Laboratory Evaluation of Dynamic Routing of Air Traffic in an En Route Arrival Metering Environment

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1. Background

- Challenges
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- Past Work
Challenges

- In clear weather
  - Efficient, precision air traffic flow management.

- However, when convective weather is present...

Frequent Vectoring (Tactical)

- Less predictable
- High workload

Playbook (Strategic)

- Inefficient (“One-size-fits-all”)
- Slow to respond
Solution

- Desired: Rerouting tool that...
  - Avoids weather
  - Is more predictable & responsive

- Solution:
  - Dynamic rerouting (Flight Plan amendment)
Past Work

- MIT Lincoln Lab’s Convective Weather Avoidance Model (CWAM) [DeLaura, et. al, 2008]

- MIT Lincoln Lab’s Route Availability Planning Tool (RAPT) and the Arrival Route Status and Impact [Robinson, DeLaura, & Underhill, 2009]

- NASA’s Dynamic Weather Routes (DWR) [McNally, et. al, 2015]
2. Dynamic Routing for Arrivals in Weather (DRAW)

- Concept
- Components
- Example
- User Process
Dynamic Routing for Arrivals in Weather (DRAW):

- Adapted from DWR
- Designed for Traffic Management Coordinator (TMC) at FAA ARTCC (“Center”)
- Reroutes arrivals for weather avoidance
- Supports arrival-metering operations
DRAW Components

- DRAW Advisory
- Current Weather
- Rubber-bandung
- Future Weather Conflict
- Metering Impact

Trial Planning
Example of DRAW Advisory and Trial Planning

Current scheduled times of arrival do not reflect the need to deviate for weather.
DRAW
User Process

Select → Evaluate (Trial Planning) → Accept or Reject

Accept → Flight Plan amendment
3. Laboratory Evaluation

- Airspace
- Experiment Design
- Lab Setup
Bowie and Glen Rose arrivals to DFW/DAL of ZFW were simulated.

*: Not controlled by human participants
Experiment Design

- TMC Sessions (32 runs) and Controller Session (16 runs) conducted separately
- **Independent Variables:**
  - 2 DRAW conditions (DRAW vs. No-DRAW)
  - 2 Weather Scenarios
  - 4 TMCs (2 TMCs in Controller Session)
  - 2 Controller Seating Positions (Controller Session)
- Clear-weather day traffic
- Assumed: all FP amendments instantly executed
DRAW vs. No-DRAW Conditions

- **Current Weather**
- **Future Weather Conflict**
- **Metering Impact**
- **Rubber-banding**
- **Trial Planning**

**DRAW**
- DRAW Advisory

**No-DRAW**
- Trial Planning
- Rubber-banding
Lab Setup

TMC Workstations
Lab Setup

Sector Controller
Workstations
4. Results

- Reroute Timing
- Weather Avoidance
- TMC Acceptability
- Controller Workload
TMCs rerouted earlier when using DRAW ($p = 0.001$).

- Mean = 82 min in DRAW runs
- Mean = 66 min in No-DRAW runs
DRAW reduced the number of flights that had residual weather conflicts in the Center airspace \((p = 0.017)\).

- Mean = 5.6 flights per DRAW run
- Mean = 10.8 flights per No-DRAW run
TMC Post-run questionnaire responses results:

1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree

- Mean Rating = 6 ~ 7 ("Agree" to "Strongly Agree")
  - DRAW workload was acceptable.
  - DRAW advisory timing was early enough.
  - DRAW was helpful in arrival traffic management in weather.

- Mean Rating = 4 ~ 5 ("Neutral" to "Somewhat Agree")
  - DRAW would increase probability of sustaining arrival metering in weather.
  - DRAW would delay the need for other Traffic Management Initiatives (e.g., Miles-in-Trail, Playbook).
Controller post-run questionnaire collected their NASA TLX workload ratings:

- Linear Mixed Model regression analysis found that in DRAW runs...
  - Sector 47 controller’s mental workload demand was reduced ($p = 0.029$).
  - Controllers felt their performance level poorer ($p = 0.048$).

- No other DRAW effect was found.
5. Conclusions

- Summary
- Future Work
Summary

- **DRAW assists TMCs in issuing arrival reroutes:**
  - Avoid weather.
  - Support arrival metering schedule.
  - Improve predictability and responsiveness.

- **Our laboratory evaluation demonstrated that ...**
  - TMC rerouted earlier when using DRAW.
  - Use of DRAW reduced the number of flights with residual weather conflicts in Center airspace.
  - TMCs reported their workload acceptable and DRAW generally helpful for arrival management in weather.
  - TMCs somewhat agreed that DRAW would help sustaining arrival metering.
  - DRAW did not increase controller workload.
Future Work

- Additional studies are planned to...
  - Improve arrival metering support in weather
  - Evaluate DRAW in different airspace
  - Refine DRAW concepts

- DRAW simulation demonstration in the FAA’s future Time-Based Flow Management (TBFM) environment has been in work.
Thank you.

Questions?

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