

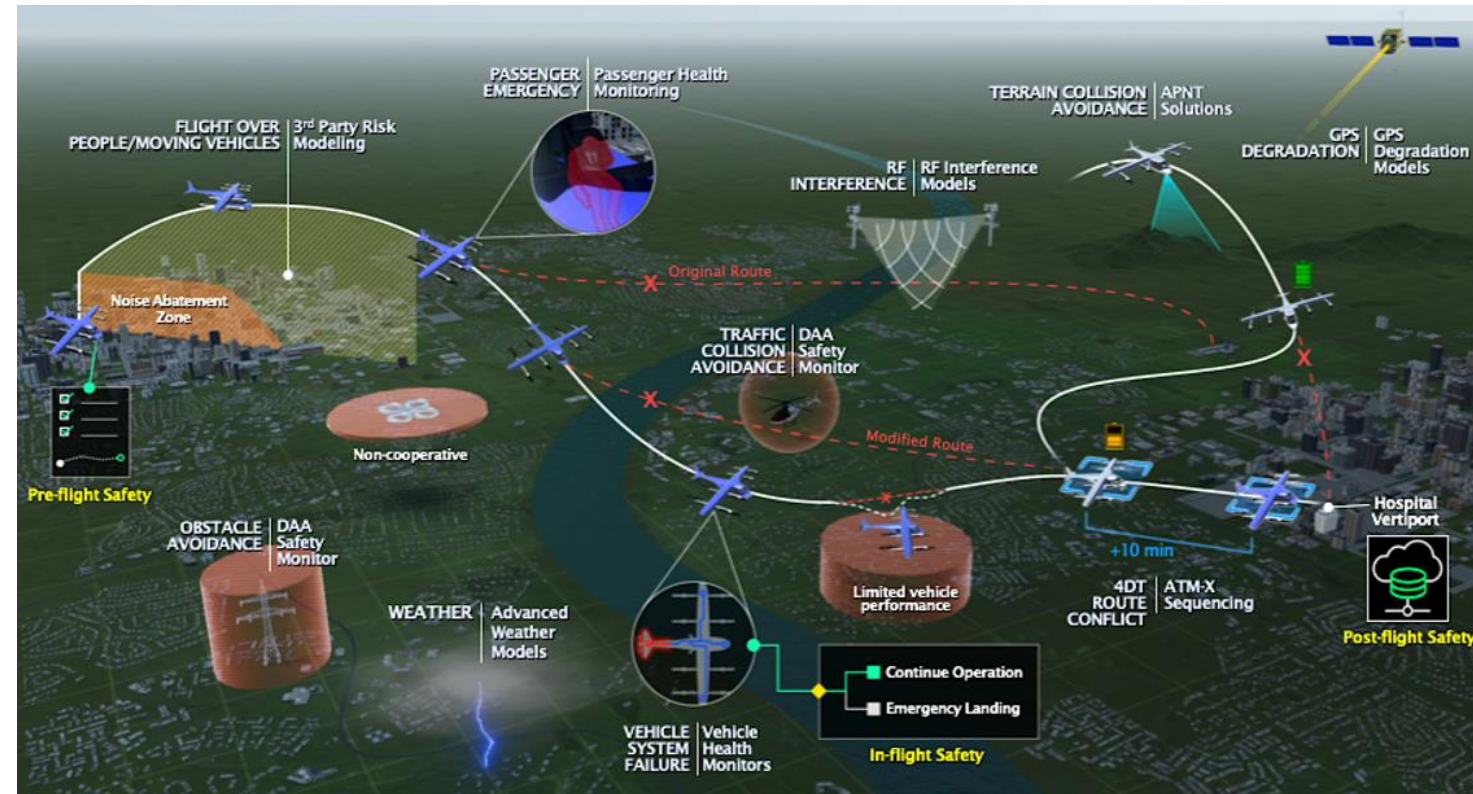
Lessons Learned: m:N Operations in the Application of UTM for Hurricane Rescue

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NASA Ames Research Center
sUAS Working Group Meeting
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System-Wide Safety Project
Airspace Operations and Safety Program
NASA Aeronautics Research Mission Directorate

- **System-Wide-Safety Project**
 - Safety Demonstrator Series (SWS TC5)
 - In-Time Aviation Safety Management System
- **Human Autonomy Teaming**





Past capabilities

- m:N operations
- Emergency response (fire)
- Package delivery
- Ground control station
- Chat assistant
- Background traffic
- Single operator (company)



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New capabilities in this study

- sUAS Traffic Management tool (UTM)
- Hurricane relief and recovery

Lessons learned from a human-autonomy teaming perspective on UTM application



Subjects

- N = 11
- 1 operator : 6 vehicles
- Pre-planned routes



Supervisory control

- Hurricane response
- Supply drops
- 1 drop per location



Pilot tasks

1. UTM management

- Choose destination
- Schedule
- Launch

2. Deconflict from unexpected hazards

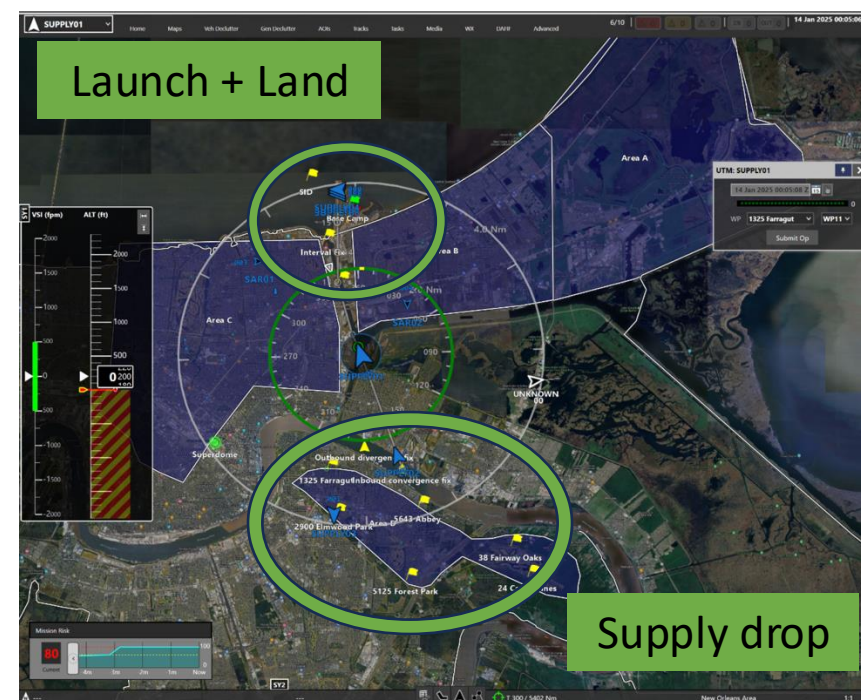
- Detect and avoid

3. Monitor state of vehicles

4. Contingency management

- Loss of GPS

5. Drop emergency supplies

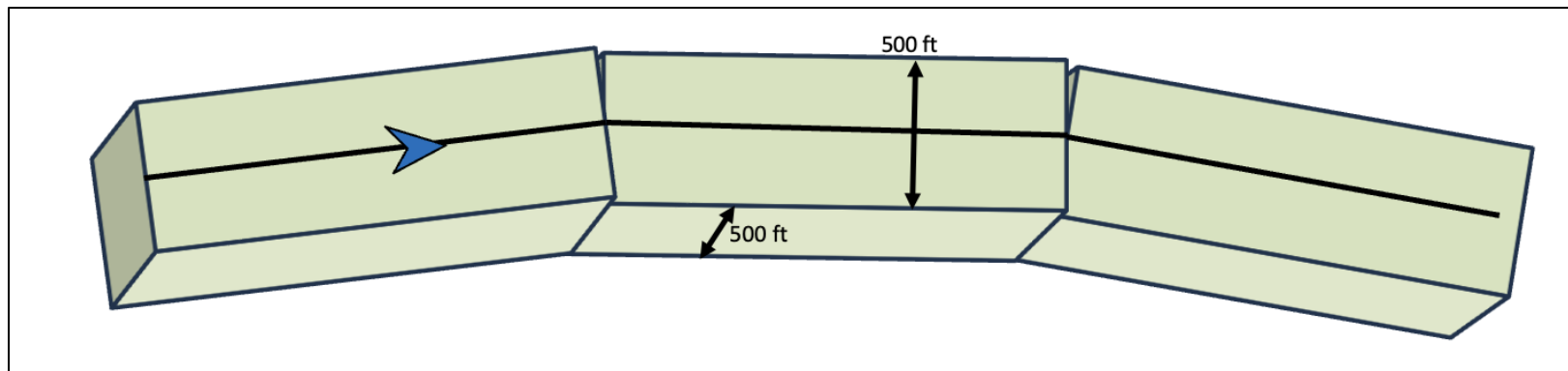
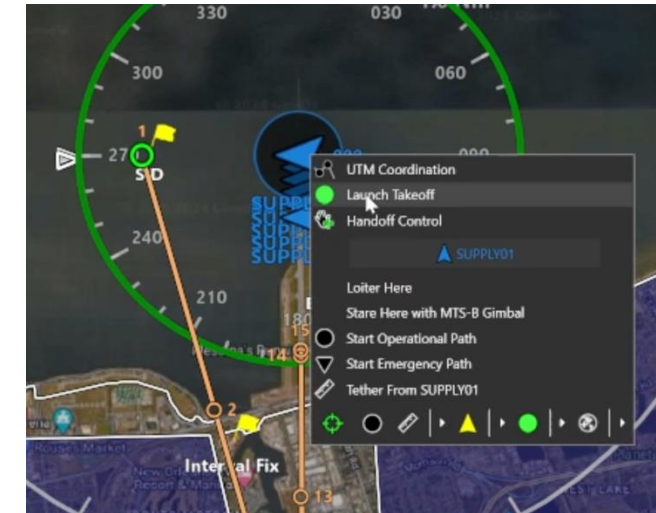
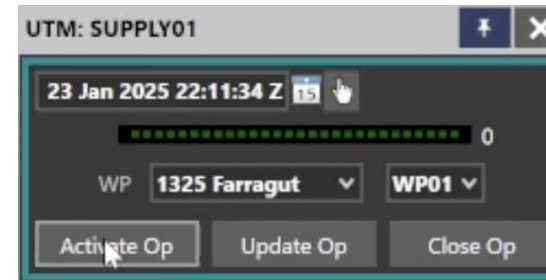
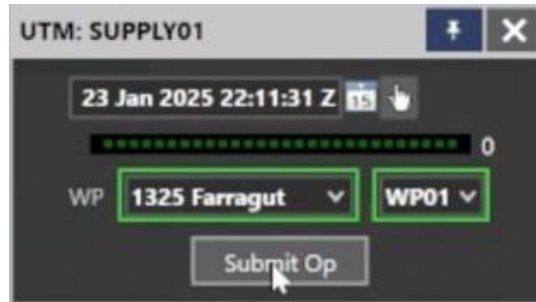
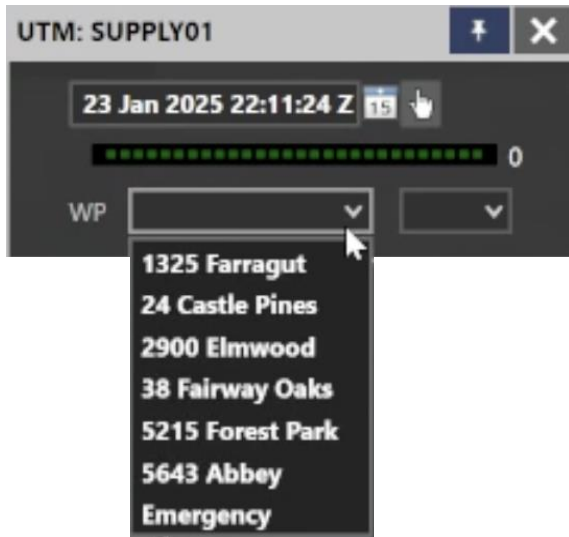


1. Select destination

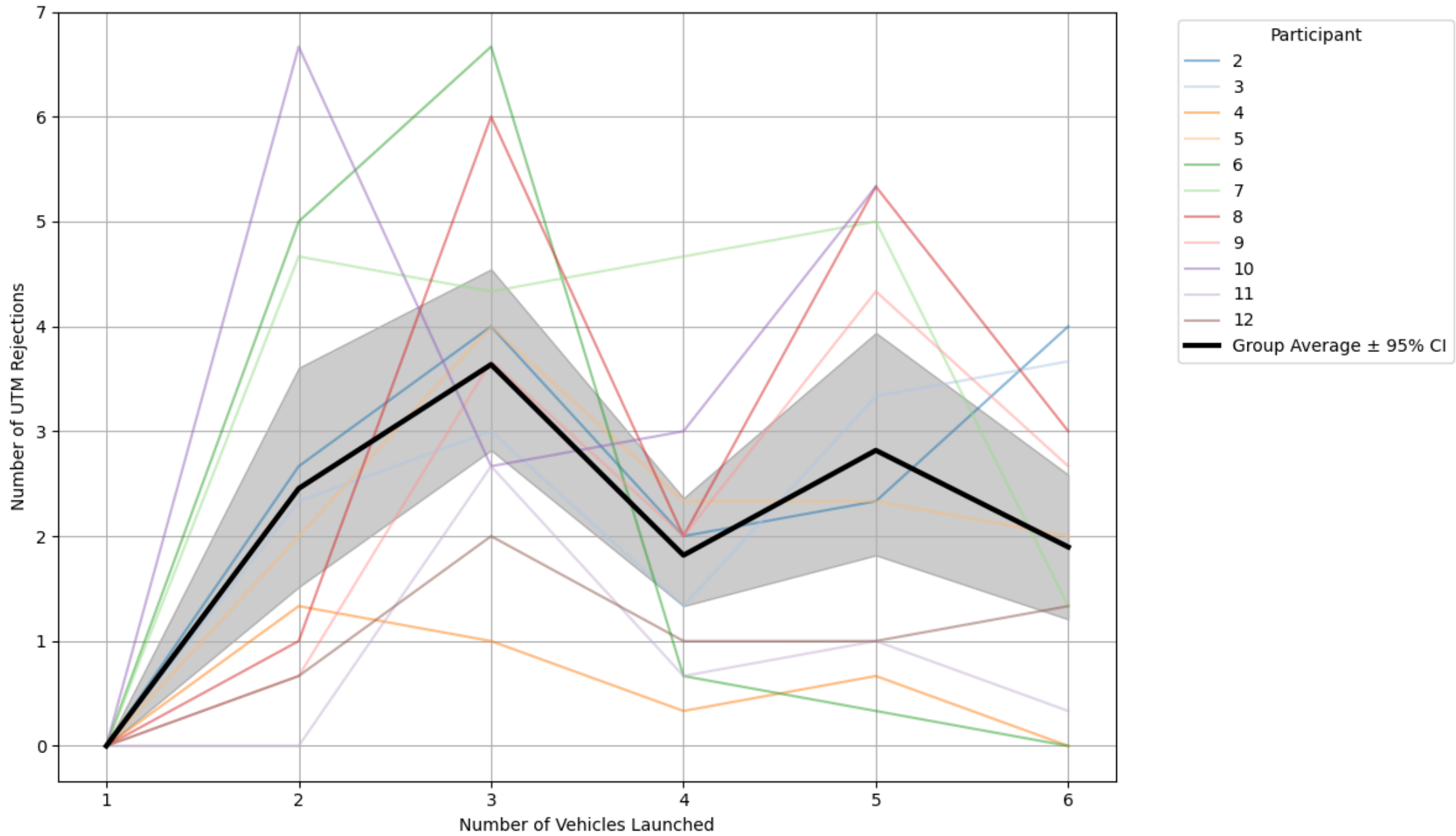
2. Submit to UTM

3. Activate operation

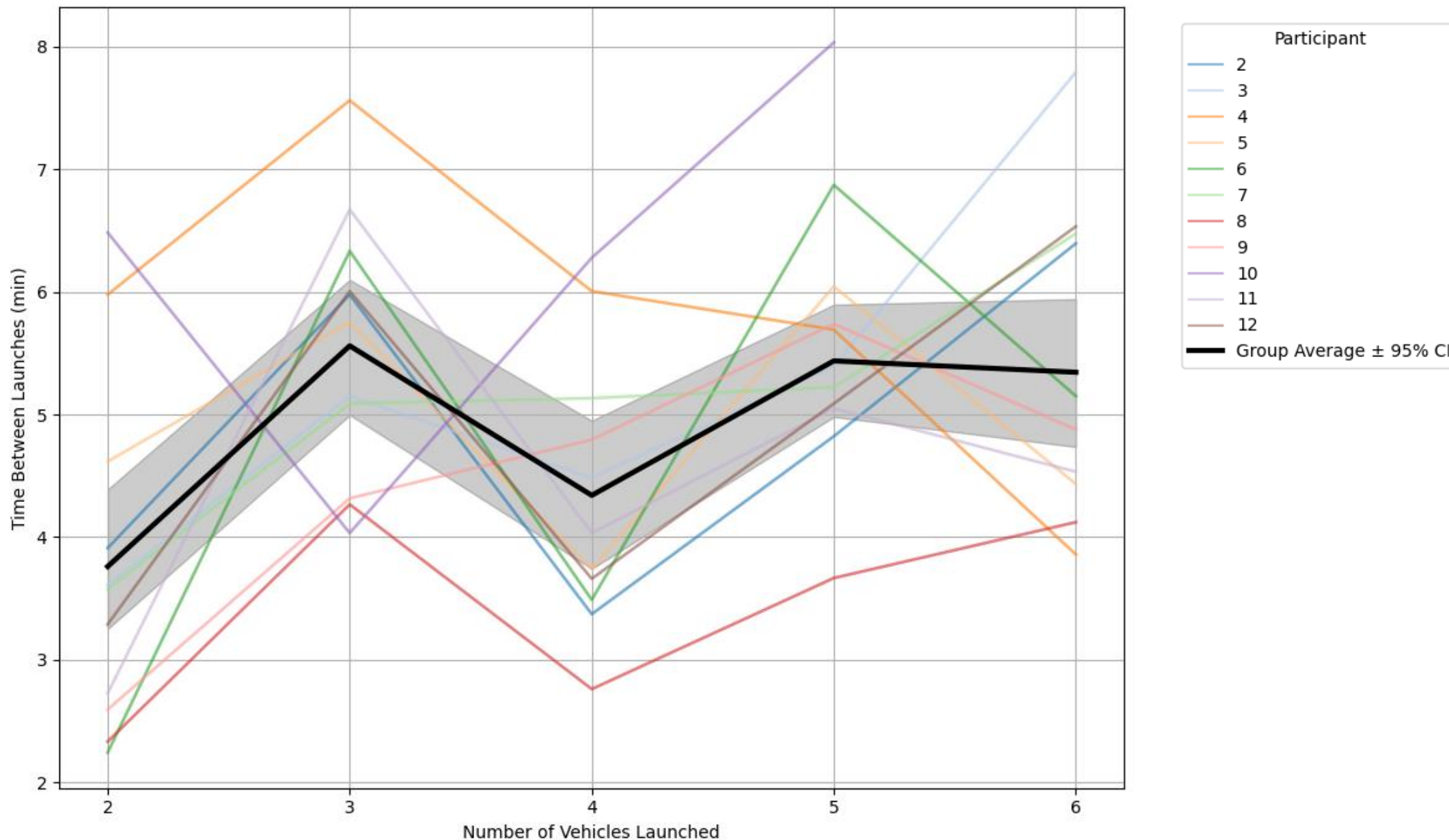
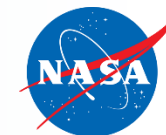
4. Launch vehicle



UTM Rejections



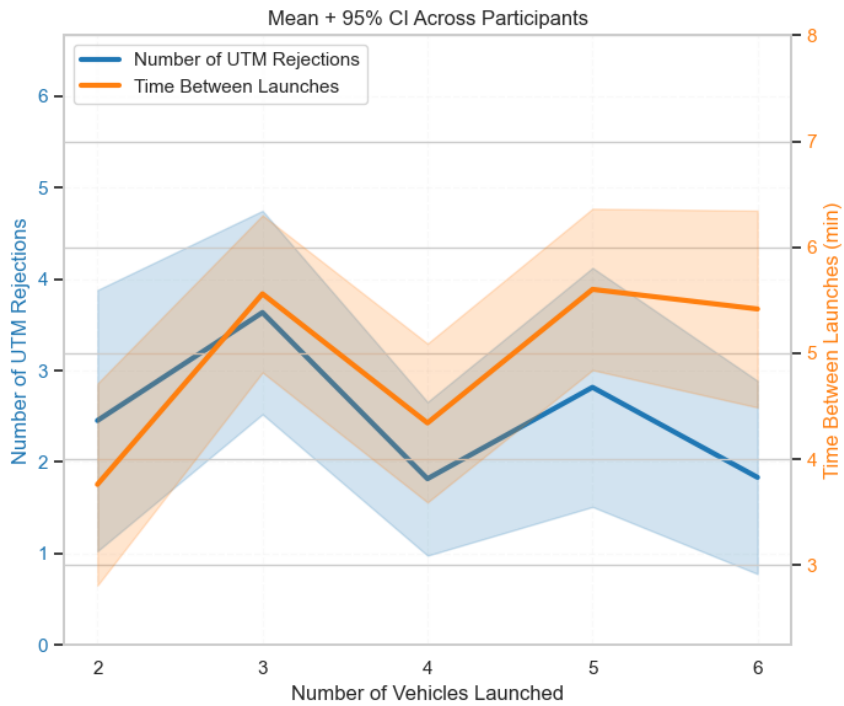
UTM Time to Launch



Typical vs Outlier Participant



Mean

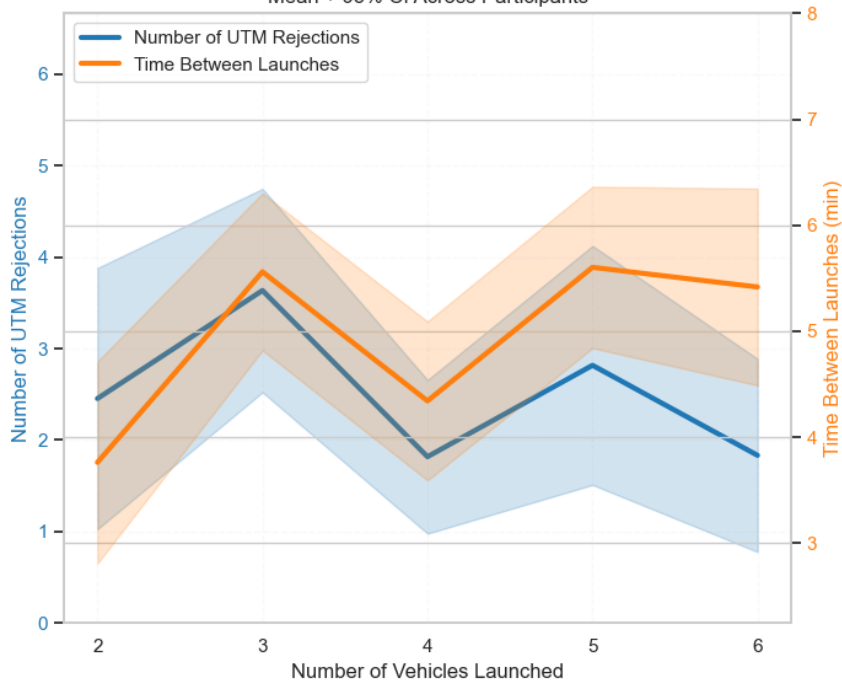


Typical vs Outlier Participant



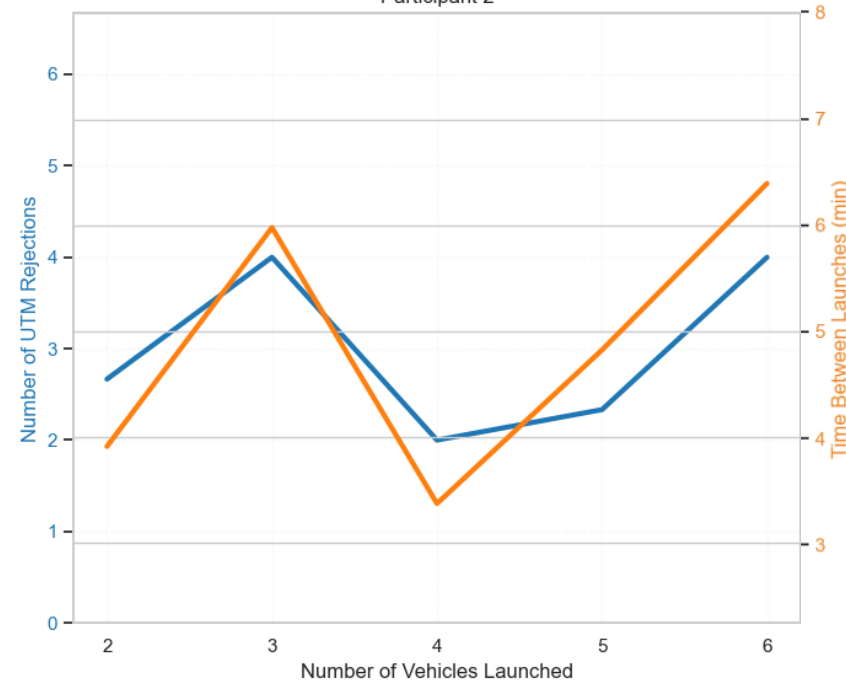
Mean

Mean + 95% CI Across Participants



Typical

Participant 2

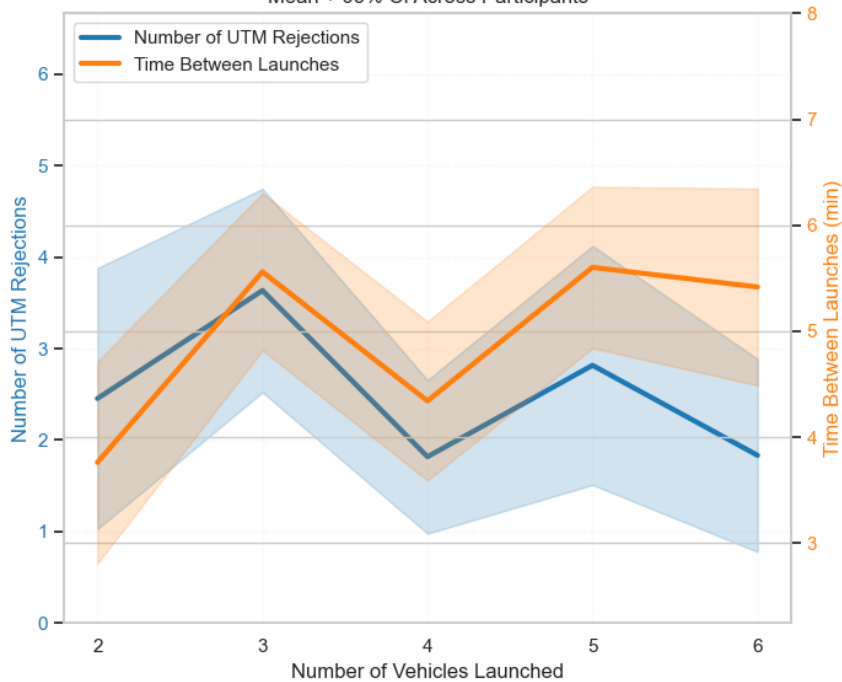


Typical vs Outlier Participant



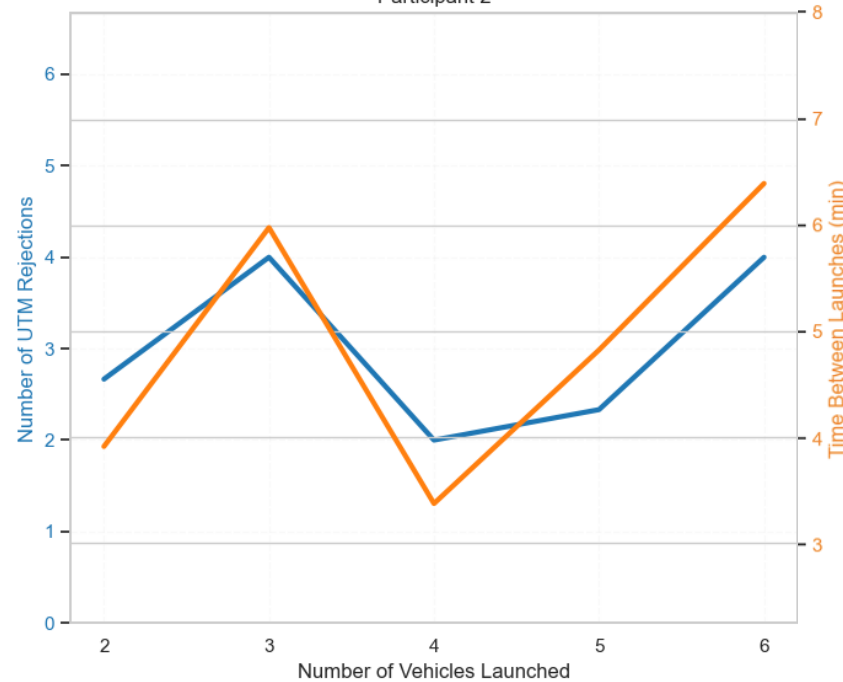
Mean

Mean + 95% CI Across Participants



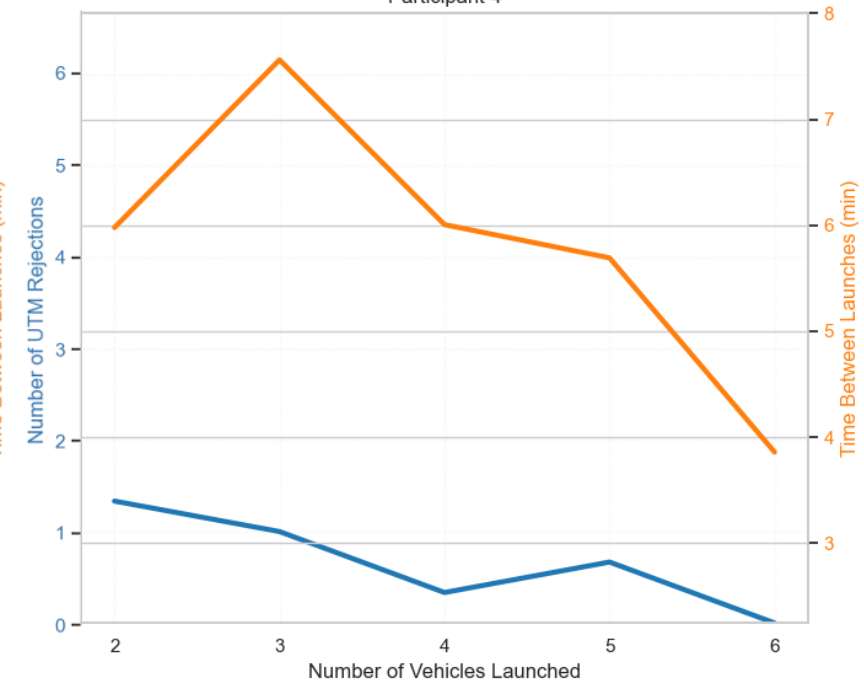
Typical

Participant 2



Outlier

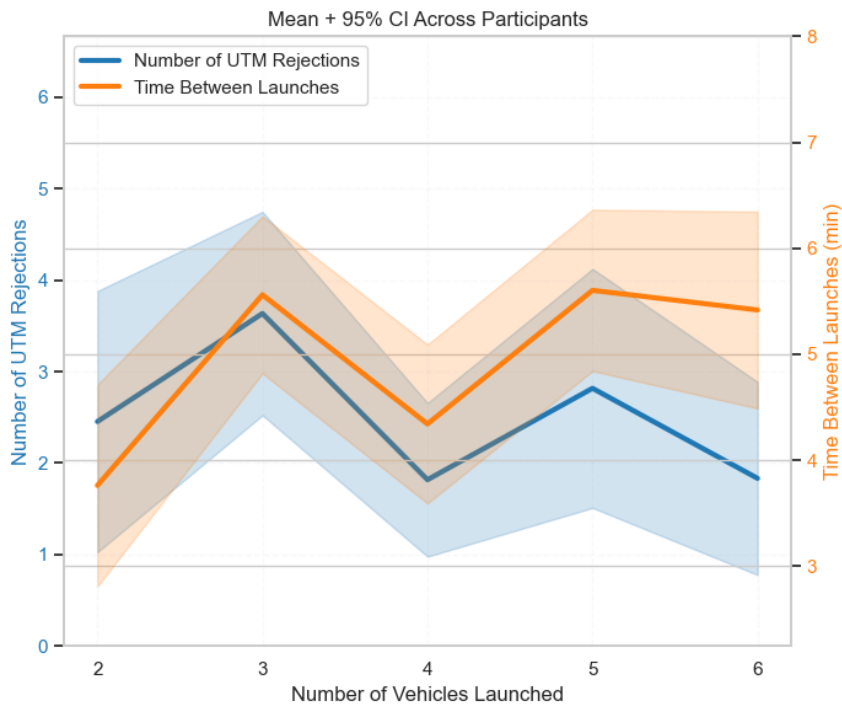
Participant 4



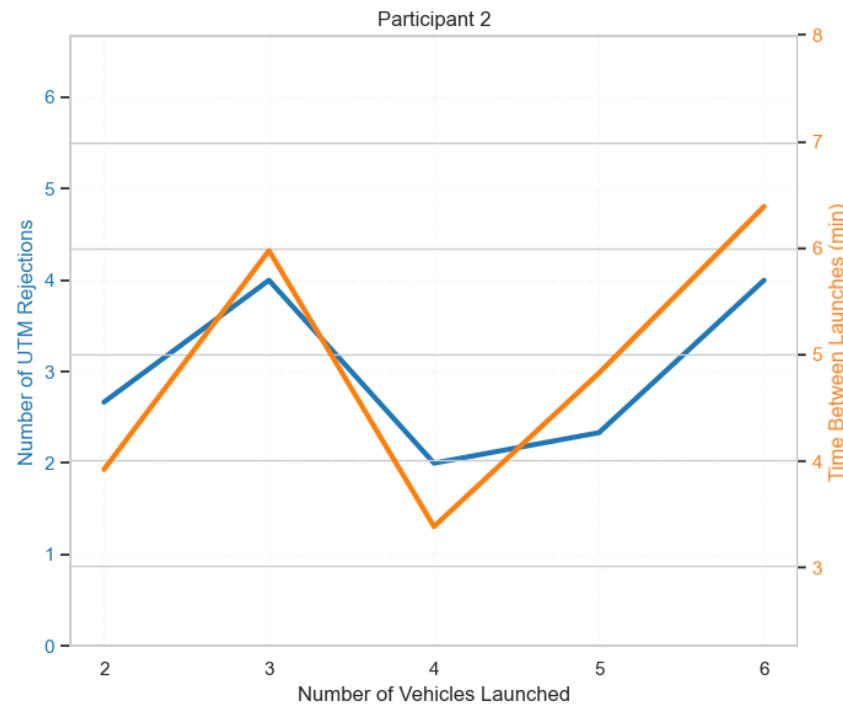
Typical vs Outlier Participant



Mean

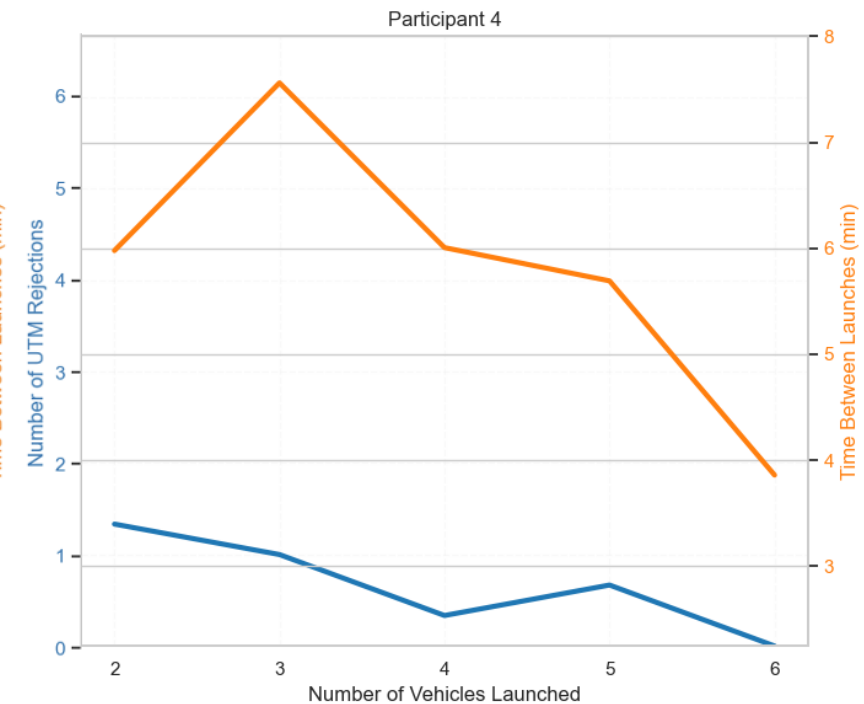


Typical



83% task completion

Outlier



55% task completion



- UTM submission spacing is difficult for human operators

"Would like a bit more information on selecting of routes to be the **most effective rather than just adding minutes...**"

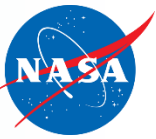
"A more **automated approach** with an effective flight plan that allows drones to **departure and arrive in the most efficient manner.**"



- UTM submission spacing is difficult for human operators
- **Opportunity for automation to help human decision making by suggesting launch time**
- Important step in human-autonomy teaming to operate m:N and BVLoS in the National Airspace
- Future studies:
 - UTM tool in a multi-Operator (company) shared airspace



Thank you to the team



NASA Researchers

- Summer Brandt
- Vicki Dulchinos
- Gita Hodell
- Jillian Keeler
- Joel Lachter
- Conrad Rorie
- Garrett Sadler
- Meghan Saephan
- Casey Smith
- Katie Homer

NASA Software Engineers

- Tom Quinonez

Contractor S/H Engineers

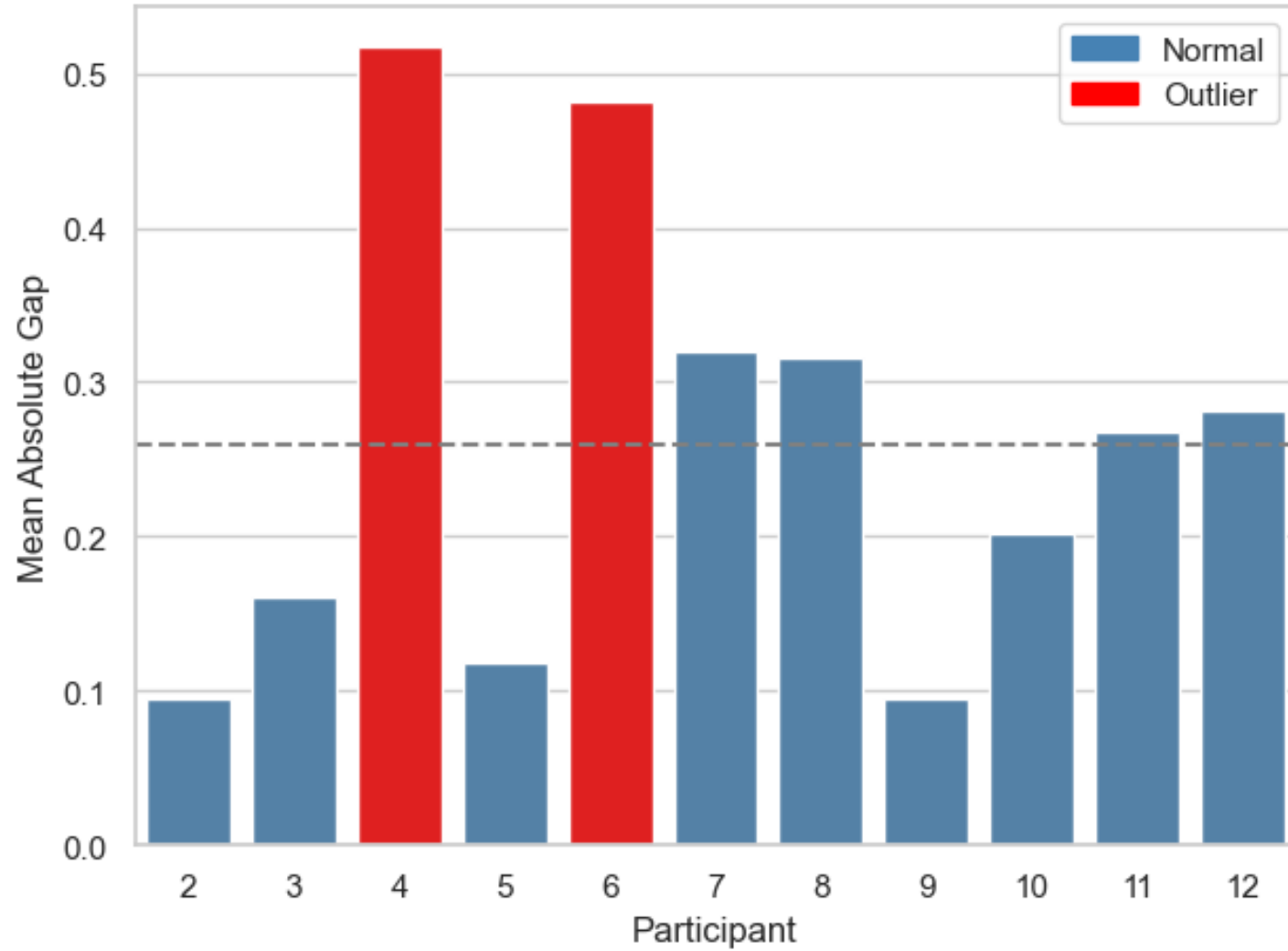
- Dominic Wong (ASRC)
- Kali Haneji (SJSURF)

Contractor Researchers

- Vernol Battiste (SJSURF)
- Alan Hobbs (SJSURF)
- Jeremy Marquis

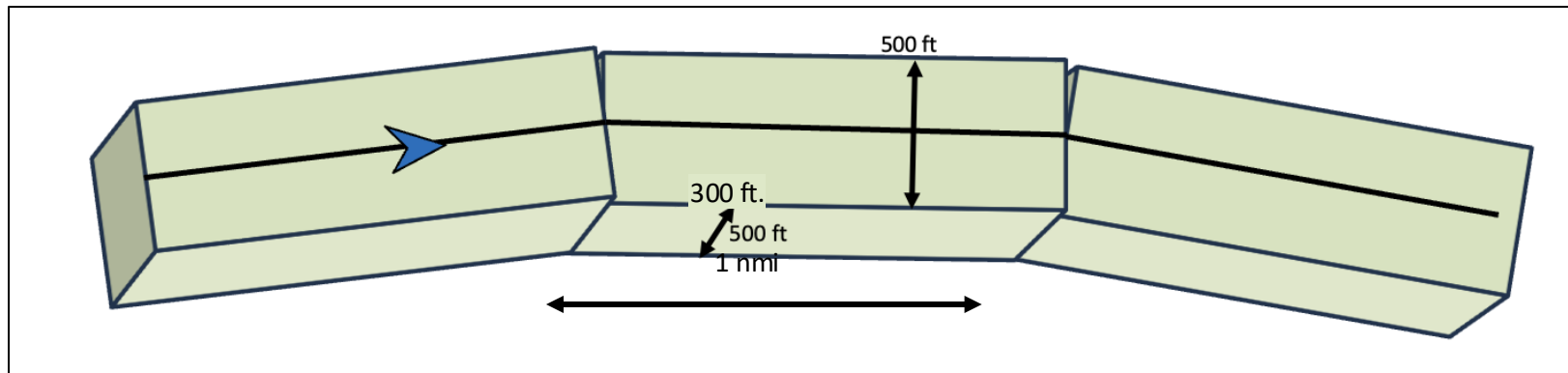


Outlier ± 1 STD



sUAS Traffic Management (UTM) Services allow for scheduling and conformance monitoring

- Strategic scheduling, based on separation criteria
 - 1 minute separation in trail
- 4-D scheduling using time and volume reservations
- Conformance monitoring of an operation to it's predicted 4-D operational volume



Operational Volumes
At 60kts, one nm per segment

