AT WORK

GIS
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IP-S2 speeds Virginia highway assessment

Jim Irey, Berner Construction.

User: Virginia Tech
Location: Blacksburg, VA

Project: Virginia Tech-VDOT Highway Asset Condition Assessment System Development
Location: Interstate highways, state of Virginia

Topcon Products:
IP-S2 mobile mapping system

Maintaining roadway system assets across vast geographic areas such as the entire state of Virginia is a daunting task. The fact that state budgets are being squeezed by declining tax revenues does not make this labor-intensive task any easier to justify.

The Virginia Department of Transportation (VDOT), through a partnership with Virginia Tech in Blacksburg, Va., recently utilized Topcon's powerful IP-S2 mobile mapping system to build a mobile condition assessment system for monitoring roadside assets along the interstate system in Virginia.

The IP-S2 collects the geospatial data and images of everything near it, not the physical objects themselves. It incorporates three redundant positioning technologies with 360-degree digital imaging and laser scanners. The system consists of a dual-frequency, dual-constellation Global Navigation Satellite System (GNSS) receiver that establishes the geospatial position of the vehicle; an inertial measurement unit (IMU) that tracks vehicle attitude (pose); and external wheel encoders that capture odometry data from the vehicle. Integration of these technologies creates a three-dimensional position for the

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'The IP-S2 offers the potential of significantly reducing the manpower component of condition assessment. If our van can move at 65 miles an hour and collect zillions of gigabytes of data, we will have semi-automated the process of assessing the condition of the assets.' – Dr. Jesus M. de la Garza, Vecellio Professor in Civil and Environmental Engineering, Vecellio Construction Engineering & Management Program, Virginia Tech University

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vehicle and provides accurate tracking in challenging or denied GNSS environments. A high-resolution digital camera provides 360-degree images. The system records and time-stamps inputs at the rate of 15 nanoseconds.

Referencing the vehicle location data, the system can capture data from the highway assets. The IP-S2 also uses 3D laser scanners with an effective range of 30 meters. Every second, the scanners collect 45,000 x, y and z points that are used to obtain accurate geospatial positions for assets. Traditionally, Light Detection and Ranging (LiDAR) data have been collected from the air; because this system collects the data from ground level, it provides critical data that cannot be obtained from aerial surveys.

Dr. Jesus M. de la Garza, the Vecellio Professor in Civil and Environmental Engineering, and graduate assistants Grant Howerton, Dimitris Sideris and Berk Uslu of Virginia Tech's Vecellio Construction Engineering & Management Program (VCEMP) laid the groundwork for the assessment system during the spring 2010 semester. Under a new such method of monitoring, vehicles driven along highways collect data for evaluation back at the office—a much more efficient way than having crews evaluate asset condition on foot. The research effort took place through the department's Center for Highway Asset Management Programs (CHAMPS) with much of the research conducted at the Virginia Smart Road, a full-scale, closed test-bed research facility that is managed by the Virginia Tech Transportation Institute (VTTI)—the school's largest university-level research center—and owned and maintained by VDOT.

A development that clinched a different approach to solving transportation problems in Virginia was enactment of the Public-Private Transportation Act (PPTA) of 1995, which allows private entities to enter into agreements to construct, improve, maintain and operate transportation facilities. After a 10-year experiment, the state's office of the attorney general and the secretary of transportation's office drafted updated PPTA guidelines in accordance with amendments enacted by the 2005 General Assembly. From that point on, VDOT established the Turnkey Asset Maintenance Services (TAMS) program and now 100 percent of the interstate system in Virginia is being managed under performance-based contracting.

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ABOVE: Civil engineering graduate students (left to right) Grant Howerton, Berk Uslu and Dimitris Sideris.
BELOW: The IP-S2 utilizes a Web browser; an Internet connection is not necessary during data collection.

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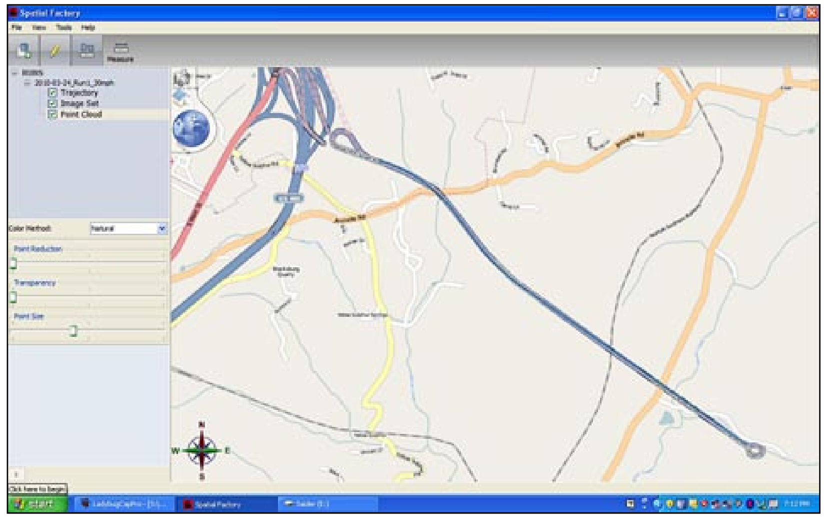

LEFT: Dimitris Sideris displays video of a Smart Road data run following a data upload to Spatial Factory software.
RIGHT: View of the Smart Road (center, blue) in the Spatial Factory software, used to merge video and "point cloud" data from a laser scanner.

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Dr. de la Garza views the assessment system development as a two-phase process. "The first step is having people watching film, which we need to do in the initial stages—that's phase one," he said. "Phase two is having computer programs that can actually find the assets by themselves. Once they find the assets by themselves, they also assess the condition with what we call 'machine vision technology.' We need to create machine vision algorithms to find a sign, for example, and once found, determine if the sign is in good condition or not." The assessment system will not only display the assets, it will also notify VDOT personnel that the asset meets or falls short of predetermined working condition parameters.

By the end of the spring 2010 semester, the IP-S2 had been utilized to collect asset data more than 20 times. While Howerton drove the van, Sideris viewed the screen of the laptop computer to ensure that the IP-S2 was collecting the data in transit. The laptop used a Web browser to communicate with the IP-S2 via an Ethernet cable; data collection does not require an Internet connection.

Five operations were performed during Geoclean data processing: processing raw data from the IP-S2 for subsequent operations; Inertial post-processing to create a geospatial vehicle trajectory; generating the LiDAR point cloud; converting compressed image files from the Ladybug camera; and registering the digital image sets to the trajectory and point cloud.

In the lab, Sideris performed the sequential upload. Howerton explained that the students often adjust the settings in Ladybug CapPro software in order to get the best view: panning, zooming, etc., using software from Point Grey Research, manufacturer of the camera. A key software program used to view, analyze, and extract features from the processed data is Spatial Factory, which merges the imagery and point cloud data "layers." Images and X, Y and Z coordinates are viewable in the model. The point-cloud data layer allows the students to incorporate feature data such as topography and reflectivity of pavement markings into the GIS model. This additional information is revealed on top of the underlying image.

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