

EAGER: Aerial Communication Infrastructure for Smart Emergency Response

Shengli Fu, University of North Texas

Yan Wan, University of Texas at Arlington

Introduction

Goal:

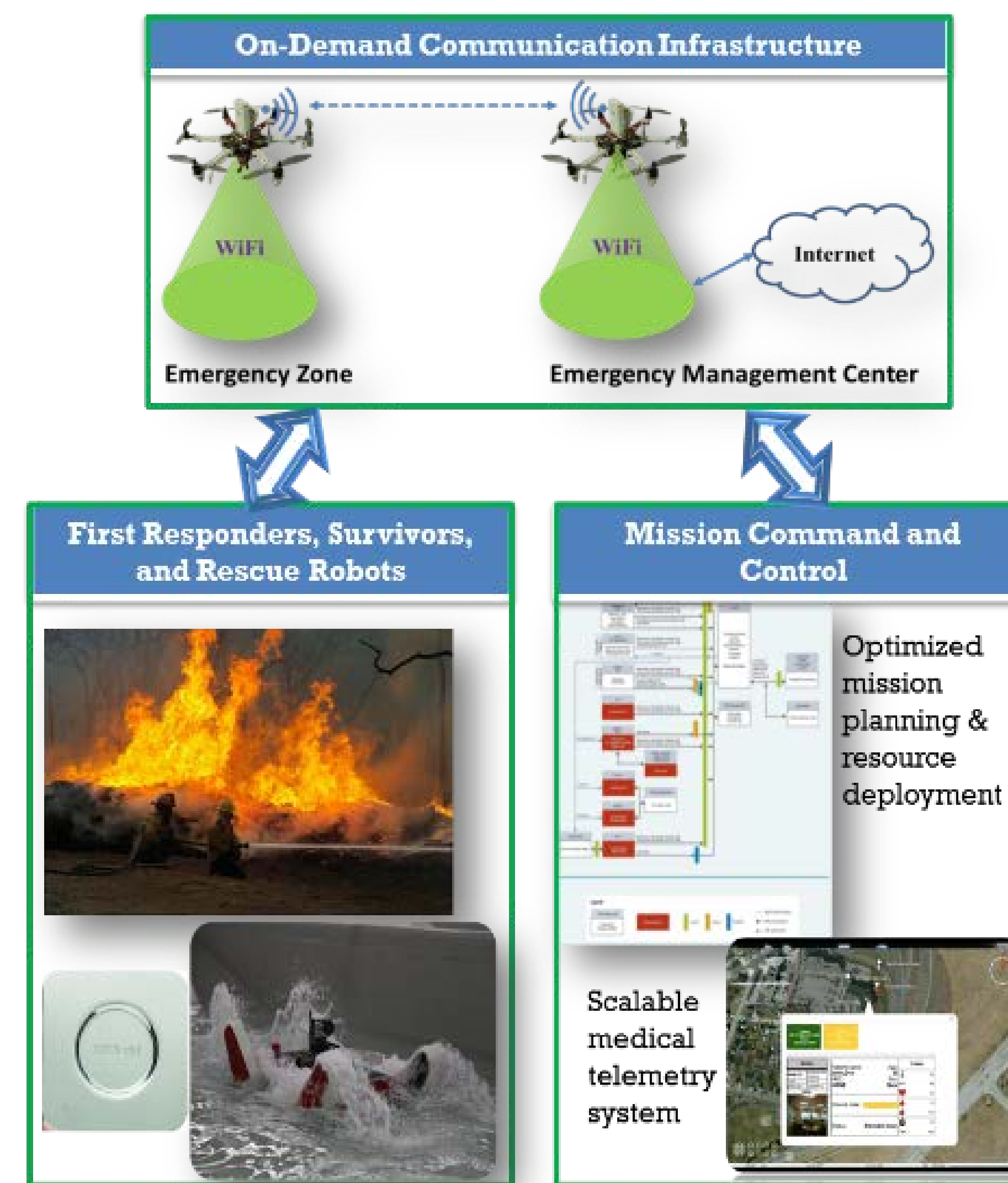
To exploit an early concept of a flexible, low-cost, and drone-carried broadband long-distance communication infrastructure and investigate its capability for immediate smart-city application in emergency response.

Tasks:

- Development of cyber-physical systems (CPS) technology that enables robust long-range drone-to-drone communication infrastructure.
- Practical drone system design and performance evaluation for Wi-Fi provision.
- A systematic investigation of its capability to address smart-city emergency response needs, through both analysis and participation in fire-fighting exercises as case studies.

Broad Impacts:

- Short term impacts in on-demand communication, fighting fires, emergency response, and saving lives.
- Long term impacts in airborne networks, multi-drone civilian applications, airspace safety, and new businesses.



Illustration

An illustration of the proposed work.

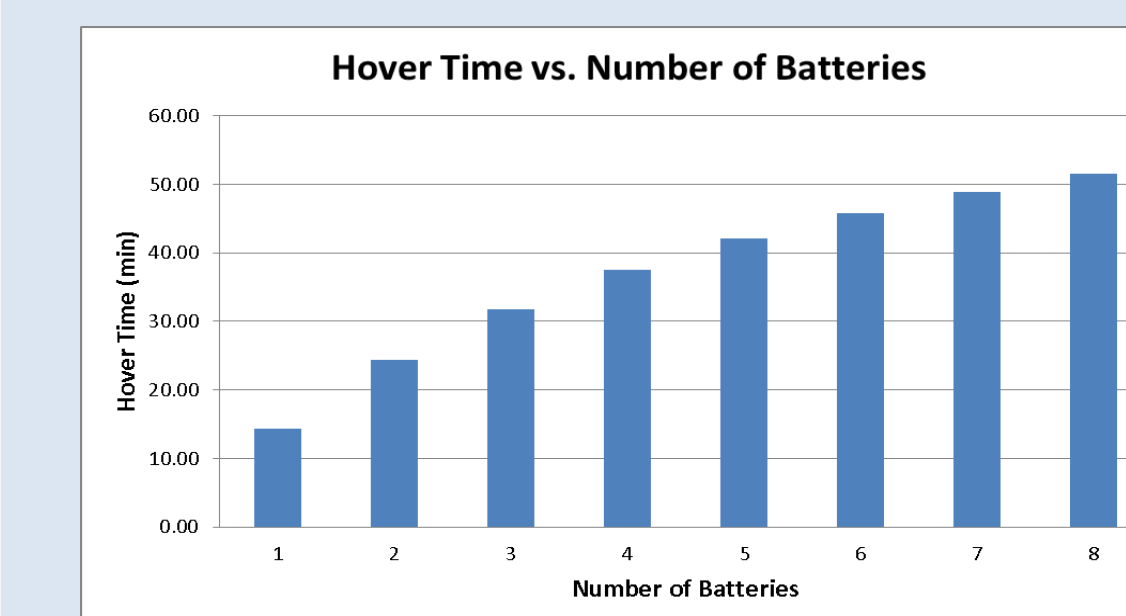
1. Innovative drone-to-drone Wi-Fi communication technology

2. Systematic investigation of practical design issues

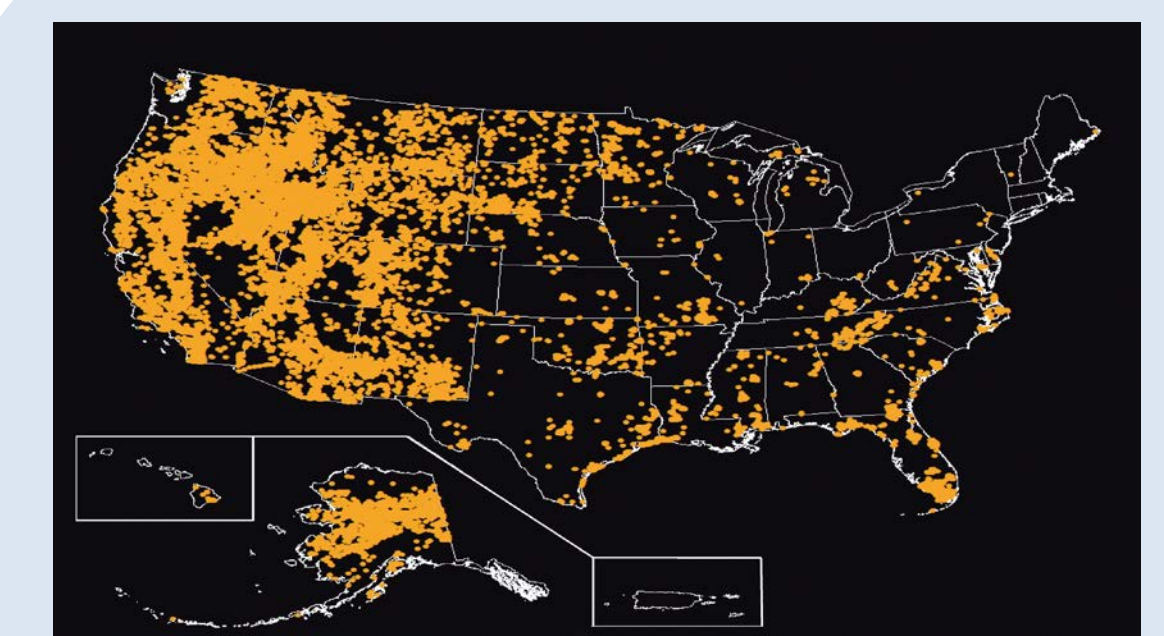
3. Proof-of-Technology using fighting wild fires as a real-world case study

- On-demand robust drone-carried long-distance communication channel
- Core CPS technology: integrated directional communication and decentralized control design
- Other features: cost-effective, broad bandwidth, standalone but integratable, flexibly configurable

- Drone system design issues, e.g., flight time
- Communication performance bounds: bandwidth, delay, and transmission distance



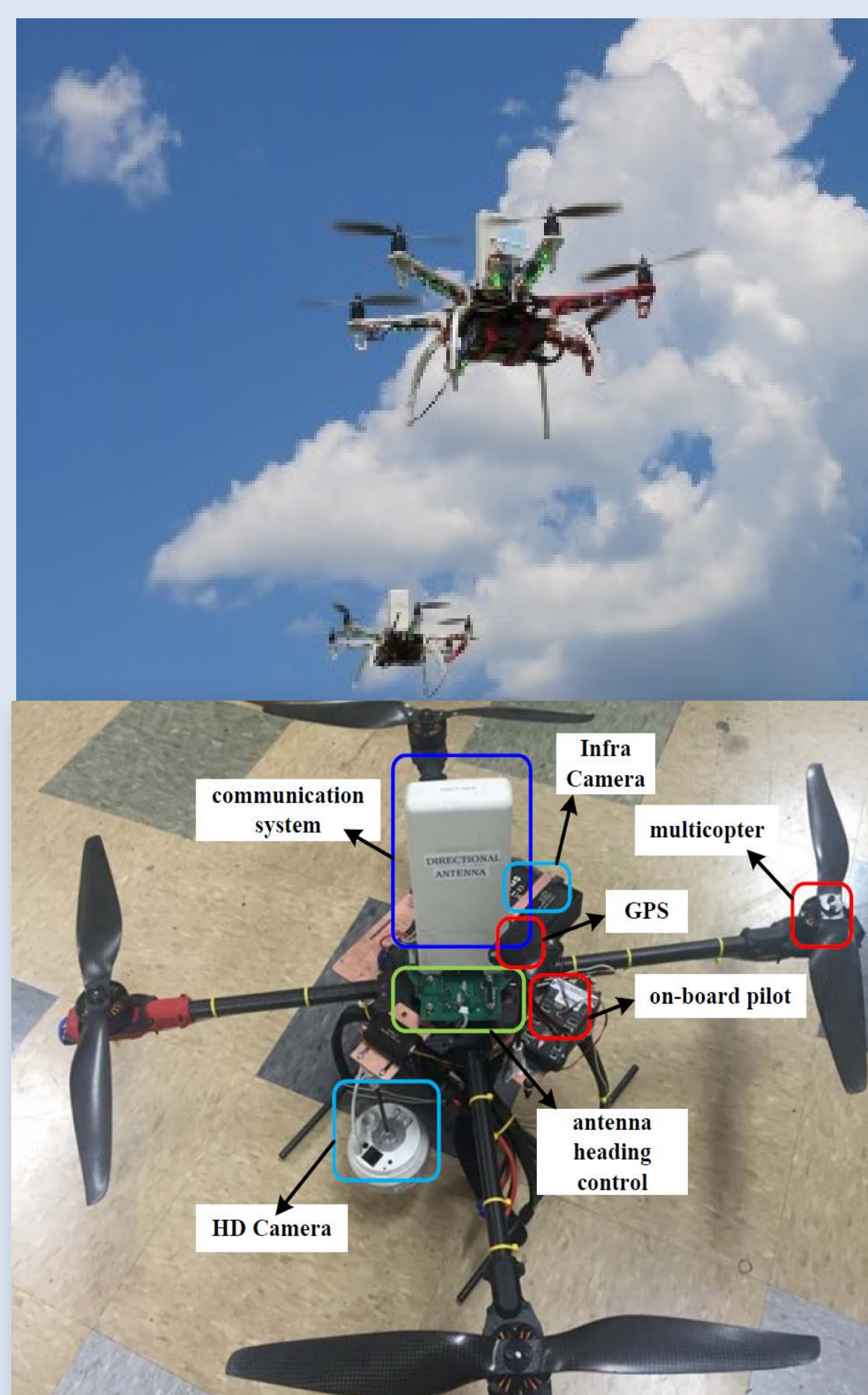
Flight time bound for all battery-powered multi-rotors: 3.8 h



- Emergency Preparedness Department of the North Central Texas Council of Governments
- Denton County Department of Emergency Services
- Austin Fire Department
- Tarrant County Fire Service Training Center
- Denton Fire Department

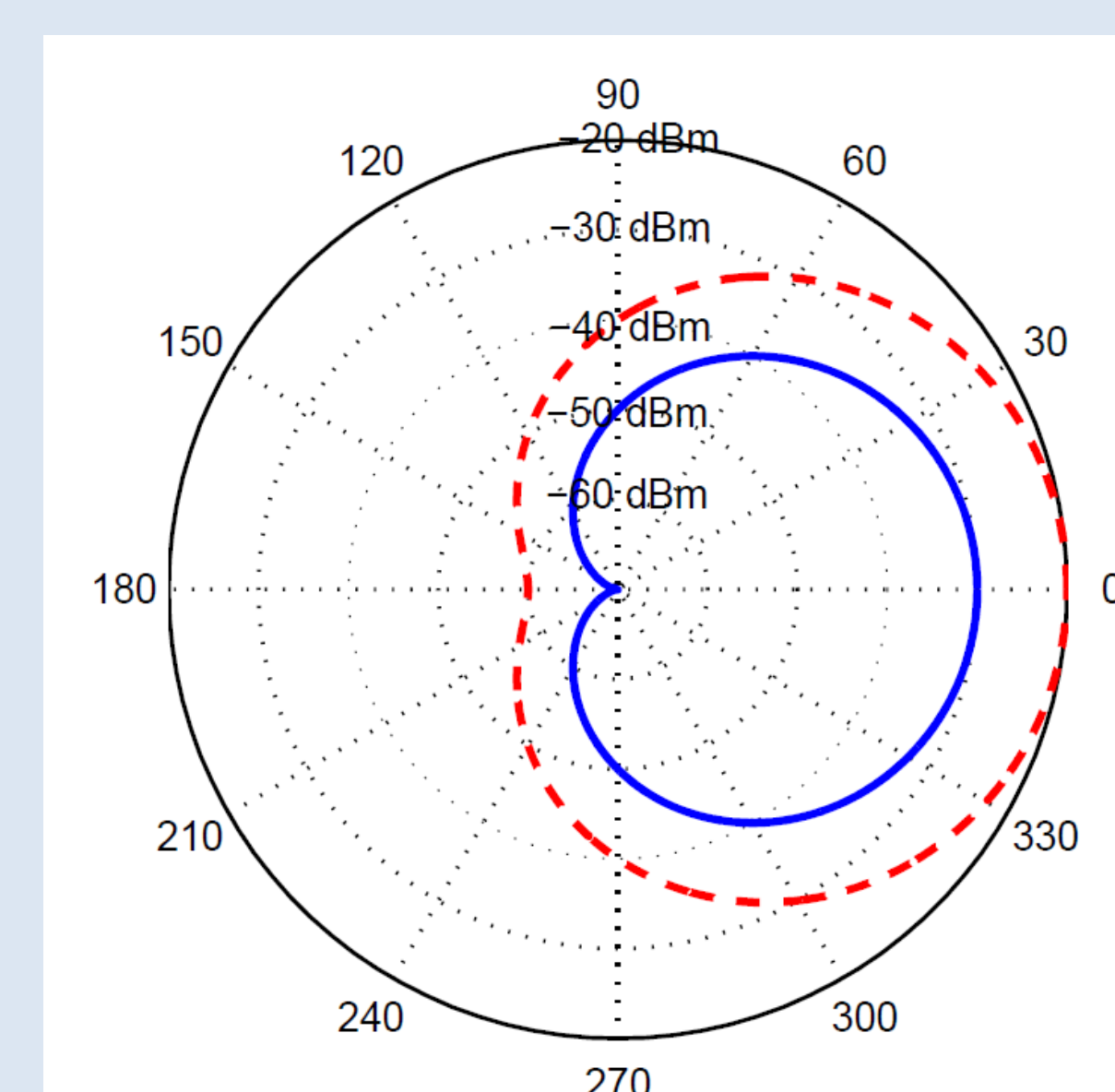
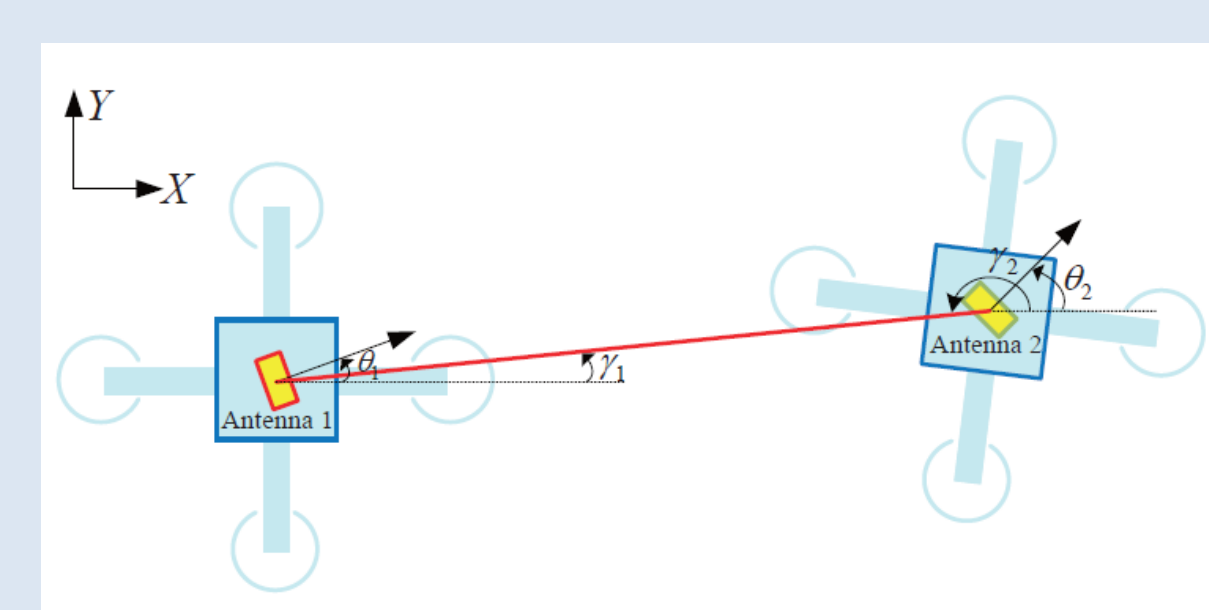
Research Progress: Intellectual Merits

Drone-carried Wi-Fi Prototype Beta



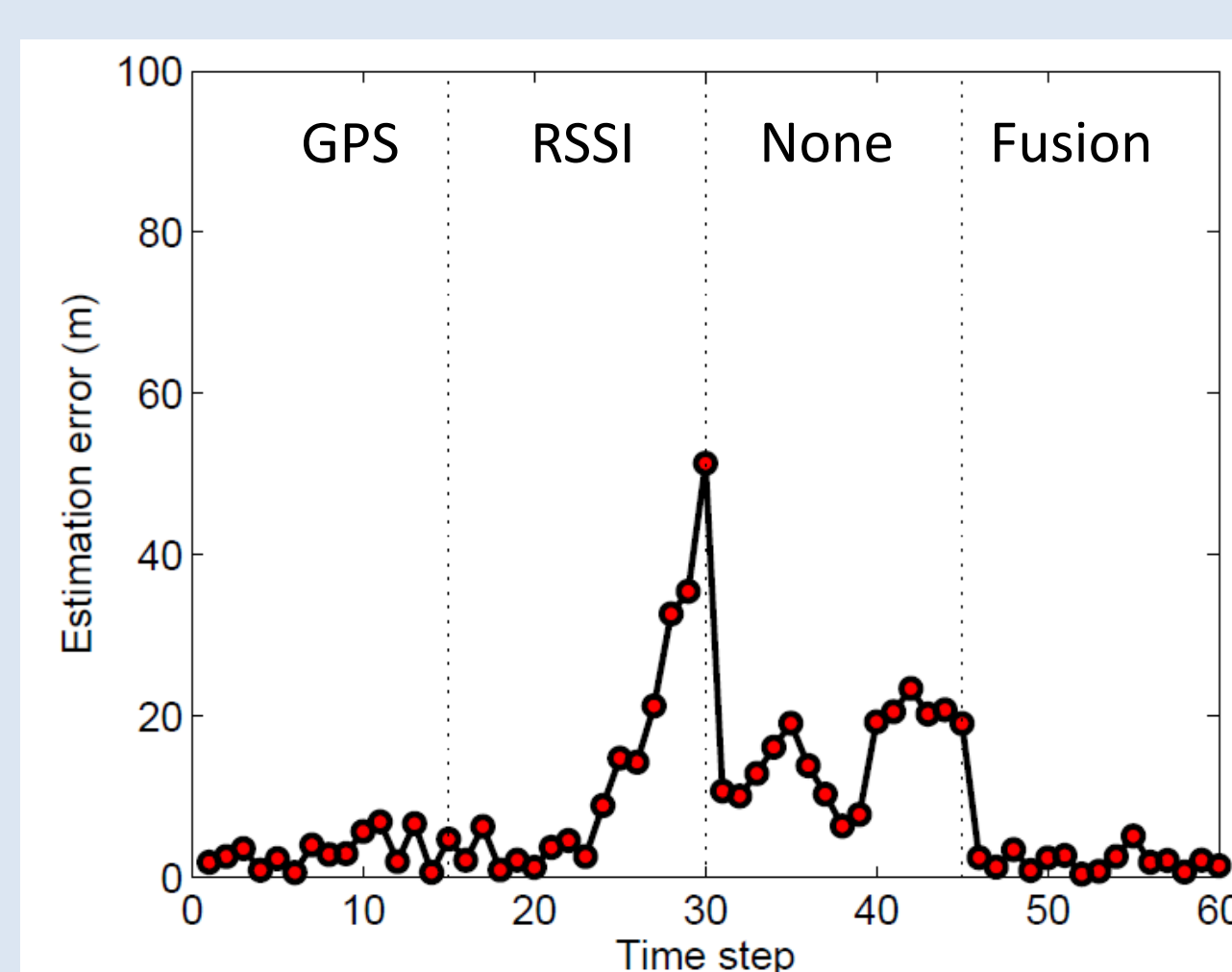
Compact design specific for search and rescue applications

Robust communication in GPS-denied environment



$$P_{t,j} \text{ [dBm]} + (G_{t,j}^{\max} \text{ [dBm]} - G_{t,j}^{\min} \text{ [dBm]}) \cos^2 \frac{\gamma_j - \theta_j}{2} + G_{r,i}^{\min} \text{ [dBm]} - L_f \text{ [dBm]} + (G_{r,i}^{\max} \text{ [dBm]} - G_{r,i}^{\min} \text{ [dBm]}) \cos^2 \frac{\gamma_i - \theta_i}{2} + G_{r,i}^{\min} \text{ [dBm]}$$

Performance analysis through simulation and field tests



G2A-A2A-A2G Link					
Distance	Throughput	Proposed	Delay	proposed	
Method [13]			[13]		
300 m	5 Mbps	36 Mbps	840ms	173 ms	
1000 m	N/A	12 Mbps	N/A	218 ms	
3000 m	N/A	2 Mbps	N/A	311 ms	
5000 m	N/A	800 kbps	N/A	419 ms	
A2A Link					
Method	[13]	Proposed	[13]	proposed	RSSI
300 m	19 Mbps	48 Mbps	230ms	41 ms	-57 dBm
1000 m	N/A	16 Mbps	N/A	67 ms	-63 dBm
3000 m	N/A	6 Mbps	N/A	87 ms	-76 dBm
5000 m	N/A	2 Mbps	N/A	101 ms	-81 dBm
Imperfect Antenna heading at 3000m G2A-A2A-A2G Link					
Degree	Throughput	Delay	RSSI		
15	1.1 Mbps	71 ms	-79 dBm		
30	N/A	N/A	-89 dBm		

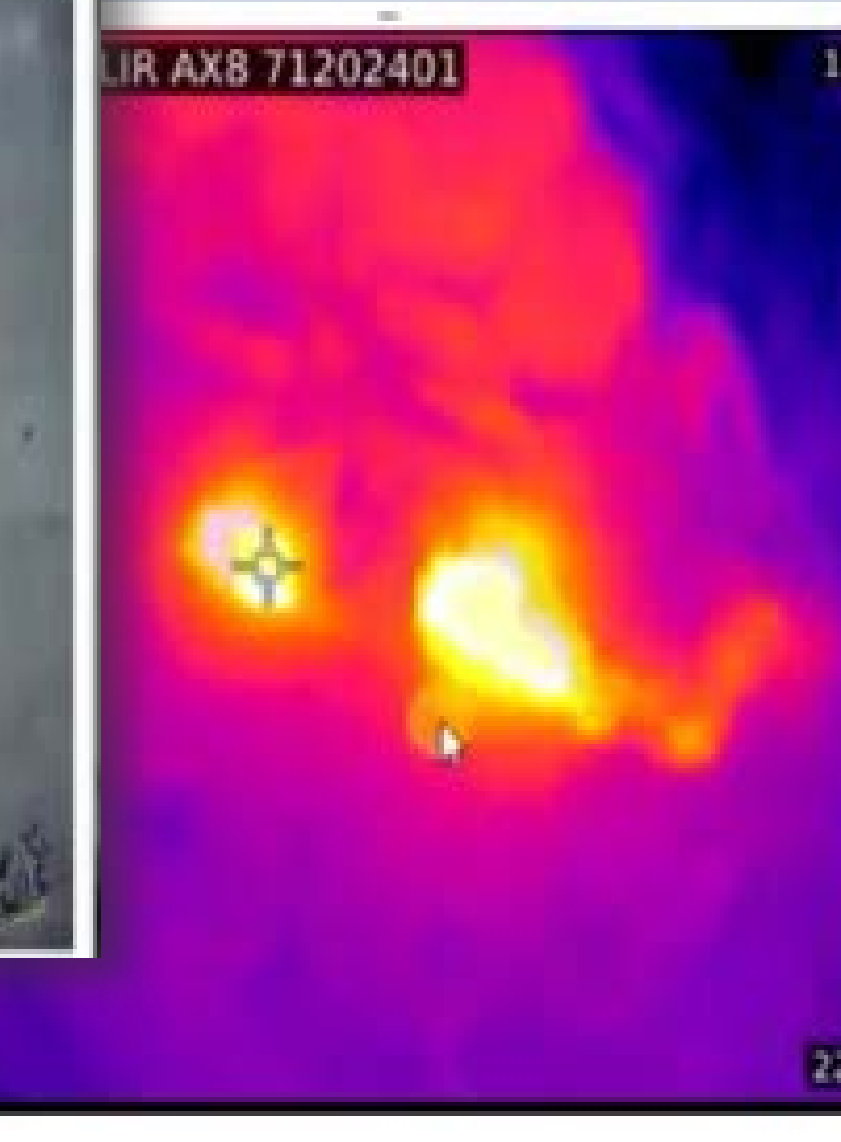
Research Progress: Broad Impacts

Field Tests

Demonstration with Tarrant County Fire Service Training Center filmed by Discovery Canada on three scenarios: 1) tracking victims in water, 2) fighting wildfire, and 3) assisting ground robot to check a criminal in a car accident.



Successful participation in the 2016 Full-Scale Disaster Exercise by City of Denton in May.



Outreach Activities

- Invited demonstration at Denton Public Safety Day, September 2016
- Demonstrated at GCTC Expo, June 2016
- Invited demonstration in the 2016 Emergency Preparedness Summit invited by deputy district director, April 2016
- Demonstrated at Defense Innovation Challenge, December 2015
- Involved high school students and undergraduate students in the project, supported by the Tech Titan of the Future – University Level Award issued by Metroplex Technology Association of North Texas, 2015-2016
- A variety of on-going efforts with Denton, Dallas, and North Texas city planners