The introduction of new and innovative technology for dry bulk storage and transportation applications brings an exciting opportunity for companies to be able to accurately monitor and manage their constantly changing inventories. Using high-resolution laser light detection and ranging technology, the OPAL™ series of rugged, obscurant-penetrating 3D light detection and ranging (LiDAR) scanners, developed by Neptec Technologies, are able to continuously and autonomously scan and report on the volume of stockpiles during the day or at night and in all environmental conditions. This fixed-installation solution monitors the pre-defined stockpile areas and delivers relevant and accurate information, such as up-to-date volume data or a series of volume measurements, to show how inventories fluctuate over a period of time. Real-time inventory information enhances operational efficiency by improving production, storage and transportation decision-making processes.

What is LiDAR?
LiDAR is a remote sensing technology, developed almost three decades ago, that employs a laser light source and sophisticated photo-detection circuitry to scan and produce a 3D model of an area and of objects present in the field-of-view. The high-resolution image is of significantly better quality than those produced by a radar or acoustic sensing system and is well suited to obtain accurate and precise measurements for further processing and action. Survey-grade LiDARs are already being used to accurately map the terrain for various purposes and have made a significant impact on improving productivity and gaining a better understanding of the movement of material. Survey LiDARs are typically hand-held, or portable, devices that are placed at various locations around a site and manually triggered by a technician or surveyor. These units are able to scan the field-of-view and retain the point-cloud data of the environment to be later offloaded and processed by external computers.

LiDAR implementation for stockpile volume measurement
A number of LiDAR manufacturers have introduced technology to the dry bulk storage and transportation industries to measure volumes of stockpiled material. These solutions rely on traditional measurement methods that require manual estimation by surveyors or estimators. They have proven to be a valuable asset to industries that produce and store material on-site or at ports and other
intermediate locations for transportation to customers. These methods can employ tripod-mounted terrestrial LiDAR scanners, aerial drones using photo capture technology called photogrammetry to capture surface data, or rely solely on traditional manual estimation techniques. While these methods are often adequate in collecting volumetric information, they are expensive, time consuming, and/or subject to varying levels of accuracy relative to the true volume. If the measurements are not achieved using internal resources and are contracted to an outside service provider, the turn-around time for the results is often delayed by days, or even weeks.

**Manual stockpile volume measurement**

Manual surveying, using terrestrial LiDAR scanners, is time consuming and labour intensive, as many operations will have dedicated personnel for collecting, analysing and reporting inventories. This process will typically take several hours from start of collection to reporting, resulting in the collected data being several hours old and thus no longer reflecting the correct volumes of the material. While this method is typically sufficient for accounting purposes, if the volumetric information was collected more rapidly, it could be used as a means to improve efficiency by optimising material flow within the operation. Additionally, these methods are only possible when personnel are working, meaning data is typically not collected in off-hours (the evening or weekend). Additionally, re-calibration of delicate survey-grade LiDAR systems is often a yearly requirement. This will increase operational expenditures and may result in system downtime, if secondary backup systems are not available.

Obtaining real-time, accurate volumes of stockpiles is a key competitive advantage for any industry but, for some, it represents a powerful tool to enable control over the financial aspect of their business. Financial executives at large corporations are increasingly showing interest in the operational aspects of the business in order to bring the management and movement of material under control. Having critical relevant data available has a tremendous impact on the bottom line when it comes to commodities sales and the ability to deliver on orders based on known inventory levels. Discrepancies in these levels, resulting from unauthorised removal of material or due to inaccuracies of manual survey methodologies, may cast doubts on the company’s ability to manage assets and may have an adverse impact on the financial health of the business.

**Automated stockpile volume reporting**

The alternative to the manual survey method are solutions that use LiDAR, mounted in fixed locations, running on a schedule, to collect and automatically compute stockpile volumes in near real time. They require a one-time setup and configuration activity that allows for immediate or scheduled stockpile volume measurements, according to the needs of the company. The operations unit can collect and obtain stockpile volumes on a half-hour or hourly basis and use this information to dynamically modify its day-to-day operations. This flexibility enables a significant and measurable improvement in performance and accountability, and improves safety since surveyor personnel are not required to manually set up and scan in the field. For fixed location systems to function outdoors, all year round, and in extreme environmental conditions, the LiDAR hardware must be designed for rugged real-time operation.

One such system is Neptec Technologies’ OPAL™3D LiDAR systems and 3DRi stockpile monitoring software. Neptec Technologies, a Canadian firm specialising in IP67, real-time rugged LiDAR, developed its 3DRi stockpile monitoring solution in response to market demands for an automated solution to real-time stockpile volume monitoring and reporting. The 3D LiDAR solutions, originally designed as a vision system for military helicopters landing in extremely dusty (brown-out) conditions, are suited for operating in a wide variety of industrial applications (Figure 1). The 3DRi solution uses in-field processing platforms, so that all information is processed at the point of collection and only the resulting volume measurements are...
transmitted over a site network to a localised server or data management system, thus significantly reducing the network bandwidth requirements. The data is easily accessible through a web-based portal, provides customisable notifications and alerts, and integrates with third-party operational intelligence systems through a REST API. The biggest advantage to these types of systems is that, once they are installed and configured, they require no manual intervention; they are a fully automated solution that can compute reliable and accurate results on demand or as scheduled events. Figure 2 shows the web interface that managers can use to log into the system and obtain up-to-date volume measurements of each defined stockpile area.

The impact on operations

Now, through the internet, a manager or executive can quickly and easily log into the automated stockpile monitoring system and obtain the most recent scanned volumes of all material monitored by the 3DRI stockpiles solution. Consequently, this user may initiate a scan to obtain the most up-to-date view in as little as 15 min.

Operational efficiency is but one advantage of a fixed LiDAR stockpile monitoring system. Automated stockpile monitoring solutions, such as the OPAL LiDAR and 3DRI solution from Neptec, are active sensing technologies that allow for scanning and taking measurements 24 hours-a-day, including during off-hours when material is not being actively handled. Given the often significant value of some stockpiled material, there are additional advantages and incentives to continually monitoring the inventory of the material, during these off hours, for any unauthorised removal. As LiDAR acts as its own laser light source, automated LiDAR solutions are not dependent on daylight or artificial lighting and can operate during night hours when the site is less secure. Using the near infrared spectrum, the laser source in the OPAL solution operates at a wavelength of 1550 nanometers, which is important to be able to see in adverse weather conditions, but is also important to maintain laser eye safety. All OPAL scanners are rated as CLASS 1 Eye Safe.

Automated stockpile monitoring for ports

Material stockpiles in ports awaiting unloading or loading onto ships or railcars is an ideal application for an automated stockpile volume reporting solution. Real-time 3D LiDAR systems can be mounted and positioned on stacker-reclaimer equipment to help optimise material handling as they load and/or unload material from a pile to a waiting ship (or vice-versa). The 3D LiDAR system acts as the independent vision/perception system to guide the equipment during operation for maximum efficiency and safety of workers all around the site. Neptec’s real-time OPAL 3D LiDAR has patented technology to be able to scan through obscured environments caused by actively handled materials (dust, smoke, etc.). Seeing through obscurants, the system is able to guide operators and avoid collisions with other equipment, avoiding potential damages and loss of life.

Other industrial applications

Recently, a number of aggregate plants in Indianapolis, Indiana, US, trialled an automated stockpile monitoring solution to improve operational efficiency, contractor accountability and site monitoring. Using the 3DRI stockpiles solution, they were able to obtain hourly inventories to ensure that they had minimum inventory to run the aggregate manufacturing process, while minimising the oversupply on other materials. As their inventories were delivered from multiple sources, the automated monitoring solution allowed them to accurately assess and invoice the incoming and outgoing materials on a daily basis. As the plant had tighter control over daily material flow, they were able to optimise material purchases by strategically buying specific materials during times of oversupply and minimising purchases during material shortages. In addition, accurate volume measurements allowed them to verify the invoices from their suppliers to ensure reported supplies were accurate. They were also able to continually and securely monitor their stockpiled reclaimed aggregate, a material that has significant value in the re-use and reprocessing of aggregates.

Conclusion

Moving towards automated stockpile monitoring solutions allows operations to improve the efficiency of day-to-day operations by inspecting and optimising material handling. While manual surveying methods, such as survey grade LiDAR or aerial surveys, have been beneficial in expediting inventory assessments for accounting purposes, the advent of relatively inexpensive rugged real-time LiDAR, such as the OPAL system, leads operations to start assessing the benefits of using automated surveying solutions. Increasing the frequency of inventory measurements will enhance operational efficiency, function as a monitoring solution for off-hours, and free up technical resources for other critical aspects of the day-to-day operations.