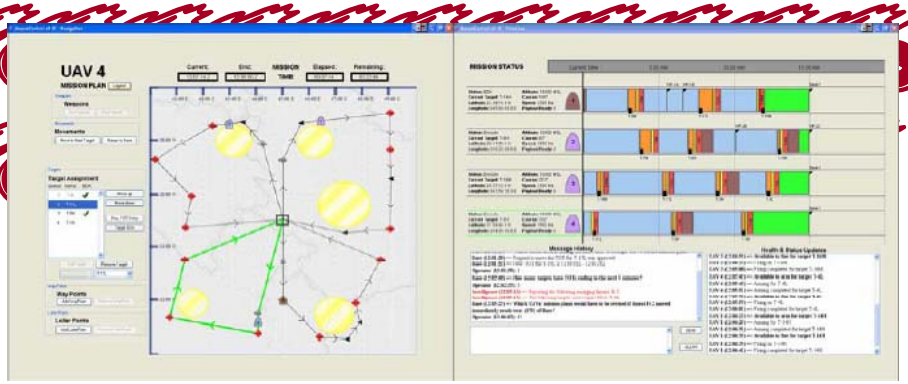
Determining the Impact of Auditory Feedback on Operator Performance



Adam Fouse

Jonathan Pfautz

Charles Rivers Analytics, Inc.

Hudson Graham

M. L. Cummings

MIT's Humans & Automation Lab

CHARLES RIVER ANALYTICS INC.

HAL

4th Annual Human Factors of UAVs Workshop

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Project Background

Auditory Displays

Experimental Design

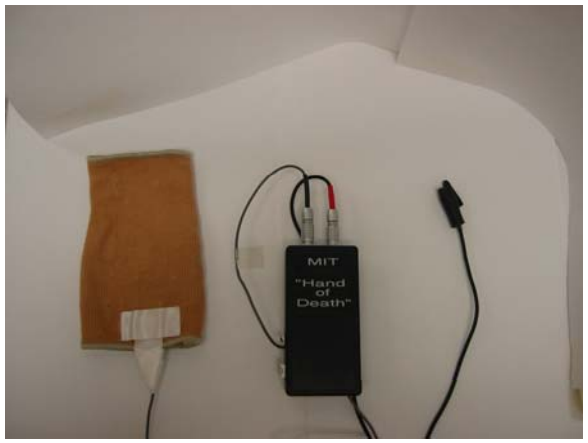
Background

General Problem:

- **Lots of information to present—how to present it?**

Our Approach:

- **Rapid prototyping and evaluation of multimodal interfaces**



Background

Why Multimodal?

- Resources within a sensory modality are limited
- May be able to offset resource demand onto alternative sensory modalities
- Usage of these alternate modalities may offer superior performance (e.g., faster response time in the auditory channel)
- Other sensory channels could also provide redundant encoding for important information

Specific Audio Benefits:

- Periodic signal detection
- Parallel listening
- Passive monitoring
- Affective response

Can we use audio to improve operators':

- **Situation awareness with multiple vehicles?**
- **Performance in completing missions?**

Can **continuous auditory displays** be designed to take advantage of pre-attentive perception and allow operators to selectively attend to critical information?

- **Previous results from anesthesiology (Watson & Sanderson, 2004)**

We have developed and are actively evaluating two sonification techniques

Based on:

- **Perceptual and cognitive abilities**
- **Cognitive and work domain analysis**
- **Processing and filtering capabilities**
- **Audio environment considerations**

We use oscillating comb filters to represent continuously-valued information

- **Frequencies are oscillated to create a periodic signal**
- **Variations in depth and rate of oscillation are mapped to data values**

Subjective experience similar to engine noise

- **Baseline is always there in the background**

Initial results:

- **"I don't need to watch the display"**

Auditory Displays for Discrete Information

What different qualities can we use to present discrete and non-numeric information?

- **Note difference between continuous audio and continuous/discrete information**
- **How can we combine multiple types of continuous audio display?**

We create harmonic displays through the use of groups of Formant filters

- **These rely partly on affective response to culturally-learned musical qualities**
- **Combines well with the oscillating comb filters**

Context is important

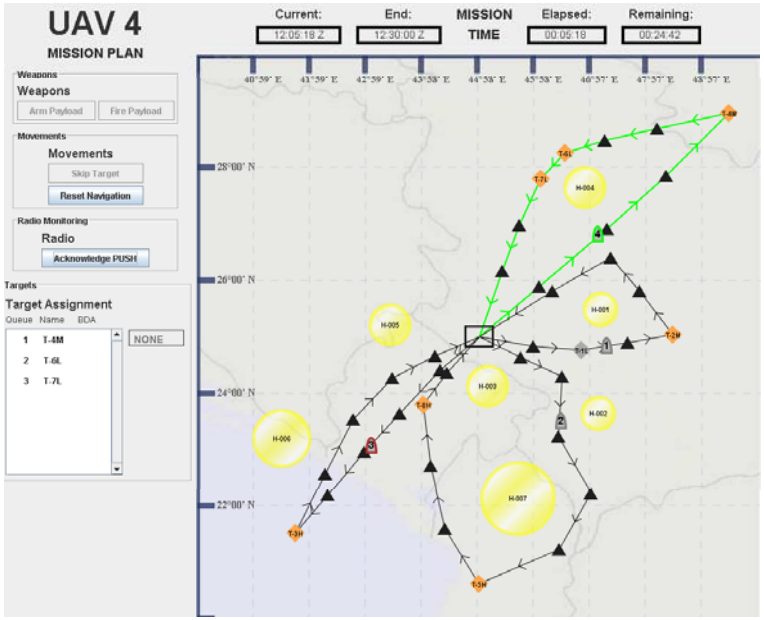
- **Both displays take advantage of auditory change detection perception**
- ***Changes*, not value, are best detected**

Specific research questions:

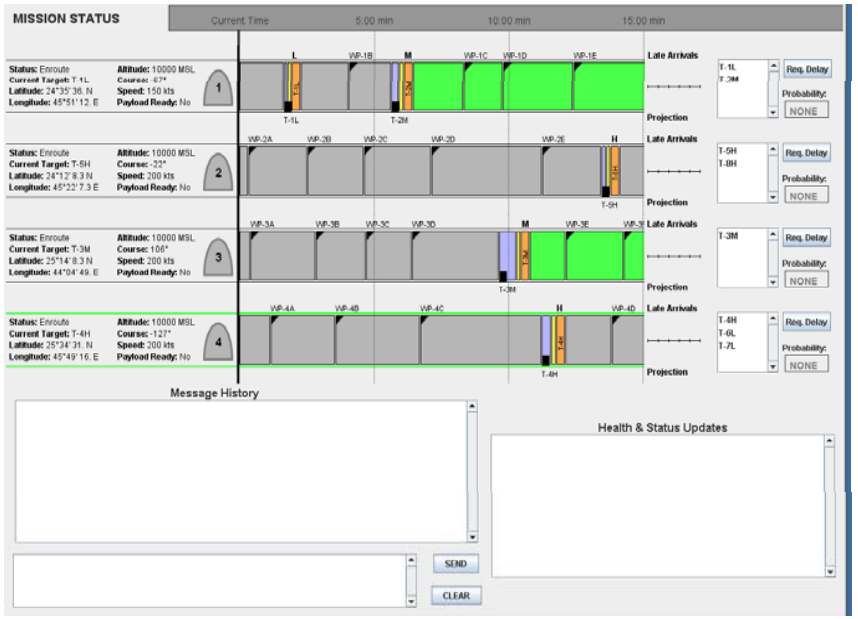
- **Do these audio conditions change an operator's performance in controlling Unmanned Aerial Vehicles (UAVs)?**
- **Is there a performance difference in controlling a single or multiple UAVs with these audio schemes?**

- **Experiment (currently in progress) at MIT's Humans & Automation Lab**

Multiple Autonomous Unmanned Vehicle Experimental Test Bed (MAUVE)



Left Display



Right Display

Multi-Modal Workstation

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Left Display – Overview

The three major screen elements on the left display are:

1

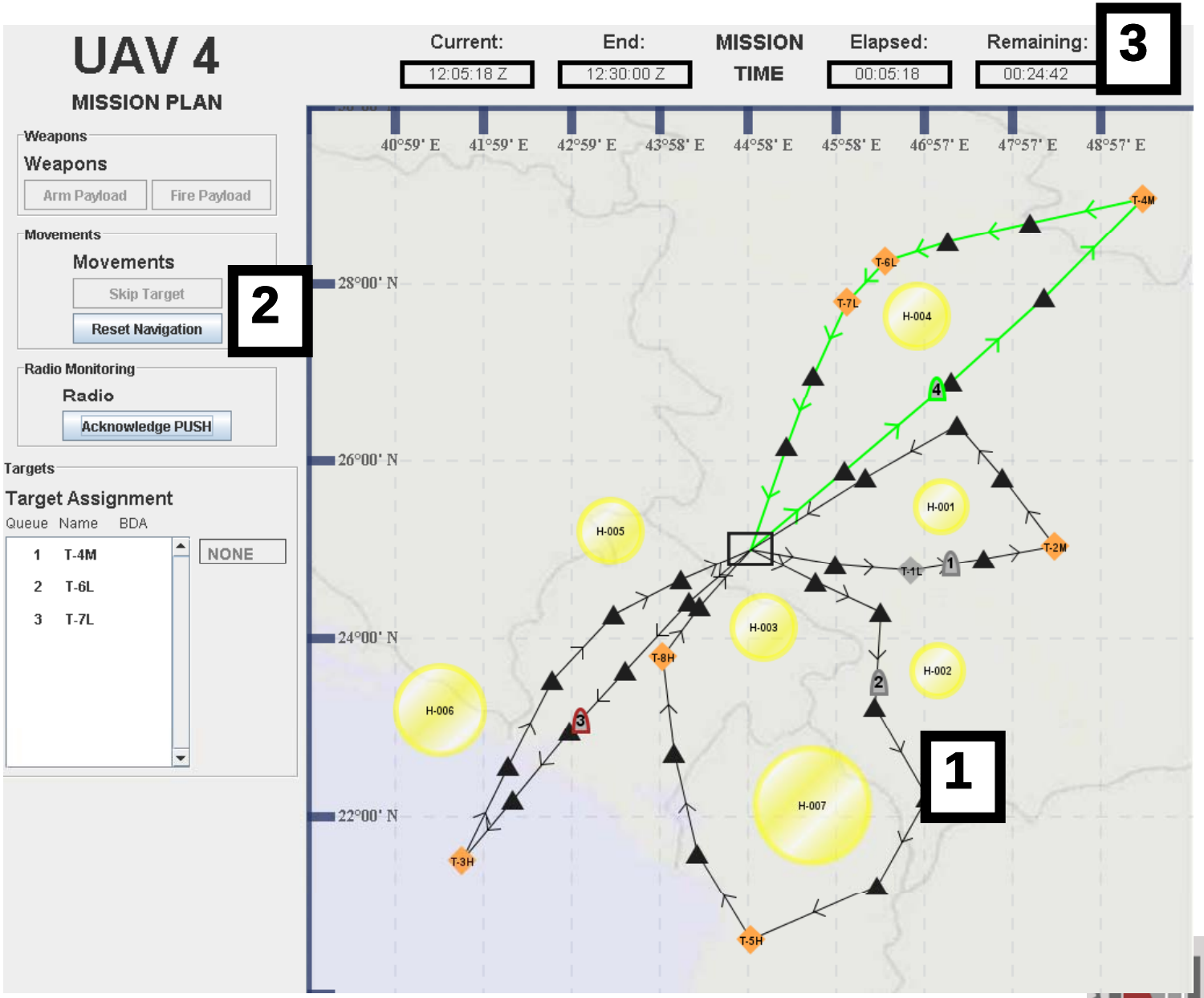
Map Display

2

Mission Execution

3

Mission Time



Right Display – Overview

The four major screen elements on the right display are:

1

15 Minute Timeline

2

Decision Support

3

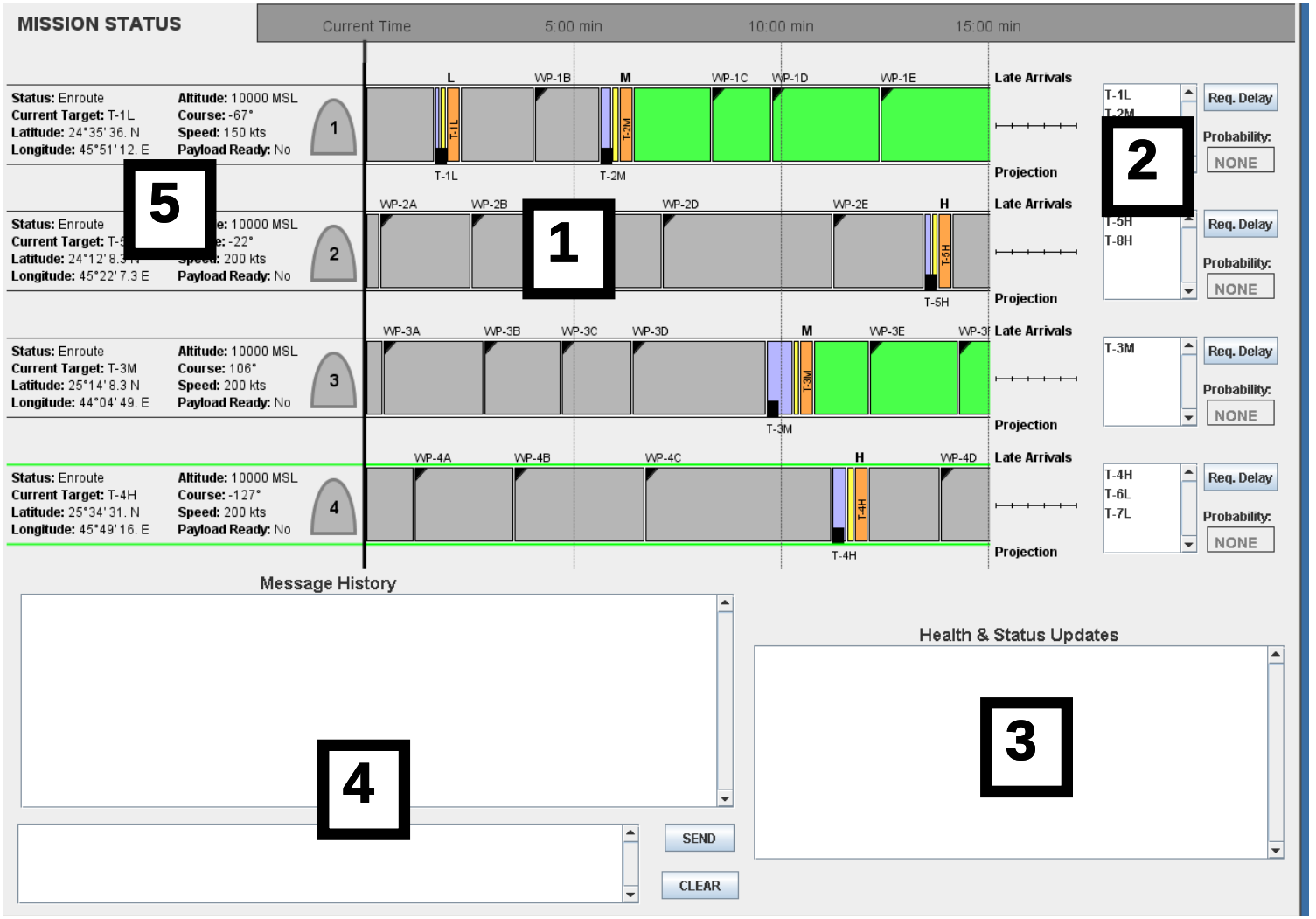
UAV Health & Status Updates

4

Chat Box

5

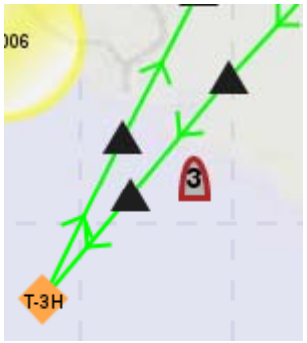
UAV Status



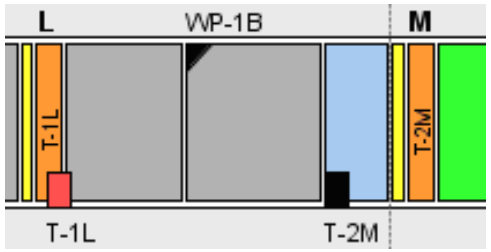
Design of Experiment

- **Subjects:**
  - **Minimum of 32**
  - **All Active Duty Air Force / Army / Navy officers and cadets**

- **Two audio schemes mapped to two control tasks**
  - **Continuous audio – Course deviations**



  - **Discrete audio – Late arrivals**



Design of Experiment – Continued

Independent Variables:

- **Audio Conditions (between subjects)**
  - **Threshold – standard industry beep for both deviations and late arrivals**
  - **Continuous – continuous for deviations and standard industry beep for late arrivals**
  - **Discrete – standard industry beep for deviations and discrete for late arrivals**
  - **Combination – continuous for deviations and discrete for late arrivals**
- **Scenario (repeated)**
  - **Single UAV**
  - **Multi UAV**

Dependent Variables:

- **Deviation Reaction Time (to measure effect of continuous audio scheme)**
- **Late Arrival Reaction Time (to measure effect of discrete audio scheme)**
- **Secondary: Count of Missed Radio Calls (to measure workload objectively)**
- **Subjective: NASA TLX Score (to measure workload subjectively)**

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Questions?

Adam Fouse

Research Scientist

Charles Rivers Analytics, Inc.

Cambridge, MA

(617) 491-3474, Ext. 531 || afouse@cra.com

Hudson Graham, 2Lt, USAF

Graduate Student

Humans & Automation Lab

Massachusetts Institute of Technology

(617) 253-0993 || hgraham@MIT.edu