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Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

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AN AUTOMATED, DRONE-BASED GRADE CROSSING INSPECTION SYSTEM

SUMMARY

There are over 200,000 highway-rail grade crossings in the U.S. Ensuring these grade crossings are safe for train and automotive vehicles is a priority of the Federal Railroad Administration (FRA). FRA has funded research through the Small Business Innovation Research (SBIR) program to promote the development of advanced, automated technologies to improve grade crossing safety inspections.

This project funded MTRI Inc. of Michigan and its partner, Michigan Technological University, to develop and demonstrate a drone-based system for automated inspection of grade crossings. The prototype system can determine whether vertical approach grades create a risk for vehicles to get stuck on tracks, assess the adequacy of visual sight lines at a crossing, and locate relevant assets such as gates, lights, signage, etc. It uses high-resolution images collected via drone/unmanned aerial system (Figure 1) that are the processed into 3D data for analysis.

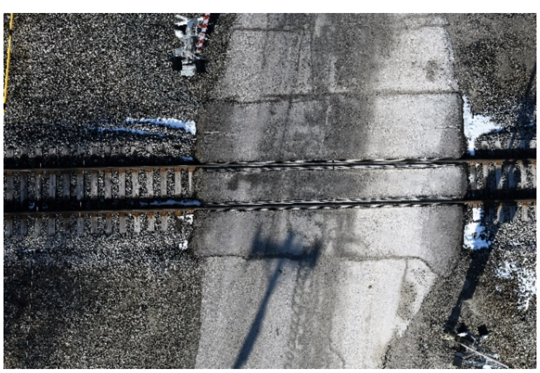

Figure 1: High-resolution drone-collected imagery of a rail grade crossing near Chelsea, MI

This Research Results provides highlights of the Phase I SBIR project, including example results from initial technology deployment and a description of a path to commercial availability.

BACKGROUND

In 2018, FRA reported 2,214 total highway-rail incidents that led to 270 fatalities [1]. A portion of these incidents were caused by inappropriate vertical design or inadequate sight distance triangles. Conditions where vehicles can become stuck on the highway-rail grade crossing are especially of concern. There are numerous examples, such as the 2017 incident in Biloxi, Mississippi, where a motorcoach stuck on a humped crossing was struck by a freight train, resulting in 4 deaths and 37 injuries [2].

OBJECTIVES

The objective of this Phase 1 project was to develop a proof-of-concept drone-based grade crossing inspection system that leverages automated processes to reveal potential safety risks. The goals for the prototype system were to assess vertical profile at a crossing against vehicle clearances, determine visual sight lines, and identify locations of gates, lights, and signage. Therefore, MTRI Inc. developed two geographic information system (GIS)-based assessment tools: an automated profile assessment tool and a railroad grade crossing viewshed tool.

METHODS

Drone imagery was collected with two drone platforms: one to collect high-resolution imagery of the rail grade crossing and the other to collect data from a larger area for visual sight line analysis. A Bergen Hexacopter with a Nikon DSLR collected imagery with a ground sample distance of 0.1 inch (~2.5 mm) directly over the rail grade crossing. This high-resolution imagery was processed into digital elevation models (DEMs) and orthoimagery of the rail grade crossings for vertical profile assessment (Figure 2). DEMs were produced through 3D photogrammetry software and required approximately 1 hour to complete processing for each site. The DEM resolution is 0.4 inch (1 cm).

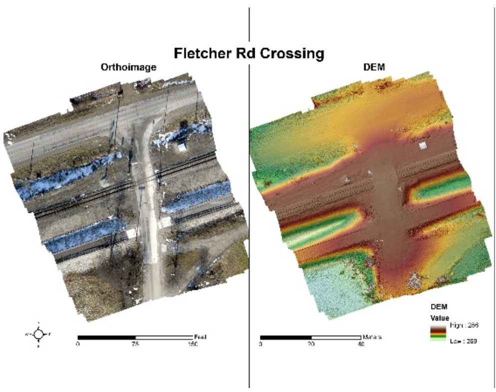

Figure 2: Orthoimage and DEM generated from drone imagery of rail grade crossing used for hang-up analysis

Elevation profiles were created from the DEM layer over the center of each lane. The profile starts 30 feet (9.1 m) before the first rail of the crossing and ends 30 feet (9.1 m) after the last rail. The total distance of these profiles is 78.8 feet (24 m). The profile locations are represented by the red line for the southbound lane over Freer Rd. (Figure 3). Using high resolution drone imagery to create 3D models allows the user to easily determine the rate of elevation change across the rail grade crossing as well as the location of each of the rails near the center of the profile.

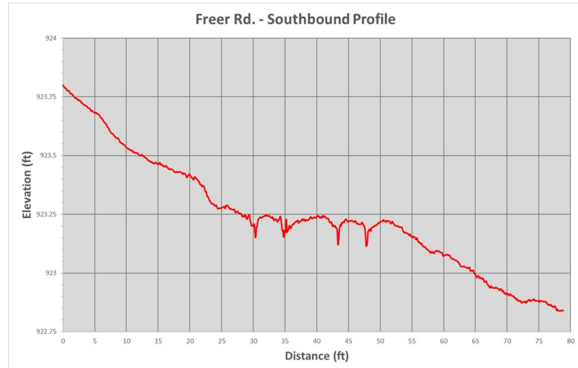

Figure 3: Freer Rd. southbound lane profile

The second drone, used for visual sight lines analysis, was a DJI Mavic 2 Pro with a 20 MP camera with a flight time of up to 25 minutes. To enable analysis of a larger area, imagery was collected at a lower resolution with the Mavic 2 Pro than with the Bergen Hexacopter, with a ground sample distance of 0.8 inch (2 cm). Image processing averaged 1.5 hours to complete and resulted in a DEM with 3.2 inches (8.2 cm) resolution.

Researchers collected additional imagery of the rail grade crossing using the DJI Mavic 2 Pro from an oblique angle for the assessment of automated sign detection capability. Mapillary was used to demonstrate the ability of artificial intelligence/machine learning to detect signs in drone-collected imagery.

RESULTS

Workflows were developed for each automated tool. Both tools require drone-derived DEMs for rail grade crossing analysis. The automated profile assessment tool requires vehicle wheelbase and ground clearance data to complete the analysis. Four vehicle types were used during the development and testing of the tool:

- A representative lowboy trailer with a wheelbase of 30 ft (9.1 m) and a ground clearance of 5 in (12.7 cm)

- A representative motor coach with a wheelbase of 27 ft (8.2 m) and a ground clearance of 7 in (17.8 cm)
- A 2020 Ford Explorer with a wheelbase of 10 ft (3.0m) and a 7.9 in (20.0 cm) ground clearance
- A representative school bus with a wheelbase of 23 ft (7.0 m) and a 7 in (17.8 cm) ground clearance

Figure 4 displays the results of the automated profile assessment tool over a humped rail grade crossing. The red polygon in each frame indicates where the bottom of the vehicle would strike the pavement. The representative lowboy trailer would encounter a hang-up situation on this rail grade crossing.

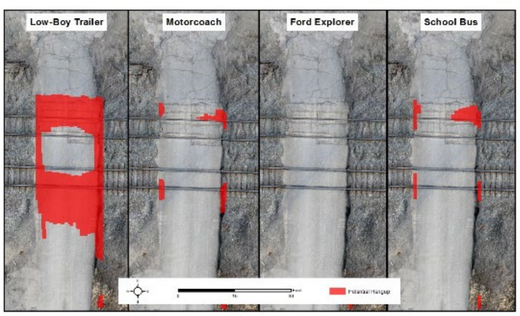

Figure 4: Analysis results of potential hang-up areas for four vehicle types, using high-resolution drone-collected imagery processed with photogrammetry

The railroad grade crossing viewshed tool was used for visual sight lines analysis. This tool uses the vehicle and train speeds to determine if a crossing has acceptable visual sight lines based on requirements defined in the AASHTO Green Book. Figure 5 shows the results of a visual sight lines analysis over a private drive crossing near Chelsea, Michigan using DEM data derived from drone-collected imagery. The areas highlighted in green would be visible by a driver in a vehicle stopped at the stop sign (represented by the blue dot). Areas highlighted in pink would not be visible to the driver.

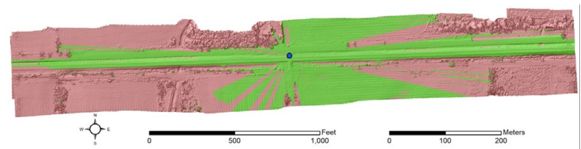

Figure 5: Analysis results of visual sight lines

Oblique imagery collected by the DJI Mavic 2 Pro was processed through Mapillary to identify signs at a rail grade crossing. Figure 6 is an example of an oblique image collected for sign identification. Signs identified by the software are outlined by an orange box with the sign interpretation beside it.

Figure 6: Results from Mapillary detecting signs from a drone collected image

CONCLUSIONS

This Phase I SBIR developed a prototype drone-based grade crossing inspection system and tested the system on three grade crossings. The results demonstrate an advanced and practical capability to use drones for the assessment of various crossing characteristics, such as inadequate vertical profiles, visual sight line triangles, and sign identification. The data collection process required 45 minutes at each site, including flights with both drones and collecting GPS positions at ground control targets placed at the site.

Additional development is required under a Phase II project is anticipated to continue development and to produce a system for commercial implementation. This will include streamlining drone data to reduce collection time, continued development of the automated profile assessment and railroad grade crossing viewshed tools to meet customer requirements, and extensive testing to ensure the system meets stakeholder accuracy and usability requirements.

FUTURE ACTION

FRA has requested a Phase II project proposal to further develop drone-based inspections of rail grade crossings for commercial applications.

REFERENCES

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