U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 22-37 | **November** 2022

UTILIZATION OF UNMANNED AERIAL VEHICLES IN ACCIDENT RECONSTRUCTION

SUMMARY

The Volpe National Transportation Systems Center (Volpe), under the direction of the Federal Railroad Administration's (FRA) Office of Research, Development and Technology (RD&T), conducted a research study to evaluate the effectiveness of using Unmanned Aerial Vehicles (UAVs) (also known as drones) and photogrammetry software to expedite the accident reconstruction process.

In September 2021, RD&T conducted an impact test at the Transportation Technology Center (TTC) in Pueblo, CO, where a truck collided with a train. Volpe collected drone imagery of the post-crash scene in an effort to better understand what is involved in capturing the required incident data for a simulated highway-rail grade crossing environment. Figure 1 shows a Volpe researcher using a drone to capture aerial imagery from the accident scene.

Figure 1 - Researcher using drone to capture accident scene imagery

Volpe processed this data and took several measurements similar to those that would be taken at an actual accident scene. Figure 2 shows an orthomosaic image produced from the data collected from this scene.

The research team also interviewed engineers who participated in railroad accident investigations to better understand the products needed to produce accident investigation reports.

Results indicate that the use of UAVs in accident reconstruction is quickly becoming a standard practice among State and even local police departments. Federal investigators, who often arrive a day or more after an incident, value the high quality orthomosaic imagery captured shortly after the event because the scene is often significantly changed during the search-and-rescue process.

Figure 2 - Orthomosaic of highway-rail grade crossing impact test

BACKGROUND

When rail accidents occur, an investigation is conducted, usually by State or local law enforcement. In some cases, especially when there are fatalities involved, the National Transportation Safety Board (NTSB) will participate in the investigation and issue a report. Collecting the information related to the incident can be a time-consuming procedure which involves capturing extensive accurate measurements and photographs. This can result in the extended closure of roadways or rail lines. The data collected is essential in "reconstructing" an accident, which is a process used to find the root causes that led up to it.

Volpe conducted prior rail safety research using drones for trespasser detection that are documented in an FRA report (Baron, W. 2021). Researchers also studied the use of drones in producing accurate grade crossing profile data (Baron, W., & daSilva, M. 2020) and using photogrammetry in conducting line-of-sight analyses (Baron, W., & daSilva, M. 2019).

OBJECTIVES

The objective of this study was to examine the potential benefits and challenges associated with using drones to collect the data required for railroad accident reconstruction.

The research team could also determine if UAV technology can shorten the time required to capture the required data without compromising its accuracy.

METHODS

Historically, the accident reconstruction process involved sketching the scene, setting up civil engineering equipment such as a "total station" (which provides an accurate geo-location of a point in the scene), measuring important parameters such as the length of skid marks and the resting places of all vehicles and debris. It also required photographing the scene from many angles.

Using drones simplified all this data collection. The drone can be programmed to capture hundreds of photographs using both a grid and orbital flights over the scene and capture all the data in minutes with minimal effort with a few evidence markers highlighting key parameters. There is also an advantage in using a drone to capture very large accident scenes those on difficult terrain, and those involving the spillage of hazardous materials, all are common in railroad incidents.

Photogrammetry software is an essential component to the drone data collection toolkit. It can be used to produce what is known as an orthomosaic image of the scene, which appears to be a satellite image, but it was produced by using many low altitude photographs stitched together. While the image appears to be a single image captured from a high altitude, it has sufficient resolution to examine small details on the ground. In some cases, three dimensional models of the scene are also valuable and can be produced using photogrammetry software.

The preponderance of the highway-rail grade crossing collision test images captured at the TTC were taken autonomously by the drone from a height of 75 feet. These were used to produce a single orthomosaic image using Pix4D software. This image was then imported into a geographic information system (GIS) software package called QGIS. This is a free, open-source GIS product that enabled Volpe to take measurements that are accurate because the orthomosaic was overlaid onto the Web Mercator coordinate reference system.

Volpe engineers participate in FRA forensics investigations and often travel to a train accident scene within 24–48 hours of a severe accident occurring. Even within this narrow response time, critical evidence has typically been disturbed in the search-and-rescue process. Because trains generally do not maintain passenger manifests, the only way to know that there are no victims unaccounted for is to bring in heavy equipment and lift or roll each railcar to ensure no one is trapped underneath.

Federal investigators have often requested imagery from other sources, especially those with helicopters, to try to better establish the positions at which railcars and vehicles came to rest. Figure 3 shows an image obtained by investigators of the Amtrak derailment near Dupont, WA, in 2017. State law enforcement took this photograph from a helicopter, overlaid with railcar numbers and other notes. As valuable as this image was to investigators, it is not accurate enough to be used for measurements.

Figure 3 – Annotated aerial view of Dupont, WA, derailment scene captured by Washington State Police helicopter (National Tranpsortation Safety Board 2019)

If it were common practice for first responders to capture drone imagery early in the incident response, the positions of key evidence could be established. Fortunately, more and more first responder agencies are acquiring drones, becoming well versed in their use, and are using them routinely as part of their incident response procedures.

During the course of this study, it was found that the use of drones by State and local police departments for reconstruction of vehicular accidents has grown dramatically. Just a few years ago, only a handful of police agencies were using them. Now, it is a common practice. This is because using a drone greatly shortens the time required to gather the necessary data for reconstructing an accident. When proper techniques are adhered to, the data captured can be every bit as accurate as that gathered through careful collection of measurements and photographs.

RESULTS

The research team used the data it collected at the TTC to perform some sample accident reconstruction tasks, such as developing an orthomosaic overview of the crash scene, importing this data into QGIS and taking some sample measurements. Figure 4 shows an example where the length of the tank car was measured and found to be 75 feet from mid-coupling to mid-coupling. This corresponds to a measurement taken at the scene with a tape measure. Note that it was important to apply a web Mercator projection system onto the orthomosaic so that accurate measurements could be achieved. Note that capturing the images used to produce the orthomosaic from lower altitudes, higher resolution can be achieved, resulting in higher precision.

Certainly, smaller measurements, such as the number of inches the truck of the railcar was pushed off the rail, are easier to take manually. But larger measurements more common in typical accidents such as skid mark length, or the distance between the impact point and where a vehicle came to rest, are more easily captured using the orthomosaic.

It should be noted that it took 21 minutes for the drone to capture the photographs using the default grid pattern from takeoff to touchdown. Similar results could be expected in real world conditions for accident scenes of this size. However, not all data collection activities can be replaced by the drone-based data collection process. Additional time will continue to be required for the placement of evidence markers, testing vehicular equipment and grade crossing warning devices, capturing closeup photographs, etc.

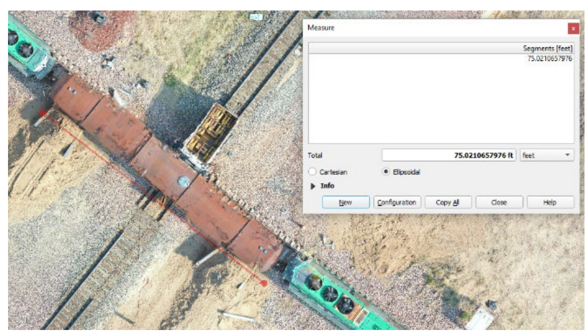

Figure 4. Measurement of tank car length using orthomosaic and QGIS software

CONCLUSIONS

Volpe observed that UAVs are quickly becoming standard equipment for both State and local law enforcement crash investigators. The data collected is of significant value to Federal investigators, who usually arrive after the accident scene has been disturbed. While some training and experience are required to utilize the equipment effectively, the time saved on site following an accident is substantial.

FUTURE ACTION

In light of the growing widespread adoption of UAVs as an essential part of incident response, no action by FRA is required to continue this trend.

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ACKNOWLEDGEMENTS

This work was performed under interagency agreements between FRA's Signals, Train Control and Communications Division and the Volpe National Transportation Systems Center's Systems Safety and Engineering Division. FRA's Rolling Stock Division sponsored the highway-rail grade crossing impact test.

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KEYWORDS

Photogrammetry, accident reconstruction, grade crossing, railroad safety, highway-rail grade crossing, train control

CONTRACT NUMBER

DTFR5317X00026