Trouble in Paradise: The Challenges of Mobile Lidar Surveying on a Remote Pacific Island

Josh QUINT, USA; Daina MORGAN, Canada; Dario CONFORTI, Canada

Key words: mobile terrestrial lidar, mapping, surveying, disaster preparedness

SUMMARY

The island of American Samoa was hit by a tsunami in 2009. The National Oceanic and Atmospheric Administration (NOAA) needed current, accurate topographic data to assess the island's vulnerability to future storms and tsunamis.

This paper describes how the topography and remoteness of American Samoa presented unique challenges to the surveying team and how mobile terrestrial lidar technology was deployed to overcome these challenges.

After showing how each of many challenges were overcome the paper demonstrates that in areas where airborne lidar surveying is not feasible, mobile lidar can provide a viable alternative.

The Optech Lynx Mobile Mapper used in the survey collected data with an RMSE that ranged from 1 to 6 cm accuracy in each village, a result that far exceeded the contractor's requirements of 18 cm. The survey was completed at a cost well under that of a comparable airborne survey. The client, NOAA, acquired up-to-date, accurate spatial data that will be invaluable in future planning.

Trouble in Paradise: The Challenges of Mobile Lidar Surveying on a Remote Pacific Island

Josh QUINT, USA, Daina MORGAN, Canada, Dario CONFORTI, Italy

1. PREPARING FOR THE WORST-CASE SCENARIO

Surveyors are familiar with a number of challenges when they set up a survey: availability of staff, weather conditions, GPS reception, traffic flow, state of the site's infrastructure, logistics, transporting, installing and deploying equipment. When a survey is conducted abroad there can also be administrative hurdles involving passport, visa, inoculation or other required documentation.

So even in an "ideal" surveying environment—say San Diego, California, a place with a favorable climate, a well developed telecommunications and GPS infrastructure, a modern highway system and easily accessible support networks—surveyors still have to meet many of the challenges cited above.

A survey team from Sanborn Map Company recently took on a project with all the expected challenges plus an unusual one: the site is located in one of the most remote areas of the world, a tiny speck of land out in the vast expanse of the South Pacific Ocean: American Samoa.

Figure 1: Google Maps image shows remote location of American Samoa (circled)

A typical picture of American Samoa evokes the postcard image of a Pacific island: emerald green forested mountains, black volcanic sand beaches, coconut and palm trees, clear turquoise water, rolling surf and cloudless azure skies (Figure 2). If the Sanborn survey team was hoping for respite in a tropical paradise, they were in for a surprise.

Figure 2: Lynx Mobile Mapper mounted on survey vehicle in American Samoa

One of the first things the surveyors realized upon arrival in American Samoa is just how remote the island actually is. It took 15 hours to fly there from Denver, Colorado. Once there, it took another 2 hours to get from the airport to the initial survey site. A survey team of four—crew chief, lidar specialist, survey technician and geomatics specialist—were conveyed to the site along with all their equipment. Apart from an Optech Lynx Mobile Mapper, they also brought a Total Station, 3 RTK rods, 6 base stations, 10 reflective targets, one laptop computer for each member, plus a desktop workstation built for production.

Sanborn had shipped every tool, computer hardware component and software program they could anticipate, as well as backups for all. They soon discovered, however, that certain supplies, such as the recommended gauge battery cable, were difficult to find or ship to the island.

Back in Colorado Springs, Sanborn assembled a mock-up system and sent all parts to the island to ensure that the survey team would have everything they needed on site. After the first day of collecting data, the survey team was reminded of the island's bare amenities: they could not find a building to store the Lynx survey vehicle, so to protect the equipment from torrential rain, they would wrap the entire system in tarp every night (Figure 3).

Figure 3: Lynx survey vehicle wrapped under tarp in lieu of a proper storage facility

American Samoa was hit hard by the tsunami of 2009. The National Oceanic and Atmospheric Administration (NOAA) needed data—current, accurate topographic data to assess the island's vulnerability to future storms and tsunamis. Exactly where are the lowest, most flood-prone areas? What are the elevations of the various towns clustered along the coast? Has the sea level been rising recently? If so, how much, and for how long? What is the rate of increase? Are there areas on the island that, due to their location relative to tides, currents and prevailing winds, risk greater exposure to flood waters than others?

1.2 Ground view over bird's-eye view

NOAA contracted Sanborn to carry out a survey of the island, specifying, as one of their deliverables, position data with an accuracy of 18 cm or better. One of the unique aspects of this project was that airborne surveying, the method that first comes to mind, was never a viable option owing to the island's remote location. Quite simply, the logistics involved in collecting airborne lidar were too great to overcome. When the cost of flying a properly configured airplane all the way to the remote island was considered in light of the client's limited budget, mobile lidar mapping suddenly became a very attractive alternative.

Mobile lidar surveying is often conducted in developed urban areas that generally have good to excellent GPS coverage. The Sanborn crew discovered another example of just how remote American Samoa is. Because it is a tiny island with a very small population far out in the open waters of the South Pacific, GPS and other satellites do not cover this area with the same density and frequency as more populous and developed areas. Consequently, when the survey team drew up their mission plans they had to pay much closer attention than usual to PDOP values. To adapt to this situation the team would mobilize at any hour of the day to ensure that they were collecting position data during the optimal PDOP windows. Whenever the PDOP solution was lost, they might alter their route or maneuver the survey vehicle in different ways in order to reacquire a viable PDOP solution.

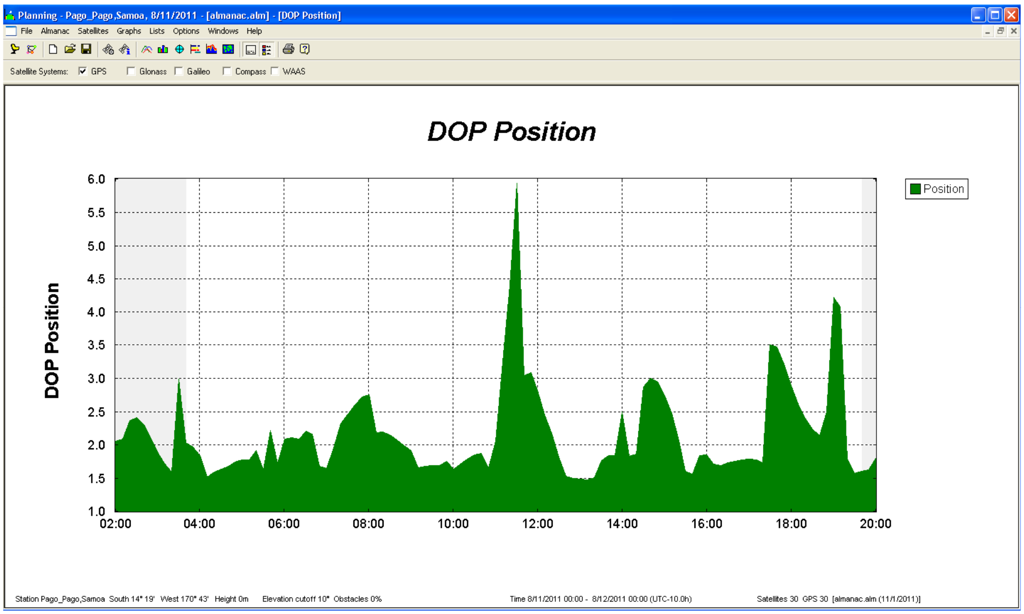

Figure 4: PDOP graph of Pago Pago, American Samoa

Figure 4 shows the approximate coordinates of American Samoa, the time zone and a date when the crew was surveying on the island. The optimal survey window was between 6 a.m. and 12 p.m. There were smaller windows after noon but these were not risked due to traffic, travel time, and in deference to the local residents' traditional practice of refraining from work during the evening prayer time.

Along with the island's remote location were other unusual challenges, such as the mountainous terrain. Short of traveling to American Samoa, a dramatic impression of the island's mountains can be seen by visiting Google Earth and "flying" over the island. Zoom to an altitude that approximates an aircraft flying over the island—you may be startled by the sudden appearance of towering peaks directly below. These are more reasons why airborne surveying over American Samoa is impractical: low-altitude flight is out of the question, and the near vertical faces of mountains would cause extensive laser "shadowing"—areas that remain "invisible" to the scanning laser because they do not present a sufficient planar surface.

The unique design of the Optech Lynx Mobile Mapper minimizes laser shadowing by accommodating two laser sensors on one platform. By using a dual sensor configuration, each sensor optimizes the line-of-sight least accessible to its companion. In post-processing, range, angle and intensity data are combined from both sensors to produce a much more complete and accurate 3D model.

The Lynx had no problem with laser shadowing, but the close proximity and density of the surrounding vegetation was another matter. In some places the overarching foliage was so thick it turned the roadway into a choked tunnel through which the survey vehicle could not pass (Figure 5). In these places crew members walked into the jungle, carrying RTK rods and collected shots out of range from the Lynx. In order to avoid any substantial gaps in the data collect, a Total Station was used to collect control and interpolation points from those areas that were inaccessible to both the survey vehicle and the surveyors on foot.

Figure 5: Optech Lynx Mobile Mapper mounted on survey vehicle surrounded by dense vegetation

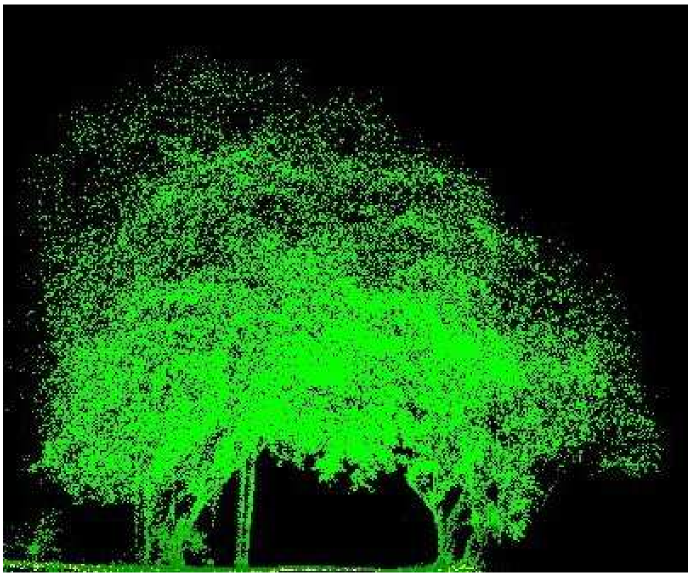

Figure 6: Lidar point cloud visualizes the density of the island's surrounding vegetation

2. ACTION PLAN

Based on a comparable experience surveying in Hawaii, Sanborn's lidar specialist made a plan for each village that specified where and when to drive. The survey team concentrated on the main and secondary roads of the coastal villages. Survey start times were determined by the availability of viable PDOP windows and weather conditions.

The plan had the lidar specialist and a technician operating the Optech Lynx Mobile Mapper, and other team members setting up base stations and laying down painted targets for the scan. By the time the Lynx arrived in a village the targets and base stations were up and running.

After the scan was completed the technician and lidar specialist would return to the base and start downloading the day's collection, and continue processing all the way through the DASHMap workflow. They checked the data systematically to ensure that they had a good solution and complete coverage. Data was checked in LAS format to see if "ghosting" or other anomalies seen in similar surveys were present. If no anomalies were found, calibration was then performed.

While processing and checking data, other crew members were collecting control and interpolation points to fill in those areas the Lynx could not penetrate. Before leaving the island, Sanborn's geomatics specialist set up their control network so that data could be checked against it before shipping all equipment and personnel back to the U.S. mainland, far away.

3. CONCLUSION

In areas where airborne lidar surveying is not a feasible method, for whatever reason, mobile lidar can provide a viable alternative. The Optech Lynx Mobile Mapper collected data with an RMSE that ranged from 1 to 6 cm accuracy in each village, a result that far exceeded the contractor's requirements of 18 cm. The survey was completed at a cost well under that of a comparable airborne survey. The client, NOAA, now has up-to-date, accurate spatial data that will be invaluable in future planning. Now that American Samoa has the data that is essential to effective planning, it is in a better position to help minimize or avert the extensive property loss and damage that it experienced in 2009.

BIOGRAPHICAL NOTES

Josh Quint has more than five years of experience in the lidar and GIS industries with expertise ranging from basic mapping techniques to advanced lidar production. He has worked as a Senior Lidar Analyst and Project Coordinator for multiple projects and programs. As a Senior Lidar Analyst, he is not only responsible for the collection, processing, and generation of final deliverables for all assigned lidar programs, he is also directly involved in process development and troubleshooting. Mr. Quint's thorough understanding of each step in lidar production ensures that programs are run effectively and efficiently.

Daina Morgan is the Product Manager for the Optech Lynx Mobile Mapper. Her sales experience with a diverse European client base, and 11 years in the lidar industry, have given her an extensive understanding of lidar applications and projects. Ms. Morgan is open to new ideas on mobile mapping applications and developing the market place.

Dario Conforti has a degree in Urban Architecture from the Polytechnic University of Milan. His studies included both cartography and photogrammetry. With more than ten years experience in laser scanner technology, he joined Optech in early 2006 as a worldwide Technical Support Specialist for land products. He also has extensive experience in GPS, bathymetry and airborne photogrammetry.

CONTACTS

Josh Quint
Sanborn Map Company
1935 Jamboree Drive, Suite 100
Colorado Springs, CO 80920
U.S.A.
1 + 719-593-0093
1 + 719-528-5093
Email: jquint@sanborn.com
Web site: www.sanborn.com

Daina Morgan
Optech Incorporated
300 Interchange Way
Vaughan, Ontario
CANADA
1 + 905-660-0808
1 + 905-660-0829
Email: Daina.Morgan@optech.com
Web site: www.optech.com

Dario Conforti
Optech Incorporated
300 Interchange Way

Vaughan, Ontario
CANADA
1 + 905-660-0808
1 + 905-660-0829
Email: Dario.Conforti@optech.com
Web site: www.optech.com