Drone Network Design for Emergency Response in Rural Utah

CTIPS-060 – UTC Project Information

Recipient/Grant Number:	North Dakota State University, University of Utah Grant No. 69A3552348308
Center Name:	Center for Transformative Infrastructure Preservation and Sustainability
Research Priority:	Preserving the Existing Transportation System
Principal Investigator(s):	Xiaoyue "Cathy" Liu, Ph.D., P.E. Chenxi "Dylan" Liu, Ph.D.
Project Partners:	USDOT, Office of the Assistant Secretary for Research and Technology – $50,000 Utah Department of Transportation – $50,000
Total Project Cost:	$116,000
Project Start and End Date:	12/13/2025 to 12/12/2027

Project Description

Rural areas of Utah face significant challenges in providing timely and comprehensive emergency response. Long distances, limited road infrastructure, mountainous and desert terrain, and weather-related disruptions can significantly delay ambulances and rescue teams. These factors often increase response times for medical, disaster, and search-and-rescue emergencies, directly impacting outcomes and endangering lives.

Traditional emergency services remain essential, but they are insufficient in covering all rural needs quickly. Unmanned Aircraft Systems (UAS), or drones, present a transformative opportunity to bypass geographic and infrastructure barriers. Drones can rapidly deliver critical supplies, e.g. medical kits, blood units, communication devices, food, water, or specialized equipment, within minutes rather than hours. However, to make such a system viable, Utah requires a data-driven framework to determine where drone bases should be located, what fleet capabilities are needed, and how to integrate these operations with regulatory and local constraints. This project addresses the need to design an optimized drone network for comprehensive emergency response in rural Utah.

The primary objective of this research project is to develop an optimized drone network design to significantly reduce emergency response times in rural Utah by identifying strategic drone base locations, fleet requirements, and deployment strategies. Secondary objectives of this research project are to evaluate the technological, regulatory, and operational feasibility of drone-based emergency response,

ensuring alignment with community needs and positioning Utah Department of Transportation (UDOT) as a leader in innovative public safety solutions.

USDOT Priorities

Section left blank until USDOT's new priorities and RD&T strategic goals are available in Spring 2026.

Outputs

The research findings and decision-support framework will be shared through peer-reviewed journals such as Transportation Research Part D, Computers, Environment and Urban Systems, and presented at major conferences, including TRB and ASCE T&DI. The project team will also prepare short summaries and visuals for dissemination through UDOT and CTIPS online platforms. These activities aim to promote practical adoption of the proposed drone network design framework and support future UAS applications in emergency response.

Outcomes/Impacts

This research is expected to generate both methodological advances and practical tools for improving emergency response in rural regions. The project will produce a validated modeling framework that integrates spatial analytics, optimization, and simulation to guide drone network design under realistic operational and regulatory constraints. The findings will advance current practices in transportation systems planning by introducing a data-driven approach to emergency logistics that accounts for terrain, weather, and population access. We will deliver a GIS-based decision support tool and accompanying Python-Gurobi optimization code that UDOT and local agencies can use to identify optimal drone base locations, estimate service coverage, and evaluate investment options. These tangible products will allow practitioners to visualize network performance and adapt the model for future use cases, such as disaster relief or medical supply delivery. The results will also inform policy and procedural guidance for integrating UAS into state emergency management strategies and will lay the groundwork for future research on regulatory coordination, reliability modeling, and human-drone team operations in rural settings.

Final Report

Upon completion, the final report link will be added to the project page on the CTIPS website.