

DRONE-ENABLED HEAT STRESS MITIGATION IN CONSTRUCTION

What's the Risk?

Geo-Technology Associates (GTA) is a geotechnical and environmental consulting company, providing engineering, construction and environmental services to support infrastructure projects throughout the United States. Accordingly, many field workers perform physically demanding work outdoors, where prolonged sun exposure, radiant heat, humidity and limited access to shade and hydration on remote worksites elevate their risk of heat stress.

At GTA, site surveying is a significant contributor to the amount of heat stress exposure hours experienced by workers. Depending on site size and complexity, survey crews may spend between four and eight hours outdoors collecting survey data while exposed to direct sunlight and reflective surfaces such as asphalt, soil and concrete. In addition to increasing heat stress risk, this physically demanding work also contributes to fatigue risks and reduced productivity over the course of a workday. Between 2022 and 2024, GTA experienced 128 workdays with temperatures above 90°F, including 45 days in 2024 alone. In the same year, the organization also experienced four heat-related incidents requiring first aid.

As heat regulations continue to expand across the United States, the latest being Maryland's Heat Illness Prevention Standard, organizations are increasingly seeking methods that reduce worker heat exposure rather than relying exclusively on administrative controls. This pilot evaluated a holistic heat stress mitigation strategy by combining aerial drones with onsite hydration stations to reduce the time workers spent performing traditional surveying activities while improving access to drinking water on remote jobsites.



Figure 1. Outdoor workers are often exposed to heat-related hazards like sun exposure, high temperatures and limited access to shade and water.

Pilot and Technology Overview

With support from a pilot grant awarded by the [Work to Zero](#) initiative at the National Safety Council, Geo-Technology Associates (GTA) partnered with Critical Ops to evaluate two complementary technologies designed to reduce occupational heat stress:

- **Drone-enabled surveying.** Critical Ops deployed unmanned aerial systems, also known as aerial drones, equipped with LiDAR (*Light Detection and Ranging*) technology to survey and map the worksite. The technology created detailed three-dimensional maps to support site inspections and planning while reducing the time workers spent performing traditional survey activities outdoors. **Critical Ops and its remote sensing technology was a semifinalist in the 2025 Safety Innovation Challenge, an annual competition hosted by the National Safety Council that recognizes innovative technologies designed to address critical workplace safety challenges.**
- **Atmospheric water harvesting.** The pilot also evaluated a portable atmospheric water harvesting system (*Atmosphere H2O*) capable of generating potable drinking water directly from the humidity in the air. Unlike conventional water deliveries, the system continuously produces drinking water onsite, providing an additional hydration source for remote projects where water logistics can be challenging.

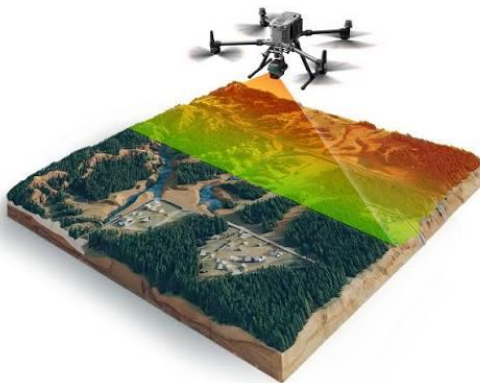


Figure 2. LiDAR-equipped drones use lasers to measure distances and create detailed three-dimensional maps.



Figure 3. Water harvesting systems can pull potable water directly from the humidity in the air.

The pilot was conducted over a six-month period, from June to November 2025 at an active construction site in Akron, Ohio. A total of eight workers were directly involved in the pilot, participating in field activities and evaluating both the drone operations and atmospheric water harvesting technology. The primary objectives of the pilot were:

1. Evaluate whether drone-enabled surveying can reduce worker heat exposure while improving the efficiency and accuracy of construction surveying and site planning;
2. Assess the feasibility and effectiveness of atmospheric water harvesting as a sustainable source of drinking water for remote construction environments;
3. Provide workers with updated safety protocols and real-time field training to equip crews with the practical knowledge to prevent and respond to heat-related illness; and
4. Collect and analyze data on worker health outcomes, productivity under heat stress and resource utilization to evaluate the effectiveness of the interventions and identify opportunities for refinement.

Pilot Findings

Throughout the pilot, GTA and Critical Ops collected implementation data, field observations and participant feedback to assess the effectiveness and practicality of the technologies, yielding several key findings:

1. Drone surveying substantially reduced worker heat exposure while improving survey quality.

First, the pilot demonstrated that replacing traditional ground surveying with LiDAR-enabled drone surveys substantially reduced worker exposure to heat. According to pilot data, surveying a 55-acre site, like the one used in this pilot, traditionally required an estimated 23 hours of work in direct sunlight. Using LiDAR-equipped drones reduced that time to just one hour—a **96% reduction in exposure hours** during one of the most physically demanding phases of site preparation (see *Table 1*). Rather than requiring workers to be exposed to harsh outdoor conditions, these drone pilots could safely perform flights under shaded cover or indoors.

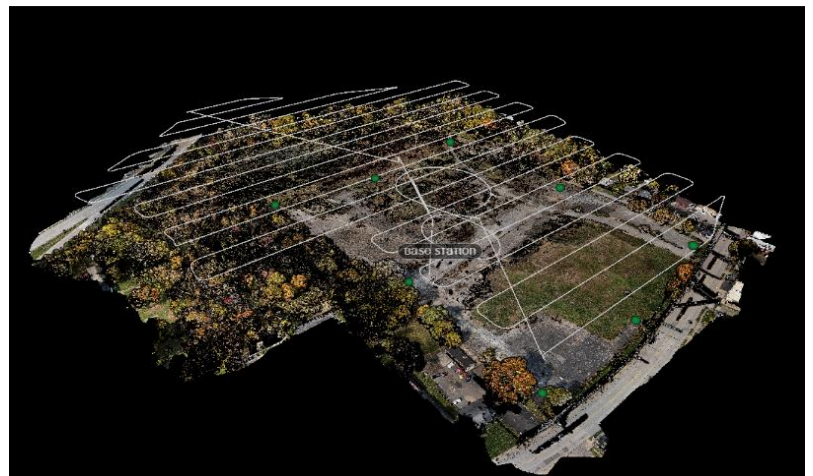


Figure 4. Drone flight paths used to survey the worksite, replacing many traditional surveying activities while creating a highly detailed 3D site model.

The LiDAR survey also outperformed traditional surveying across several measures of data quality. Survey quality is often measured by point density, or the number of data points collected within a given area. Higher point density creates a more complete and detailed representation of the worksite. As shown in *Table 1*, traditional surveying captures individual measurements every 25 to 50 feet, while the LiDAR survey collected approximately 62 data points per square foot, creating a much more complete and detailed representation of the worksite. The LiDAR survey also demonstrated improved vertical accuracy, meaning its elevation

measurements were typically within 0.039 feet (about half an inch) of the true ground surface, compared with 0.05 to 0.10 feet for traditional surveying. LiDAR surveying also had a lower standard deviation and mean delta in elevation, simply meaning that measurement errors were smaller and more consistent, ultimately resulting in a more accurate survey overall.

Table 1. Traditional vs. LiDAR Drone Survey Comparison (55 acres)		
Metric	Traditional Survey	LiDAR Drone Survey
Time outside (<i>in sun</i>)	23 hours	1 hour
Time outside (<i>in shade</i>)	1 hour	4 hours
Survey point density	Single points every 25-50 ft	62 points/ft
Vertical accuracy	0.05-0.10 ft	0.039 ft
Standard deviation (<i>elevation delta</i>)	0.05-0.10 ft	0.039 ft
Mean delta in elevation	0.01-0.03 ft	0.002 ft

2. Drone surveys improved site planning for heat mitigation.

Second, the pilot demonstrated that use of drones for surveying can also help improve and inform heat-related strategies on the worksite. Unlike traditional surveying, which captures measurements at selected locations, LiDAR generates a highly detailed three-dimensional model of the entire worksite. This comprehensive view of the site's topography, vegetation and surface conditions gave project teams a more complete understanding of where heat exposure was likely to be greatest. For example, LiDAR data can help identify areas with limited natural shade, large expanses of heat-absorbing pavement or locations where terrain could provide opportunities for shaded rest areas. These insights allowed leadership to make more informed decisions about the placement of hydration stations, break areas and other heat mitigation resources. In doing so, the technology not only eliminated a significant source of worker heat exposure by replacing traditional ground surveying but also informed additional engineering and administrative controls that further reduced heat-related risks across the worksite.

3. Atmospheric water harvesting can serve as a practical source of drinking water for remote worksites.

Results also demonstrated early evidence that atmospheric water harvesting can provide a practical supplementary water source for remote or outdoor worksites. Throughout testing, the Atmosphere H2O water harvesting system consistently produced potable drinking water onsite, demonstrating the feasibility of the

technology as a supplemental hydration source. During one five-hour test, the unit generated 3 liters of drinking water under average conditions of 66°F (19°C) and 50% relative humidity (see *Table 2*). Although production was lower under these relatively dry conditions, the system still provided an onsite source of drinking water. Additional testing under hotter and more humid conditions is planned at GTA, but the pilot demonstrated the potential of water harvesting to improve hydration access in environments where logistics might be more challenging.

Table 2. Atmosphere H2O Water Harvesting Results (5 Hours)	
Metric	Results
Water produced	3 liters
Average temperature	66°F (19°C)
Average relative humidity	50%
Water temperature	64°F (18°C)
Energy consumed (kWh)	2.53 kWh

Lessons Learned

GTA and Critical Ops cited several lessons learned throughout the duration of the pilot, including:

- **Reducing exposure is one of the most effective ways to reduce risk.** A core outcome of this pilot was the shift from reactive heat mitigation to proactive exposure reduction. By replacing traditional ground surveying with drone-based data collection, workers spent significantly less time performing physically demanding tasks in high-heat environments, directly reducing heat exposure before it occurred.
- **Innovation must be operationalized, not just introduced.** Introducing new safety technology alone does not reduce risk; instead, value is created when technology can be integrated into day-to-day operations. This pilot demonstrated that drones, hydration systems and safety protocols are most effective when embedded into existing workflows and daily decision making.
- **Standardized implementation resources support broader adoption.** According to GTA, the development of field-ready checklists and training materials (*i.e., a Pre-Flight Checklist, Water Planning Calculator and Water Harvesting Checklist*) was critical in providing field personnel with the guidance to translate technology into repeatable actions and will serve as valuable frameworks for future implementation of technologies across the organization.

- **Real-world testing accelerates both adoption and refinement.**

Conducting this pilot in an active construction environment allowed for immediate feedback, rapid iteration and practical validation of what works. For example, technical issues with data storage required portions of the LiDAR survey to be redone, while lower humidity also impacted the effectiveness of the water harvesting system. These challenges were viewed not as barriers, but as opportunities to learn and refine future processes.

According to GTA and Critical Ops, the outcomes of this pilot have the potential to benefit a much larger segment of GTA's workforce. With approximately 450–500 employees across the United States, many perform high-risk activities such as construction inspection, materials testing and geotechnical services. Based on the pilot's findings, GTA and Critical Ops plan to expand the use of both technologies across future construction projects to further reduce heat stress risks. In addition, drone-enabled surveying has already been incorporated into additional client projects and is being integrated with digital twin environments to support site planning, logistics and broader safety management beyond heat stress.



Figure 5. Drones have many safety applications, including site planning, inspections and surveying.

Geo-Technology Associates, Inc.



Geo-Technology Associates (GTA) is a client-focused geotechnical engineering company that provides comprehensive support services across a variety of markets, including geotechnical, environmental, drilling and construction materials testing. GTA employs roughly 450 to 500 people across the United States.

CRITICAL OPS LLC

Critical Ops, LLC

Critical Ops is a woman- and veteran-owned technology and consulting company that develops and integrates innovative solutions to improve safety, operational performance and project execution. **Critical Ops was a semifinalist in the 2025 Work to Zero Safety Innovation Challenge, focused on addressing occupational heat stress.**

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