National Aeronautics and Space Administration

Air Traffic Management Research at NASA Ames

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NASA Ames Research Center

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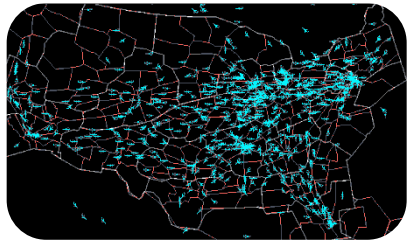
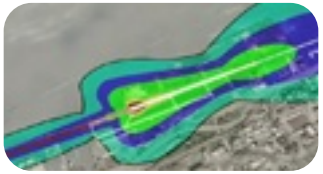
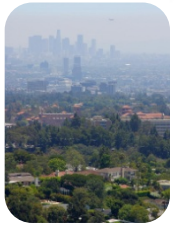
NASA Aeronautics Programs



Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment





Fundamental Aeronautics Program

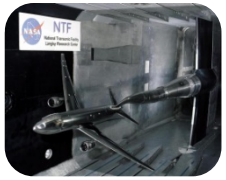
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant Increases in the capacity, efficiency and flexibility of the NAS.

Aviation Safety Program

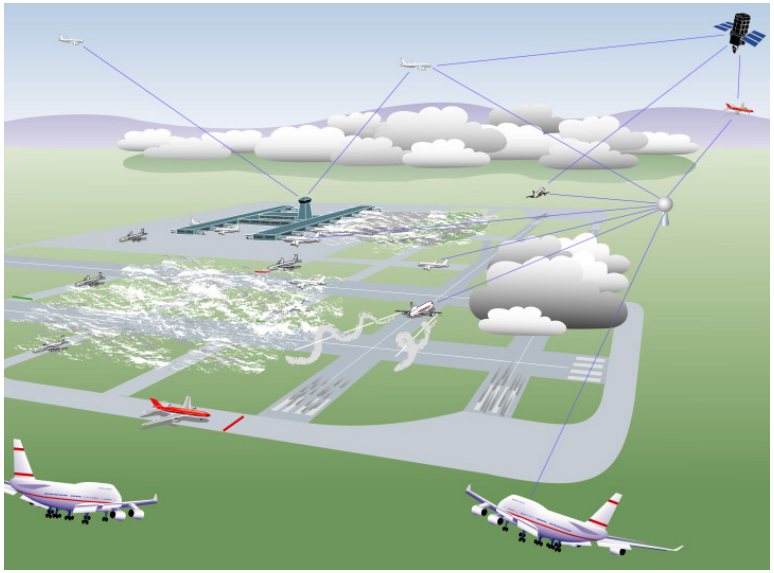
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.



Aeronautics Test Program

Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.

Airspace Systems Research @ Ames



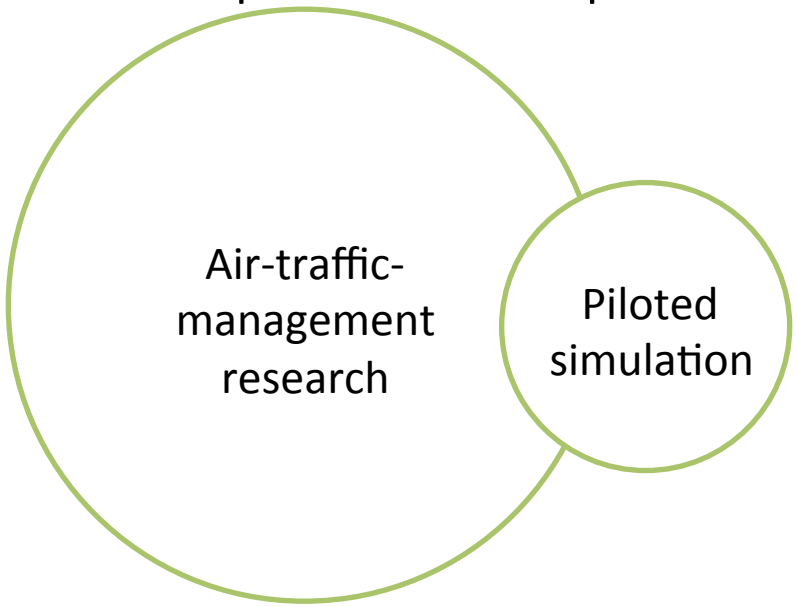
Air Traffic Management

Boeing 747 Simulator

Vertical Motion Simulator

What do we do?

- Our research business is air-traffic-management and flight simulation
  - We have already made your flying experience better
  - We are trying to safely and effectively automate tomorrow's air traffic control system ("NextGen")
  - Our flight simulation capabilities and experience are unrivaled



Research Challenges for NextGen

Why is it difficult?

- System must accommodate aircraft with:
  - Widely varying performance capabilities
  - Different flight phase (descending, climbing, cruising) in the same airspace
  - Many levels of equipage
- Operators have widely varying/competitive mission objectives
  - Hub and spoke operations and point-to-point operations are different
- Transition from current state to desired end state
- Assuring a collision risk of less than 1 in ~100 million flight hours
- Impracticality of validating ~10 million lines of software code to assure safety of automated system
  - Design of fail-safe architecture
- Testing and validation to discover the “unknown unknowns”

What are the research focus areas?

- Concepts and Technology Development
  - Traffic Flow Management
  - Dynamic Airspace Configuration
  - Safe & Efficient (Airport) Surface Operations
  - Super Density Operations
  - Separation Assurance
- Systems Analysis, Integration and Evaluation
  - System Portfolio Analysis
  - Interoperability Research
  - Integration, Evaluation & Transition

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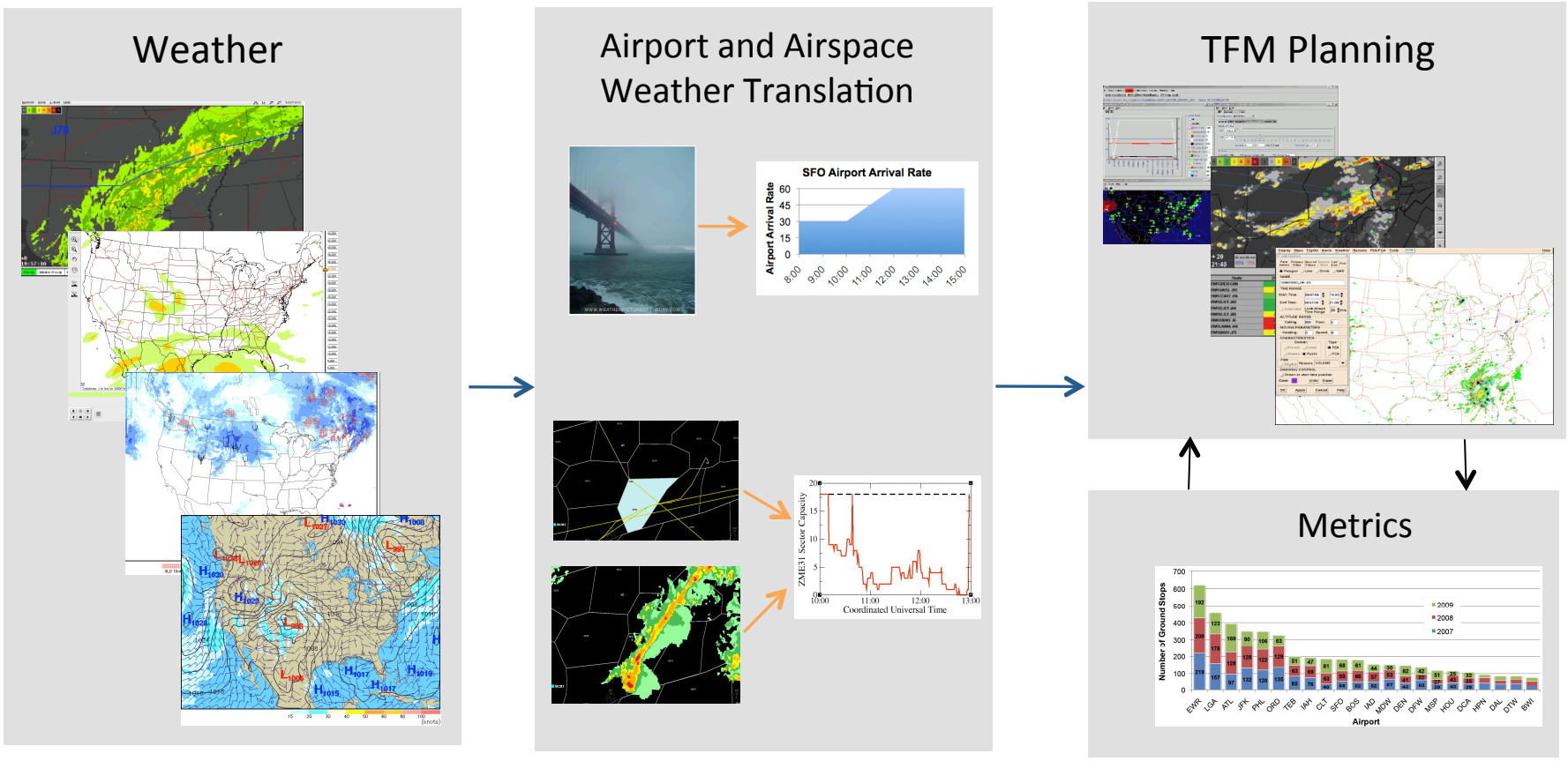
Traffic Flow Management



Investigate modeling, simulation and optimization techniques to manage air traffic flows subject to airspace and airport capacity constraints while accommodating user preferences with increased traffic demand in the presence of uncertainty

Spot and Runway Departure Advisor (SARDA)

Problem - Surface traffic suffers from excessive taxi delay and fuel spending due to lack of planning and coordination among stakeholders

Technical Progress in FY12

- Enhanced scheduler for optimal runway sequence, spot release, and gate push back
- Flight info and Tower controller advisories displayed on the Electronic Flight Strips (EFS)
- Added realism by using the air traffic control tower simulator

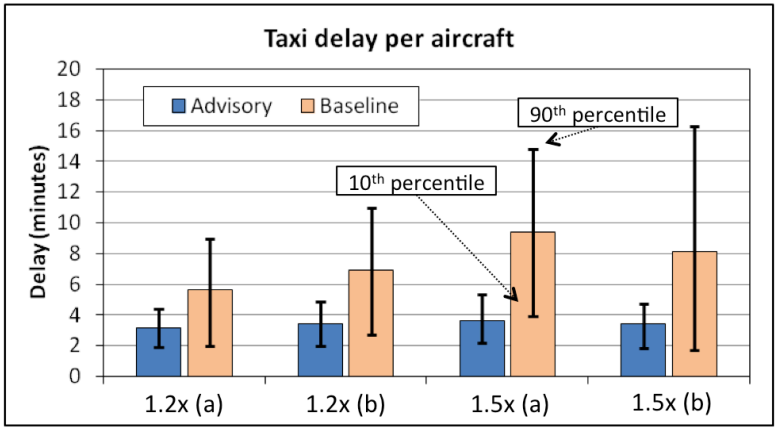
Impact

- The human-in-the-loop simulation showed promising results:
  - Up to 60% reduction in taxi delay
  - Up to 34% reduction in fuel consumption
  - No increase in controller workload
- Demonstrated a potential as a near-term decision support tool for ATC and airlines

Next Steps

- Build a partnership with airline industry and the FAA
- Develop and test the SARDA tool for field evaluation

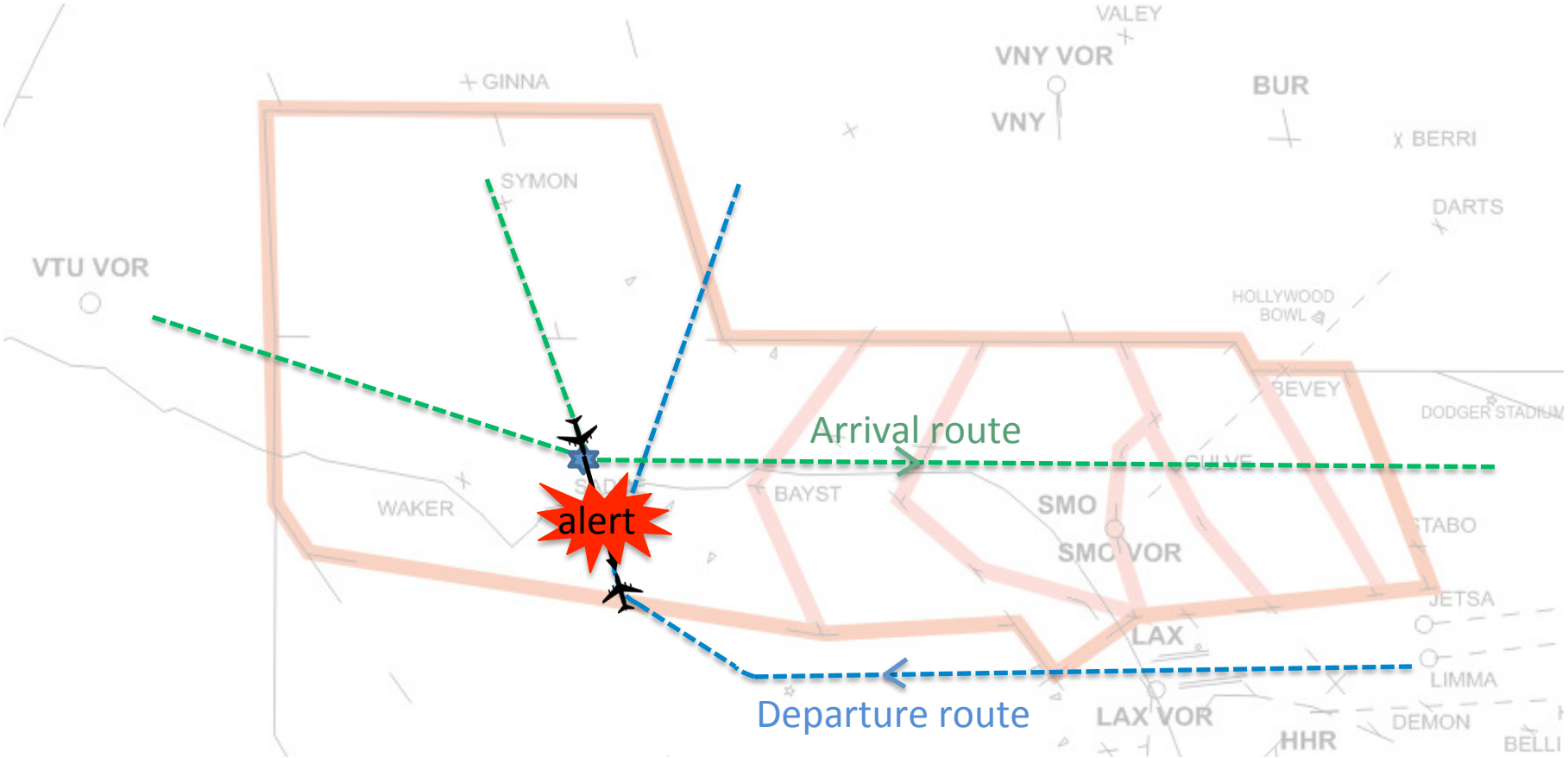
SARDA Human-in-the-Loop Simulation, 2012
(Local Controller Position)



Total Taxiing Delay for Departures

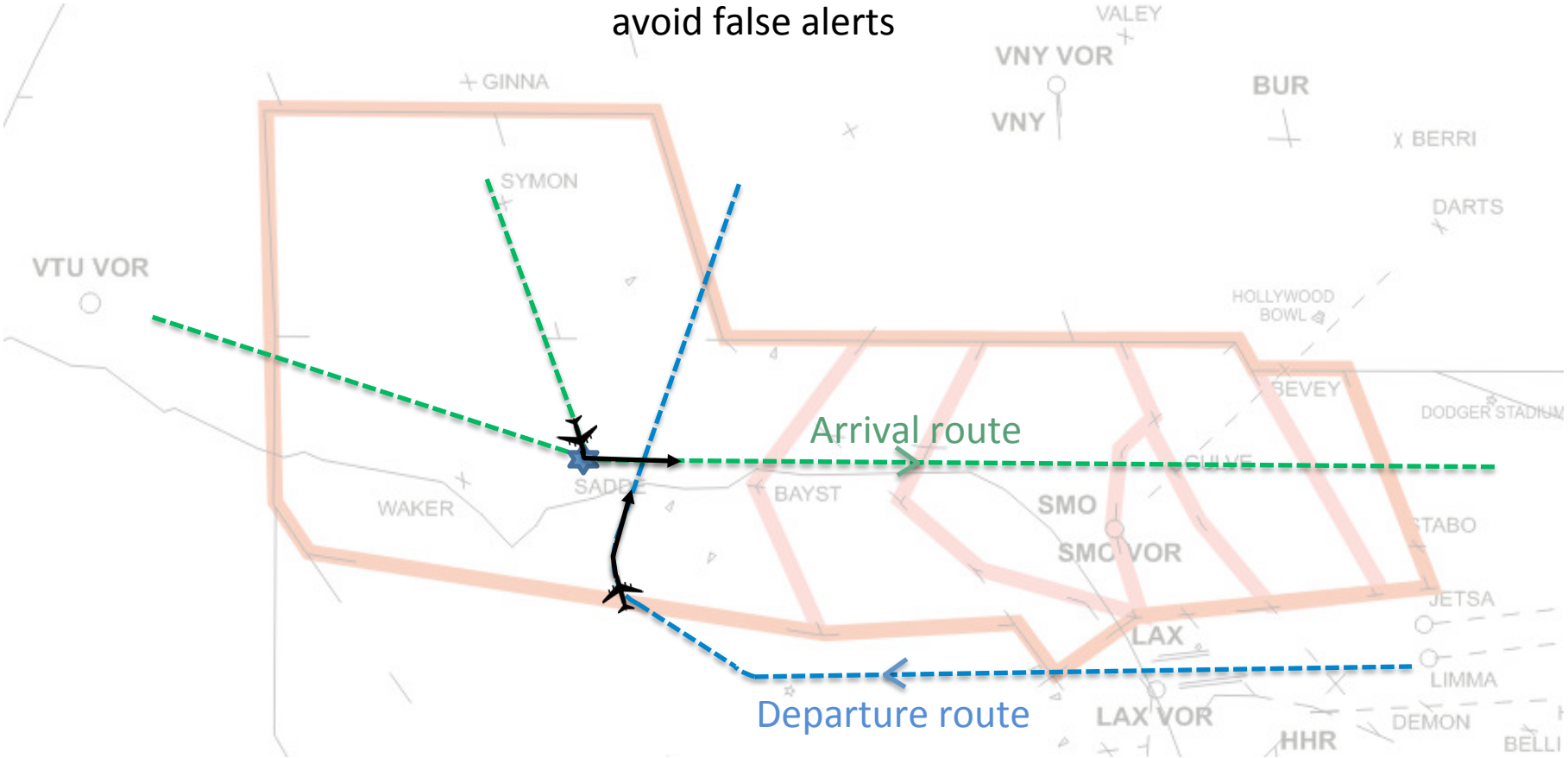
Current Day Conflict Alert
Dead Reckoning

false alert, a.k.a. nuisance alert



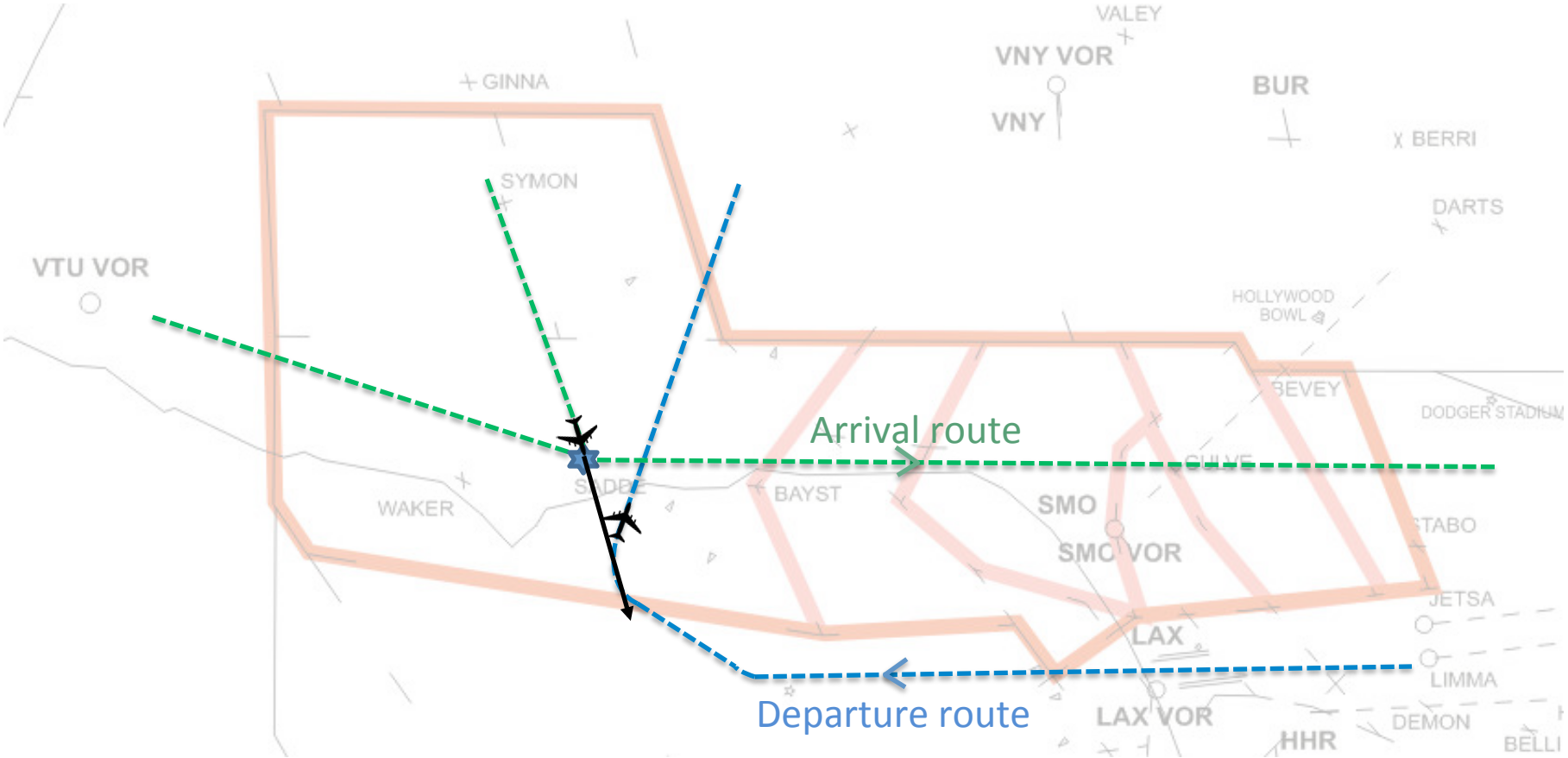
Terminal Tactical Separation Assured Flight Environment

Use flight intent information to avoid false alerts



Current Day Conflict Alert
Dead Reckoning

Missed alert, not safe!



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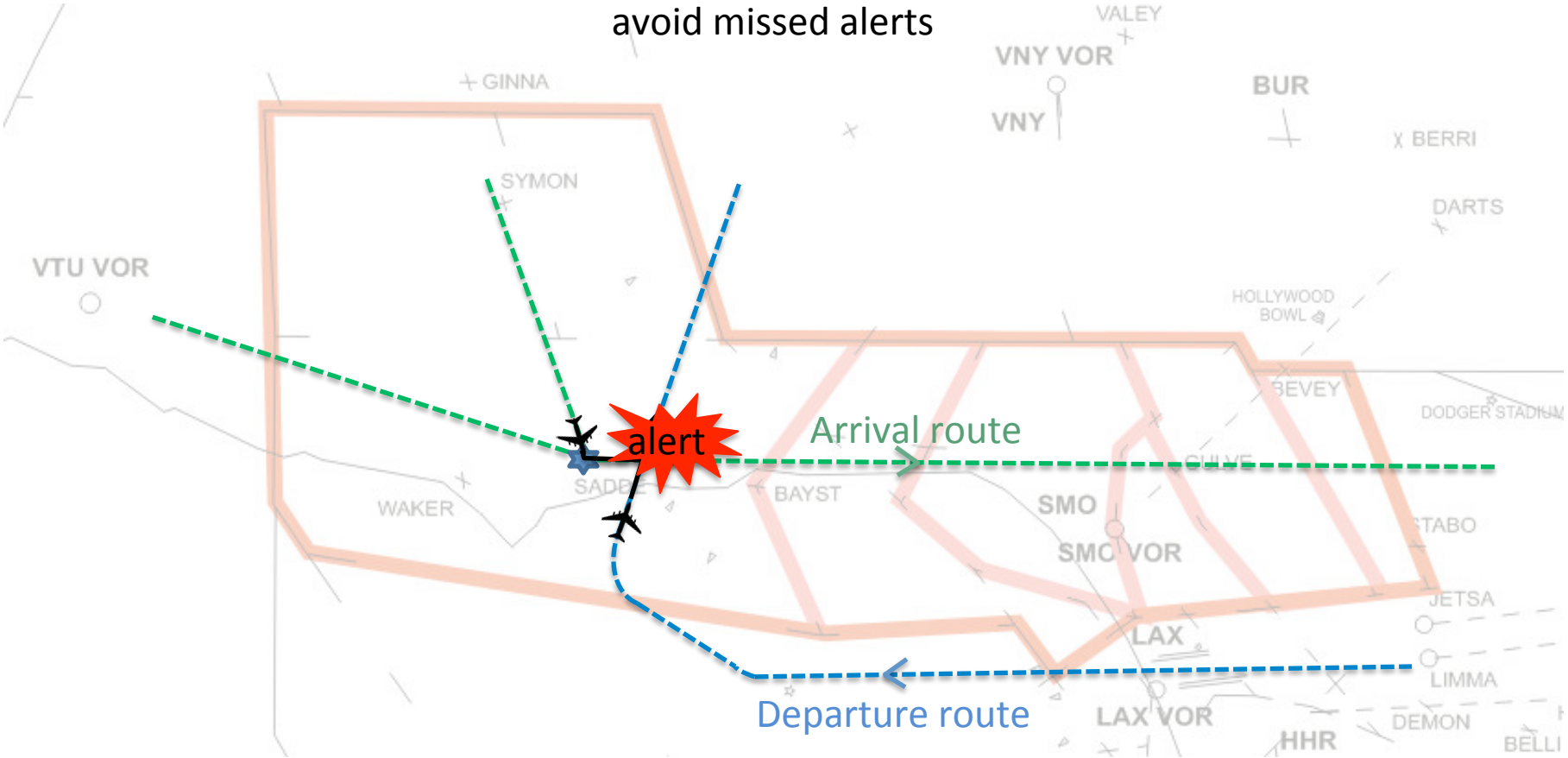
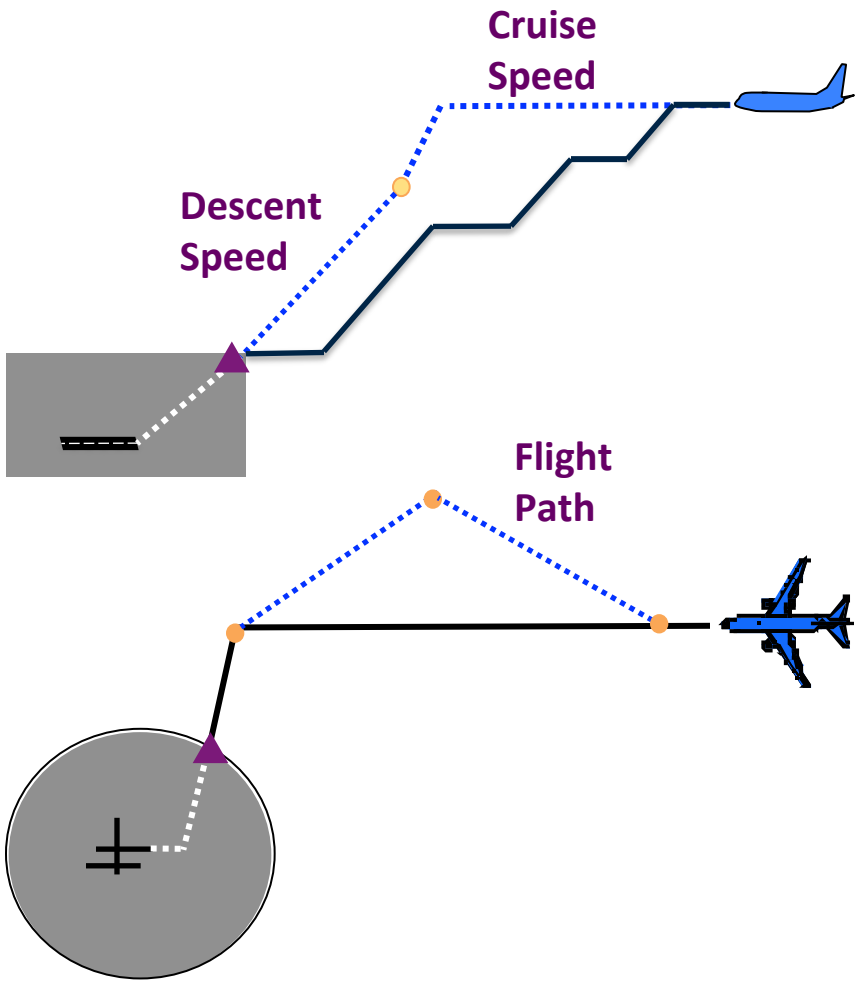


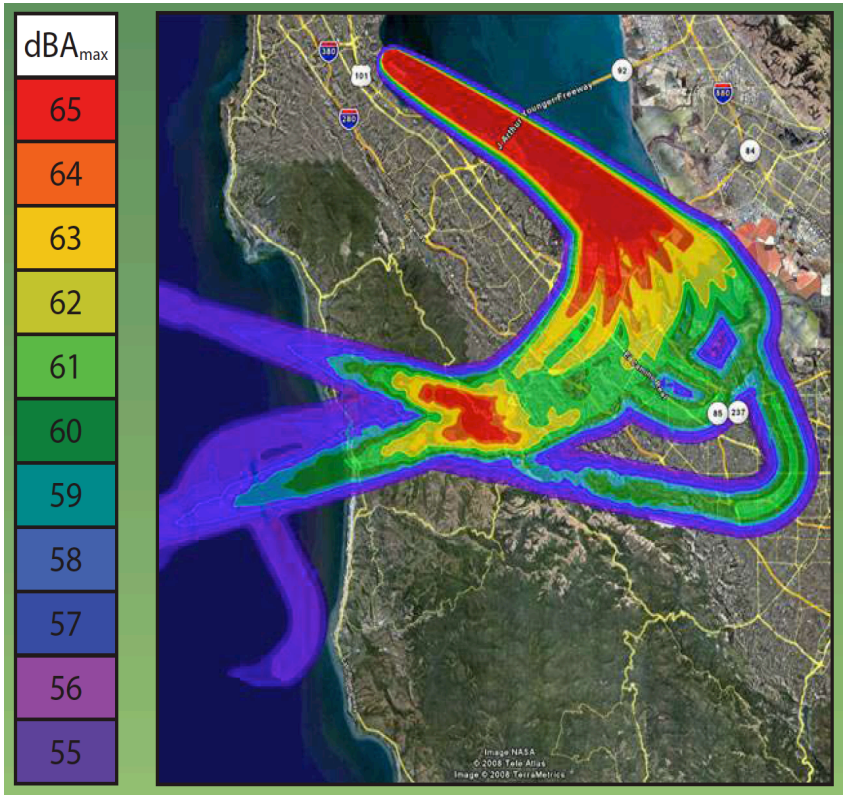
Efficient Descent Advisor (EDA)

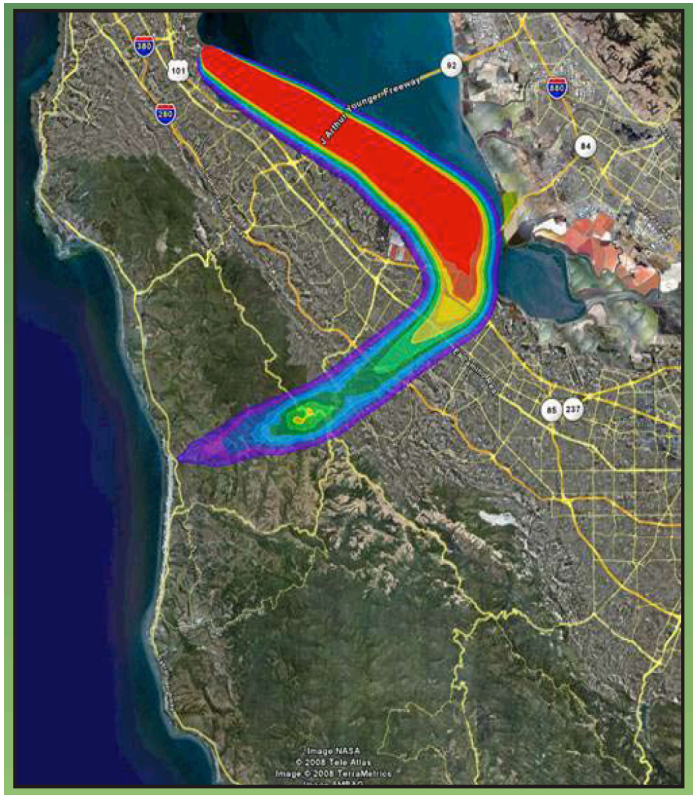
Computes trajectory-based advisories for ARTCC controllers that:

- Enable continuous descents at near-idle thrust
- Conform to Traffic Management Advisor (TMA) arrival schedules for maximum throughput
- Avoid traffic and airspace conflicts along the arrival path
- Allow clearance delivery by voice or data link
- Leverage existing flight deck automation for precision guidance and control

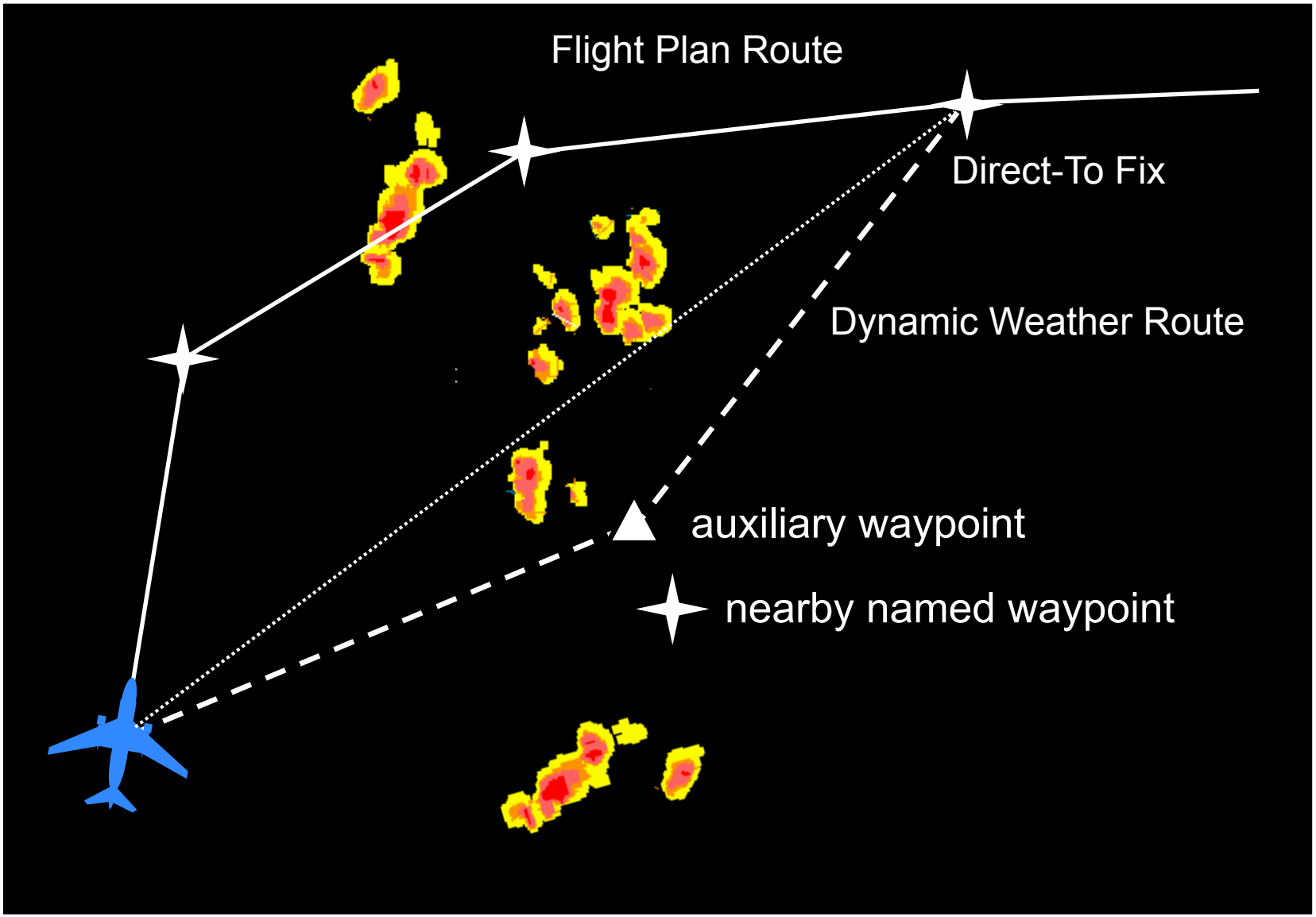


Potential Benefits:
Noise Reduction from Tailored Arrivals
SFO

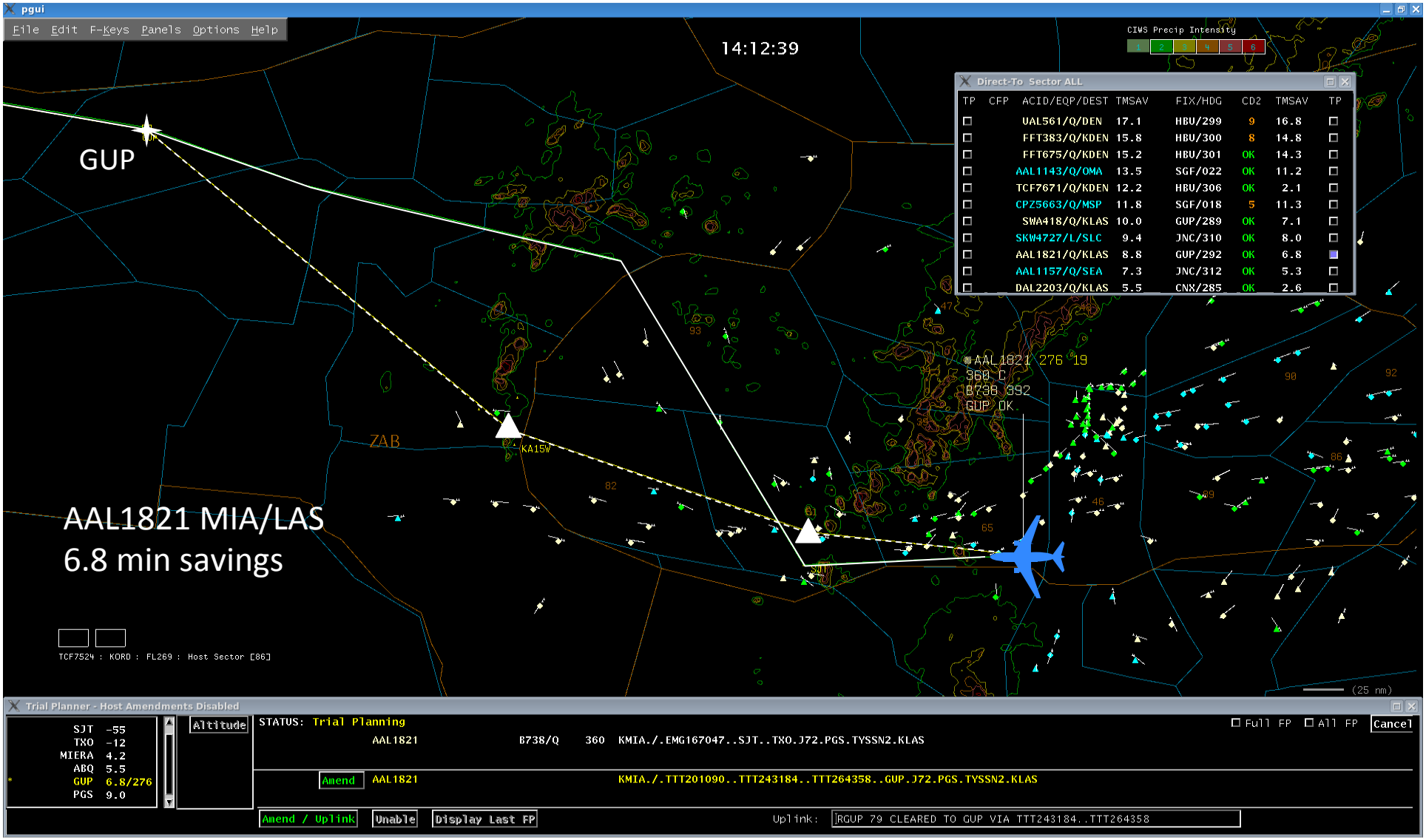




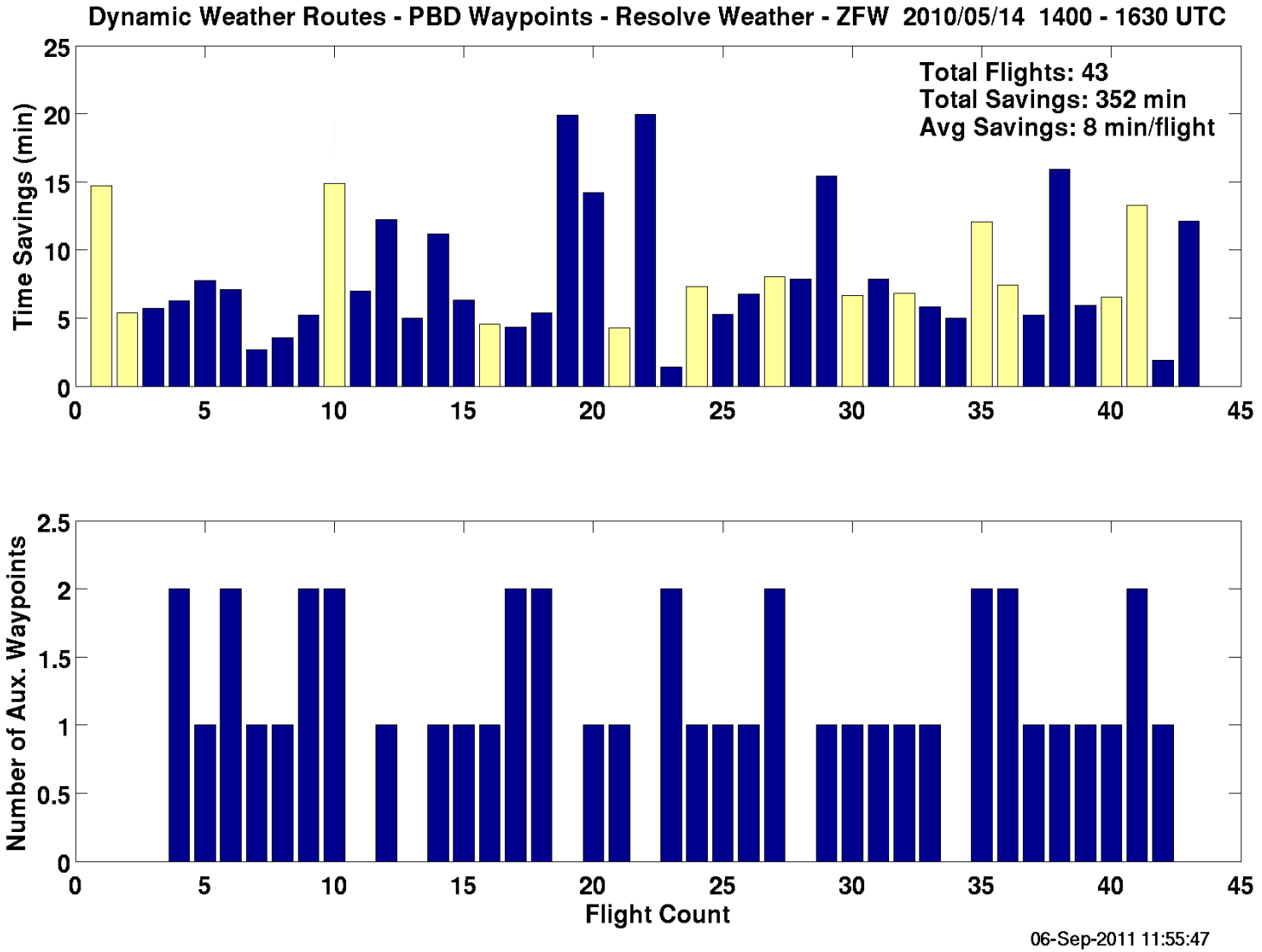
Dynamic Weather Routes



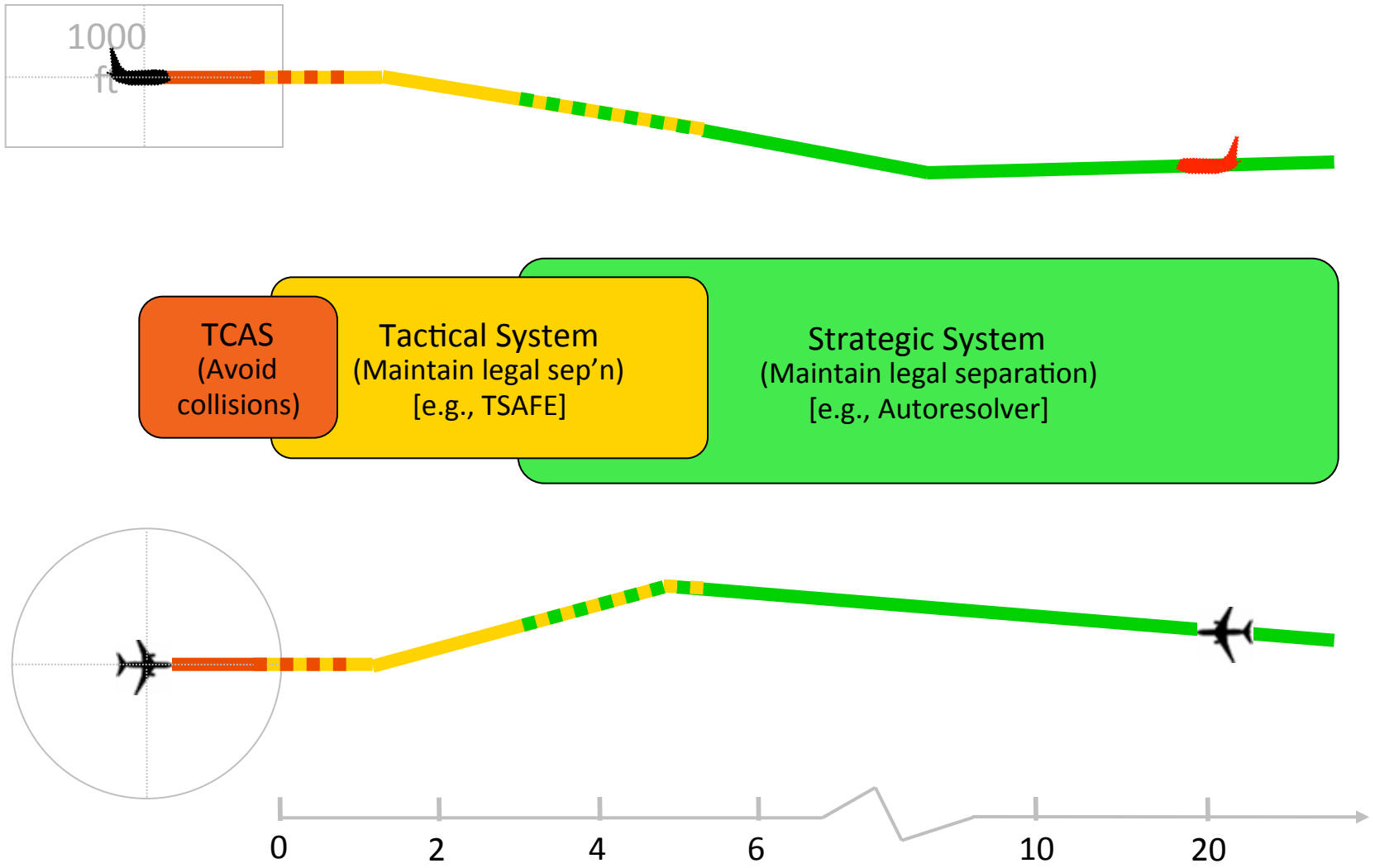
AAL1821 MIA/LAS



Potential Flying Time Savings



Advanced Airspace Concept



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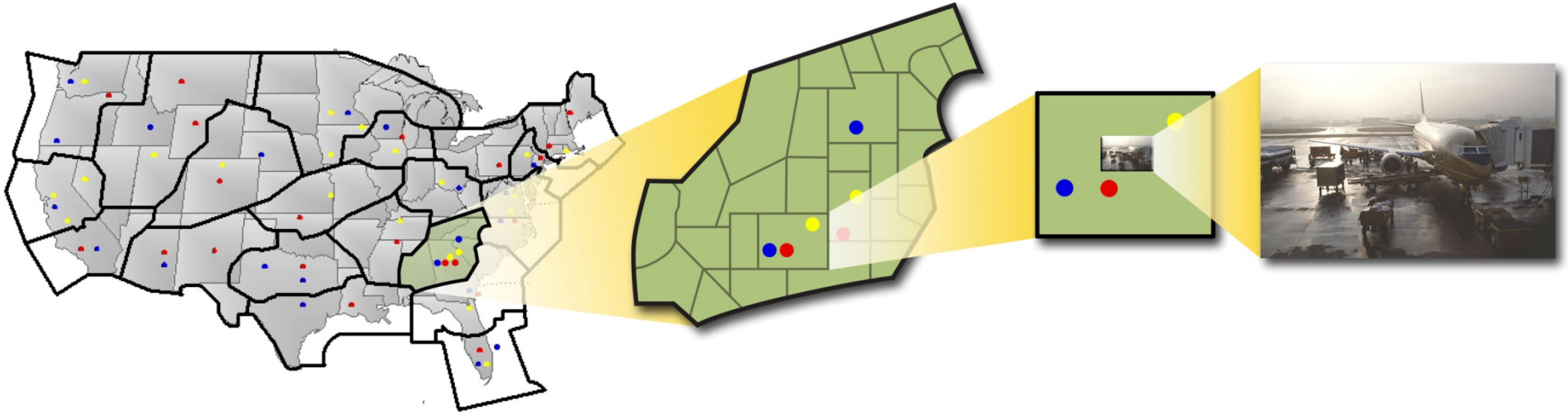
System-wide Performance & Analysis: ACES Models



National Traffic Management

Fast-time nationwide gate-to-gate simulation of NAS operations

Full flight schedule with flight plans, winds, gate-to-gate operations

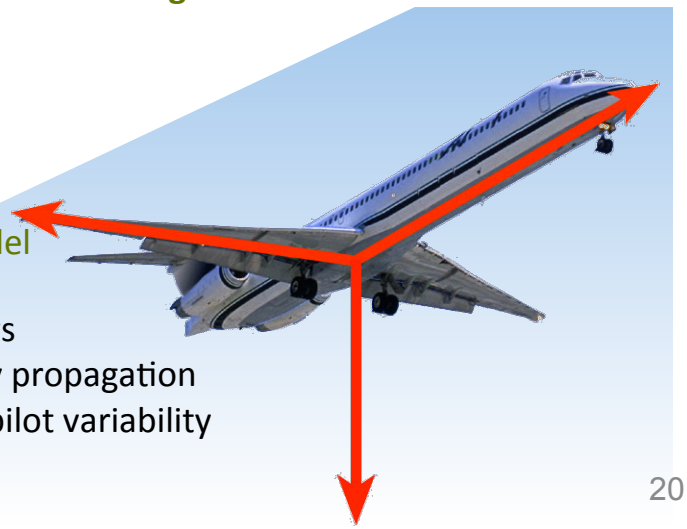
Regional Traffic Management

Thousands of agents:

• National	1
• Regional	20
• Local	100s
• Airports	100s
• Aircraft	10,000s
• Airlines	10s

Local Approach and Departure Traffic Management

Airport and Surface Traffic Management



High Fidelity 4-DOF Trajectory Model

- Based on laws of physics
- Realistic pilot-based control laws
- Includes elliptic-Earth trajectory propagation
- Contains modeling for aircraft/pilot variability

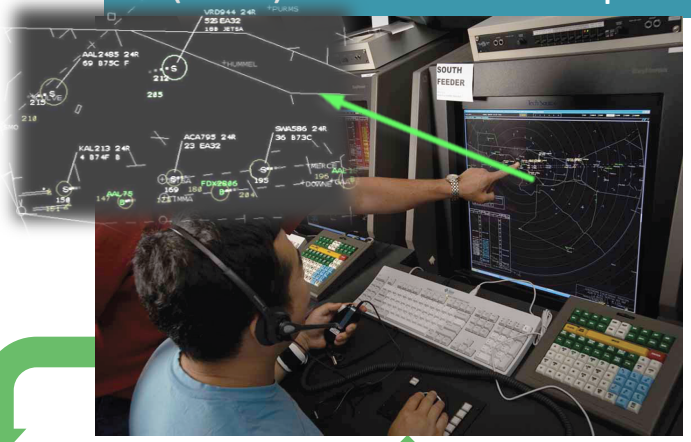
Taking the research to the real world…

ATM Technology Demonstration 1:

Maintaining efficient operations during higher densities

Flight Deck Interval Management (FIM) for Arrival Operations

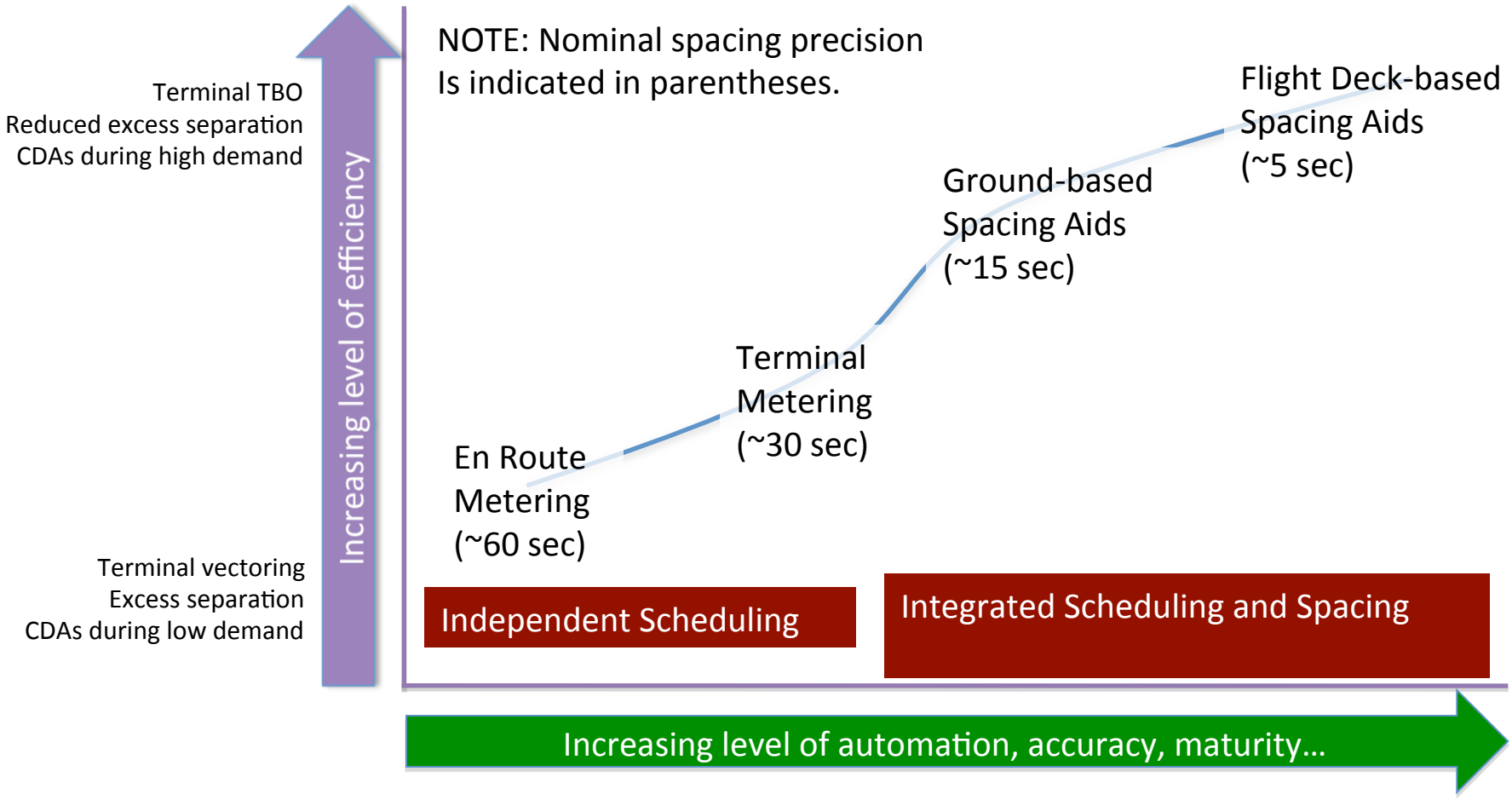
Controller Managed Spacing (CMS) in Terminal Airspace



Integrated Arrival Solution

Traffic Management Advisor with Terminal Metering (TMA-TM)

Operational Context

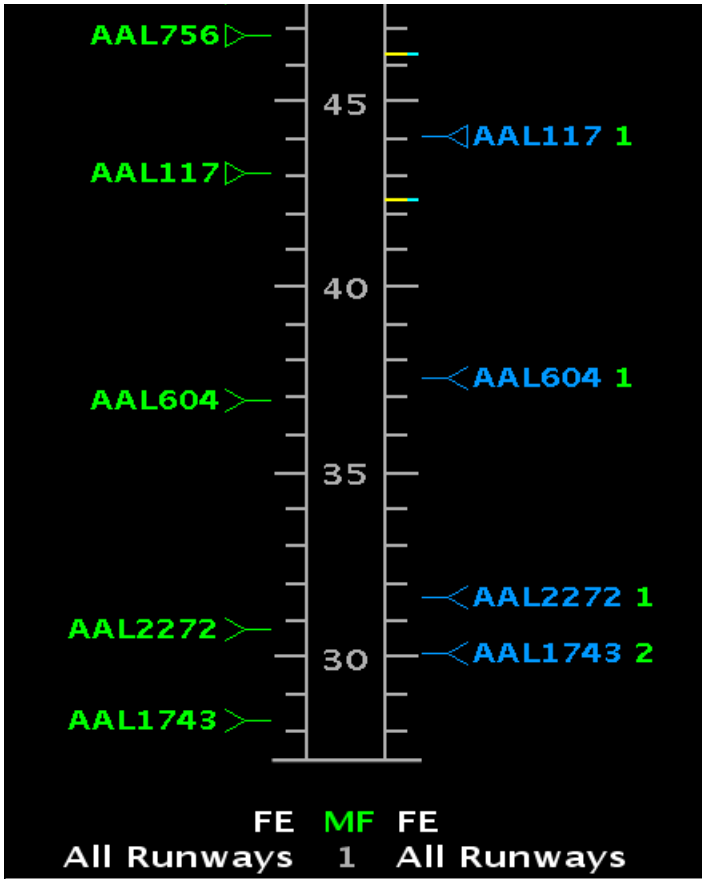


ATD-1 Objectives

- Demonstrate increased, more consistent use of Performance-Based Navigation
  - Precision arrival procedures from cruise to touchdown
  - Optimized Profile Descents using speed control
  - Simultaneous high throughput and fuel-efficient terminal operations
- Demonstrate ADS-B In for arrival flow management
  - ADS-B In receives surveillance information for nearby aircraft
- Accelerate transfer of NASA scheduling and spacing technologies for inclusion in NextGen
  - Scheduling based upon Ames' Traffic Management Advisor (TMA)
  - Airborne spacing application based upon Langley's ASTAR
  - Controller tools based upon Ames' Controller Managed Spacing (CMS)

Terminal Metering

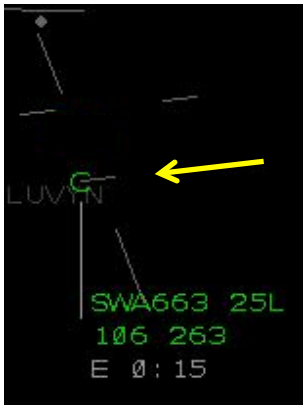
- Precision route structure to runways
  - Mostly RNAV OPD arrivals
  - Primarily speed control past top-of-descent
- TMA scheduler
  - Models terminal merges that affect traffic flow
  - Compatible with Interval Management and RTA operations
- Controller decision support
  - Timelines to meter points
  - TMA information displayed to en route and terminal controllers



Controller-Managed Spacing

Three Successively More Advanced Toolsets

”Schedule"



Early/Late Indicator

"Slot Marker"

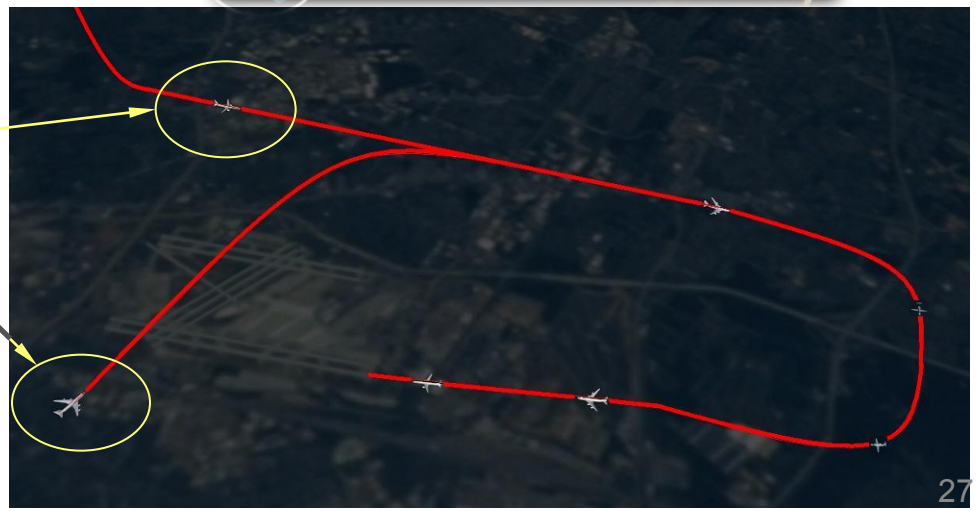
Early/Late Indicator +
Slot Marker

"Speed Advisory"

Slot Marker +
Speed Advisory

Flight Deck Interval Management

- Computes lead and ownship times of arrival at runway
- Calculates speed guidance to achieve desired spacing over remainder of route
- Commands speed, if necessary, to prevent spacing errors



- Assigned spacing interval: 90 sec
- 15 seconds early

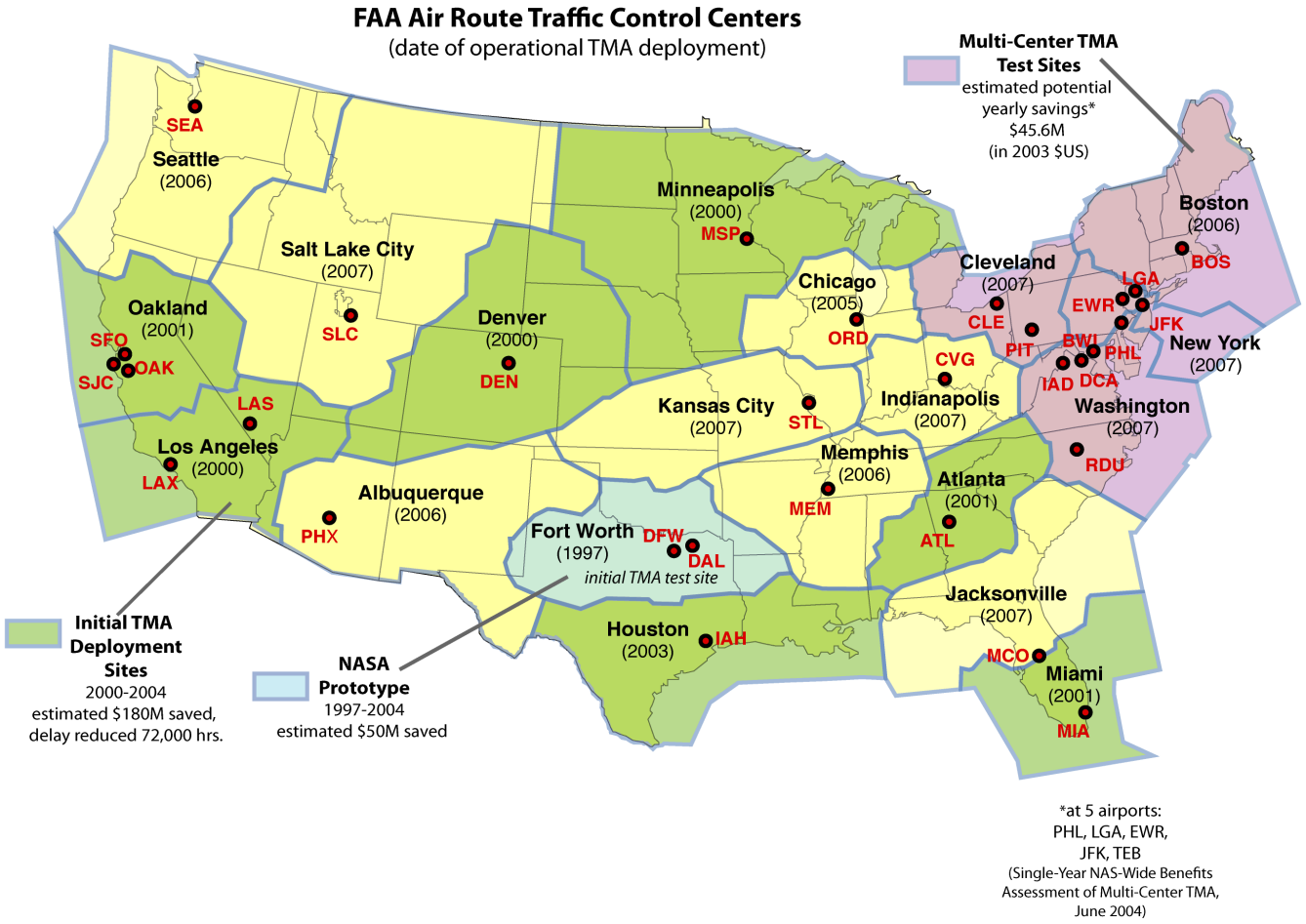
→ Slow down 5 knots

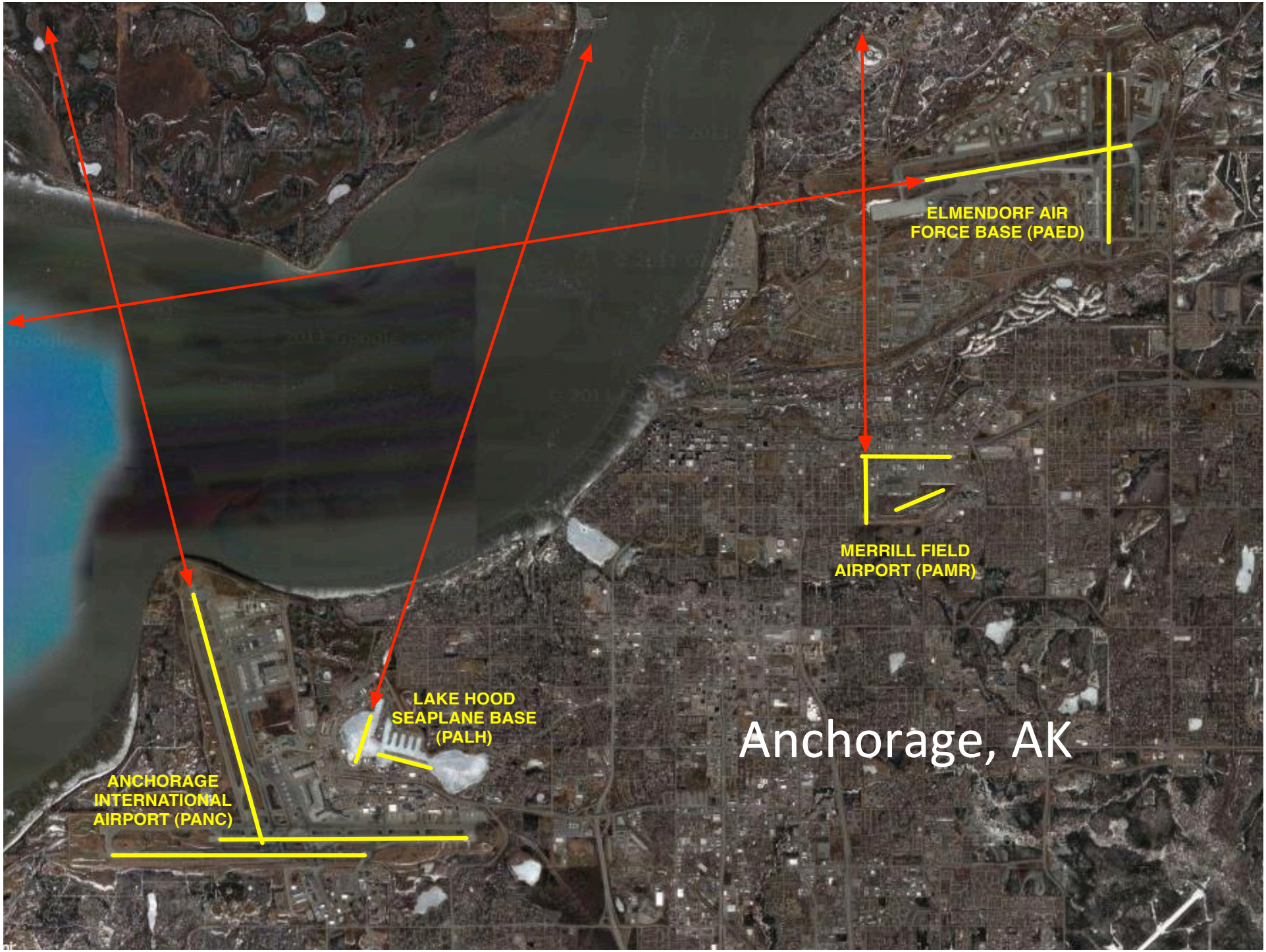
Summary

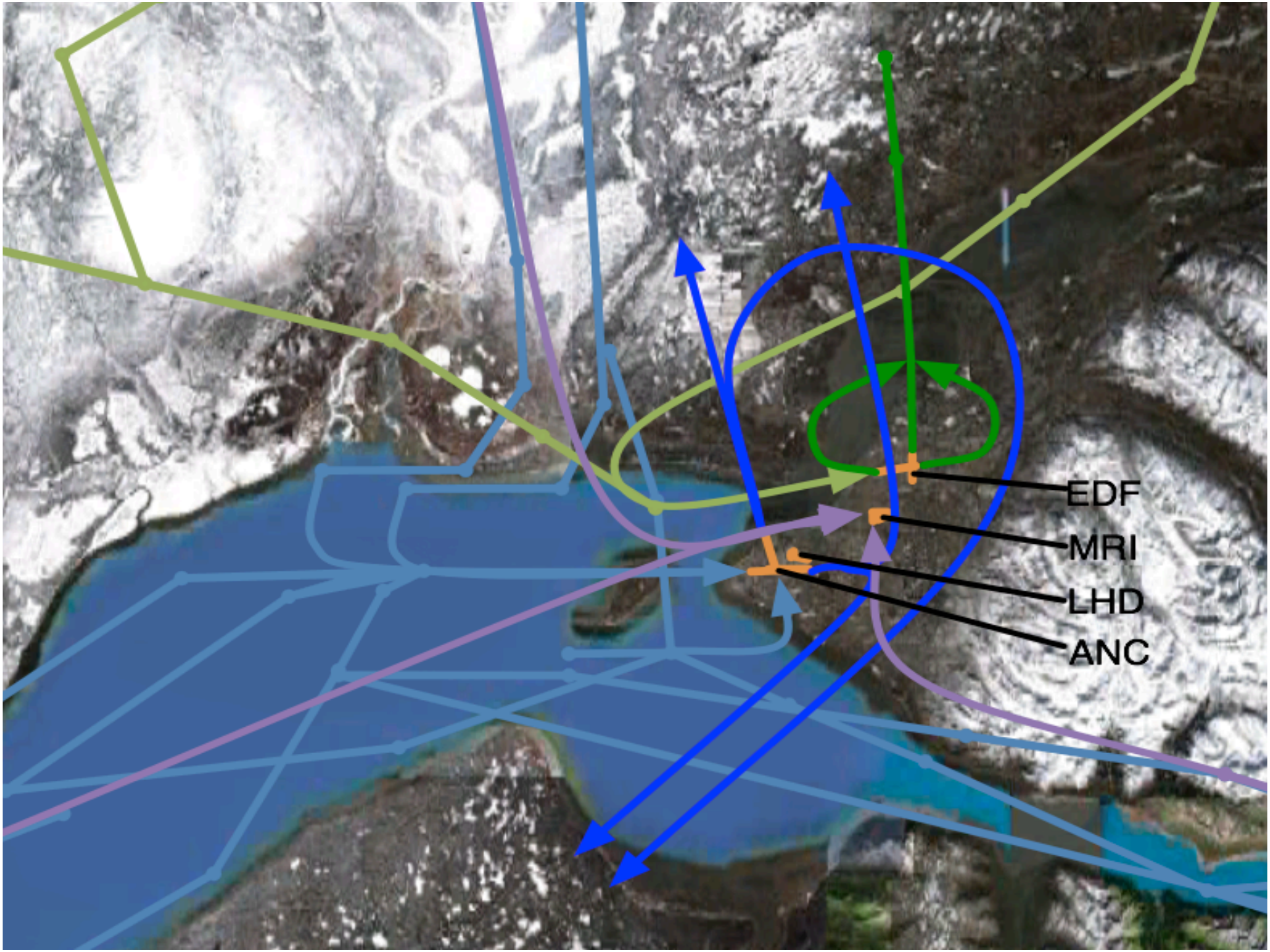
- Our research business is air-traffic-management and flight simulation
  - We have already made your flying experience better
  - We are trying to safely and effectively automate tomorrow's air traffic control system
  - Our flight and air traffic simulation capabilities and experience are unrivaled

Backup Slides

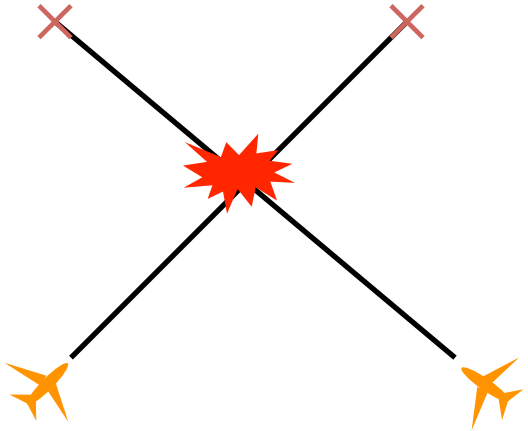
We have already made your flying experience better: Nationwide Deployment



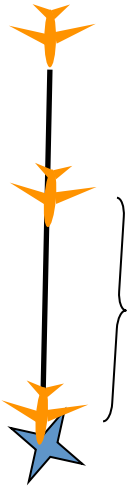

ELMENDORF AIR
FORCE BASE (PAED)
MERRILL FIELD
AIRPORT (PAMR)
LAKE HOOD
SEAPLANE BASE
(PALH)
ANCHORAGE
INTERNATIONAL
AIRPORT (PANC)
Anchorage, AK


EDF
MRI
LHD
ANC

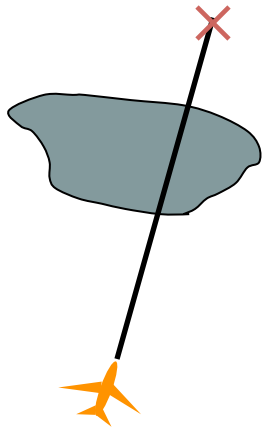
AAC Autoresolver



Conflicts



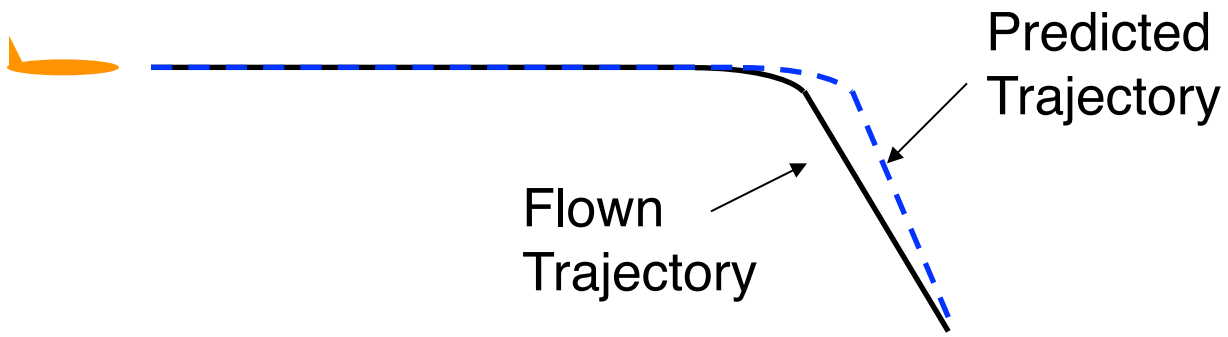
Arrival Spacing



Weather Avoidance

Solve aircraft-to-aircraft conflicts, arrival metering and weather avoidance in integrated fashion

Major AAC Research



- Handle trajectory prediction errors in robust and efficient fashion
- Assure seamless integration of strategic and tactical systems
- Prove feasibility of future arrival management concepts