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

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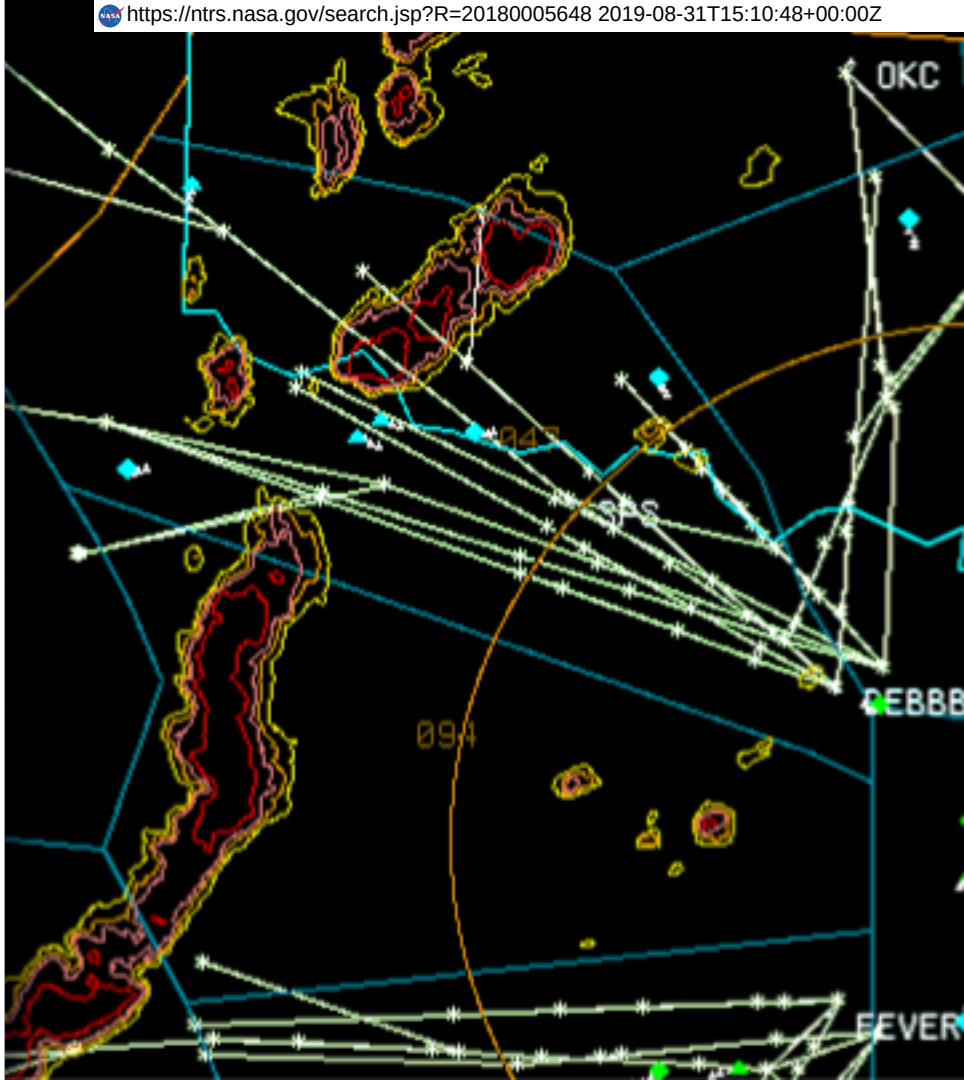

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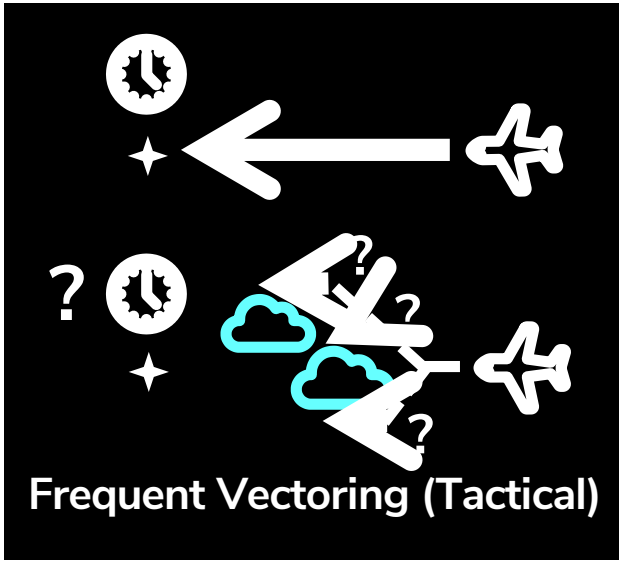
1. Background

- *Challenges*
- *Solution*
- *Past Work*

Challenges

- In clear weather
  - Efficient, precision air traffic flow management.
- However, when convective weather is present…



Less predictable
High workload

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

Dynamic routing in weather

- **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)

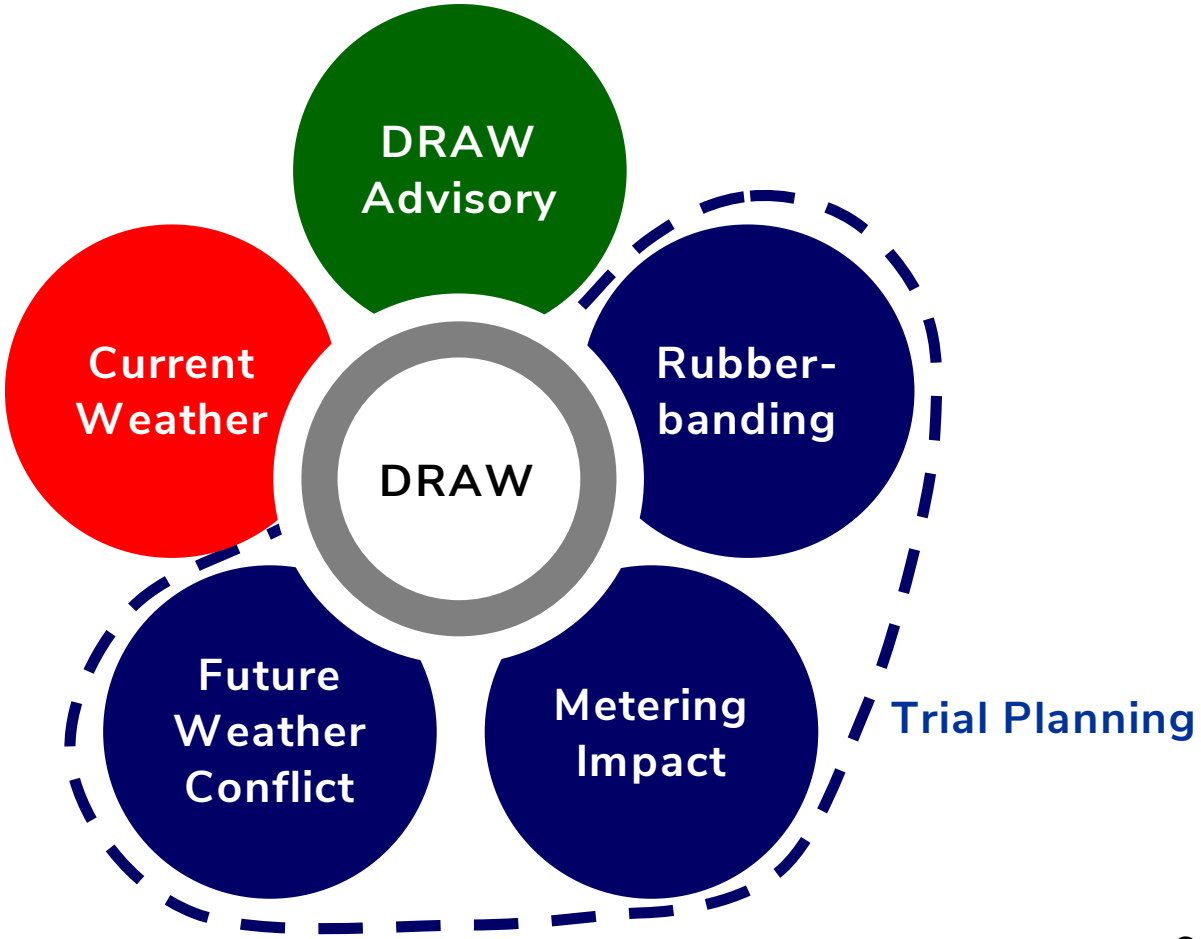
- *Concept*
- *Components*
- *Example*
- *User Process*

DRAW Concept

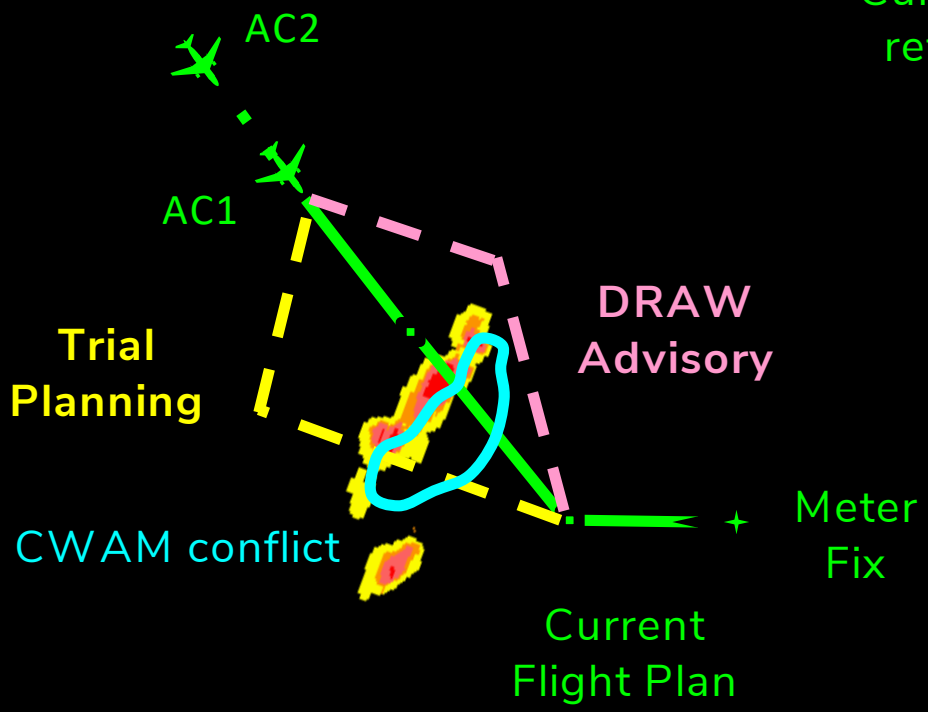
Dynamic Routing for Arrivals in Weather (DRAW):

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

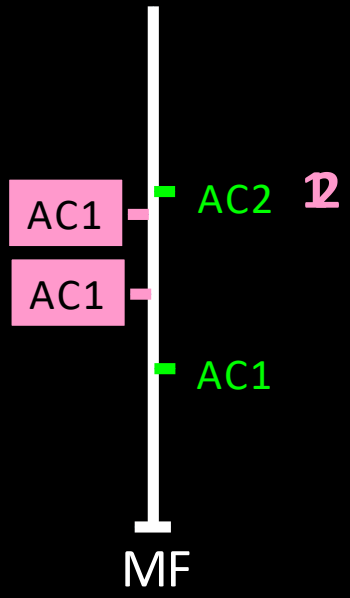
DRAW Components



Example of DRAW Advisory and Trial Planning



Current scheduled times of arrival do not reflect the need to deviate for weather



DRAW
User Process

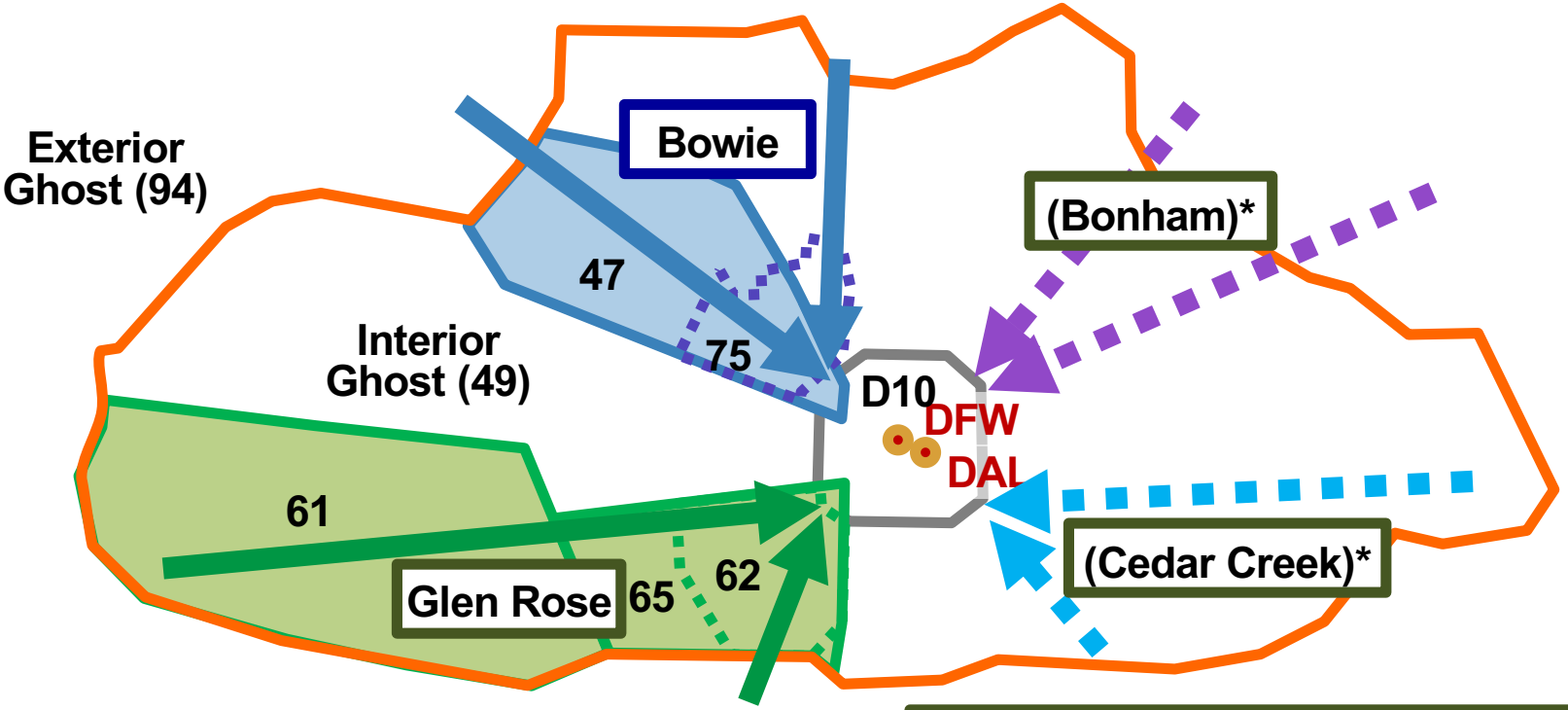
Accept → Flight Plan amendment

3. Laboratory Evaluation

- *Airspace*
- *Experiment Design*
- *Lab Setup*

Fort Worth Center (ZFW) Airspace

Bowie and Glen Rose arrivals to DFW/DAL of ZFW were simulated.

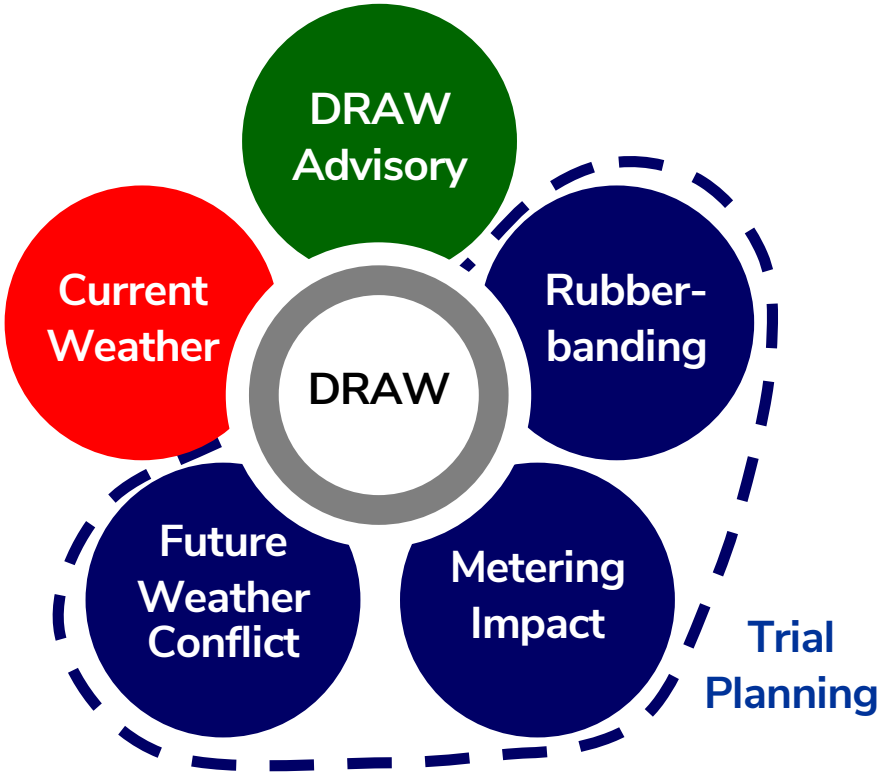


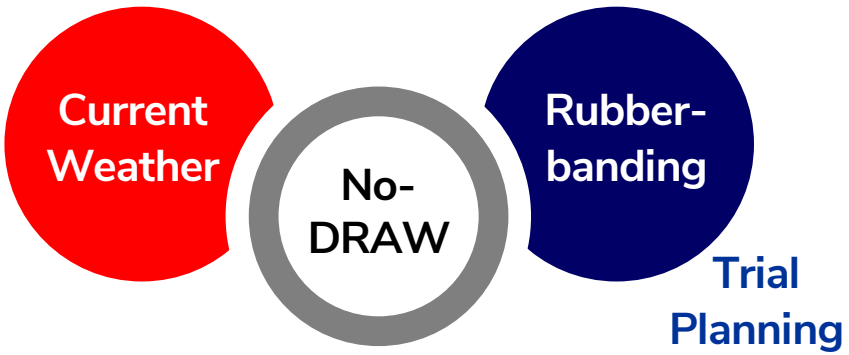
*: Not controlled by human participants

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



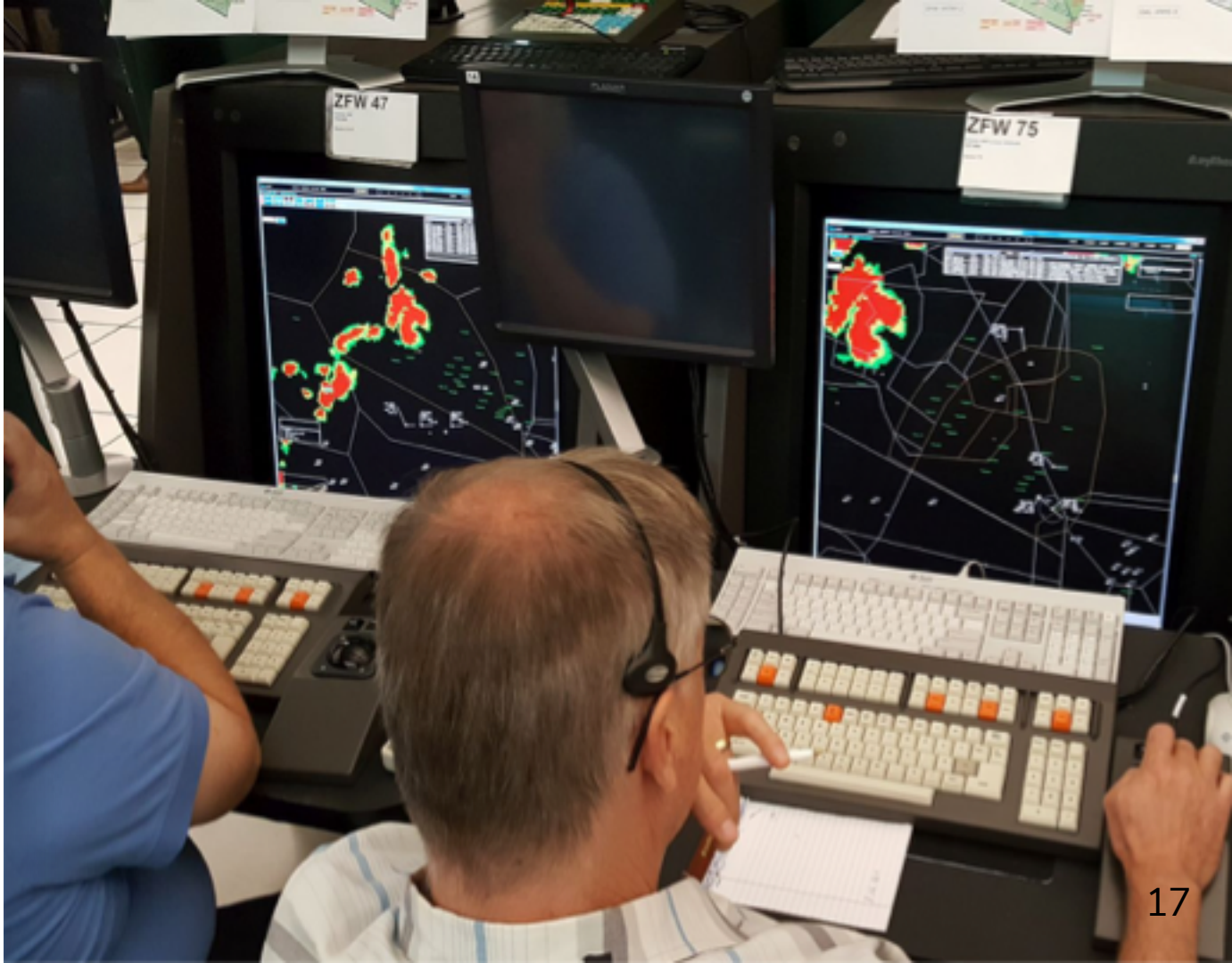


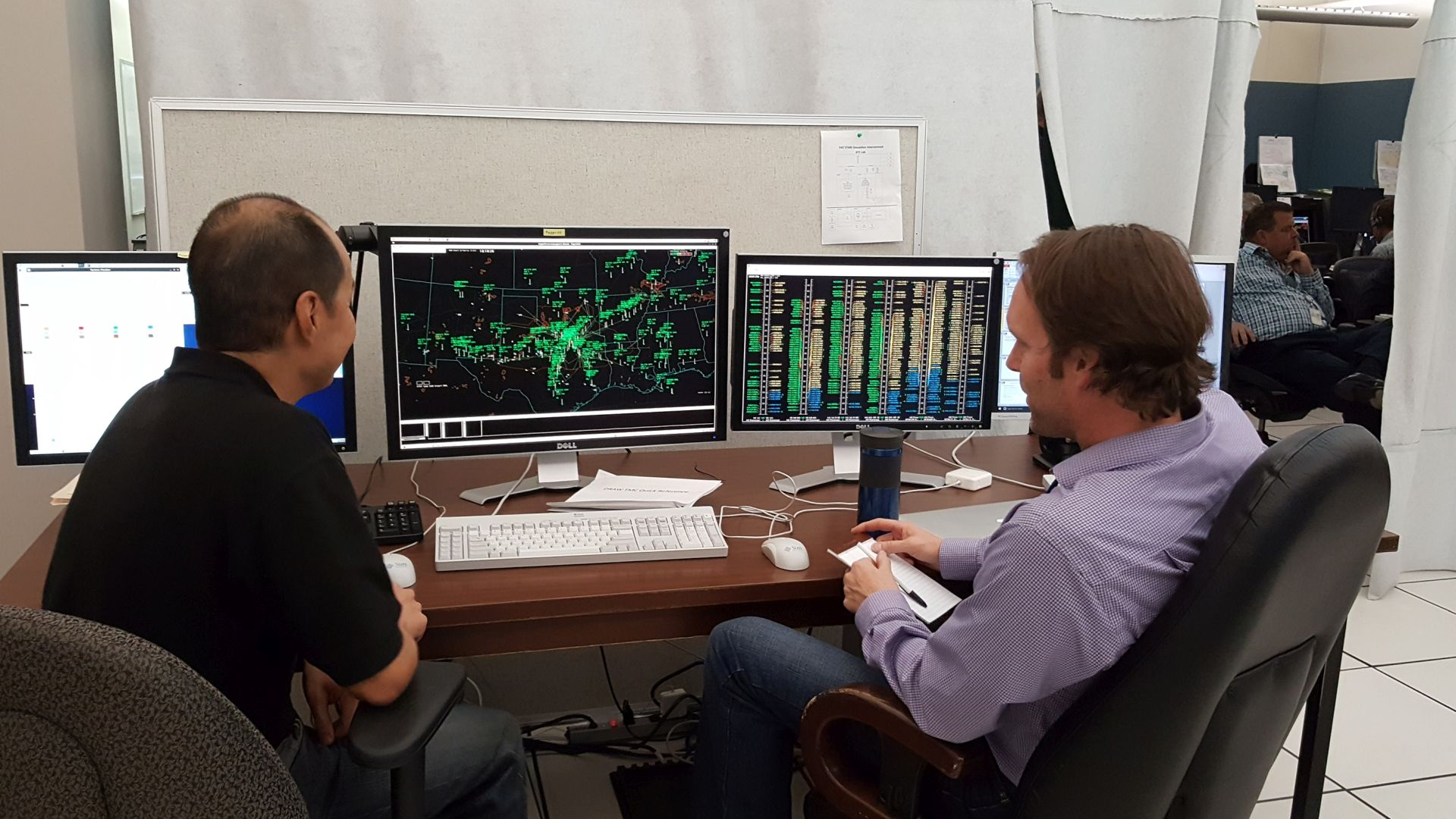
Lab Setup

TMC Workstations

Lab Setup

Sector Controller Workstations

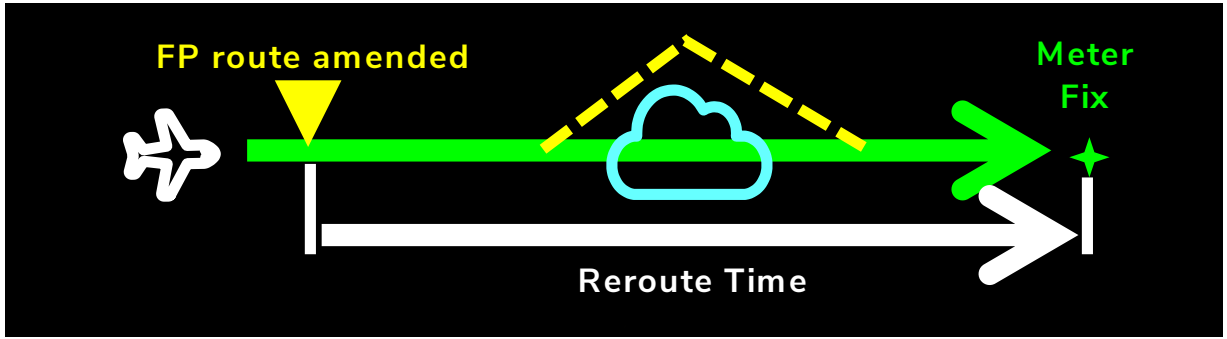




4.
Results

- *Reroute Timing*
- *Weather Avoidance*
- *TMC Acceptability*
- *Controller Workload*

Reroute Timing



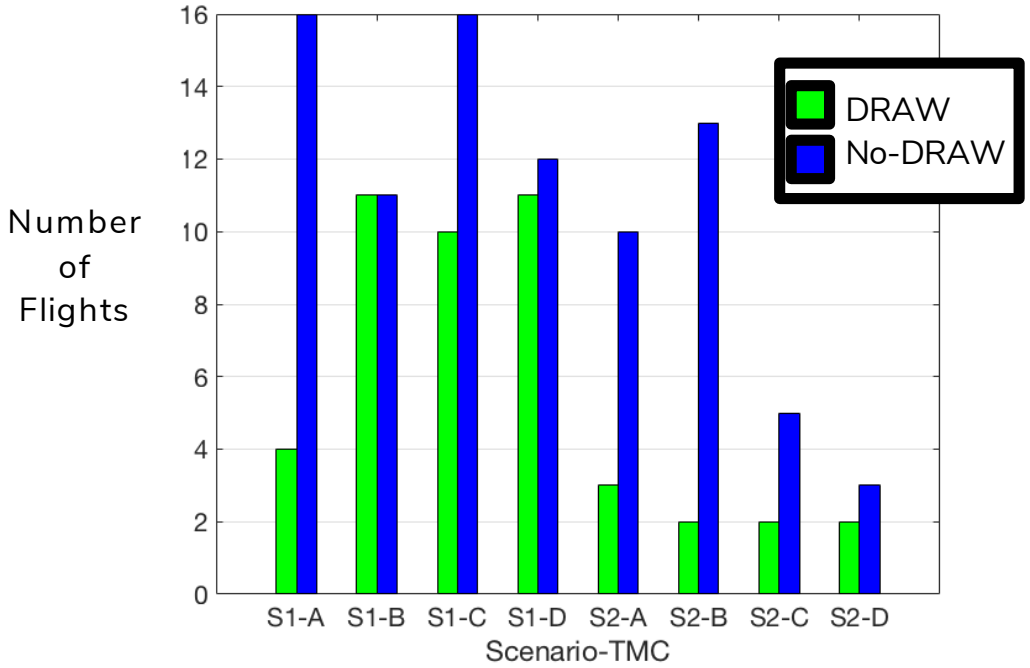
TMCs rerouted earlier when using DRAW (p = 0.001).

- Mean = 82 min in DRAW runs
- Mean = 66 min in No-DRAW runs

Weather Avoidance

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 Acceptability

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 Workload

- 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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