



TASAR Overview Briefing

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“Traffic Aware Strategic Aircrew Requests”

Objectives:

1. Optimize flight trajectories for fuel and flight time
2. Increase ATC approval of user requests
3. Provide near-term benefits for ADS-B equipage, cockpit automation, and networked connectivity
4. Transition towards more advanced applications of cockpit automation for ATM & user benefit



TASAR Concept:

Pilot use of automation for improving an aircraft's trajectory

- Proactively suggests beneficial trajectory modifications (e.g., save fuel and/or flight time)
- Agile to changing conditions and environment (e.g., winds, weather)

Increase ATC acceptability of user requests

- Combines flight path optimization with traffic/hazard compatibility
- Used at pilot's discretion in making “intelligent” clearance requests to ATC

Leverage networked airborne connectivity to real-time data

- Avionics connectivity for “own-ship” data
- ADS-B connectivity for traffic data
- Internet connectivity for environmental/airspace data, operational constraints, etc.



- ✓ Per-aircraft capability
 - Not dependent on other aircraft or users to be TASAR equipped
 - Allows gradual implementation
- ✓ Leverages aircrew availability en route
 - More benefit opportunities
- ✓ No changes to current FAA systems & procedures
- ✓ No changes to aircrew/controller roles and responsibilities
- ✓ Requires no display of traffic aircraft
- ✓ Seeks no operational credit
- ✓ Compatible with low-cost hardware
 - Class 2 EFB, Type B software
- ✓ Ripe for integration and growth
 - Integrate with avionics for auto-load
 - Integrate with dispatch for improved coordination
 - Integrate with more data sources for increased awareness
 - Integrate with datacomm (when available) allowing more complex requests
- ✓ Establishes the infrastructure for expanded applications

Early adopter benefit

Workload benefit

FAA cost benefit

Policy & training benefit

Certification benefit

Operational approval benefit

Equipage cost benefit

Integration benefit

Investment benefit

TASAR Project Strategy

Approach:

Define a viable near-term, low-cost, operational concept, and assess its benefits

Assess FAA certification and operational approval requirements, and vet with FAA

Develop the technology and mature it through simulations and flight trials

Partner with airlines for operational-use testing, leading to tech transfer

Leverage operational usage to mature & expand to future applications



Emerging Airline Partnerships



Ready to Work with NASA

Traffic Aware Planner

Auto Mode computes real-time route optimizations

- Displays lateral, vertical, and combination route change solutions
- Pre-checked to be consistent with traffic, weather, restricted airspace

Manual Mode supports pilot entry of desired routes

- Touch-screen selection with “find nearest waypoint” capability
- Computes time/fuel outcomes, traffic/hazard impacts



Operates on Class 2 EFB

Includes updated HMI suitable for modern tablet EFBs

Connects to avionics via aircraft interface

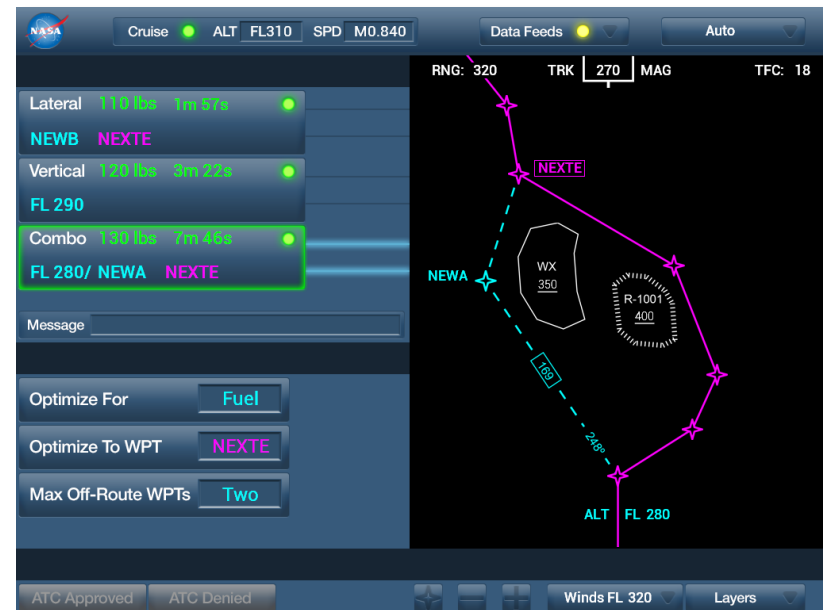
Ownship data, ADS-B data

Connects to external data via broadband

Winds, weather, airspace activation status, etc.

Leverages onboard databases

Aircraft performance; navigation database



ADS-B: Automatic Dependent Surveillance Broadcast

EFB: Electronic Flight Bag

HMI: Human Machine Interface

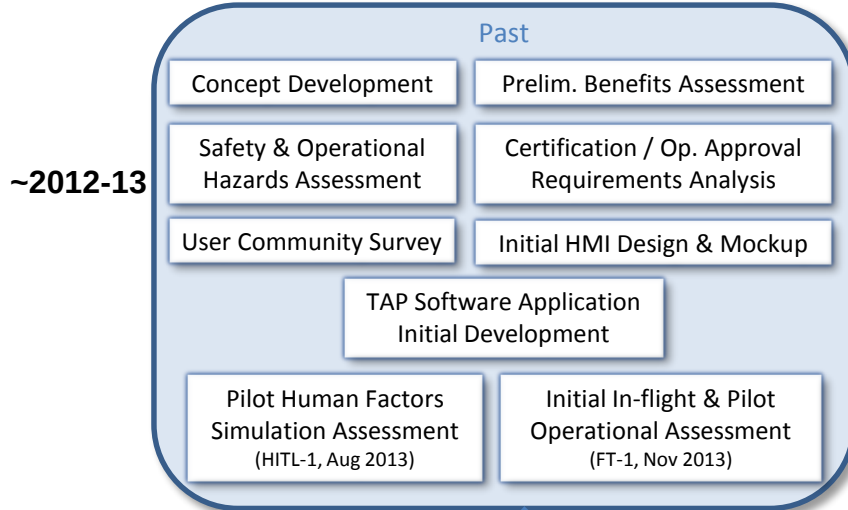


- NASA Dynamic Weather Routes
 - Ground-based capability, dispatch center (ATC desk)
 - Uses winds & Wx to detect delay-reduction opportunities
 - Lateral solutions (directs and 1 or 2 off-route waypoints)
 - Top-saving flights displayed for dispatcher consideration when able
- Boeing Direct Routes
 - Ground-based capability, subscription service
 - Based on NASA “Direct To” tool (same heritage as DWR)
 - Lateral “direct” solutions, includes some local ATC knowledge
 - Solutions uplinked directly to aircraft via ACARS
- Pace Labs
 - Airborne capability, EFB application (Class 2)
 - Powerful flight profile optimization capability
 - Longitudinal solutions including step climbs
 - Re-computes ECON speeds/altitudes based on real-time aircraft data

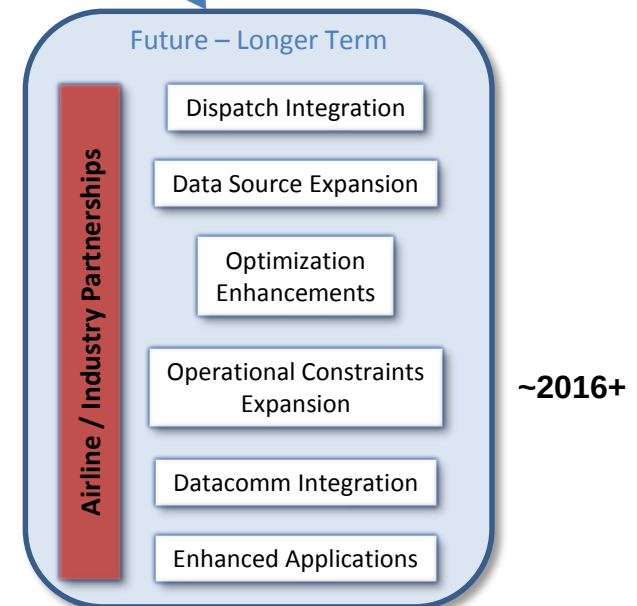
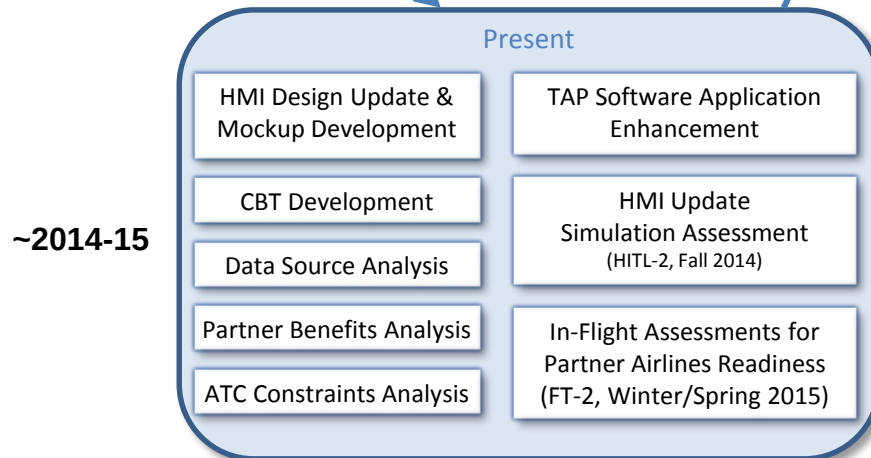
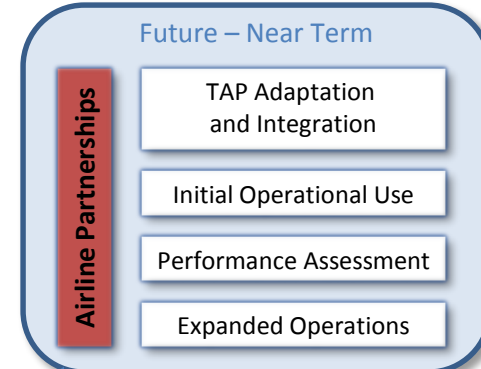
TAP's Unique Combination of Capabilities

- ✓ Accesses real-time flight data from avionics
 - Aircraft data (accurate), ADS-B (air-to-air, non-delayed)
- ✓ Optimizes independently for time savings or fuel burn
 - Future option: weighted time/fuel (customized per flight, per airline)
 - Future option: include add'l complex cost factors (e.g. overflight fees)
- ✓ Produces lateral and vertical solutions
 - Plus independent lateral/vertical “combo”
- ✓ Solutions include 3 competing reroute patterns
 - “Directs” plus 1, 2 off-route waypoints
- ✓ Solutions not filtered for only large time savings
 - Pilots not workload limited en route, small savings accumulate
- ✓ Solutions are filtered for traffic/hazards
 - To increase ATC approval frequency
- ✓ Solutions displayed to pilot in context
 - Winds, weather polygons, restricted airspace, conflicting traffic
 - Compare to FMS active route
- ✓ Manual mode for in-situ adjustments, trial planning
 - Also aids timing of ATC requests of ground-based solutions

Concept & Technology Development

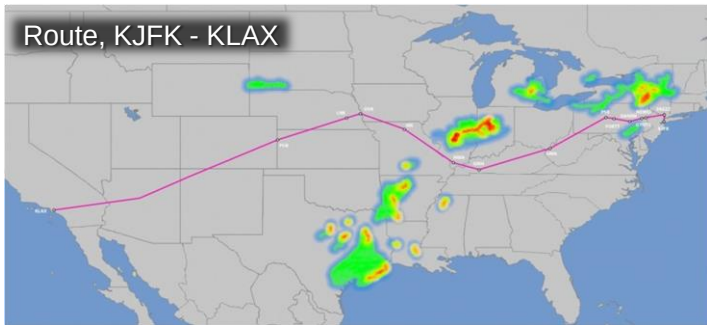


Operational-Use Assessment



Airline Partnership Development

Integration & Growth



- Conducted in August 2013
- TAP v2, Goodrich Class 2 EFB
- OPL fixed-based flight deck simulator
- 2 simulated routes, 5 use cases
- 12 pilot participants



- Implemented rigorous Human Factors experimental design
- Evaluated during normal and non-normal flight conditions

Objectives

1. Pilot assessment of TAP v2 usability during simulated flight operations
2. Assess level of interference on primary duties of the pilot

TAP: Traffic Aware Planner
 EFB: Electronic Flight Bag
 OPL: Operator Performance Lab, Univ. of Iowa

Results of Analyses

- Did not induce additional cognitive loading on the pilots compared to standard flight-deck baseline condition
- Perceived to be useful, understandable, intuitive, and easy to use
- Response to non-normal event was not adversely affected



- Conducted in November 2013
- TAP v3 installed on Class 2 EFB
- 26 hours, 9 flights, round-robin routes
- 4 route profiles from KPHF (W, SW, NE)
- 8 independent evaluation pilots

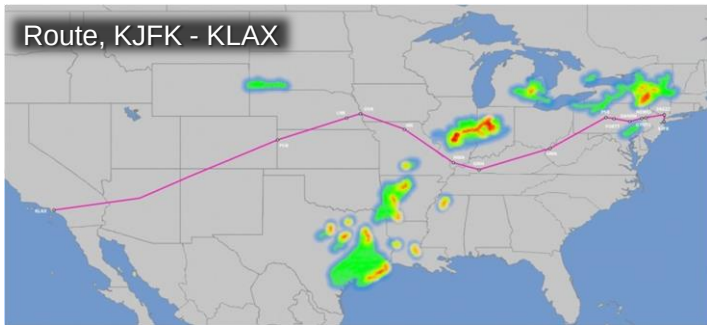


Objectives

1. Verification of live data interfaces
2. Verification of TAP v3 functionality
3. Pilot assessment of TAP v3 usability in an operational environment
4. TASAR requests to ATC

Results of Analyses

- TAP v3 functioned properly in live avionics & ADS-B environment
 - “Real world” data characterized by dropouts, latency, and ADS-B message content fluctuations
- Usability rated high and workload rated low
 - Extensive pilot feedback on TAP v3 HMI design
- Twelve TASAR requests submitted to ATC
 - Nine approved, all saved fuel and flight time



- Conducted in Oct-Nov 2014
- TAP v14.1, HMI v4, Tablet EFB
- OPL fixed-based flight deck simulator
- Same 5 use cases for comparison
- 12 pilots (incl. 9 from partner airlines)



- Implemented rigorous Human Factors experimental design
- Evaluated during normal and non-normal flight conditions

Objectives

1. Pilot assessment of TAP HMI v4
2. Assess effects of EFB multi-tasking
3. Assess efficacy of CBT for TAP

Results

- Data collection completed Nov 18, 2014
- Analysis of data in progress

TAP: Traffic Aware Planner

EFB: Electronic Flight Bag

OPL: Operator Performance Lab, Univ. of Iowa

CBT: Computer-Based Trainer

Current Activities

HITL-I & FT- I Data Analysis



No significant effect
on pilot workload

High usability
ratings

Understandable,
intuitive, and useful

Recommendations
for improvement



Significant HMI Design Update



TAP HMI v4



Airline Use Preparations



Tablet EFB

CBT Module



Partnership / Risk Reduction Activities



Data
Source
Analysis



Partner
Benefits
Baseline



HITL-2
Human
Factors

FT-2
Operational
Readiness

Formalize Airline
Partnerships
Alaska Air, Virgin Am.

Partner Aircraft
Integration Prep
Analysis / Design / Test

Convective Weather, Turbulence, and Icing

- Challenge is generating avoidance polygons
- Public source polygons (SIGMETs)
 - Conservative since used for all aircraft types
- WSI and Schneider Electric polygons
 - Tailored to jet aircraft
 - Same data source that is used by dispatchers

Special Use Airspace (SUA) Activation Schedule

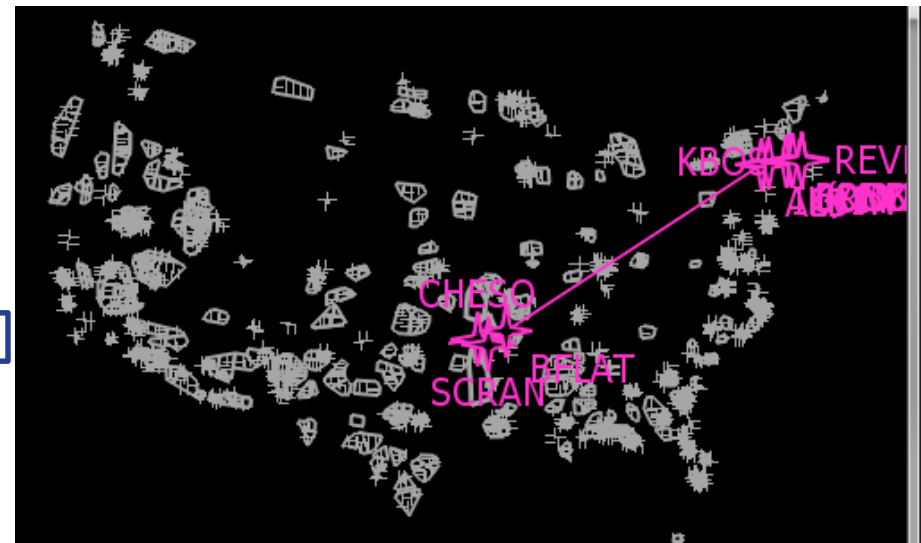
- Schedule obtained from sua.faa.gov
- Focus on prohibited, restricted, and MOA SUAs
- TAP algorithms modified to address computational issue of multiple activation schedules per SUA

Analyzed public source download time

- 200 kbps satellite internet
- 80 second download time for RAP winds during first flight test

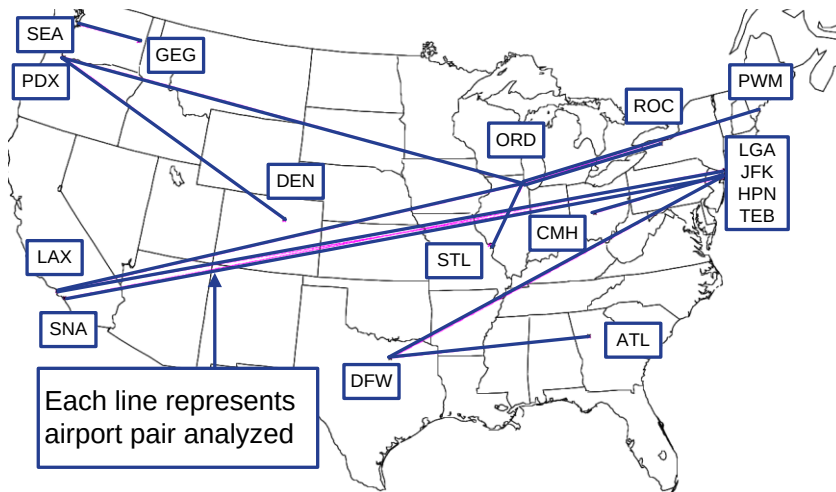
Data Provided	Description	Download Time
Convective weather	Convective SIGMET	9 seconds
	NCWD	5 seconds
Winds aloft	RAP with 40 km grid	80 seconds
Temperature aloft		
Turbulence	PIREPs	18 seconds
	G-AIRMET	18 seconds
	Non-convective SIGMETs	
	GTG	18 minutes
Icing	CIP	55 seconds
SUA status	sua.faa.gov	9 seconds

Percentage of satellite internet bandwidth used by data sources during 5 minute peak 65% (excludes GTG)



TAP screenshot showing SUAs considered by TAP

Preliminary TASAR Benefits Estimate (2012): All Airspace User Classes are Projected to Benefit

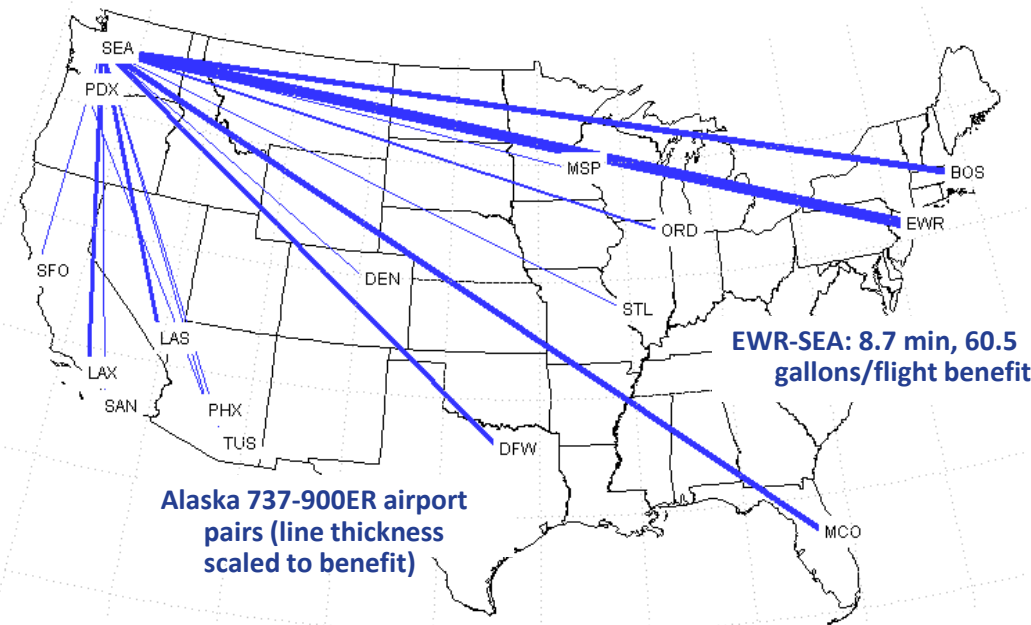


Fast-time simulation study quantified potential benefits

- Historical trajectories between 12 representative airport pairs analyzed
 - 510 flights between July 11-20, 2012
 - 300-2000 alternative trajectories evaluated for each, five minute intervals
 - Convective weather on East Coast, Midwest
- Benefit per operation analyzed for different flight objectives
 - Mean savings per flight shown in table
- Conservative filtering applied
 - No requests during initial climb
 - No requests with conflicts
 - One request per sector
 - No requests near handoff
 - No requests within 200 nmi of dest. airport

Class of Airspace User	Time Objective		Fuel Objective		Time/Fuel 50/50 Objective	
	TS	FS	TS	FS	TS	FS
Network	4.2	-122	3.4	575	3.6	543
Low Cost	2.9	-123	2.5	406	2.6	344
Regional	1.0	-88	0.8	137	1.0	66
Business	1.2	-22	1.6	64	1.5	53

TS: Time savings (minutes) FS: Fuel savings (pounds)



Extension of fast-time simulation study presented at ATIO 2012

Historical trajectories used as a baseline for estimating benefits

- 1,606 Alaska flights analyzed
- 1,554 Virgin flights analyzed

Fuel savings converted to cost savings using average fuel cost

- \$3.26 Alaska, \$3.03 Virgin

Time savings converted to cost savings based on aircraft maintenance and depreciation

ATC impacts

- 4 to 8 TASAR requests per sector during peak hour

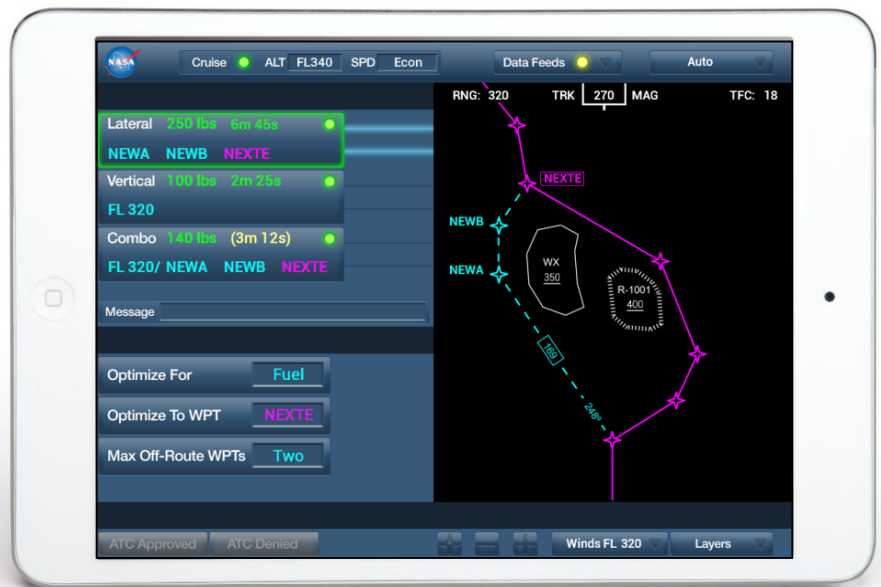
Operator	Annual TASAR Fuel Benefit	Annual TASAR Time Benefit	Annual Benefit (est.)
Alaska* 109 737s	1,040,000 gallons @ \$3.26/gallon = \$3,390,000/year	110,700 min @ (\$17 to \$28/min) = \$1,759,000/year	\$5.15M
Virgin 53 A320s	1,411,000 gallons @ \$3.03/gallon = \$4,275,000/year	133,500 min @ about \$6/min = \$812,000/year	\$5.09M

* Excludes Alaska, Oceanic, and international operations

FT-1



FT-2



Goal: Increase operational readiness for partner airline activities

Plan: 6 flights from PHF to SE airports
(Jacksonville and Atlanta ATC Airspace)

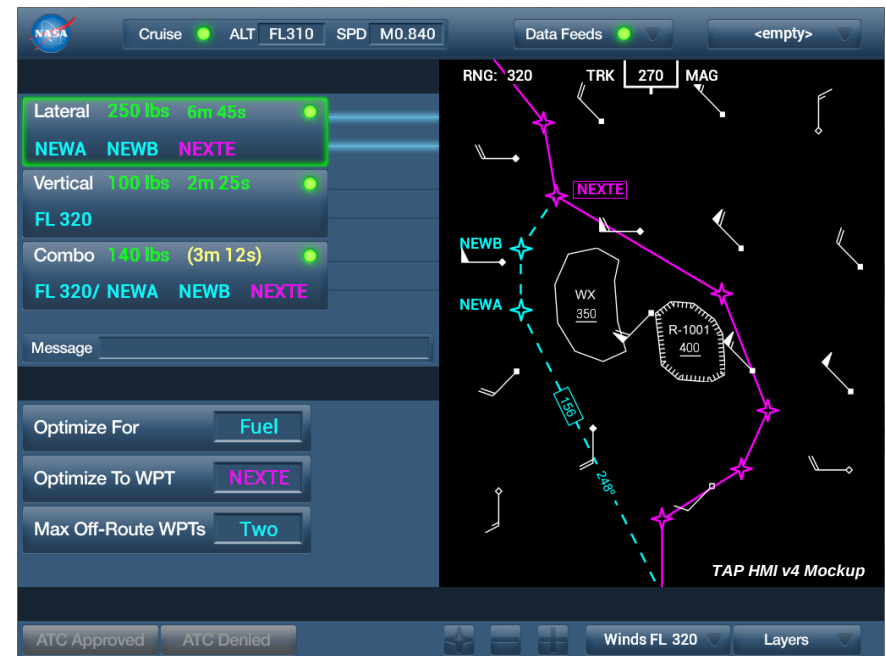
Schedule: Spring 2015 (2 week duration)



Objectives:

1. Verify TAP software operates effectively on partner airlines hardware
2. Verify processing of external data
3. Assess the methodology to characterize TAP computed outcomes
4. Assess acceptability of TASAR requests
5. Assess usability and acceptability of TAP HMI
6. Assess effect on Crew Resource Management (CRM)

- **Concept definition**
 - AIAA-2012-5623, NASA/CR-2013-218001
- **User benefits (preliminary)**
 - AIAA-2012-5684
- **Low-cost, near-term approach**
 - AIAA-2013-4231
- **Safety and operational hazards**
 - NASA/CR-2013-218002
- **Certification and operational approval**
 - DASC.2013.6712530, Best in Session
- **TAP software application description**
 - AIAA-2013-4967, AIAA-2013-4968
- **HITL-1 simulation experiment**
 - Pending NASA CR
- **Flight Trial 1 (FT-1)**
 - AIAA-2014-2166, NASA/CR-2015-218673

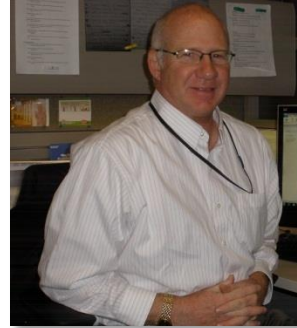


The TASAR Team

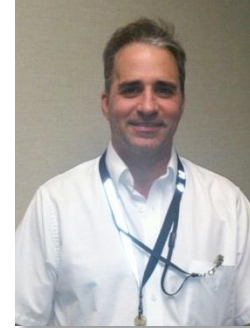
LaRC Crew Systems



LaRC Procurement



Mymic (LITES)



Cotton Av. (NIA)



Engility Corporation (NRA/LITES)



Rockwell Collins / Univ. of Iowa (NRA)



Advanced Aerospace Solutions / Marinvent Corporation (NRA)



