Assessment of Air Traffic Controller Acceptability of Aircrew Route Change Requests

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Outline

- Background and Motivation
  - TASAR Concept and Technology Overview
  - TASAR Flight Trial Overview
- Controller Acceptability Assessment Approach and Data Collection: Observations and Interviews
- Event Observations Overview
- Results from Interviews
  - General Statistics
  - Quantitative Acceptability Factor Characterization
- Concluding Remarks
- Current and Future Activities

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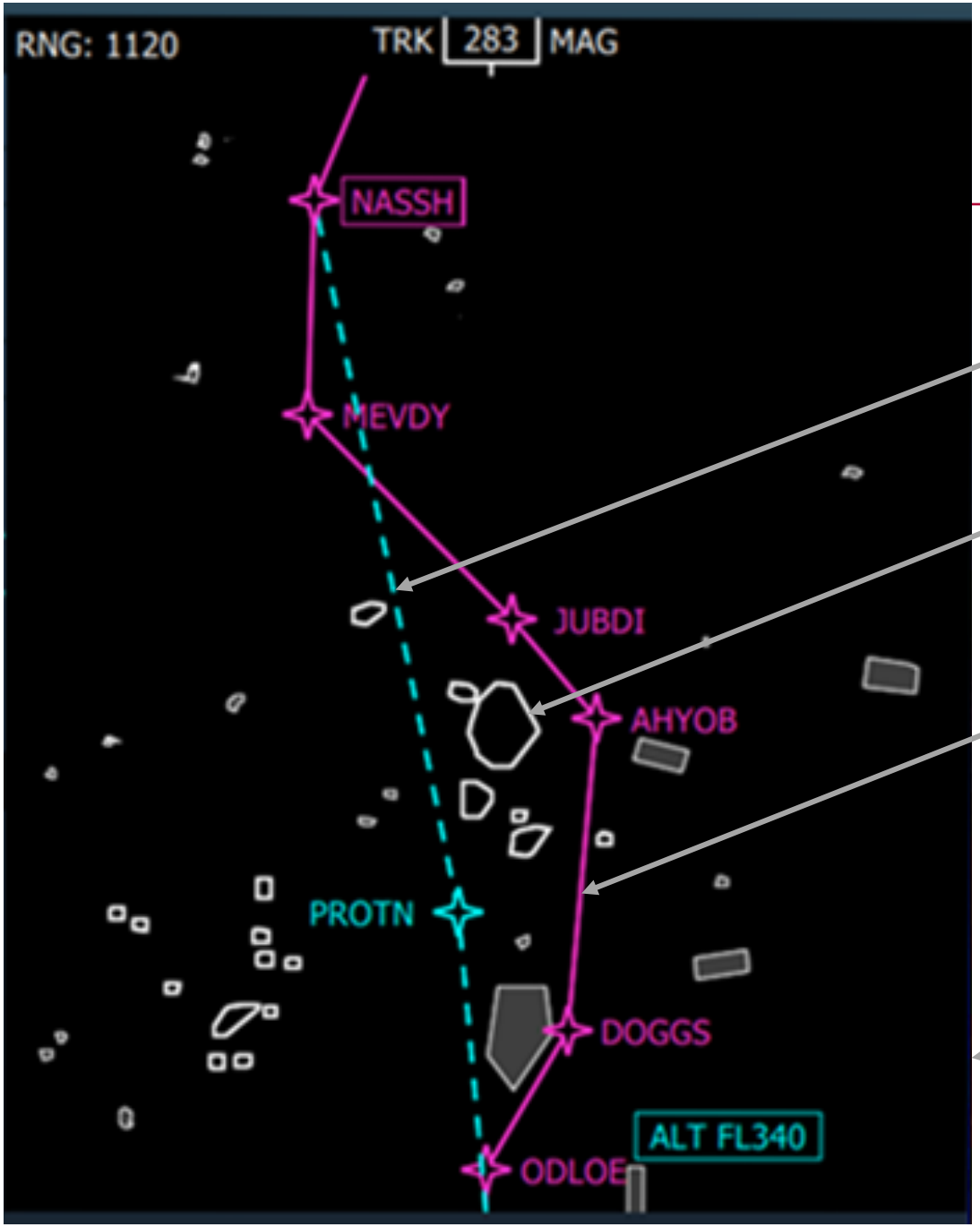
TASAR Overview

- Traffic Aware Strategic Aircrew Requests (TASAR) is a NASA NextGen concept intended to assist flight optimization while accounting for wind and traffic interactions
- Advises aircrew of routes that save time or fuel and avoid known constraints such as traffic and weather

Traffic Aware Planner (TAP) Electronic Flight Bag (EFB) Application

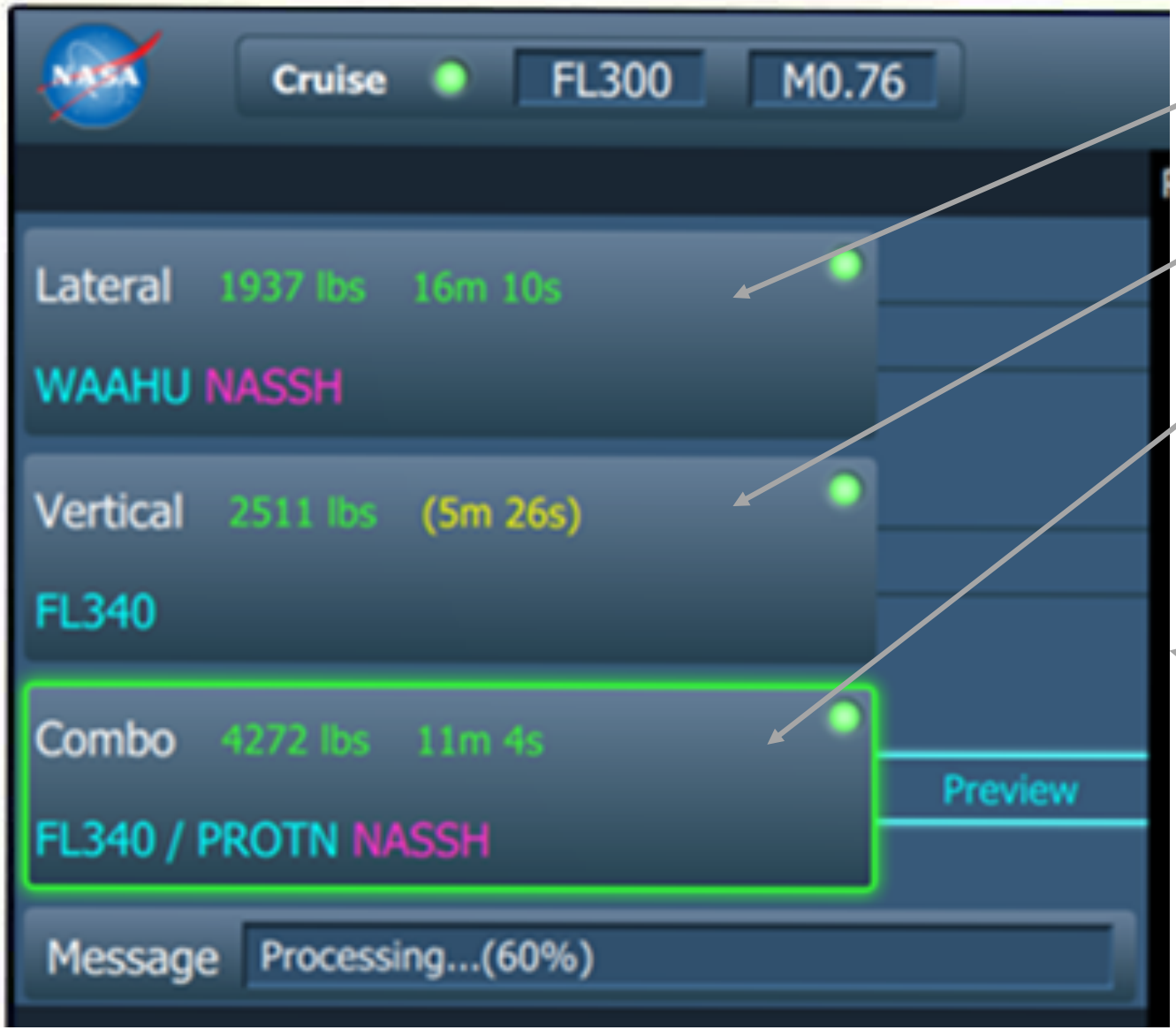


Proposed route

Hazards

Current route

TASAR Multiple Route Advisories



Lateral route advisory

Vertical route advisory

Combination route advisory – Selected as best choice

TASAR Pilot Inputs

Pilot enters objective which can come from dispatcher: optimize time, fuel or trip cost

Pilot enters return waypoint limit

Pilot enters maximum additional waypoints

TASAR Benefits Overview

- Benefit for users in terms of time and fuel savings – Initial fast-time simulation benefit assessment estimated
  - 1-4 minutes saving per flight
  - 50-550 lbs fuel savings per flight
  - (Henderson et. al. 2012)
- Increase in controller acceptance of requests by avoiding known constraints
  - ADS-B traffic from aircraft within range equipped with ADS-B Out
  - Weather, restricted airspace, flow restrictions through internet connectivity
  - On-board radar weather (planned)

TASAR Previous Research Activities

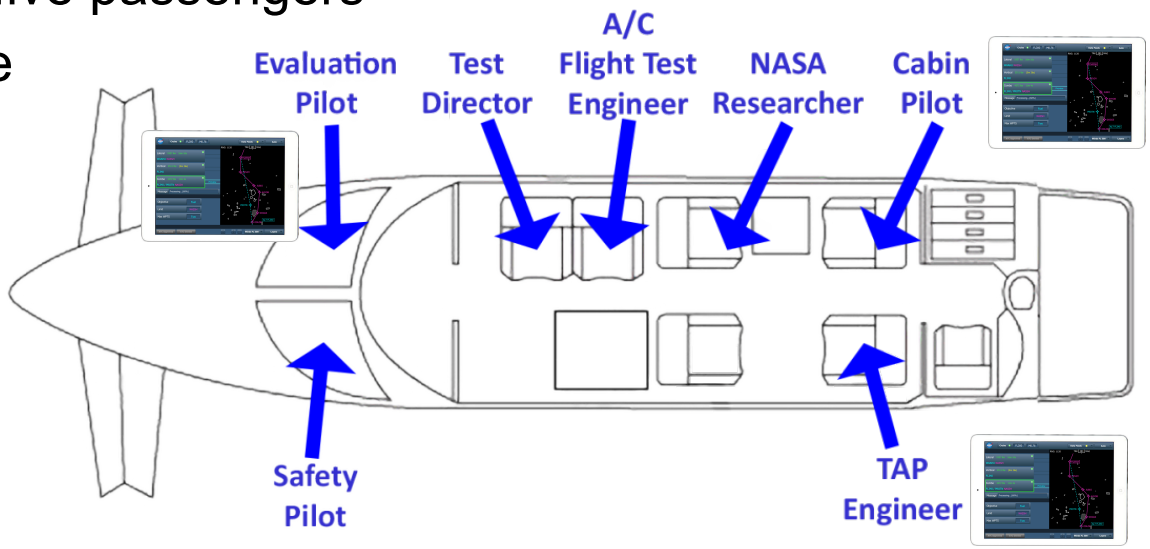
- Fast time benefit assessment
- Safety and certification analyses
- Prototyping and human machine interface (HMI) design
- Human-in-the-loop simulations for human factors analysis, for example: workload, distraction, and usability
- Flight testing
  - Flight Trial 1: Proved concept and technology feasibility in operational environment
  - Flight Trial 2: Proved operational readiness in airline environment and assessed pilot and controller acceptability (topic of this paper)

Related Research Activities

- NASA's National Airspace System Evaluation and Notification Tool (NASCENT) is ground-based platform for route change advisories
  - Provides single-flight route change advisories to airline dispatchers
  - Provides multiple-flight common-route (MFCR) advisories to traffic flow managers
- NASA is investigating air-ground integration between these tools
- Identification of controller acceptability of route changes based on objective analysis of historical traffic and flight amendment data
  - Recent publication: Evans et al, Aviation Forum 2017
  - Compliments the subjective analysis using observations and interviews presented in this paper

TASAR Flight Trial 2 Overview

- Flight trial had multiple objectives including data processing, pilot evaluation of TAP interface and controller acceptability of route change requests
- Flight test aircraft: AdvAero's Piaggio Avanti P180 – Envelope: FL410, 400 knots; two pilots and five passengers
- Evaluation pilots were senior captains from Alaska, Virgin, and other airlines
- Aircraft fitted with three instances of TAP software



TASAR Flight Trial 2 Overview

- Six Flight Pairs from Newport News VA, Patrick Henry Field (KPHF):
  - Two to Birmingham International Airport (KBHM) and two to Montgomery Regional Airport (KMGM) in Atlanta center (ZTL) to interact with high traffic
  - Two to Tampa International Airport (KTPA) in Jacksonville center (ZJX) to interact with special use airspace (SUA)
- During June 8-16, 2015 – outbound in morning, inbound in afternoon

- Researchers stationed at ZTL and ZJX
  - Controller observations during Avanti transits and interviews with volunteer controllers
  - Coordination with Area Supervisors on flight plans, reroute requests, and interviews
- Pre-approval from FAA and NATCA

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Controller Acceptability Assessment Overall Approach

- **Overall Goal: Identify key factors that impact air traffic controller acceptance of pilot requests to change their trajectories while in flight**

- Two independent activities conducted by observers

1. Observations of controller handling of Avanti pilot requests
   - Some requests made as suggested by the TAP tool
   - Some requests were pre-scripted to invoke acceptance factors of interest
   - Discussed acceptance issues with controller in follow-up interview
   - Provided anecdotal examples of controller acceptance issues

2. Focused Interviews with volunteer controllers
   - To elicit general statistics about controller acceptance factors
   - To quantify two types of controller acceptance factors:
     1. Requests interaction with airspace structure such as sector boundaries and SUA
     2. Maneuver complexity such as number of waypoints

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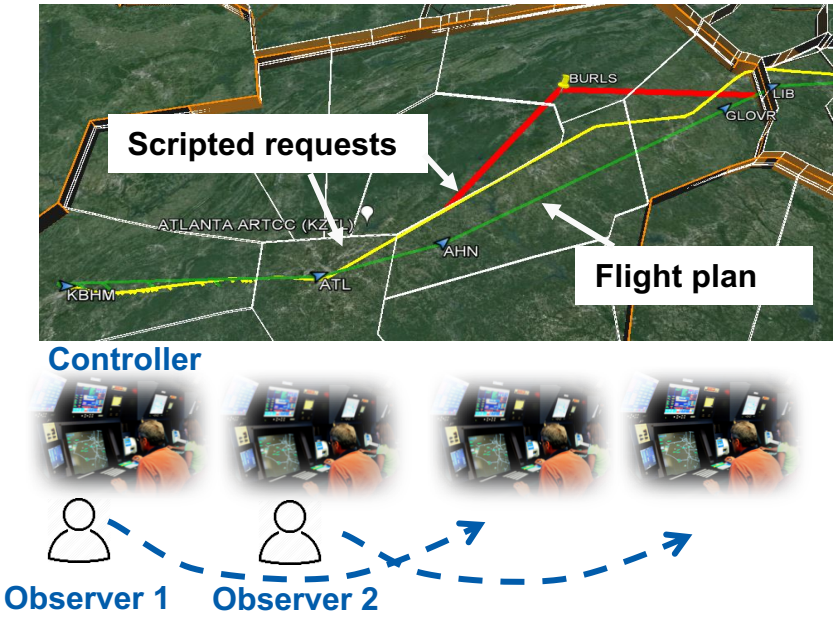
Observation Process

Process planned with facility management and approved by NATCA

1. Before flight, ground observers adjust flight plans and scripted scenario based on weather and traffic, and convey them to airborne team in teleconference

2. While enroute, engineer onboard selects scenario based on flight position and conveys request to evaluation pilot who makes request from controller

3. Controller, not aware of test, clarifies, coordinates, accepts, or rejects request while shadowing observer takes notes



4. Observers follow flight from sector to sector

5. After flight, each observer conducts interviews with shadowed controllers – interviews are coordinated by area supervisor

Scripted Event Observations

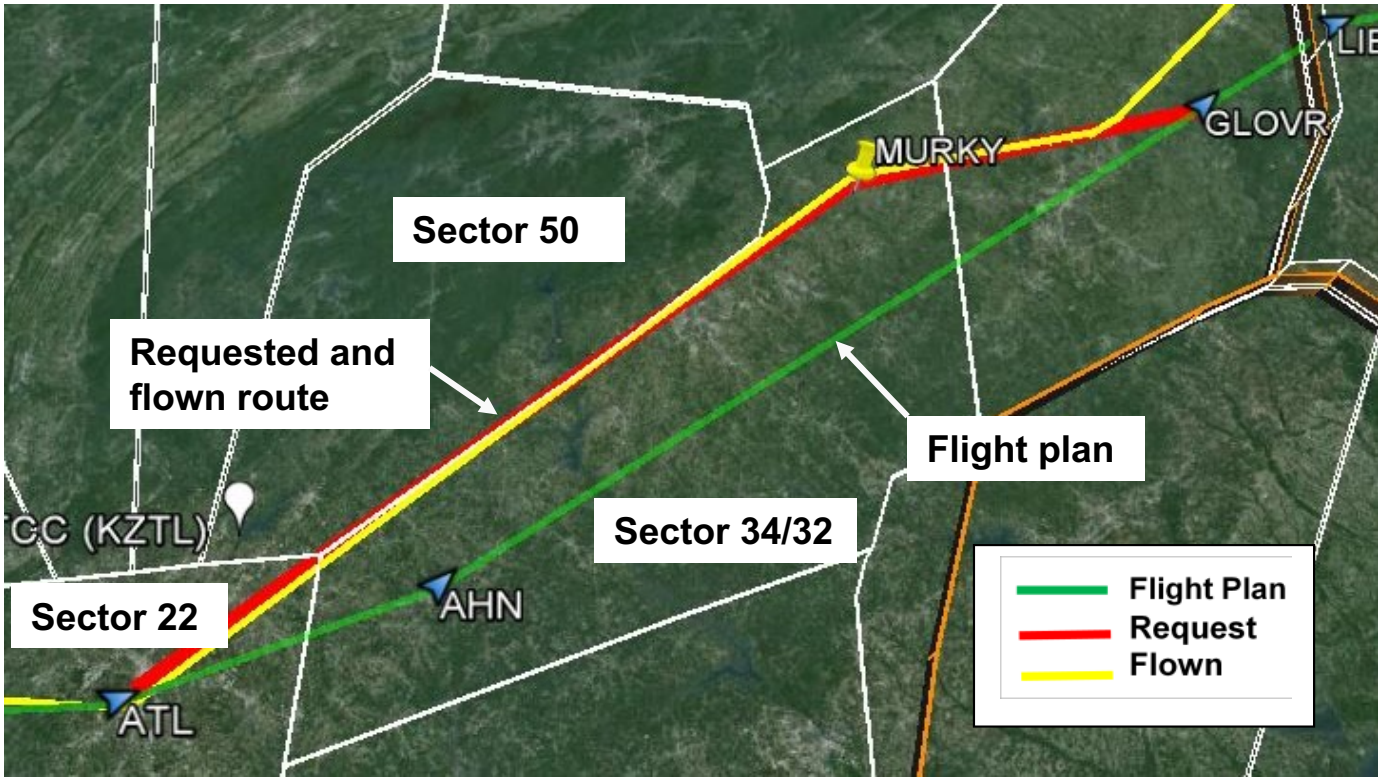
- Observed controllers were elicited about the observed requests made by the Avanti
- Total of 36 requests were made (7 requests from tool advisories)
  - 19 requests accepted without delay (4 requests form tool advisories)
  - 9 requests accepted with delay due mainly to coordination needs (2 from tool advisories)
  - 8 requests rejected for seven different reasons (only 1 from tool advisory)

  Workload during event elicited from controller or estimated by observer

Rejections	Reason	Workload
2	Handoff	Moderate
1	Weather	High
1	Unfamiliar fix	Low
1	LOA violation	Low
1	Opposite to traffic	Low
1	Center intrusion	Low
1	Active SUA intrusion	Moderate

Example Event: Request Flies Along Sector Boundaries

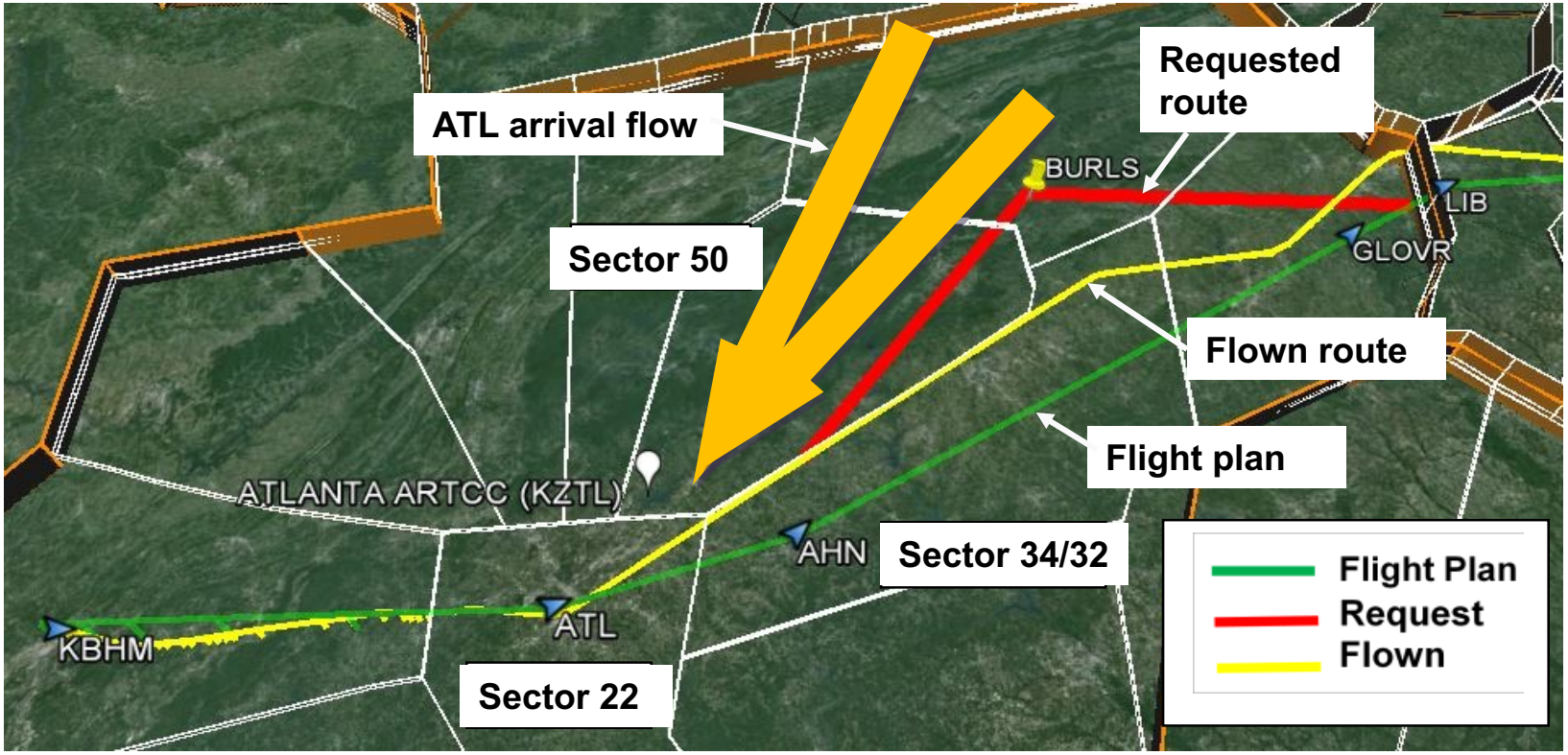
Request was accepted despite flying along boundary between sectors 50 and 34/32



(MAP OBTAINED FROM GOOGLE EARTH)

Example Event: Request Interacts with Major Airport Flow

Request rejected due to interference with major arrival flows to ATL in sector 50



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Interview Data Collection

- Fifty controllers interviewed
  - including controllers who handled and did not handle Avanti test flight
- Wide range of age and experience
  - Age ranged between 25 and 55 years
  - Experienced ranged between 1 and 35 years
- Controllers signed informed consent forms before interview
- Questionnaires included
  - General statistics
  - Quantitative parameters
- Answers noted manually by observers during interview

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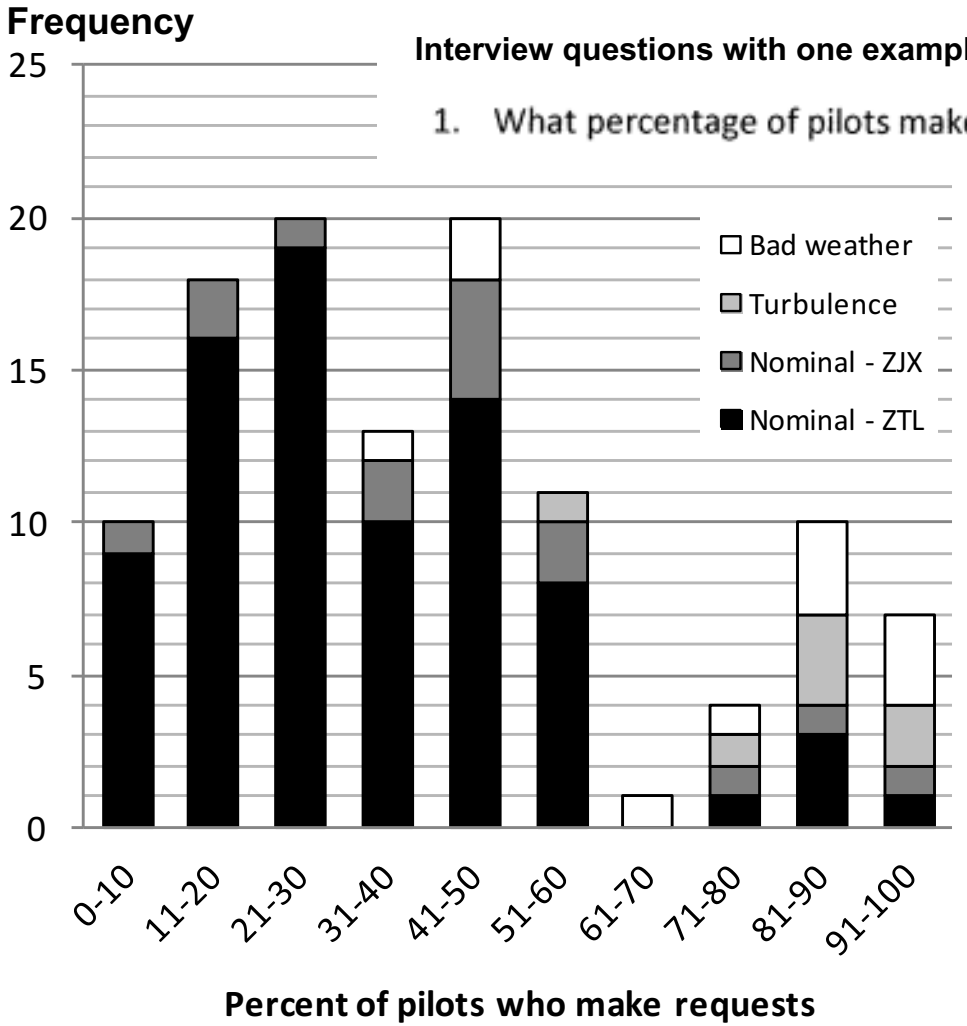
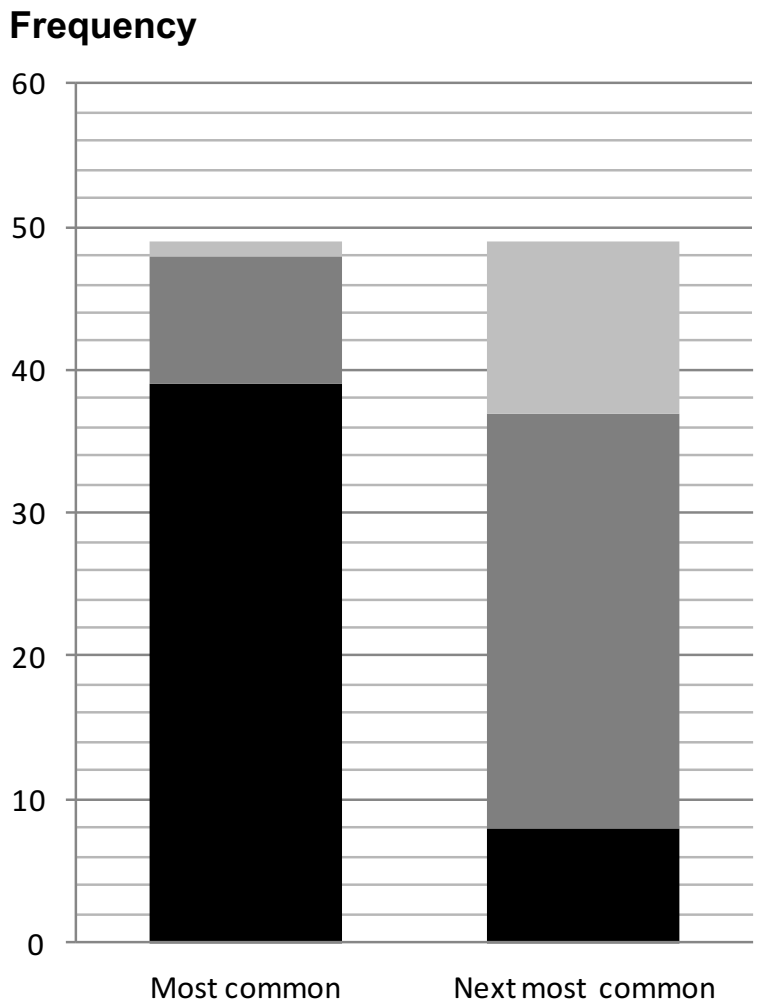
How Often Pilots Make Requests



- About 30% of pilots make requests under nominal conditions
- Increasing to 90% under weather and turbulence

Most Common Pilot Requests



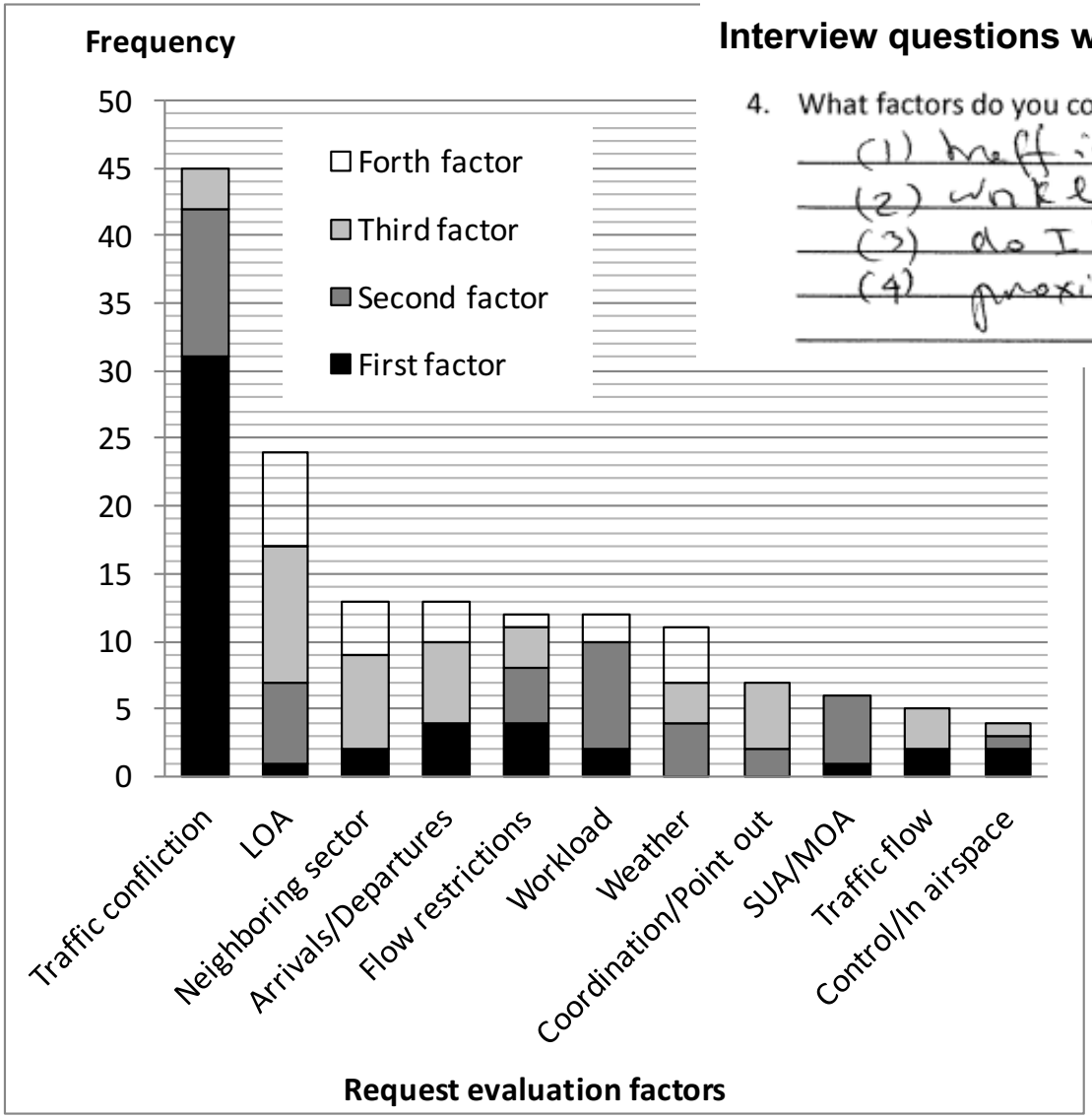
Interview questions with one example response

2. What is the most common type of trajectory change requested? short cut

3. What is the next most common type of trajectory change requested? altitude

Most common requests are short cuts followed by altitude change (mostly for turbulence)

Request Evaluation Factors

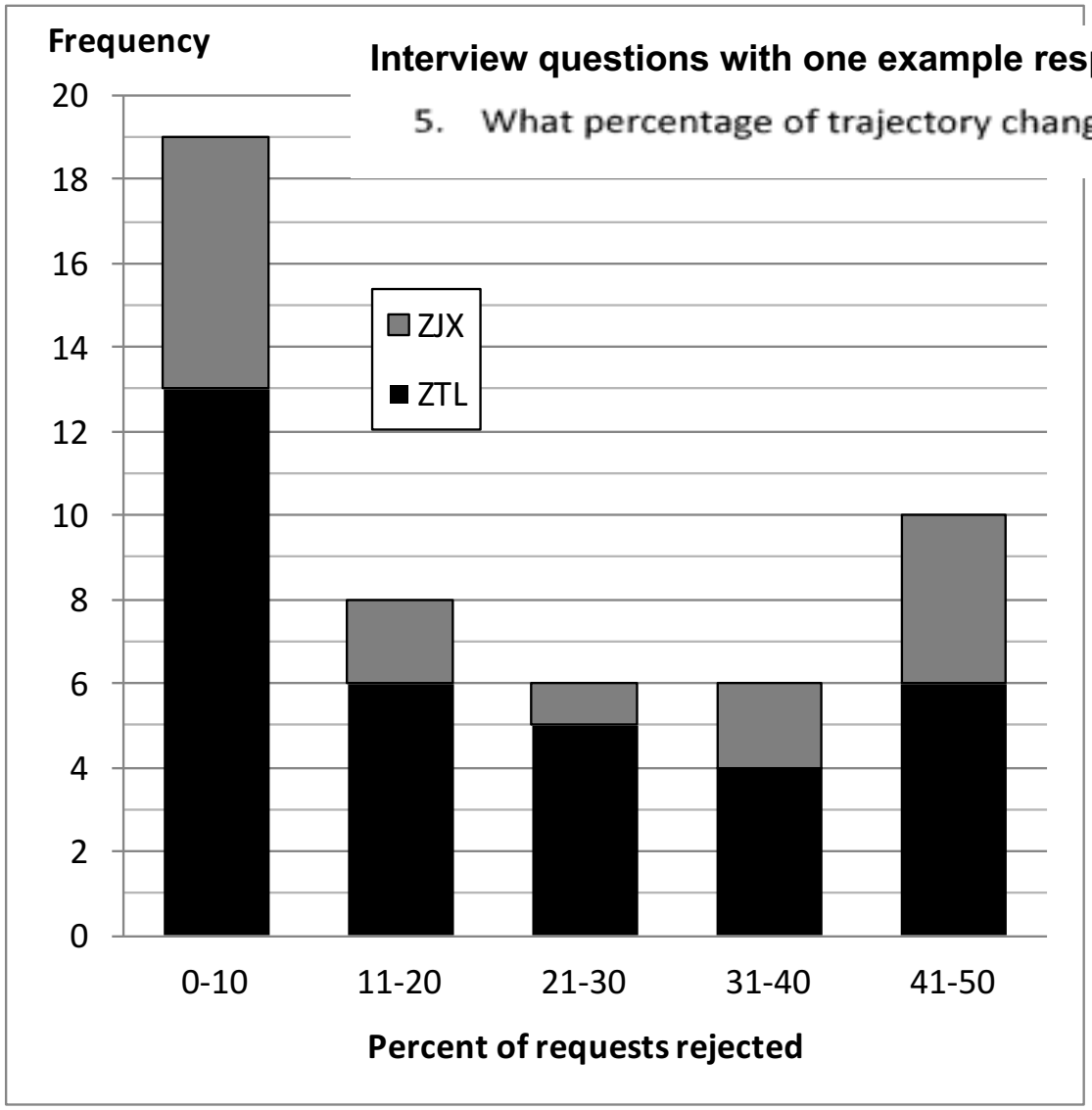


Interview questions with one example response

4. What factors do you consider when evaluating a request?
   (1) traffic
   (2) workload
   (3) do I have coordination (handoff)
   (4) proximity to airport destination

- Traffic confliction is first evaluation factor then letters of agreement (LOAs)
- Evaluation factors are subjective and their interpretation may differ between controllers

Request Rejection Rate



- All controllers reject less than 50% of requests
- Most controllers reject less than 10% of requests

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Quantitative Data Collection

- Each controller provided examples of low, moderate and high workload situations

8. What constitutes high, moderate, and low workload? Give an example of each situation

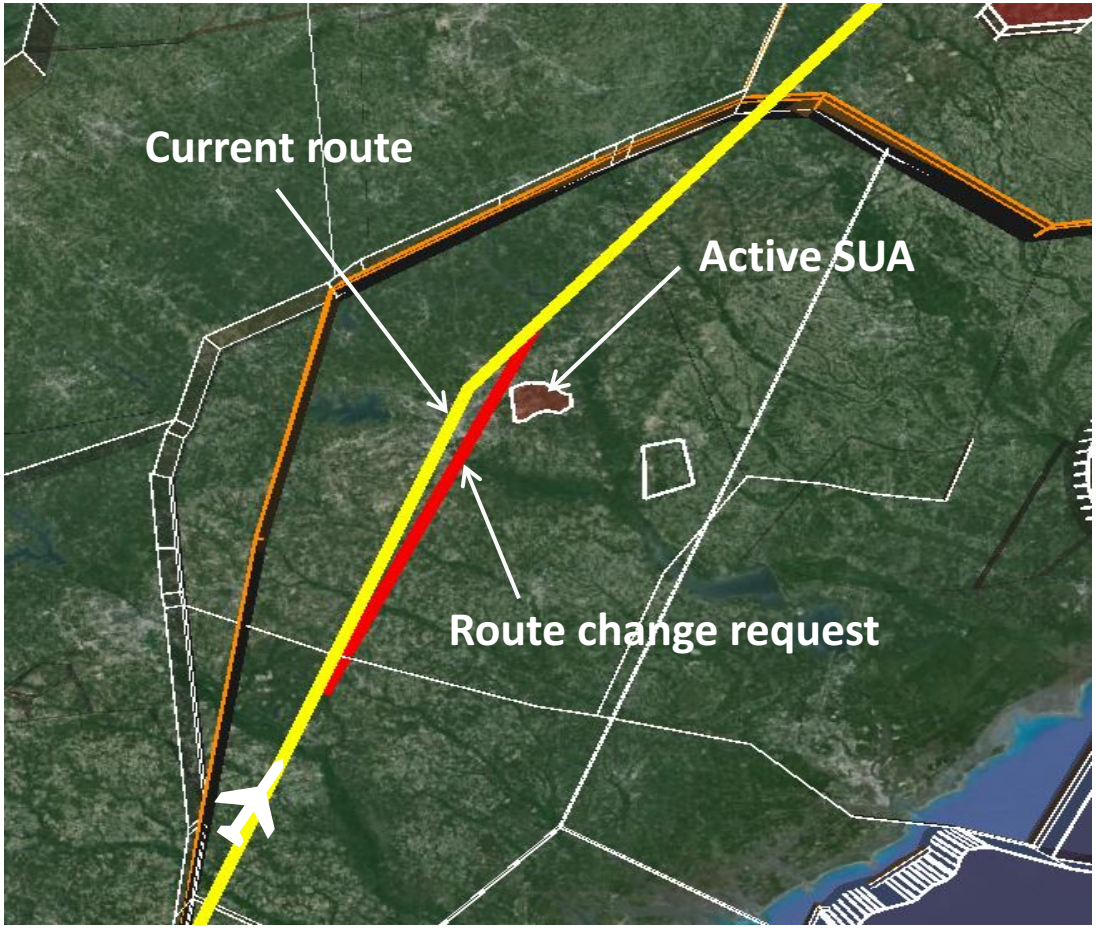
High workload	Moderate workload	Low workload
WX . + ≥ 5 a/c.	15 a/c w/o weight wx	< 10 no wx .

- Then each controller was elicited about quantitative parameters that characterize the acceptability factors under the three workload levels

Sheets were filled by observers

	High workload	Moderate workload	Low workload
Acceptable Distance from Active SUA	required 5 miles 3	3	3
Acceptable Distance from Sector Boundary	have to have 2.5 3	0	0
Clipping Sector Boundaries	no issue	no issue →	
Acceptable Time before Handoff	5min	2	2

Acceptability Factors Studied



Scripted scenarios

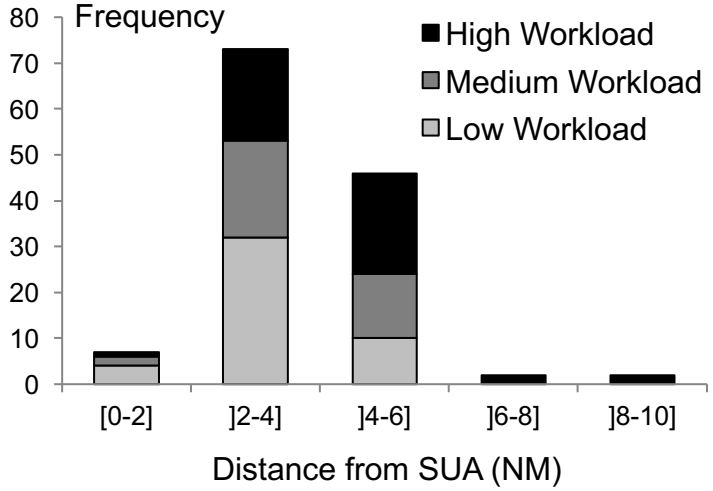
Factor 1:

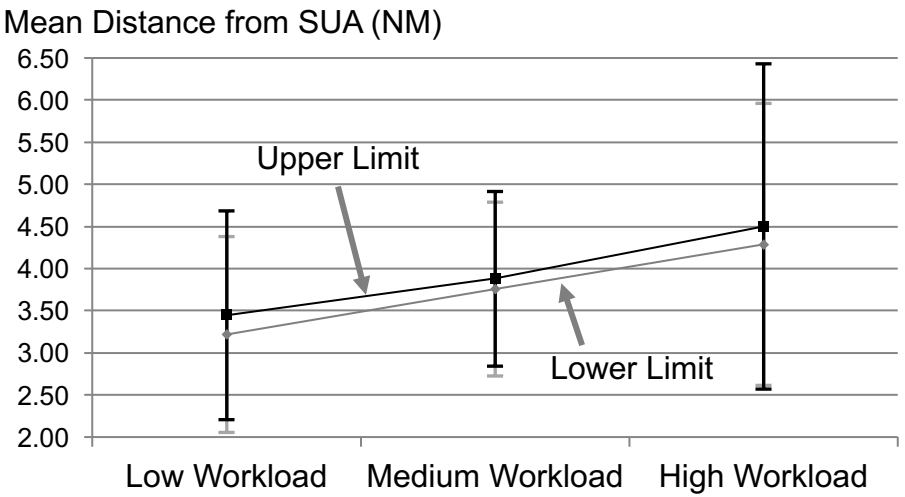
How close can requested route be from an active SUA?

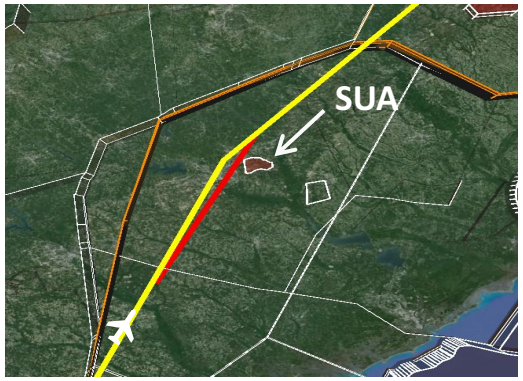
Flight Plan
Request

Factor 1: Acceptable Distance from Active SUA

Acceptable **distance from an active SUA** ranged between 0 under low workload and 10 nautical miles under high workload

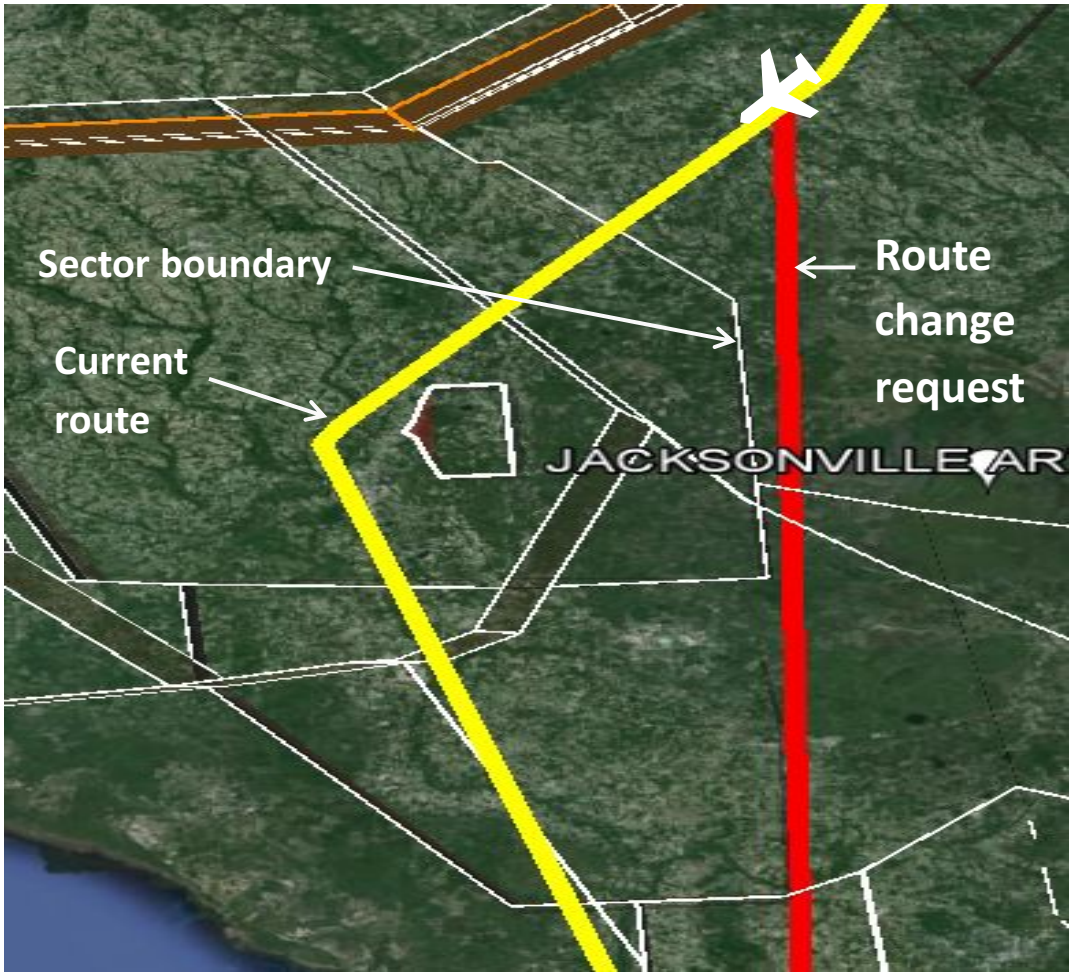






- ATC procedure requires 3 NM from active SUA
- **<u>Recommendation:</u>**
  - **Maintain 3 NM always**
  - **Add 2 NM under high workload**

Acceptability Factors Studied



Scripted scenarios

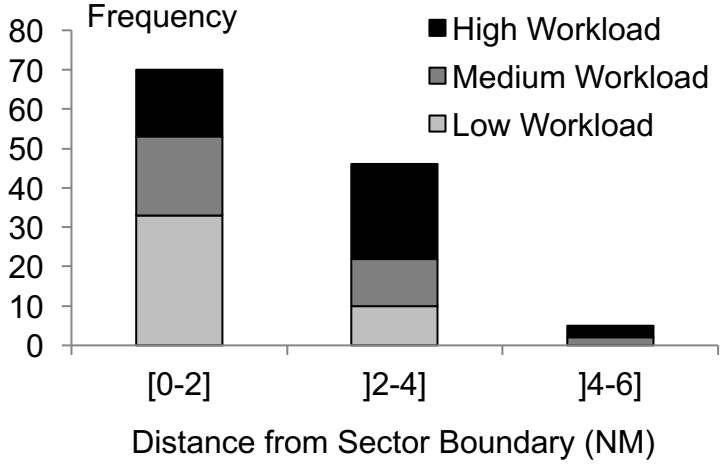
Factor 2:

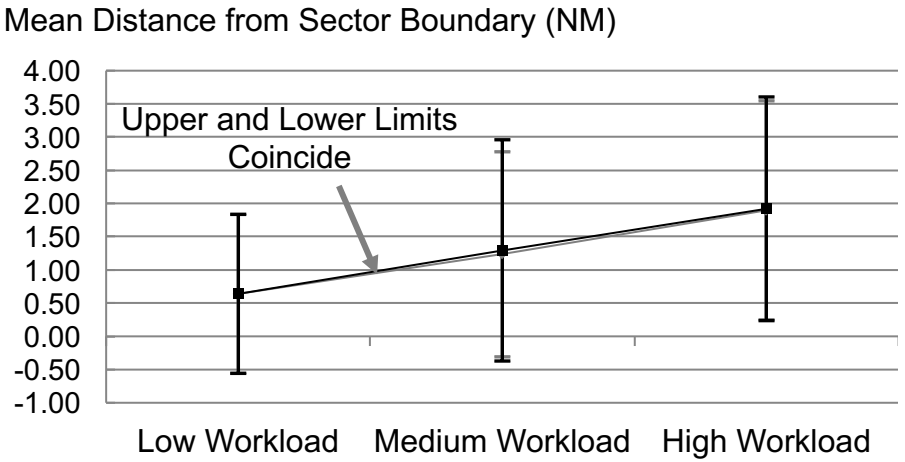
How close can requested route be from boundary between sectors causing "point out" to neighboring sector controller?

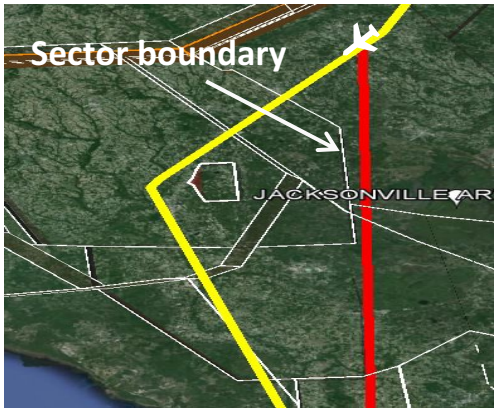
Flight Plan
Request

Factor 2: Acceptable Distance from Sector Boundary

Acceptable distance to **fly parallel to sector boundaries** ranged between 0 at low workload and 6 nautical miles at high workload

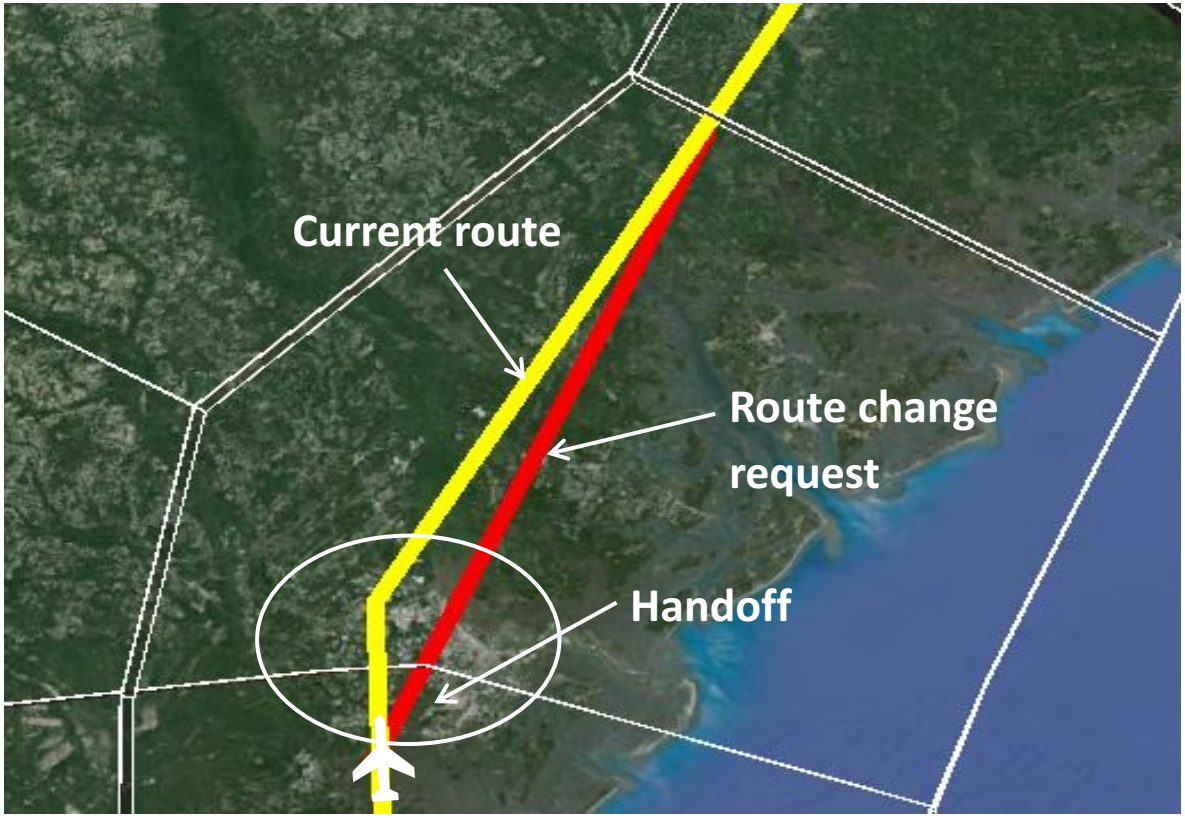






- ATC procedure requires point out at 2.5 NM
- **Recommendation:**
  - **No buffer under low workload**
  - **Maintain 2.5 NM from boundary under high workload**

Acceptability Factors Studied



Scripted scenarios

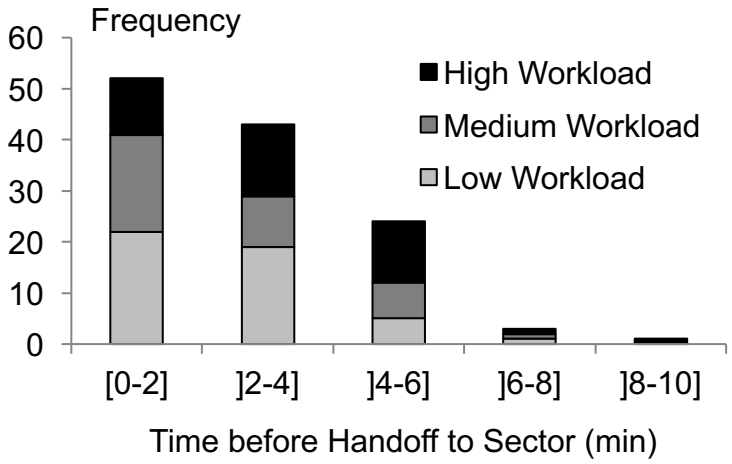
Factor 3:

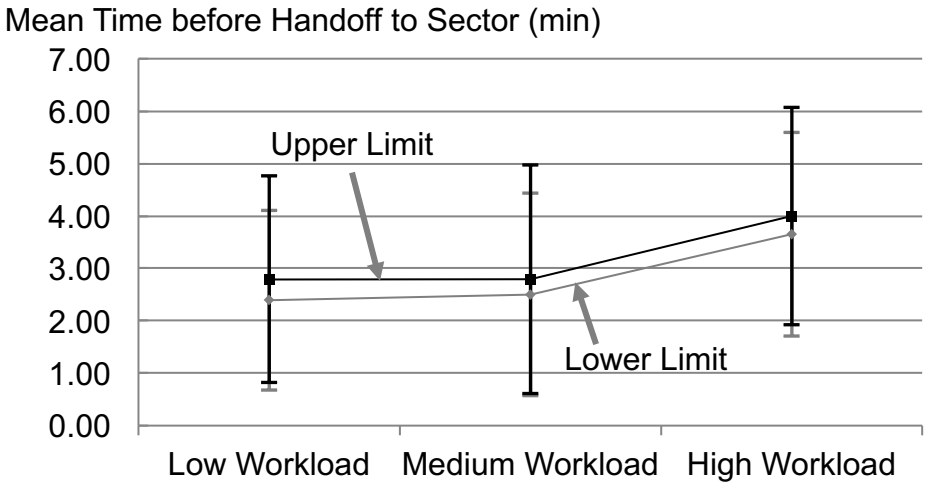
How does making route change request during or close to aircraft handoff from one sector to next sector affect acceptability?

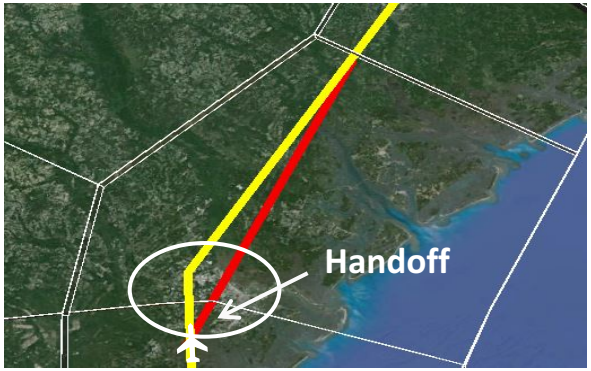
Flight Plan
Request

Factor 3: Acceptable Time Before Handoff to Another Sector

Acceptable **time before handoff to another sector** ranged from 0 under low workload and 10 minutes under high workload situations



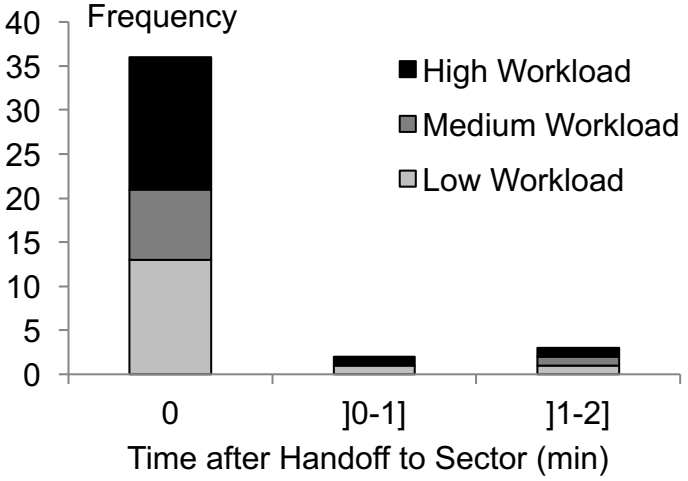


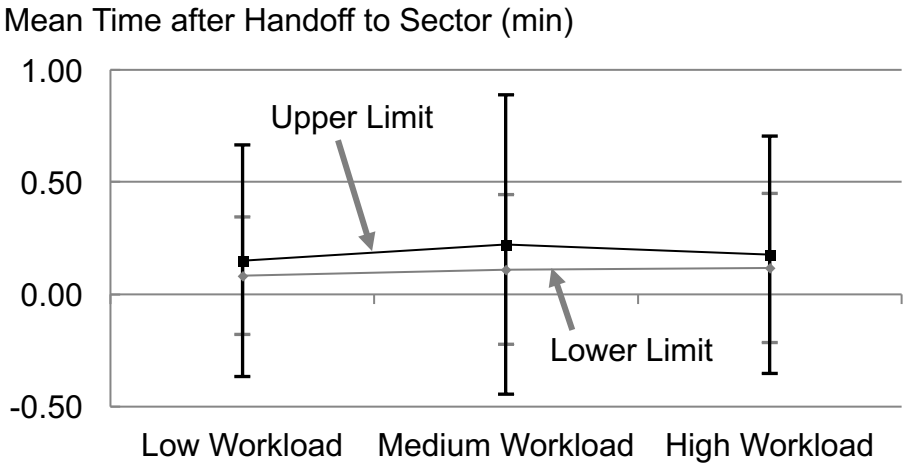


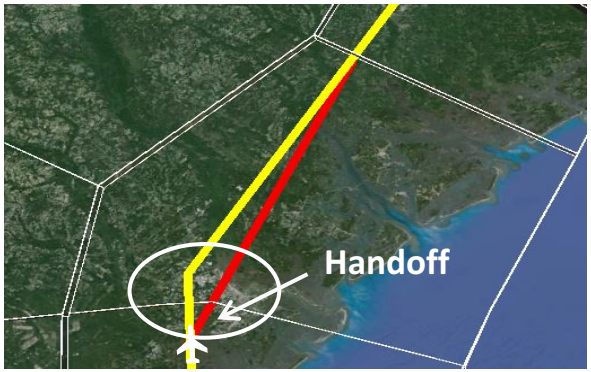
- Automated handoff flashes 3 NM from boundary
- **<u>Recommendation:</u> Make request about 1 to 2 minutes before automated handoff threshold, mainly under high workload**

Factor 3: Acceptable Time After Handoff

Acceptable **time after handoff from another sector** ranged from 0 under low workload and 2 minutes under high workload conditions

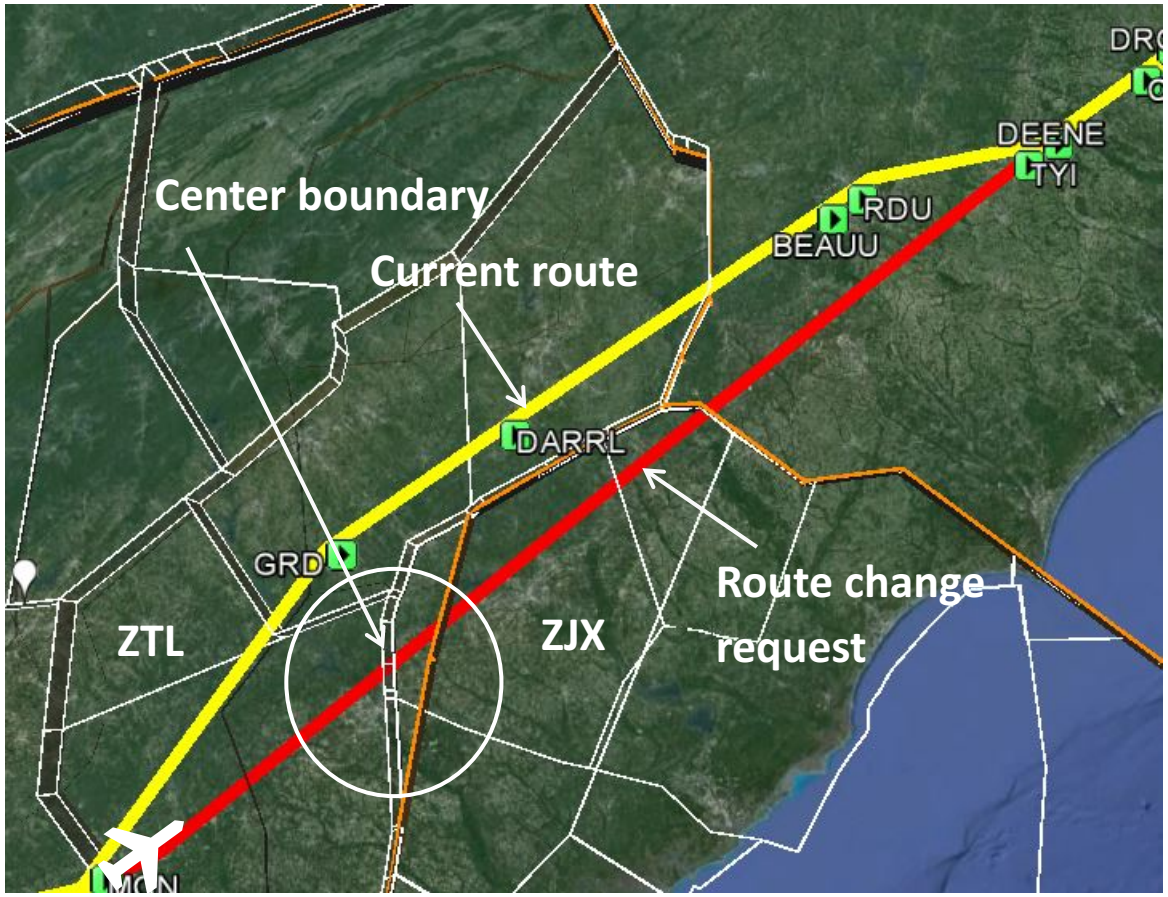






- Controllers want to know request as soon as possible after flight checks in on frequency
- **<u>Recommendation:</u> Do not delay request after handoff even under high workload**

Acceptability Factors Studied



Scripted scenarios

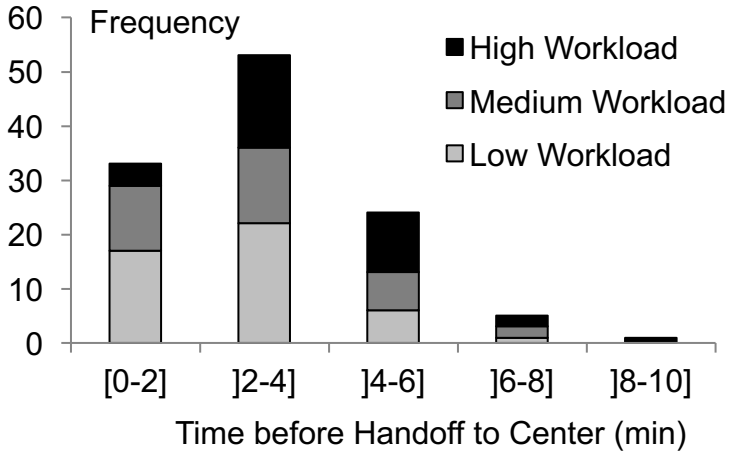
Factor 4:

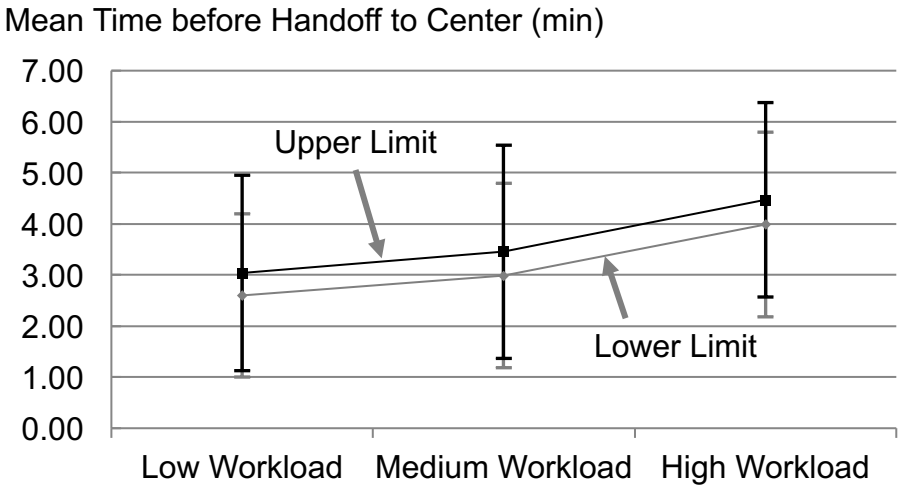
How does making route change request that crosses from current center to next center affect acceptability?

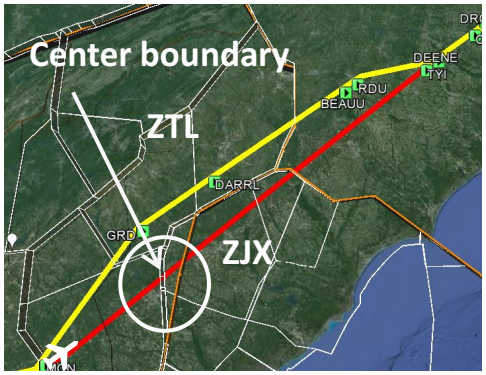
Flight Plan
Request

Factor 4: Acceptable Time Before Handoff to Another Center

Acceptable **time before handoff to another center** ranged from 0 under low workload and 10 minutes under high workload situations







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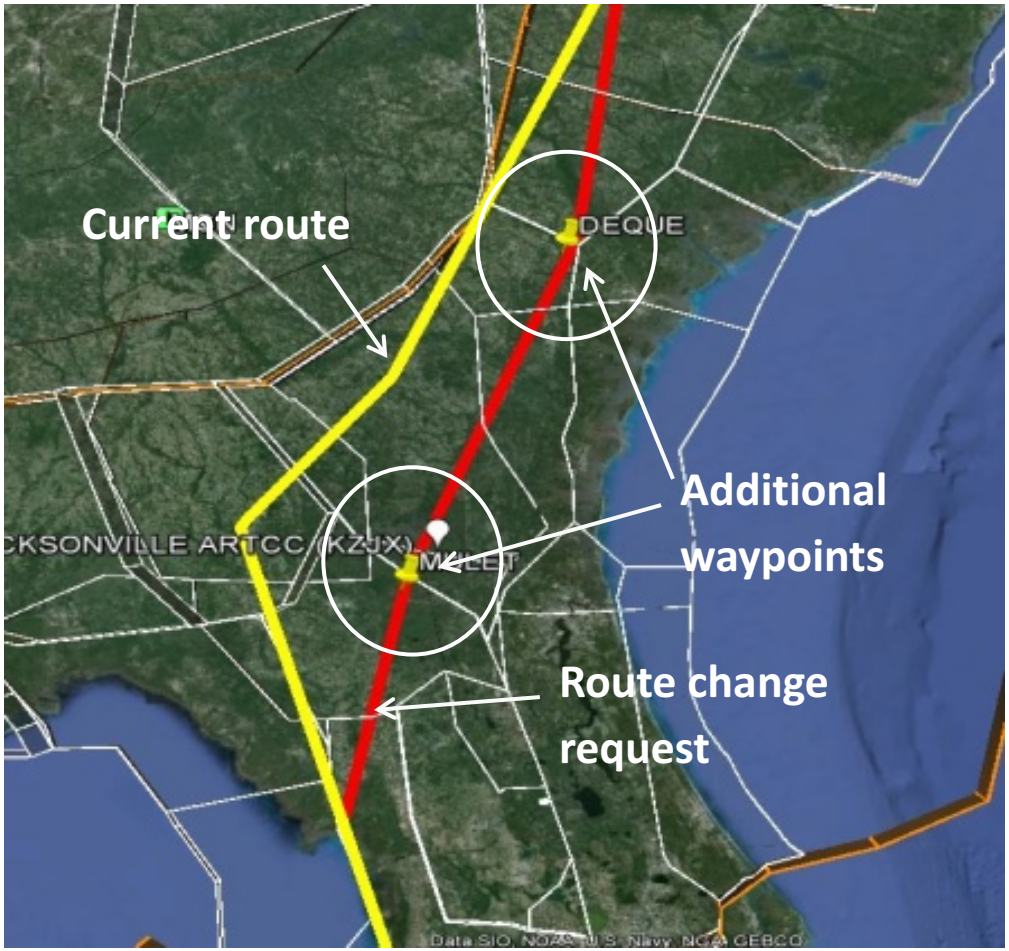
Acceptability Factors Studied



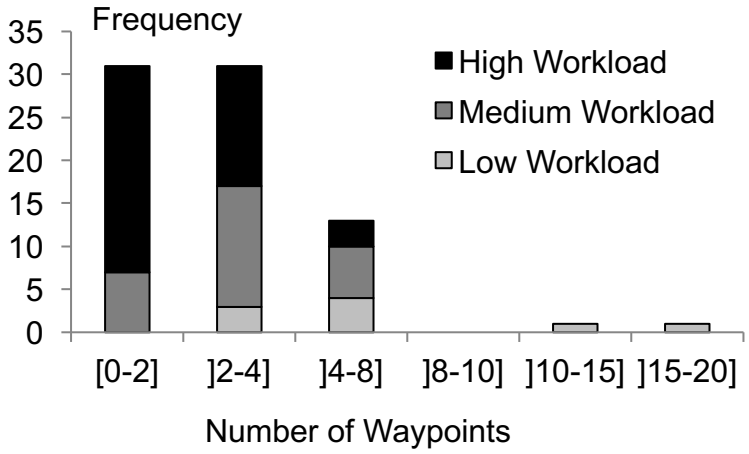
Scripted scenarios

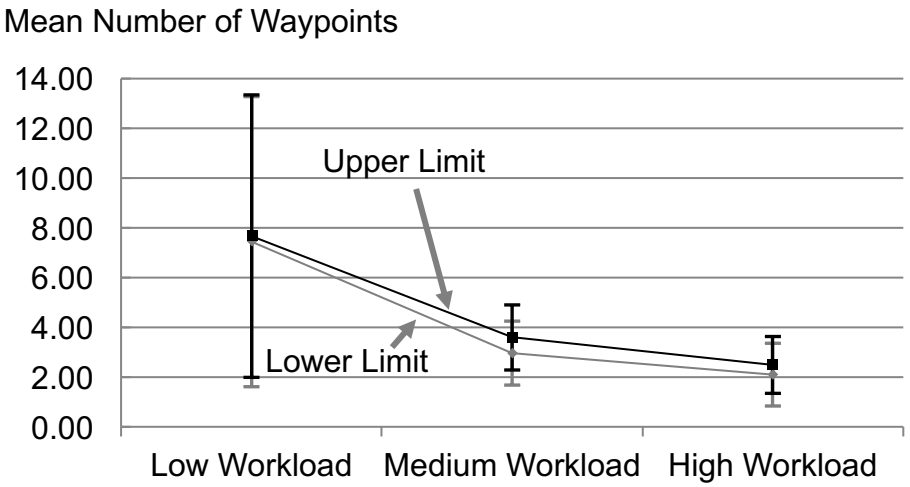
Factor 5:

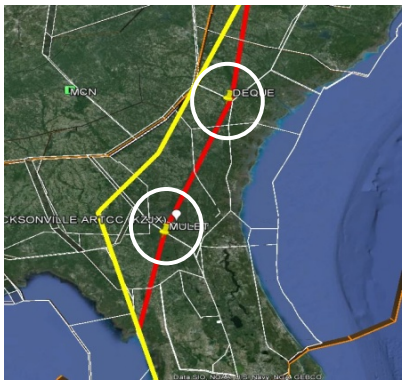
How many additional waypoints can route change request include to be acceptable?

Factor 5: Acceptable Number of Additional Waypoints

Acceptable **number of additional waypoints** ranged from 20 under low workload and 0 under high workload situations.

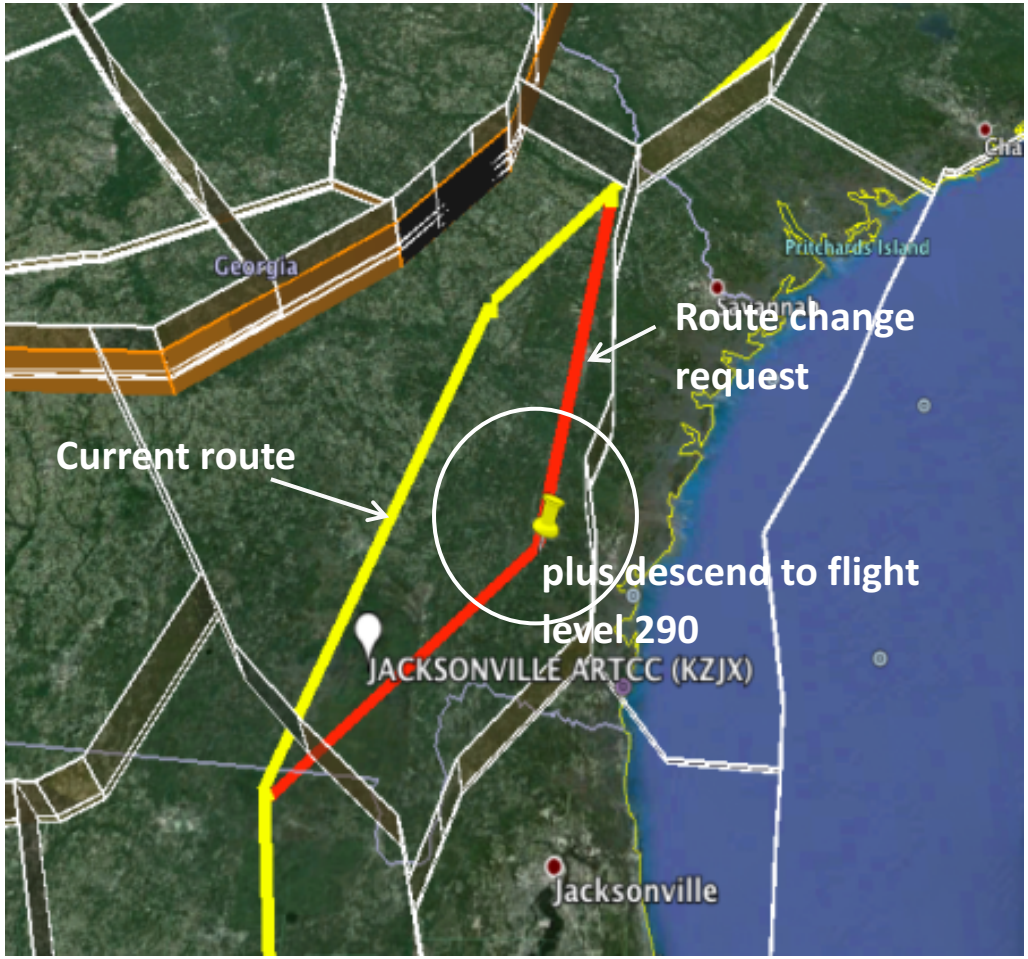






- Majority of controllers accept any number of additional waypoints under low workload
- **<u>Recommendation:</u> Limit to 2 additional waypoints under high workload**

Acceptability Factors Studied



Scripted scenarios

Factor 6:

Can route change request combine lateral and vertical maneuvers?

<u>Recommendation:</u>
No problem combining lateral and vertical maneuvers in request

Flight Plan
Request

Additional Recommendations

- **Avoid unfamiliar waypoints** and waypoints that are not in database
- **Avoid violating LOAs** such as required routes and transition points particularly to major airports
- Avoid opposing common traffic flows at same altitude, particularly arrivals and departures of major airports
- **Avoid making requests during high workload**, for example, if controller on communication frequency is clearly busy
- Avoid making requests that interact with weather systems
- Avoid making requests that violate flow restrictions or pass through congested airspace
- **Consider request impacts on downstream sectors** not just the current sector where request is made

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Concluding Remarks

- Controllers made concerted effort to accommodate pilot requests
- All controllers were enthusiastic about pilots knowing about their environment when making requests, for example
  - Know sector boundaries
  - Avoid traffic confliction and major arrival/departure flows
  - Avoid violation of LOA's
- Some controller acceptability factors can be quantified and included in automation logic, for example: Maintain 3 NM from SUA and 2 NM from sector boundary
- Acceptability is highly dependent on workload of current and downstream controller which is harder to incorporate in automation

Current and Future Activities

Research continuing under NASA's Airspace Technology Demonstration (ATD-3)

- Flight Trial 3 (2018) will investigate integration of weather constraints from on-board radar and from ground sources
- Air-ground integration between aircrew and dispatch (2018-2020)
  - TAP for aircrew route advisories accounting for onboard weather and ADS-B traffic constraints
  - NASCENT for dispatch route advisories accounting for fleet-wide objectives and constraints, ground-based weather constraints, traffic congestion, and traffic flow restrictions
  - Partnership with major airline: demonstration on up to 10 aircraft by 2020

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Questions?

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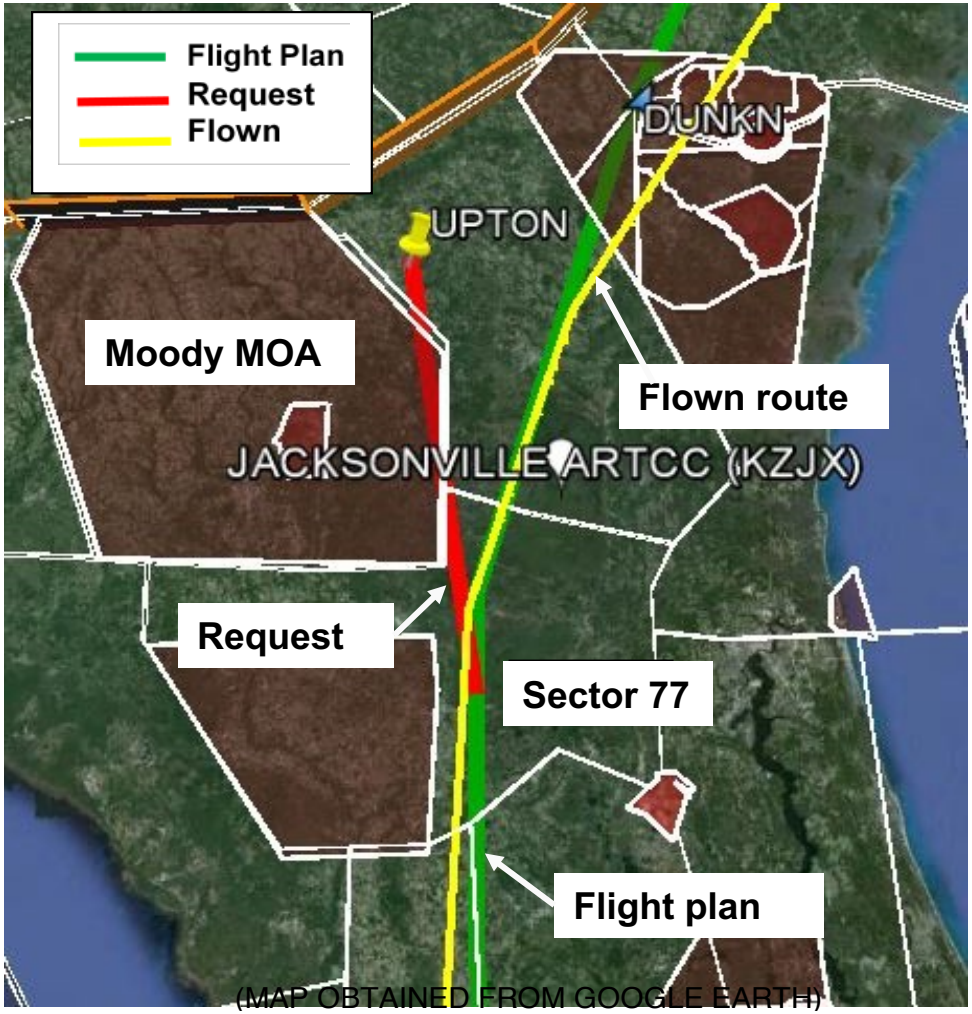
Backup Slides

TASAR Flight Trial 2 Overview

- TASAR Flight Trial 2 goal:
  - Increase operational readiness of TASAR for airline partnership activities
- Several objectives to accomplish this goal:
  1. Verify TAP software operates effectively on partner airlines hardware
  2. Verify processing of external data
  3. Assess methodology to characterize TAP computed outcomes
  4. **Assess** pilot and **controller acceptability of TASAR requests**
  5. Assess usability and acceptability of TAP HMI
  6. Assess effect on crew resource management (CRM)

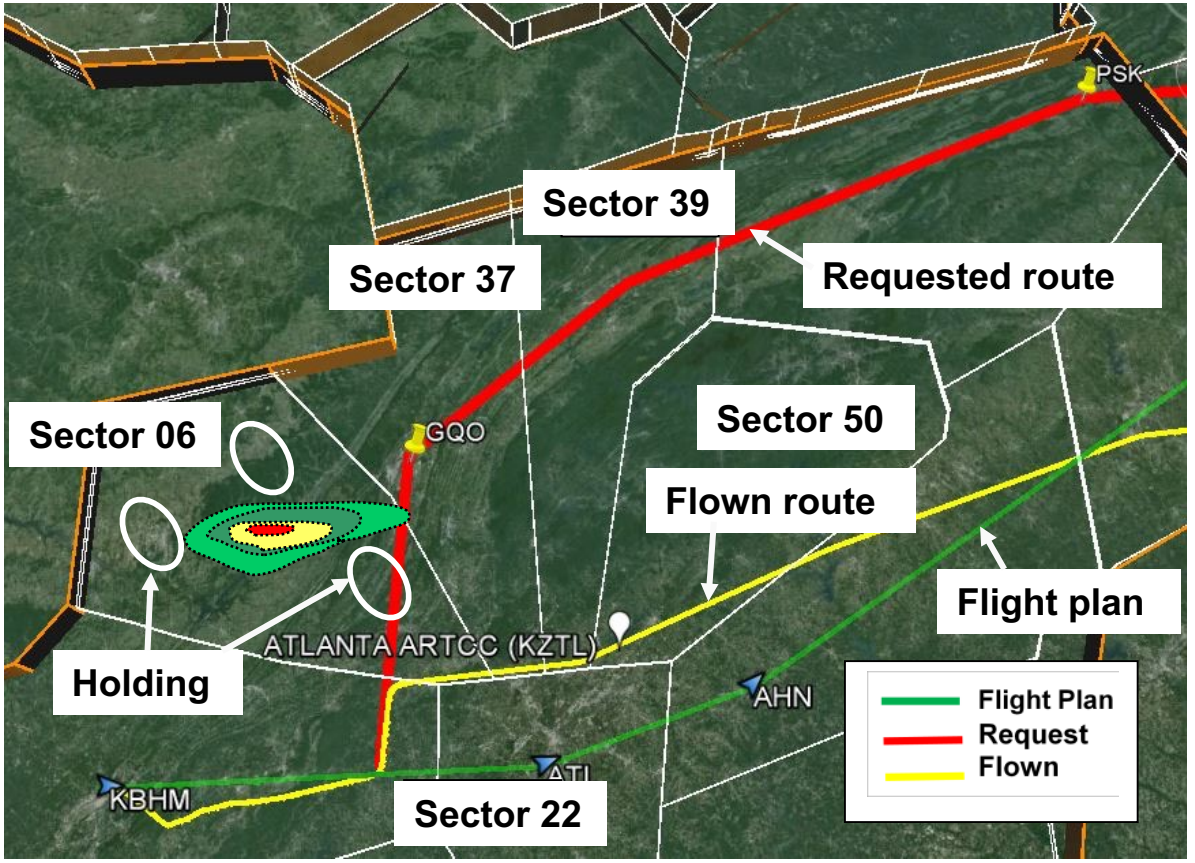
Example Event: Request Intrudes into Active Military Airspace

Request rejected due to interference with active military airspace (MOA) Moody



Example Event: Request Interacts with Convective Weather Activity

Request was accepted by sector 22 which had low workload, then it was rejected by next sector 06 due to weather and holding patterns in sector. Flight was tactically handled by Sector 22 along boundary and handed off to Sector 50



WEATHER EVENT (MAP OBTAINED FROM GOOGLE EARTH).