Urban Air Mobility Fleet Manager Gap Analysis and System Design

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Abstract. NASA's Urban Air Mobility (UAM) Sub-Project is engaged in research to facilitate the introduction of air taxis into the US National Airspace System. Given the history of conventional aircraft operations, it is clear that dispatcher support will be required for UAM. This paper presents a gap analysis, system requirements, and a workstation design concept for the UAM dispatcher or Fleet Manager (FM) position. The gap analysis focuses on the differences between the tasks of the airline dispatcher and those projected for the FM. FM system capabilities and data requirements are then presented as foundations for software development. An initial user interface concept is provided. The FM software uses a single, large display. The system supports prediction, monitoring, and task execution. This paper is intended to support FM software design for future air taxi systems.

Keywords: Air taxi, urban air mobility, dispatcher, user interface design, human factors

1 Introduction

NASA's Urban Air Mobility (UAM) Sub-Project is engaged in research to support the introduction of air taxis into the US National Airspace System. Such operations will require a range of communication, navigation, and surveillance capabilities. Air vehicles for UAM are under development and will initially have human pilots. Separation from other aircraft, obstacles, and weather may be a pilot responsibility or provided by an operator's ground-based systems. Eventually, air taxis may be flown from the ground or fly autonomously. [1]

"An air taxi could be defined as a flying vehicle with a range of 50-120 miles, carrying two to four passengers and cruising at an altitude of 3,000 to 5,000 ft. In the near term, based on the current battery technology, the most common commute might be a 50-mile round trip with two short vertical takeoffs and a 30-minute energy reserve on a single battery charge." [2]

2 Background

Given the history of conventional (Part 121 and Part 135) operations, it is clear that dispatch functions will be required for UAM. The FAA may mandate these services, as with passenger and cargo aircraft today.

Airline dispatcher (AD) tasks include:

- Maintain operation control
- Evaluate weather and hazards
- Create and deliver flight plans
- Monitor flights and intervene as needed for:
  - Weather changes
  - Delays
  - Aircraft system problems
  - Fuel reserves
  - Air traffic control actions
- Monitor fleet schedule
- Manage aircraft maintenance

At this time, the role of the UAM ground operator is not defined. For air taxis, there may be advantages in combining remote piloting functions with dispatcher tasks. For now, we will treat the UAM dispatcher as a dedicated position with no other duties. To distinguish this from AD operations, we will call the UAM dispatcher the "Fleet Manager" or FM.

This report presents a gap analysis, capability and data requirements, and workstation design concepts for the UAM FM position. The gap analysis focuses on the differences between the tasks of the AD and FM.

3 Gap Analysis

In the original internal report (available from the first author), AD tasks are listed with the comparable FM task. FM tasks that have significant differences compared to the AD are highlighted. These findings are summarized below.

- FM needs a software tool to support shift change since FMs may be located in different geographical locations
- Flight planning has different parameters (latitudes/longitudes for waypoints, referencing surface features such as buildings or roads for navigation, pre-defined routes, reserved airspace corridors, etc.)
- For flight planning, altitude options are very limited since maximum altitude will be constrained (e.g., 5,000 ft.)
- FM must monitor low-altitude flights using detailed geographical and weather information

- FM must make quick decisions to manage low altitude traffic over and within urban areas
- FM handles a mix of scheduled and on-demand flights
- Payload and weight balance are critical for small, air taxi aircraft
- Standard (recurring) routes must be regularly checked due to the constantly changing low altitude environment
- FM submits flight plan to a private service supplier rather than the FAA
- FM coordinates with a corporate service provider for traffic and separation management (rather than the FAA)
- FM must notify the FAA if vehicles deviate into controlled airspace

4 Functional and Information Requirements

The following lists show the software functions that are required for the FM to perform their tasks.

Operations
- Flight planning
- Flight following
- Hazard alerting
- Flight path manipulator (in the event of a contingency)
- Conflict prediction and resolution
- Airspace corridor saturation monitor
- In flight route optimizations
- Weather integration into decision-making
- Aircraft energy/consumption monitor

Communications
- Voice and text links with pilot
- Messaging with passengers
- Voice and data communications with air traffic management and local authorities
- Data communications with service suppliers
- Two-way data contact with aircraft (equipment status, fuel/battery level, etc.)
- Voice and text with vertiports
- Voice and text with aircraft maintenance

System
- Vehicle scheduling
- Vehicle maintenance control
- Personnel role management and delegation
- System health monitor
- Pilot scheduling

The following lists show the information requirements for the FM software.

Shift Briefing

- Current and projected impacts of crew roster
- Aircraft complement and availability
- Gate assignments
- Weather
- Vertiport status
- Company policy changes
- Emergency procedures in progress
- FAA/local authority publication changes
- Current customer status (complaints)
- Public events (e.g., airshow)
- Ground traffic
- Information technology or computer-related issues or changes
- Outgoing FM notes

Map

- All UAM aircraft identifier, type, position, speed, heading, altitude, and flight plan
- Other aircraft displayed as needed
- Flight corridors
- Speed and descent profiles
- Trip legs and waypoints
- Human-made and natural obstructions (e.g., buildings, trees, hills, etc.)
- Temporary flight restrictions
- Special use airspace
- Noise regulations that affect vehicle choices and routes
- Vertiport obstruction areas
- Vertiport detailed map view with traffic
- Vertiport status
- Emergency and safety related notices affecting flights

Weather

- Very detailed, real time surface to 5000 feet weather data
  - Barometric pressure
  - Temperature
  - Relative humidity
  - Dew point
  - Wind speed and direction
  - Precipitation
  - Icing aloft

- Detailed wind flows for urban canyons, structures, topographical areas, and vegetation (e.g., trees) with a few meters resolution
- Localized ceiling and fog

Aircraft
- Fuel/battery capacity, range, and remaining
- Time to charge battery
- Payload:
  - Aircraft capacity
  - Weight
  - Manifest
  - Loading notes
- Human pilot, ground pilot, or autonomous
- Safety procedures
- Repair and maintenance data
- Deferred maintenance items
- Onboard system status

Communications
- Downloads of updated regulations, management advisories, etc.
- Information about crew schedule changes
- Security or emergency items (terrorism threats, reroutes, medical emergencies)
- Company system status (communications, facilities, personnel, etc.)
- Information technology or computer-related issues or changes
- Gate assignments
- Curfew issues
- Noise footprint
- Noise abatement
- Community feedback
- Backup pilot for emergency events

5 User Interface Design

FMs will be challenged by the number of flights they must control and the sheer complexity of low-altitude vehicle management. Therefore, information displays are forward-looking and assist the FM with suggested courses of actions rather than just displaying data.

System capabilities include:
- Predictive interactions as a core design principle
- Optimization of FM to vehicle management ratio
- Decrease training needs of FMs relative to ADs
- Enhanced safety considerations for a low altitude, automated flight environment

The system architecture provides two modes. One mode reveals recommended interface actions based on user tasks, with the computer looking ahead and presenting calculated options. If the user wishes to drill down to understand the process by which the system is making recommendations, or perhaps create other courses of action, a "behind-the-curtain" or detail mode of operation can be accessed. The behind-the-curtain views are designed with the goal of being secondary to the assisted mode.

The FM interface uses a single, large display. Information in the interface is shared. An example might be that the user chooses a route, the impact is noted as an issue during or after creation of the route, a map graphically shows the issue, and the user can take several actions including a computer-generated option. The user communicates the chosen action to others, logs the issue, and continues to monitor the flight path. Three actions are at the center of the architecture: Prediction, Monitoring, and Execution.

Prediction: This is an assisted automation mode. The system is aware of the user's intended actions and unobtrusively makes recommendations based on a larger set of data than is available to the user, and with greater depth by use of algorithmic processes. For example, a change in a vertiport landing area causes extensive rolling delays. The computer generates efficient responses, weighs the choices for the user, and presents the results.

Monitoring: Situational awareness is maintained pre-flight, in-situ, and post-flight. This allows users to understand how the computer's choices are being carried out and, if needed, change the plan based on factors perhaps outside of the system's scope.

Execution: The user puts a plan in place, such as authorizing a flight the system has recommended or that the user has constructed. The interface makes user decisions and their effects obvious, showing timing and pertinent state data feeding back to Monitoring.

Figure 1 depicts a high-level user interface architecture. The maximum number of windows is four. The user can drag the controller at the center to resize all windows simultaneously. The information flow starts in top left and then moves to top right, bottom left, and finally to the bottom right, with each user selection defining what information populates the next window, thus maintaining data continuity. Information in the interface is inherited and relevant rather than disparate, as with browser tabs.

6 Summary

This gap analysis was completed as an initial step toward designing software to support the UAM FM. AD and FM tasks are compared and those FM tasks that differ from conventional FD duties are highlighted. Functions and information requirements are listed that could guide software and user interface design. For additional information on the work on the FM workstation, please contact the first author.

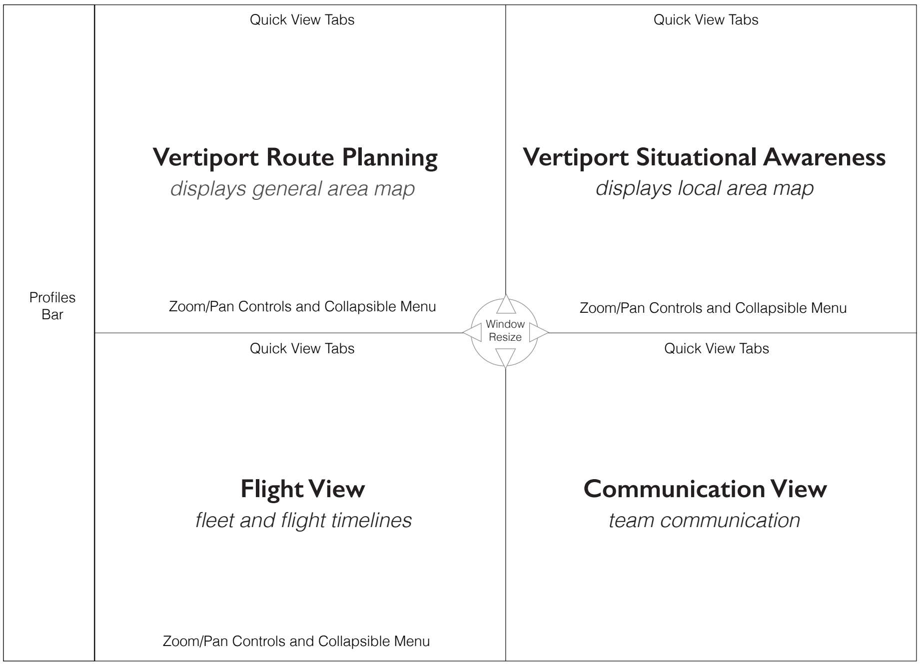

Fig. 1. UAM dispatcher software screen layout.

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