# Vertiport Management from Simulation to Flight: Continued Human Factors Assessment of Vertiport Operations

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# Introduction

- Urban Air Mobility (UAM) proposes an innovative way to transform transportation in urban environments.
- Advancements in technology allow for solutions that were not possible prior.
- However, these solutions require more research and development.
- NASA's High Density Vertiplex Sub-project is dedicated to researching and developing critical roles and infrastructure for high volume UAM operations.
- Vertiports are a necessary component in UAM operations.

# Introduction

Source: NASA

# Introduction

- Research to develop vertiport operations capable for envisioned UAM operations is in its infancy.
- Yet, there are many works describing the infrastructure, roles, and architecture necessary.
- One critical role that is theorized but under researched is the vertiport manager (VM).
- What role the VM will take is currently undefined.
- There is active debate on what role automation should play within the VM role.
- More research on the VM is required.

# Current Work

- We investigated the role of a vertiport manager within a remote operations environment across both simulated and live flight operations.
- Five participants monitored five vertipads across three vertiports in a vertiplex located at NASA Langley.
- Participants were exposed to five operational scenarios.
- Several knowledge elicitation techniques and cognitive interviews provided insights on the role of the vertiport manager.

# Method

- Apparatus
  - ROAM UAS Operations Center
    - VM Workstation
- Vertiport Manager Task
  - Monitoring all incoming and outgoing traffic
  - Managing the closure and opening of vertipads/vertiports
- Operational Scenarios
  - Five vertipads at 60 operations per hour across


Image credit – Bill Buck (NASA)

[1]ROAM = Remote Operations for Autonomous Missions

# Human Factors Data Collection

- An inductive process across multiple types of measurement to make discoveries in this novel environment.
- Methods used:
  - Naturalistic observation
  - Open ended questionnaires
  - After-action review discussion with the participants
  - Cognitive Interviews
    - Critical decision method
    - Applied Cognitive Task Analysis
    - Simulation Interview
    - Task Diagram

# Analysis – Thematic Content Analysis

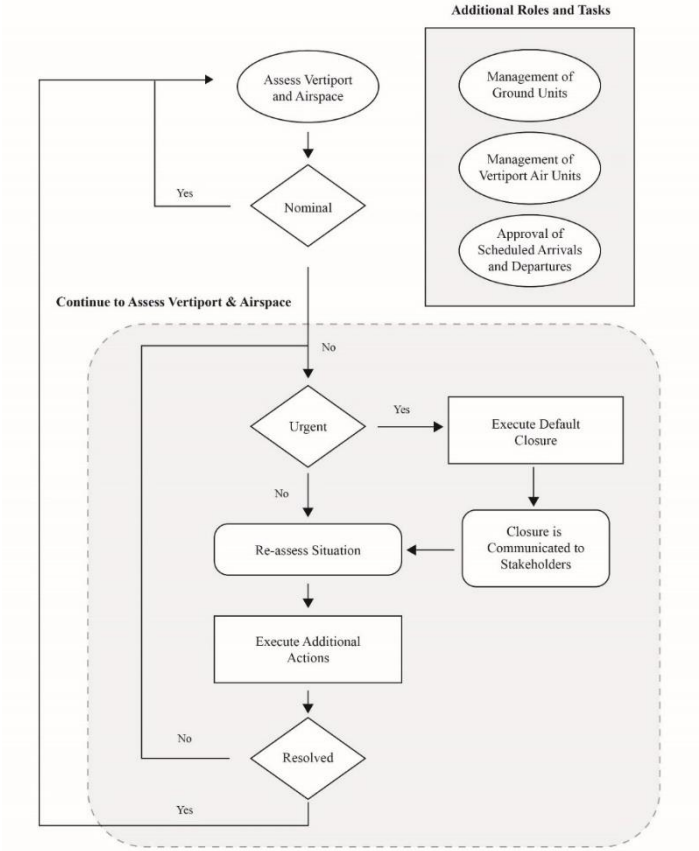
- Thematic Content Analysis (506 statements from open-ended questionnaire)
- Coding of Thematic Content Analysis data comprised the following:
  - All statements were coded into seven initial codes.
    - Some example codes were display design, procedural, and information requirements.
  - After the initial codes, each statement was re-coded into 19 themes
    - Some example themes were situation awareness or sensemaking, managing attention, and time demand.
  - The aforementioned codes and themes were constructed using the theoretical concept of macrocognition. which encompasses the cognitive functions and processes most relevant to real-world tasks.
  - The purpose of this work was to gain insights and understanding about the role of a vertiport manager. Themes were analyzed and transformed into a list of 13 insights.

# Analysis – Example Insights

- Insight 1: VMs need time to make decisions and time demand is a primary factor for vertiport management.
- Insight 6: Communication can support sensemaking for off-nominal events.
- Insight 10: Vertiport and airspace monitoring without an active role can increase boredom and make the task more difficult.

# Analysis – Simplified Cognitive Task Diagram

- Assess Vertiport and Airspace
- Decision on the urgency of the off-nominal situation
- Execute default closure
- Communicate default closure.
- Reassess situation
- Execute Additional Actions.
- Conflict Resolution



# General Discussion

- The purpose of this work was to explore the role of a vertiport manager
- Vertiport Manager Role
  - Automated
    - Minimum: assess, notice anomalies, and execute and communicate vertipad closures
  - Human
    - Reinforce: adaptability, anticipation of future events, and coordination to resolve conflicts before they occur
  - Human-Autonomy Teaming

# Design & Training Recommendations

- Design
  - Mapped coding
    - Displays should have the same information mapped similarly across different displays or functions.
  - Pictorial realism
    - Displays should represent information as the human mind would conceptualize that information
      - E.g., waterfall display illustrating the arrival and departure of aircraft
  - Proximity compatibility principle
    - Displays relevant to a common task should be rendered close together in perceptual space
  - Interactivity
  - Pre-attentive processing
- Training
  - Checklist for procedures
  - Strengths: deconfliction, communication, and coordination efforts

# Limitations & Future Directions

- Exploratory
  - Requires replication
- Data is subjective
  - Influenced by cognitive biases, heuristics, and limited information processing
- Scalability

# Conclusion

- Vertiport management will be a critical role as the UAM vision is actualized
- Generated the following:
  - Insights gained from professionals performing simulated and live flight operations
  - Cognitive task diagram of the vertiport manager's primary task
  - Design recommendations
  - Training recommendations
- This work can provide a strong foundation to build the infrastructure required to make the UAM vision a reality
- Human-Autonomy Teaming

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