FROM ALL SIDES - INTEGRATING LASER SCANNING AND UAV DATA GIVES INVESTIGATORS A NEW 3D VIEW

Laser scanning and UAV have their strengths and benefits in the field. But the ability to seamlessly combine the two different data sources into one point cloud gives a complete 3D view from all sides of a crime scene.

by Mary Jo Wagner

Det. Gunderson acquired this photo of damaged vehicles and rail cars with his UAV.

In a job that demands that officers and investigators are ready for any possible scenario at any time, enabling technology is a welcome tool.

No one would dispute that courage is at the core of any police officer. It takes a certain braveness to dress for a job in which every day is a mystery people could go missing, be hurt, be fatally wounded and one's own life could be at risk of injury or worse.

For detective Eric Gunderson of the Washington State Patrol (WSP), that fearlessness extends to his department's adoption and use of technology, where they regularly move beyond spec sheets to discover new and innovative ways to make technology work for them. For example, they once hung a Trimble TX5 laser scanner upside down through a sunroof to scan the inside of a car.

This level of comfort with advanced technological tools has come from years of asking "What if," and a willingness from the chief down to embrace technology that can benefit both the WSP and the people it serves.

Laser scanners are now as common as radios for each of the WSP's 15 detective units across the state the scanners have been in the field for

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the past four years. And in 2017, they began adding Unmanned Aerial Vehicles (UAV) to their arsenal of technology.

“Whenever we acquire new equipment, my captain always says, ‘This technology is another tool in your toolbox," says Gunderson, the WSP's technology liason based in Tacoma. “So, if you need a Phillips [screwdriver], you've got one. If you need a flat head, you've got one. No one tool will solve all your needs. It’s important to get comfortable with many different tools both in the field and back in the office.”

Indeed, Gunderson’s penchant for experimentation has been key to becoming at ease with technology. Case in point: soon after acquiring their first UAV, Gunderson used Trimble RealWorks Forensics software to test the possibility of merging scan and UAV data of the same scene into one, integrated point cloud. It was not only a success, the integrated forensics view has become a formidable tool for accident reconstruction cases, which make up 65 percent of their responses.

“Individually, both laser scanning and UAV have their strengths and benefits in the field,” says Gunderson. “But the ability to seamlessly combine the two different data sources into one point cloud gives us a complete 3D view from all sides of a crime scene. That is an additional and powerful forensics tool. The technological versatility we have makes us confident that we’ll be able to respond to any incident and investigate it thoroughly.”

And it’s a good thing, too. Because it was that same level of comfort with technology that gave WSP responders the confidence to answer the call to the 2017 DuPont train derailment outside Tacoma, Wash an accident so unpredictable and so massive that no training drill could have adequately prepared them. It not only put the WSP to the test, it provided the opportunity for Gunderson to push the limits of the integrated scanning/UAV point cloud approach and display it on a national scale.

Responding from All Sides

On the crisp early morning of December 18, 2017, an Amtrak passenger train was making its inaugural run between Tacoma and Portland, Oregon. As it neared a curve leading to an Interstate-5 overpass near DuPont, the train was traveling at 78 mph–50 mph over the speed limit and the lead locomotive, along with 11 of its 14 rail cars, derailed. It was 7:33 a.m. and I-5 was already teeming with commuters. The lead locomotive and three rail cars landed on I-5, causing a 14-vehicle pile-up. Three of the 77 passengers onboard the train were killed, and 62 passengers and 6 crew members were injured. The initial damage was estimated to be $40 million.

“Where this happened couldn’t have been a worse spot as far as impact to the region,” says Gunderson. “I-5 is the major artery between Tacoma, Olympia, Portland and Seattle. With Puget Sound to the west, the Nisqually River to the south and a military base to the east, your only driving option is I-5.”

WSP troopers were on scene within five minutes of the crash. By 8:30 a.m. the scene was swarming with hundreds of troopers, detectives, firefighters and paramedics, all of whom had one thing on their mind: rescue.

“For that kind of incident, the last thing you’re thinking of is preserving evidence,” says Gunderson. "If I need to move a train or car to get someone out, that’s what’s going to happen."

Figure 1: The as-found scene of the Dupont train incident where 11 of 14 rail cars of an Amtrak derailed, killing three people and injuring 62 passengers and 6 crew members.

Figure 2: A TX5 stands protected by the elements as it scans the mangled rail car in front of it.

So our first hour was consumed by all lifesaving first. But once we cleared the scene, everything began to slow down and we could start investigating. Then we owned the scene.

Working in collaboration with the National Transportation Safety Board (NTSB), the lead investigating organization, Gunderson led the accident reconstruction phase, bringing in four Trimble TX5 scanners and one DJI Matrice 200 UAV. Although he had been successfully using Trimble RealWorks Forensics to merge scan and UAV data into point clouds, he had never applied the approach to an incident of this magnitude.

Teams of WSP collision investigation detectives first walked through the debris-riddled scene, taking photographs, painting the footprints of important objects such as cars and tire marks, and documenting them. In parallel, he dispatched two teams per each of the four TX5 scanners and split them into two groups, one to work on the overpass section and one to manage the roadway section.

Setting up on each end of the tracks, the railway teams methodically moved towards each other, scanning all four sides of the individual rail cars and any strewn debris, and recording each object as it was found. The ground crew followed the same process. Starting at each end of the I-5 scene, the teams collected data points of the rail cars, vehicles, roadway, tire marks, paint marks, and anything that laid within the boundaries of the accident. In total, the four teams collected 82 scans and more than one billion data points in five hours.

"What's awesome about scanning is that it ensures you don't miss anything," says Gunderson. "At the accident scene, you only get one shot to get what you need. You can't put the trains back where they used to be, so you need to be right the first time. Scanning captures everything incredibly quickly and often captures something you didn't know you'd need."

Figure 3: While the teams were scanning the tracks and roadway, Gunderson flew the scene with the UAV and collected 682 photos with the unit's 20MP camera.

Figure 4: Wreckage from the Dupont train derailment captured by a Trimble TX5 laser scanner. In total, four teams collected 82 scans and more than one billion data points in five hours.

While the teams were scanning the tracks and roadway, Gunderson flew the 920-ft-long by 340-ft-wide scene with the UAV. After a 10-minute set-up, he flew an overall pass at 200 ft at roughly 70 percent front lap and 50 percent side lap to establish a base. He flew a second pass at 100 ft and a final flight at altitudes between 15 ft and 50 ft to acquire some oblique photos. In 89 minutes, Gunderson collected 682 photos with the unit's 20MP camera.

"I could've handled the accident with just one technology, but given its scale, I wanted to have data redundancy," says Gunderson. "The drone would provide different view angles since the scanner can't get the top of the train. In addition, with the volumes of data I'd collect, it would be a great opportunity to test how well I could merge the two massive datasets together."

By 2:00 that afternoon, Gunderson was able to pack up the gear and head back to the office to process the data.

For efficiency, Gunderson loaded

the UAV photos into their photogrammetry software for batch processing overnight, so when he returned to the office the next morning, the data would be ready.

Creating a Complete 3D picture

Preparing the 3D point cloud began by importing the 82 scans into the RealWorks software, which allows investigators to quickly register, segment and classify 3D laser scan data for analysis and reconstruction. As there was data from four different scanners, Gunderson had to first group and register, or stitch together, all scans from each scanner to produce four scan-data groups. Then he merged each of the four groups to create one overall point cloud.

Since teams were collecting data during the active accident investigation, the scanners also captured the hundreds of responders working the scene, which resulted in superfluous or "parasite" points. RealWorks provides automated clean-up tools to help clear unneeded points. With the automatic classification feature, he moved irrelevant objects into designated layers and removed the parasite measurements from the finished point cloud.

"RealWorks' ground extraction tool is excellent," says Gunderson. "I can separate the ground from another layer, and then cut out the parasite points like the police cars, fire trucks, and people walking around so I can produce the clearest model possible. Being able to almost freeze the scene gives us more confidence when investigating after the fact."

With the laser scan point cloud complete, Gunderson focused on importing the processed UAV point cloud into the RealWorks point cloud. Once imported, he used the automated extraction tool to clean up and remove any superfluous points and then combined the dataset with the master point cloud to produce the final 3D model of the train derailment

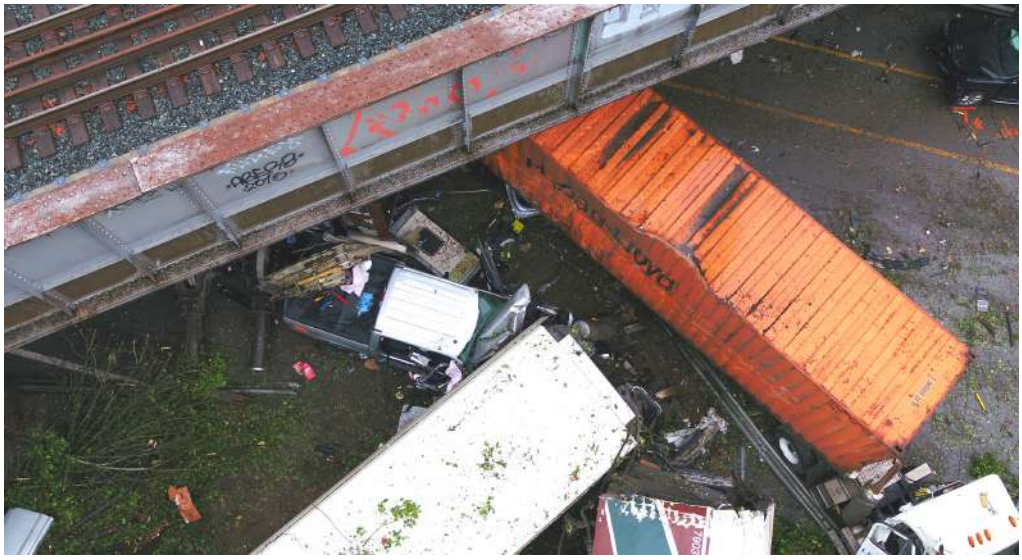

Figure 5: WSP troopers were on scene within five minutes of the crash. Search and rescue consumed the hundreds of troopers, detectives, firefighters and paramedics for the first two hours.

The two came together perfectly, he says, "Integrating UAV data into RealWorks is nearly seamless because the software views the data as a LAS (laser scan) file," says Gunderson. "Pairing the tops of the train cars from the UAV data with the scanning data of the cars gives us a complete view of the incident scene, and one we wouldn't have if we had just used one technology. You can spin the model, rotate it, move along any axis, measure anything and zoom in. It's just like being there."

In total, it took Gunderson about nine hours to create the finished incident model. In less than 36 hours after the initial derailment, he was able to provide a 3D view of the entire accident scene and any object in it.

That afternoon he presented the NTSB with the 3D data and "walked" the officials through the point cloud, demonstrating its visual content and its capabilities.

"They were wowed by the model," says Gunderson. "I don't think they'd ever seen something like this before and as I moved through the scene, they could immediately see the benefits of the detail, accuracy and interaction the point cloud provides for their investigation. They can now revisit the scene from their desktops anytime they need to find evidence or verify details, and they may even find something new to aid the analysis."

The NTSB is expected to issue its final report on the accident in 2019.

Value for Money

The final point cloud result of the DuPont train derailment not only demonstrated the success of Gunderson's multi-pronged approach on a large scale, it helped cement these technologies as core data sources for the WSP.

"The benefits of the laser scanner and the UAV are unparalleled, both individually and together," says Gunderson. "I can't fly the UAV in a house, but I can definitely scan it. But if I have a mile-long accident scene, I can fly that in five minutes, and I can supplement with the scanner. I can capture great scanning data at each end of the scene and then connect the two in RealWorks. Having these choices allows us to tackle any scene."

Last summer, the department upgraded their scanners and acquired three Trimble TX6 laser scanners. The new units give them 500,000 points per second, better intensity detail, which makes objects stand out more clearly, faster scanning and the ability to scan in the rain–an important feature for the Pacific Northwest.

They also launched a UAV pilot program last July and outfitted 15 collision technology specialists across the state with smaller UAV units. The aim was to assess whether the technology could help them map straightforward accident scenes more efficiently and accurately. Soon after the pilot began, a team responded to a one-car pedestrian accident on I-5. Prior to the UAV, they would have worked the scene for a few hours with traditional baseline methods. Using the UAV, they cleared the scene in 18 minutes.

"Someone from the state DOT (Department of Transportation) once told me that any time the I-5 is shutdown, the cost to the region is about $350-$400 a minute," says Gunderson. "That adds up to a big number really quickly."

Based on the success of the pilot, the WSP is adding 75 more smaller UAVs to its force this summer and more than 50 WSP detectives have been issued the smaller UAVs–each criminal investigation division has a Matrice UAV.

It's clear the WSP's commitment to asking "What if" and investing in technological choices is not abating. In a job that demands that officers and investigators are ready for any possible scenario at any time, enabling technology is a welcome tool.

"Pushing the envelope with our technology is having a huge impact," says Gunderson. "It's almost unmeasurable to account for what we capture and the impact that data has on the people we serve. We could never have trained for an incident like the derailment. But when it happened, we didn't hesitate to respond because we knew we had the technology and tools we needed. You're going to have victims who want answers and investigators who have to give those answers. Our ability to provide information that will help people find the answers feels really good. And that's real value for money."

Figure 5: The aerial view of the train incident provides just a small sample of the strewn debris.

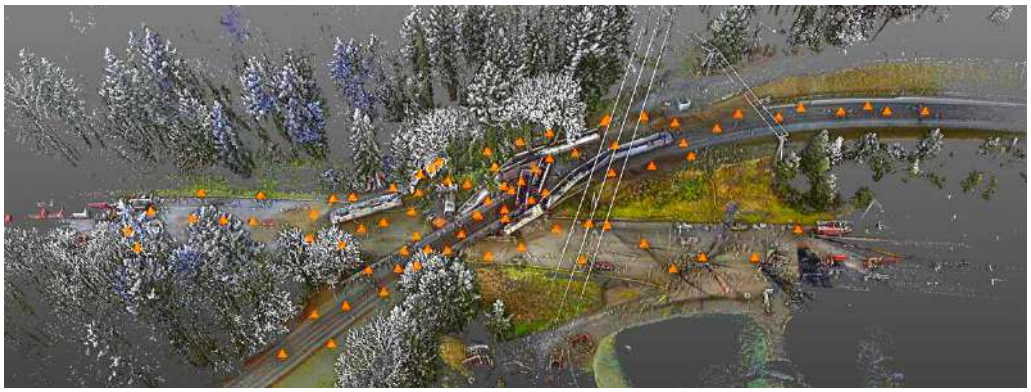

Figure 6: Gunderson integrated scanning data and UAV photos into Trimble's RealWorks software to create a 3D point cloud of the incident scene. In this view, orange markers indicate the location of each of the 82 set ups taken with the Trimble TX5.

Figure 7: Det. Gunderson operates the WSP's Matrice 200 UAV.