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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Development and Testing of an Unmanned Aerial System (UAS) Cellular & Wi-Fi Repeater: Phase 2

Investigating the use of unmanned systems to provide a communications repeater to expand Caltrans communications coverage in rural areas.

Rural

MAY 2025

Project Title:
Development and Testing of an Unmanned Aerial System (UAS) Cellular & Wi-Fi

Task Number: 4297

Start Date: November 2023

Completion Date: April 2025

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WHAT IS THE NEED?

In rural areas, there are often no available network communications options beyond satellite services which can be costly due to high equipment and service costs.

Research performed under Task 3280, showed that a UAS could elevate a payload into the cellular signal that is typically blocked by terrain and create a Wi-Fi network on the ground for worker communications. The next step in development is to conduct field trials to verify the technology's success in various terrain situations and validate the next-generation design for improved setup time, weather resistance, and improved ground Wi-Fi network quality. With a temporary WiFi network in construction and emergency response areas, communication can now occur through emails and WiFi calling, assisting in efficiency, resource management, and accurate equipment deployment the first time.

WHAT ARE WE DOING?

The goal of this research is to expand upon the successful UAS aerial repeater that was created in Task 3280. To improve the ground Wi-Fi network, the researchers will evaluate several commercial offthe-shelf (COTS) vehicle routers and antenna configurations. After the components are selected, a weather-proof, easily assembled payload package will be designed. The researchers will work with Caltrans to determine field test areas and develop training for Caltrans staff to utilize the UAS aerial repeater in construction projects and emergency response incidents in areas that lack a cellular network at the roadway.

Caltrans

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WHAT IS OUR GOAL?

This project will have two major deliverables: 1) A complete UAS payload package will be delivered that will create a ground Wi-Fi network for Caltrans employees to use in construction zones and emergency response. 2) The researchers will work with Caltrans to determine field test areas and develop training for Caltrans staff to utilize the UAS aerial repeater in construction projects and emergency response incidents in areas that lack a cellular network at the roadway. The training materials and resources to assist in the field trials and future deployment will be finalized per workers' feedback.

WHAT IS THE BENEFIT?

The research will increase worker safety, resource management, and communication. Caltrans staff would be able to effectively communicate with personnel and agencies outside of the construction or emergency response area through the ground WiFi network connection to the cellular network previously inaccessible at their location. Having the proper resources arrive quickly is critical in rural settings when response distances can be over 50 miles.

WHAT IS THE PROGRESS TO DATE?

The technical advisory panel has selected UC Davis AHMCT to continue researching this project.

- A scope of work has been accepted; project began in November 2023.
- Ground tested 7 WiFi antennas at simulated 400ft of elevation. Three were chosen for flight testing.
- Finalized CAD file of the payload package to evaluate mounting options and methods for weight reduction, optimized model for rapid prototyping capabilities at AHMCT.
- Fabricated payload package.Data collection has been initiated on CA State Route 299 and CA State route 70 in District 2.
- Data was collected over multiple days across both routes at different locations and different flight heights.
- Initial results demonstrated that locations more than 10 miles from a cellular antenna did not have enough signal strength for modem to establish any communication.
- Additionally, it was discovered that it was not necessary to fly the drone to establish communication. The addition of the external antennas to the modem on the drone was sufficient to establish TCP/IP communication without the need to deploy the drone. There were no location where flying the drone at any altitude provided better signal than at ground level.
- Project finalized April 30, 2025 and final report is being prepared. Additional research in this area will not be conducted as LEO satellite communication is gaining coverage in remote areas and has already surpassed cellular coverage.

IMAGES

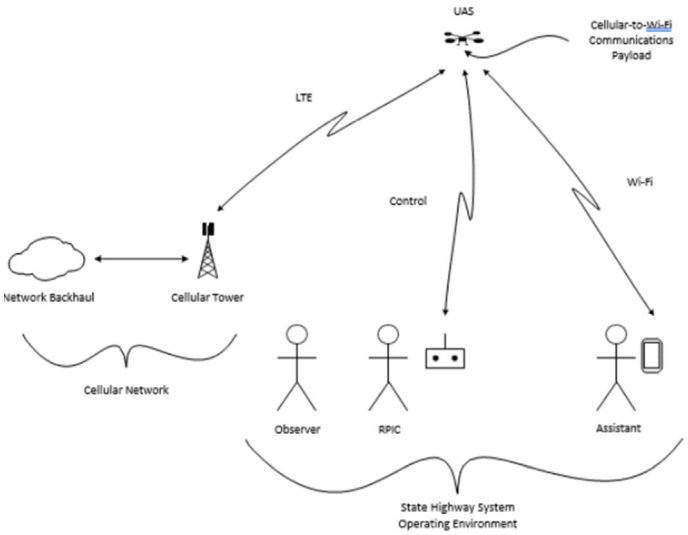

Image 1: High level architecture of the system

Image 2: DJI Matrice 300 RTK outfitted with cellular modem and WiFi repeater.