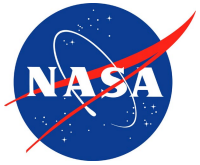


Dynamic Weather Routes: Overview for Technology Transfer

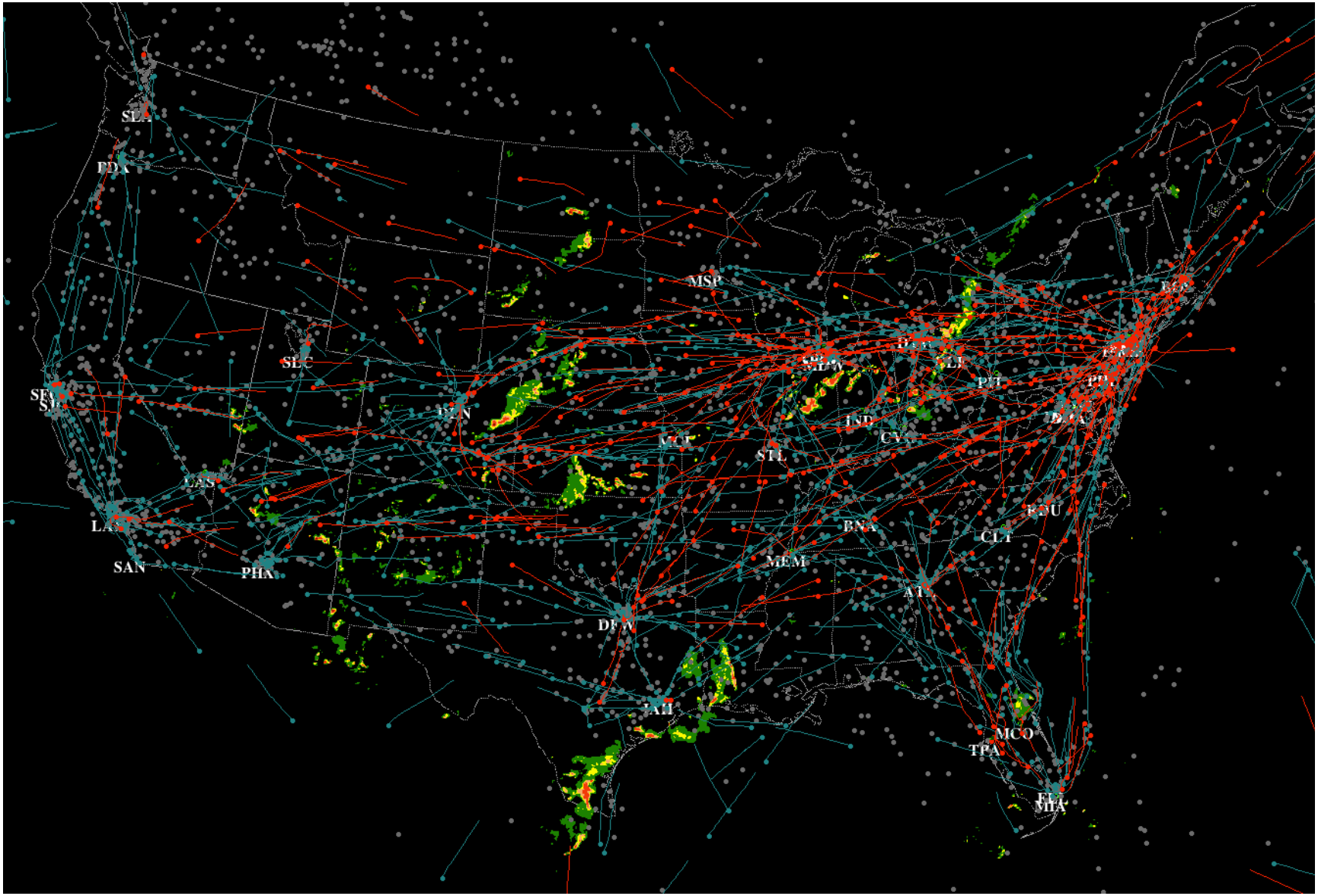
Dave McNally, Kapil Sheth, Hassan Eslami, Chester Gong
Aviation Systems Division
NASA Ames Research Center

Airspace Systems Program Webinar
April 29, 2014

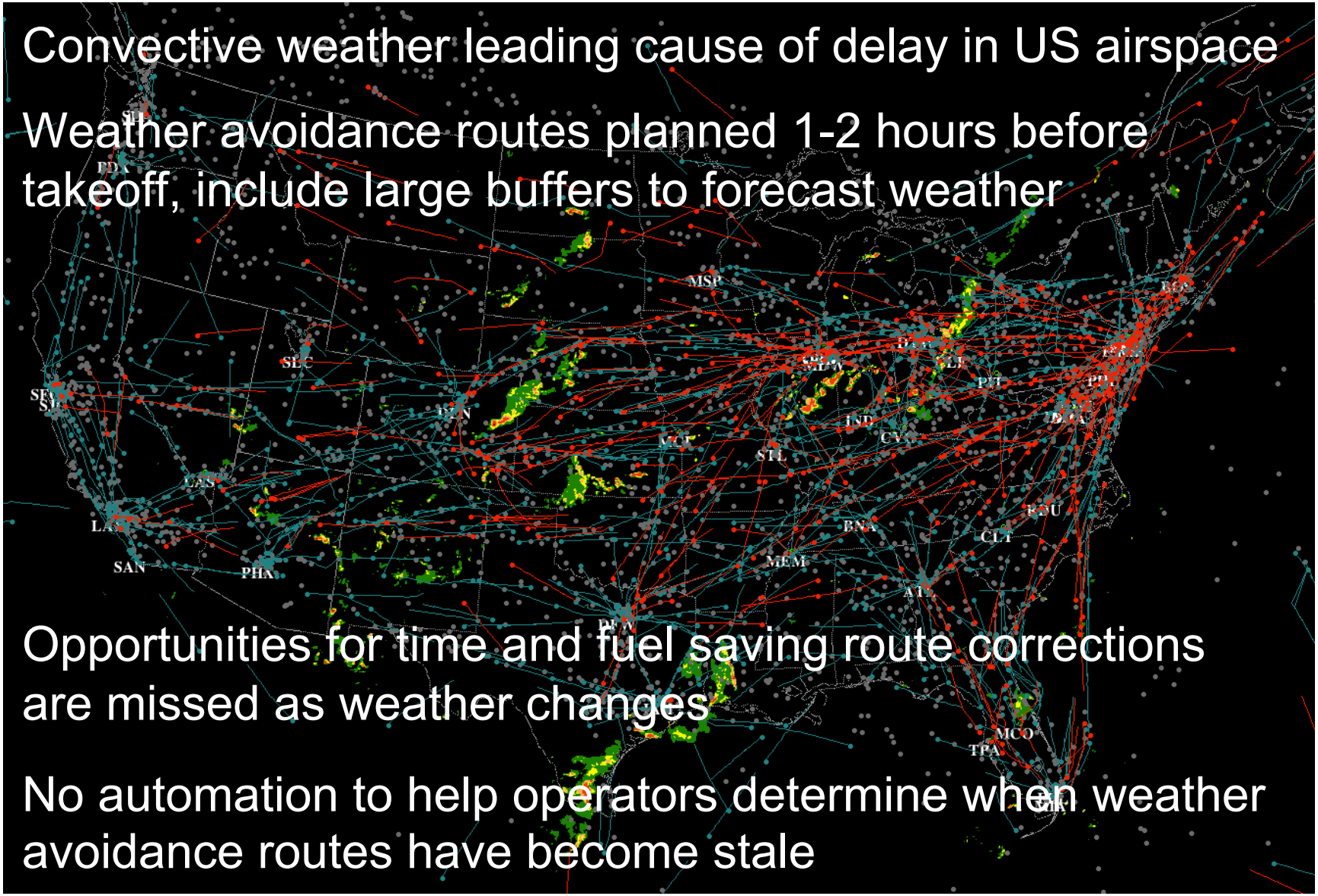
Take Away Message

- Ground automation, continuous automatic search finds high-value route corrections, airborne flights, en route airspace
- Integrates convective weather, wind-corrected flying time, traffic conflicts, sector congestion, special use airspace, FAA route restrictions
- Net potential savings 100,000 flying minutes for 15,000 flights, Fort Worth Center in 2013
- Operational testing, American Airlines Integrated Operations Center, Fort Worth, TX, July 2012 to present

What's the Problem



What's the Problem



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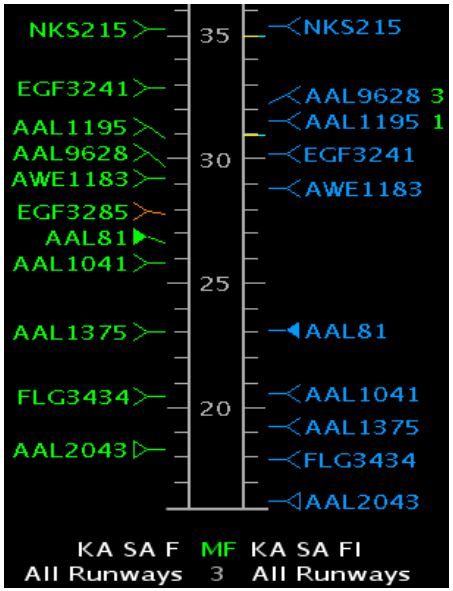
- Next Steps

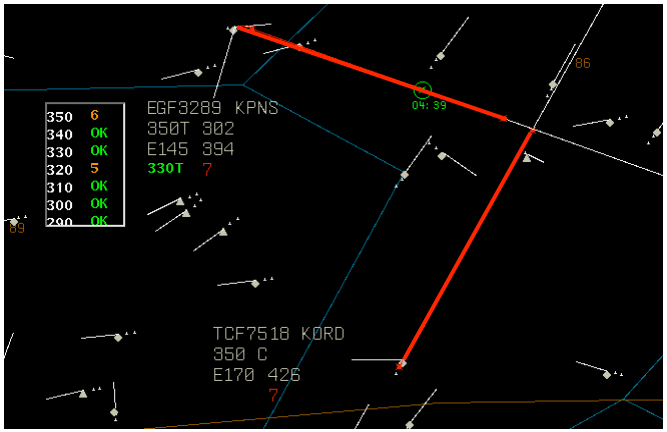
Center/TRACON Automation System (CTAS)

Ground-Based Trajectory Analysis Methodology and Software

Traffic Management Advisor

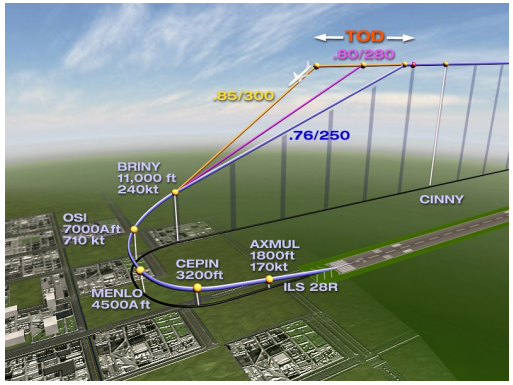


Conflict Probe

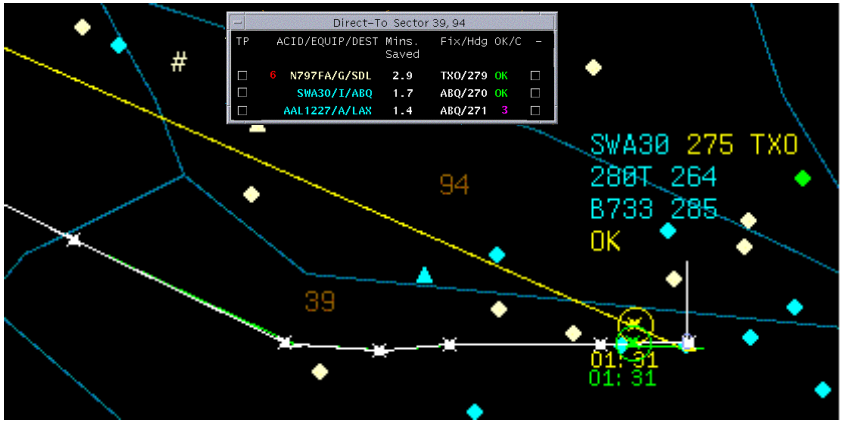


Weather & Traffic Conflicts Integrated

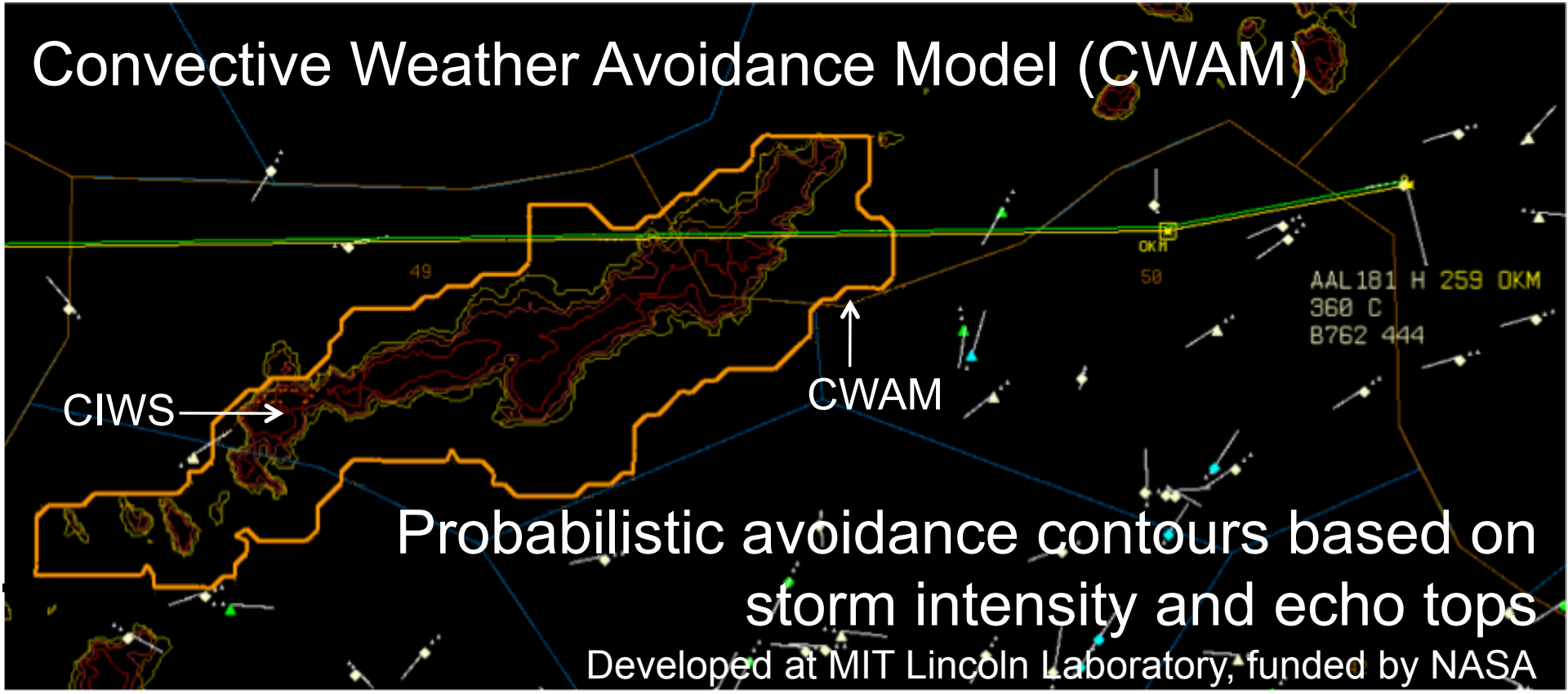
En Route Descent Advisor



Direct-To



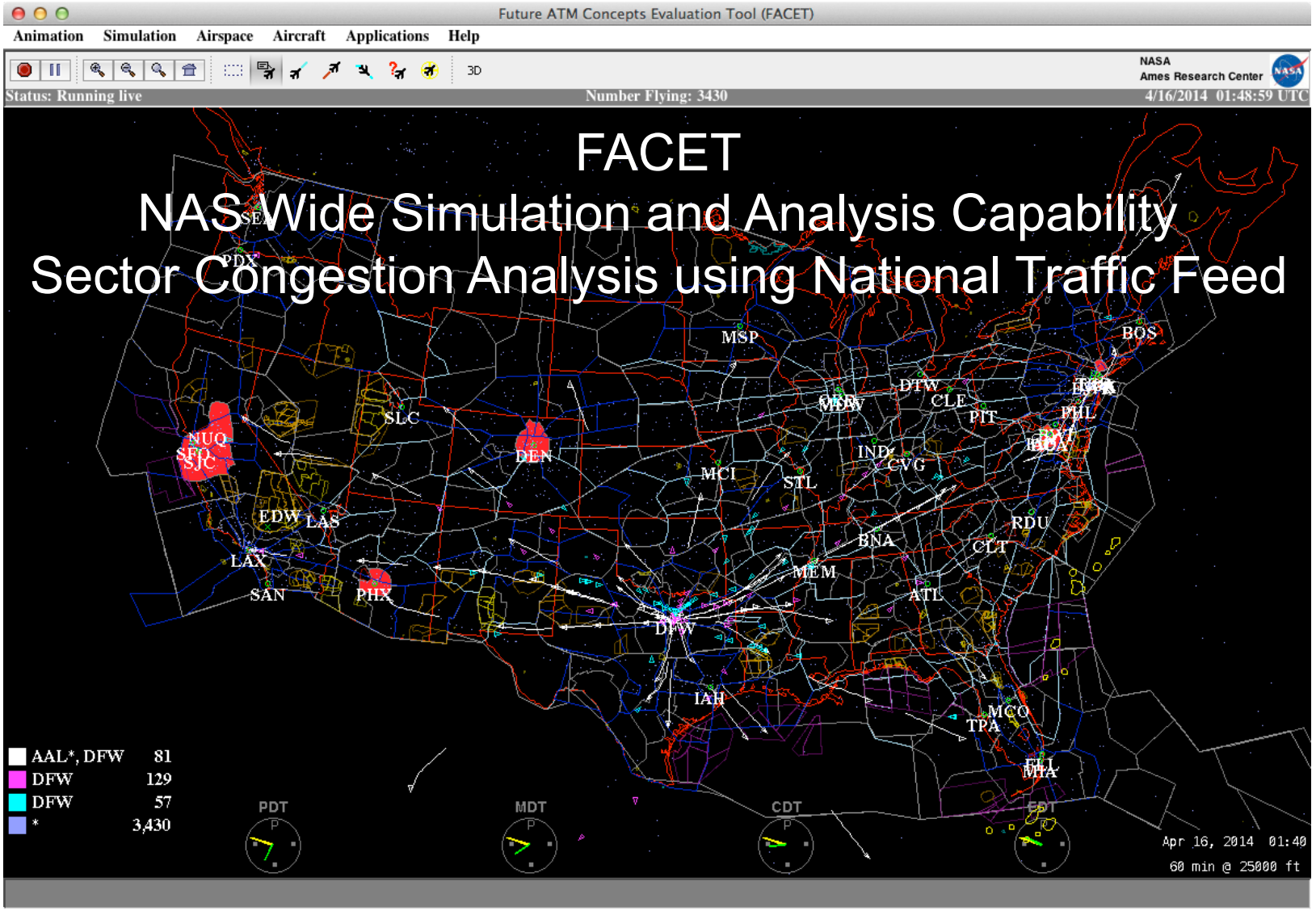
How Does DWR Detect Conflicts with Convective Weather?



Corridor Integrated Weather System (CIWS)

Convective Weather Avoidance Model (CWAM)

Future ATM Concepts Evaluation Tool



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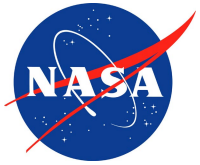
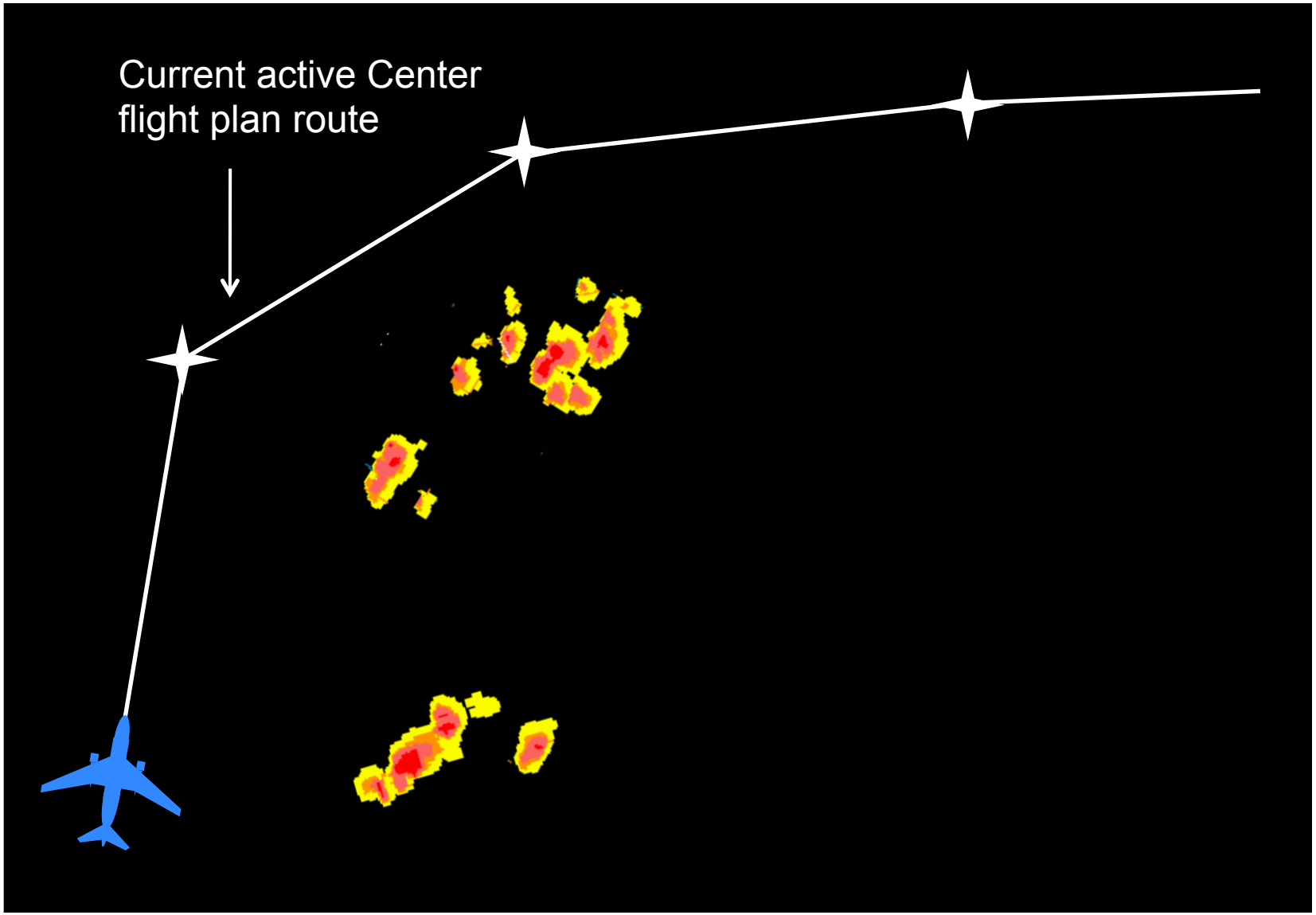
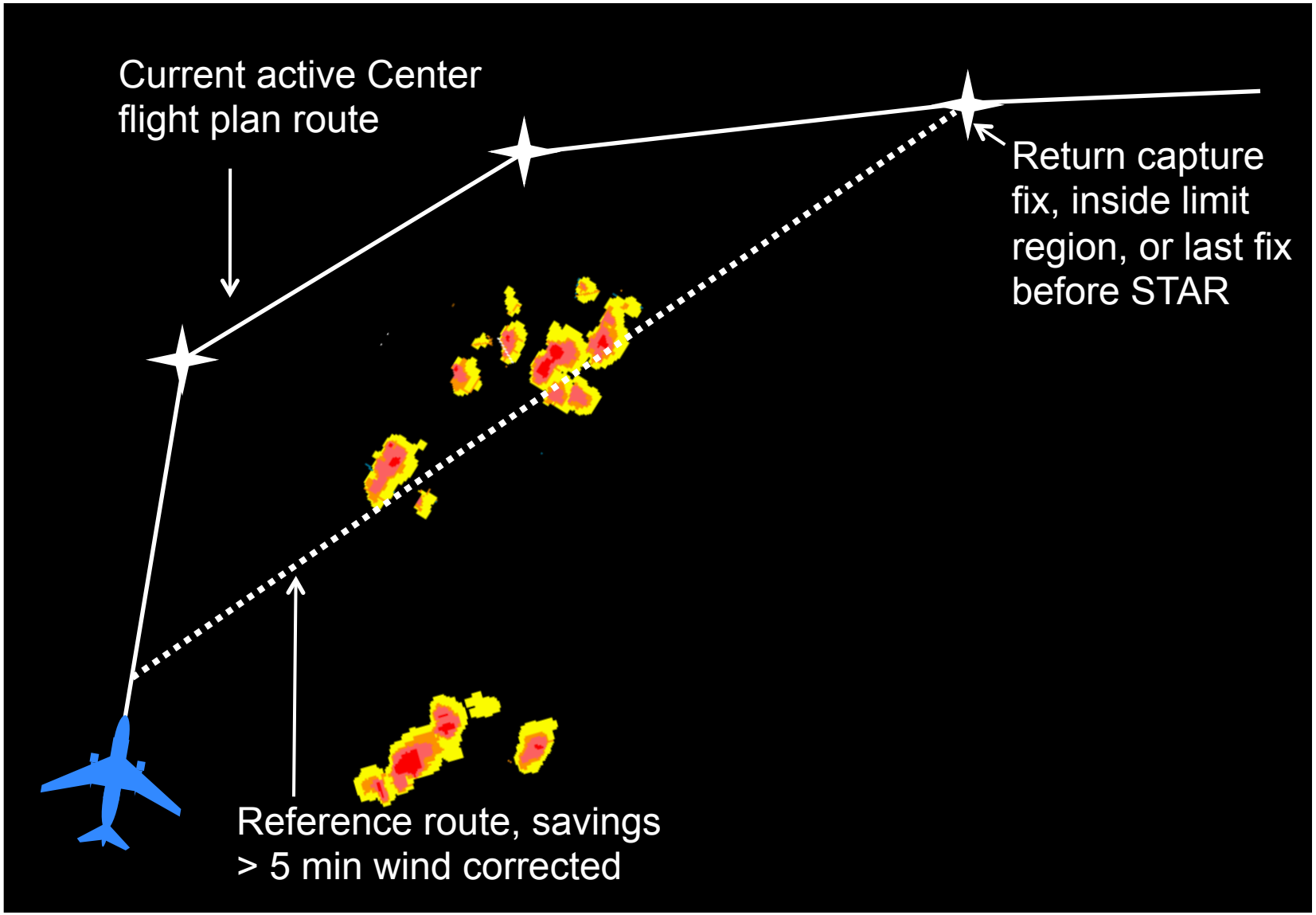


How does DWR select flights and propose route corrections?

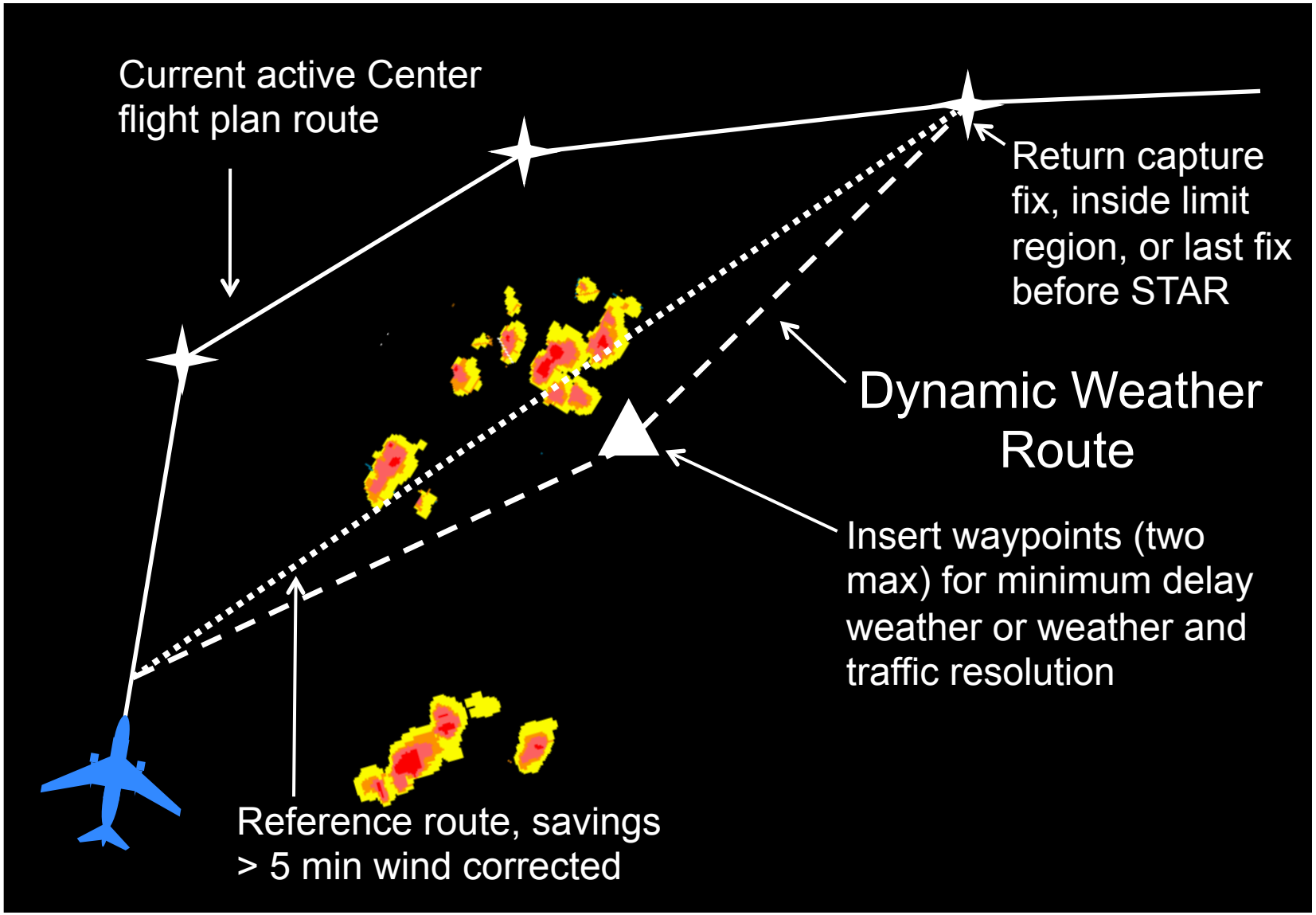
Analyze Airborne Flights, En Route Airspace



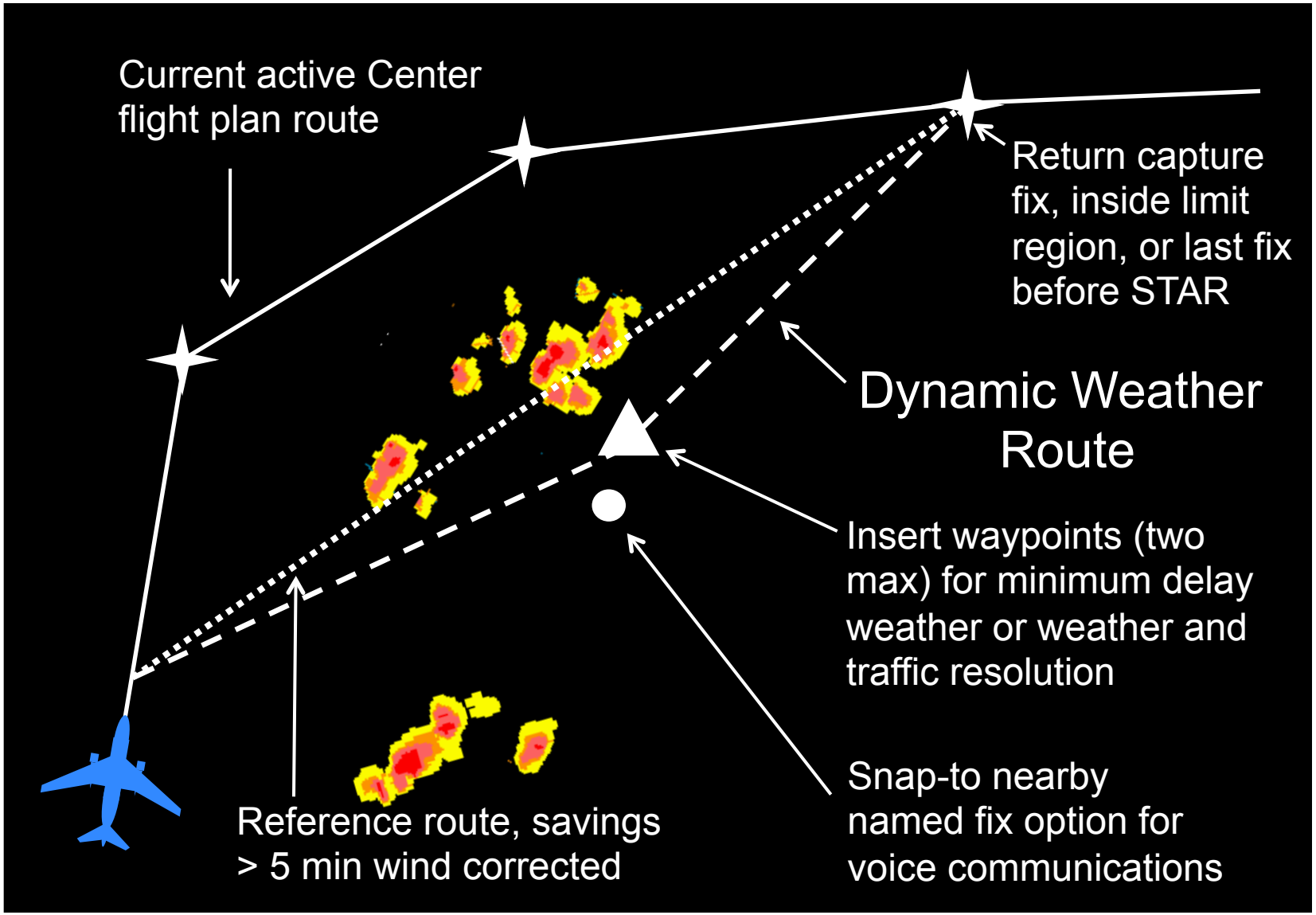
Find Inefficient Route Segments



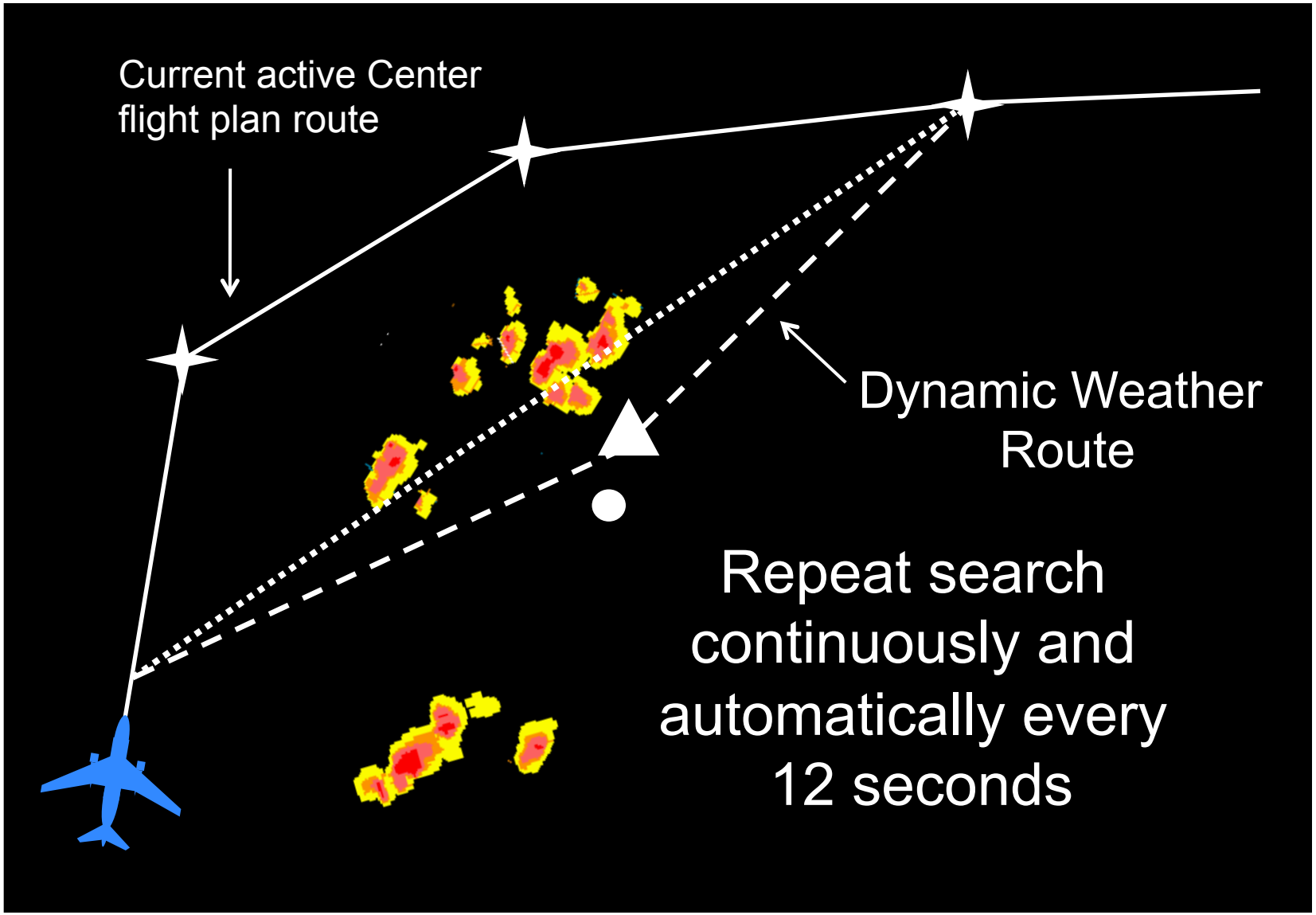
Resolve Weather and Traffic Conflicts



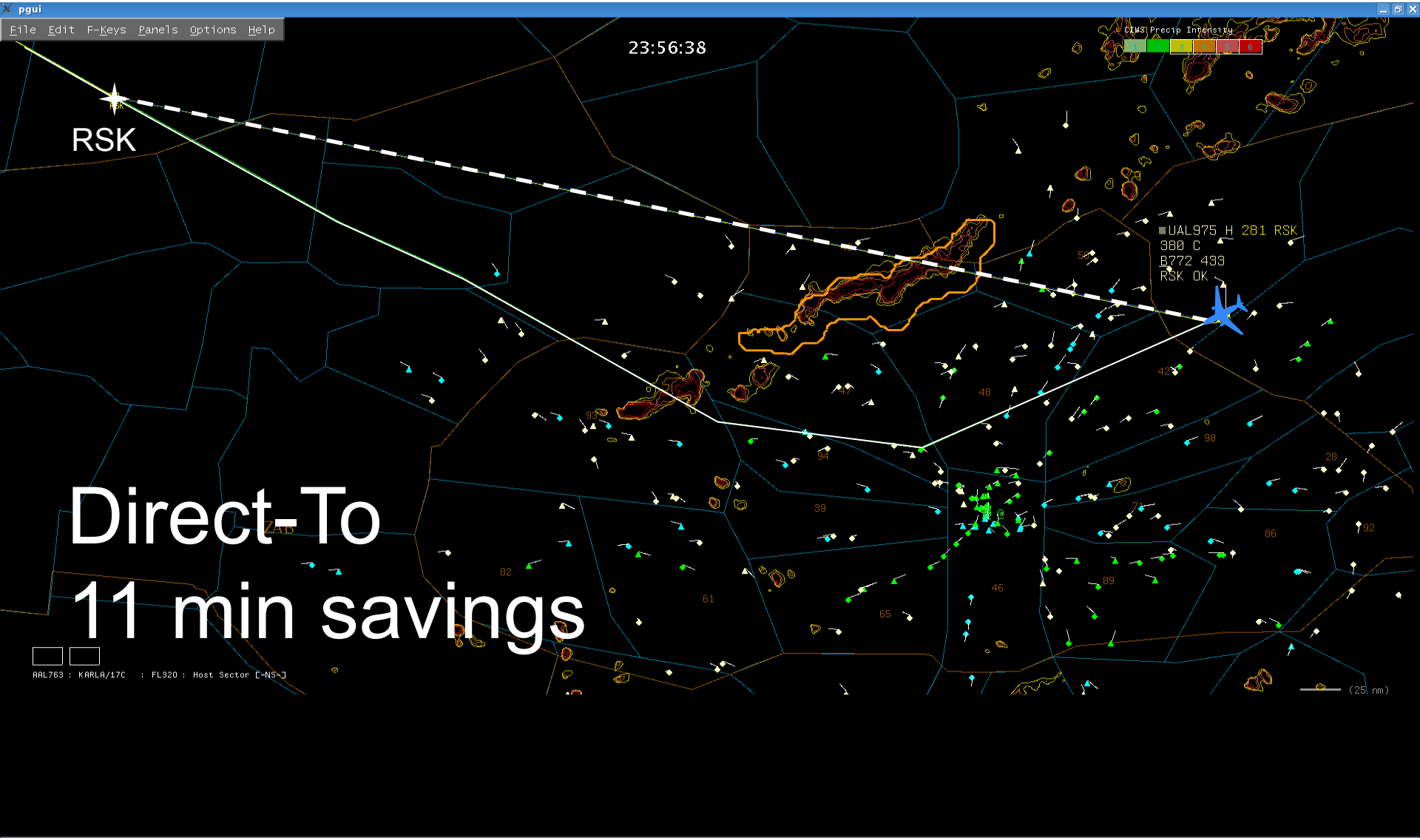
Snap to Nearby Named Fixes



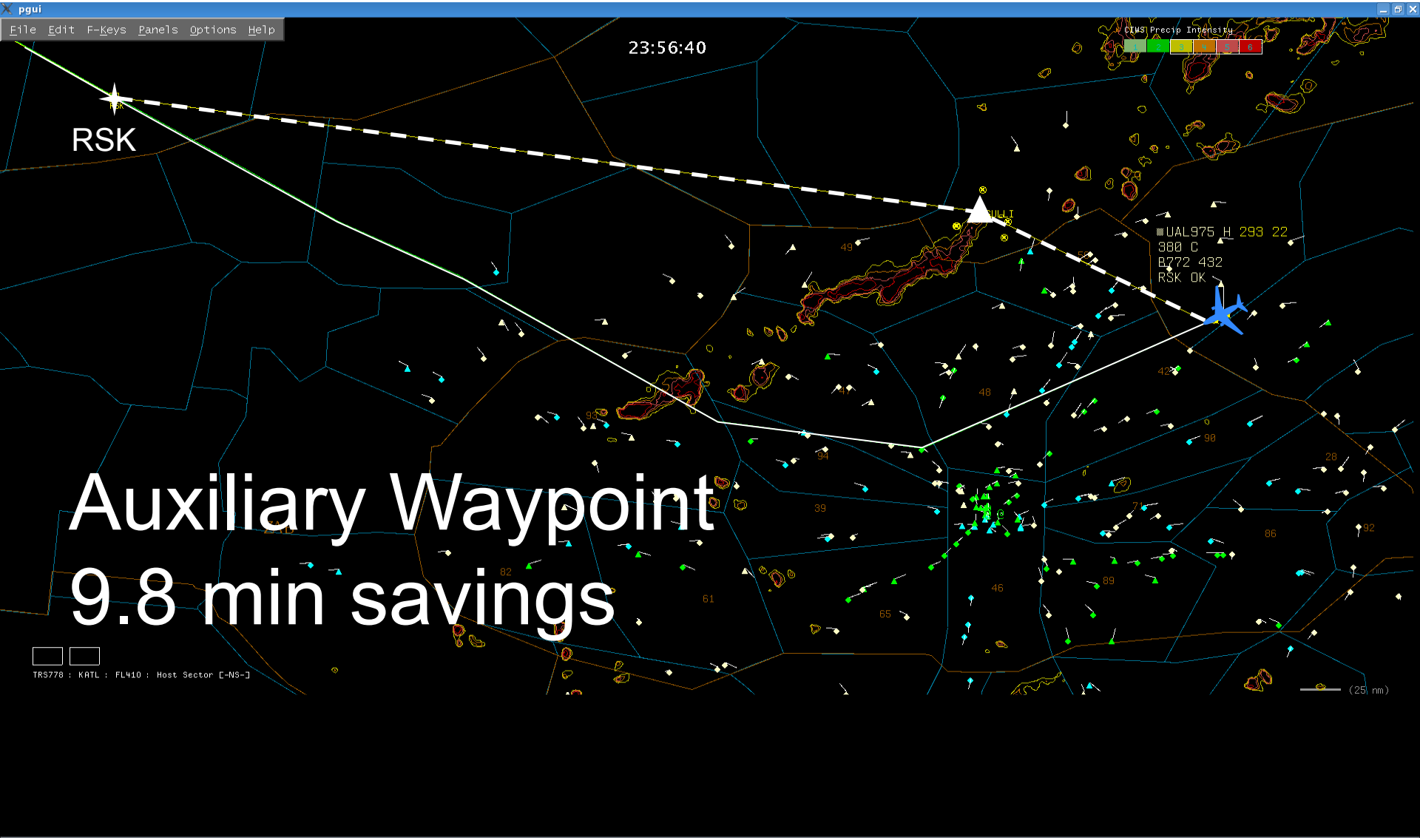
Continuous Automatic Search



Sample: UAL975 IAD to SFO

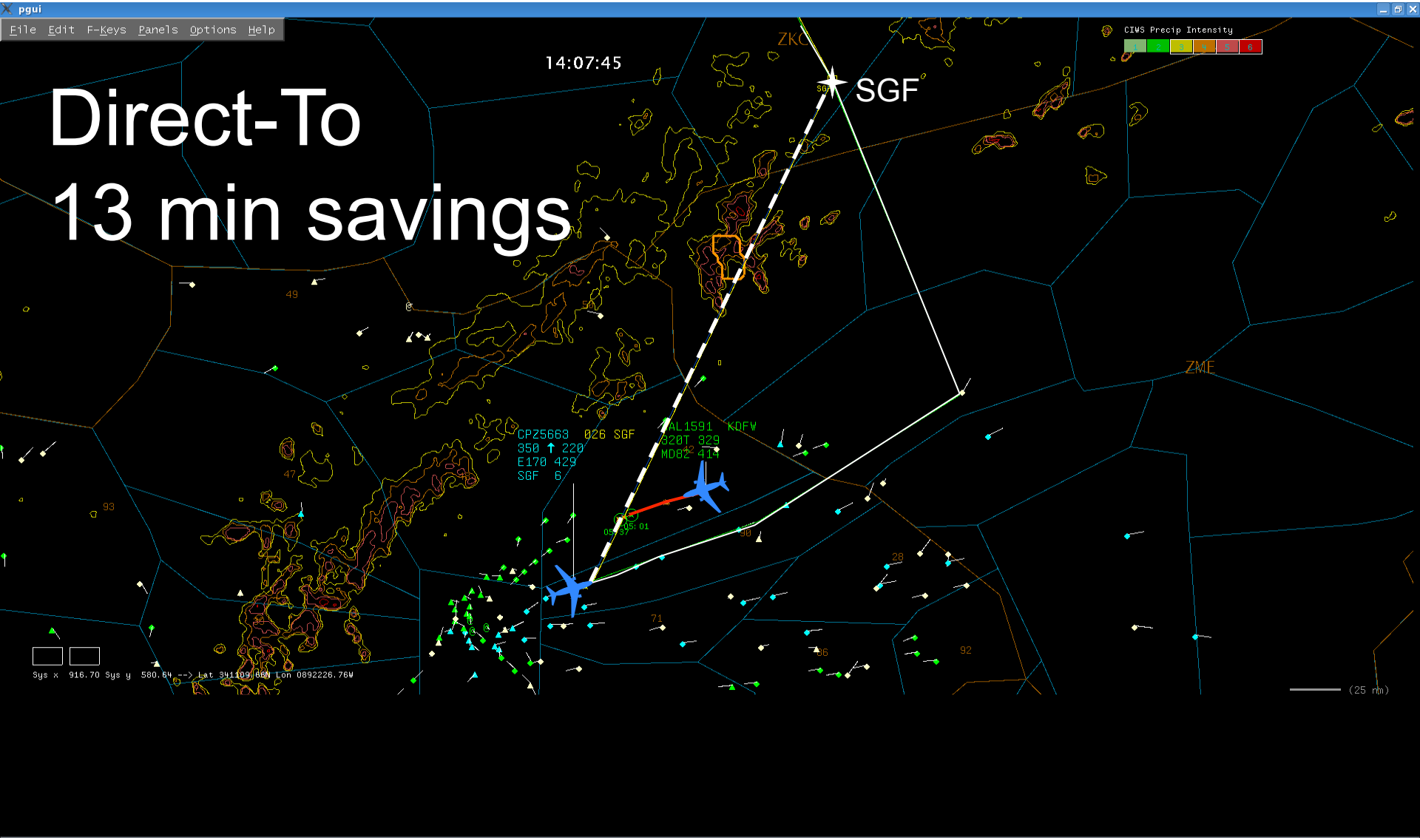


Sample: UAL975 IAD to SFO

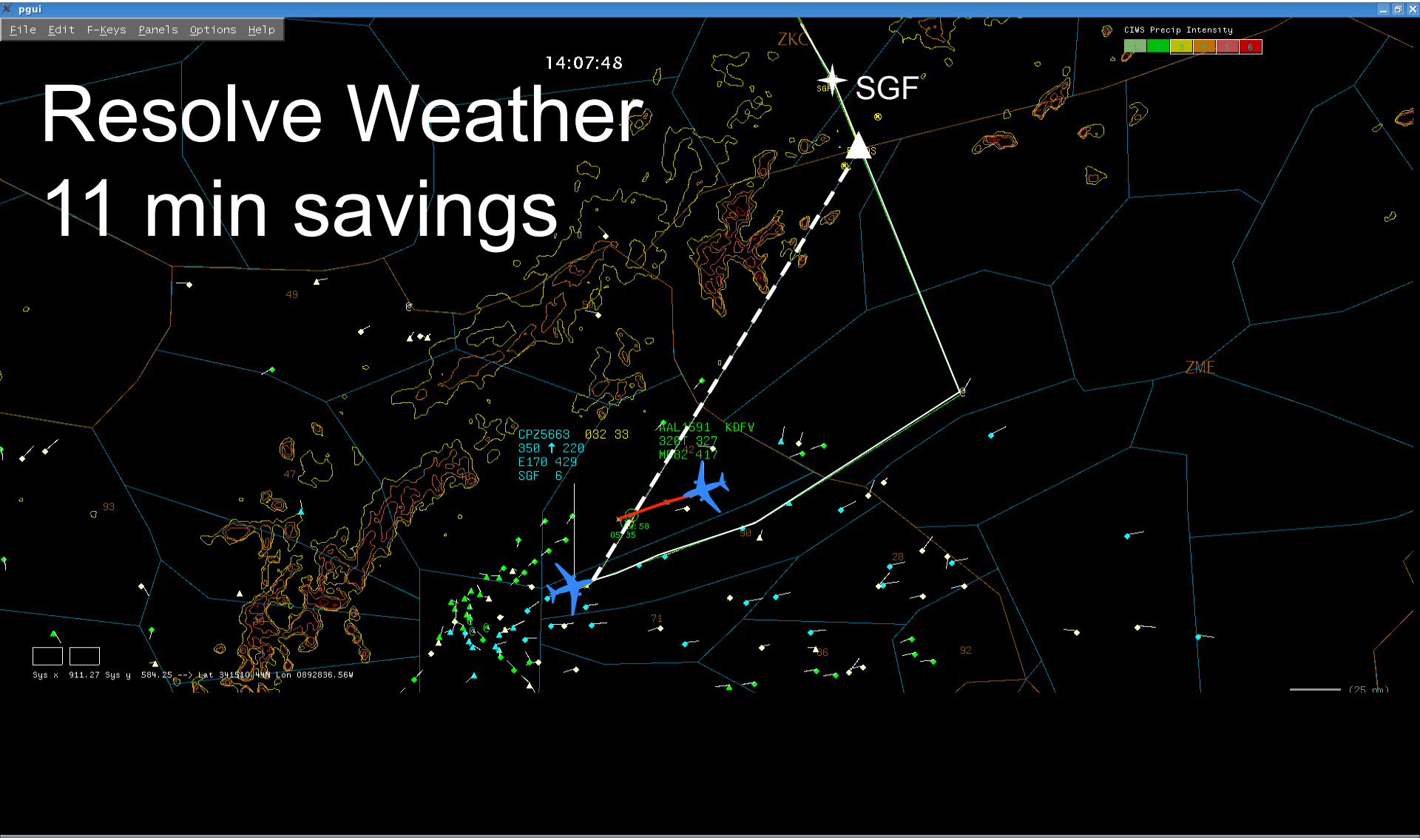


Sample: UAL975 IAD to SFO

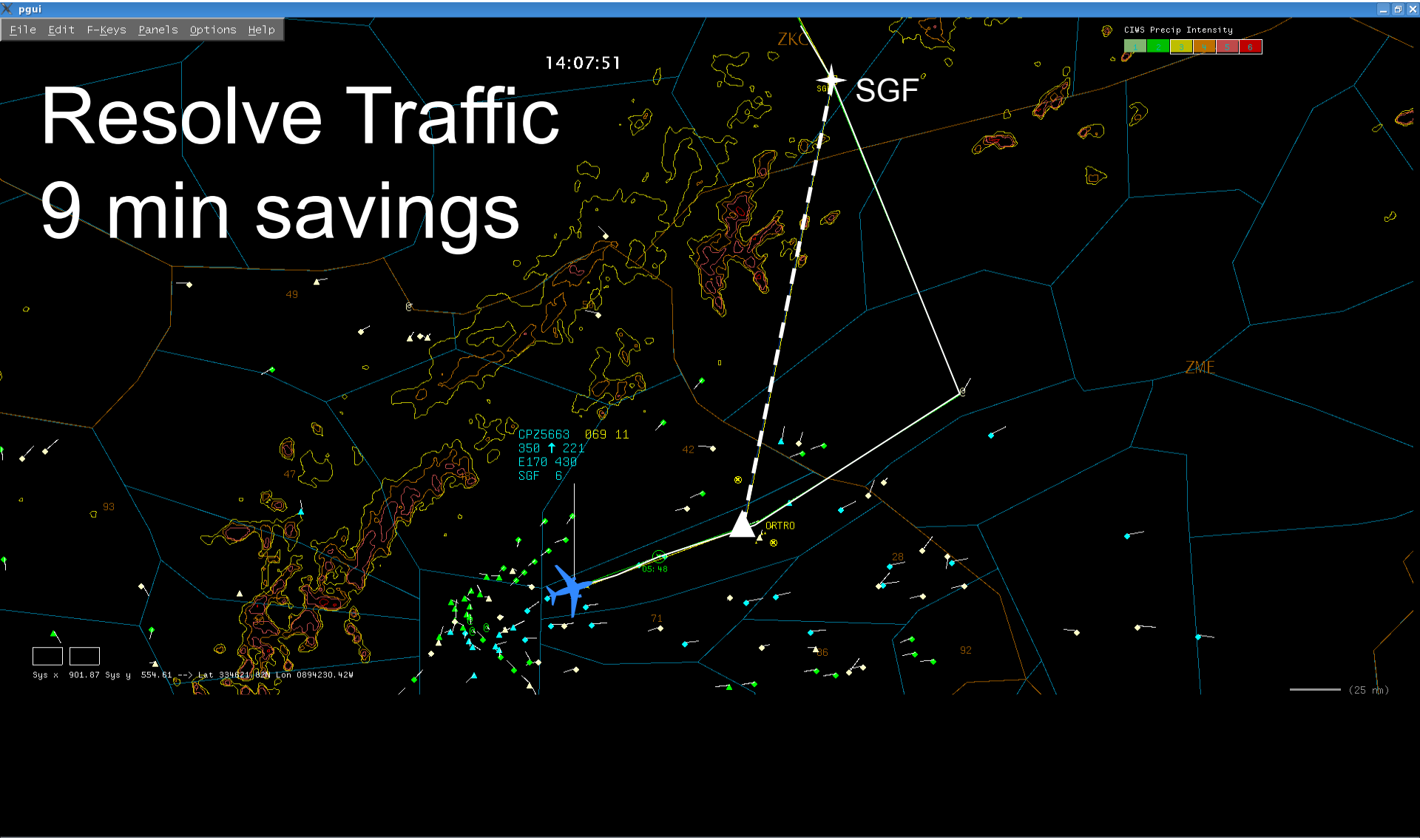
Sample: CPZ5663 DFW to MSP



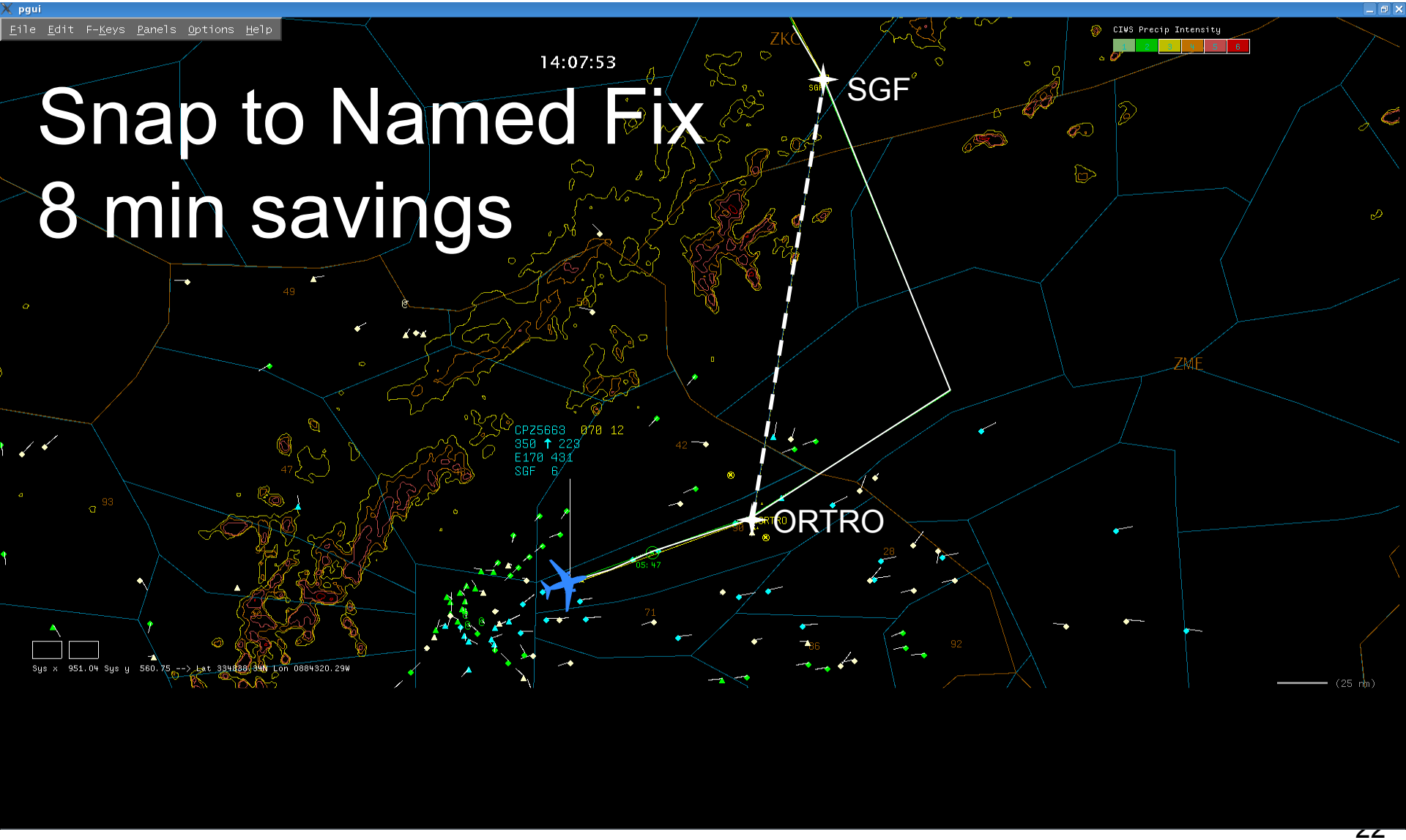
Sample: CPZ5663 DFW to MSP



Sample: CPZ5663 DFW to MSP



Sample: CPZ5663 DFW to MSP



Snap to Named Fix
8 min savings

DWR Flight List

Potential flying time savings (min)

Capture fix / number aux waypoints

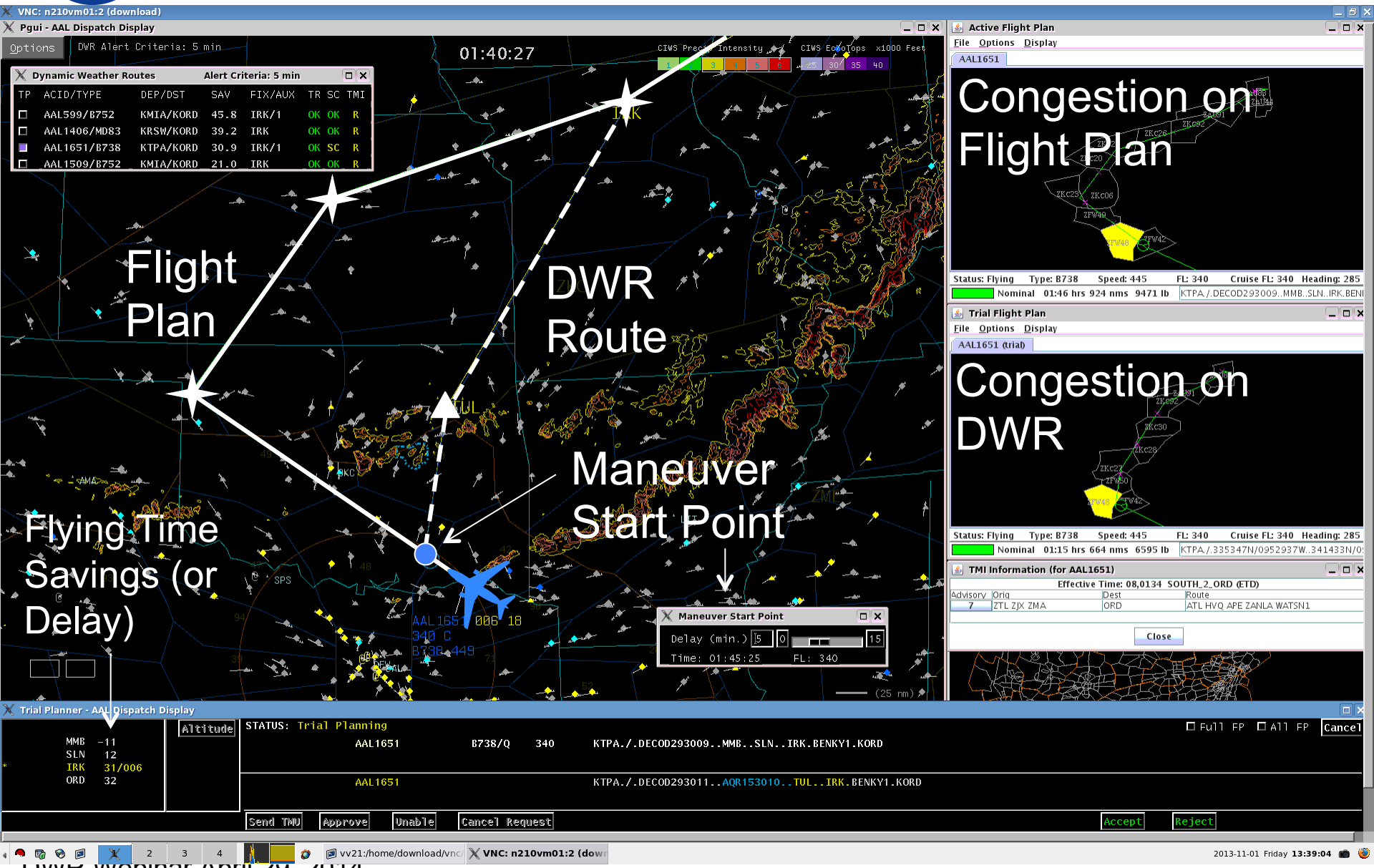
Minutes to traffic conflict

Sector congestion on DWR route

Reroute Traffic Management Initiatives

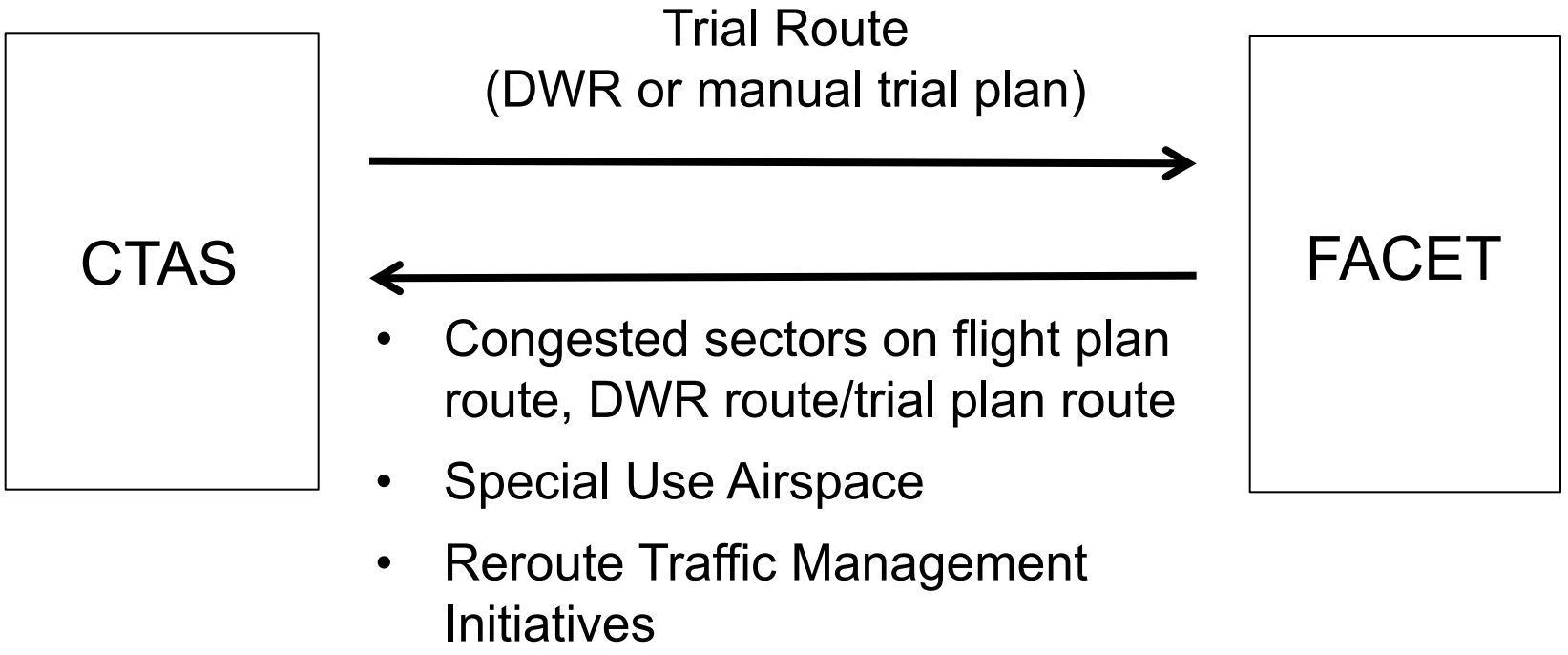
Adjustable Alert Criteria

User Interface with Trial Planner



CTAS/FACET Integration

Real-time two-way communication

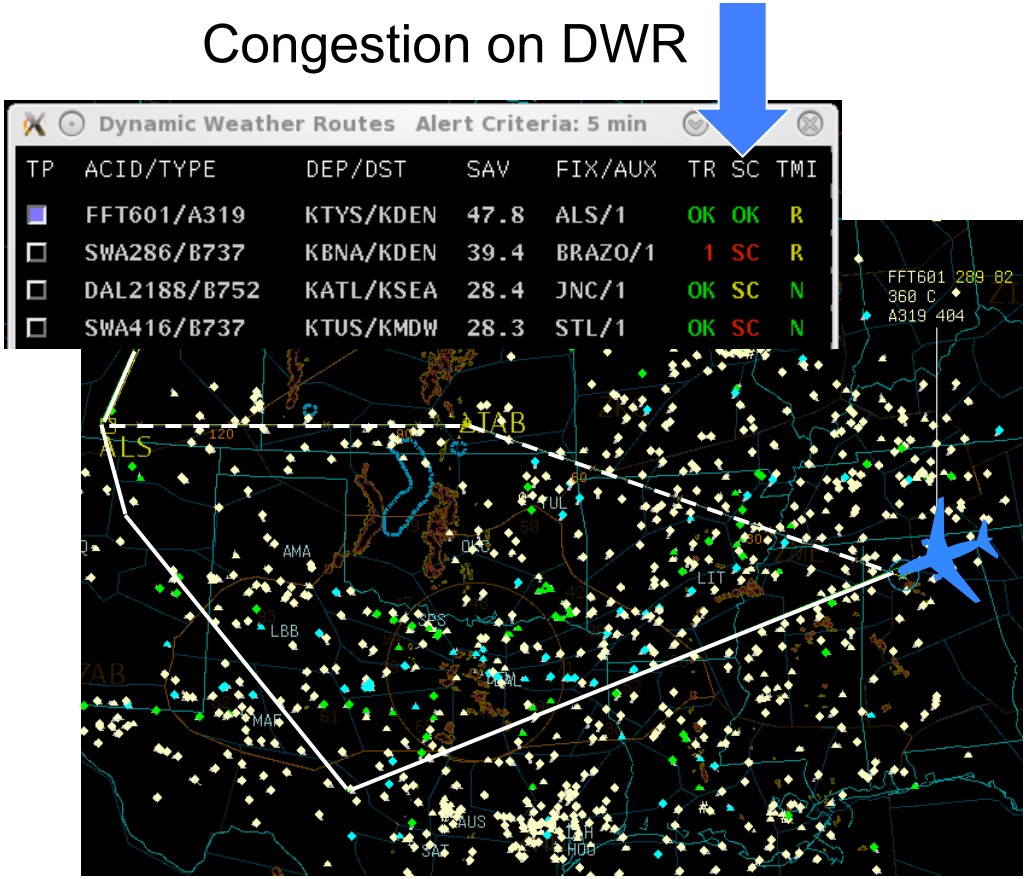


Congested Sectors: Predicted red or yellow based on Monitor Alert Parameter (MAP)

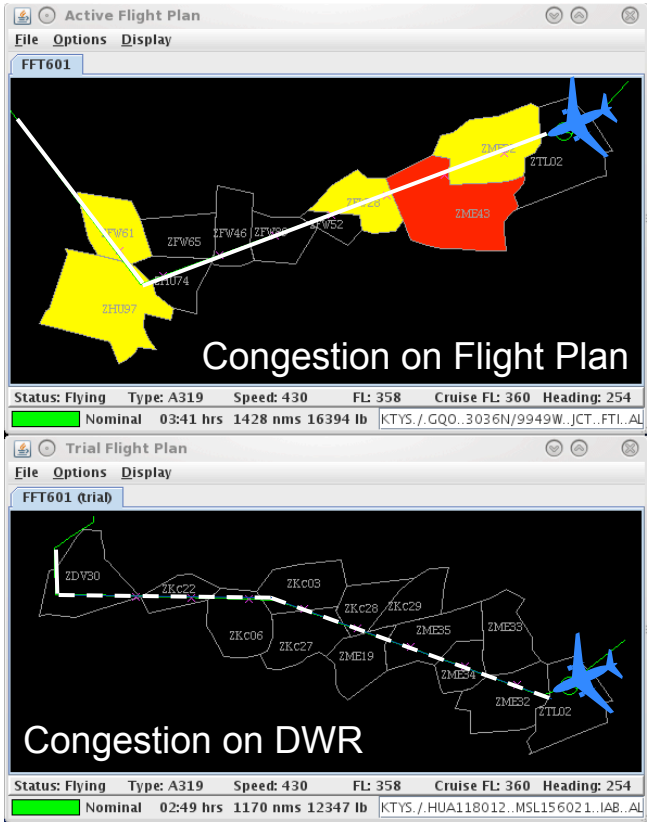
Sector Congestion

Future Air Traffic Management (ATM) Concepts Evaluation Tool (FACET)
Integrated for Sector Congestion Analysis

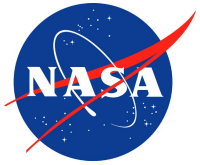
Congestion on DWR



Sector Congestion

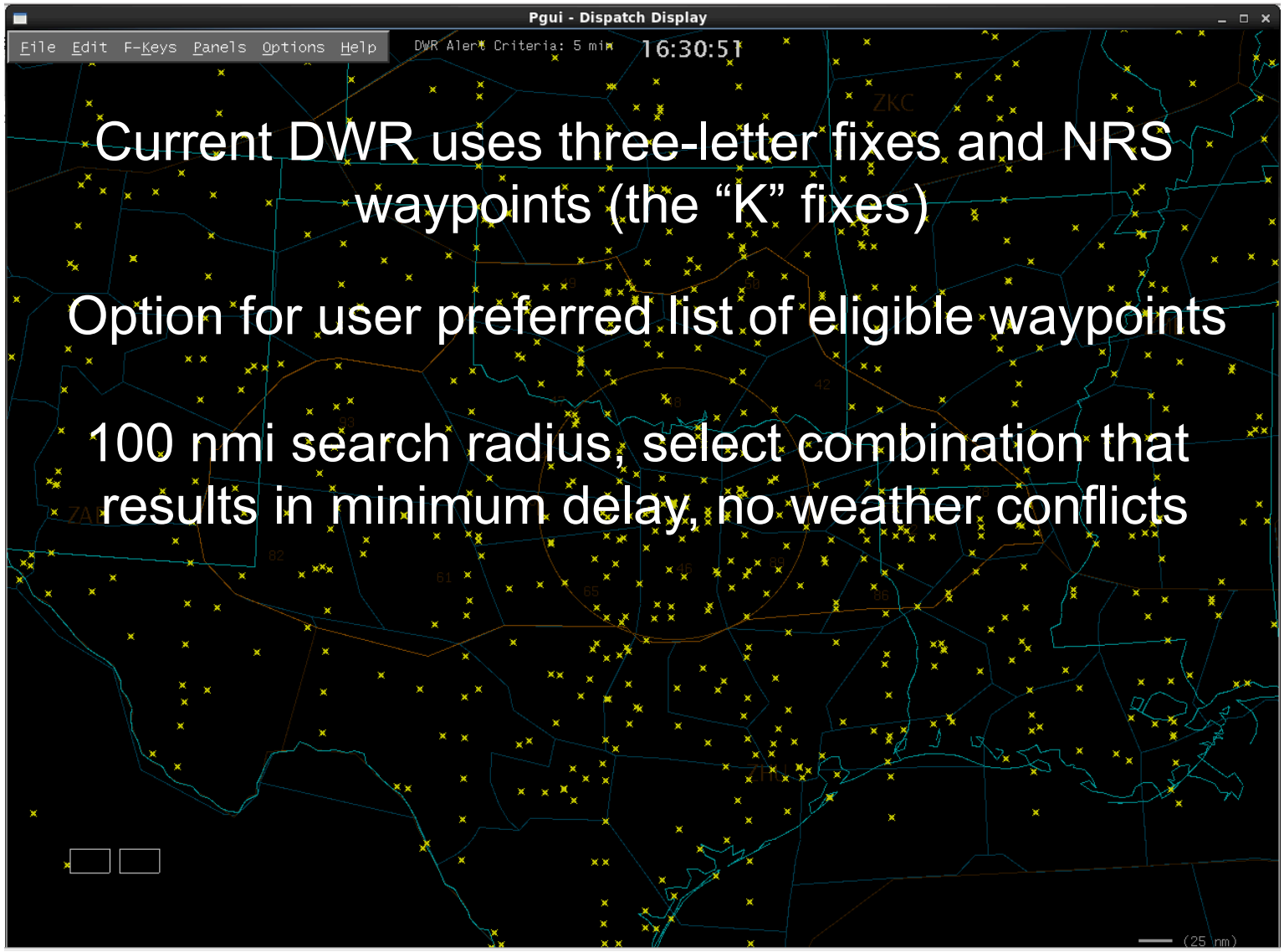


For user information only, currently no filtering based on sector congestion data



Movie 1
Sample DWR Routes from AA Trial

How are snap to fixes selected for auxiliary waypoints?

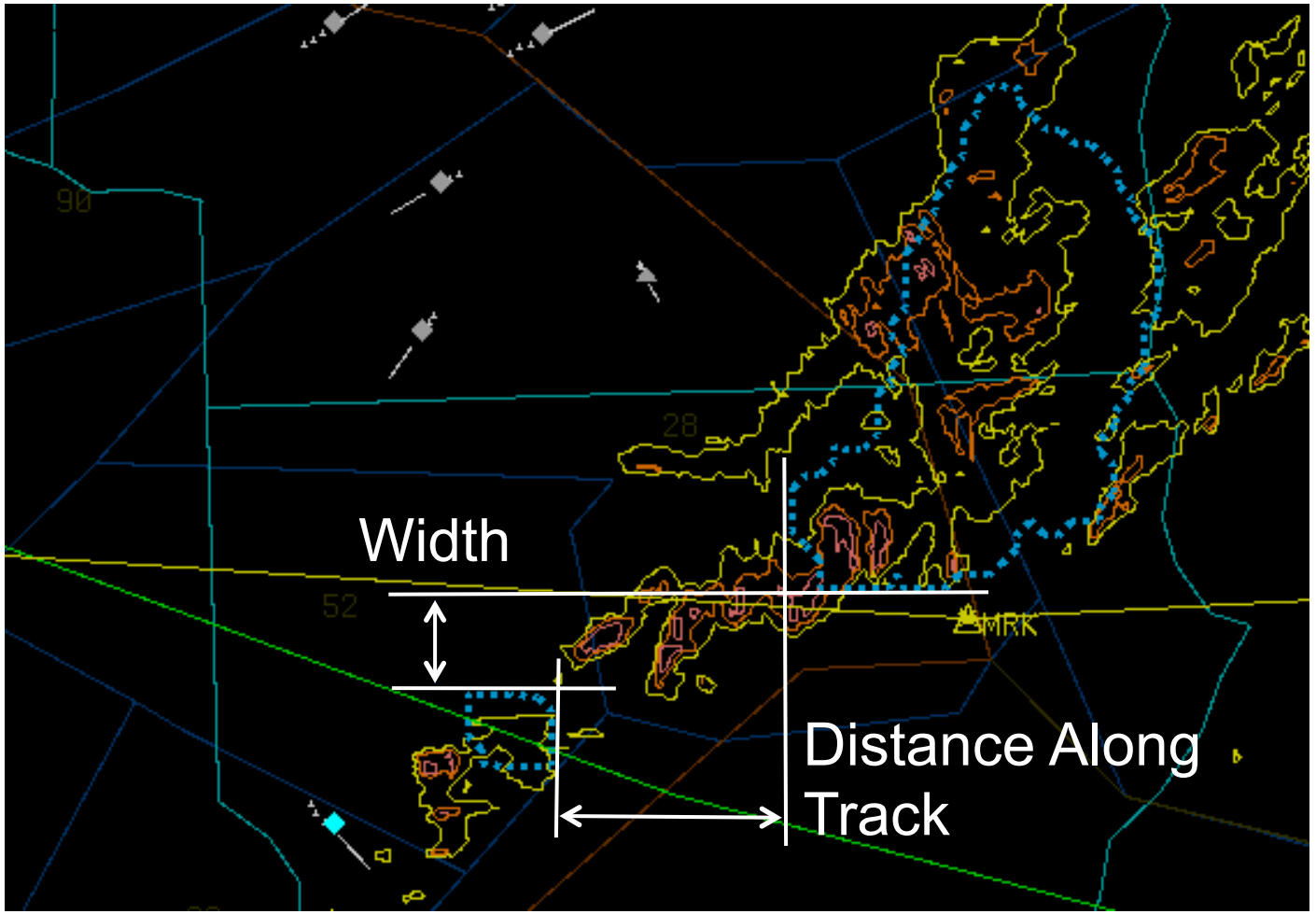


Current DWR uses three-letter fixes and NRS waypoints (the “K” fixes)

Option for user preferred list of eligible waypoints

100 nmi search radius, select combination that results in minimum delay, no weather conflicts

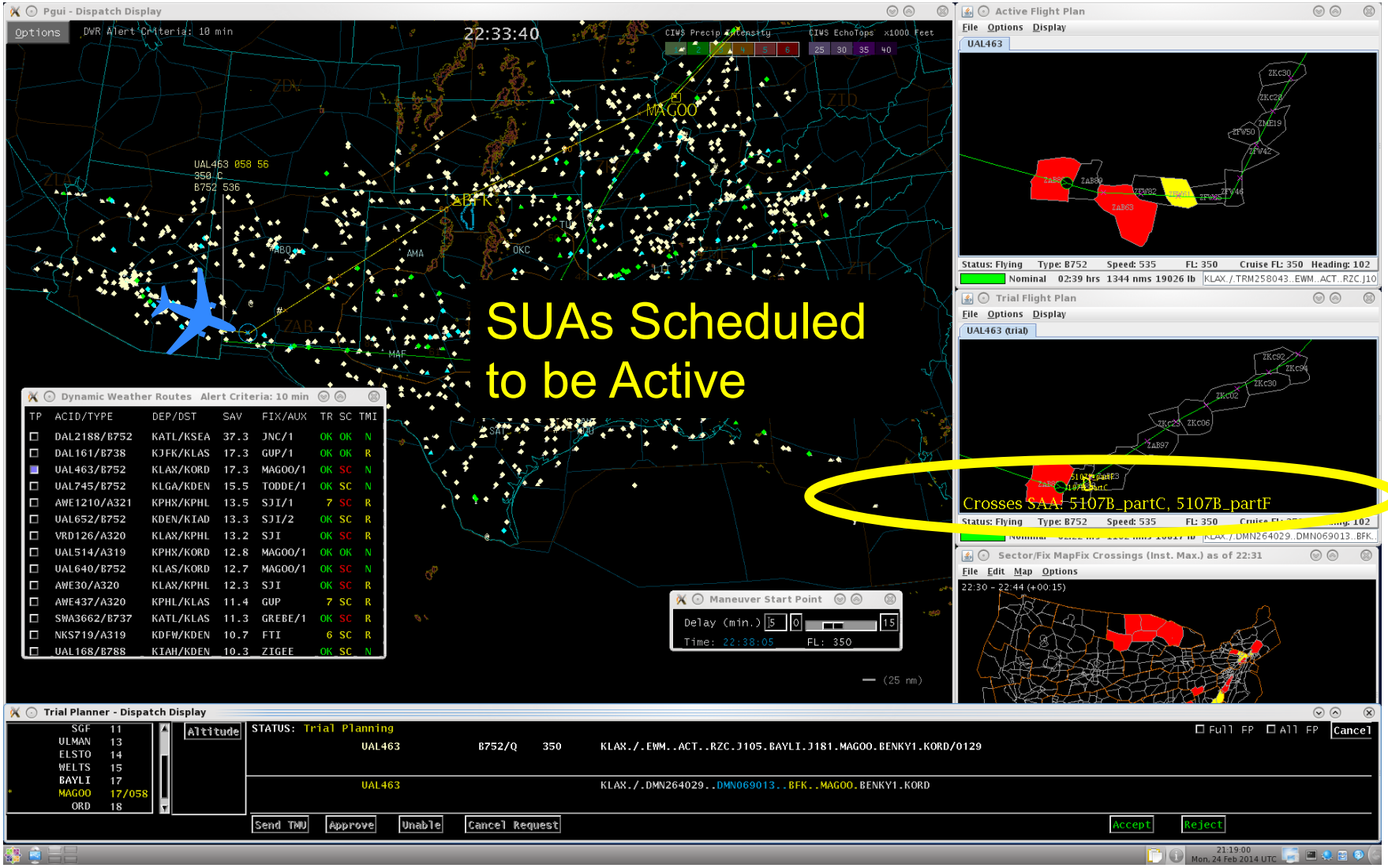
Weather Gap Detection



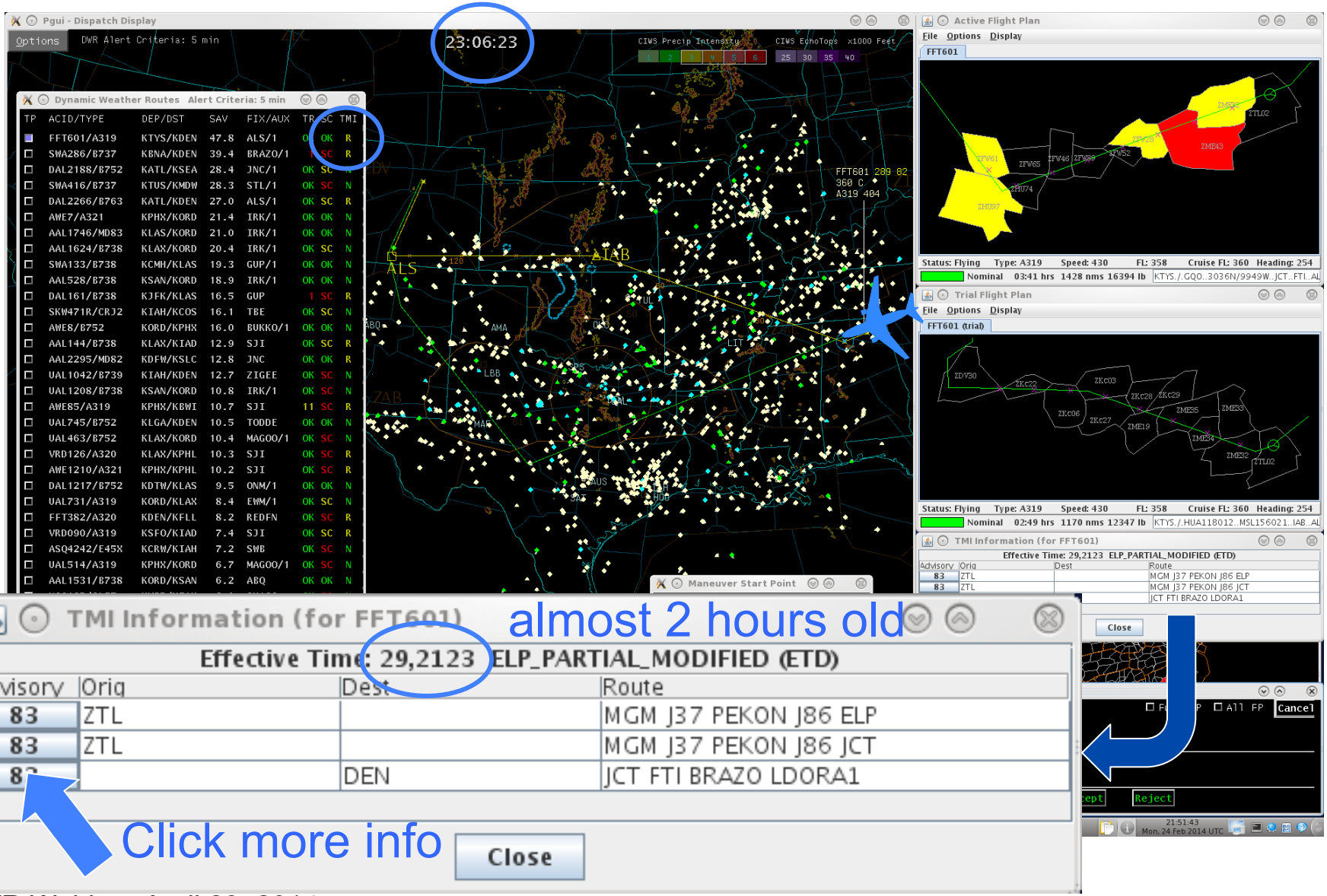
Default Width: 25 nmi

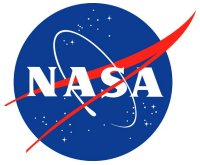
Default Distance Along Track: 50 nmi

Special Use Airspace



Reroute Traffic Management Initiatives





Movie 2
Key DWR Functions

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Trial at American Airlines

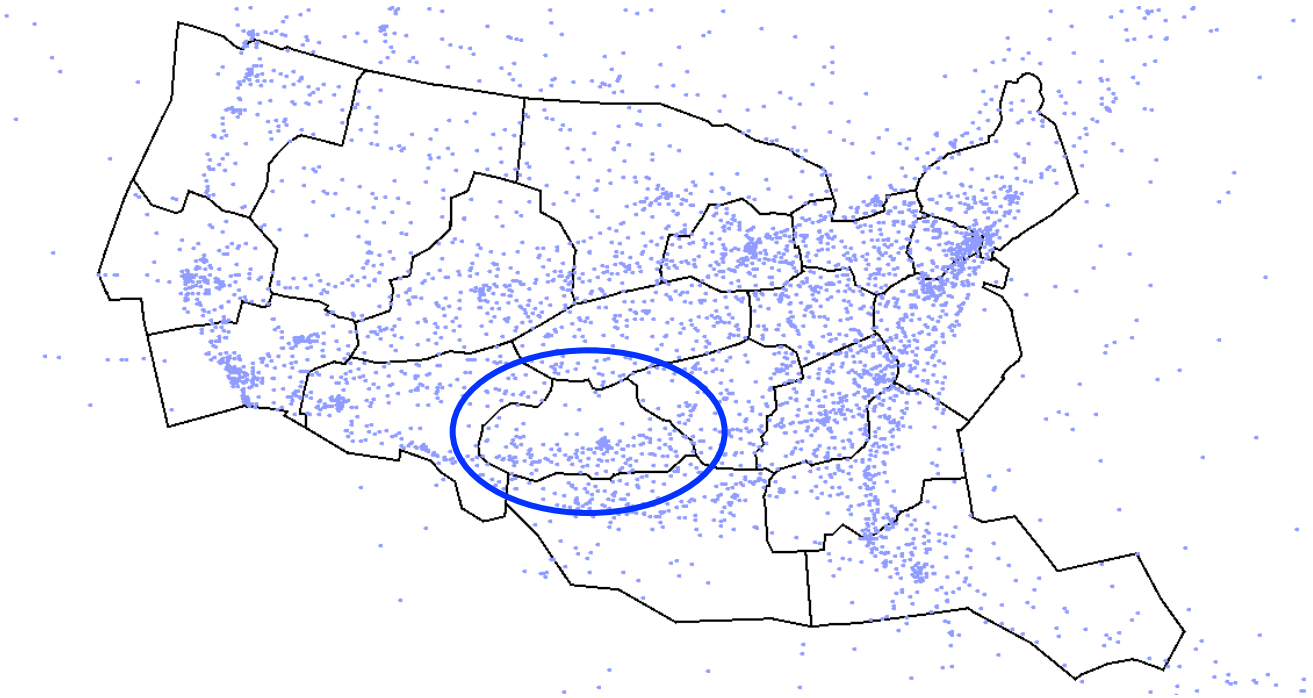
American Airlines Integrated Operations Control Center, Fort Worth, Texas

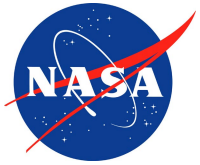
Trial at American Airlines

Integrated Operations Control Center, Fort Worth, Texas

Test Operations

- Fort Worth Center traffic only
- System runs 23 hrs/day, 7 days/week since July 2012
- Usually staffed during heavy weather





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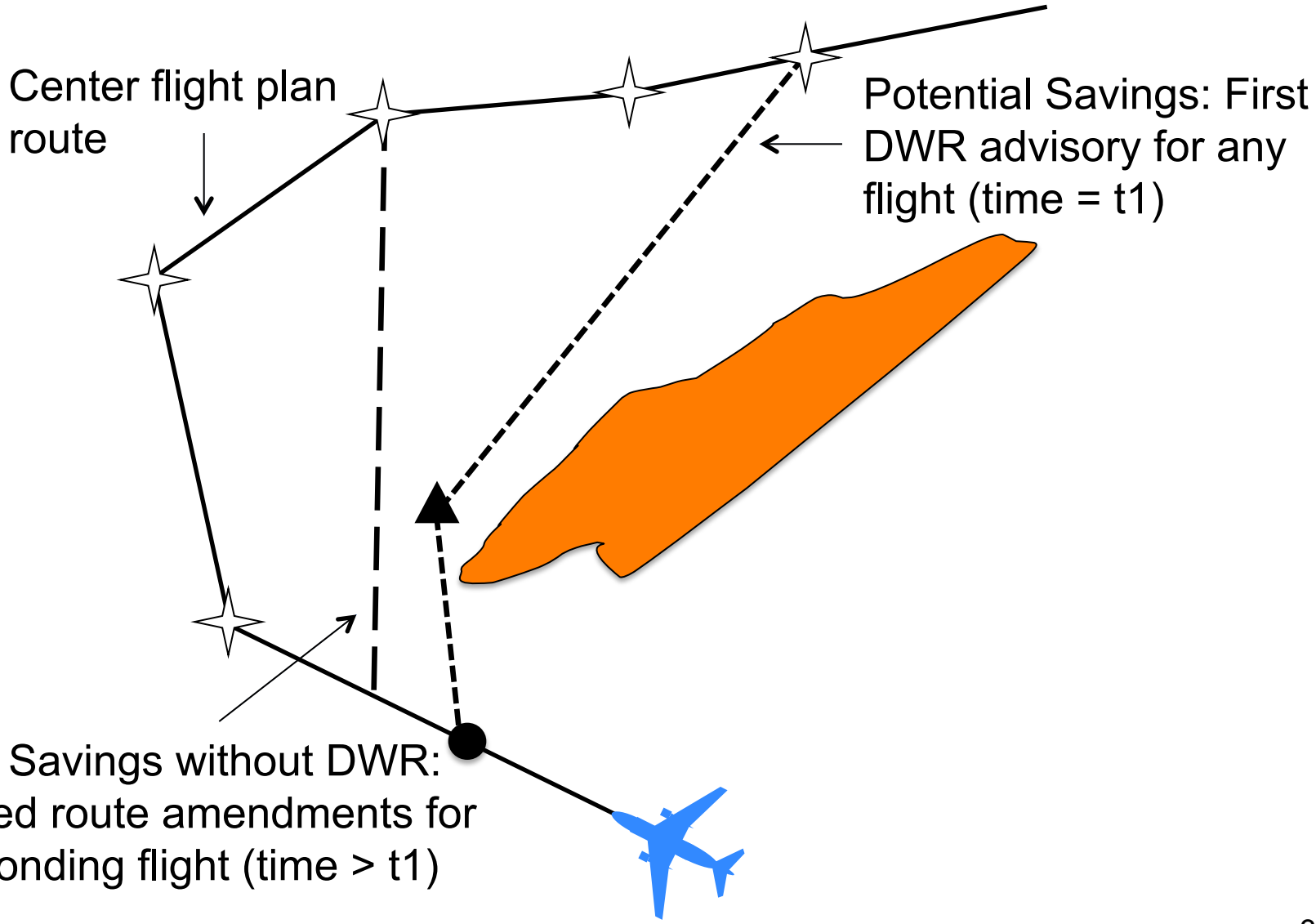
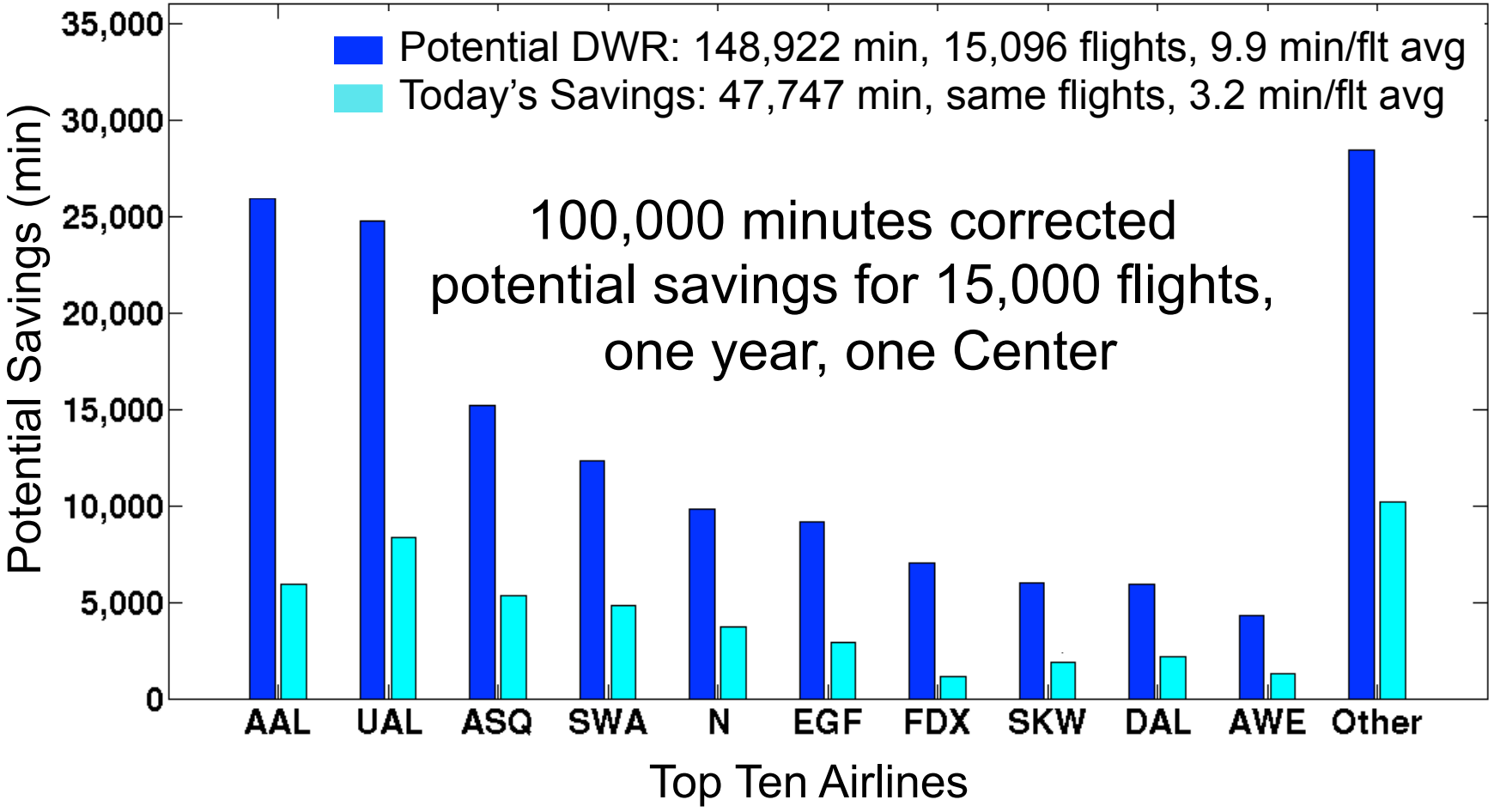
Potential DWR Savings and Today's Savings without DWR

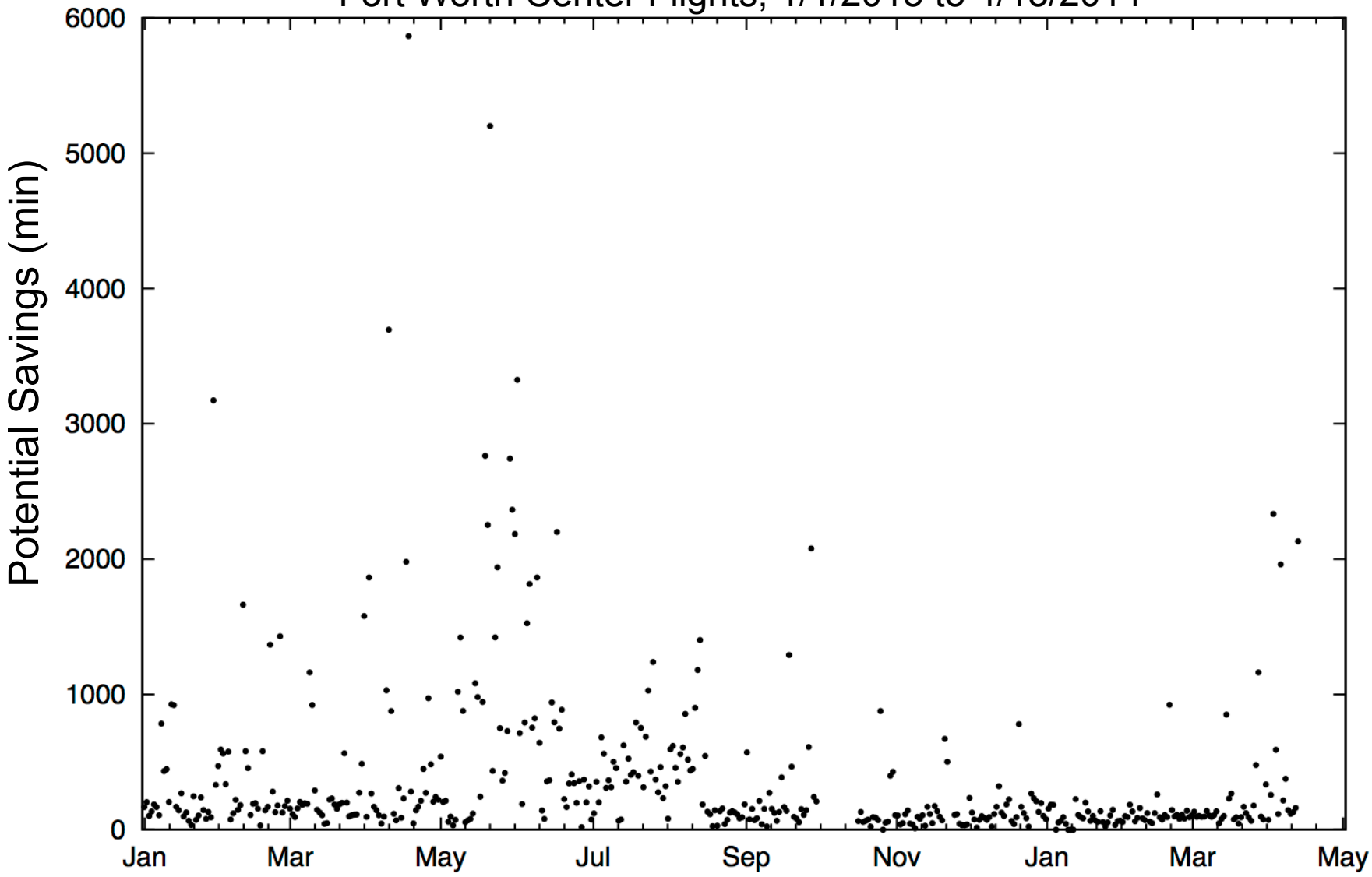


Potential Savings in 2013

All Flights, Fort Worth Center, Savings ≥ 5 min

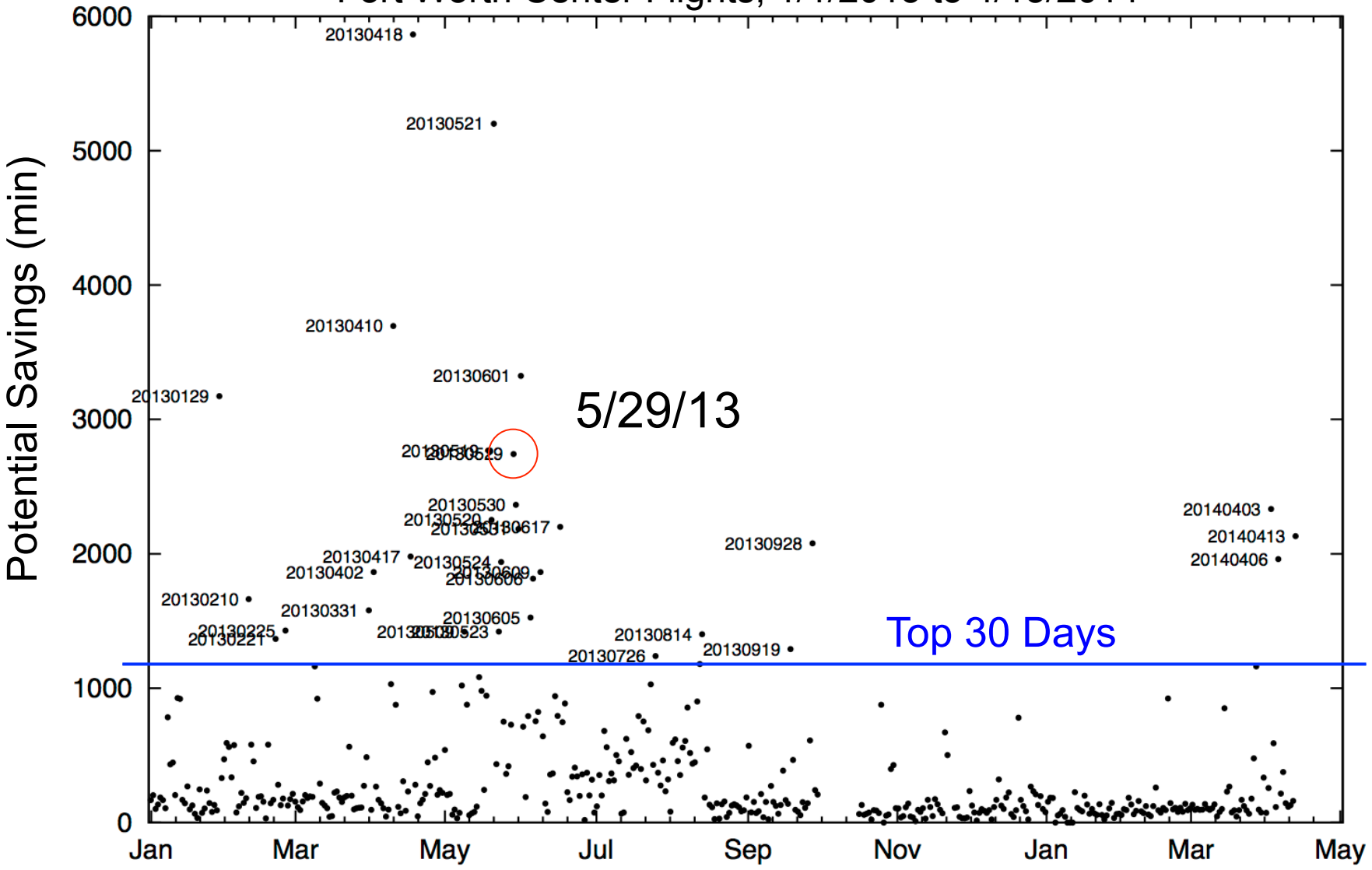


Potential Savings by Day 2013/2014

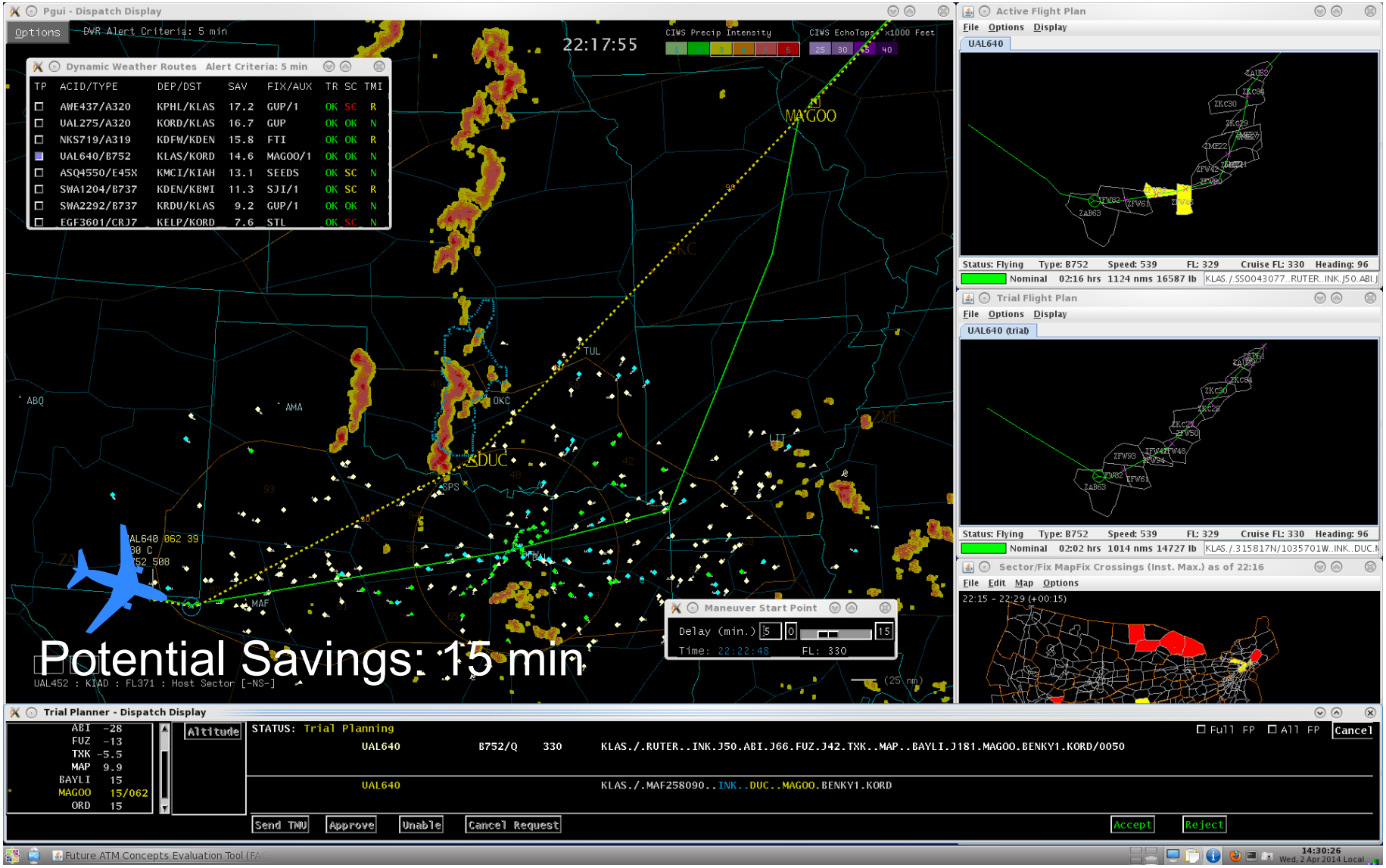


Potential Savings by Day 2013/2014

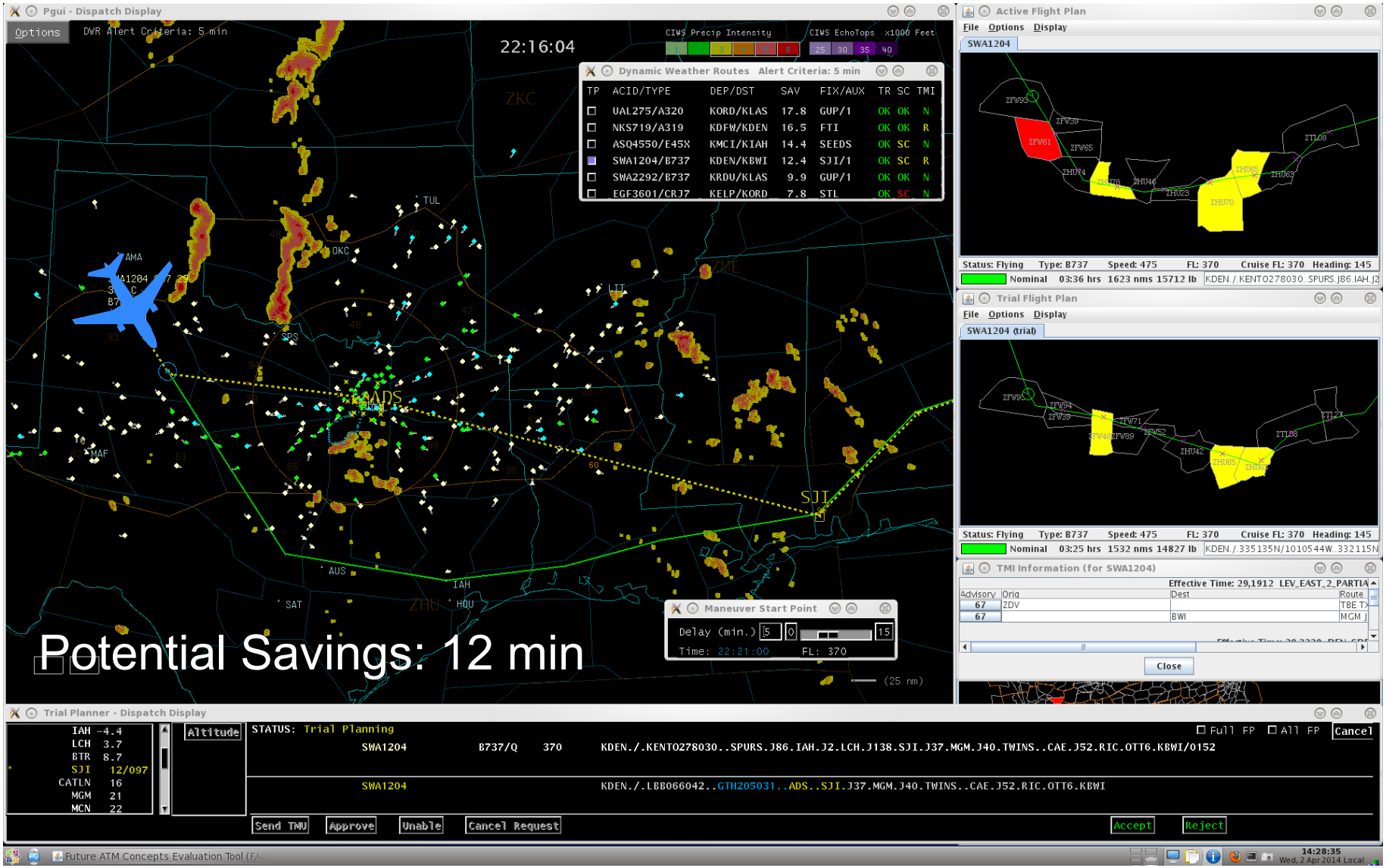
Fort Worth Center Flights, 1/1/2013 to 4/13/2014



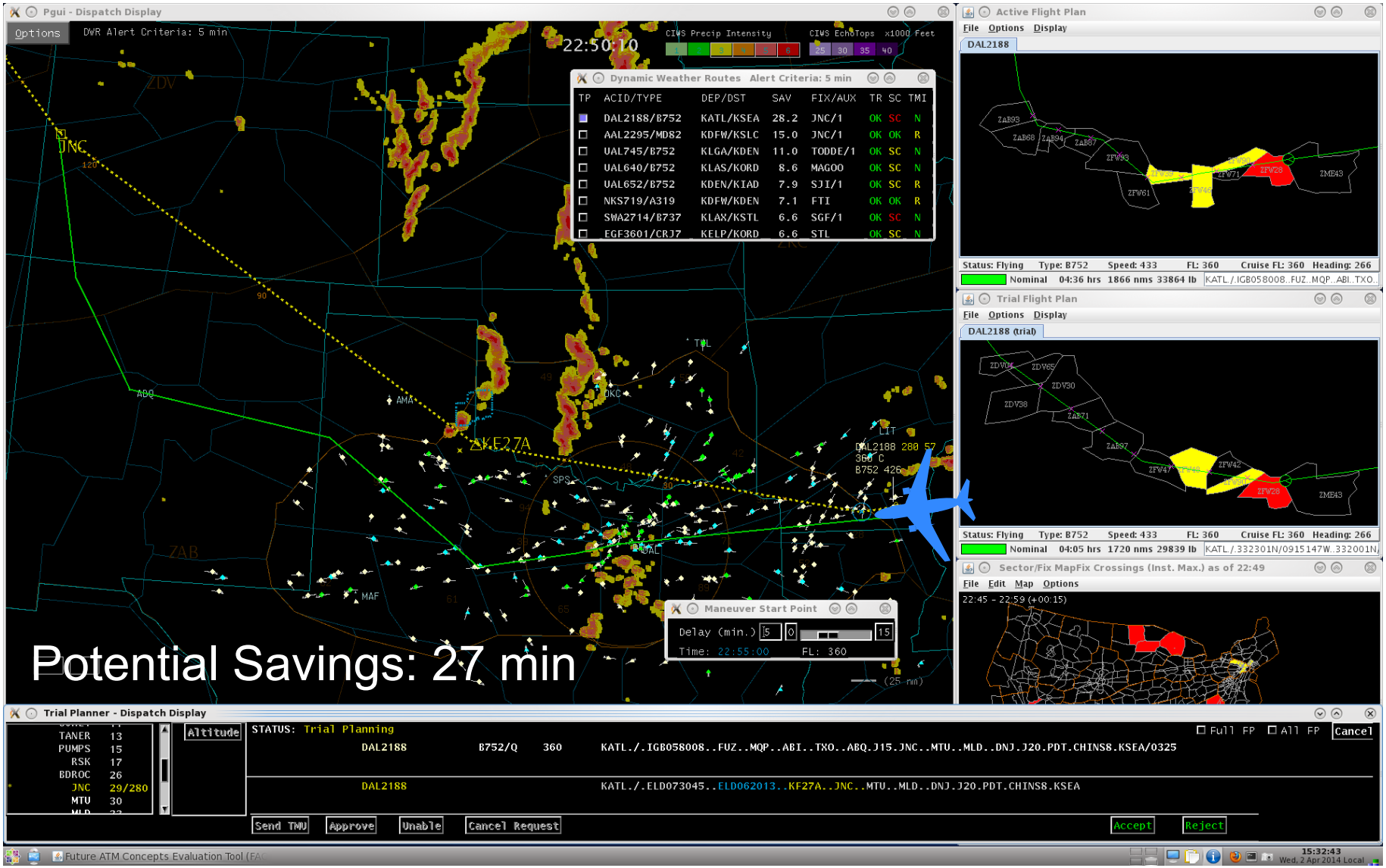
Sample: Las Vegas/Chicago



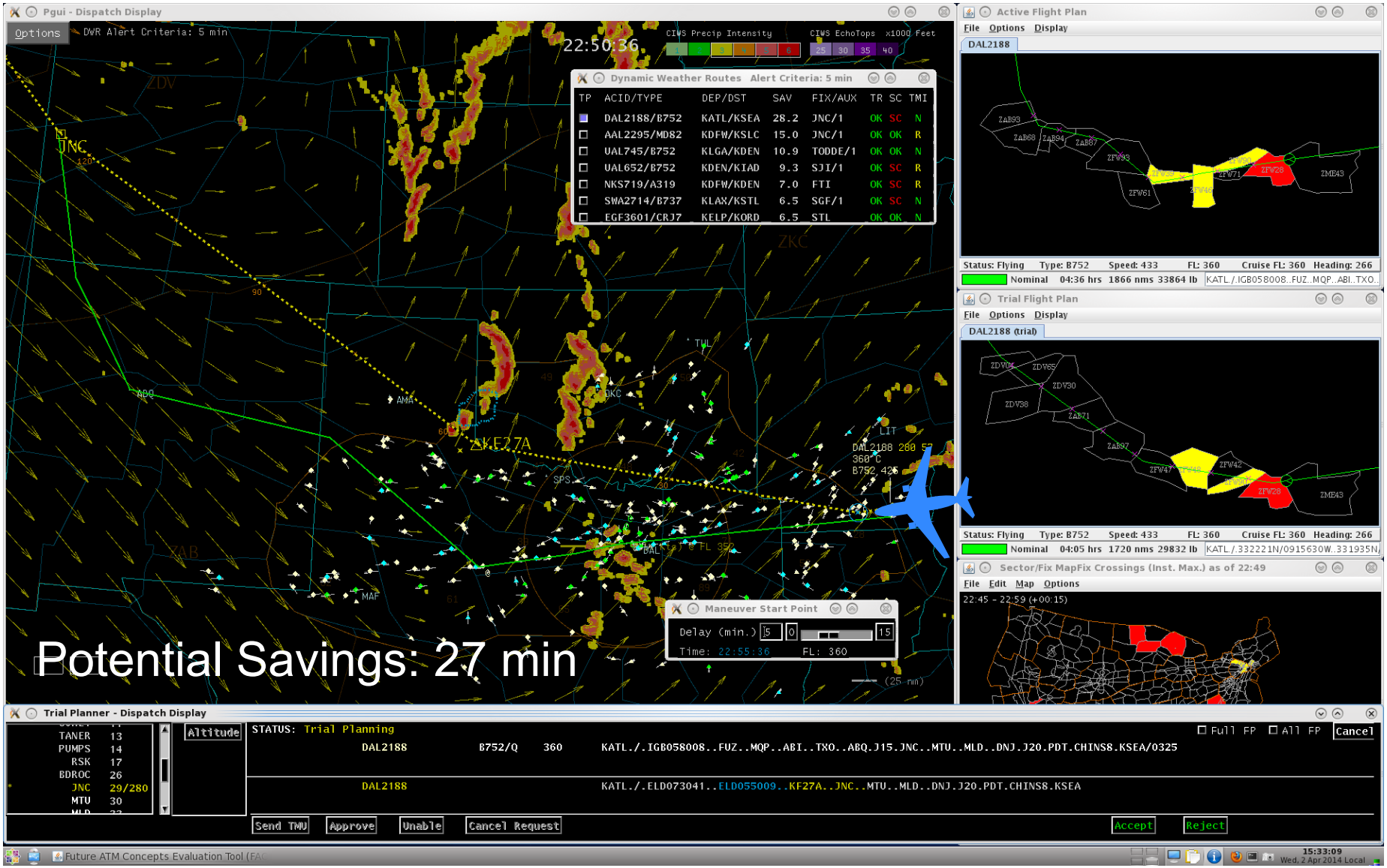
Sample: Denver/Baltimore



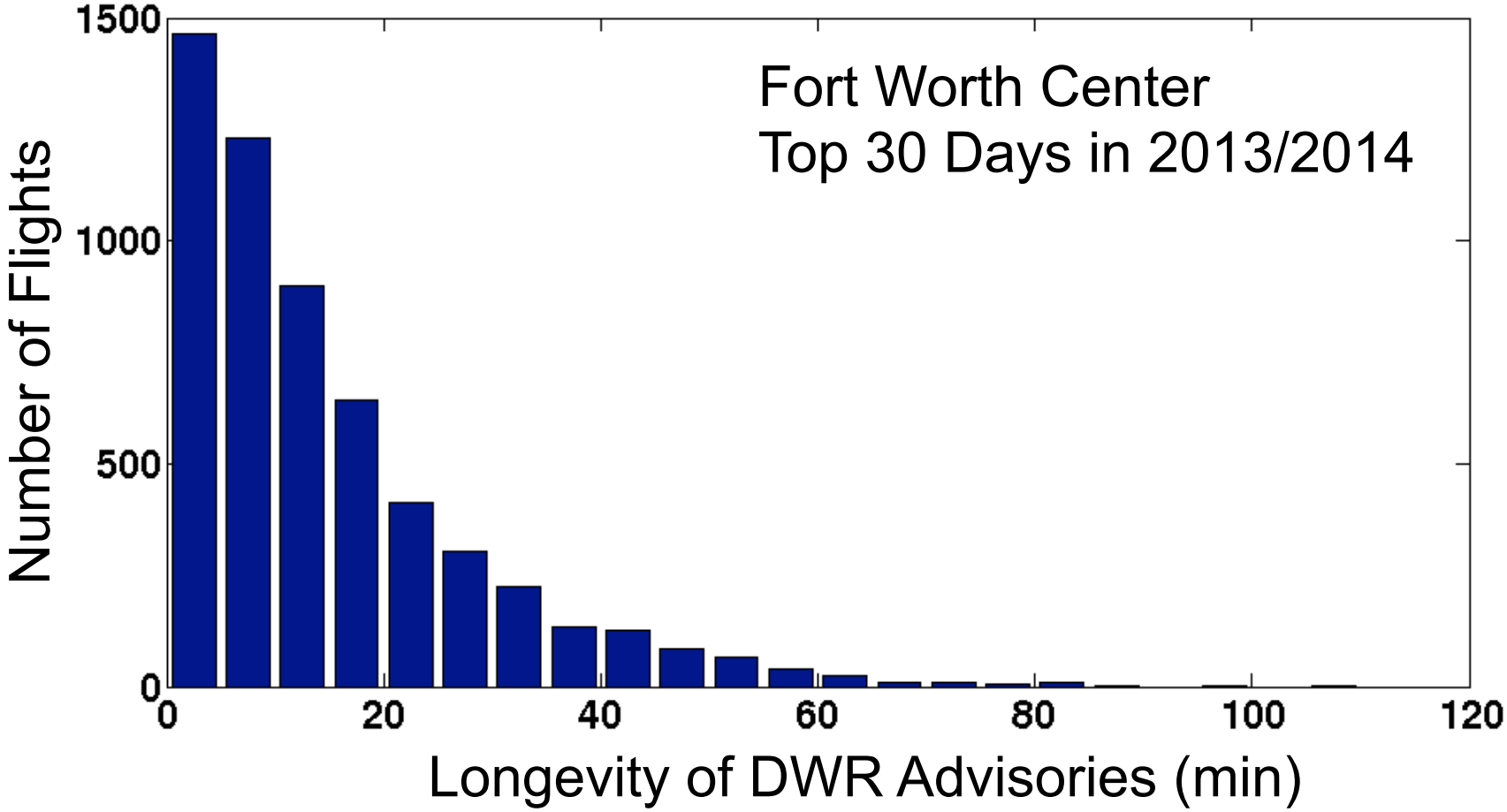
Sample: Atlanta/Seattle



Sample: Atlanta/Seattle

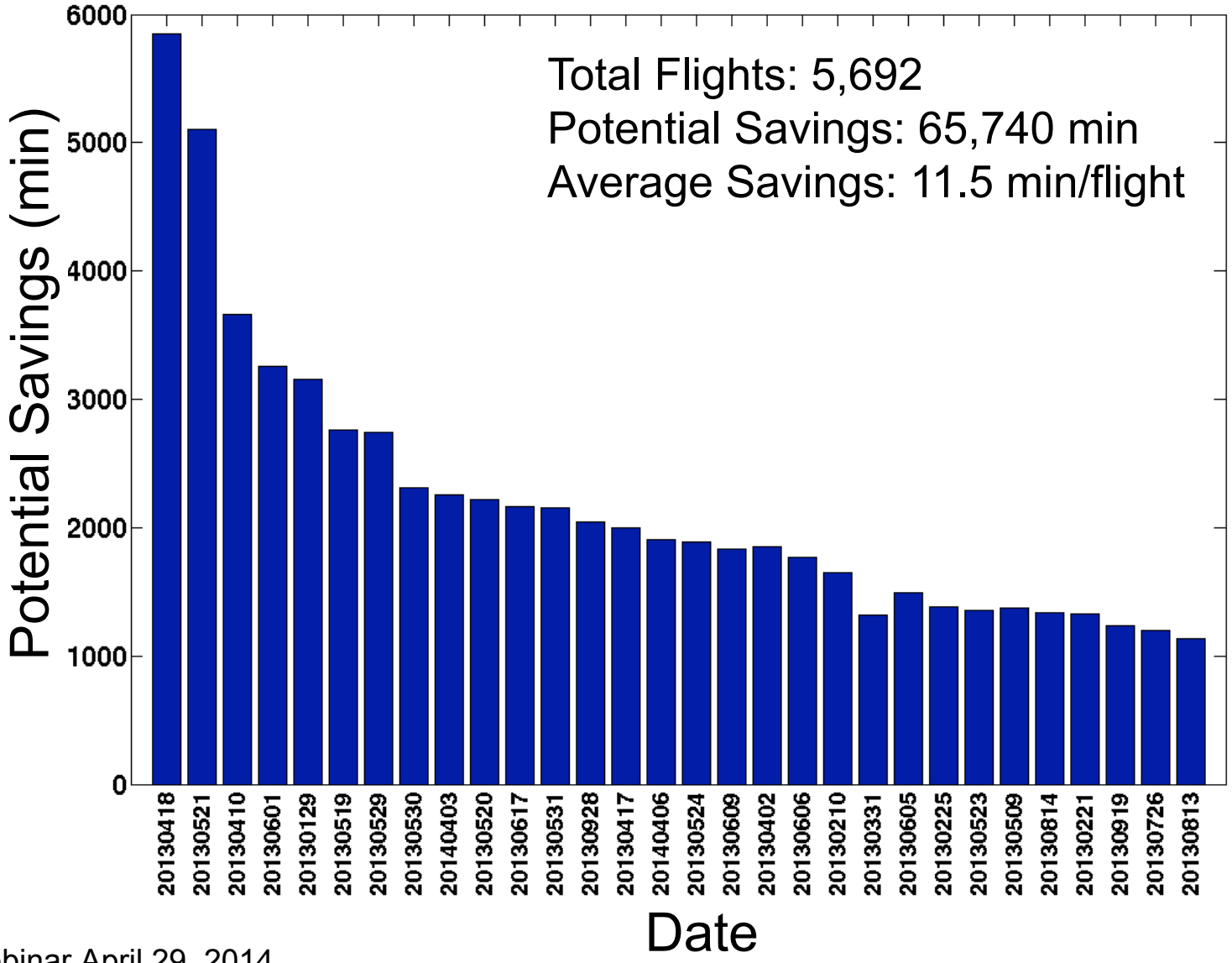


How long does a flight stay on the DWR flight list?

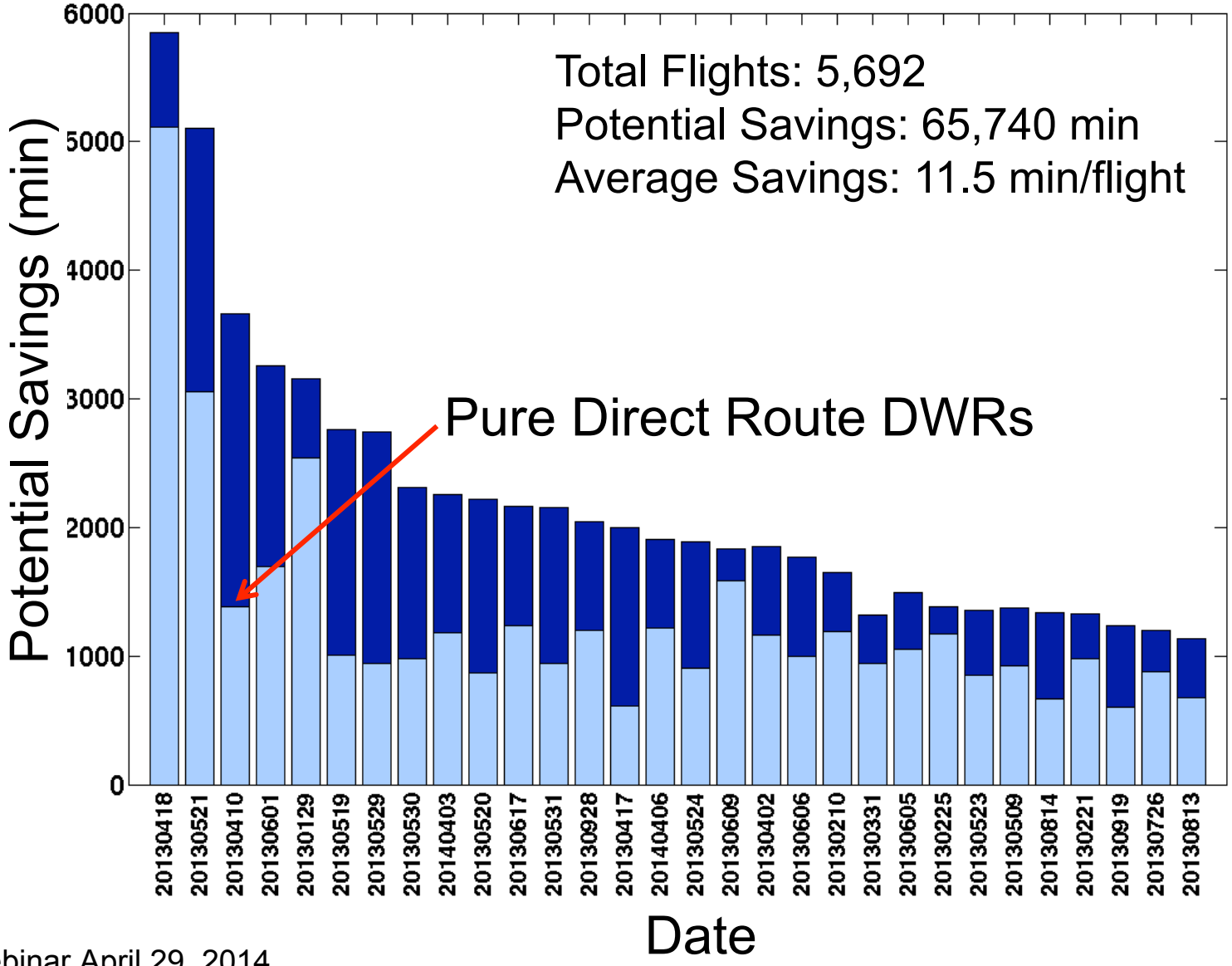


Potential Savings All Flights

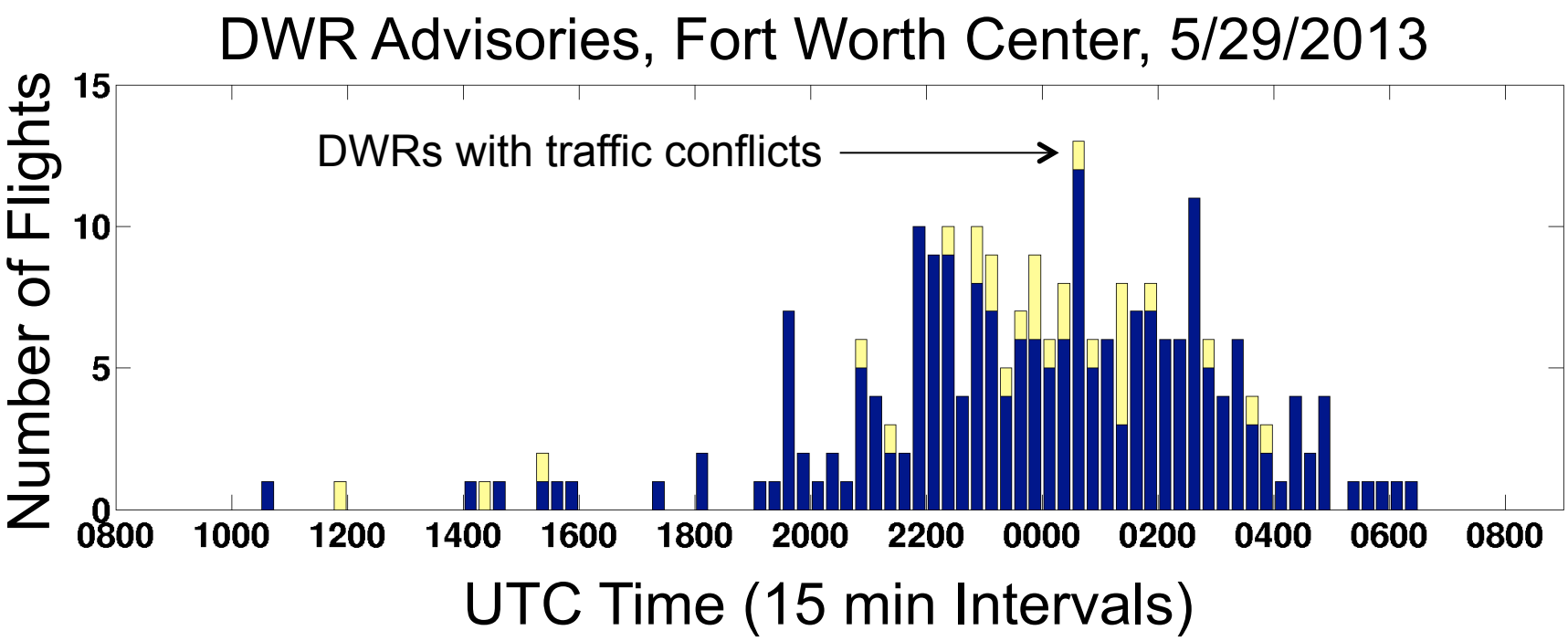
Fort Worth Center, Top 30 Days in 2013/2014

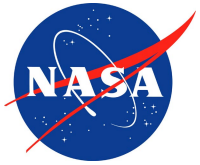


How many DWRs are pure direct routes vs. those with auxiliary waypoints?



How many flights get DWR route advisories over 15 minute intervals?





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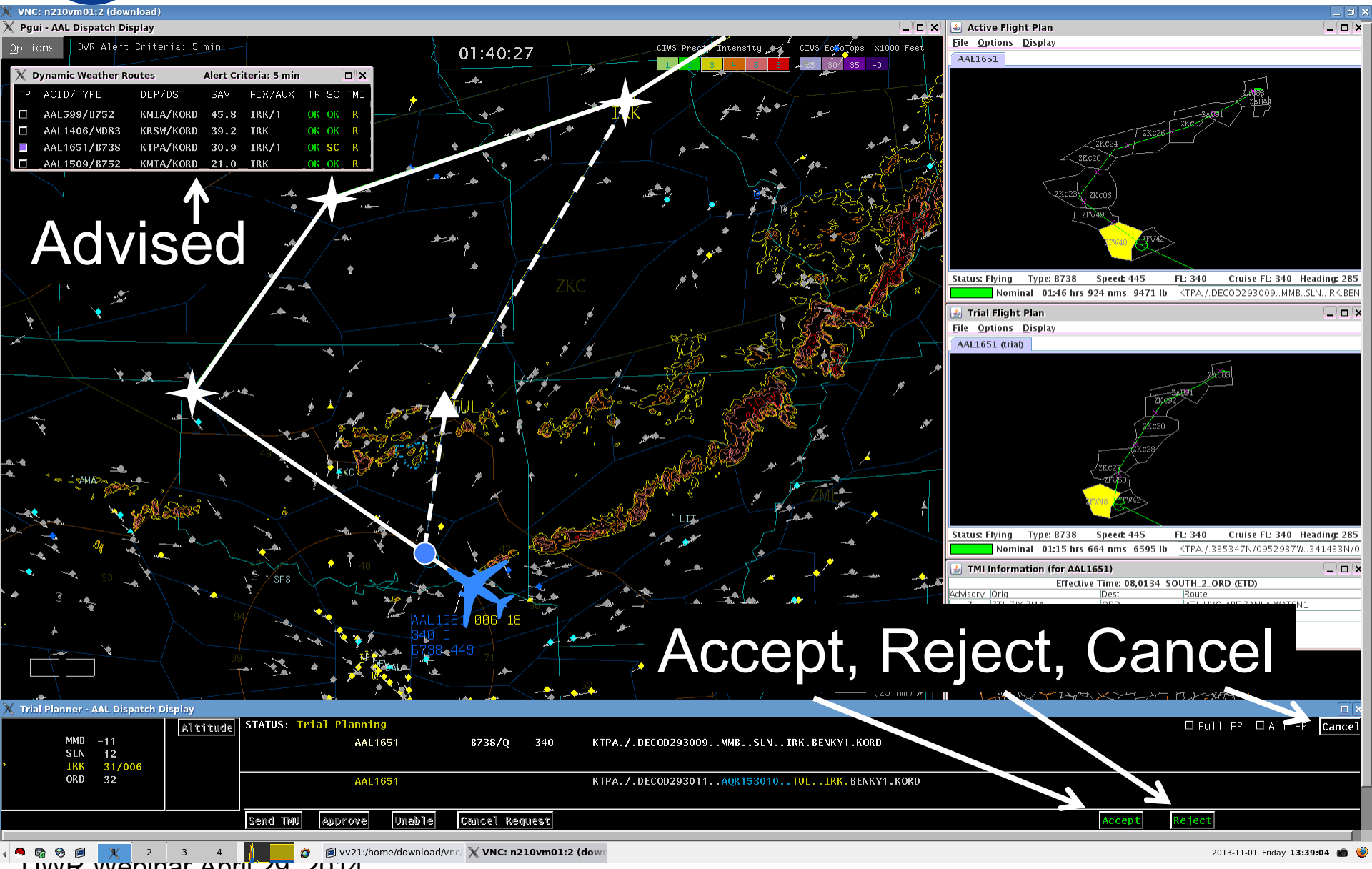
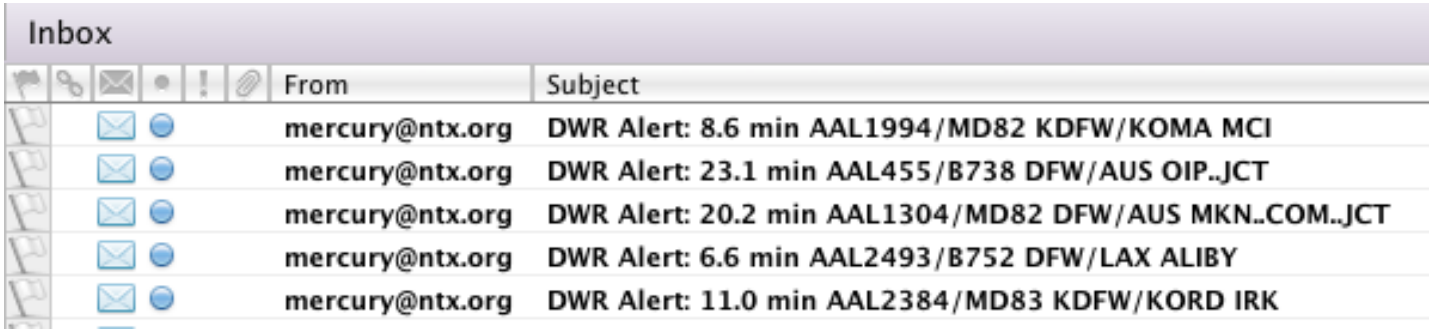
Data Recording



Email Alerts and the Daily Report



DWR Report 2013-05-30 Thu

		Flights	Estimated Savings (min)
Total DWR Initialized Flights		39	355.3
	Evaluated	29	278.7
	Accepted	25	209.7
	Rejected	3	15.9
	Canceled	1	
Total AA Initialized Flights		0	
	Accepted	0	0
	Canceled	0	
Estimate of Actual Savings (ZFW Route Amendments)	Total Accepted	25	209.7
	Total ZFW Actual	11	89.9

Advised

Evaluated

Accepted

Rejected

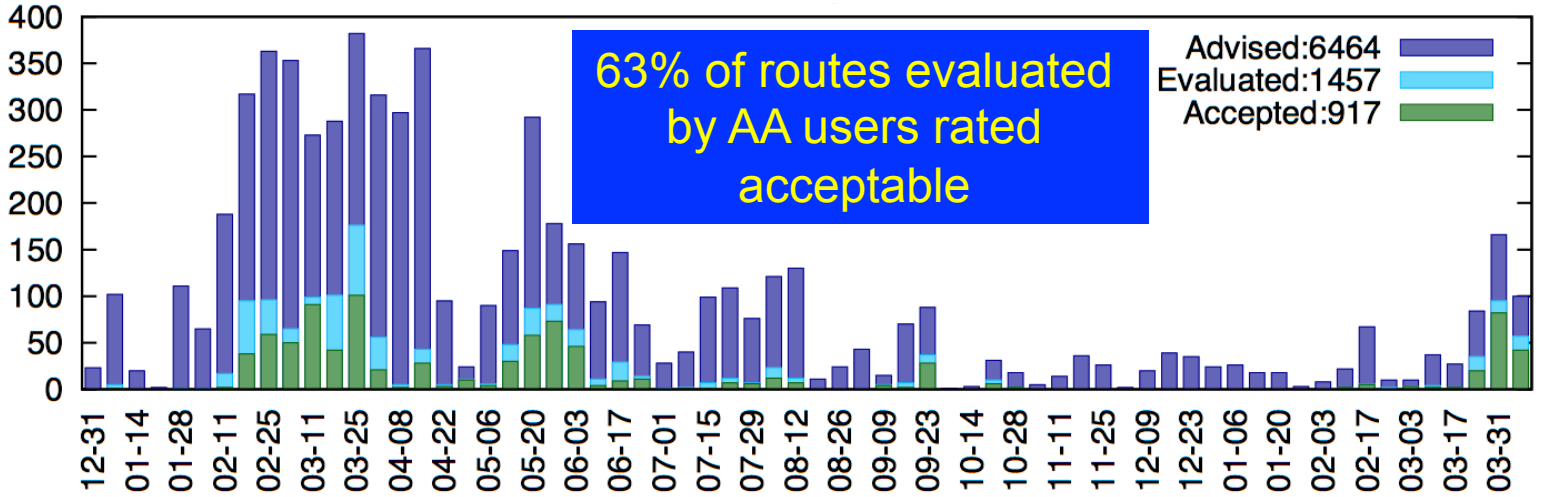
Estimated Actual Savings

Note: sample email alerts and daily report are from different days.

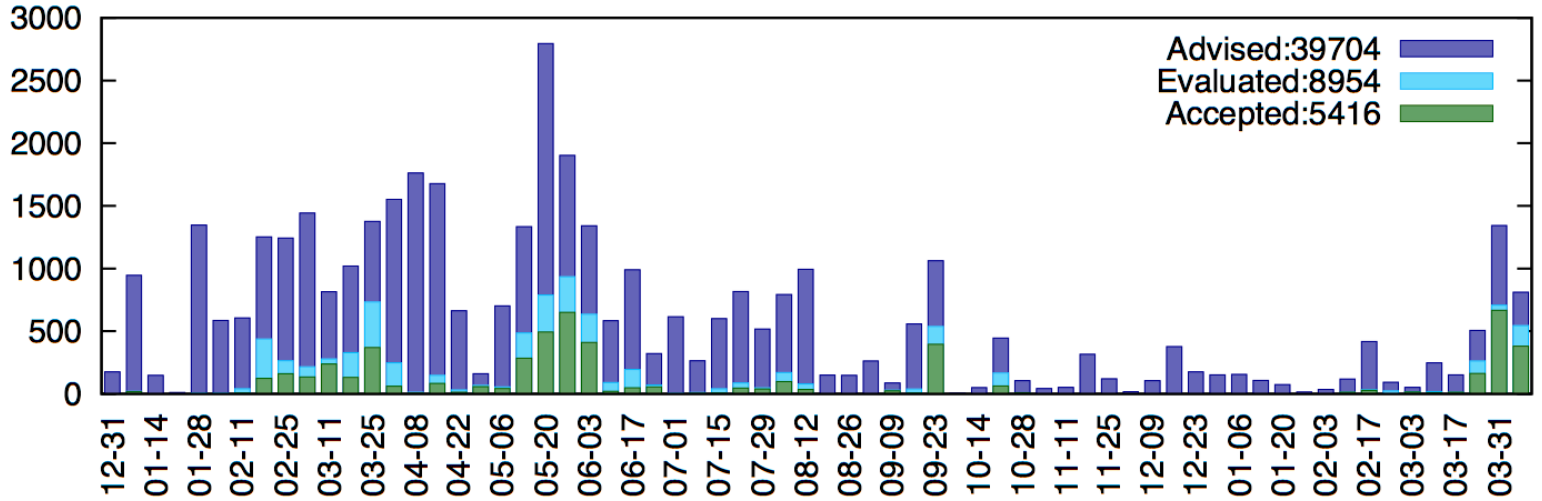
DWR Advised Routes and AA User Actions

AA Flights 1/1/2013 to 4/13/2014

AA flights

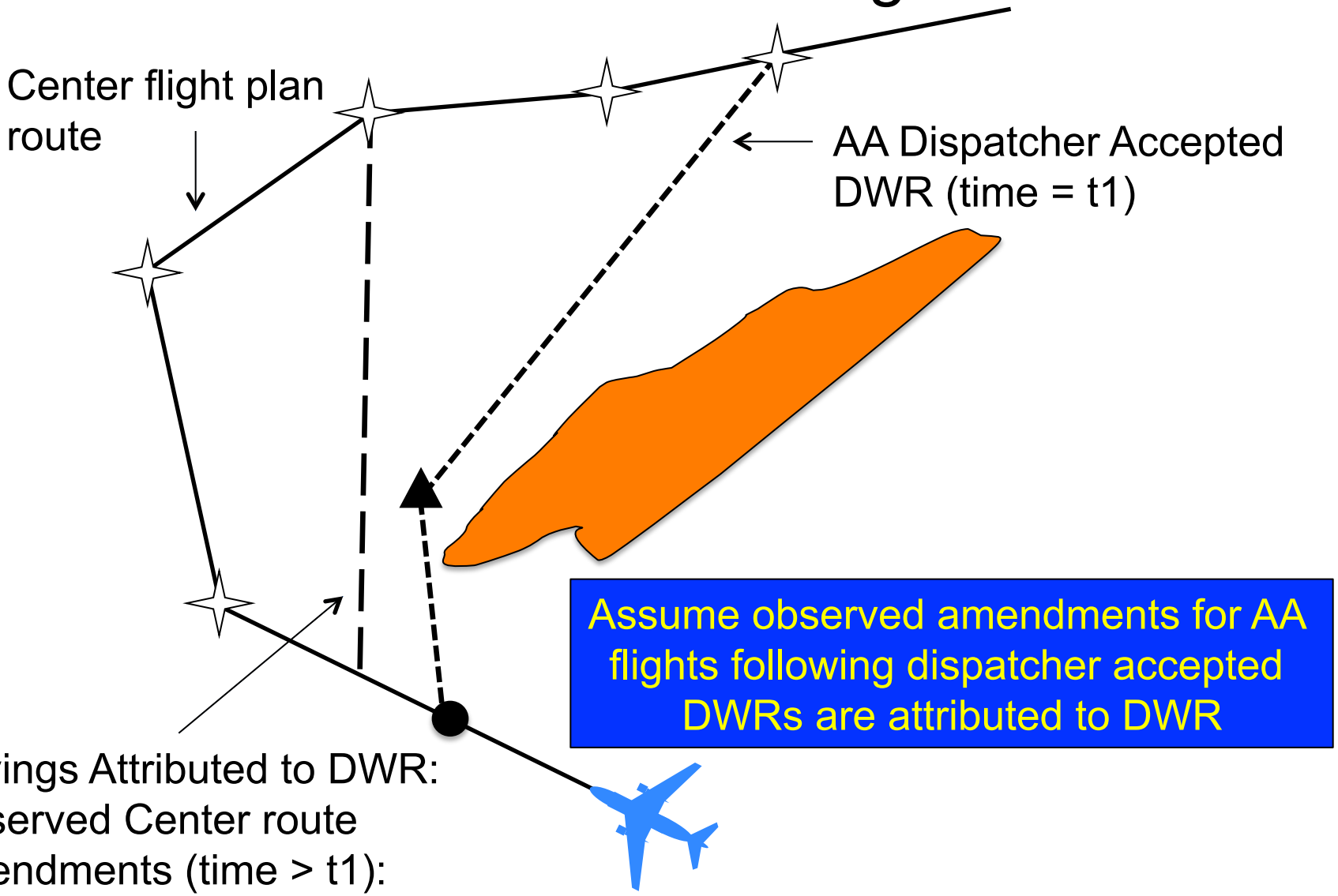


Potential flying time savings (min)



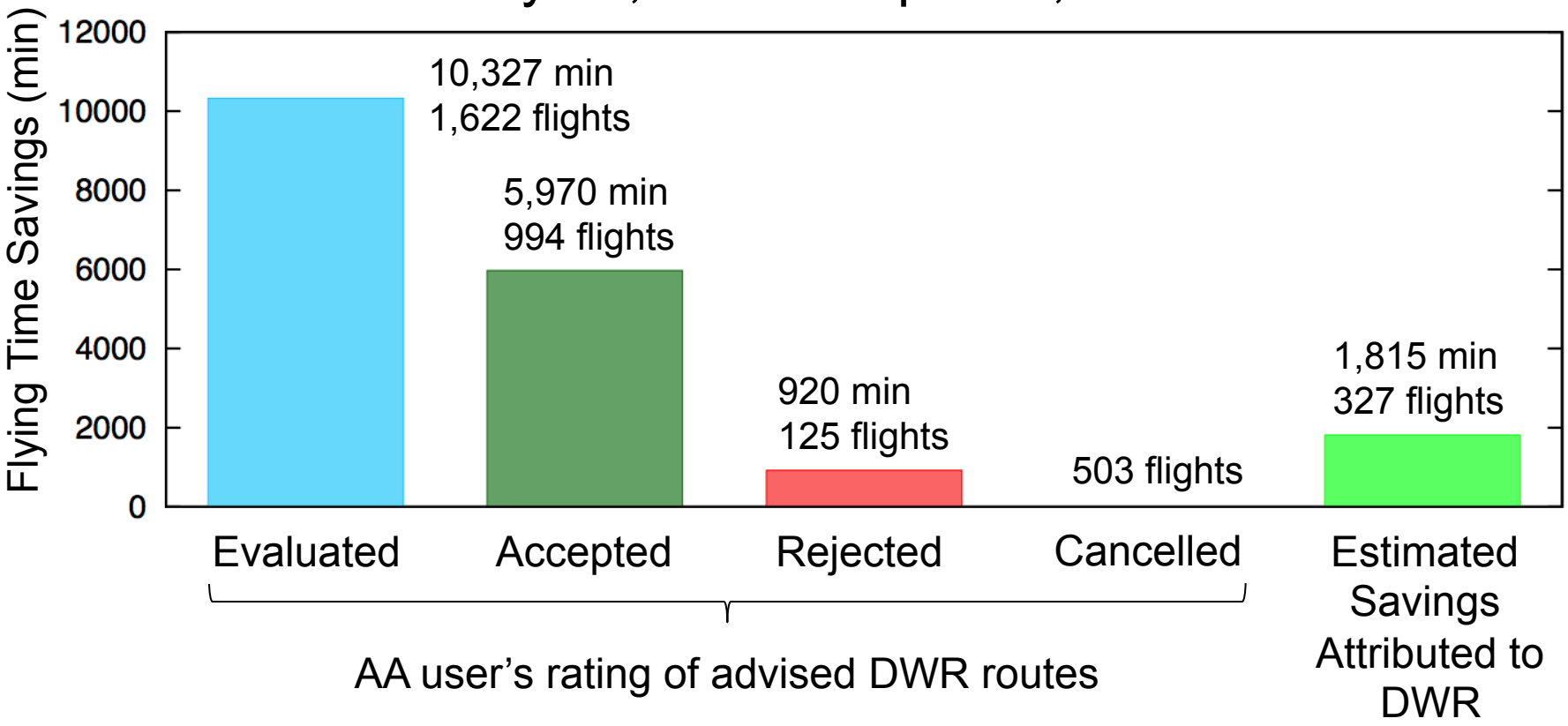
Week in 2013 and 2014

What is the Estimated Actual Savings for American Airlines flights?



DWR Activity at American Airlines

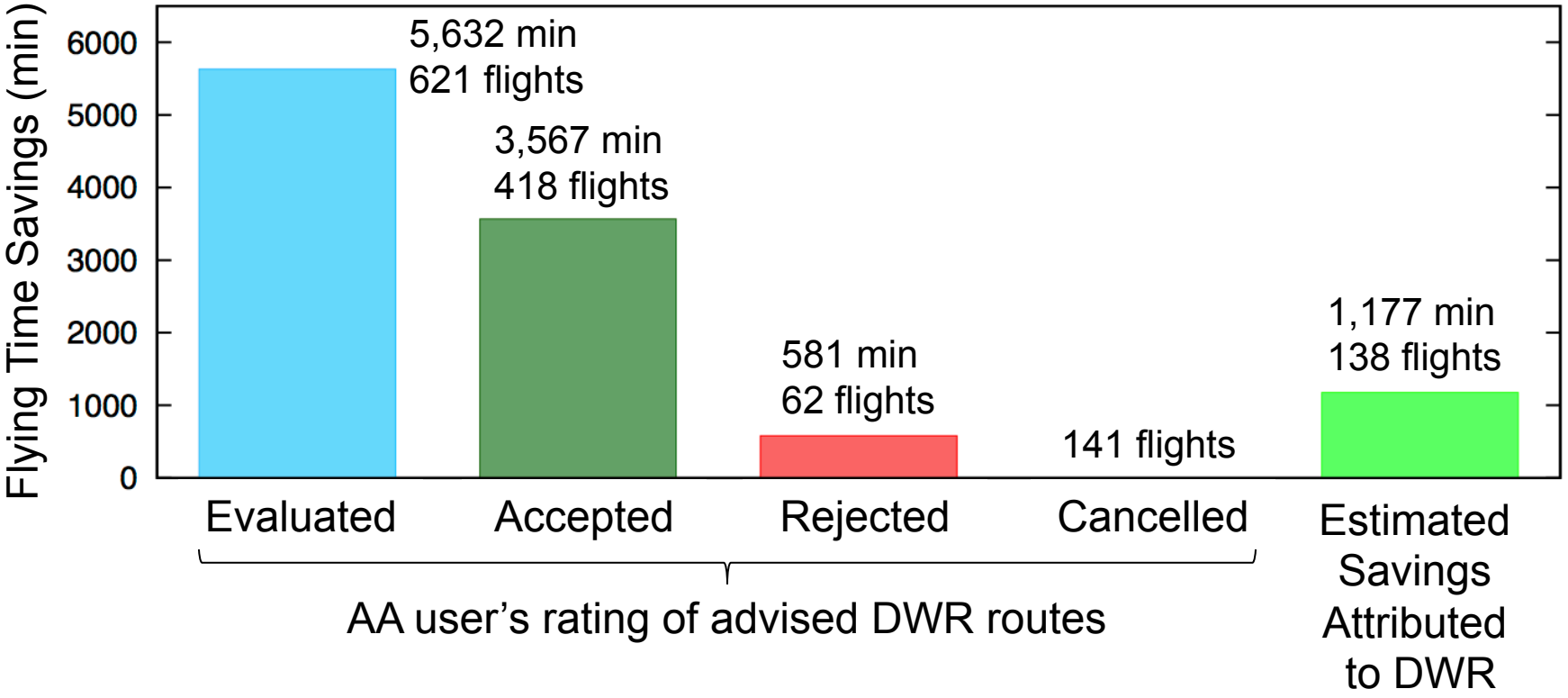
July 31, 2012 to April 13, 2014



Estimated Actual Savings Overall
1,815 minutes for 327 revenue flights

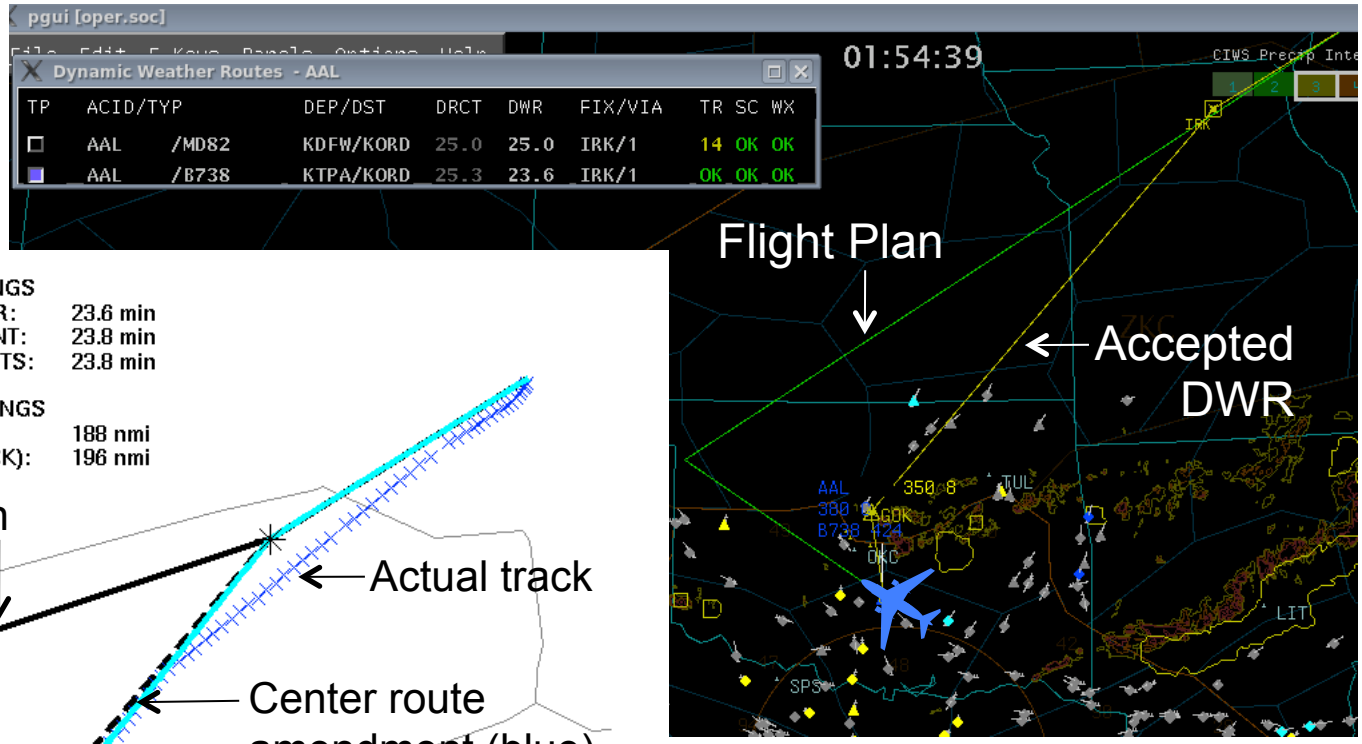
DWR Activity at American Airlines

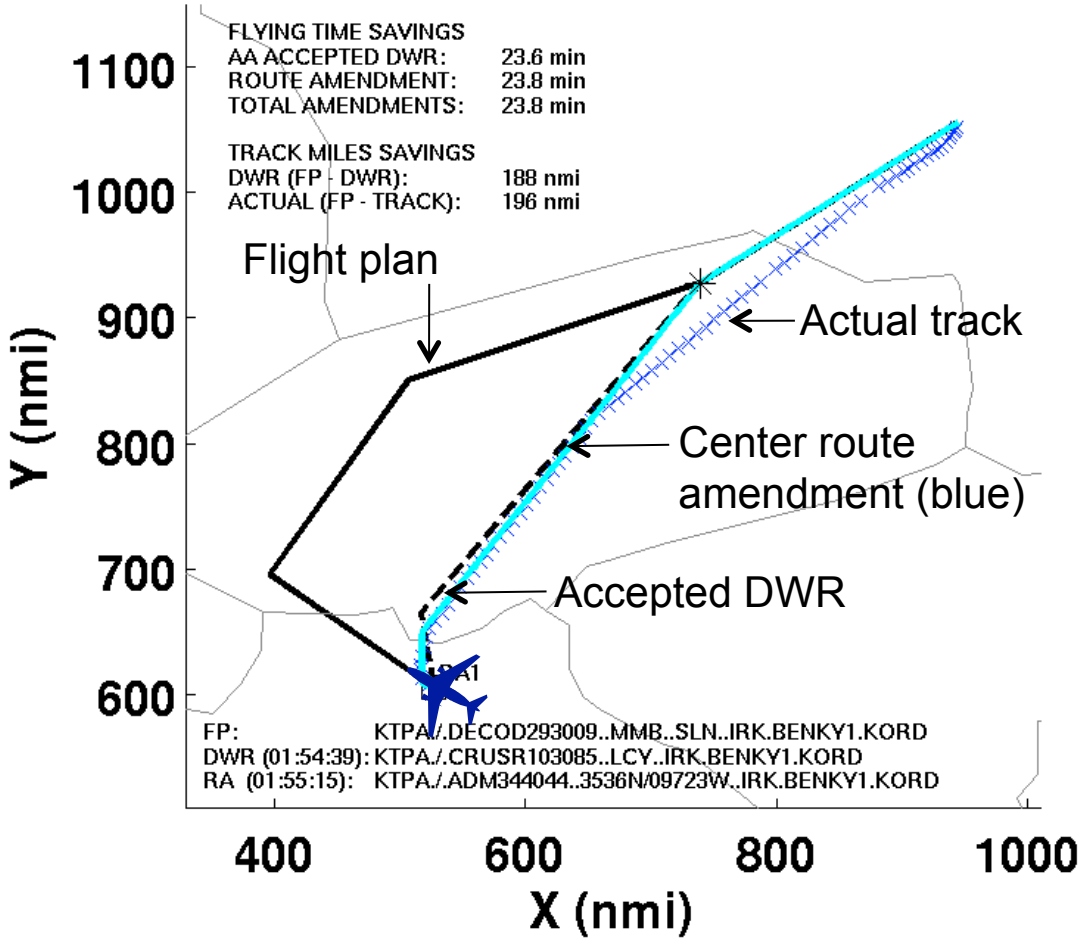
27 Days with High AA Value (Potential AA Savings ≥ 200 min),
High AA Use (Potential Evaluated ≥ 20%)



Estimated Actual Savings on 27 High-Value, High-Use Days
1,177 minutes for 138 revenue flights
$4,300/day at $100/min

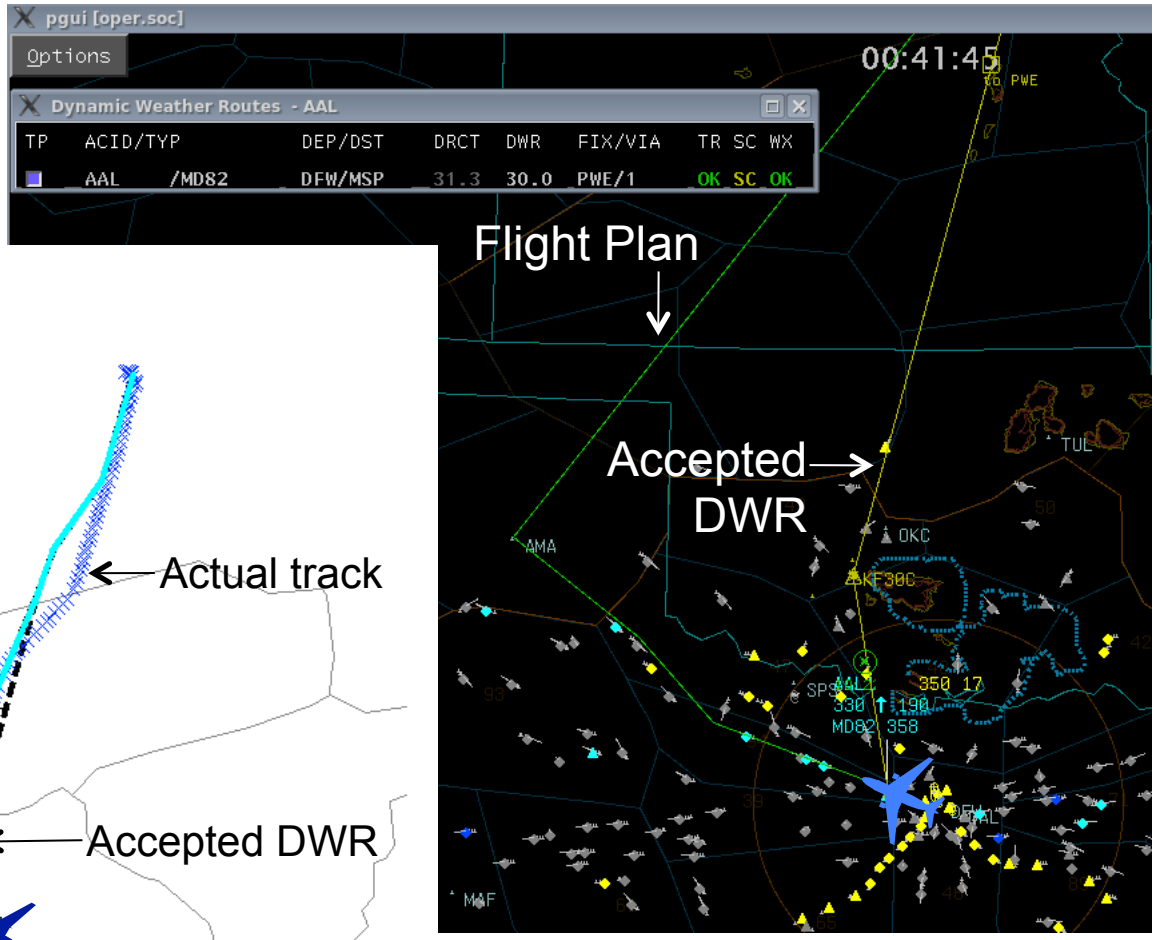
Sample: Tampa/Chicago

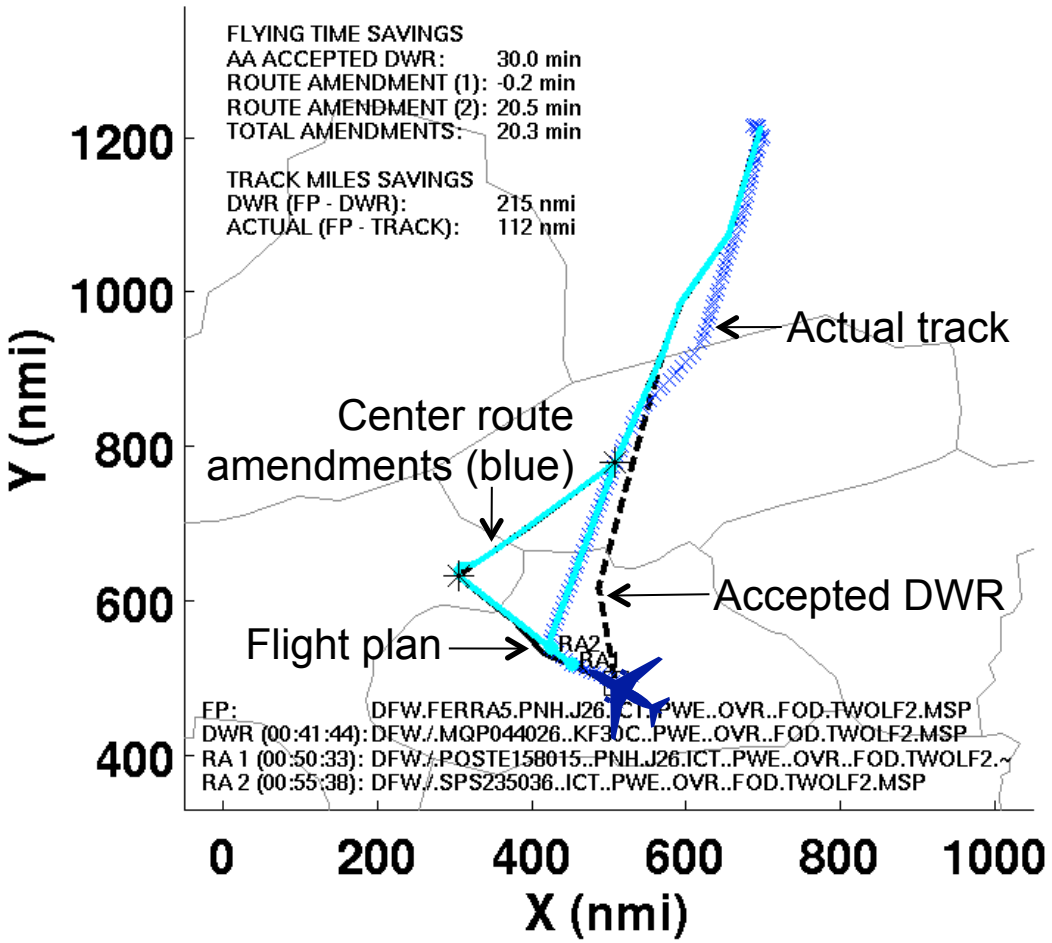




Estimated Actual Savings: 24 minutes

Sample: Dallas/Minneapolis





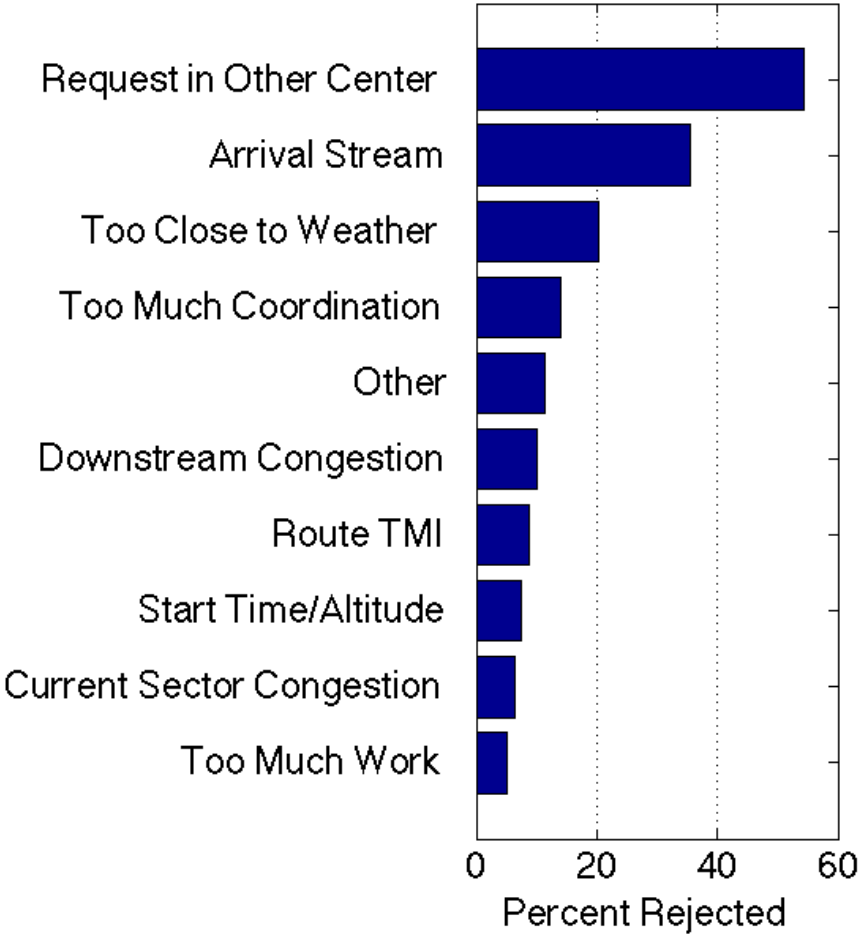
Estimated Actual Savings: 20 minutes

TMC Evaluation of AA DWRs

Six recently retired ZFW Traffic Management Coordinators and Area Supervisors evaluated 39 actual DWR routes rated “Accept” by AA users

- 62% of AA routes approved
- 57% (151 minutes) of DWR savings
- Rejects primarily due to Airspace configuration
  - Center boundaries
  - Arrival stream/sector

Reasons for Rejected DWRs



Outline

- Building Blocks
- DWR Concept, Tool, Functional Components
- Operational Trial at American Airlines
- Analysis Results
  - Potential Benefits all Fort Worth Center Flights
  - American Airlines Test Results
  - Sector Congestion Analysis
- Software Architecture and Required Inputs
- How to Acquire DWR Software
- Next Steps

Sector Congestion Analysis

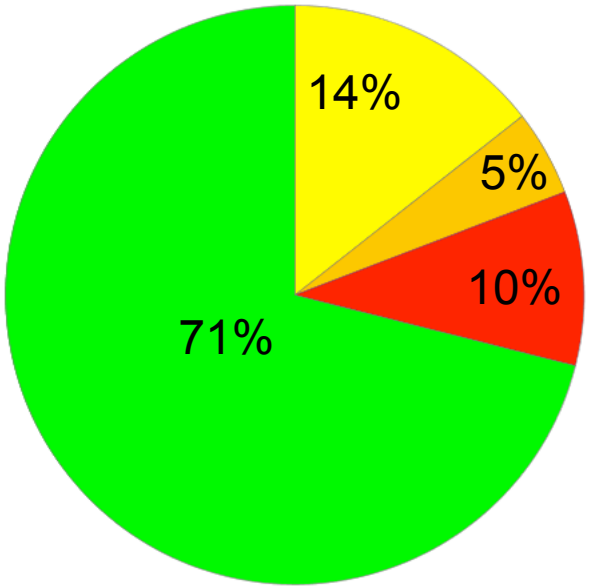
- How many DWR flights encounter congestion? How much travel time in sectors with congestion?

- What happens if all flights are granted DWRs?

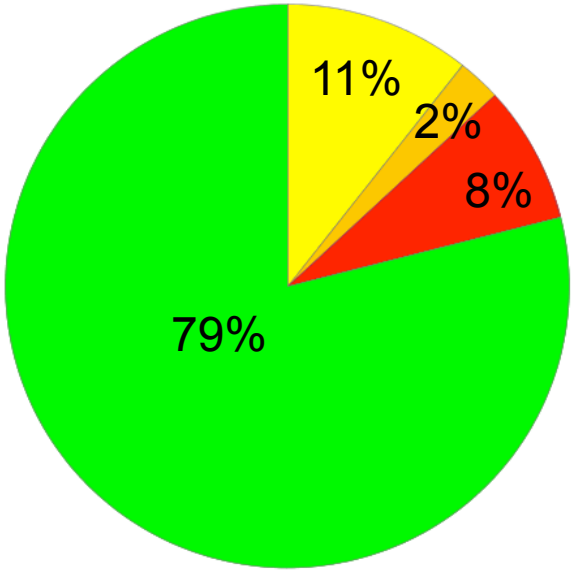
How Many DWR Flights Enter Congested Sectors?

Proposed DWRs for 4,327 ZFW Flights, Top 24 days 2013/2014

Congestion on Flight Plan



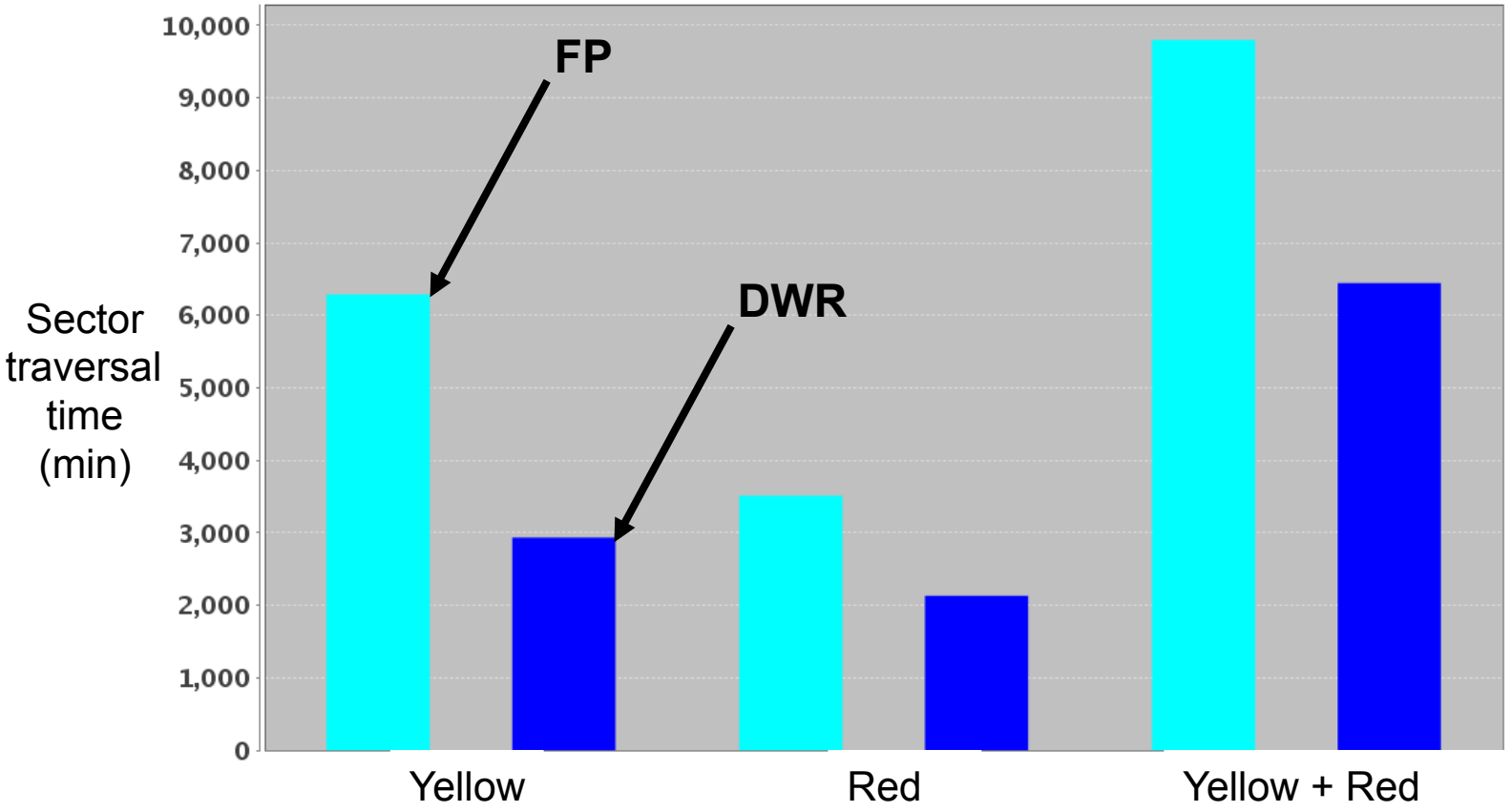
Congestion on DWR



Flights fare better with DWRs for congested sector encounters

Time Spent in Congested Sectors

Proposed DWRs for 4,327 ZFW Flights, Top 24 days 2013/2014

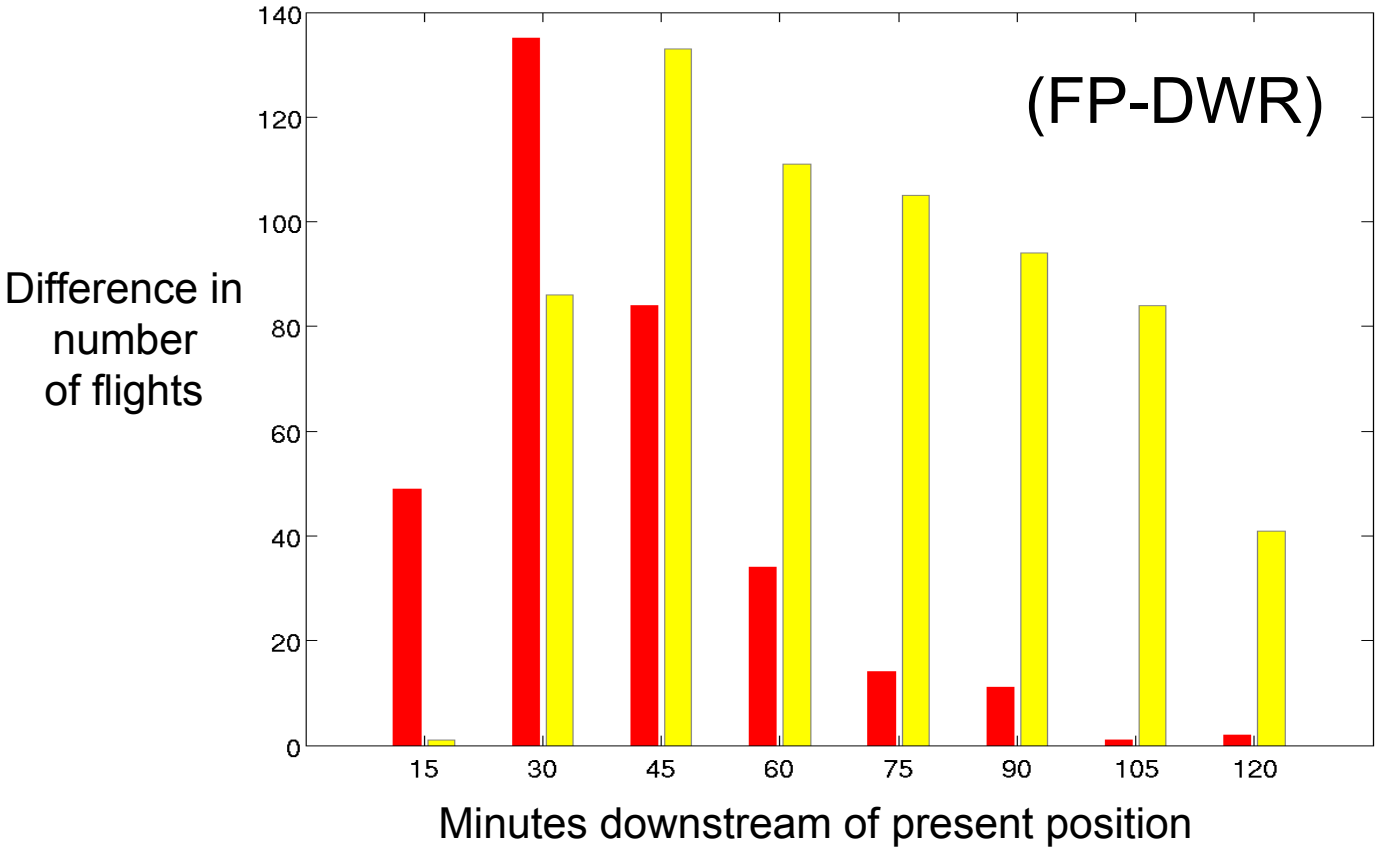


DWR trajectories spend less time in congested sectors

(39% fewer min in red sectors, 53% fewer min in yellow sectors)

Congestion vs. Congestion Look-Ahead Time

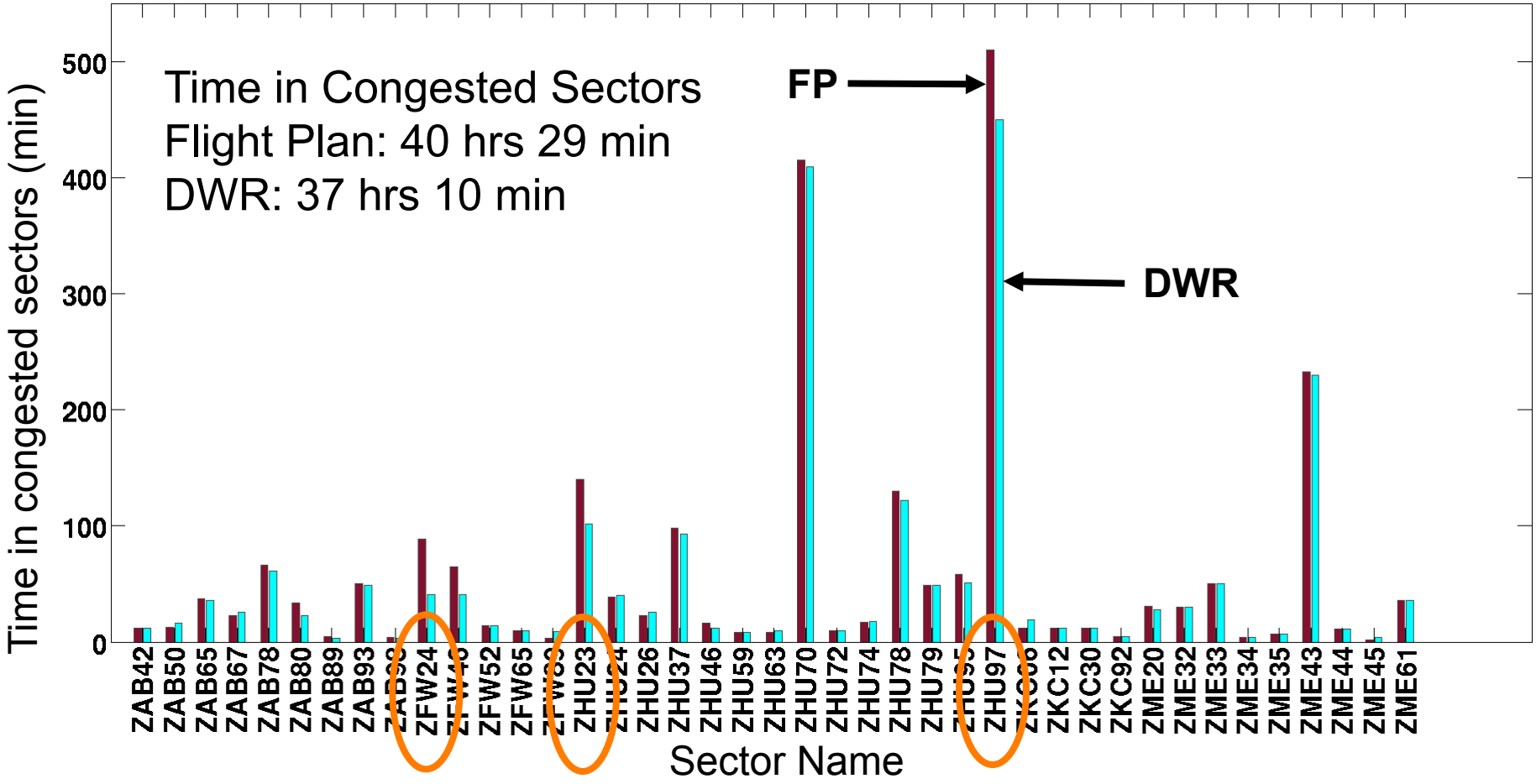
Proposed DWRs for 4,327 ZFW Flights, Top 24 days 2013/2014



In the first 45 min flights on flight plan routes encounter more congestion than flights on DWR routes

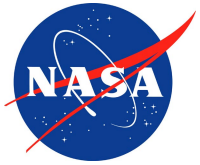
What if all DWRs are Granted?

Proposed DWRs for 4,327 ZFW Flights, Top 24 days 2013/2014



DWRs reduce congestion 8 percent overall

Most savings occur over 5 days in 3 sectors



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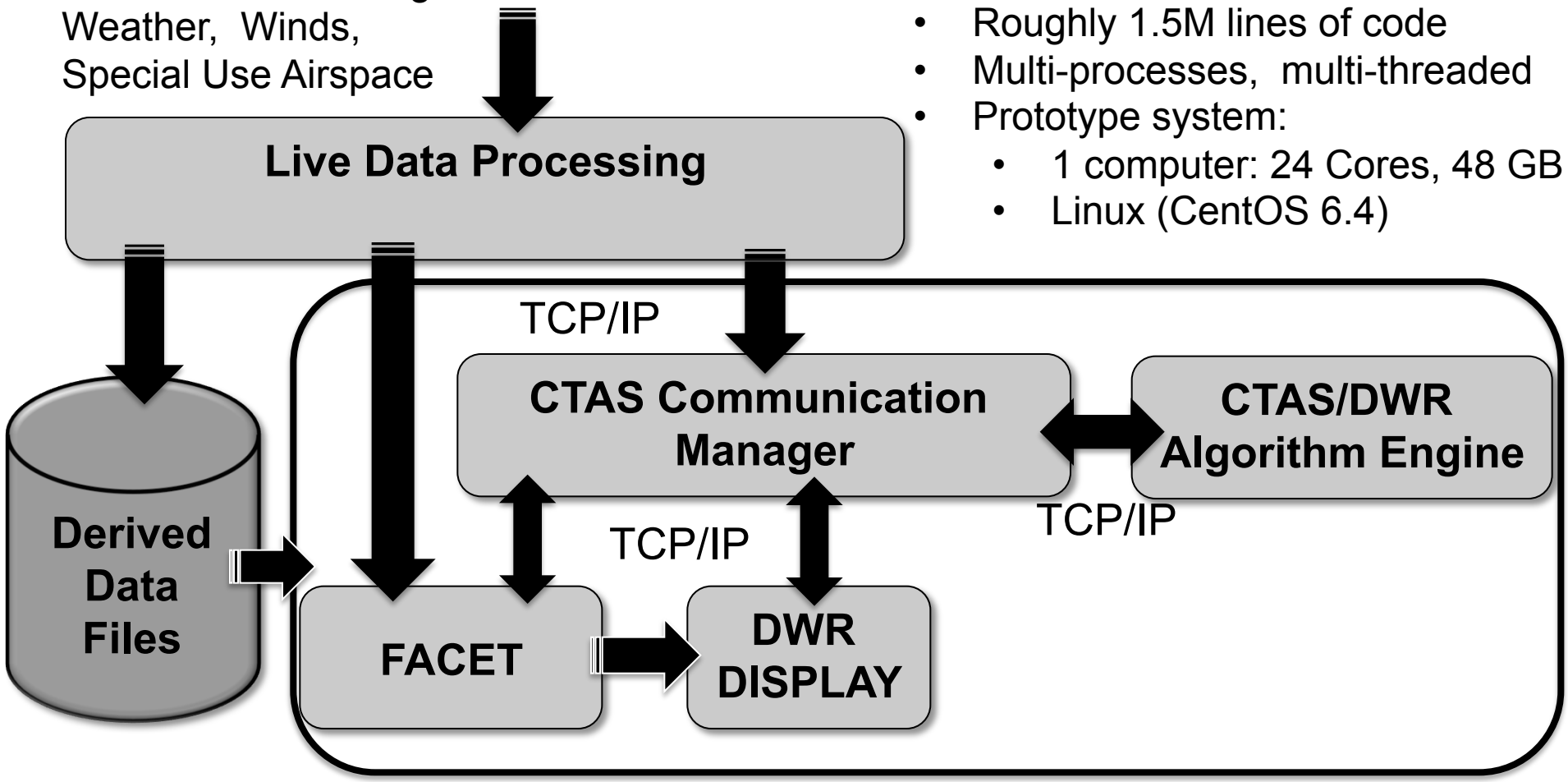
External Live Data Sources

Data Type	Source	Update Rate
Host/ERAM data (Flight plan, Track, etc.).	Direct from FAA	12 sec
ASDI - Aircraft Situation Display For Industry data.	Direct from FAA	1 min
CIWS - Corridor Integrated Weather System Convective Forecasts	Direct from FAA	5 Min, 120 min forecast
RR – Rapid Refresh Weather information	Direct from NOAA ftp site	60 min, 60 min forecast
TFMDI - Traffic Flow Management Data to Industry for route traffic management initiative information	Raw data from FAA, stored locally in a database	5 min
SUA - Special Use Airspace data	From FAA public website	5 min

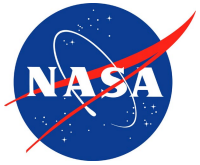
Derived and Static Input Data

Data Type	Source	Update Rate
CWAM - Convective Weather Avoidance Contours	**Derived from CIWS by DWR weather processing scripts**	**5 min, 120 min forecast, 5 min time step**
Adaptation - NAS configuration Chart Change Update	**Direct from FAA**	**56 days**
Aircraft performance data	**Internal to DWR software, used to generate trajectories**	**N/A, Static**

DWR Software Architecture



- Mixture of C, C++, Java, scripts
- Roughly 1.5M lines of code
- Multi-processes, multi-threaded
- Prototype system:
  - 1 computer: 24 Cores, 48 GB
  - Linux (CentOS 6.4)



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How Do I Get the DWR Software?

- DWR is available for licensing on a non-exclusive basis both for commercial purposes as well as for internal evaluation.
- Details on licensing and NASA license request requirements can be accessed at

  http://www.nasa.gov/ames-partnerships/opportunities/licensing

- Point of Contact for Licensing:

  Trupti Sanghani, Technology Partnerships Division
  NASA Ames Research Center
  Telephone: (650) 604-6889
  Email: Trupti.D.Sanghani@nasa.gov

- Technical Point of Contact:

  Dave McNally, Flight Trajectory Dynamics and Controls Branch
  NASA Ames Research Center
  Telephone: (650) 604-5440
  Email: dave.mcnally@nasa.gov

Next Steps

- Adjacent center traffic for more coordination time, more benefit, better analysis of merging arrival streams
- Smart filtering and route adjustment to avoid merging arrival streams – separate DWRs from traffic not airspace
- Support commercialization of DWR technology
- Streamline evaluation and coordination, faster delivery to dispatcher display, web-based DWR advisories
- Leverage DWR technology for groups of flights, identify and correct stale weather avoidance routing restrictions