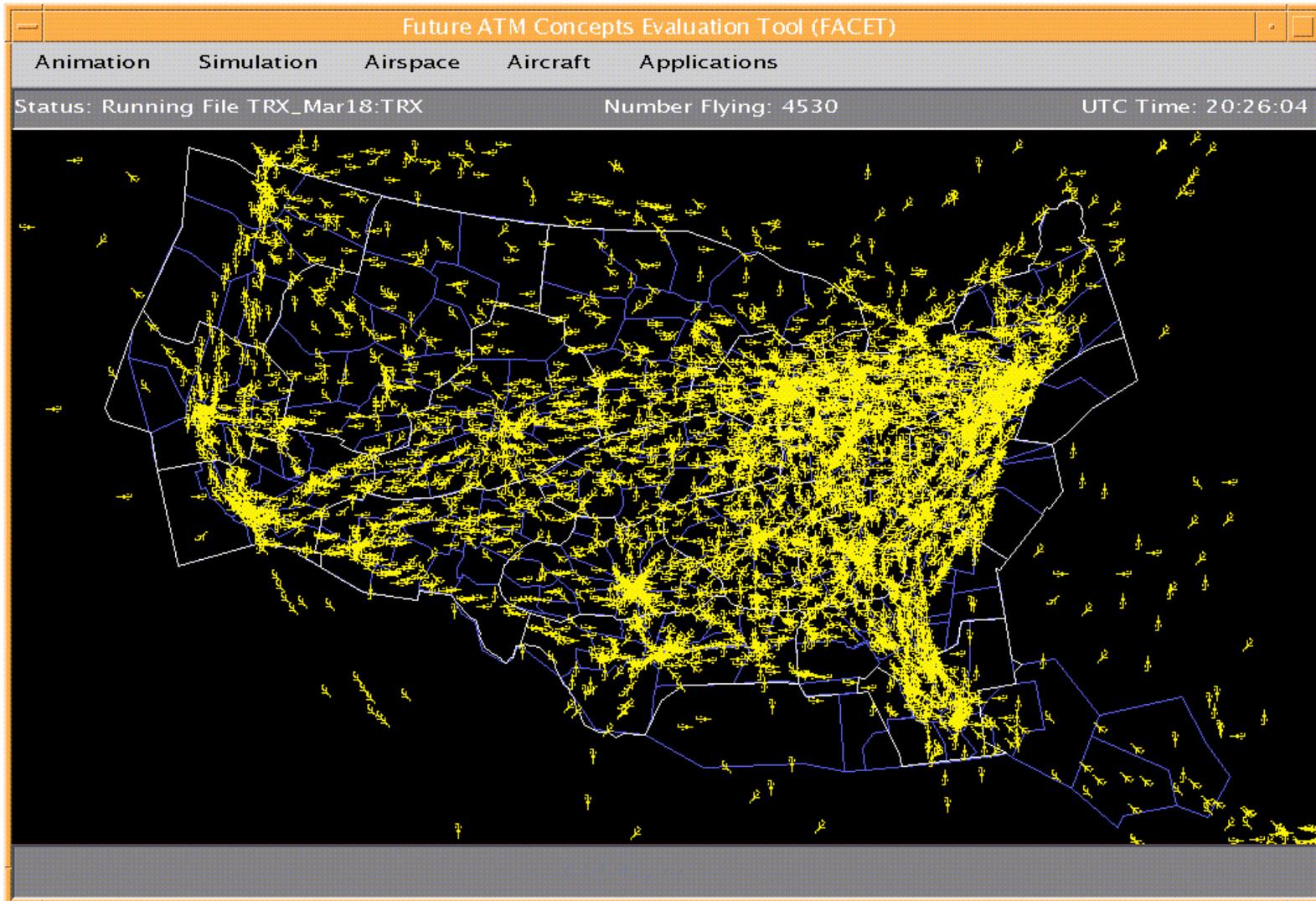


Visualization of Air Traffic Data

QuickTime™ and a
Animation decompressor
are needed to see this picture.

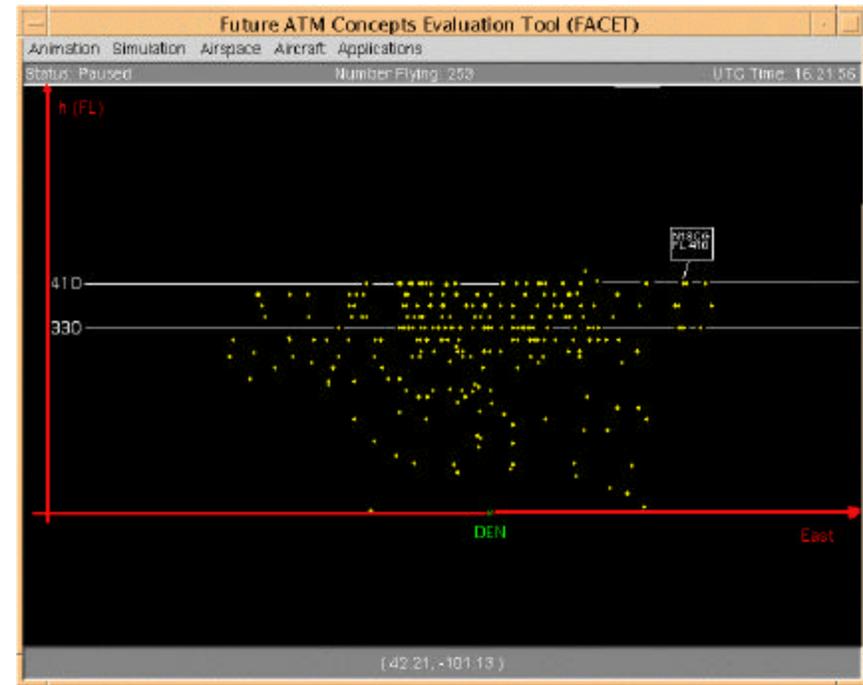
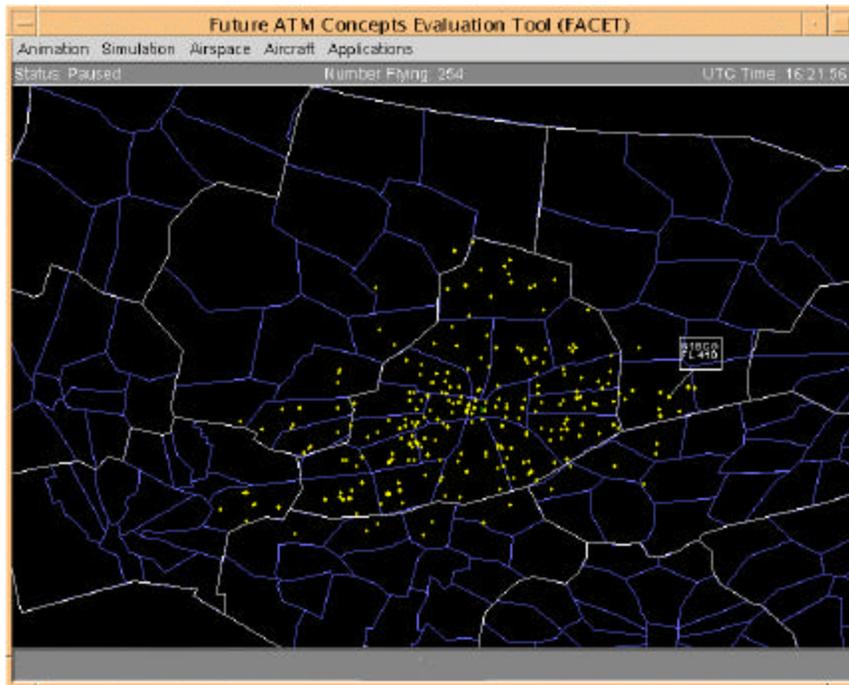


Graphical User Interface



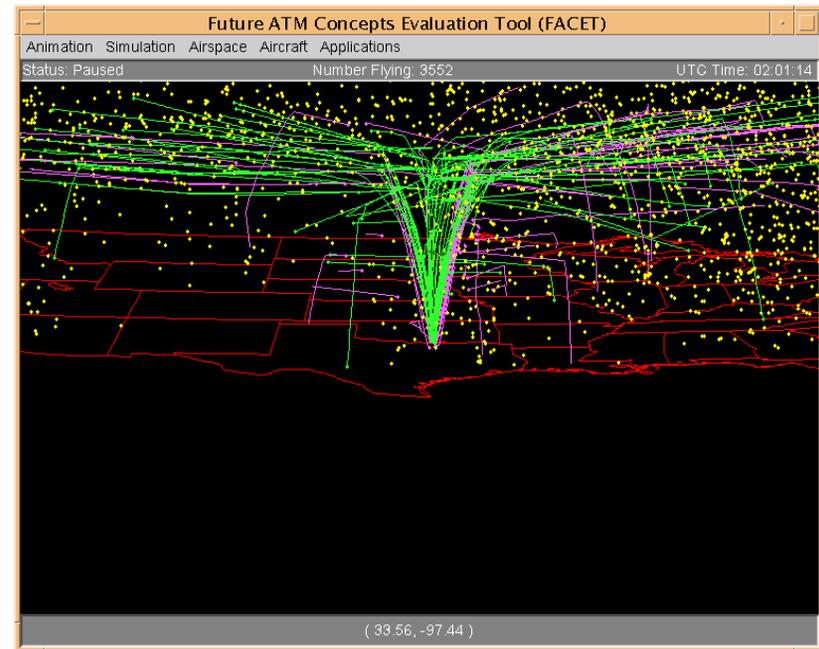
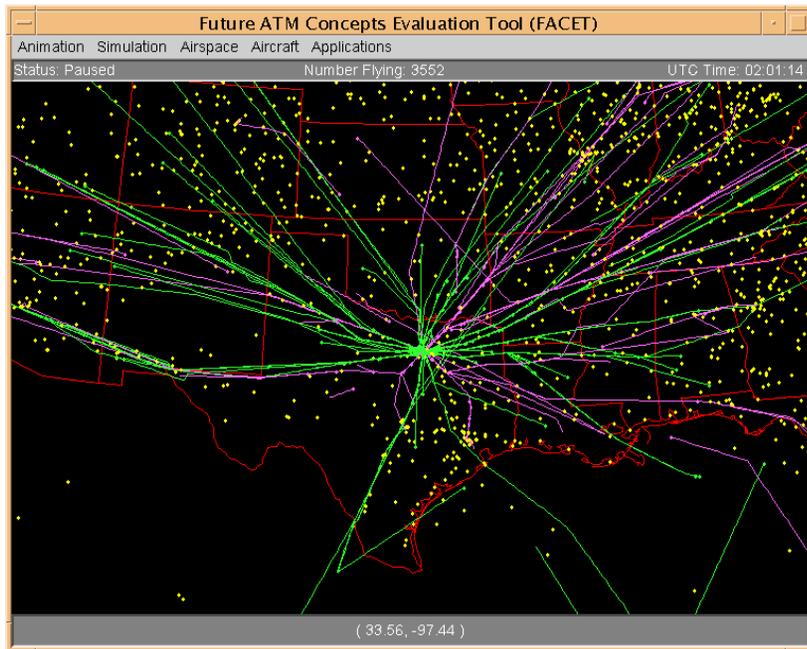


Aircraft in Denver Center



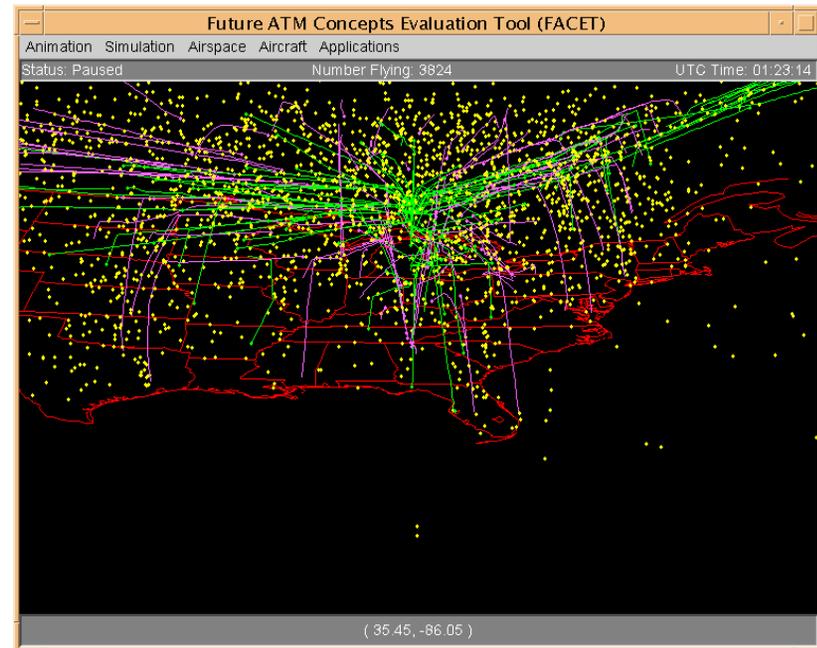
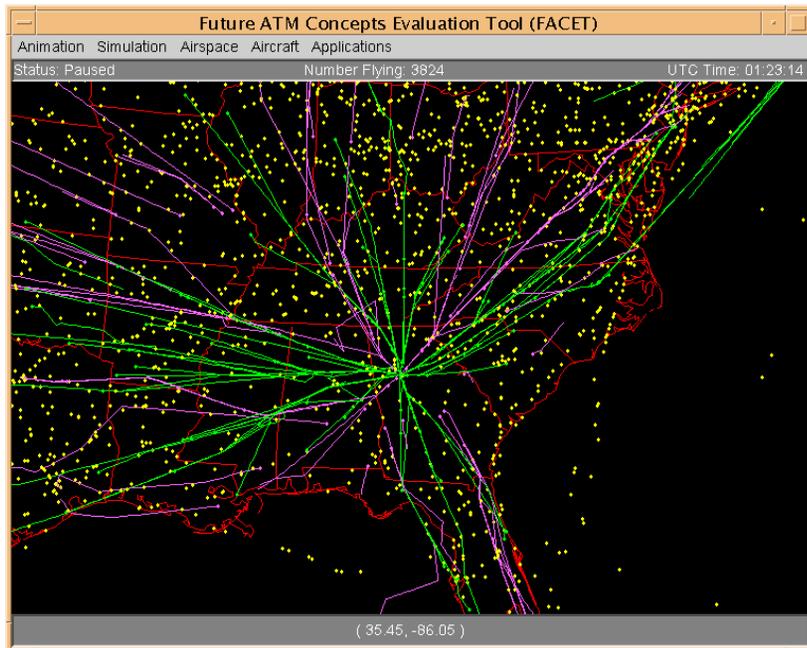


DFW Arrivals (Purple) and Departures (Green)





ATL Arrivals (Purple) and Departures (Green)





FACET/System-Wide Evaluation and Planning Tool (SWEPT)



Outline

- **Objective**
- **Operational Concept**
- **Activities**
- **Milestones**
- **Resources**
- **Issues**



Objective

- **Complete development of FACET-based System-Wide Evaluation and Planning Tool (FACET/SWEPT) and conduct a field test in a FAA facility/AOC by December 2002**



Operational Concept

- **Field Test State (Dec 02)**
 - FACET/SWAP Tool on auxiliary display (compact, flat panel) located at the specialist's desk (SCC, TMC, AOC)
 - Specialist uses the tool to select and display plays, modify a plan and assess the impact of the play and share it with other specialists
-
- **Initial Deployment State (Dec 03)**
 - Availability to SCC, TMC and AOC with ability to change and share plans
 - **End State (DEC 04)**
 - Integration of SWAP tool with TSD
-



SWEPT Functions

- **Setup SWEPT configuration**
 - SCC, TMC, AOC
- **Select a planning option**
 - Planning Templates: ZMP1, ZMP2,.....
 - West-East Arrival Routes
 - Airway Closures: J48, J6, J75,.....
 - Airway/Fix Closures: ZNY, BOS, CVG,.....
 - AOC specific route evaluation
- **Display the plan**
 - Textual Information
 - Graphical display of routes
- **Construct/Modify plan**
 - Modify a route to accommodate new information (FCA, Weather, etc)
 - Select route options from Code Departure Routes (CDR), Low Altitude Arrival Departure Routes (LAADR),...



SWEPT Functions

- **Evaluate plan**
 - Analyze and provide rapid feedback (~10 sec) to user e.g. Sector count, aircraft list...
- **Share plan with other NAS users**
 - Distribution of plan changes to planning team
 - Distribution mechanism: Centralized/Distributed server
- **Advanced Functions**
 - Integration with other TFM actions (MiT, GDP)
 - Availability and accuracy of MIT, GDP information
 - Level of optimization based on user need and other considerations
 - Optimization /functionality to vary with time horizon



ZMP_SWAP_PLAN_1

ZMP PLAN #1

ZMP SWAP PLAN #1 – THE GRB END RUN (WX WEST OF ORD)

TRANSCON ROUTES

Close

Future ATM Concepts Evaluation Tool (FACET)

Animation Simulation Airspace Aircraft Applications

Status: Waiting Number Flying: 0 UTC Time:

National Playbook Dialog

Display

Available Plans

- National Playbook
- Airport Closures
- ZMP Weather
 - ZMP_SWAP_PLAN_1
 - ZMP_SWAP_PLAN_2
- Airway Closures
- West-to-East Routes

Display Plan

Cancel Display

Display Text

Implement

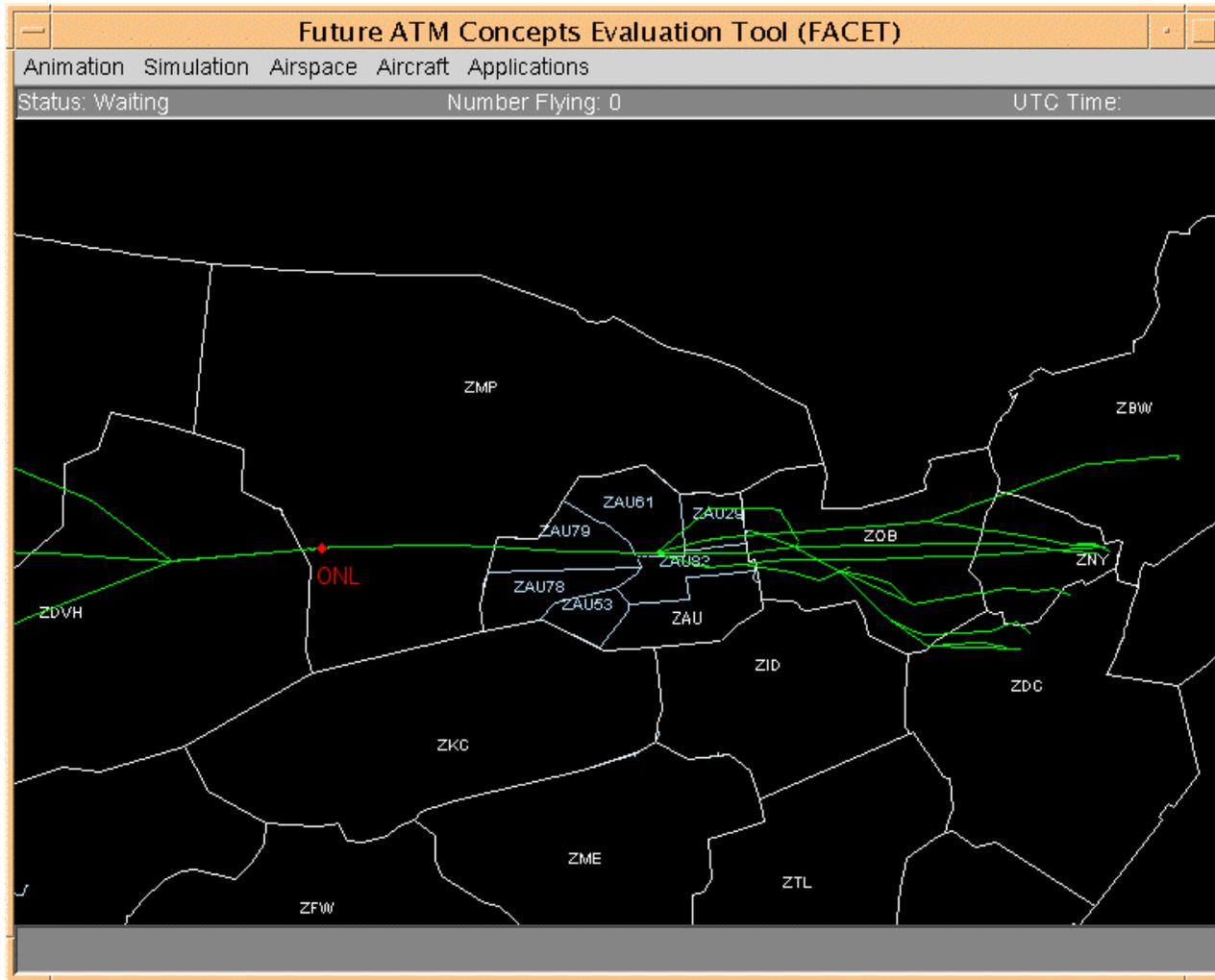
Cancel

Close

Implemented Plans



West North Brook (OBK)





Traffic Density in Chicago Center Sectors using West North Brook Plan

Sector Counts (Inst. Max.)						
File	Edit	Table				
Time	ZAU29	ZAU53	ZAU61	ZAU78	ZAU79	ZAU83
Cap	12	12	18	12	12	16
00:00	10	7	12	15	14	14
00:15	15	6	13	28	19	12
00:30	11	10	12	34	23	10
00:45	12	10	14	23	15	15
01:00	10	6	10	17	17	13
01:15	10	5	4	14	13	10
01:30	10	5	11	11	14	13
01:45	8	2	9	9	10	14
02:00	8	5	8	13	6	19
02:15	7	5	6	12	9	16
02:30	8	5	8	12	8	15
02:45	10	2	11	10	8	12
03:00	5	4	11	7	7	11
03:15	11	6	6	14	17	12
03:30	13	7	8	17	17	11
03:45	5	3	8	20	15	10

Current Plan

Sector Counts (Inst. Max.)						
File	Edit	Table				
Time	ZAU29	ZAU53	ZAU61	ZAU78	ZAU79	ZAU83
Cap	12	12	18	12	12	16
00:00	10	7	11	15	14	14
00:15	15	6	10	24	18	12
00:30	10	9	9	30	21	8
00:45	9	9	8	22	20	12
01:00	7	6	7	17	21	12
01:15	10	5	9	13	21	10
01:30	12	5	11	10	25	12
01:45	10	2	10	9	19	17
02:00	9	4	9	12	12	20
02:15	8	5	8	11	18	18
02:30	9	4	9	9	17	16
02:45	13	1	12	8	16	11
03:00	8	3	10	6	12	14
03:15	11	5	6	13	20	11
03:30	12	7	8	17	18	10
03:45	5	3	3	19	16	10

Rerouting due to bad weather_ Situation gets worse in Sector 79

Sector Counts (Inst. Max.)						
File	Edit	Table				
Time	ZAU29	ZAU53	ZAU61	ZAU78	ZAU79	ZAU83
Cap	12	12	18	12	12	16
00:00	10	7	11	15	14	14
00:15	15	6	10	24	18	12
00:30	10	9	9	30	21	8
00:45	9	9	8	22	15	12
01:00	7	6	7	17	16	12
01:15	8	5	5	13	14	9
01:30	9	5	10	10	14	10
01:45	8	2	8	9	11	13
02:00	7	4	7	12	8	19
02:15	7	5	6	11	11	17
02:30	10	4	7	9	7	16
02:45	9	1	7	8	8	12
03:00	4	3	8	6	8	12
03:15	9	5	4	13	17	14
03:30	11	7	6	17	17	7
03:45	5	3	4	19	17	8

Rerouting and slowing aircraft flow provides partial recovery in sector 79

Further traffic flow action required to recover from overloading in some sectors!!



Major Milestones

- **Demonstration of basic SWEPT concept on a laptop (2Q 02)**
- **Feedback on SWEPT concept from SCC, TMC and AOC and requirements for Graphical User Interface (GUI) enhancements (3Q 02)**
- **Shadow testing with live data at NASA (4Q 02)**
- **Complete development for conducting a field test at a FAA facility/AOC (1Q 03)**



Development Activities

- **FACET currently can select, display and evaluate plays**
- **Software Modifications**
 - Spin-off PET functionality from FACET
 - Restructuring of software for repeated (~10 sec update) planning applications
 - Enhancements to Graphical User Interface
- **Integration with live ETMS**
 - Continuous operation
 - Collaborative Convective Forecast Product (CCFP)
- **Shadow testing with live data and Field Test Activities**
 - Feedback from SCC, TMC and AOC

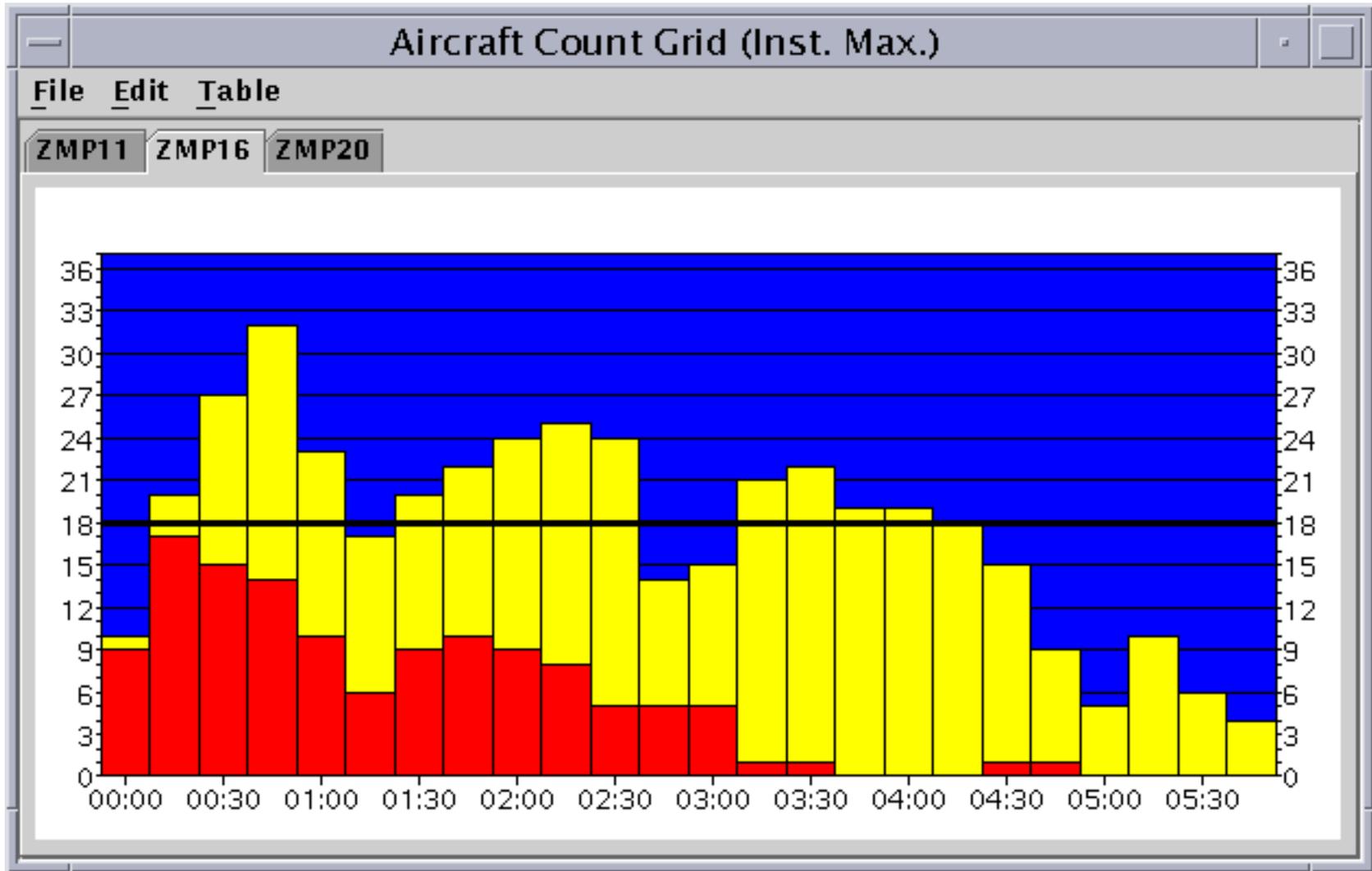


Background

- **The remaining viewgraphs provide background information.**



Predicted Traffic in Sector 16





Discussion

- **Impact of LOA and SOP on TFM decisions and level of modeling required in SWPET**
- **Relationship between Regions and System Command Center**
- **New procedures to deal with increased traffic and better situation awareness**
- **Research in other organizations**

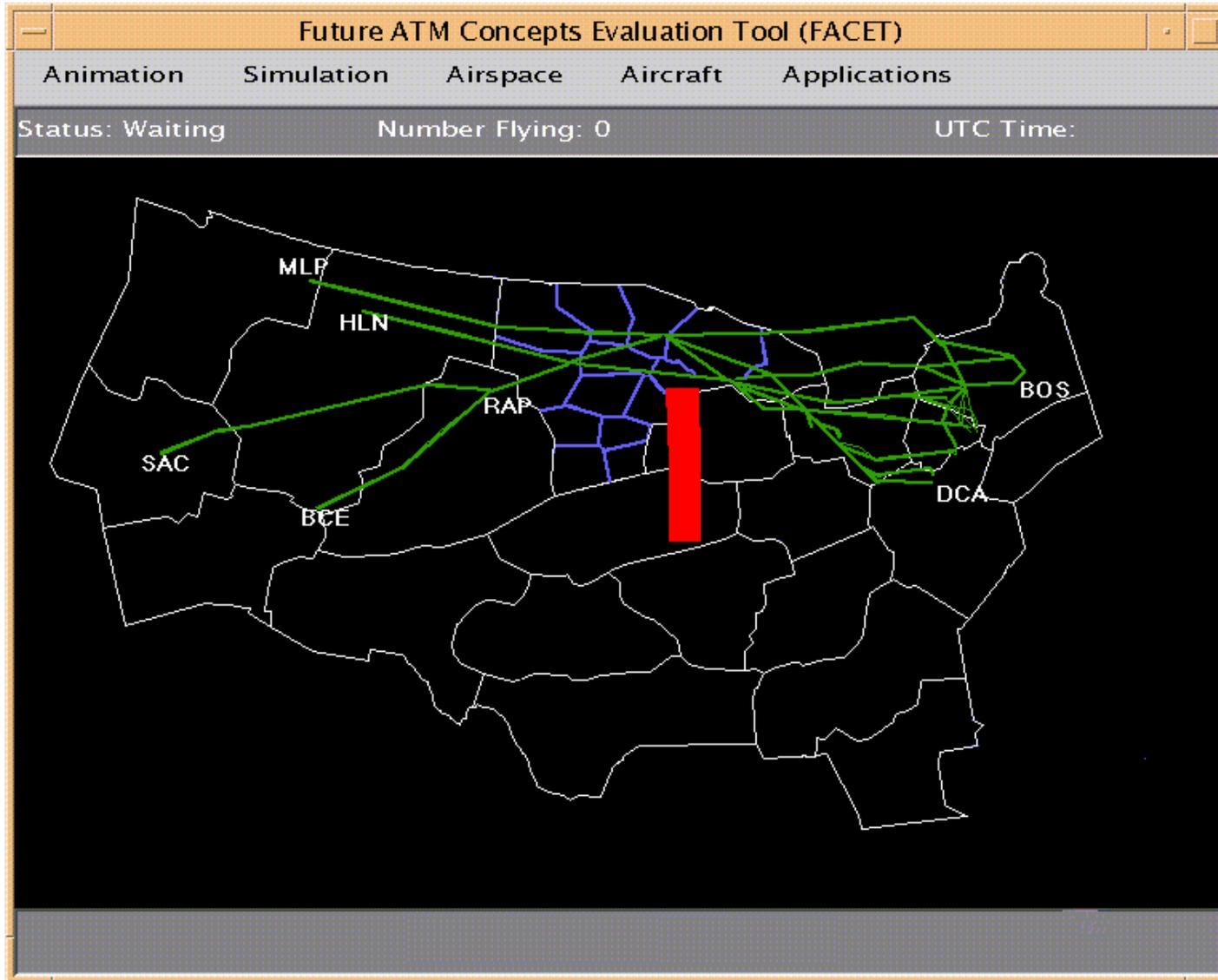


Types of Control (TFM actions)

- **Ground Delay Program**
 - Controlling aircraft departure time to manage aircraft arrival rates
- **Metering (Miles-in-Trail)**
 - Controlling flow of aircraft into a center by imposing flow restrictions on aircraft one or more centers away
- **Reroutes**
 - Congested En-route area
 - Weather
 - Special Use Airspace
- **Playbook**
 - Effort to provide a common understanding of re-routing strategy under previously defined situations

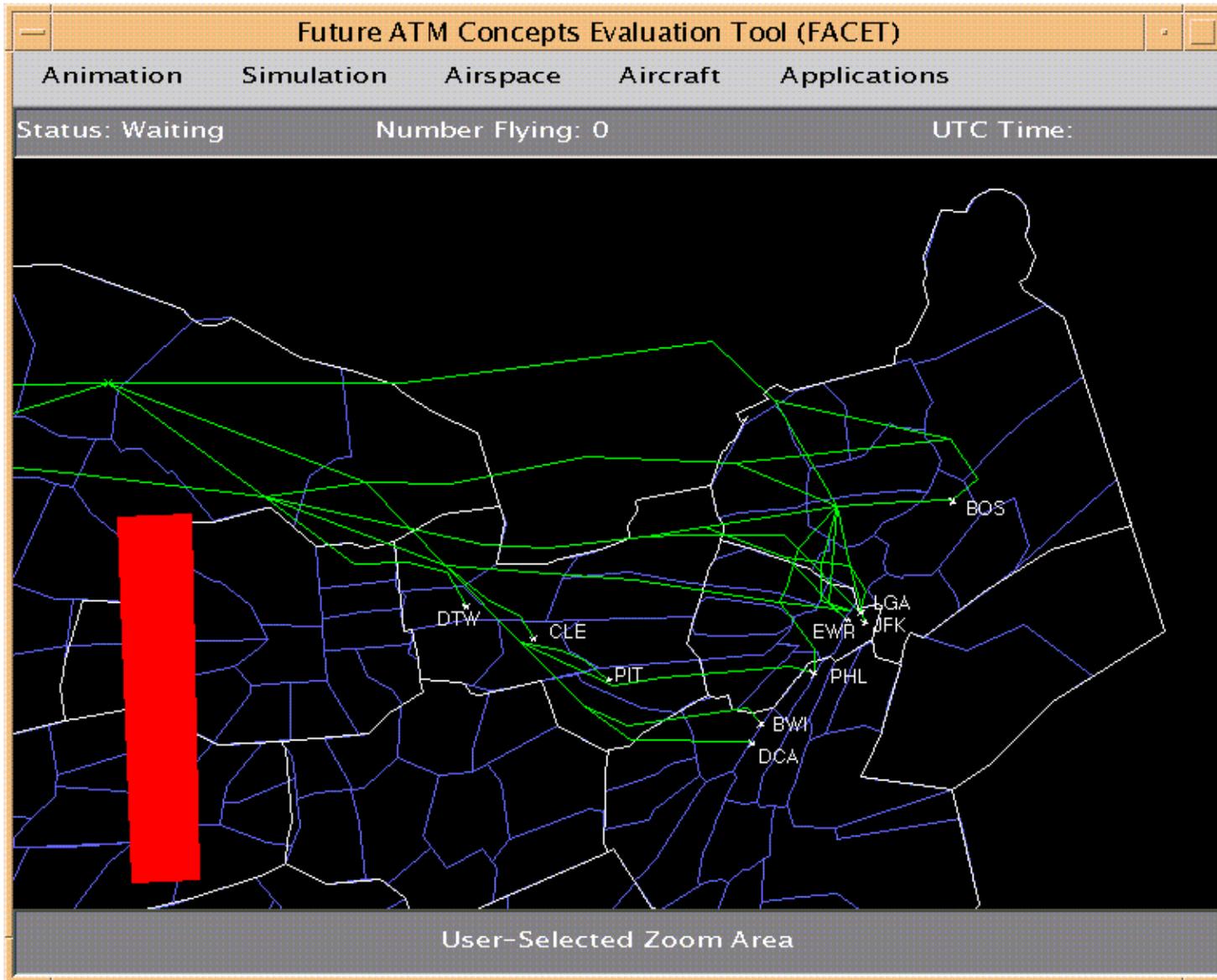


ZMP Plan#1



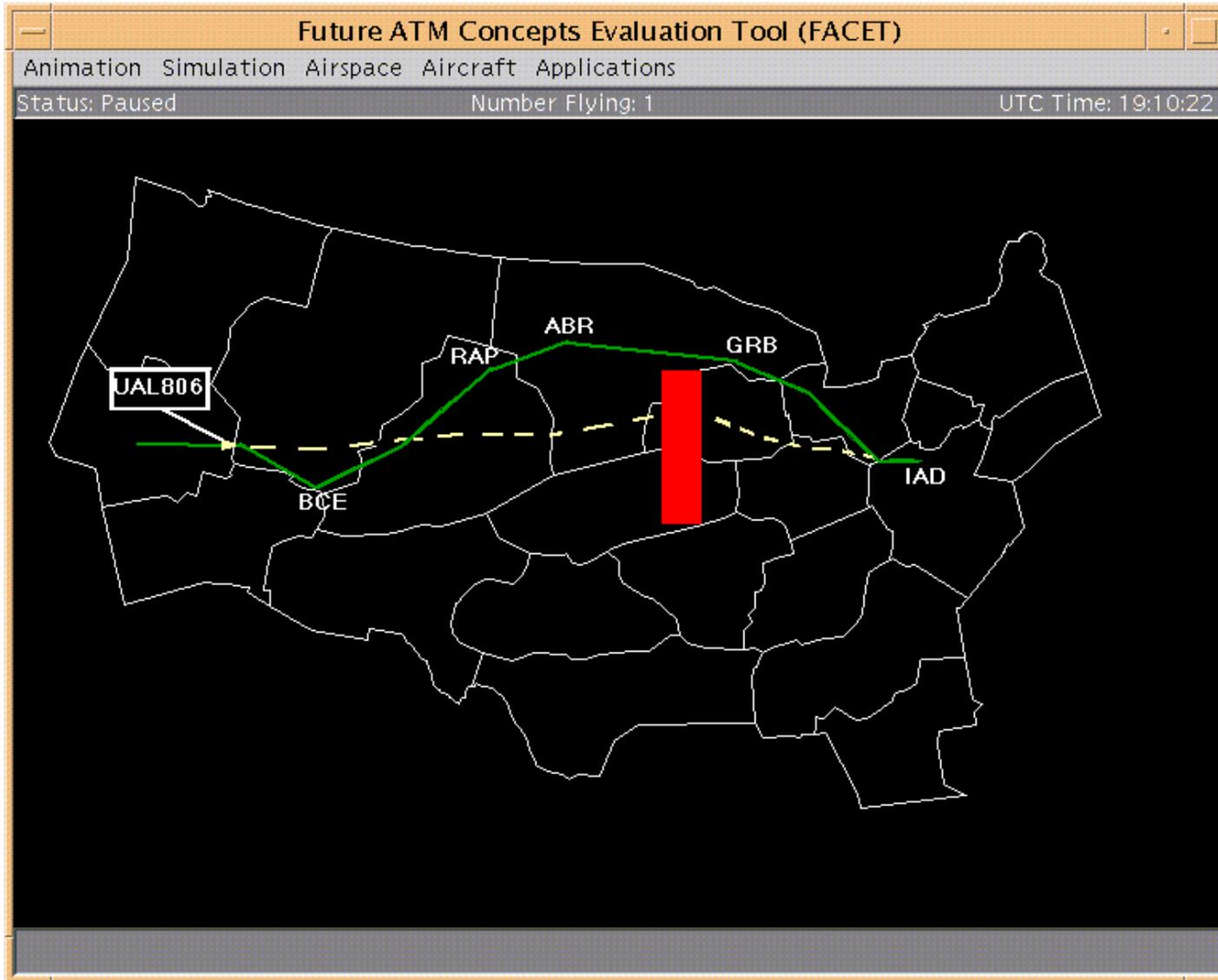


ZMP Plan #1 - Arrival Routes



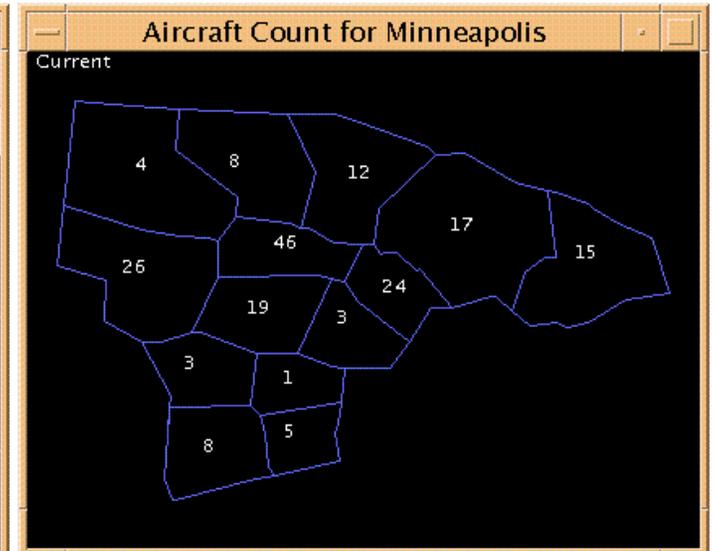
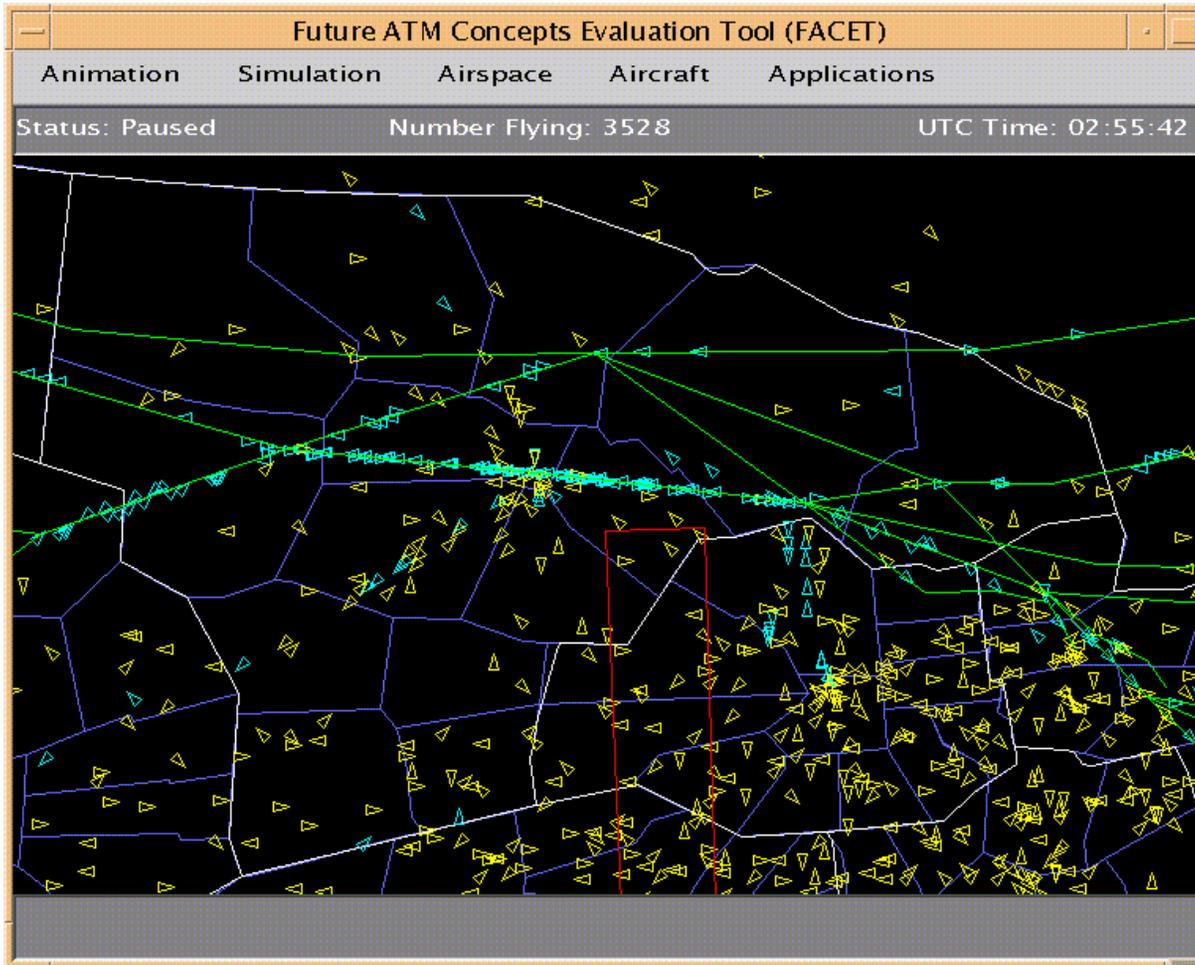


Impact on aircraft route



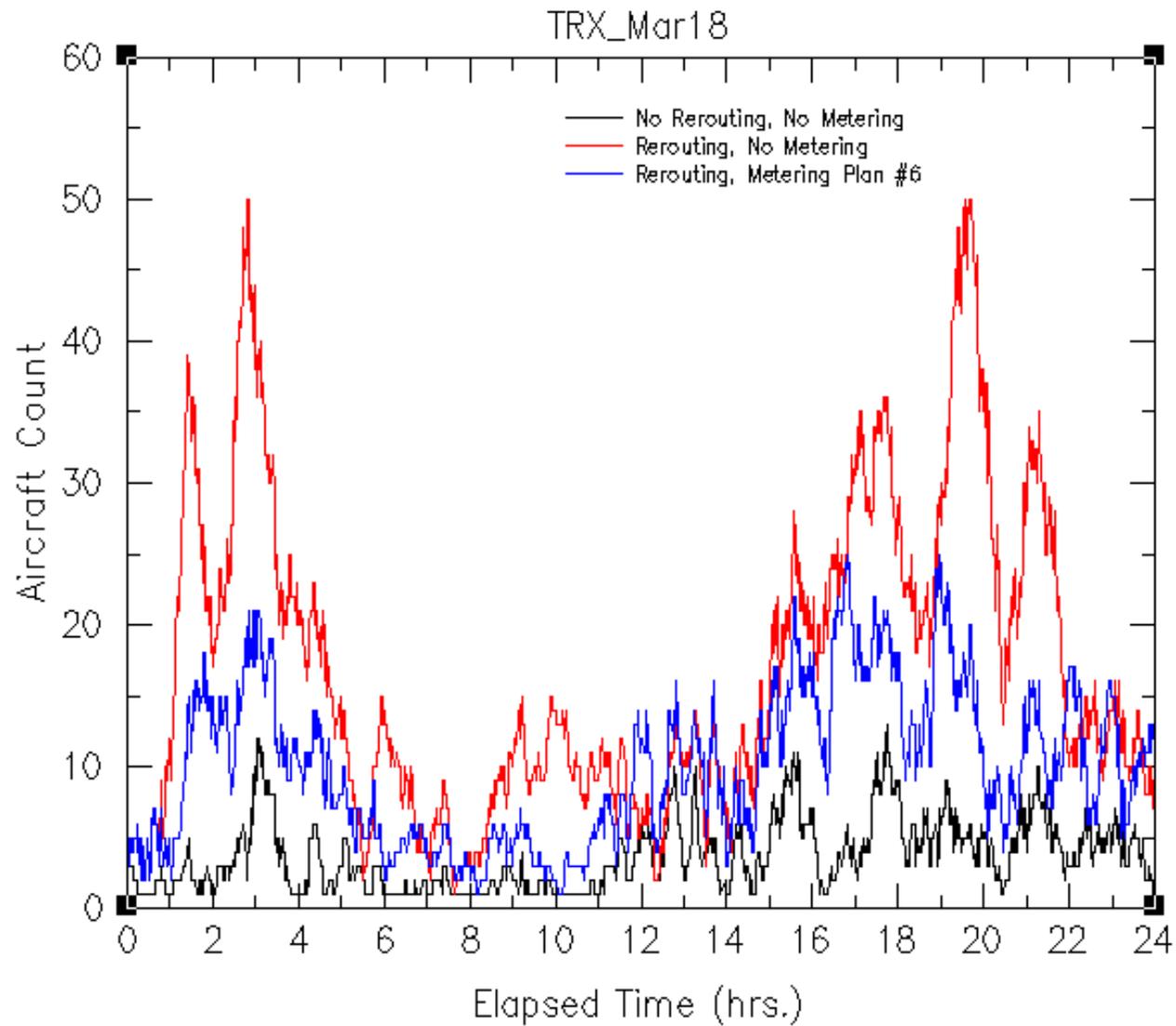


ZMP Plan #1 with Sector Count





ZMP11 Aircraft Count





ZMP20 Aircraft Count

