



Part 2 of Joint Briefing

Traffic-Aware Strategic Aircrew Requests

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2011 Industry Day
March 28–31 2011
San Diego, CA

www.nasa.gov





En-route Flight Optimization

- *Addressed from pilot's perspective*
 - Seeking improved/optimized conflict-free trajectories while airborne
 - New technology in the aircraft provides an alternative method for improving trajectories
 - Stand-alone concept; can also complement ground-based approach
- *Today: Aircraft's current route/altitude is typically not user-preferred or user-optimal*
 - Situation is fluid (e.g. weather, turbulence), changes often needed
 - Pilots seek to improve their flight's efficiency, passenger comfort, and arrival time
 - Pilots make requests to ATC over voice comm.
- *Today: Pilots make requests without traffic awareness*
 - Some requests are disapproved (traffic not considered in request)
 - Some requests are never made (pilots unaware of approvable reroute)



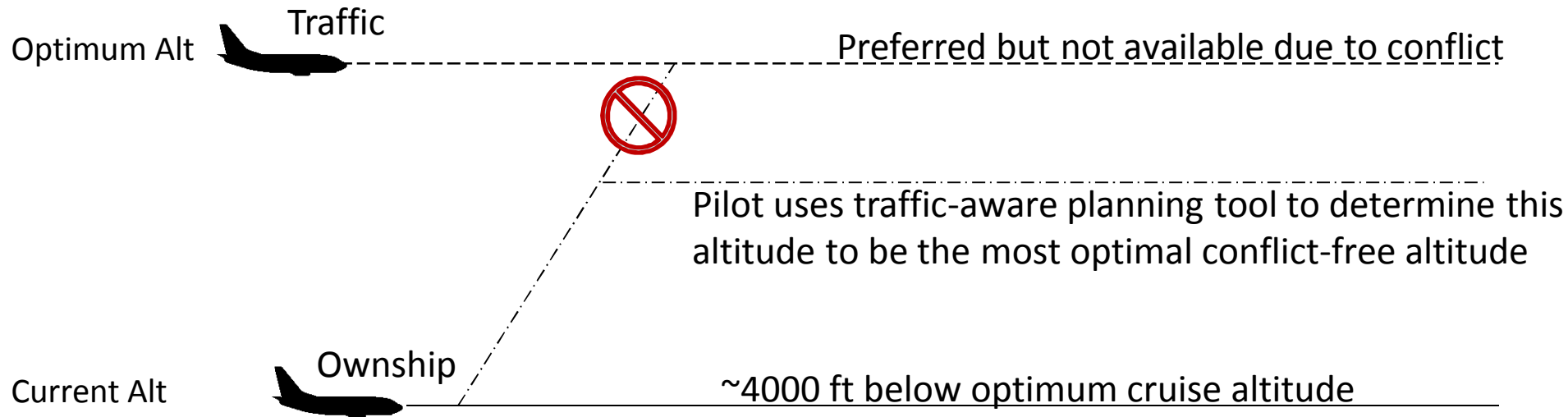
Concept:

Traffic Aware Strategic Aircrew Requests (TASAR)

- *This concept leverages the emergence of airborne surveillance*
 - ADS-B Out (FAA: all aircraft in most airspace to equip by 2020)
 - TIS-B (broadcast of non-ADS-B aircraft surveillance)
- *A prospective aircraft operator equips with ADS-B In*
 - This allows reception of ADS-B Out and TIS-B messages
 - Can now build a surveillance picture of most aircraft in the airspace
- *The aircraft is also equipped with technology to process and analyze the surveillance data with respect to its preferred or optimal trajectories*
 - Monitors for more-optimal trajectories that are conflict-free
 - Serves as a pilot's tool to probe prospective trajectory changes for traffic conflicts
- *Now pilots can make flight-optimizing requests that are checked against traffic to be approvable by ATC*
 - Benefits directly accrue with every approved request



Scenario Example: Save Fuel



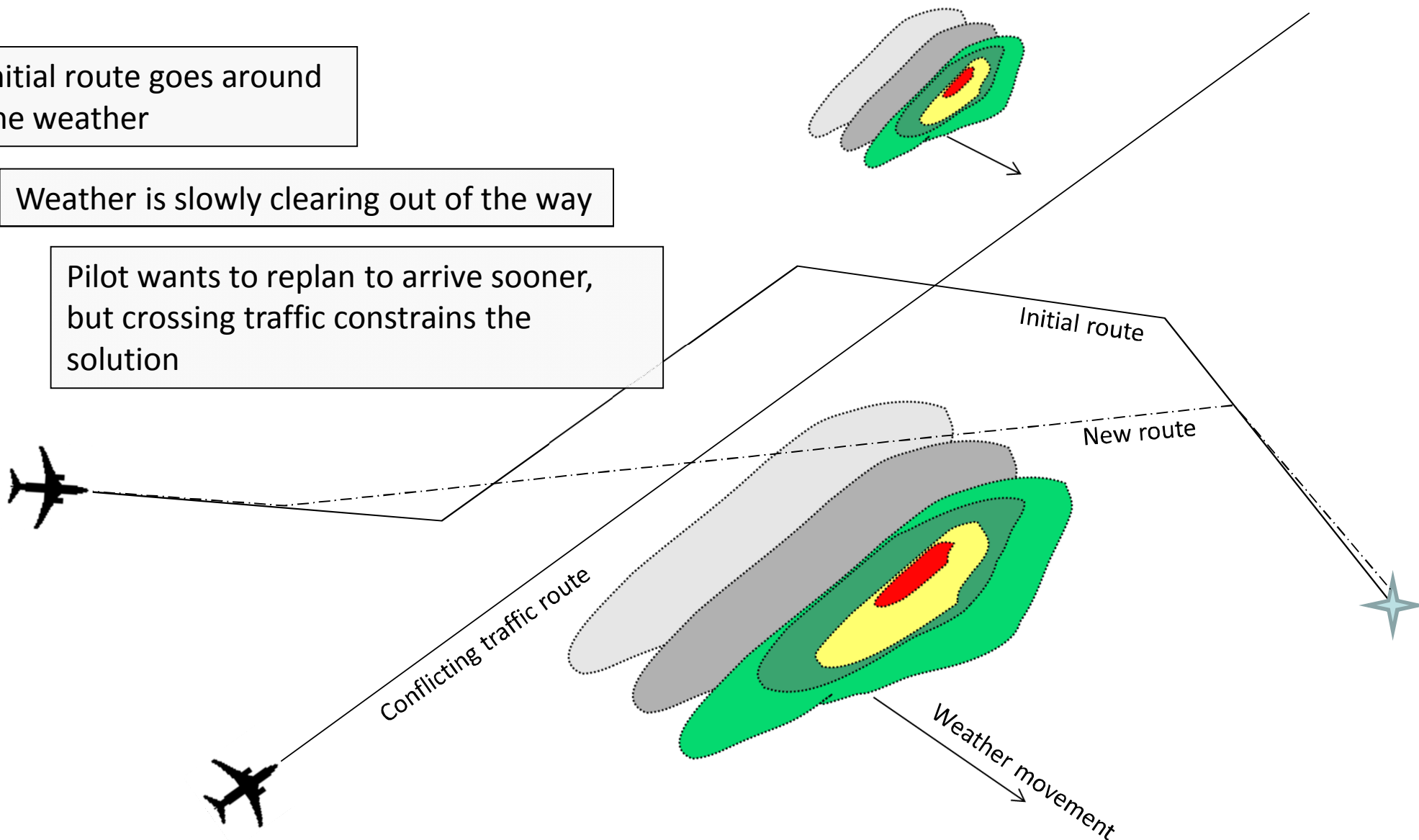


Scenario Example: Save Flight Time

Initial route goes around the weather

Weather is slowly clearing out of the way

Pilot wants to replan to arrive sooner, but crossing traffic constrains the solution



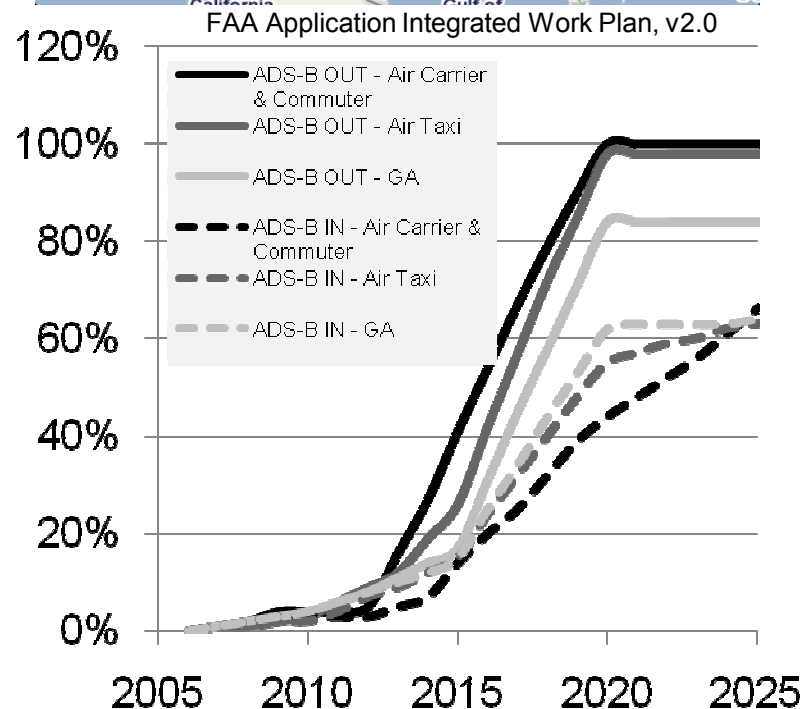
Pilot uses traffic-aware planning tool to compute a conflict-free, weather avoiding path that saves flight time (and fuel)



Applicable Environments

- *Benefits pool is greatest in regions with airborne surveillance of significant portion of traffic*
- *Applicable right now in ADS-B surveillance rich environments such as oceanic, Alaska Capstone, and Gulf of Mexico*
- *Migrate towards other environments such as domestic/enroute/transition*

Snapshot of an iPhone application that displays ADS-B broadcasting aircraft (captured on March 16, 2011)





Technology Functions Needed

- *Traffic monitoring*
 - State-based now, future: trajectory-based
- *Computation of optimized trajectory*
 - Fuel-efficient altitudes, time-saving lateral reroutes
 - Other user-specific criteria (e.g. weather avoidance buffers)
 - Optimized to destination (as opposed to real-time temporary optimization)
 - Based on highly accurate aircraft knowledge (e.g. performance of this airframe/engine, current weight, sensed winds and weather)
- *Conflict detection and resolution*
 - Integrated with optimization function (above)
 - Traffic and weather avoidance, as an integrated capability
- *Conflict prevention*
 - Probing of pilot-preferred trajectory changes for conflicts
 - Display of conflict-free options (lateral and vertical)

***NASA has this airborne technology now – contains all of these functions.
Has been matured through a decade of self-separation R&D.***

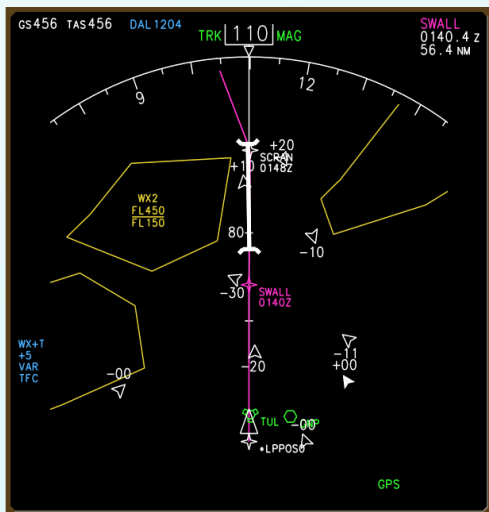


Mature Technology for Airborne Trajectory Mgmt.

Autonomous Operations Planner (AOP)

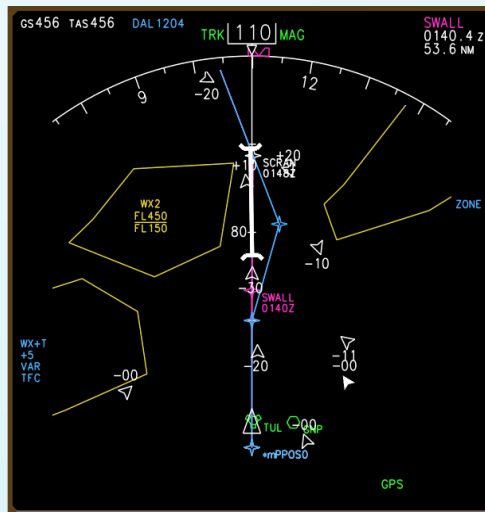
Conflict Management Functions

Conflict Detection

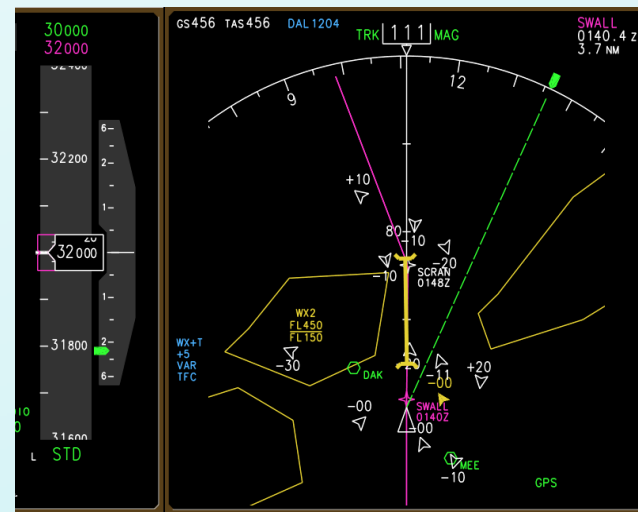


Intent-based
Prediction uncertainty handling
Priority-based alerting

Conflict Resolution Guidance



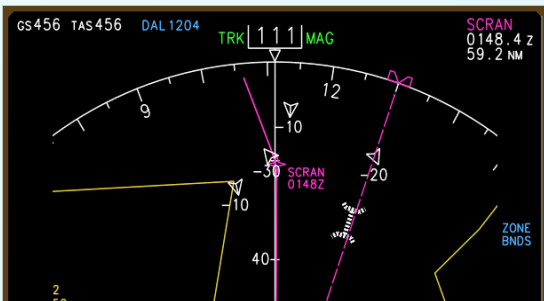
Strategic (FMS) intent-based
All traffic, hazards, constraints
Flight Optimization



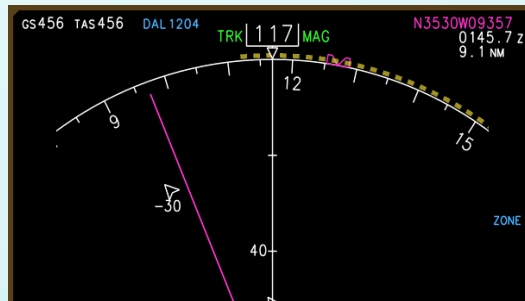
Tactical (MCP) all autoflight modes
All traffic, hazards (intent-based)
Maneuver coordination (state-based)

Conflict Prevention Functions

Trajectory Planning Guidance



Potential maneuvers: "what if..."



Maneuver restrictions "at a glance"

Conformance and Predictability Functions

Conflict-free
Path Stretching to
Meet RTA

Conflict-free
Reconnect to
FMS Route



Mature Technology for Airborne Trajectory Mgmt.

Autonomous Operations Planner (AOP)

AOP functions prototyped and integrated with modern 429 avionics suite model

- Traffic separation in FMS and MCP flight modes
- Trajectory constraints conformance
- Provisional probing for conflict-free trajectory changes
- Coordination with traffic
- Optimization of trajectories (within de-confliction)

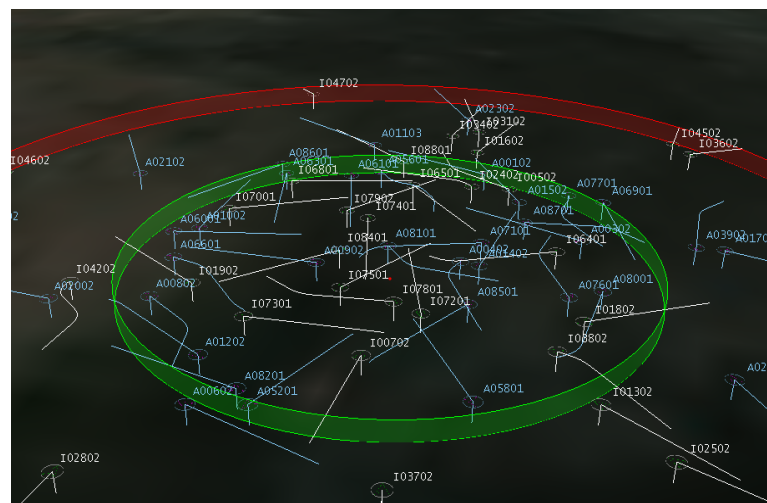
Algorithms stress-tested in batch simulations with extreme high traffic density

- Up to 10x traffic density, randomized scenarios
- Pilot delay effects
- Wind uncertainty effects
- ADS-B range and interference effects
- Dynamic weather avoidance w/ traffic separation

Procedures and tools tested in dynamic human-in-the-loop (HITL) simulations

- Simultaneous traffic and flow constraints (RTA)
- Strategic and tactical separation
- Mixed operations (airborne and ground control in shared airspace)
- Delay absorption w/ traffic separation

Batch Simulations for Stress Testing

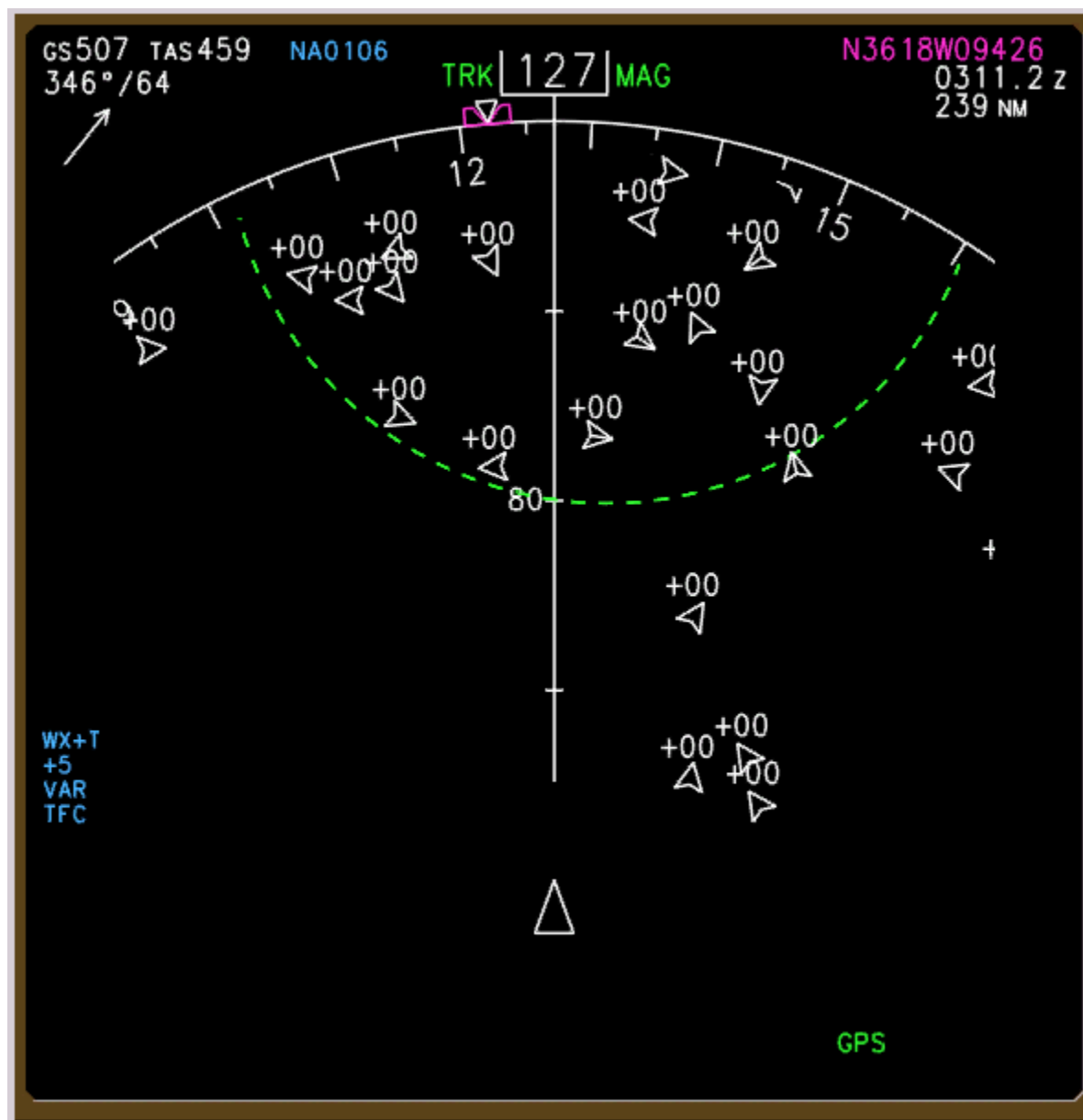


HITL Simulations for Operations Testing





AOP Movie of Conflict Detection & Resolution (~10x playback speed)





Pilot Tool for Traffic-Aware Planning

How it Would Be Used

Traffic Aware Planner (TAP)

- To be created by leveraging the mature functions of AOP
- Hosted on an Electronic Flight Bag (EFB)

TAP running in background

- Monitor for trajectory improvement opportunities
- Notify flight crew when {pre-programmed preference} is available
 - Shortcut or modified route
 - New cruise altitude

TAP use initiated by flight crew

- Provide tools for pilot to discover / probe trajectory changes
 - “Weather is impacting my current route. What conflict-free reroutes are available?”
 - “Due to turbulence, I need a new altitude. Is this altitude free of conflicting traffic?”
- Support pilot in periodically optimizing the flight
 - “Can I save fuel or time with a new route/altitude? What route/altitude?”





Initial TASAR R&D Plan (FY11-13)

- *Quantify the expected opportunities and benefits*
 - Specific to TASAR concept
- *Assess requirements for equipment certification and operational approval*
 - Preliminary analysis says these should be relatively light
- *Design and develop a software/hardware prototype implementation of the flight-deck technology for use in simulation research, flight trials*
 - Leverage mature AOP functions to create “Trajectory Aware Planner” (TAP)
 - Customize optimization function based on user-specified criteria
 - Modify optimization trajectory patterns to facilitate voice requests
 - Develop EFB instantiation and interface
- *Conduct a pilot assessment of the human interface design*
- *Create partnerships and prepare for flight trials*



Motivation and Benefits

Achievable in near term

- Doesn't require widespread equipage of ADS-B IN (even one aircraft is sufficient)
- Doesn't rely on new ground-based services or infrastructure
- Should have minimal certification and operational approval requirements

Offers tangible user incentives

- User may receive immediate improvements in flight efficiency during evaluation
- Gives user-specific data for ADS-B IN business case (for future applications)

Potential to motivate and accelerate ADS-B IN equipage



Backup Charts

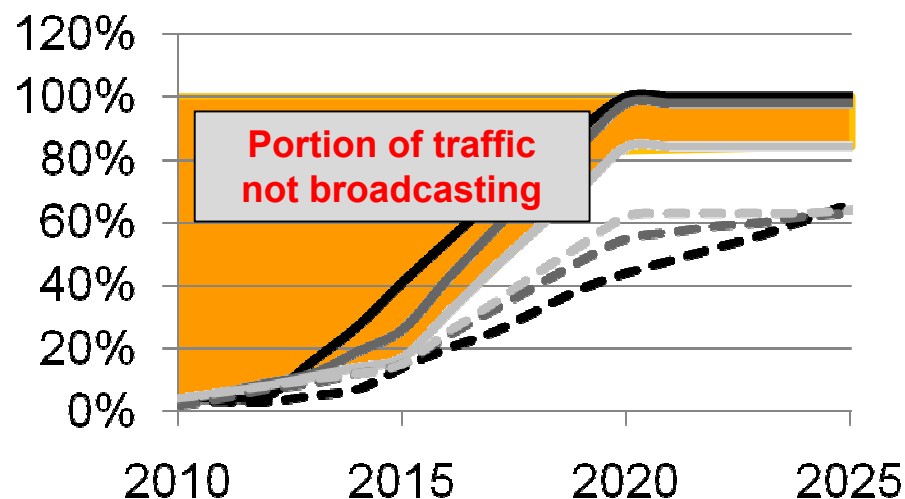


Technical Considerations

Surveillance Coverage

Issues

- Substantial but decreasing proportion of traffic not yet ADS-B Out equipped
- TIS-B is inadequate to compensate: it heavily filters its broadcast by quadrant and traffic pair proximity
- Potential to reduce achievable benefits



Possible solutions (all require exploration and/or partnering)

- TIS-B system modification
 - Remove or relax filtering; leverage overlapping of TIS-B service volumes
 - No additional receiver required
- Commercial services (e.g., in-flight internet, satellite S-band radio)
 - Bandwidth and refresh rates may be issues
 - *Class One User* status required to receive near-real-time ASD/NASSI data
- SWIM uplink (longer term solution, too late for Segment 1)
- Focus application on regions with high ADS-B surveillance



Technical Considerations

Operational Implementation

Operational Approval Requirements

- There should be no operational approval requirements. No operations are changed. The TASUR concept is not requesting “operational credit.”

EFB Minimum Hardware Requirements¹

- Class II EFB (portable, connected, requires administrative control process)
- No data transfer from EFB to aircraft system

EFB Software Requirements and Restrictions¹

- TAP would be categorized as Type B software (dynamic, interactive applications that can manipulate data and presentation)
- Requires evaluation, but not FAA design approval
- No ownership position to be shown on moving maps (at present)
- FAA approval is based on operator’s training and procedures

Software Certification Requirements²

- As Type B software, TAP does not require compliance with RTCA DO-178B

¹ FAA Advisory Circular 120-76A ² RTCA DO-178B