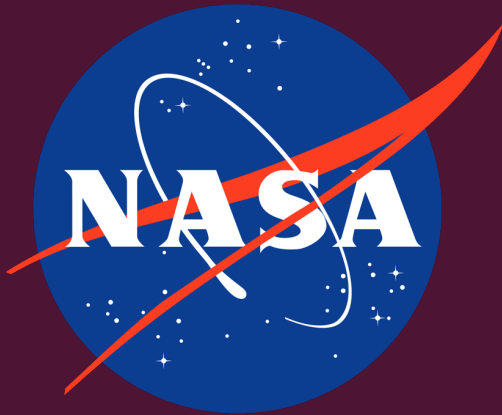


---

# USABILITY EVALUATION OF FLEET MANAGEMENT INTERFACE FOR HIGH DENSITY VERTIPLEX ENVIRONMENTS

PRESENTED BY MADISON GOODYEAR



RESEARCH FOUNDATION

GITA HODELL  
QUANG DAO  
JEFF HOMOLA  
MADISON GOODYEAR  
SCOTT KALUSH  
SHRADDHA SWAROOP  
YOONA JUN

# INTRODUCTION

- Madison Goodyear
- Human Factors Researcher & Designer working for San Jose State Research Foundation @ NASA Ames
- M.S. in Human Factors and Ergonomics
- B.A. in Psychology



## OUTLINE

- Background
- Research Questions
- Methods
- Results
- Conclusions
- Discussion

### Purpose and Overview

- To evaluate the FM implementation for terminal airspace operations
- Conduct the simulation and live flight with participants with fleet management and flight crews
- Reported on results collected from the evaluation

## BACKGROUND

- HDV is building upon this work by focusing on terminal management and how arrival/departure management can be scaled to support higher densities
- The three human operator roles to look into are the: fleet manager (FM), vertiport manager (VM), and ground control systems operator (GCSO)
- The FM is in charge of assigning GCSOs timeslots for landing
- This application is called the Fleet Manager Interface (FMI) and its key features include:
  - A 2D display of the airspace, routes, flight plans, and waypoints
  - Operation status changes, such as state changes
  - Critical alert messages for operations
  - Trial planning automation to amend routes while airborne



## RESEARCH QUESTIONS

- ~~1. What is the impact of demand on human and system demand?~~
2. What are the FM and GCSO information requirements for accomplishing flight replanning?
3. What is the impact on the timeliness of coordination when the GCSO is required to review and approve operational updates from the Fleet Manager?



# GOALS

## Goals:

- Collect human factors data on workload, awareness, and trust in automation
- Understand human performance data through user interactions with the FMI
- Improve the FMI software through usability data collected

## Participants:

- 3 FM participants from NASA Ames
- 6 GCSO participants from NASA Langley

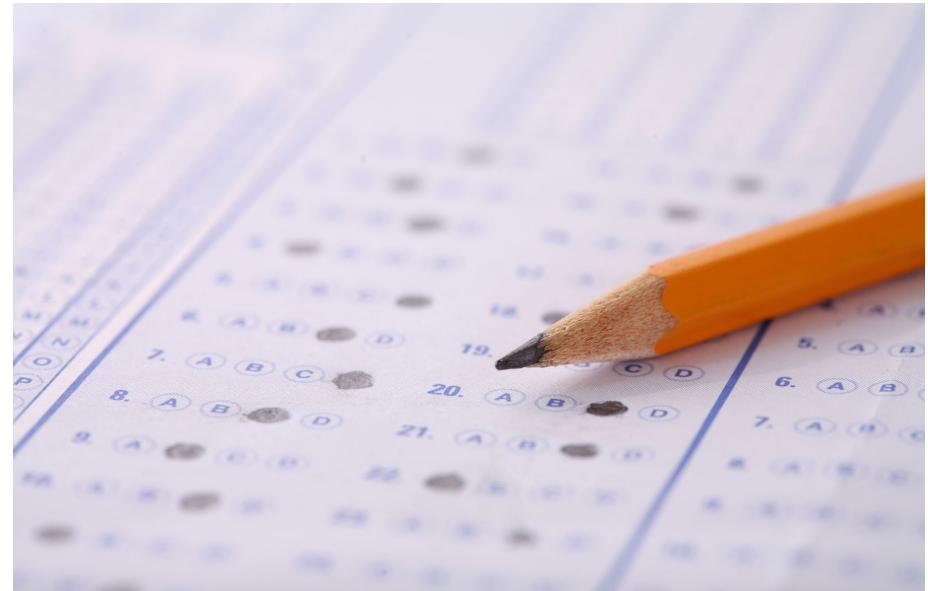


# METRICS

- Video and audio recordings
- 9 unique subjective questionnaires across 12 runs
  - NASA-TLX [7]
  - Situation Awareness Rating Technique (SART) [10]
  - Perceived Risk [12]
  - Human-Automation Trust [8]
  - Trial Planner UX Survey
  - Post-Scenario review

## END OF DAY

- Human-Automation Trust [8] (again)
- Post Study System Usability Questionnaire [9]
- Safety and Risk Perceptions of Automation [3]
- FMI Usability Questionnaire



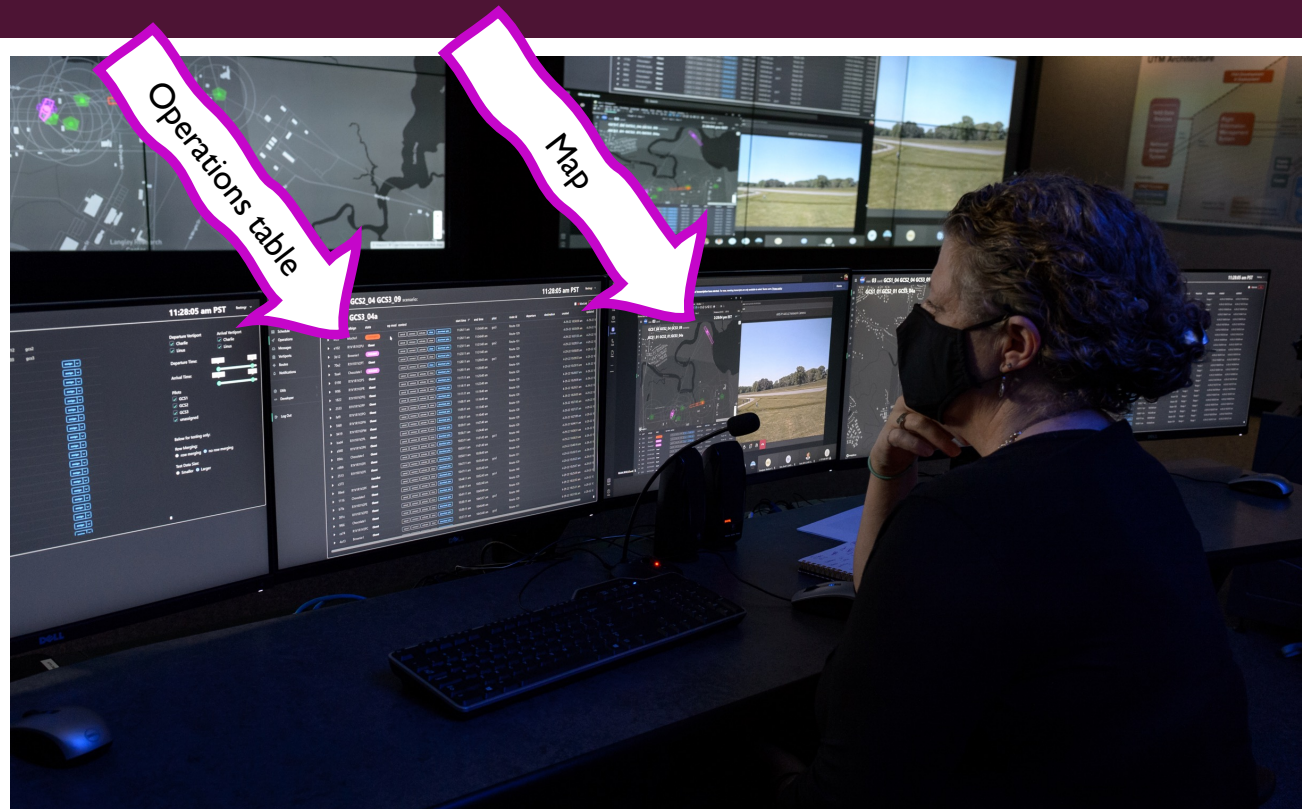
# PROCEDURE

- 1 hour training session with the FMI for both roles
- 3 FM participants ran:
  - 3 runs a day, each run was 30 minutes (1.5 hours)
  - 4 days total ( $1.5 \times 4 = 6$  hours total)
- 20 minutes for the scenario, 10 minutes for the questionnaire
- Run example:
  1. GCSO performs preflight checklist
  2. FM confirms FMI connectivity
  3. GCSO commands takeoff
  4. GCSO and FMI monitored the airspace
  5. Scenario Types:
    - A. Scenario 1: Nominal automated landing occurred at scheduled vertiport
    - B. Scenario 4: Original vertiport closes, and diverted route created through use of the trial planner and automated landing at an unscheduled alternate vertiport

\* *Ground Control Station Operator (GCSO), Fleet Manager (FM), Fleet Manager Interface (FMI)*



# FLEET MANAGER WORKSTATION



# I. CREATE AND SUBMIT AN OPERATION



☰

Map

Schedule

Operations

Messages

Vertiports

Routes

Notifications 1

Utils

Developer

Log Out

10:35:11 am PST

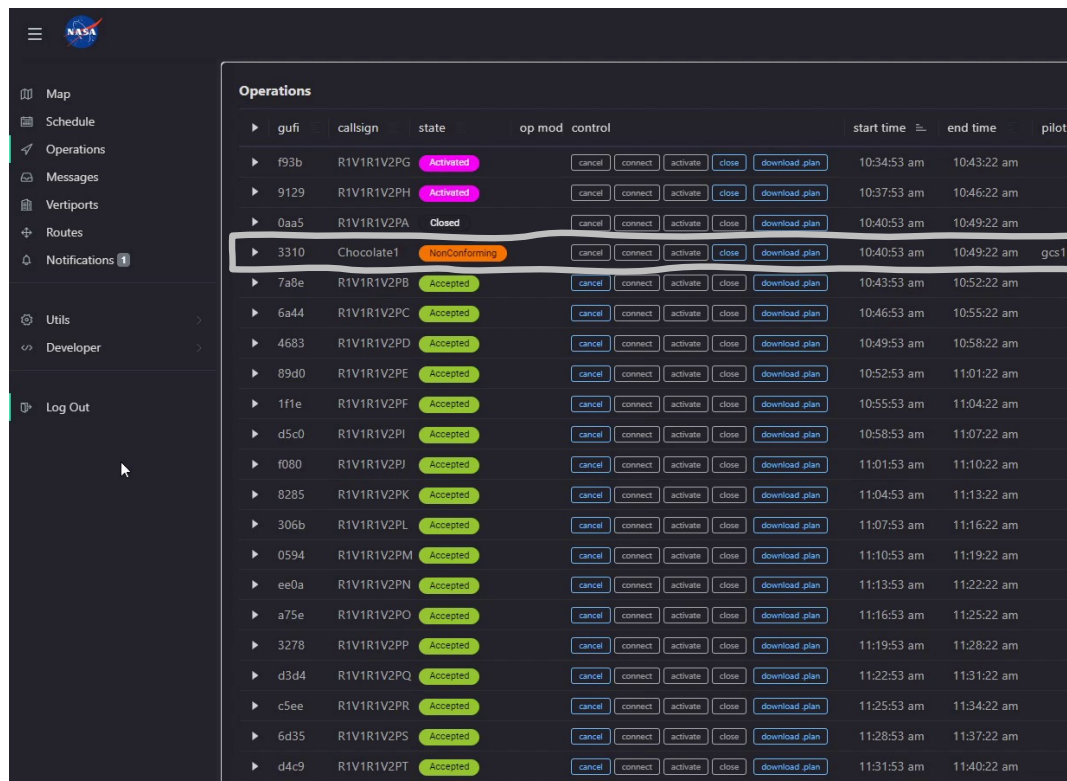
fleetmgr

new

Operations

| gufi   | callsign   | state     | op mod | control                                                                                                                     | start time  | end time    | pilot | route id  | departure | destination | created             | updated     |
|--------|------------|-----------|--------|-----------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-------|-----------|-----------|-------------|---------------------|-------------|
| ▶ 193b | R1V1R1V2PG | Activated |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:34:53 am | 10:43:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:32:52 am | 8-05-22 10: |
| ▶ 9129 | R1V1R1V2PH | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:37:53 am | 10:46:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:33:09 am | 8-05-22 10: |
| ▶ 0aa5 | R1V1R1V2PA | Closed    |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:40:53 am | 10:49:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:33:28 am | 8-05-22 10: |
| ▶ 3310 | Chocolate1 | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:40:53 am | 10:49:22 am | gcs1  | Route-130 | Range 1   | Range 1     | 8-05-22 10:35:04 am | 8-05-22 10: |
| ▶ 7a8e | R1V1R1V2PB | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:43:53 am | 10:52:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:33:45 am | 8-05-22 10: |
| ▶ 6a44 | R1V1R1V2PC | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:46:53 am | 10:55:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:34:03 am | 8-05-22 10: |
| ▶ 4683 | R1V1R1V2PD | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:49:53 am | 10:58:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:34:21 am | 8-05-22 10: |
| ▶ 89d0 | R1V1R1V2PE | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:52:53 am | 11:01:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:34:40 am | 8-05-22 10: |
| ▶ 1f1e | R1V1R1V2PF | Accepted  |        | <a href="#">cancel</a> <a href="#">connect</a> <a href="#">activate</a> <a href="#">close</a> <a href="#">download plan</a> | 10:55:53 am | 11:04:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:34:57 am | 8-05-22 10: |

## 2. LOAD FLIGHT PLAN AND TAKE OFF

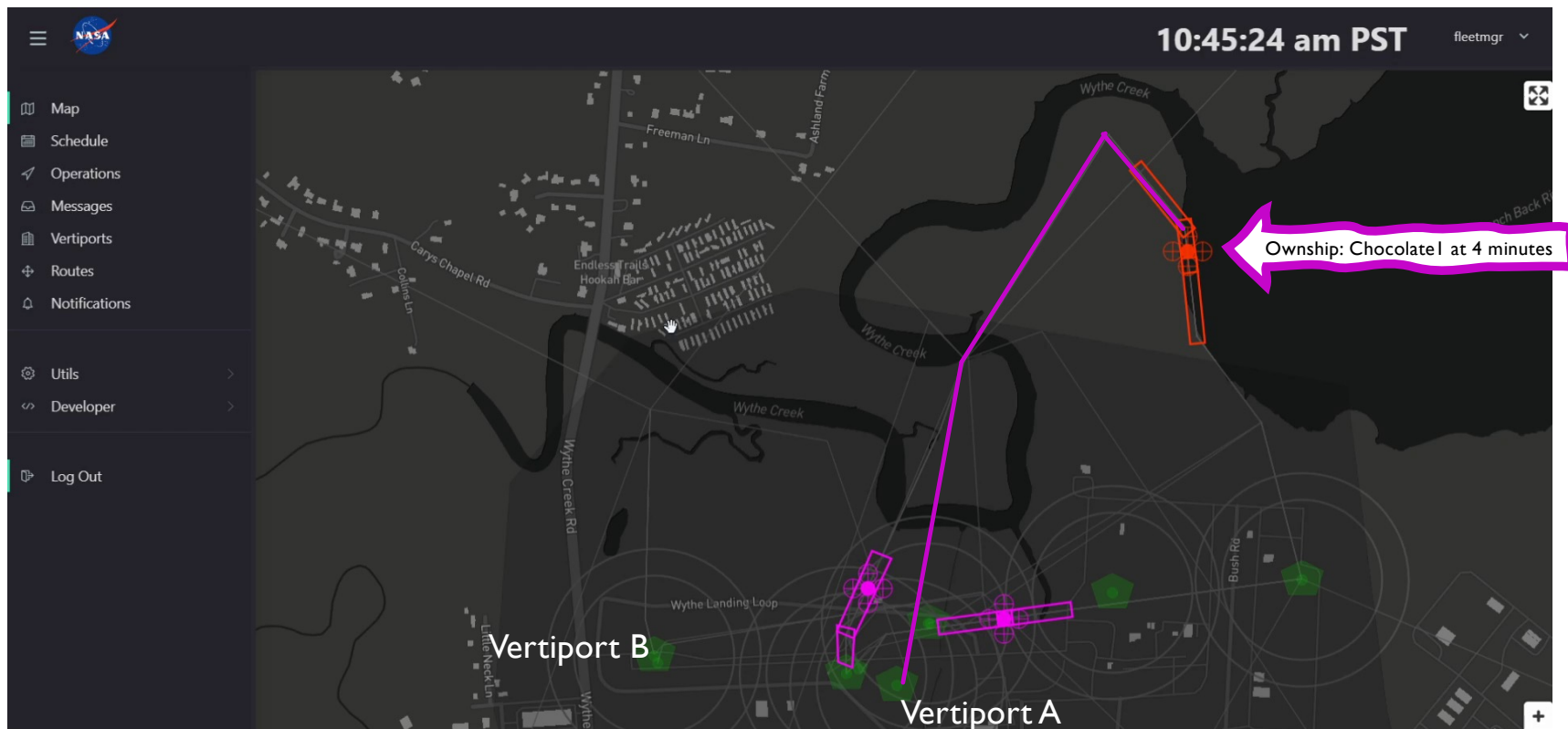


The screenshot shows the NASA Operations interface. On the left is a sidebar with navigation options: Map, Schedule, Operations, Messages, Vertiports, Routes, Notifications (1), Utils, Developer, and Log Out. The main panel displays a table of operations.

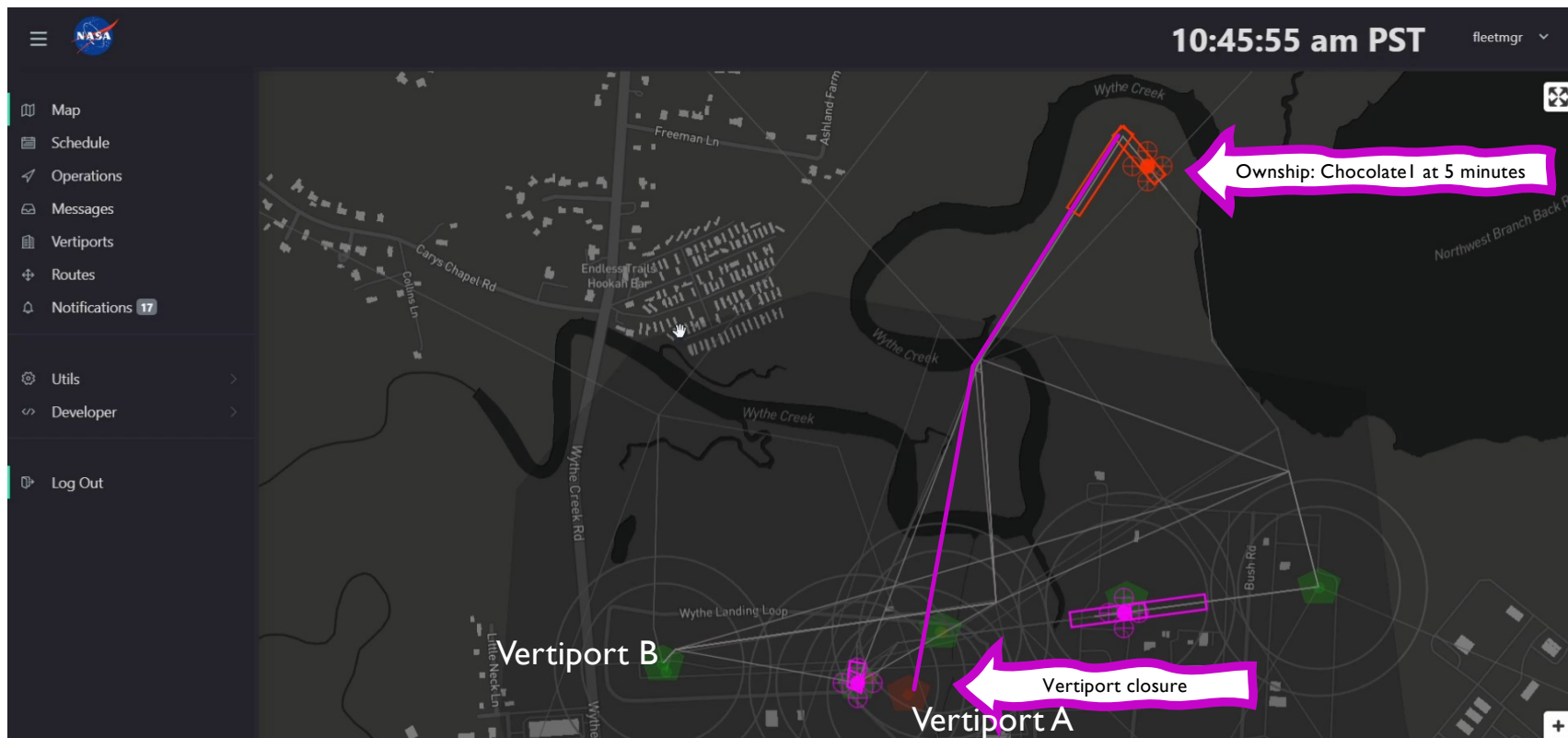
|   | gufi | callsign   | state         | op mod | control                                                                                                                          | start time  | end time    | pilot |
|---|------|------------|---------------|--------|----------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-------|
| ▶ | f93b | R1V1R1V2PG | Activated     |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:34:53 am | 10:43:22 am |       |
| ▶ | 9129 | R1V1R1V2PH | Activated     |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:37:53 am | 10:46:22 am |       |
| ▶ | 0aa5 | R1V1R1V2PA | Closed        |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:40:53 am | 10:49:22 am |       |
| ▶ | 3310 | Chocolate1 | NonConforming |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:40:53 am | 10:49:22 am | gcs1  |
| ▶ | 7a8e | R1V1R1V2PB | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:43:53 am | 10:52:22 am |       |
| ▶ | 6a44 | R1V1R1V2PC | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:46:53 am | 10:55:22 am |       |
| ▶ | 4683 | R1V1R1V2PD | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:49:53 am | 10:58:22 am |       |
| ▶ | 89d0 | R1V1R1V2PE | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:52:53 am | 11:01:22 am |       |
| ▶ | 1f1e | R1V1R1V2PF | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:55:53 am | 11:04:22 am |       |
| ▶ | d5c0 | R1V1R1V2PI | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:58:53 am | 11:07:22 am |       |
| ▶ | f080 | R1V1R1V2PJ | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:01:53 am | 11:10:22 am |       |
| ▶ | 8285 | R1V1R1V2PK | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:04:53 am | 11:13:22 am |       |
| ▶ | 306b | R1V1R1V2PL | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:07:53 am | 11:16:22 am |       |
| ▶ | 0594 | R1V1R1V2PM | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:10:53 am | 11:19:22 am |       |
| ▶ | ee0a | R1V1R1V2PN | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:13:53 am | 11:22:22 am |       |
| ▶ | a75e | R1V1R1V2PO | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:16:53 am | 11:25:22 am |       |
| ▶ | 3278 | R1V1R1V2PP | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:19:53 am | 11:28:22 am |       |
| ▶ | d3d4 | R1V1R1V2PQ | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:22:53 am | 11:31:22 am |       |
| ▶ | c5ee | R1V1R1V2PR | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:25:53 am | 11:34:22 am |       |
| ▶ | 6d35 | R1V1R1V2PS | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:28:53 am | 11:37:22 am |       |
| ▶ | d4c9 | R1V1R1V2PT | Accepted      |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:31:53 am | 11:40:22 am |       |



### 3. GCSO AND FMI MONITOR THE AIRSPACE



## 4. VERTIPOINT CLOSURE



## 5. TRIAL PLANNER IS ACTIVATED, AND ROUTE OPTIONS WERE PRESENTED

10:46:20 am PST fleetmgr

Operations

Messages Volume Info Trial Planning Json Tree Raw Json

Stop Trial Planning Invoke Trial Planning

| # | id   | created     | updated     | expires     | destination | status   | duration | distance   | casualty | terrain | weather | control                                         |
|---|------|-------------|-------------|-------------|-------------|----------|----------|------------|----------|---------|---------|-------------------------------------------------|
| 3 | 758f | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:15     | 1.72 km    | 40       | 5       | 60      | <button>submit</button> <button>reject</button> |
| 2 | 5450 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | ** 3:15  | 1.71 km    | 50       | 5       | 50      | <button>submit</button> <button>reject</button> |
| 1 | 0649 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:22     | ** 1.71 km | 60       | 5       | 40      | <button>submit</button> <button>reject</button> |

Operations table:

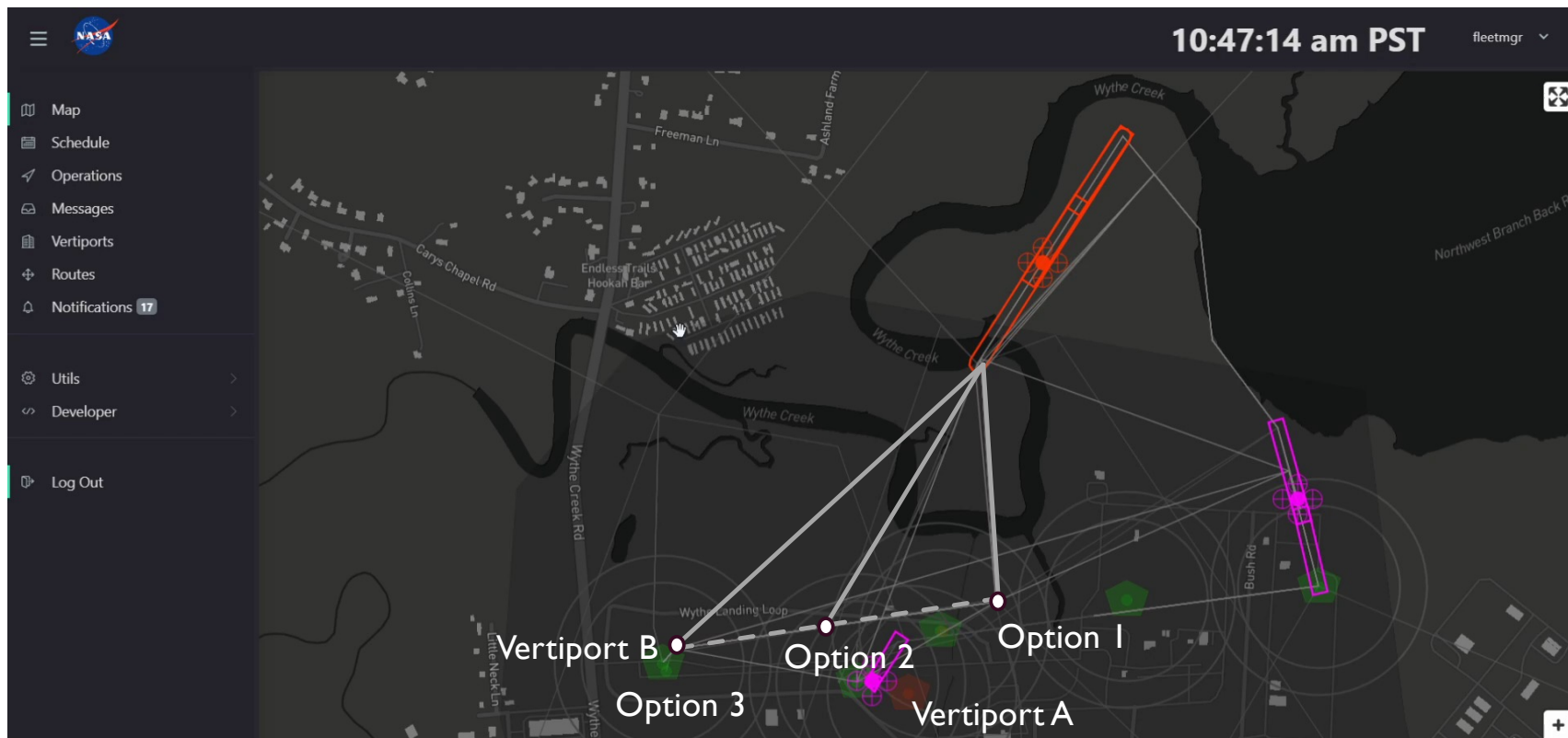
| gufi | callsign   | state      | op mod | control                                                                                                                          | start time  | end time    | pilot | route id  | departure | destination | created             | updated             |
|------|------------|------------|--------|----------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-------|-----------|-----------|-------------|---------------------|---------------------|
| f93b | R1V1R1V2PG | Closed     |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:34:53 am | 10:43:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:32:52 am | 8-05-22 10:32:52 am |
| 9129 | R1V1R1V2PH | Activated  |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:37:53 am | 10:46:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:33:09 am | 8-05-22 10:33:09 am |
| 0aa5 | R1V1R1V2PA | Closed     |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:40:53 am | 10:49:22 am |       | Route-129 | Range 1   | Range 1     | 8-05-22 10:33:28 am | 8-05-22 10:33:28 am |
| 3310 | Chocolate1 | Contingent |        | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:40:53 am | 10:49:22 am | gcs1  | Route-130 | Range 1   | Range 1     | 8-05-22 10:35:04 am | 8-05-22 10:35:04 am |

Operations table (continued):

|      |            |           |  |                                                                                                                                  |             |             |  |           |         |         |                     |                     |
|------|------------|-----------|--|----------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|--|-----------|---------|---------|---------------------|---------------------|
| 7a8e | R1V1R1V2PB | Activated |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:43:53 am | 10:52:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:33:45 am | 8-05-22 10:33:45 am |
| 6a44 | R1V1R1V2PC | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:46:53 am | 10:55:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:34:03 am | 8-05-22 10:34:03 am |
| 4683 | R1V1R1V2PD | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:49:53 am | 10:58:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:34:21 am | 8-05-22 10:34:21 am |
| 89d0 | R1V1R1V2PE | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:52:53 am | 11:01:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:34:40 am | 8-05-22 10:34:40 am |
| 1f1e | R1V1R1V2PF | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:55:53 am | 11:04:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:34:57 am | 8-05-22 10:34:57 am |
| d5c0 | R1V1R1V2PI | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 10:58:53 am | 11:07:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:35:15 am | 8-05-22 10:35:15 am |
| f080 | R1V1R1V2PJ | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:01:53 am | 11:10:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:35:33 am | 8-05-22 10:35:33 am |
| 8285 | R1V1R1V2PK | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:04:53 am | 11:13:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:35:51 am | 8-05-22 10:35:51 am |
| 306b | R1V1R1V2PL | Accepted  |  | <button>cancel</button> <button>connect</button> <button>activate</button> <button>close</button> <button>download plan</button> | 11:07:53 am | 11:16:22 am |  | Route-129 | Range 1 | Range 1 | 8-05-22 10:36:09 am | 8-05-22 10:36:09 am |

## ROUTE OPTIONS

\*NOT ACTUALLY DISPLAYED ON MAP





| Route | Ground Risk | Terrain | Weather |
|-------|-------------|---------|---------|
| A     | 40          | 5       | 60      |
| B     | 60          | 5       | 40      |
| C     | 50          | 5       | 50      |

\*Factor values were notional

# ROUTE DECISION FACTORS: DISTANCE, GROUND RISK (CASUALTY), TERRAIN, WEATHER

Map

Schedule

Operations

Messages

Vertiports

Routes

Notifications 18

Utils

Developer

Log Out

10:46:20 am PST

fleetmgr

new

Operations

Messages

Volume Info

Trial Planning

Json Tree

Raw Json

Stop Trial Planning

Invoke Trial Planning

| # | id   | created     | updated     | expires     | destination | status   | duration | distance   | casualty | terrain | weather | control                 |
|---|------|-------------|-------------|-------------|-------------|----------|----------|------------|----------|---------|---------|-------------------------|
| 3 | 758f | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:15     | 1.72 km    | 40       | 5       | 60      | <div>submitreject</div> |
| 2 | 5450 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | ** 3:15  | 1.71 km    | 50       | 5       | 50      | <div>submitreject</div> |
| 1 | 0649 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:22     | ** 1.71 km | 60       | 5       | 40      | <div>submitreject</div> |

7a8e

R1V1R1V2PB

Activated

cancelconnectactivateclose

download plan

10:43:53 am

10:52:22 am

Route-129

Range 1

Range 1

8-05-22 10:33:45 am

8-05-22 10

6a44

R1V1R1V2PC

Accepted

cancelconnectactivateclose

download plan

10:46:53 am

10:55:22 am

Route-129

Range 1

Range 1

8-05-22 10:34:03 am

8-05-22 10

4683

R1V1R1V2PD

Accepted

cancelconnectactivateclose

download plan

10:49:53 am

10:58:22 am

Route-129

Range 1

Range 1

8-05-22 10:34:21 am

8-05-22 10

89d0

R1V1R1V2PE

Accepted

cancelconnectactivateclose

download plan

10:52:53 am

11:01:22 am

Route-129

Range 1

Range 1

8-05-22 10:34:40 am

8-05-22 10

1f1e

R1V1R1V2PF

Accepted

cancelconnectactivateclose

download plan

10:55:53 am

11:04:22 am

Route-129

Range 1

Range 1

8-05-22 10:34:57 am

8-05-22 10

d5c0

R1V1R1V2PI

Accepted

cancelconnectactivateclose

download plan

10:58:53 am

11:07:22 am

Route-129

Range 1

Range 1

8-05-22 10:35:15 am

8-05-22 10

f080

R1V1R1V2PJ

Accepted

cancelconnectactivateclose

download plan

11:01:53 am

11:10:22 am

Route-129

Range 1

Range 1

8-05-22 10:35:33 am

8-05-22 10

8285

R1V1R1V2PK

Accepted

cancelconnectactivateclose

download plan

11:04:53 am

11:13:22 am

Route-129

Range 1

Range 1

8-05-22 10:35:51 am

8-05-22 10

306b

R1V1R1V2PL

Accepted

cancelconnectactivateclose

download plan

11:07:53 am

11:16:22 am

Route-129

Range 1

Range 1

8-05-22 10:36:09 am

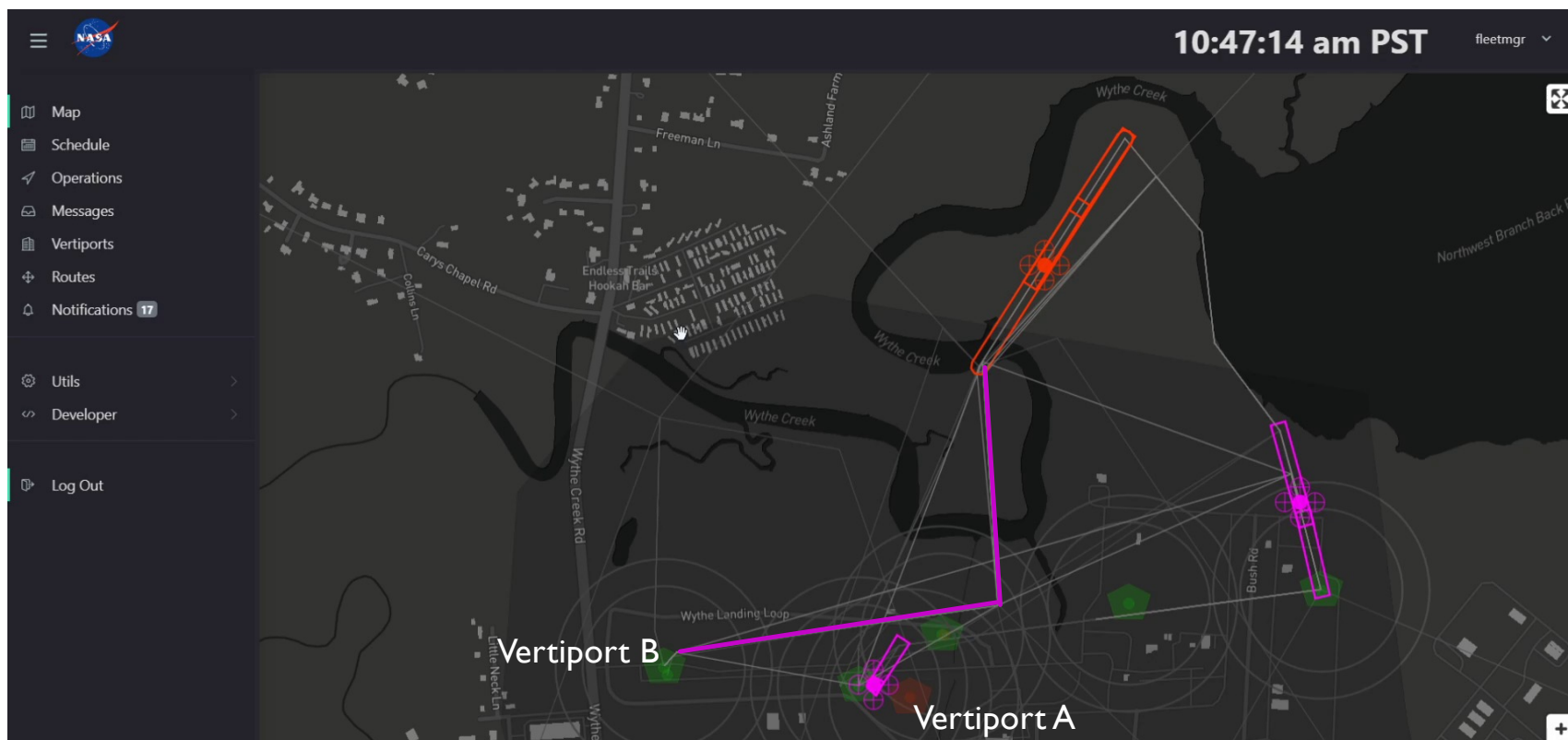
8-05-22 10

## 7. TRIAL PLANNER IS ACTIVATED, AND A NEW REROUTE IS SELECTED

The screenshot displays the NASA Operations interface. The left sidebar contains navigation links: Map, Schedule, Operations, Messages, Vertiports, Routes, Notifications (18), Utils, Developer, and Log Out. The main content area is titled 'Operations' and shows a list of operations. The 'Trial Planning' tab is selected, and a pink box highlights the 'Trial Planning' section. This section includes a table with columns: #, id, created, updated, expires, destination, status, duration, distance, casualty, terrain, weather, and control. The table contains three rows of data. The 'control' column for each row has 'submit' and 'reject' buttons. A pink arrow points to the 'submit' button in the first row, labeled 'Route selection button'.

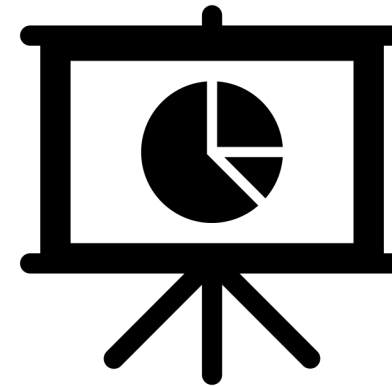
| # | id   | created     | updated     | expires     | destination | status   | duration | distance   | casualty | terrain | weather | control                                         |
|---|------|-------------|-------------|-------------|-------------|----------|----------|------------|----------|---------|---------|-------------------------------------------------|
| 3 | 758f | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:15     | 1.72 km    | 40       | 5       | 60      | <button>submit</button> <button>reject</button> |
| 2 | 5450 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | ** 3:15  | 1.71 km    | 50       | 5       | 50      | <button>submit</button> <button>reject</button> |
| 1 | 0649 | 10:45:47 am | 10:45:47 am | 10:47:16 am | Linus       | Proposed | 3:22     | ** 1.71 km | 60       | 5       | 40      | <button>submit</button> <button>reject</button> |

## 8. FLIGHT CREW REVIEWED AND EXECUTED NEW ROUTE



## RESULTS SUMMARY (CONTINUED)

- Between-run outcome summary for FM participants:
  - (Positive) NASA TLX [7] showed high self-assessed performance
  - (Positive) Situation Awareness Rating Technique [10] showed high levels of alertness, spare mental capacity, and familiarity across both scenarios
  - (Negative) The Perceived Risk [12] questionnaire showed that participants had higher levels in Scenario 4 for uncertainty, riskiness, negative consequences, and going poorly
  - (Negative) The Human Automation Trust [8] showed participants felt there was low underhandedness and deception on the part of the automation



## RESULTS SUMMARY (CONTINUED)

- Between-run outcome summary for FM participants (continued):
  - Questionnaires on usability given after the trials were complete showed peak levels on questions on effectiveness for completing tasks, feeling comfortable, learnability and likability of the system
- Most frequent comments were:
  - Wanting the trial planner to show previews on the FMI map before final selection
  - Wanting the vertiport closure and vehicle replan notifications to provide more info on why a replan is required
  - Wanting the schedule page in the FMI to be more responsive

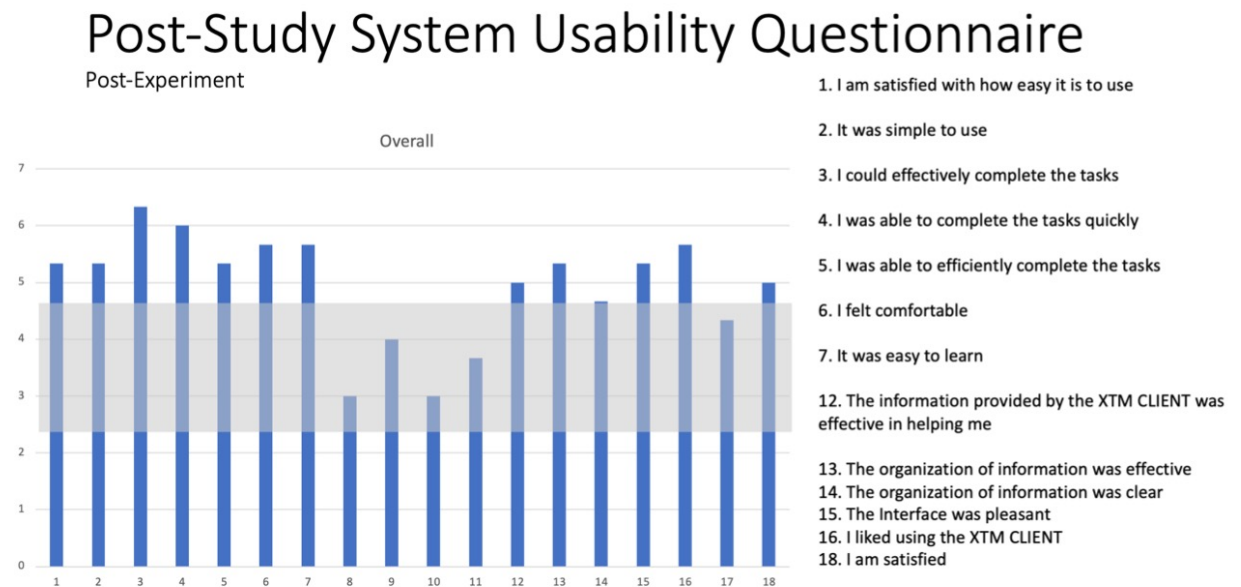
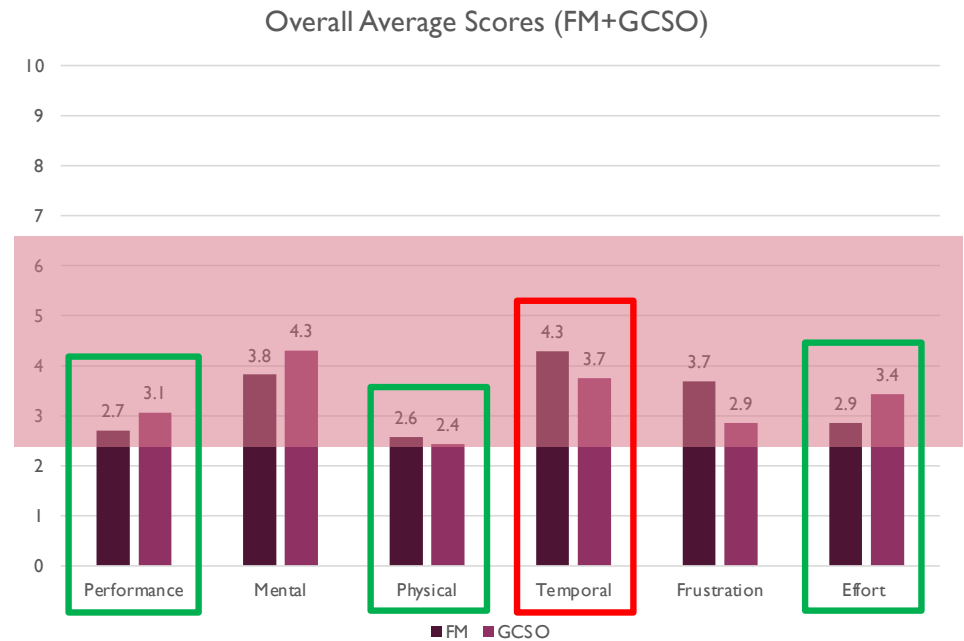


Figure 5. Usability study outcome for FM participants

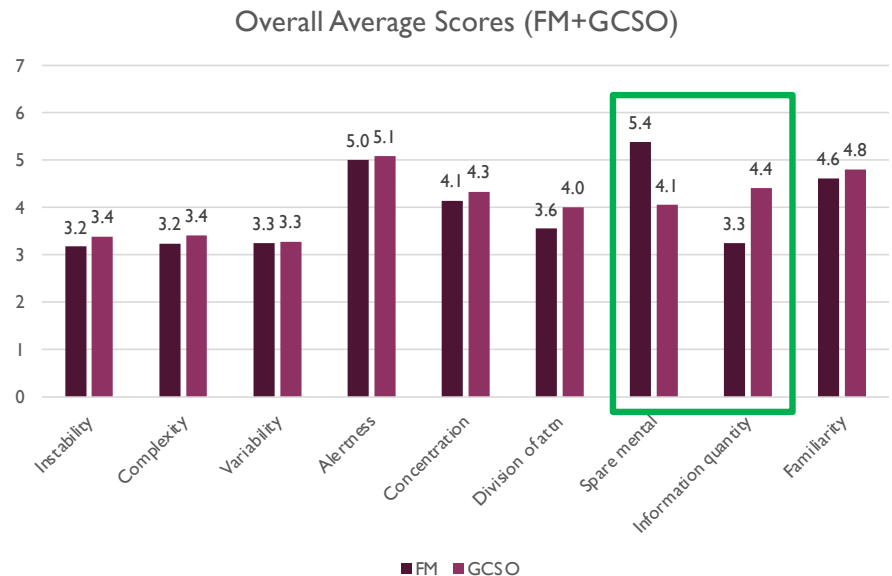
## RESULTS (CONTINUED)

- Task Load Index [7]:
  - (Positive) FM and GCSO had high self-assessed performance
  - (Positive) Both had low physical demand and effort scores
  - (Negative) Both had high mental and temporal demand scores
  - There were no meaningful differences between either position



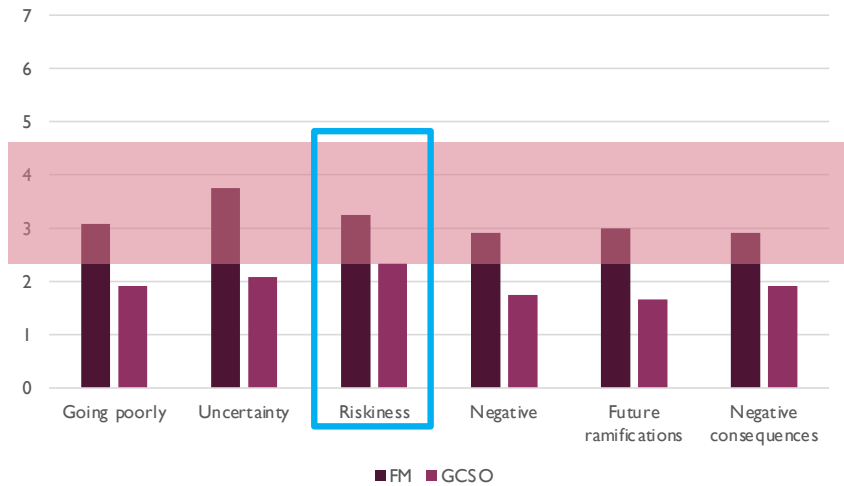
## RESULTS (CONTINUED)

- Situation Awareness Rating Technique [10]:
  - FMs reported more spare mental capacity on average than the GCSOs at 14%
  - (Positive) Greatly increased situational awareness (suggesting more spare mental capacity)
  - GCSOs reported better information quality than the FMs (14%)

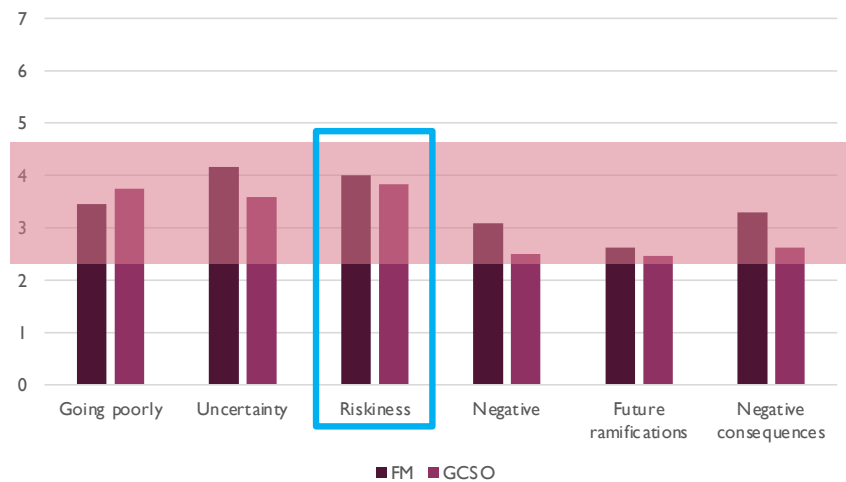


## RESULTS (CONTINUED)

Average S1 scores (FM +GCSO)



Average S4 scores (FM +GCSO)



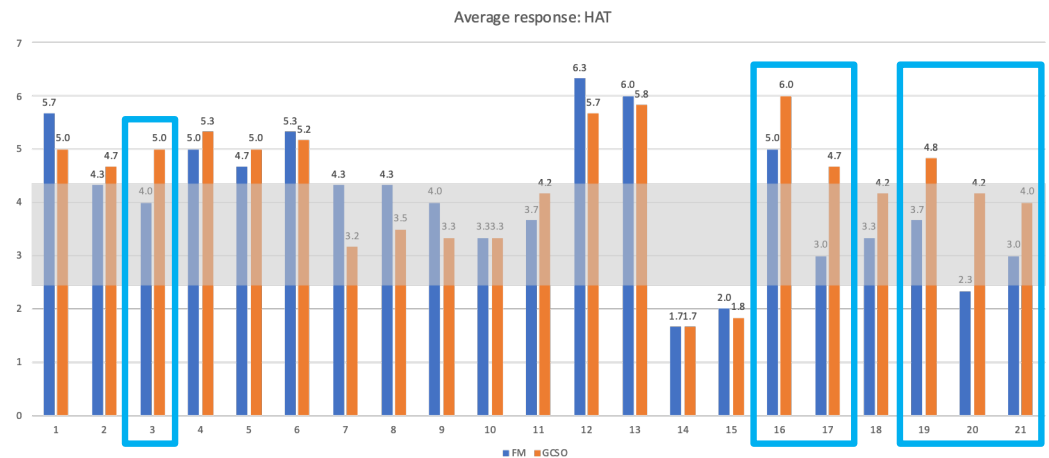
- Perceived Risk [12]:
  - Both rated Scenario 4 as riskier than Scenario 1

## RESULTS (CONTINUED)

### Human-Automation Trust [8]:

- GCSO rated these 15% higher than the FM:

- 3. FMI system routing reliably gets vehicle to destination
- 16. FMI system should provide routing functionality
- 17. I trust the FMI system to route my vehicle even if I am unsure if it is correct
- 19. Even if I am unsure of how to route my vehicle, I trust the FMI system to provide good routing to my destination
- 20. Even if the FMI system behaves in strange ways, I am certain that it will provide the correct routing functionality
- 21. Even if I suspect that the FMI system will not function properly, I feel certain it will provide the needed route functionality

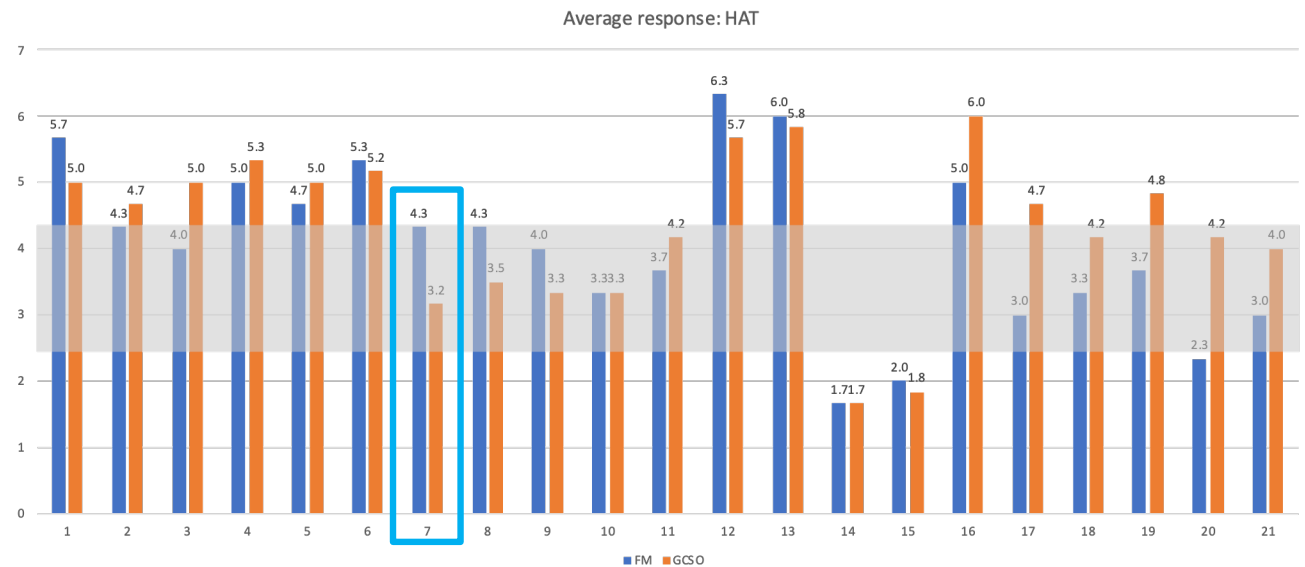


## RESULTS (CONTINUED)

- Human-Automation Trust [8] (continued):

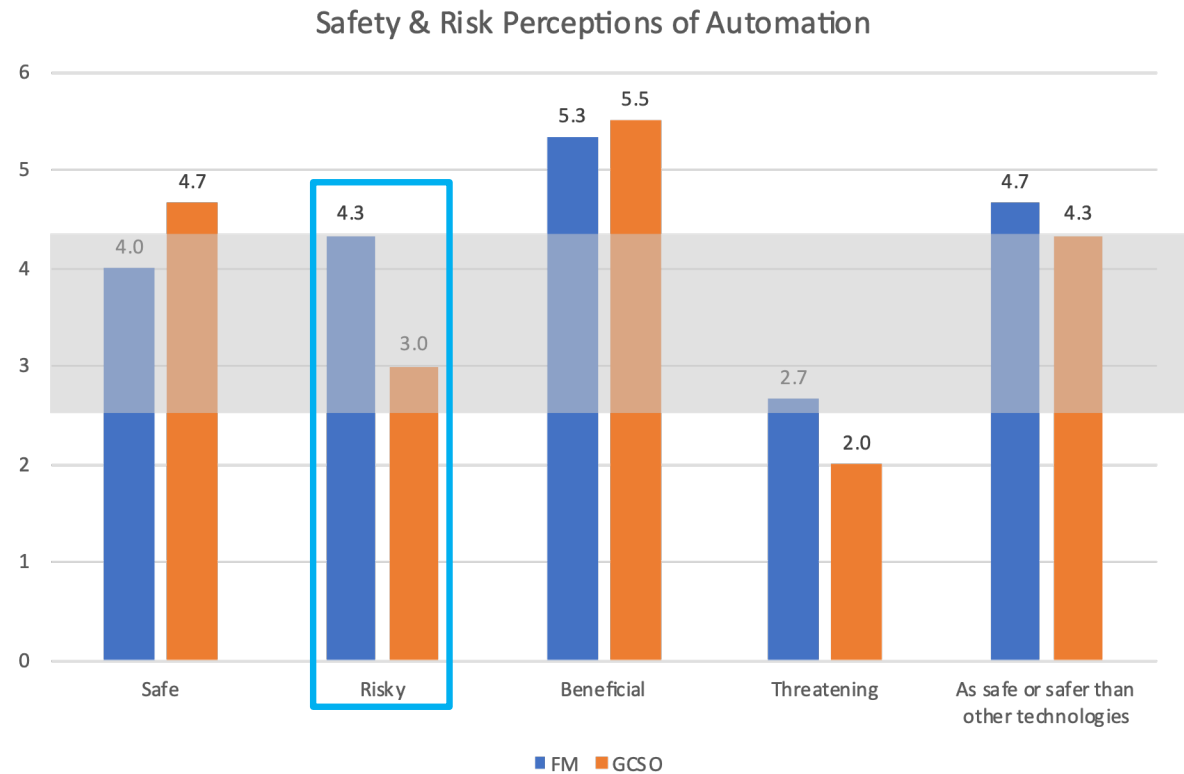
- FM rated these 15% higher than the GCSO:

7. I know how to use the FMI system to get my vehicle to its destination because I understand how it works



## RESULTS (CONTINUED)

- Safety and Risk Perceptions of Automation [3]
  - FMs perceived FMI as riskier than GCSO



## DISCUSSION

- (Positive) FMI display interface usability ratings were moderately strong to favorable
- In the Between Runs Questionnaire, most responses were near “I don’t know”, which may mean interactions with the FMI display did not generate strong feelings or not enough information was provided
- (Positive) Post-Experiment Questionnaire responses were strongly favorable in terms of trust, usability, and risk
- Risk and Trust was different between Scenario 1 and 4, with 4 being less trustworthy
- Operators required more information to assess FMI operator interface performance

## DISCUSSION (CONTINUED)

- Limitations
  - Three Trial Planner routes were available, but participants were only allowed to select one specific route each time
  - Sample size was smaller than desired
    - Actual: 3 FMs and 6 GCSOs
    - Desired: 5 FMs and 6 GCSOs
  - SME were used instead of actual airline dispatchers and ATCs



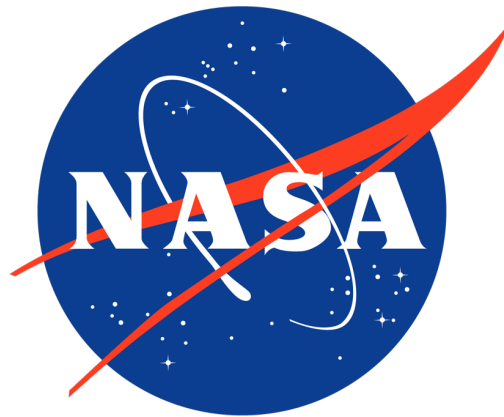
## RECOMMENDATIONS

- **Trial planner display should show a preview of routes**
- **Popup messages and notifications should contain more info on replan and vertiport closures**
- **The schedule page should sync with the operations page and should not be unresponsive**
- Ability to highlight a row in the FMI operations table, and for that operation to highlight on the map
- Red highlight on an operation that needs Trial Planning, since the red triangle isn't salient enough
- FM/GCSO handoff enhancements
- More detailed and draggable datatags for vertiports/vehicles

## SUMMARY

- Study was to take the first steps to assess the usability for the FMI display for the FM and GCSO
- FM role is still being defined, unclear if they should be a novice or expert
- Usability issues need to be corrected before further testing
- Less experienced individuals will be the focus next time





**SAN JOSÉ STATE**  
UNIVERSITY

---

RESEARCH FOUNDATION

THANK YOU!

## HUMAN-AUTOMATION TRUST (PERFORMANCE, PROCESS, PURPOSE, FAITH)

- 1 I trust the xTM system to route my vehicle to its destination.
- 2 The xTM system always provides the routing functionality I require to get my vehicle to its destination.
- 3 The xTM system's routing functionality reliably gets my vehicle to its destination.
- 4 The xTM's routing functionality consistently gets my vehicle to its destination.
- 5 To get my vehicle to its destination, I can rely on the xTM system's routing functionality to work properly.
- 6 The xTM system's routing functionality adequately gets my vehicle to its destination.
- 7 I know how to use the xTM system to get my vehicle to its destination because I understand how it works.
- 8 I will be able to get my vehicle to its destination the next time I use the xTM system because I understand how it works.
- 9 I understand how the xTM system is able to get my vehicle to its destination.
- 10 It is easy to follow what the xTM system does to get my vehicle to its destination, because I understand how it works.
- 11 I usually recognize how the xTM system's routing functionality is working when using it to get my vehicle to its destination.
- 12 I understand why the xTM system was developed.
- 13 The xTM system was designed to help route my vehicle to its destination.
- 14 I do not understand why the xTM system was developed.
- 15 The xTM system was not designed to help route my vehicle to its destination.
- 16 The purpose of the xTM system is to provide routing functionality.
- 17 When getting my vehicle to its destination, I trust the xTM system's routing functionality even when I don't know for certain it is correct.
- 18 I would trust the xTM system to safely route my vehicle to its destination rather than myself.
- 19 If I am not sure about how to route my vehicle to its destination, I have faith that the xTM system will provide good routing functionality.
- 20 Even when the xTM system behaves in unusual ways, I am certain it will correctly provide the needed routing functionality.
- 21 Even if I have no reason to expect that the xTM system will function properly, I still feel certain it will provide the needed routing functionality.

# XTM CLIENT USABILITY QUESTIONNAIRE

- |   |                                                                                                                                  |
|---|----------------------------------------------------------------------------------------------------------------------------------|
| 1 | Rate your experience today with using the XTM Client Interface.                                                                  |
| 2 | Rate the responsiveness of the interface.                                                                                        |
| 3 | Rate your interactions with the map.                                                                                             |
| 4 | Rate the changes in this alternative map design [to be shared with participant on a display] compared to the map you used today. |
| 5 | Rate the size of the symbols on the alternative map design.                                                                      |
| 6 | Rate the usefulness of the flight path information at the bottom edge of the map design above.                                   |
| 7 | How do you prefer to receive/view notifications?                                                                                 |

## TRIAL PLANNER USER EXPERIENCE

- |   |                                                       |
|---|-------------------------------------------------------|
| 1 | The trial planner solutions were acceptable.          |
| 2 | The trial planner solutions were understandable.      |
| 3 | The trial planner solutions were trustworthy.         |
| 4 | The trial planner displayed too much information.     |
| 5 | The trial planner did not display enough information. |