

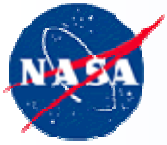
Self-Separation with “Autonomous Flight Rules”

David Wing and Tim Lewis

Crew Systems and Aviations Branch
Airspace Concepts and Technology Development Project

AFRL-FAA Visit
NASA Langley Research Center

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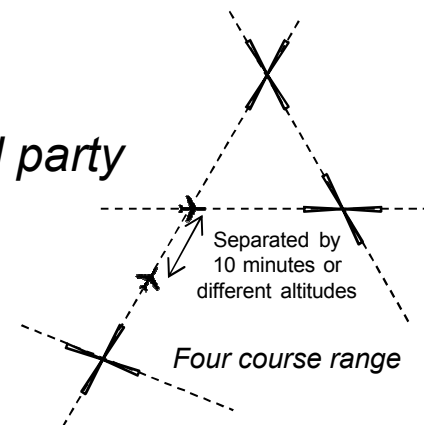
Agenda

- *Concept and flight-deck technology overview*
- *Demonstration scenario*
- *Technology update in progress – for discussion*
 - Flight-deck technology capability updates
 - Display changes under consideration (shown in mockup tool)

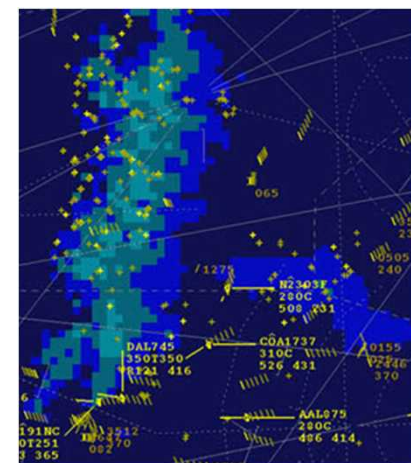


Origins of IFR Flight Restrictions

- *Early IMC navigation limited to a few radio-defined airways*
- *Surveillance by position reports, communications through third party*
 - Led to ATC procedural separation by assignment of route, altitude, speed
- *Indirect routes, alt/speed restrictions became the norm*



- *By 1960s – radar, direct pilot/controller comm., RNAV*
 - New technologies enabled reduced separation standards
 - But assignment of route, etc. still the norm
- *Airspace “sector” controller became the limiting factor*
 - Limitations of human cognition demands “orderly” traffic flows
 - Sectors, human capabilities limit numbers of aircraft simultaneously handled
 - Airways, “preferred” routes, cardinal altitudes, “pass back” of delays
- *Restriction, delay, and inflexibility still the norm for IFR*
 - Necessary to enable ATC to maintain responsibility for separation
 - Inefficient routing, non-optimum altitudes, reduced speeds
 - Miles-in-trail spacing, ground delay programs due to en route “congestion”
 - En masse rerouting for weather

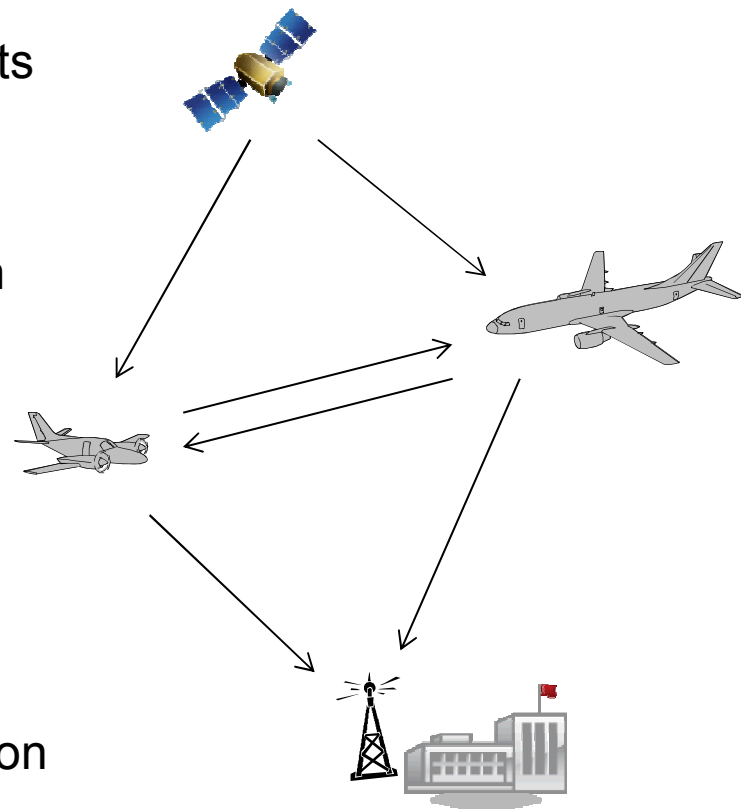


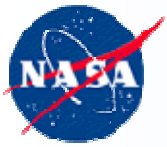
Radar display



Maturing Technology Enables Alternative

- *Navigation*
 - GNSS, RNP-RNAV for all-weather, all-points precision navigation
- *Airborne surveillance*
 - ADS-B OUT/IN for high-rate, high-precision air-to-air surveillance
- *Computational capabilities*
 - Onboard automation providing conflict detection, resolution and prevention flight guidance
- *Air-ground data communications*
 - Supplemental airspace and traffic information
 - ANSP coordination
 - Arrival planning





Autonomous Flight Rules (AFR)

A Concept for the Airspace User to Recover Flexibility

- *A proposed companion to IFR and VFR*
 - IMC (and VMC) alternative to IFR and its costly restrictions
 - “For Spacious Skies” – primarily an en-route concept that leverages the vast capacity of the airspace
 - Self-separation is the enabling capability
 - Removes aircraft from ATC separation responsibility
 - Withdraws aircraft from ATC-related “congestion” that results in many IFR restrictions
 - Designed for non-intrusive mixed operations with all traffic
- *Why a New Rule Set?*
 - Preserve what already works
 - Opportunity to define it properly and uniquely
 - Phase it in gradually
 - Set proper expectations for pilot responsibility



The Key Elements of AFR Operations

AFR Operators



Infrastructure

1. ADS-B & TIS-B for surveillance
2. SWIM & CPDLC for comm.

Mixed Operations

1. IFR has right-of-way
2. AFR coordination of burden and maneuvers
3. VFR see-and-avoid
4. ANSP arrival scheduling

AFR Pilot Rules & Procedures

1. Separate from traffic
2. Maneuver w/o conflict
3. Fit into ANSP TFM plan

AFR Automation Tool



Tool monitors the traffic and airspace hazards continuously during the flight

Tool also ensures all traffic and hazards are avoided

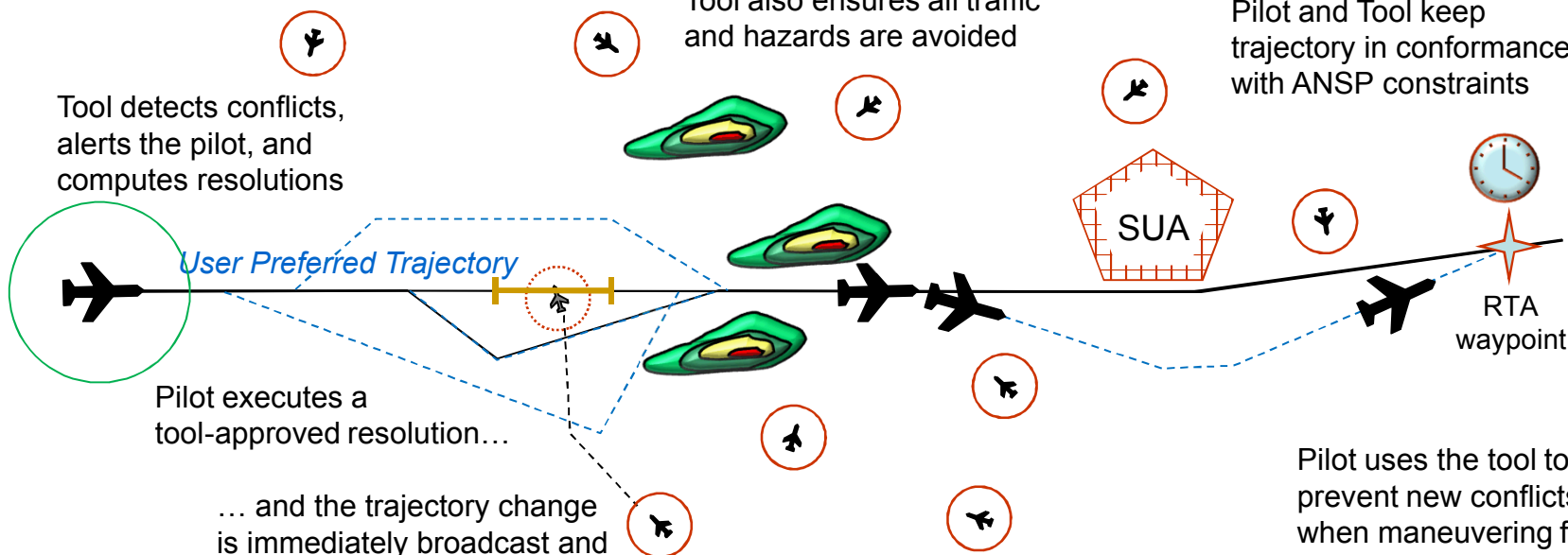
Pilot and Tool keep trajectory in conformance with ANSP constraints

Tool detects conflicts, alerts the pilot, and computes resolutions

Pilot executes a tool-approved resolution...

... and the trajectory change is immediately broadcast and downlinked to ANSP

Pilot uses the tool to prevent new conflicts when maneuvering for weather, turbulence, etc.



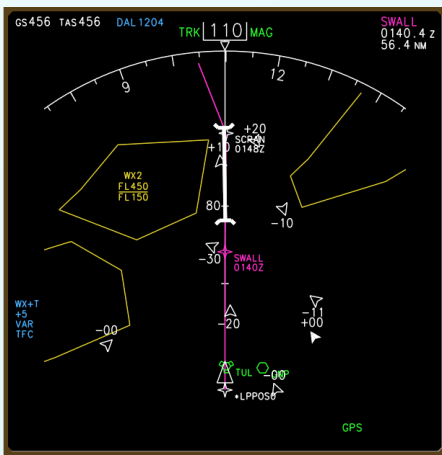


Avionics Technology for Self-Separation

NASA "Autonomous Operations Planner" (AOP)

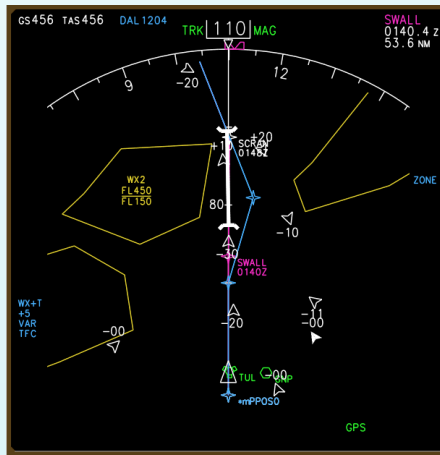
Conflict Management Functions

Conflict Detection

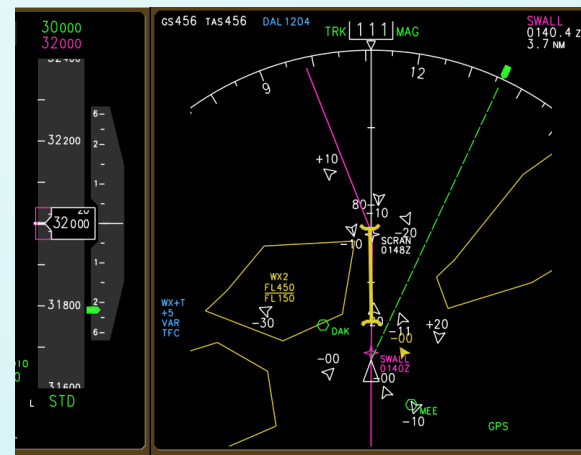


Intent-based
Prediction uncertainty handling
Priority-based alerting

Conflict Resolution Guidance



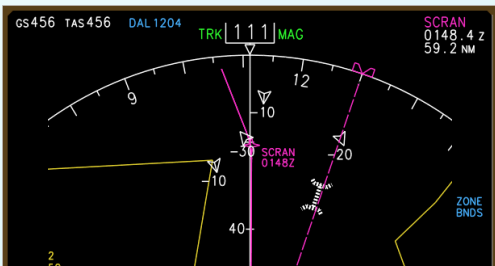
Strategic (FMS) intent-based
All traffic, hazards, constraints
Flight optimization



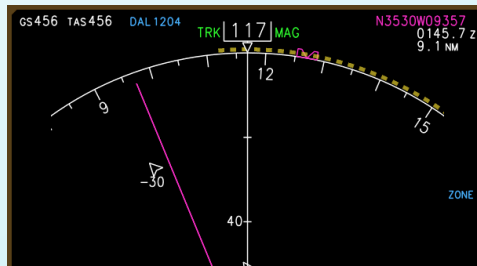
Tactical (MCP) all autoflight modes
All traffic, hazards (intent-based)
Implicit coordination of maneuvers

Conflict Prevention Functions

Trajectory Planning Guidance



Potential maneuvers: "what if..."

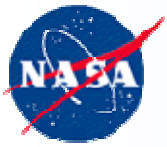


Maneuver restrictions "at a glance"

Conformance and Predictability Functions

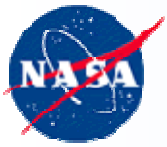
Conflict-free
Path Stretching to
Meet RTA

Conflict-free
Reconnect to
FMS Route



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AOP Updates in Progress

- *Regrouping self-separation functions*
 - Primary CD&R, Secondary CD, Strategic Planning, Tactical Planning
 - Improve conflict management near Top-of-Descent
- *Improving strategic CD&R capabilities*
 - Start strategic resolutions automatically
 - Redesign the “reconnect” feature with better routes, conflicts resolved
 - New CD&R capabilities for MOD routes and FMS coupling
- *Improving tactical CD&R capabilities*
 - Exhaustive search with fitness-based selection
 - Integration of intent-based and state-based algorithms
 - Implicit coordination with traffic aircraft maneuvers
- *Redesigning interfaces and procedures*
 - New “status and planning” panel (the “SNAPI”)
 - Auto-navigate between AOP pages based on situation context
- *Modifying conflict symbology and display*
 - Clutter reduction, focus on key information
 - Planning conflicts linked to AOP page, pilot preference





SNAPI Panel

Status Notices and Planning Indicators

Purpose: Primary information critical for AFR responsibilities

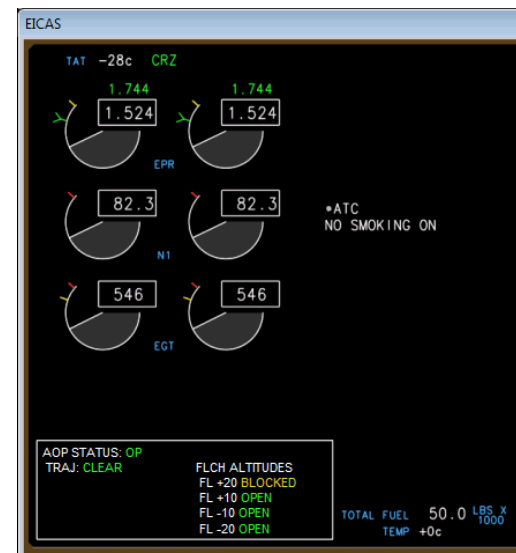
- Always visible, persistent location
- Simple text, context sensitive
- **AOP overall status/health**
- **Clear indication of conflict status**
 - Primary conflicts with color-coded alert level
 - “Clear” means no action required
 - Secondary conflicts with MCP ALT reset reminder
- **Clear indication of planning trajectory conflict probe**
 - Mod route, FMS coupling, tactical plans
 - “Clear” means pilot may execute the plan
- **Tactical conflict resolution options**
 - Shown if pilot-selected, in tactical MCP mode, or “override”
 - Lateral and vertical options
- **Change-altitude probe**
 - Similar to maneuver restriction bands

AOP STATUS: OP
TRAJ: CONFLICT
FLCH ALTITUDES
FL +20 BLOCKED
FL +10 OPEN
FL -10 OPEN
FL -20 OPEN

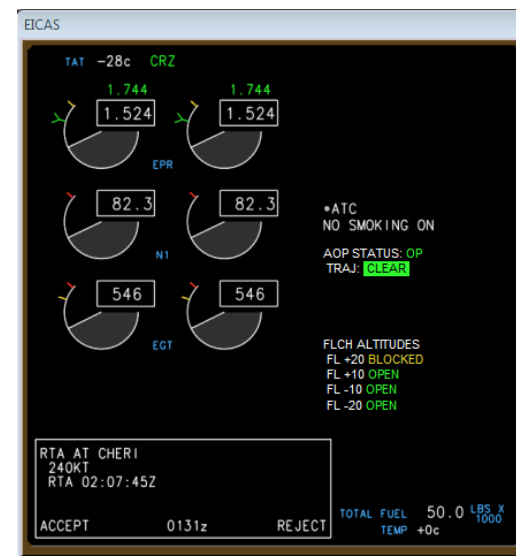
AOP STATUS: OP
TRAJ: CONFLICT
RECOUPLE: CLEAR
TACTICAL RES
LAT: LEFT TO 285
VRT: CLIMB TO FL370
FLCH

Sample
status and planning
indications

AOP STATUS: OP
TRAJ: CLEAR
MOD RTE: UNABLE RTA
RECOUPLE: CLEAR
MCP PLAN: CONFLICT
FLCH ALTITUDES
FL +20 BLOCKED
FL +10 OPEN
FL -10 OPEN
FL -20 OPEN



EICAS location alternatives





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