MIT Lincoln Laboratory
Technical Support Capability
to
Federal Aviation Administration

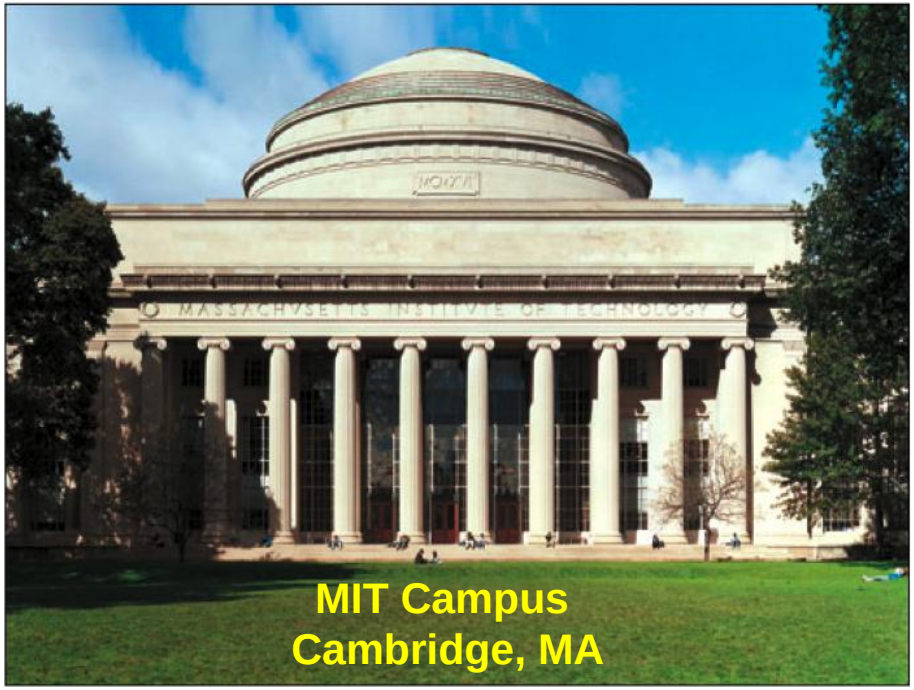
55th ATCA Conference
National Harbor, MD
24 – 27 October 2010

Carmine Primeggia
Kathy Carusone, Jessica Olzsta, Maria Picardi-Kuffner

Outline

- MIT Lincoln Laboratory
  - Background
- Surveillance and Automation
  - Tower Flight Data Manager (TFDM)
  - Runway Status Lights (RWSL)
- Weather Integration for ATM Decision Making
  - Corridor Integrated Weather System (CIWS)
  - Consolidated Storm Prediction for Aviation (CoSPA)
  - Route Availability Planning Tool (RAPT)

MIT Lincoln Laboratory



Mission

Technology in Support of National Security

Staff	
Technical:	2370
Support:	830
Total:	3200

Primary Roles

- System architecture engineering
- Long-term technology development
- Rapid system prototyping and transition

MIT Lincoln Laboratory is a Federally Funded Research and Development Center (FFRDC)

Lincoln Air Traffic Control Mission Area Program History

1970 1980 1990 2000 2010 2020

Communication, Navigation and Surveillance

- Discrete Address Beacon System — Mode S

- Air Surveillance Radar - 9
- Unmanned Aircraft Airspace Access

- Traffic Alert and Collision Avoidance System

- NextGen Collision Avoidance
- Airport Surface Surveillance

- Precision Runway Monitor

- Surface Surv. Enhancements

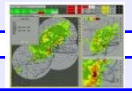
- Runway Status Lights

- Automatic Dependent Surveillance – Broadcast — ADS-B
- System Wide Information Management / NNEW

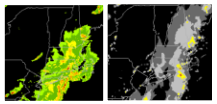
Weather

- Turbulence

- Terminal Doppler Weather Radar



- NextGen Weather Processor

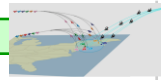


- Integrated Terminal Weather System

- Corridor Integrated Weather System
- Multi-function Phased Array Radar

Automation

- Airport Surface Traffic Automation
- NextGen Arrival/Dep Mgmt



- Terminal ATC Automation

- NextGen Towers
- NASA ATM Research

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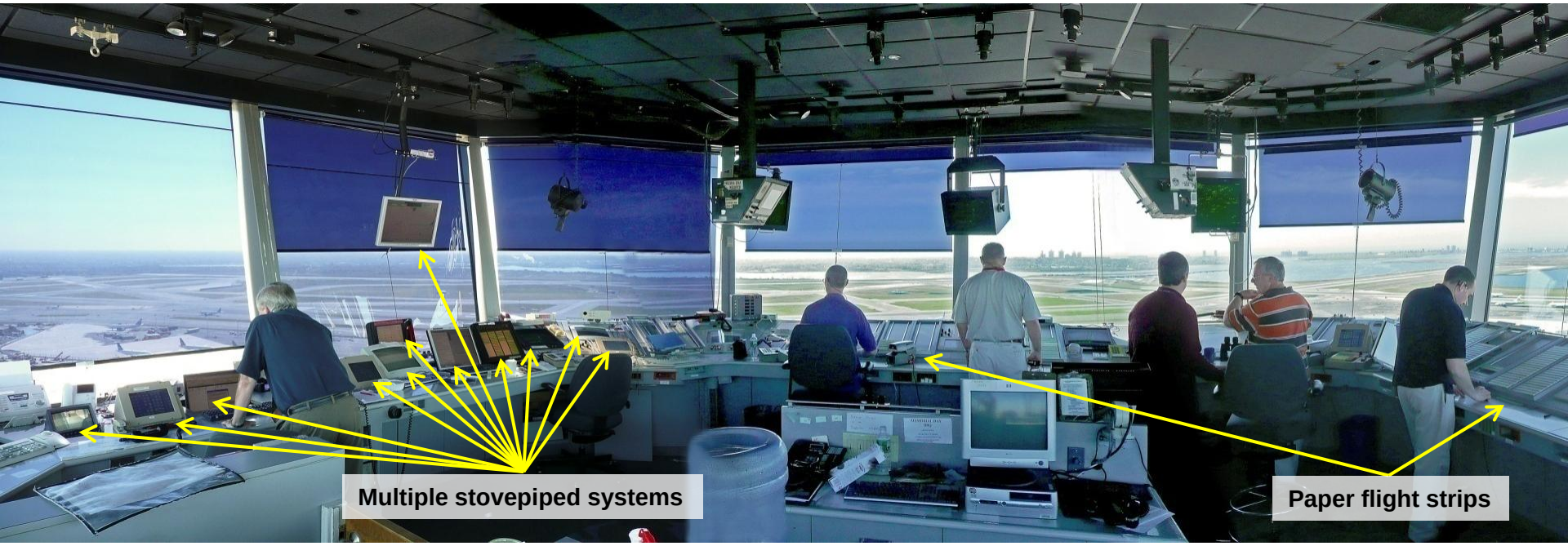
Air Traffic Control Tower Challenges



- **Objective: develop the architecture, processing, and interfaces to:**
  - **Consolidate tower systems**
  - **Provide electronic data exchange**
  - **Enable Surface Trajectory-Based Operations (STBO) decision support tools**
- **Lead: AJT Terminal System Engineering**

Electronic Data Exchange Elements

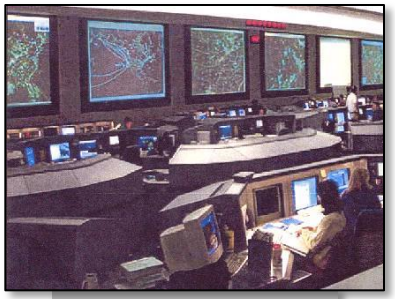
Flight Operations Center

Alternate Route Preferences

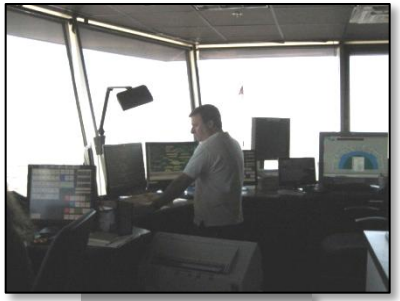
Departure Route Viability

Traffic Management Initiatives

Surface Delay



ATCSCC / TFMS



Ramp Tower

Expected Pushback Time

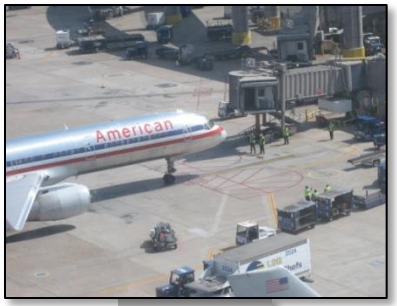
Surface Delay

TFDM

Flight Plan Amendments

Flight Plan Data

ARTCC



Aircraft

Taxi Clearances

Aircraft Derived Data

Runway Closure Request

Runway Demand

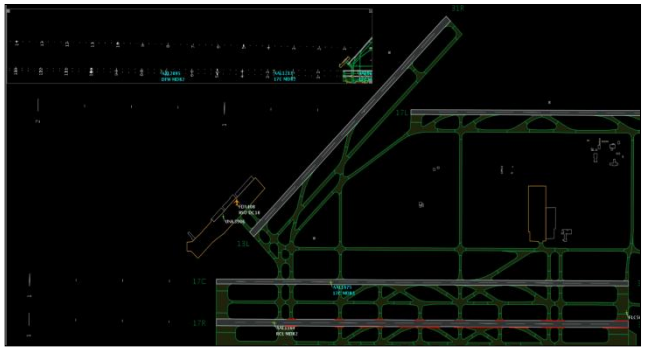
Airport Authority

Planned Config. Change

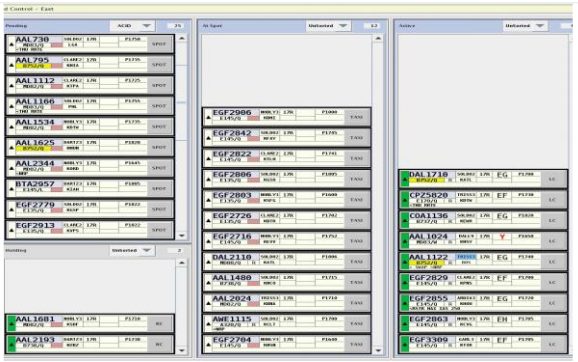
Controlled Time of Arrival

TRACON

Tower Displays



Tower Information Display System (TIDS)



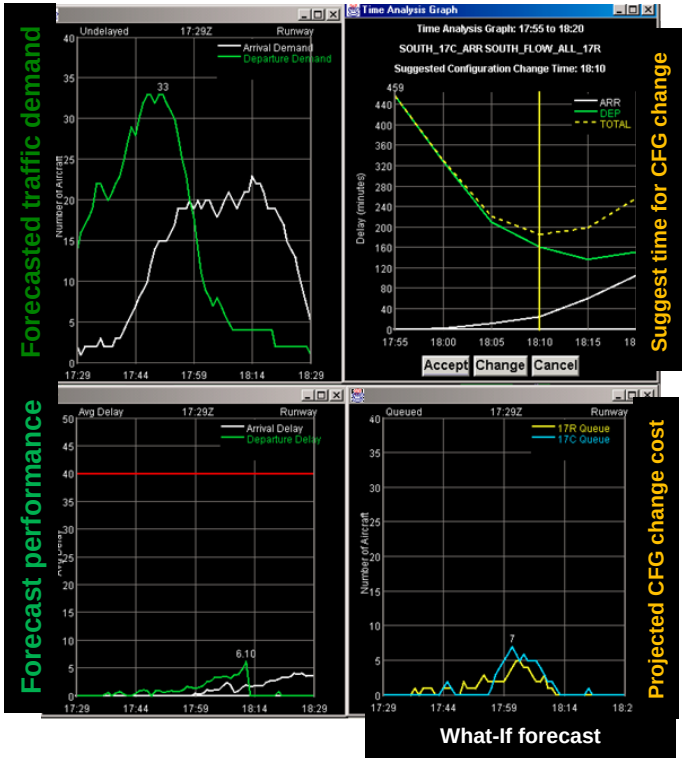
Flight Data Manager (FDM) Display

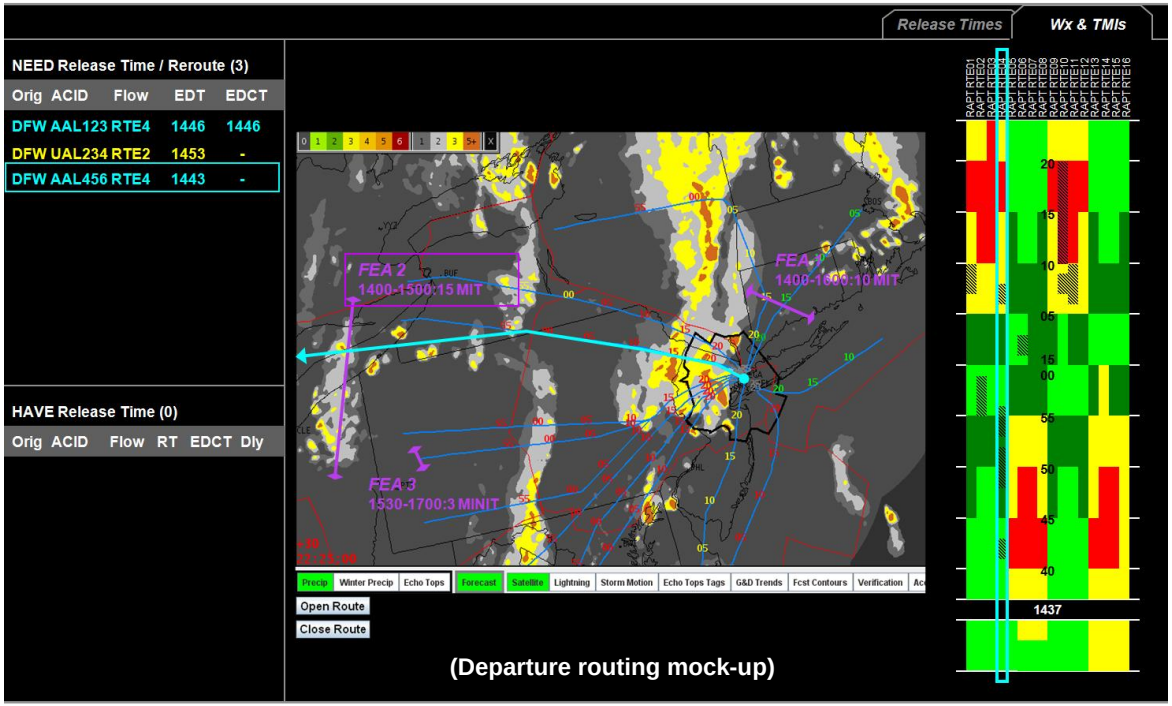
Decision Support Tools (DST)

- **Adapted / customized / consolidated across several tower user positions**
  - **Ground, local, supervisor, clearance, flight data**
- **Tower Information Display System (TIDS)**
  - **Surface traffic situation, taxi routing, airport status**
- **Flight Data Manager (FDM) Display**
  - **Flight strips showing aircraft state data, queues**
- **Decision Support Tool (DST) Displays**
  - **Airport configuration control, demand management, weather impacts**

Decision Support Tool (DST) Suite

(30” high-resolution display, 2560x1600 pixels)





- **Components**
  - Airport configuration
  - Runway assignment
  - Departure routing
  - Sequencing and scheduling
  - Taxi routing
  - Weather, NOTAMs, …
  - Traffic management initiatives

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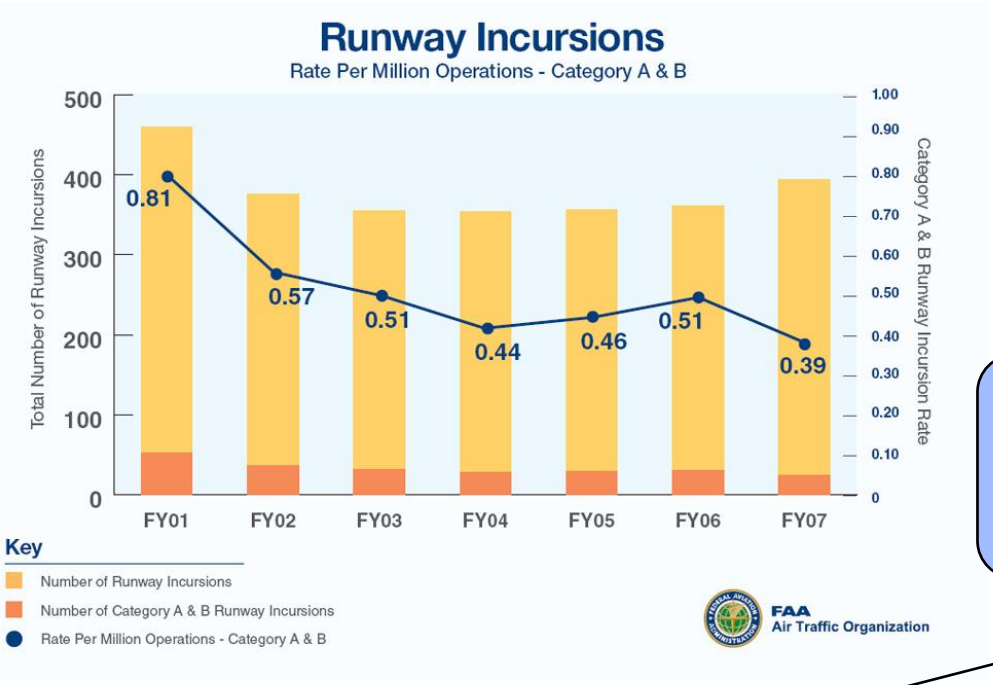
RWSL Safety Benefit Addresses Runway Incursion Problem



No on-board equipment required or heads-down time in cockpit

Give direct warnings to all pilots and vehicle drivers on the airport surface

RWSL reduces incursions

"…runway incursions have significantly decreased on the RWSL test runway at DFW (70%)"

- DOT Inspector General, 2007

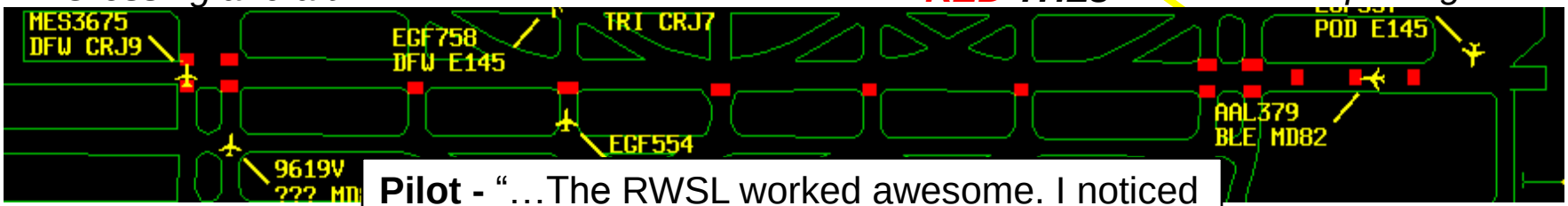
5 known "saves" at DFW since 2008
- Likely more unreported

RED THLs prevent takeoff from occupied runway at DFW

Crossing aircraft

***RED* THLs**

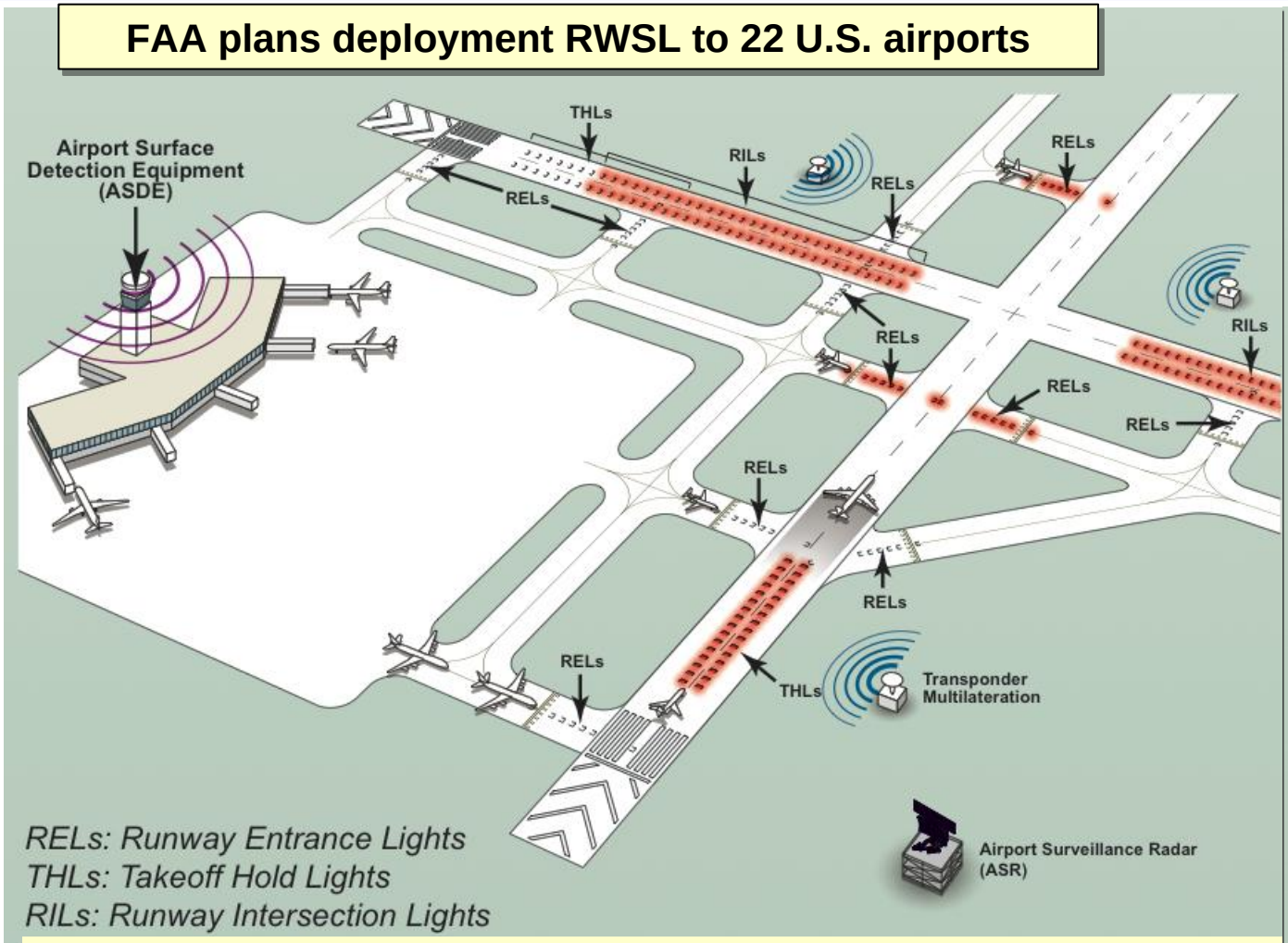
Departing aircraft

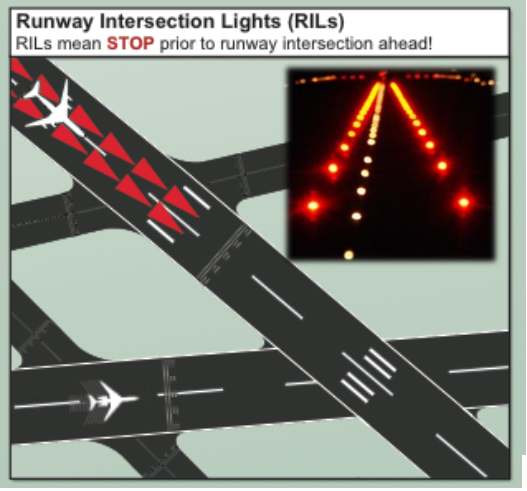


Pilot - "…The RWSL worked awesome. I noticed that BEFORE I saw the intruding regional jet."

Runway Status Lights (RWSL)

FAA plans deployment RWSL to 22 U.S. airports





Fused surveillance sources and safety logic automatically illuminate lights to *directly* warn pilots that runway is unsafe

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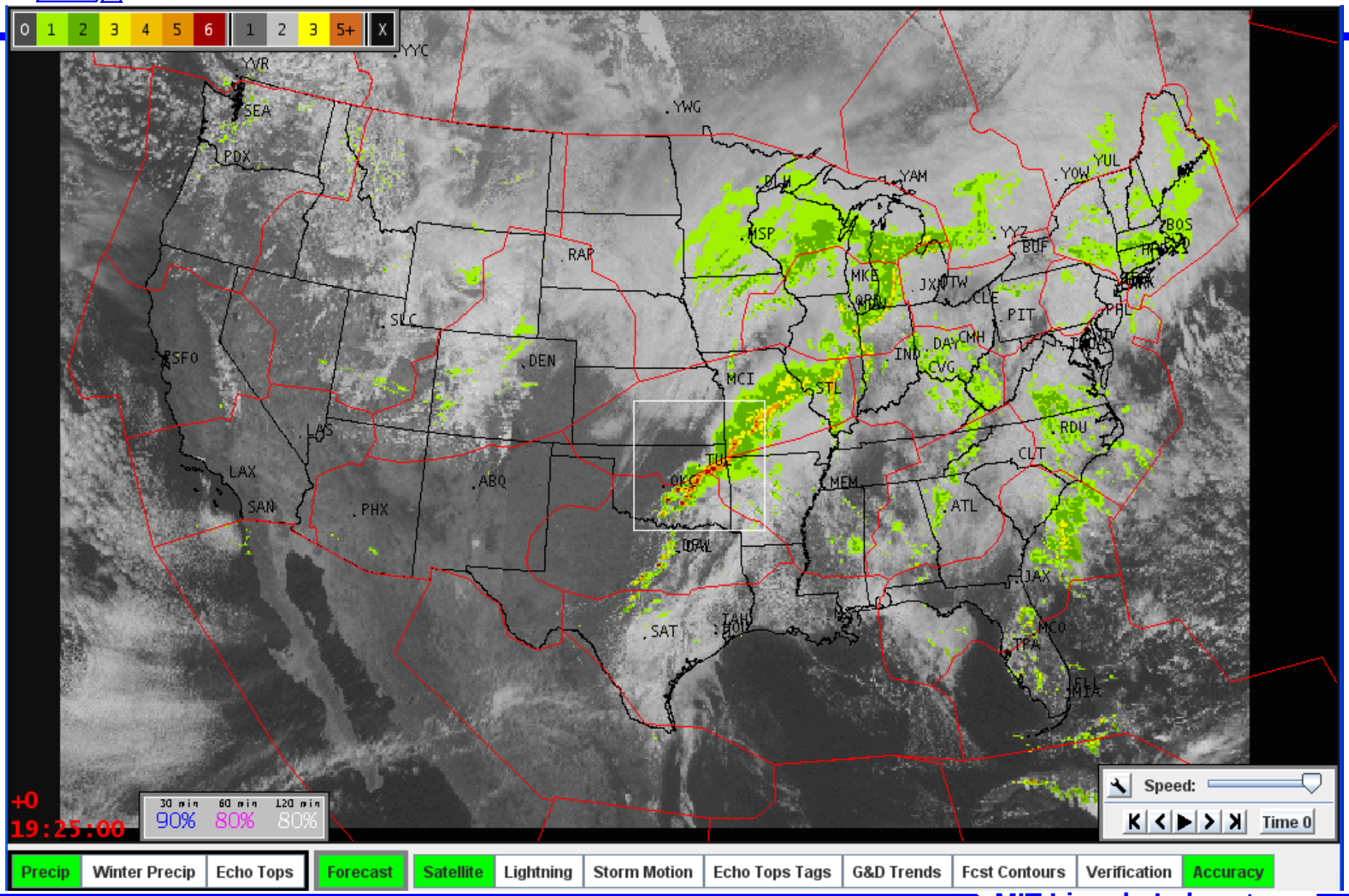
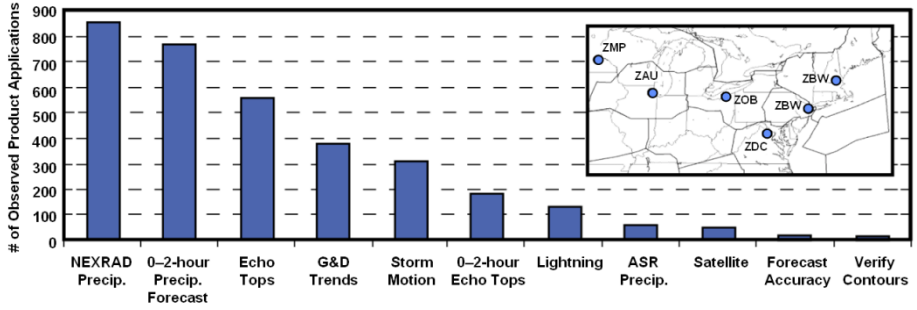
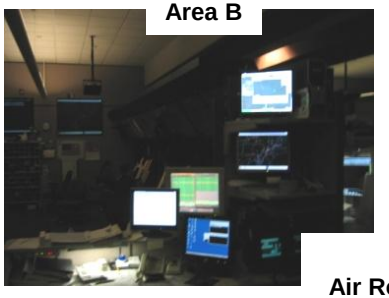
Corridor Integrated Weather System (CIWS)



CIWS Benefits Assessment

Observed CIWS Product Usage

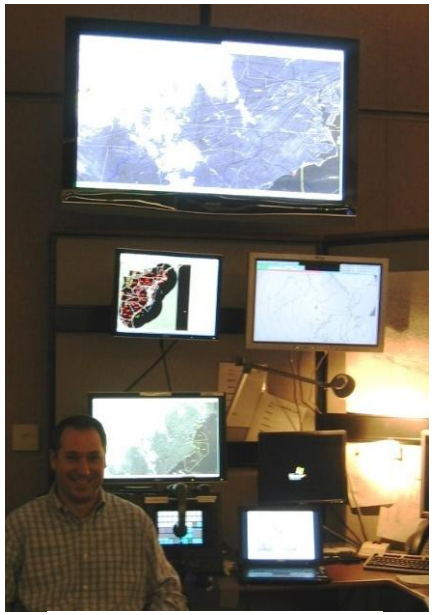




Area B

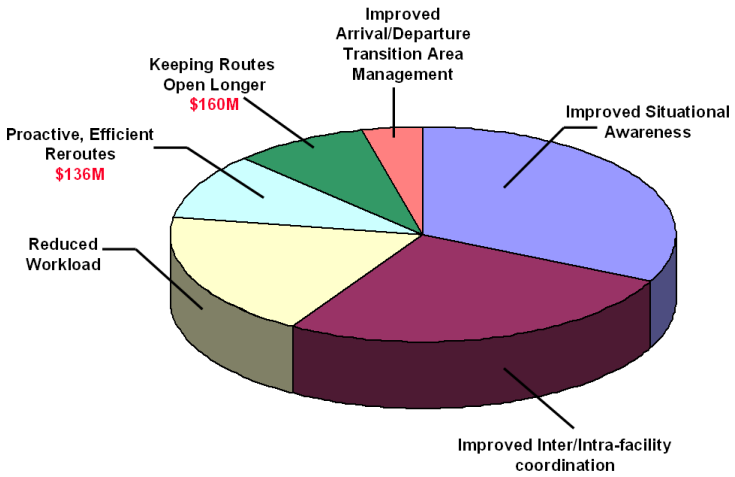
Traffic Management Unit

New York
Air Route Traffic Control
Center



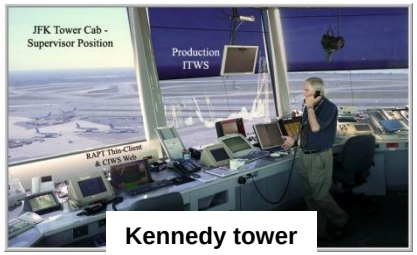
Washington DC
Air Route Traffic Control
Center

Relative Frequency of Benefits Categories



New York TRACON

Continental Airlines



Kennedy tower

FAA Air Traffic Control
System Command Center

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CoSPA Storm Prediction for Aviation

Observations


TDWR


NEXRAD


Canadian Radars


Surface Obs.


Lightning

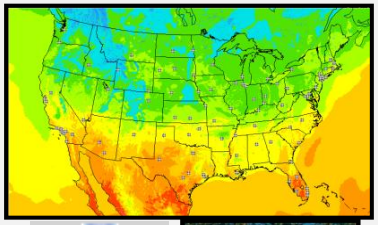

Satellite


Profilers

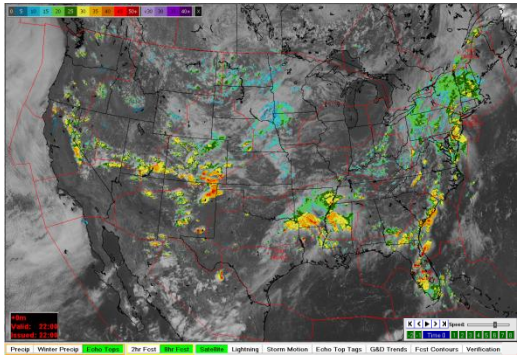

Aircraft

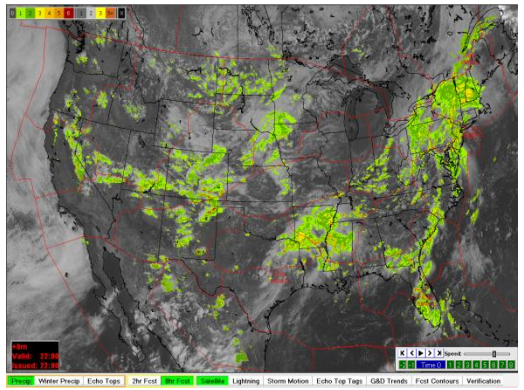
Product Generator

Numerical Weather Prediction (NWP)



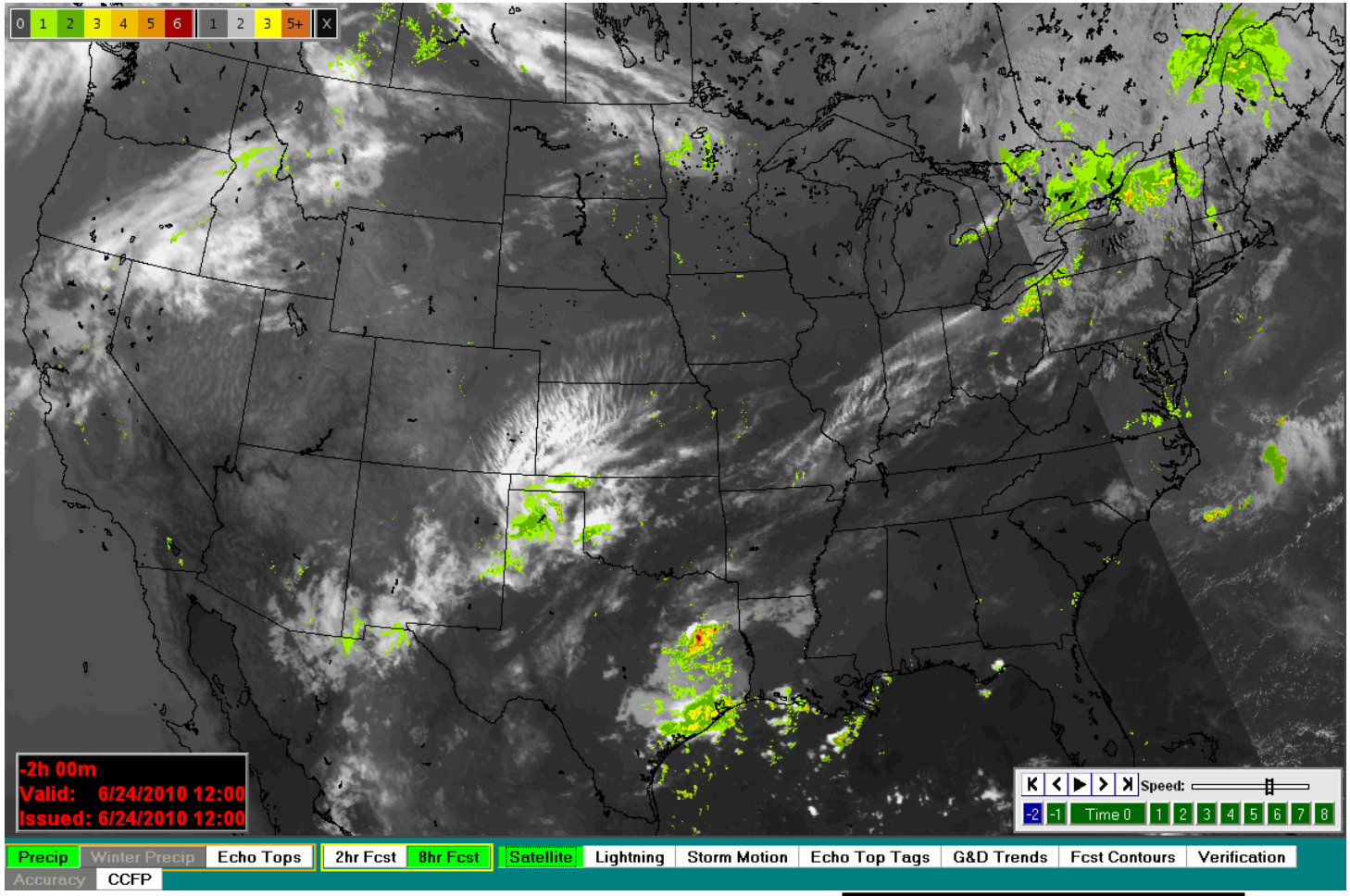
CoSPA Situation Display


Echo Tops


Precipitation

CoSPA Forecasts

Strategic Decision-Making ⟷ Tactical Decision-Making



- High resolution, deterministic 0 – 8 hr Precipitation and Echo Tops Forecast
- Animates in 15 min or 60 min increments
- Forecasts interpreted like radar – show "what radar will look like in the future"
- Updates every 15 min
- Improved forecast of storm organization & evolution
- Can be readily translated to forecast of airspace capacity impact

2 – 8 Hours
"National & Planned"

0 – 2 Hours
"Local & Dynamic"

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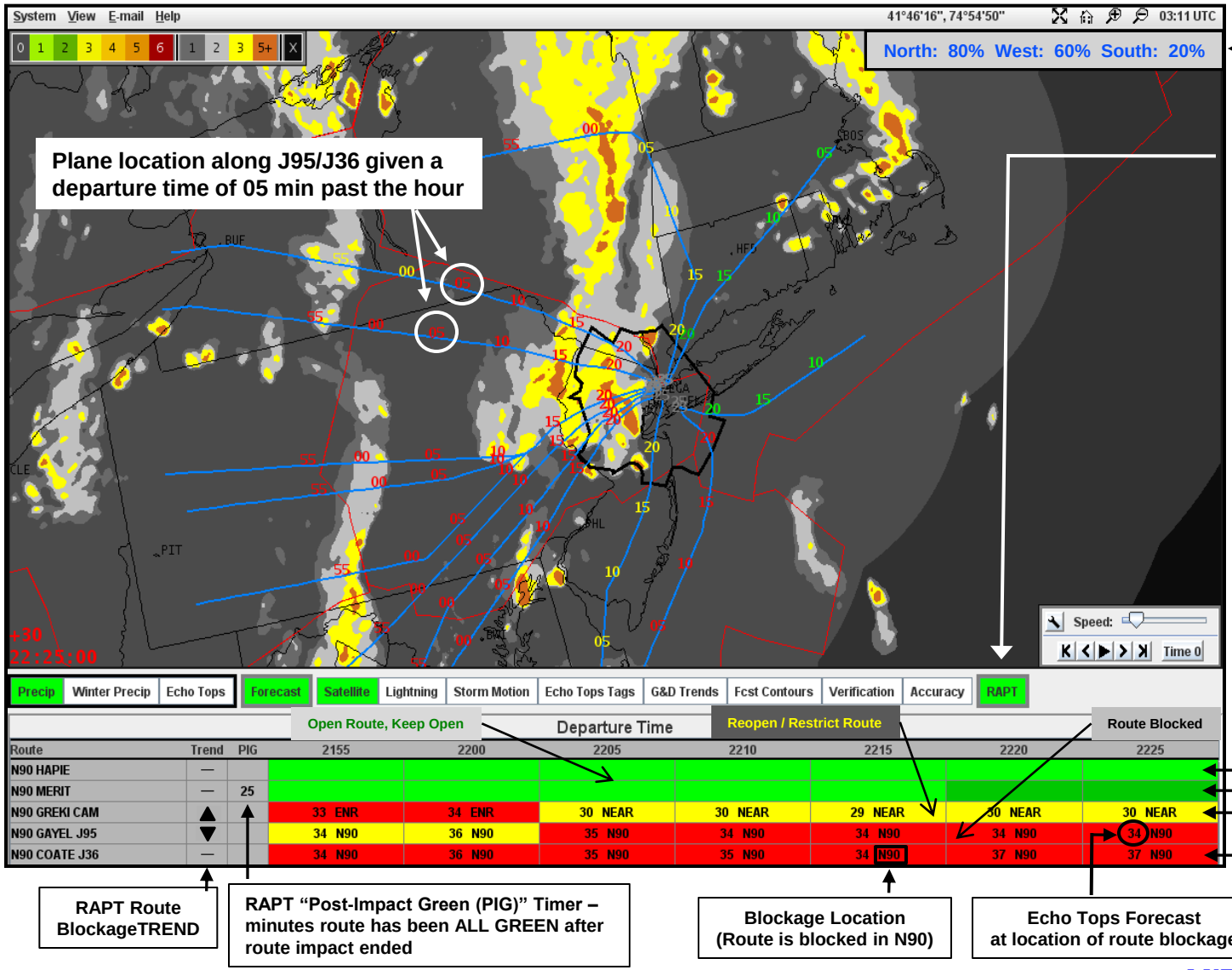
RAPT Display



RAPT Route Blockage Forecast Accuracy (by Departure Gate)

Left-click RAPT

- Displays RAPT timelines
- Re-Centers / Re-Zooms CIWS on NY Region
- Displays NY departure routes & animated dep's
- CIWS Precip Forecast ON
- Adds N90 TRACON overlay

- RAPT fully integrated into CIWS
- RAPT forecasts update every 5 minutes

No weather or < = level 1
Some weather, but passable
Route partially blocked – use loop and judgement
Route blocked by storms

RAPT Route BlockageTREND

RAPT "Post-Impact Green (PIG)" Timer – minutes route has been ALL GREEN after route impact ended

Blockage Location (Route is blocked in N90)

Echo Tops Forecast at location of route blockage

Observed RAPT Benefit Categories (2008)

		KEY
1.	More timely departure route reopenings; eased departure restrictions	RO
2.	More timely reroute planning/implementation; improved route impact planning	RRP
3.	Directing pathfinder requests	DP
4.	Keeping departure routes open longer	ROL
5.	More timely and proactive resumption of arrival flows; decreased airborne holding; potentially saved diversions	AHD
6.	Proactive runway sequencing assistance	PRSA
7.	Enhanced decision-making productivity	EP
8.	Enhanced Inter/Intra-facility coordination	I/IC
9.	Improved safety	IS
10.	Enhanced common situational awareness	SA-1
11.	Improved awareness of evolving airspace impacts	SA-2
12.	Decision/Plan/Information confirmation or evaluation	SA-3

2,600 hrs delay saved
$8.7 M Cost Savings

Summary

✓ **Lincoln Laboratory applies its expertise to air traffic control for the Federal Aviation Administration**

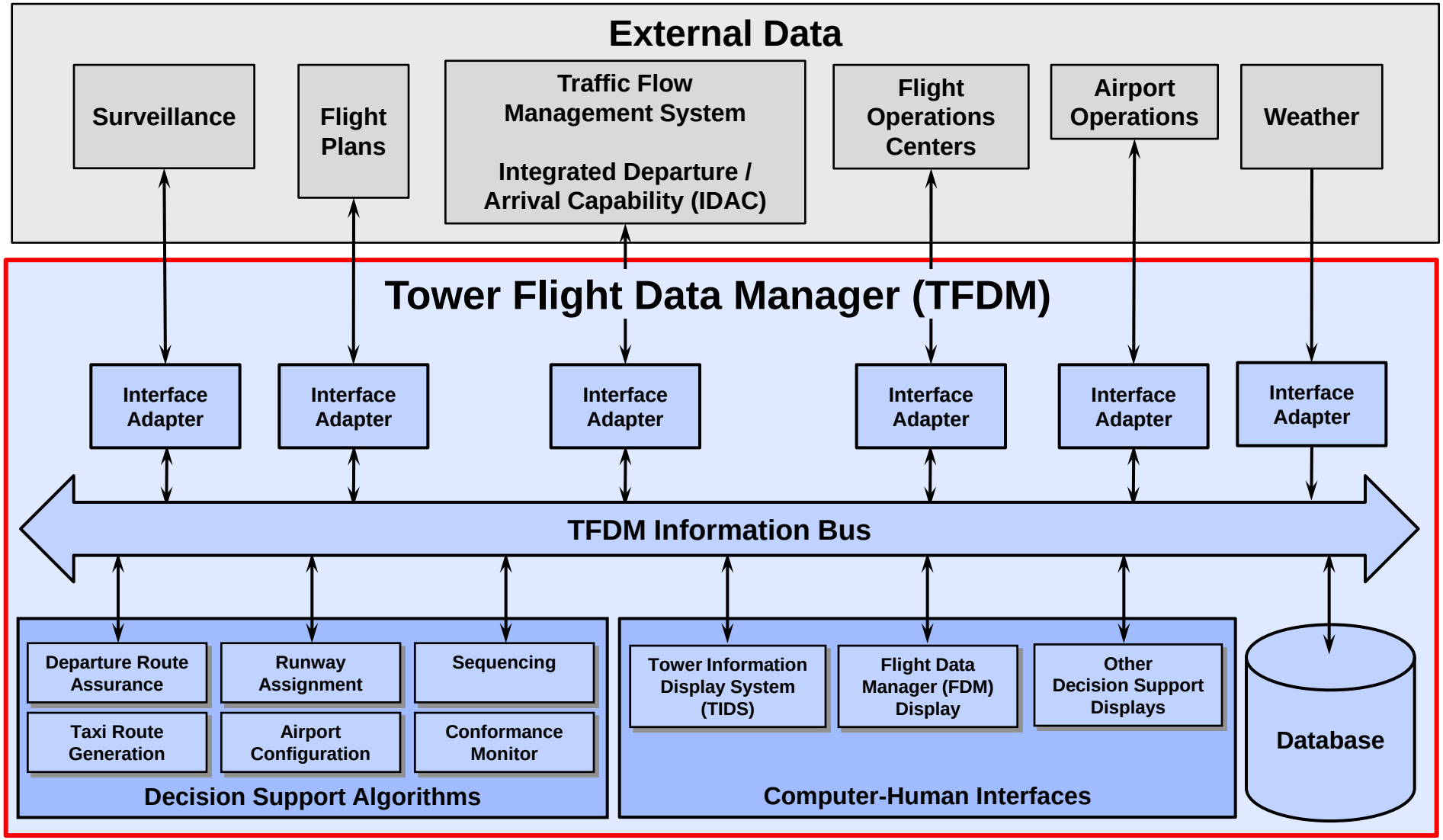
✓ **Principal technical activities provide enhanced Surveillance, Collision Avoidance, Hazardous Weather Detection, Automation, and Safety**

✓ **Technology in support of NextGen:**

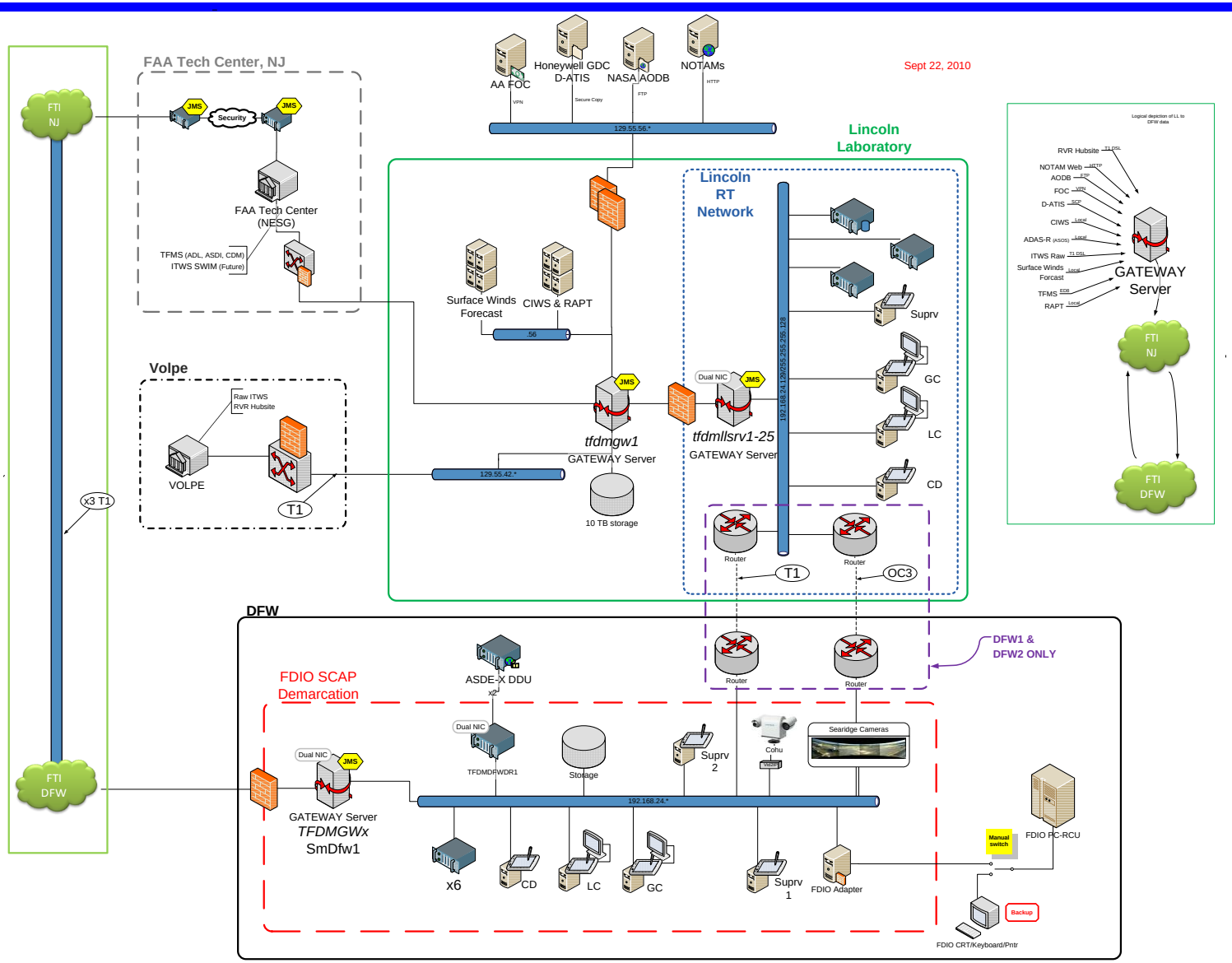
- ✓ **System architecture and human factors engineering**
- ✓ **Rapid system prototyping and transition**
- ✓ **Long-term technology development**

✓ **RWSL, TFDM, CIWS, CoSPA and RAPT capabilities are being demonstrated in the ATCA Exhibit Hall!**

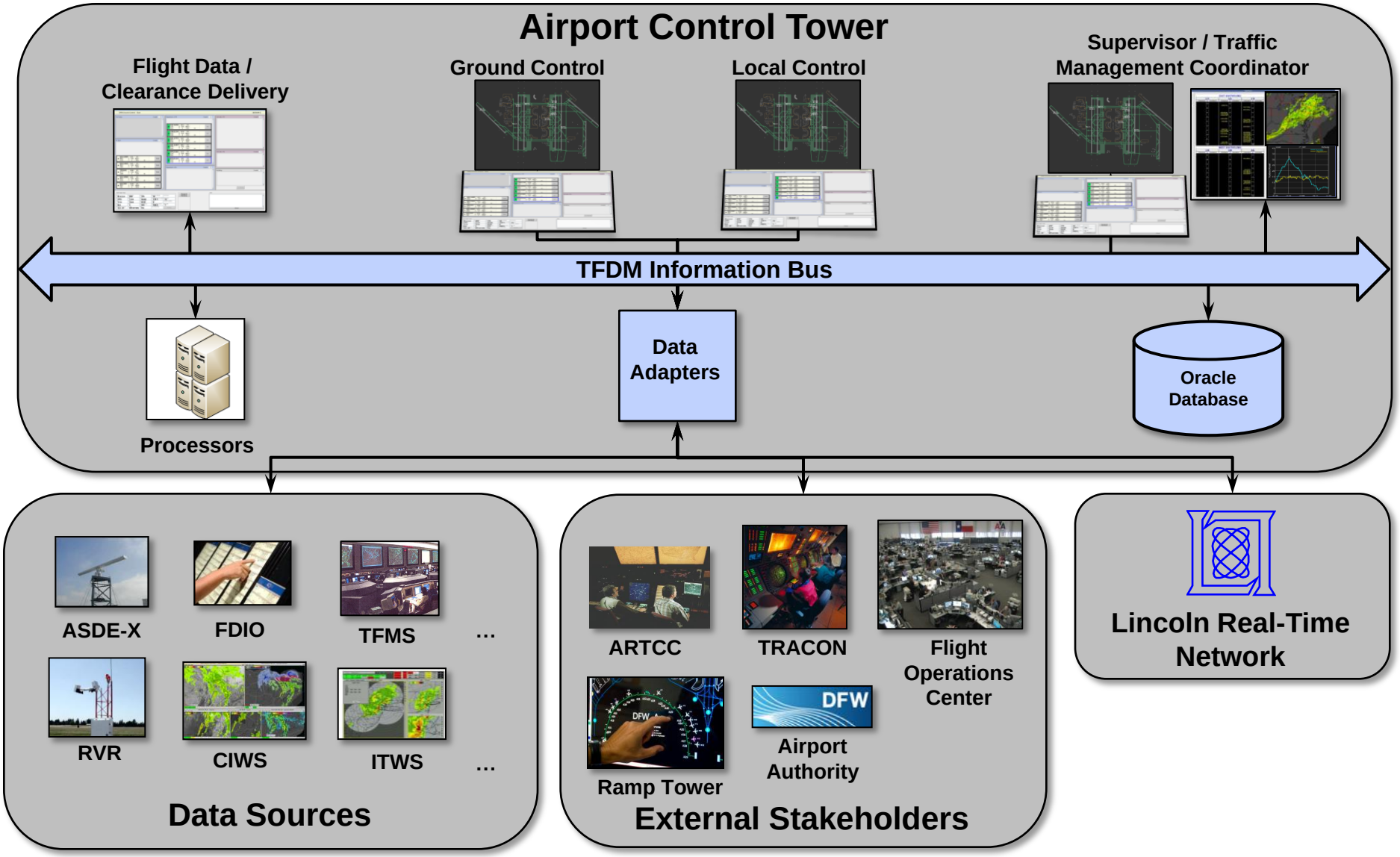
Tower Flight Data Manager (TFDM) System



TFDM Data Flow Architecture



TFDM Components

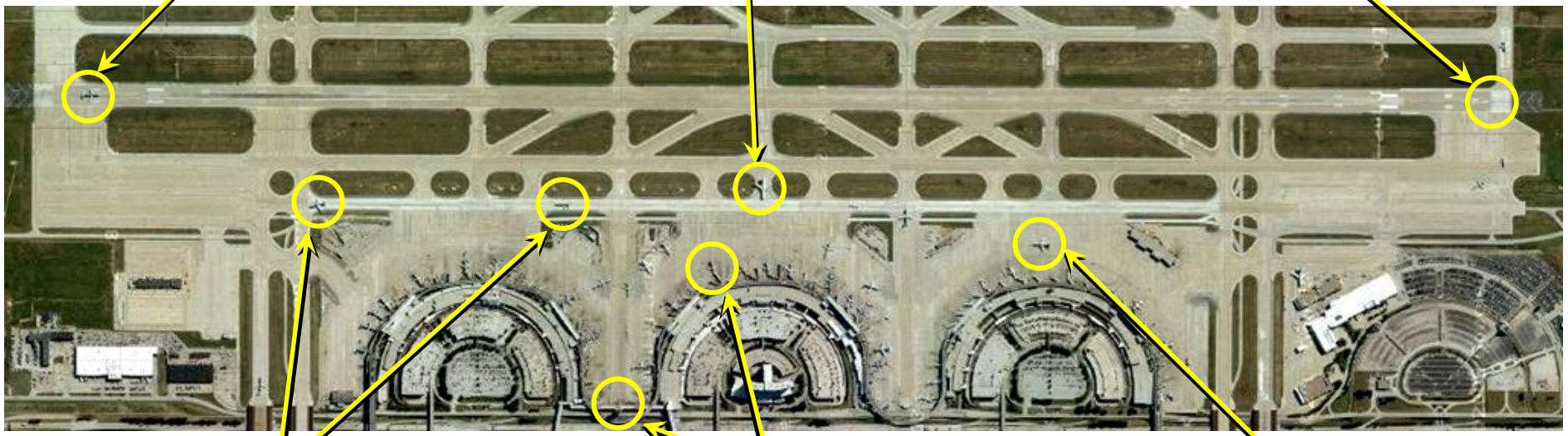


TFDM --- Capabilities

Runway Assignment
- Efficient arrival / departure balancing to maximize throughput & reduce delays

Taxi Routing
- Coordination prevents gridlock
- Enables taxi conformance monitoring for safety

Airport Configuration
- Planning tools facilitate timing configuration changes and proactively rerouting traffic



Sequencing and Scheduling
- Departure sequence optimized for throughput and flexibility
- Taxi scheduling reduces fuel burn
- Alerts and guidance for aircraft unlikely to meet time constraints

Data exchange
- Airline, TRACON, and ARTCC gain visibility into airport status
- Tower uses external data to enhance operational efficiency

Departure Route Assurance
- Proactive identification of traffic and weather constraints allows tactical collaborative rerouting

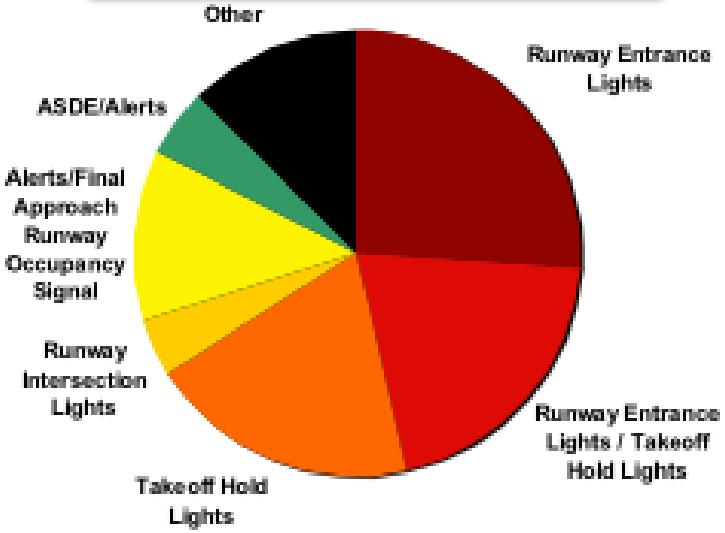
Runway Status Lights Elements

- Runway Entrance Lights (RELs), Takeoff Hold Lights (THLs), and Runway Intersection Lights (RILs) give automatic and direct warnings to all pilots and vehicle drivers on the airport surface

- No on-board equipment required or heads-down time in cockpit

RWSL Safety Benefit

RWSL is best defense in >75% of real incursions



RWSL reduces incursions

"…runway incursions have significantly decreased on the RWSL test runway at DFW (70%)"

- DOT Inspector General, 2007

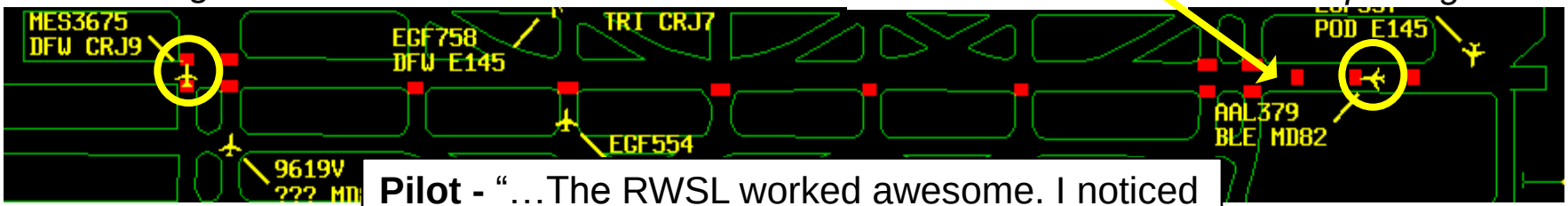
5 known "saves" at DFW since 2008
- Likely more unreported

RED THLs prevent takeoff from occupied runway at DFW

Crossing aircraft

***RED* THLs**

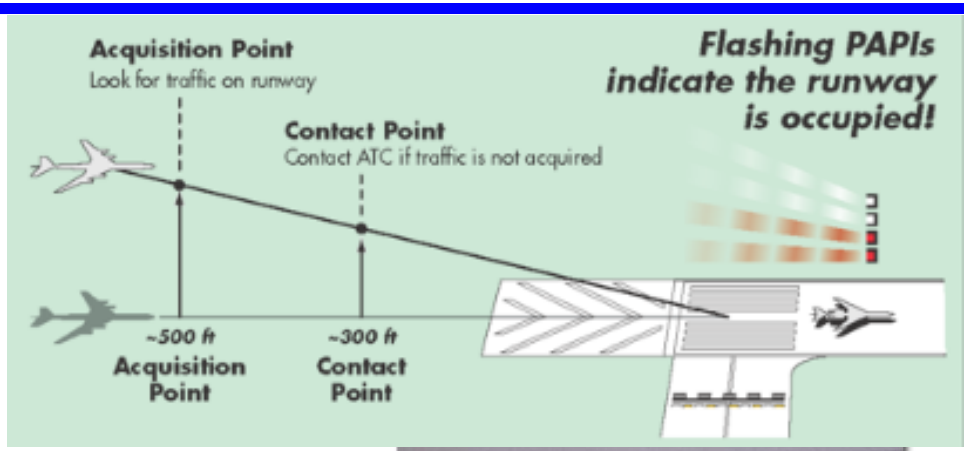
Departing aircraft



Pilot - "…The RWSL worked awesome. I noticed that BEFORE I saw the intruding regional jet."

Final Approach Runway Occupancy Signal (FAROS)

- **RWSL infrastructure is flexible to integration of additional safety functionality**
- **FAROS directly alerts landing pilots that runway is occupied**
  - PAPIs that give vertical path guidance on approach FLASH to provide situational awareness (SA) when *runway is unsafe for landing*
  - Audio alerts in tower enhance SA for air traffic controllers



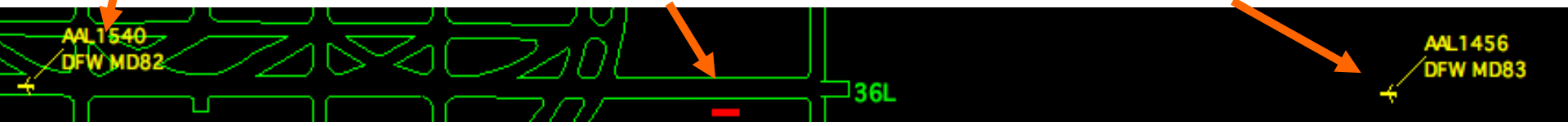
Precision Approach Path Indicator (PAPI)

6 month prototype FAROS test at DFW showed concept improved pilot SA

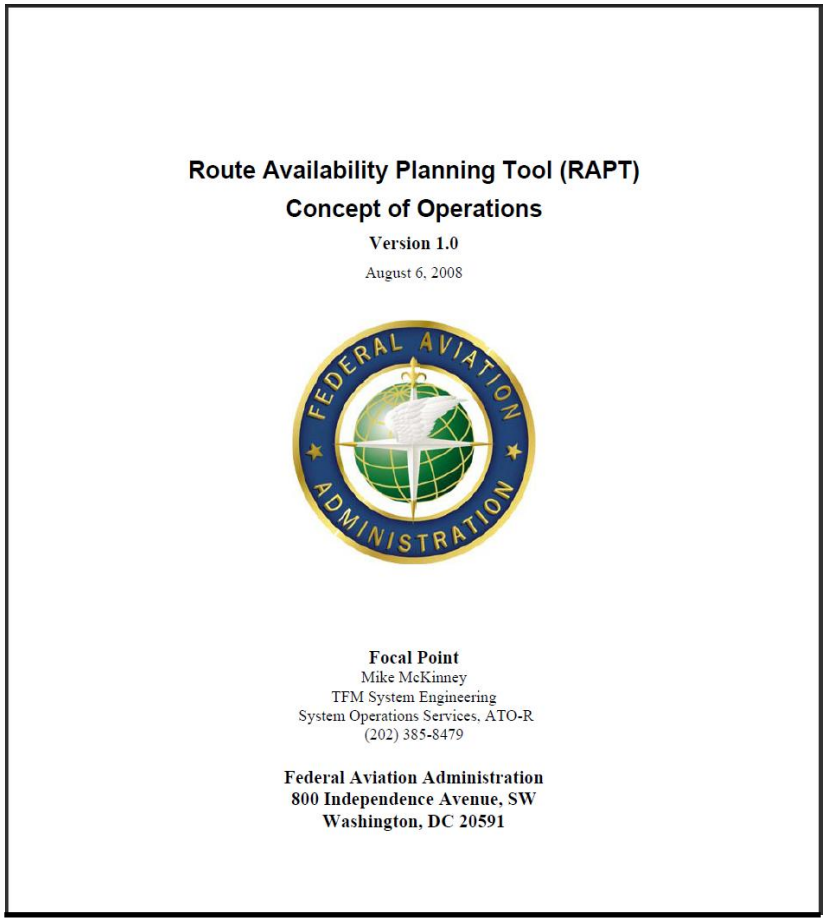
Aircraft on Runway

Flashing PAPIs

Landing Aircraft



Route Availability Planning Tool (RAPT)



Route Availability Planning Tool (RAPT)

Concept of Operations

Version 1.0

August 6, 2008

Focal Point
Mike McKinney
TFM System Engineering
System Operations Services, ATO-R
(202) 385-8479

Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

RAPT ConOps: Facilitate efficient, proactive, consistent departure management decisions that increase capacity and decrease delay

GREEN = GO — Open Route, Keep Open

YELLOW = JUDGEMENT — Reopen / Restrict Route Under Guidance

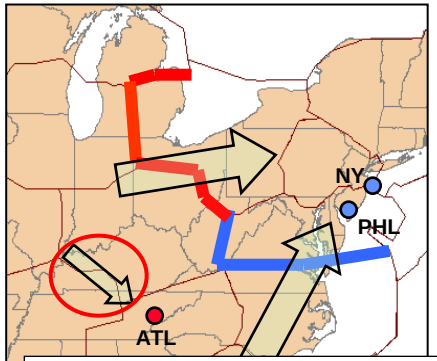
RED = REROUTE — Route Blocked, Plan / Maintain Reroute

Strategic and Tactical Planning

2 – 6 Hours
"National & Planned"

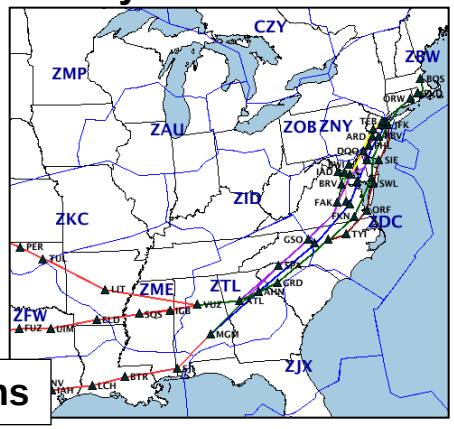
0 – 2 Hours
"Local & Dynamic"

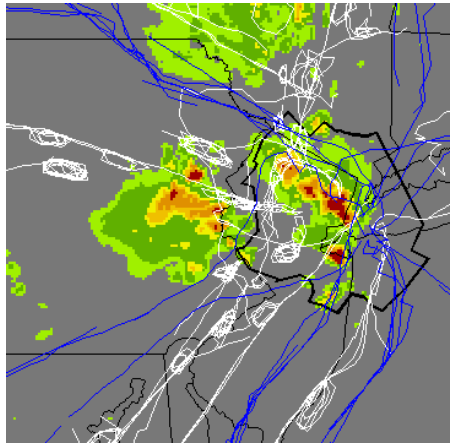
Airspace Flow Programs



Ground Delay Programs

"Playbook" Reroutes





Strategic Decision-Making

- Playbook reroutes
- Ground Delay Programs
- Airspace Flow Programs
- Collaborative Decision Making

Tactical Decision-Making

- Managing pilot deviations
- Safe management of airborne holding
- Dynamic, locally-coordinated reroutes
- Implementing local airspace restrictions
- Balancing airport arrival / departure fixes

Good Strategic Planning → **Manageable Tactical Environment**

Contributes to Successful Strategic Plan ← **Good Tactical Planning**

CoSPA Operational Evaluation Status

- Providing 2-8 hr forecasts of VIL and Echo Tops to select facilities
- Collaboration between MIT LL, NCAR and NOAA
- Objective: Evaluate suitability and quantitative benefits of CoSPA for ATM operations
- Duration: June – Oct.

Facilities

- Very positive response from users
- Improves situational awareness and strategic planning coordination
- High resolution is useful in assessing weather impacts
- Observed decisions in:
  - Airspace flow programs (AFP)
  - Ground delay programs (GDP)
  - "Playbook" reroute initiatives
  - Setting staffing needs

Benefits Collection
13-14 June
16 June
6-8 July
19-21 July
3 Aug.
4-5 Aug.
1-2 Sept.
16 Sept.