Figure 1: AirDaC aerial scanning system

Integrated Multi-Source LiDAR and Imagery

The derived benefits of LiDAR scanning in the fields of engineering, surveying, and planning are well documented. It has proven to be much faster than traditional surveying and, as a result, is more cost effective while increasing worker safety. Each LiDAR platform—airborne, mobile, and terrestrial—has its own list of advantages and limitations.

In an attempt to overcome the individual limitations associated with airborne and mobile scanning, the remote sensing department at McKim & Creed has developed a streamlined process that combines the two platforms in order to produce a dataset that surpasses the capabilities of each platform individually.

Equipment and Assets

McKim & Creed currently operates Riegl® VQ-480 and Q680i laser scanners, which enable the firm to produce large-scale (city and regional) point clouds. This capability, combined with overlaid ortho imagery, allows users to produce a comprehensive and dynamic dataset that is more accurately visualized and easily interpreted.

When tasked with the assignment of surveying a site or corridor for a road widening or a railroad management project, McKim & Creed's mobile LiDAR system, MoDaC Mobile Data Collection®, is an excellent candidate for the job.

BY RICHARD **VINCENT**

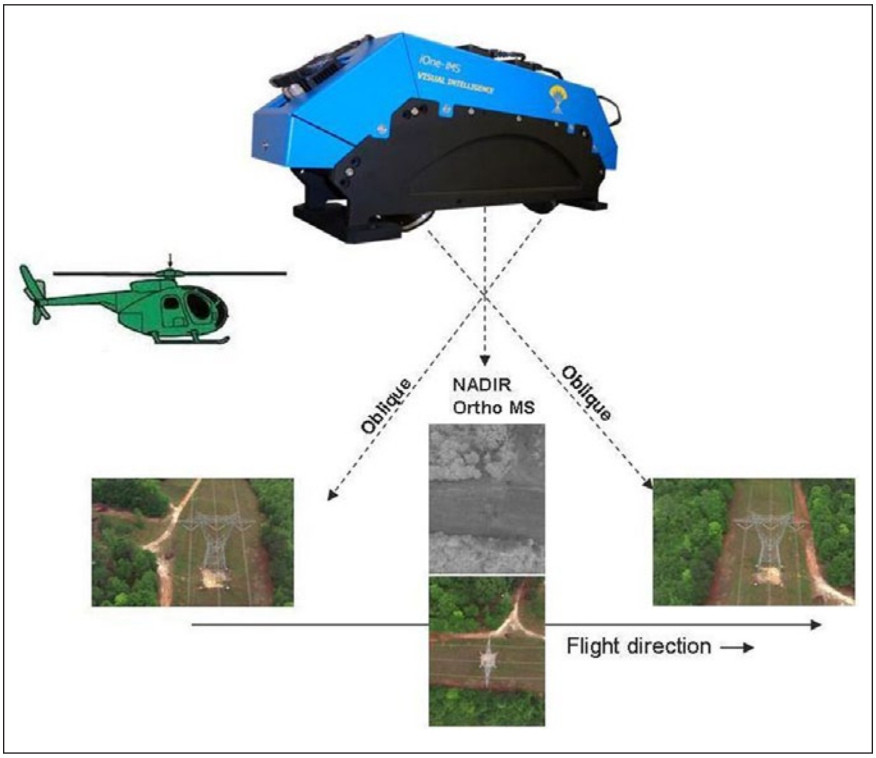

Figure 2: ORTHO MS, forward and aft oblique in one pass

MoDaC® is equipped with the Optech Lynx Mobile Mapper™ system, which includes 3D laser scanning, GPS, inertial measurement unit, and video technologies. These units are mounted on top of an automobile or rail truck and enable the collection of dense and accurate 360-degree data at up to 400,000 points per second.

While the data collected via MoDaC® provides highly detailed facade and ground coverage, it is restricted by its look angle, hindering the ability to collect data for rooftops or areas obstructed by buildings, fences, and dense vegetation. Mobile scans alone can omit valuable clearance and peripheral data, representing only part of the required data.

In order to overcome these limitations and create a more comprehensive dataset, McKim & Creed utilizes air support. AirDaC 2 (Figure 1) is one of the company's Bell LongRanger 206L-1 helicopters housing a VQ-480 laser scanner as well as a co-mounted Visual Intelligence Iris One-IMS™ multi-spectral RGB NADIR and Oblique camera. This aircraft is McKim & Creed's eye in the sky, facilitating the collection of extremely accurate LiDAR and orthographic imagery for corridor management and infrastructure projects. The fusion of the individual LiDAR datasets collected by the mobile and aerial systems produces a comprehensive point cloud with ortho imagery coverage.

Data Collection Processing

The first step in the process is data collection. There are tradeoffs associated with each scanning method in regards to their operating costs, efficiency, and reach. While the mobile unit has the cost savings advantage of roads on which to travel, the restrictive nature of using existing paths can also limit the area and scope of data collection. The airborne unit's top-down perspective and ability to chart its own course widens the coverage area, allows for scanning around all vertical obstructions such as fences and vegetation, and provides rooftop and tree canopy scans in order to fill in coverage gaps that are present in mobile scan point clouds.

Figure 3: Oblique Imagery

The airborne trajectory, or flight plan, is not restricted by existing roadways and, therefore, each course must be planned and mapped in an effort to increase cost efficiency. In all cases, they are required in order to comply with Federal Aviation Administration regulations. Flight plans are geo-referenced routes that are created using Track'Air™ and then imported into the helicopter's navigation system. Different flight pattern techniques are used, depending on the nature of the data to be collected. For instance, a road-widening project would require a series of parallel flight lines in an effort to capture a much wider area than the road alone. However, a rail corridor project would only require a single flight line that follows the long and linear track path.

After the flight plan is established, a ground crew is dispatched using the collection geometry to set a series of base stations to collect GPS data used for both surveyed ground control and LiDAR processing. The ground crew is responsible for surveying ground control, or ground truthing, which gives technicians the ability to later calibrate the data to vertical and horizontal alignment.

The true power of the AirDaC 2 lies in the aerial survey equipment housed on board. The VQ-480 laser scanner has the ability to collect more than 50 points per square meter. The collected point cloud density is dependent on both the altitude and speed of the airborne scanner. Lower and slower flights result in a higher density, more detailed point return. Flying high and fast allows for a broader area to be covered but results in less point density.

With the laser scans, the co-mounted Visual Intelligence Iris One-IMS™ cameras capture 29 MP RGB/NIR orthographic and oblique imagery. The combined high-resolution imagery and LiDAR data allows for RGB extraction to the point cloud and assists with LiDAR data identification during classification.

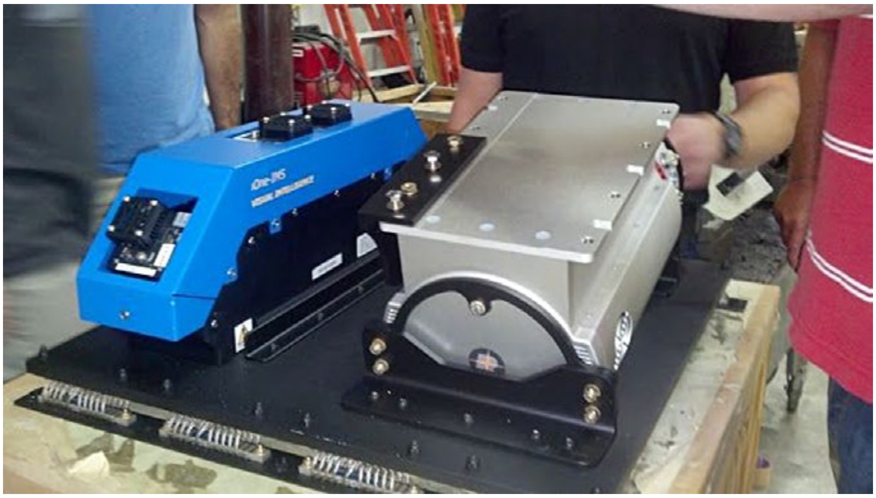

Figure 4 (a): Mounted with Riegl® VQ-480

Figure 4 (b): Bell LongRanger 206L-1

The VI Iris One-IMS™ technology is unique to McKim & Creed. Founded in 1997, Visual Intelligence (VI) has focused on research and development to provide a multipurpose metric digital geoimaging sensor technology with scalable sensor imaging arrays for automated high-accuracy metric geoimaging for mapping, surveillance, UAVs, UVs ground

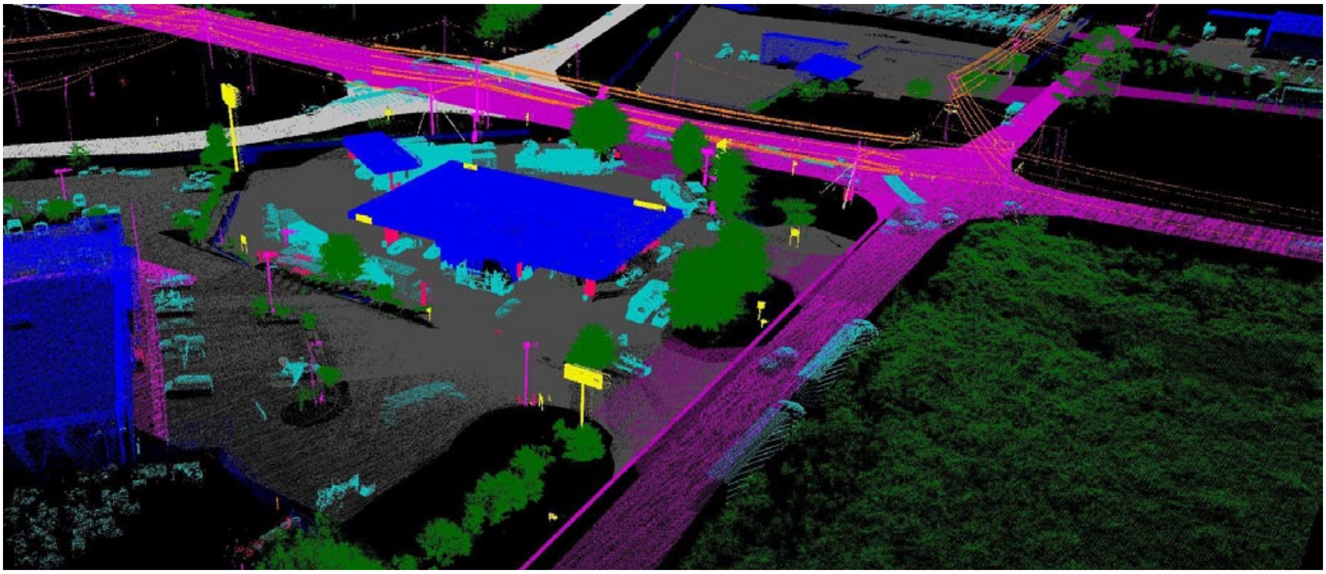

Figure 5: Classified Point Cloud

and mobile geoimaging applications. The sensor tool kit architecture is designed to implement economical (lowest cost of ownership), light, small, high collection, high resolution, and fast-in-deployment sensor systems. The multi-year research and development has resulted in various granted patents that have provided the foundation to generate the iOne STKA and the Virtual Frame (VF) camera system comprised of multiple COTS camera modules arranged at certain angles to achieve flexible and rapid configurations as different and distinct (sometimes conflicting) mission requirements may mandate.

The iOne IMS™ integrated with LiDAR is an efficient, economical, one-pass all-feature digital infrastructure capture system. From a simple interface, it can capture high-resolution oblique, wide swath multi-spectral ortho imagery, and optional thermal and video cameras referenced to a single GPS/IMU reference system for common picture and overlapping display (Figure 2). With its single pass, full-capture capability, the system produces accurate, high-quality imagery saving 50%-75% over less efficient aerial collection cost. With its multi-sensor ARCA-based platform architecture, the system can grow to accommodate additional sensors, thereby further increasing information value with little added data collection cost.

The iOne IMS™ sensor is designed to collect ortho imagery (RGB + Near Infrared) and oblique imagery (forward and aft) simultaneously with a LiDAR sensor (Figure 3). The system supports analysis functions for transmission corridors, railways, pipelines and other development projects.

Figure 6: Colorized LiDAR Point Cloud

Figure 7: Visualization model

The Iris One IMS™ will produce multiple image products for use in utility corridor analysis which include:

- RGB Oblique of full features (e.g., Towers) with 100% coverage front/back (image pair)
- GeoTIFF with lat/long location center, image scale
- One image per feature structure is generated – iOne IMS™ creates an oblique virtual frame if the feature appears in two or more images
- Provides Google Earth KML with camera orientation during exposure (MetaData option)
- Google Earth KMZ file with image and camera locations (MetaData option) and Multispectral Image -Four-Band Orthos (metrically co-registered at 1:1 resolution RGB+NIR).

The system has a small footprint to enable ease of integration with any LiDAR, e.g., the 480 Figure 4 (a); it can be flown in a helicopter pod as well as in a fixed wing aircraft. Figure 4 (b).

Onboard technicians oversee the collection with Track'Air™ and Riegl® RiACQUIRE software which is integrated into an onboard acquisition computer for seamless data collection. The data is transferred to the computer via solid state hard drive (SSD) in order to ensure data stability and increase write speed before being downloaded onto a processing workstation. Next, POSPac™ MMS software is used to calculate an IMU-GPS solution using both Continuously Operating Reference Station (CORS) network and McKim & Creed dedicated base stations for maximum accuracy. Riegl® RiPROCESS is then implemented to combine the IMU-GPS solution, collected laser data, and ground truthing points to produce a calibrated LiDAR point cloud. McKim & Creed's flexible workflow capabilities allow for data processing to occur in the field, office, or both. The end result is a LiDAR point cloud available in any format for multiple applications.

Classification

Post-processed mobile and airborne data is classified independently. LiDAR technicians classify features by applying custom-built filters developed by McKim & Creed which are finely tuned in order to meet the demands of each specific project. This allows for the identification of all major and minor features captured within the dataset (Figure 5). Once classification is complete, the data is matched geographically. The merged dataset is integrated with the ortho imagery (Figure 6) produced by the VI Iris One camera. The result is an accurate, realistic, and powerful set of deliverables.

The LiDAR industry is relatively young, with new technologies and processes that are constantly evolving. The capability exists to produce multi-platform point clouds with overlaid ortho imagery and deliver as-built visualization models on site, city, and regional scales. Remote Sensing technology will continue to have positive impacts on the civil engineering, infrastructure management, and urban planning fields in terms of cost savings, system efficiency, and more comprehensive management and design (Figures 5-7).

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