Figure 1. Testing dust penetration with OPAL.

Space Technologies Create a New Class of LiDAR

Space technologies have become an essential part of everyday life here on Earth. Many products and activities that we take for granted—such as global communications, weather forecasting, GPS, light-emitting diodes and even enriched baby food—would be almost unthinkable without the commercial adaptation of technologies originally developed for use in Space. At Neptec Technologies Corp., we're doing just that by applying space technologies developed by Neptec Design Group Ltd., to the laser scanning and robotics market. The Neptec Design Group has been an award-winning technology innovation company and NASA Prime Contractor for over 20 years.

Markets such as mining, oil and gas, construction, automotive, defense, and homeland security are increasingly turning to advanced sensors and robotics, such as those originally developed for use on the Space Shuttle

BY MIKE SEKERKA

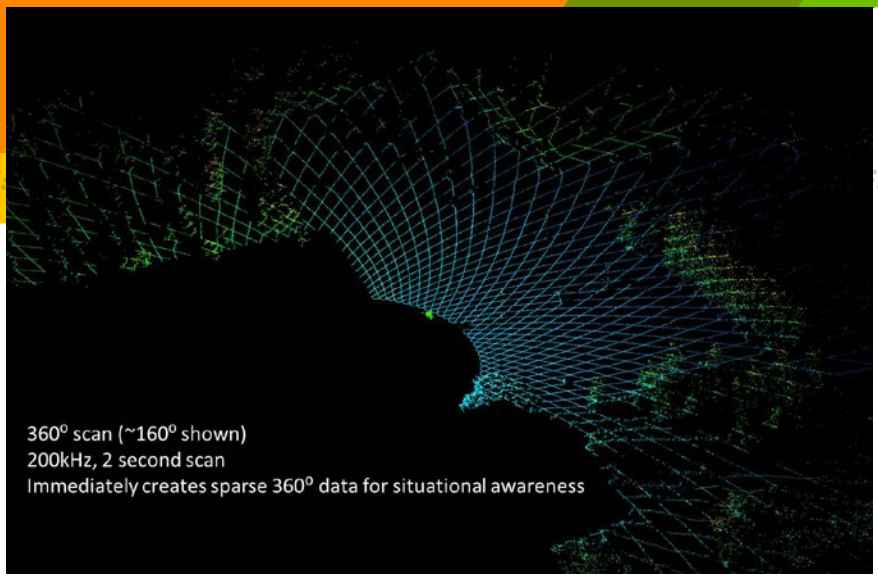

Figure 3. A 2 second panoramic scan with OPAL-360.

and the International Space Station, to improve safety and productivity, while reducing costs. 3D laser scanners have become the sensor of choice for many survey and mapping applications. They have also begun to make inroads as 3D sensors for autonomous vehicles and other real-time applications. But conventional laser scanners suffer from two main drawbacks: they cannot see through the obscurants such as dust or fog that are often encountered in harsh environments, and few are packaged to withstand the physical abuse they likely will encounter in environments often found in mining or the oil and gas industries.

To address these challenges, Neptec Technologies developed "OPAL 2.0", a new class of LiDAR specifically designed for harsh environments. OPAL—Obscurant-penetrating Auto-synchronous LiDAR—is a dust-penetrating technology originally developed for helicopters landing in the desert (**Figure 1**), but which also works for other obscurants such as fog, rain, snow and smoke. OPAL uses a patented detection method based on waveform technology and advanced temporal and spatial filtering and is the only true "see through dust" LiDAR technology in the market that operates in real-time with no post-processing. Unlike conventional approaches to dealing with obscurants, such as range-gating or multi-echo technology, OPAL distinguishes between the LiDAR returns from obscurant particles versus objects of interest in real-time. It works in near-zero visibility conditions and has been extensively tested for various types and densities of obscurants.

Figure 2. The OPAL-360 scanner for harsh environments.

However, this solves only half the problem.

The rest of the solution comes from a project Neptec undertook for the Canadian Space Agency, which needed a multi-purpose laser scanner for a concept Mars Rover that could be used simultaneously for autonomous navigation, long-range panoramic terrain mapping (>1km) and short-range (<3m) high-resolution feature inspection. The scanner also needed to be compact, rugged and work whether the Rover was moving or stationary. No commercially available scanner could meet these requirements, so Neptec developed a new one.

The design is based on a modification to the classic "Risley prism" concept. Risley scanners use a hollow shaft motor assembly to independently spin two wedge prisms while a laser beam is shot through the shaft. The prisms deflect and steer the beam. Varying the speed at which the prisms rotate creates different types of scan patterns, but most commonly a rosette type pattern. OPAL 2.0 uses a novel "hut prism" on top of the motor assembly to "fold" that pattern into 360 degrees. Since only small prisms need to be spun, the design is compact, has no externally moving parts, and is inherently rugged and well suited for harsh environments compared to other 360° scanner designs in the market.

A particularly interesting feature of these new scanners is the unique scan patterns they produce. The OPAL-360 scanner (**Figure 2**), for example, has a 360°x60° field-of-view and creates a sparse panoramic view

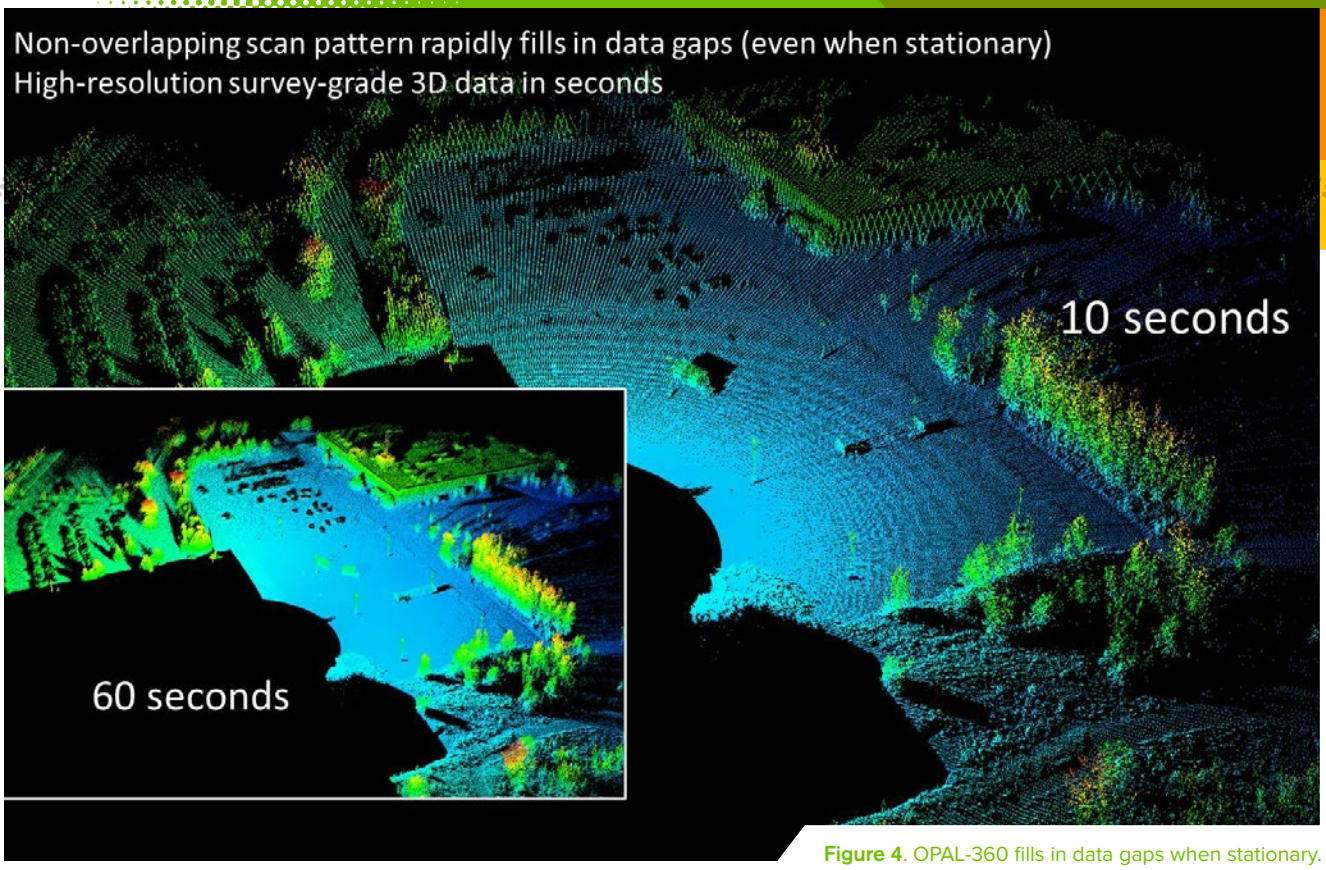

Figure 4. OPAL-360 fills in data gaps when stationary.

of its environment almost immediately (**Figure 3**). Within seconds, the scanner can fill in the data gaps in the sparse pattern to generate high-resolution survey-grade 3D point clouds (**Figure 4**)—even when stationary. The user can thus decide exactly how much data he really needs to acquire and, for example, use sparse data for surveillance and then spin up the scan pattern to fill in the gaps in seconds if something of interest is detected in the scans. More information, less data!

Different versions in the OPAL-360 series support ranges of 400m out to 3km at accuracies of one centimeter and a data acquisition rate of up to 200,000 points per second.

By adding our patented obscurant-penetrating technology and an IP-67 compliant housing and optical dome, with no externally moving parts or fans, OPAL 2.0 scanners deliver an unprecedented combination of range, data density, acquisition speed and obscurant penetrating capability—all packaged for harsh environments,

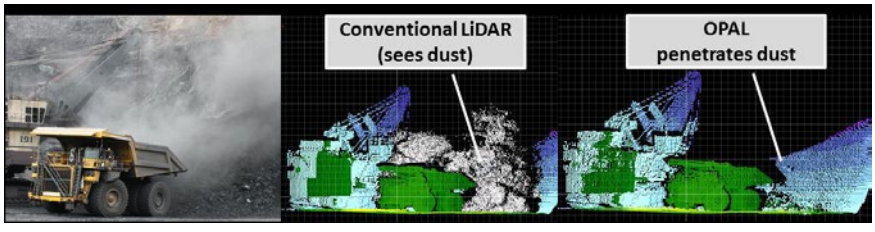

Figure 5. OPAL versus conventional LiDAR in a dusty mine.

including operating temperature ranges of -40°C to +65°C.

We are now working with clients in the mining and oil & gas industries, where it is common to encounter dusty conditions and other obscurants, on applications for our new scanners. **Figure 5** shows a series of scans in an open-pit mine, where conventional LiDAR will image the dust (colored white) while OPAL easily penetrates the dust cloud to image the slope hidden behind it. Although OPAL 2.0 was designed principally for autonomous off-road vehicles, the mobile and aerial mapping communities are also looking at this technology. OPAL's unique scan pattern and field-of-view may help mitigate shadowing effects (typical of conventional line scanners used in mapping).

We're just beginning to discover the many other ways we can apply this innovative Space technology here on Earth, but—like GPS, LEDs and, yes, enriched baby food—it won't be long before we wonder how we ever got along without it.

Mike Sekerka, P.Eng. is the Chief Operating Officer at Neptec Technologies Corp., responsible for the commercialization strategy and the day-to-day operations of the company. Neptec is based in Ottawa, Ontario and develops and sells innovative 3D machine vision products for machine automation and robotics applications in harsh environments.