UAV use in Reducing Hazards for Firefighters During Emergency Response

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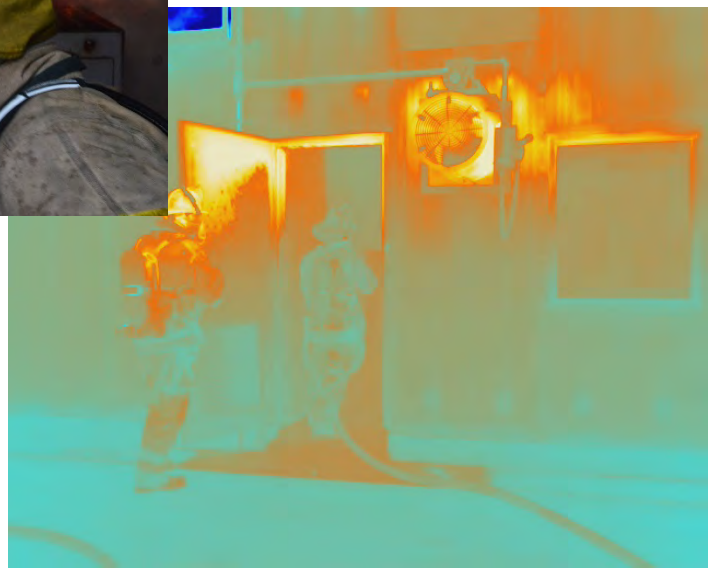


NORA Priority Areas Involved

- The NORA priority area covered under this project is related to Public Safety and is focused on the health and safety needs of public safety workers (firefighters).

Background

DJI Phantom 3

- An Unmanned Aerial Vehicles (UAVs) is an unpiloted aircraft controlled by remote control, or can fly autonomously by programmed flight patterns.
- The early focus of UAV use was for operations where manned pilot operations were at elevated risk.

DJI Mavic

DJI S900

UAVs

- UAVs are designed in a wide variety of ways, ranging in size, style, shape, and payloads (sensors)
- UAVs commonly are either quad-, hexa-, or octo-copter formats
- Unmanned aerial vehicles have been used by various agencies and industries for several decades: military operations, wild fire surveillance

Hazards in Firefighting

- Inhaling hazardous combustion products
- Falling from height due to unstable buildings
- Injuries from explosions and hazardous environments
- Burns
- Thermal Fatigue/Heat Stress
- Hazardous Rescue Operations

Purpose of Study

- The pilot project was designed to investigate the applicability of UAVs for use in reducing the hazards to firefighters during a series of exercise scenarios.

Scenario Evaluation

UAVs equipped with HD and infrared cameras, were deployed during a variety of emergency training scenarios to document and evaluate firefighter and UAV performance.

Evaluation consisted of:

1. Strengths and weaknesses of UAV operation
2. Whether the UAV helped in achieving objectives
3. The ability to communicate useful response information from UAV team to command personnel
4. Any training or staffing deficiencies
5. Any needed improvements in plans and procedures
6. The overall value of UAV to operation

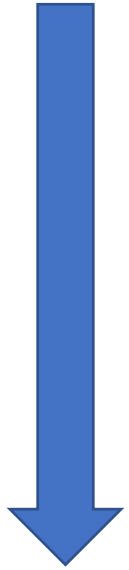
Study Design -- Scenario 1:

Evaluating performance of UAV under controlled conditions

- UAVs were operated under various loads and weather conditions to determine effects on flight performance

Results -- Scenario 1:

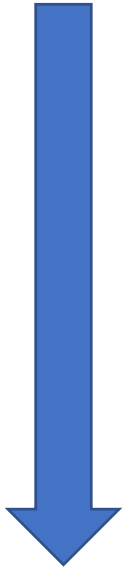
Event	Weight attachment, grams (ounces)	Temperature range	Battery life in minutes
Event 1	100 (3.5)	Warm	17
Event 2	100	Cool	16
Event 3	200 (7.1)	Warm	15
Event 4	200	Cool	14
Event 5	500 (17.6)	Warm	12
Event 6	500	Cool	11
Event 7	1000 (35.3)	Warm	9
Event 8	1000	Cool	8



UAV battery life under different weight conditions

Results -- Scenario 1:

Weight Applied	Wind speed (mph)	Average time to fly 100 meters (seconds)		Average flight speed (m/s)	
		downwind	upwind	downwind	upwind
100 g	<1 – 7	6.84	7.13	14.6	14
	7.1 – 17	7	8.05	14.3	12.4
	17.1 - 24	6.99	10.14	14.3	9.9
	24.1 - 38	6.83	13.86	14.6	7.2
200 g	<1 – 7	7.75	8	12.9	12.5
	7.1 – 17	8.12	9.27	12.3	10.8
	17.1 - 24	8.11	11.64	12.3	8.6
	24.1 - 38	7.99	14.97	12.5	6.7
500 g	<1 – 7	9.22	11.07	10.8	9.3
	7.1 – 17	9.44	13	10.6	9.1
	17.1 - 24	9.55	15.36	10.5	9.1
	24.1 - 38	9.56	17.91	10.5	9.1
1000 g	<1 – 7	10.81	12.39	14.6	8.1
	7.1 – 17	11.01	14.33	14.3	7
	17.1 - 24	10.94	17.58	14.3	5.7
	24.1 - 38	11.02	20.9	14.6	4.8



Flight time and velocity versus wind speed carrying 100, 200, 500, 1000 g weights

Study Design-- Scenario 2:

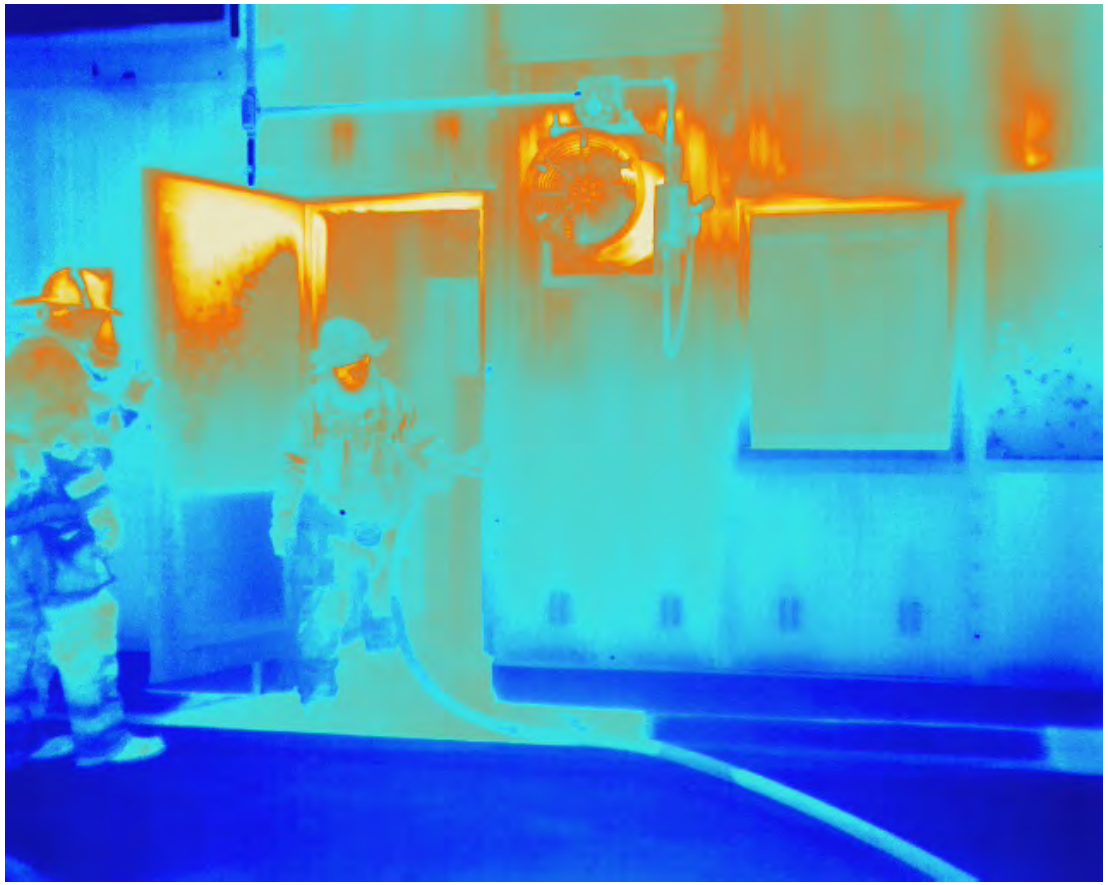
Training evaluation

- Exercise 1: high ropes training & rescue techniques
  - Retrieving victim at an elevated height of nearly 300 feet
- Exercise 2: fire ops training
  - Thermal evaluation
  - FLIR Vue Pro, Willsonville, OR thermal camera recorded images

- UAV used to document exercises
- Real time images and videos were provided to emergency personnel

High Ropes Rescue

Fire Ops



Results- Scenario 2:

Training evaluation

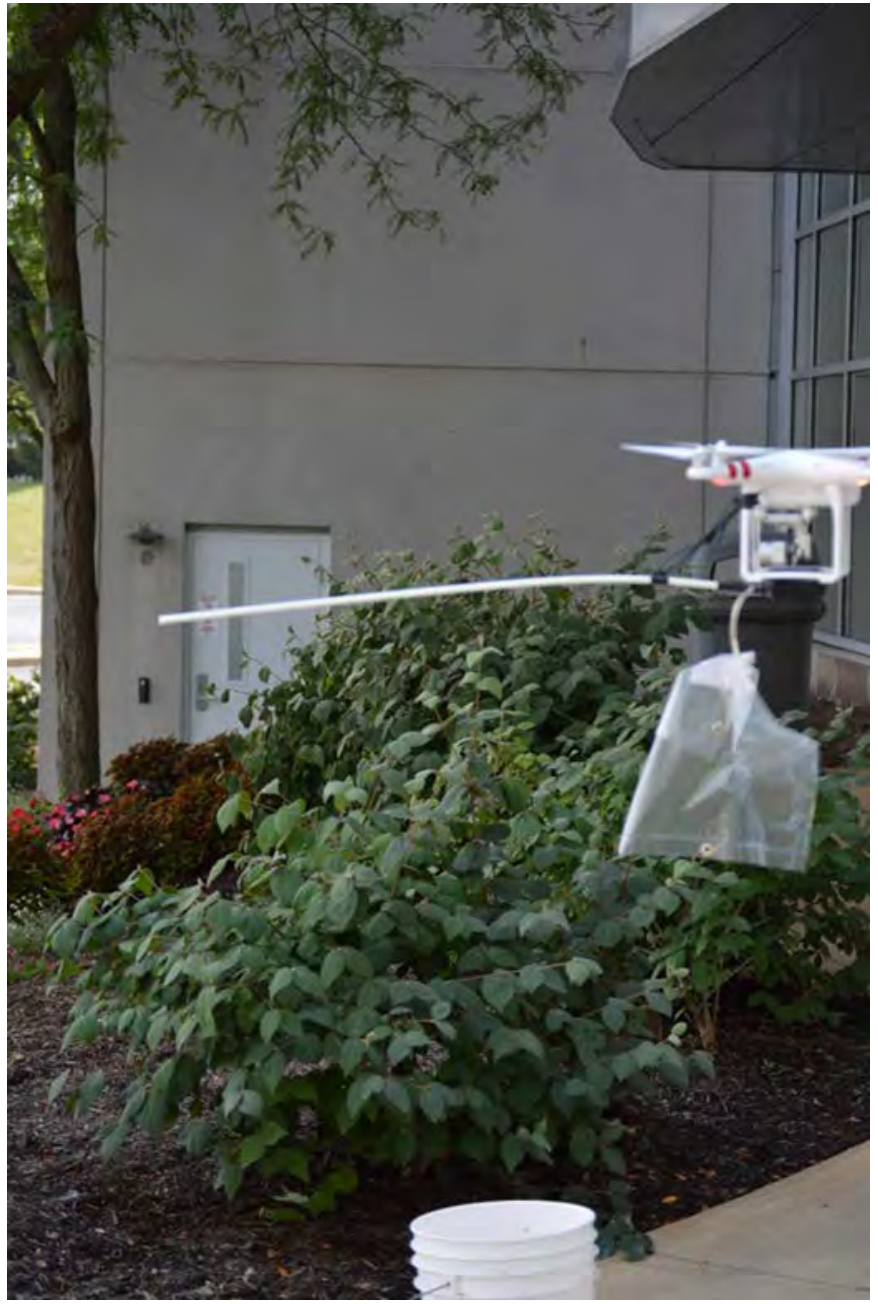
- Allowed command staff easy access to observe firefighter performance.
- Overcomes distance issues during high ropes training exercise.
- Rescue techniques could be accurately documented and analyzed at later date.
- Interviews conducted with command staff revealed the UAV presented a tactical advantage during the scenarios.

Study Design-- Scenario 3:

Chemical release sampling

- Collection of air sample
  - SKC Pocket Pump Touch (Model 220-1000TC, Eighty Four, PA)
  - Tedlar bag
  - UAV
- The ability of the UAV operator to maneuver into a proper position for obtaining a sample was evaluated.

Air sample

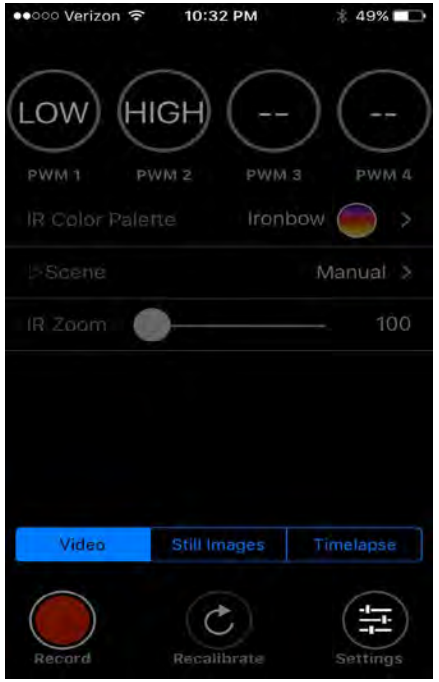


Results-Chemical Sampling

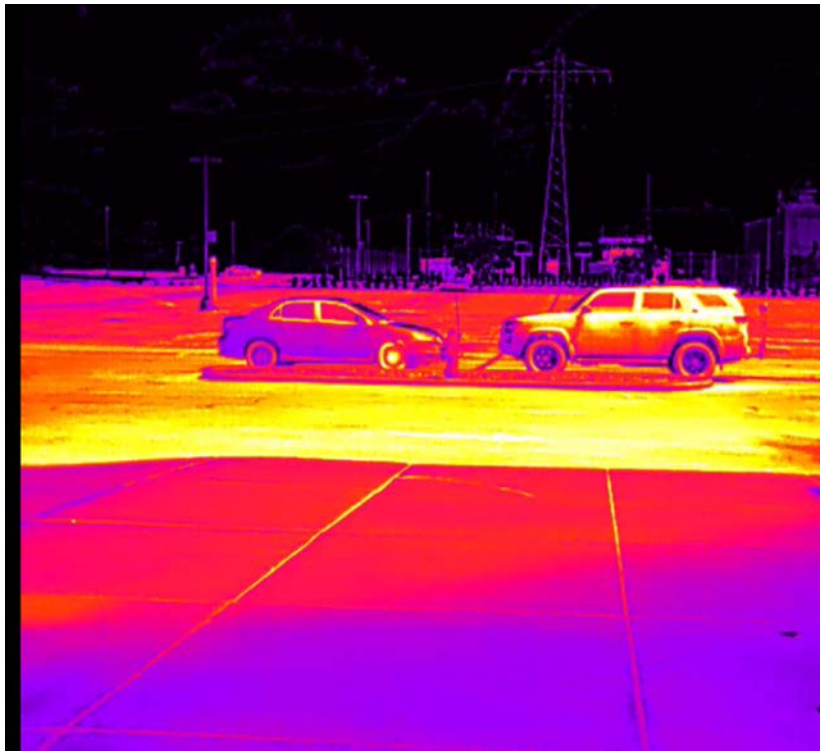
- Air sample was collected to Tedlar™ bag inline affixed to a UAV.
- Flight and propeller wash affected maneuverability, stability and landing of UAV
- Weight of sampling equipment decreases flight time of UAV.

Evaluation of thermal conditions

- A S900 UAV equipped with an infrared camera (FLIR Vue Pro, Willsonville, OR) was deployed in the field to record images of various surfaces to determine its utility in discerning differences surface temperatures.



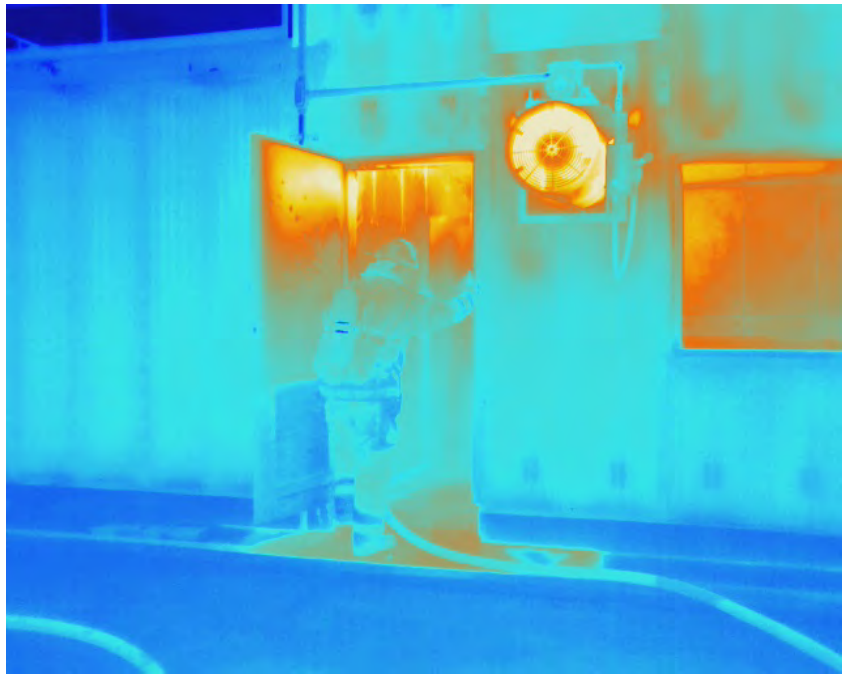
Thermal Evaluation



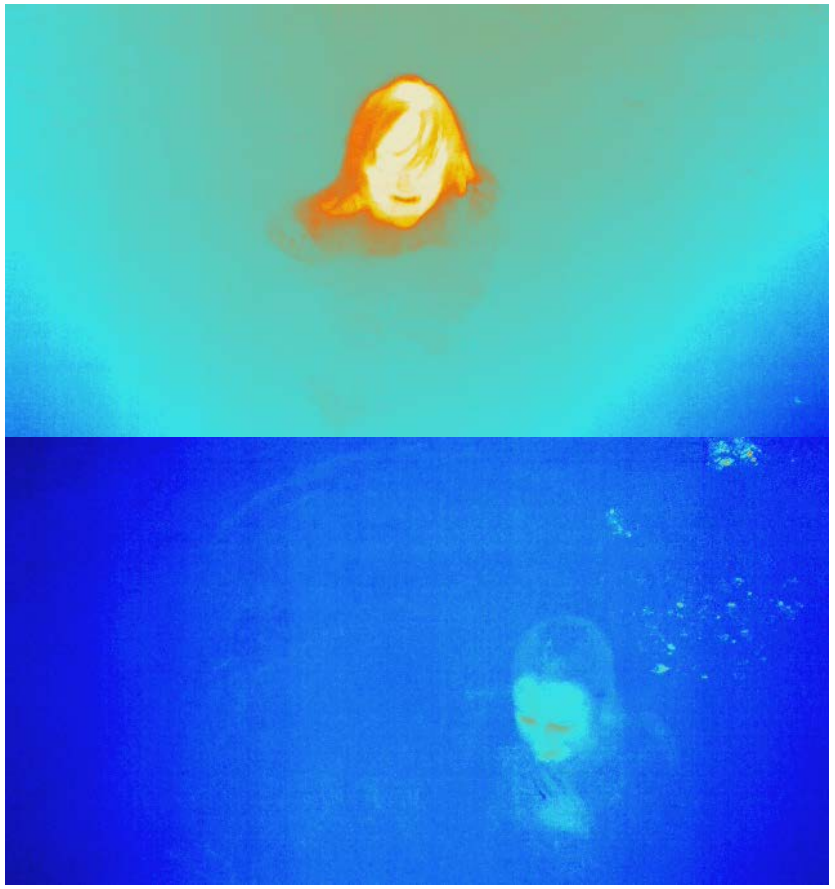
Evaluation of Surface Temperature of Various Surfaces

S900 equipped with HD and thermal cameras

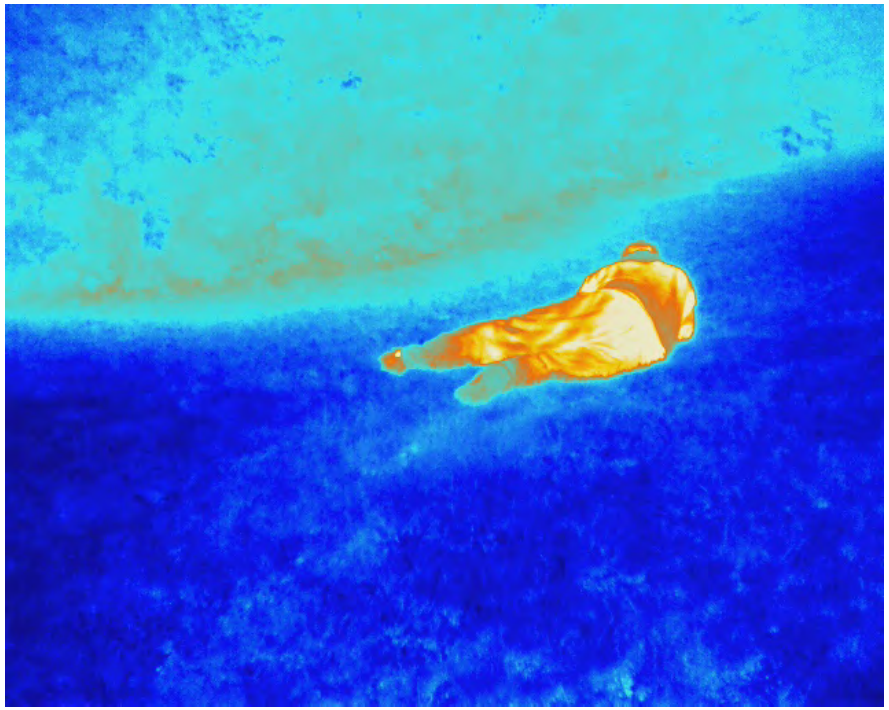
Evaluation of Live Fire exercise



Thermal Evaluation



Heat loss after being in water for only two minutes in 68°F water



Evaluation Victim Surface Temperature at Night 43°F

Discussion

- UAVs have great potential for integration into fire and hazardous material response efforts.
- UAVs represent an easy to use tool that can gather a large amount information including air samples without putting responders at risk.
- The need for accurate and actionable information is critical in a variety of emergency response and training operations.
- Information gathered by UAV can assist with exercise evaluation

Impact Statement

- The use of UAVs is still in its infancy and technology is continuing to evolve.
- The initial applications of air sample collection and evaluation of techniques are promising.
- Locally, the interest in collaboration with firefighters is very strong and we will continue to examine the value of UAVs in this field.

Future Directions

- Use of UAV equipped with thermal camera to aid in search and rescue scenarios
- Use of UAVs for fire scene evaluation prior to entry and firefighting activities (hot spot recognition)
- The firefighters in the current study expressed a willingness to participate in further research projects and suggested they are ready to use UAVs in real-life scenarios, especially hazardous materials releases.

Acknowledgements

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Thank You

- Questions