KEY COMPONENTS OF A QUALITY MANAGEMENT SYSTEM

- Management Responsibility
- Resource Management
- Product Realization
- Measurement & Analysis
- Improvement

ISO Implementation within a LiDAR Organization

Why pursue ISO Certification?

On the surface, the reasoning behind Michael Baker's pursuit of ISO (International Standards Organization) certification was quite clear—our senior management championed the initiative, and made it a priority for others. It would be quite easy to leave it at that, as ISO also requires evidence of top management commitment; however, there are much more deep-seeded reasons for making the commitment to expend time and resources to follow through—after all, in our current economy, the up-front obligation of funding to pursue what could be construed as non-essential activities to the uninitiated, is actually based on a foundation of foresight, sound logic, and return on investment.

Our goal shall always be to deliver a quality product and achieve the highest levels of customer satisfaction. Repetitively achieving the end-goal requires knowledge, expertise, commitment, and a detailed, proven methodology that addresses all aspects of the work. Achieving ISO certification ensures that all processes and procedures are in place to effectively execute

BY STEPHEN CLANCY

the work, and additionally reinforces confidence to both internal and external stakeholders through a third-party, independent validation of the program.

ISO 9001: 2008 Background

ISO was established to develop and promulgate international standards through member national standards organizations including the US-based American National Standards Institute (ANSI). Over the years, standards have been developed for an array of industrial and commercial applications covering everything from automobiles to food safety. Of particular interest to our organization is the ISO 9001:2008 standard—Quality Management Systems.

The ISO 9001:2008 standard establishes requirements for an organization's Quality Management System (QMS). These requirements include documentation, management responsibility, product realization, measurement, analysis, and improvement among others. The QMS can vary dramatically between organizations depending upon complexity of the product or service and size of the organization. The QMS is not a document or set of documents. Rather, it is a comprehensive system of people, processes and procedures dedicated to successful development of a product or service.

What ISO isn't

Prior to starting the ISO certification process, I had preconceived ideas of what ISO was, and what it meant to be certified. As the designated Management Representative, I quickly learned that the ISO requirements do not define your processes or procedures. Rather, ISO identifies what is required in your QMS, validates its existence, and provides a documented framework to identify any flaw, error or omission; then implement a corrective action to address the immediate issue, as well as a preventative action to ensure it does not occur again. Only by continuously improving your QMS through these actions will the successful implementation of the standard be realized.

Certified LiDAR Operations

Over the past year and a half, we have pursued and achieved two separate certifications involving our LiDAR operations—Mobile LiDAR Collection and LiDAR Processing. These two organizations, regardless of location and staff, are dependent on each other to complete an entire project or task, and have very similar objectives related to quality and customer satisfaction, but employ unique training, functions and processes to achieve the desired results.

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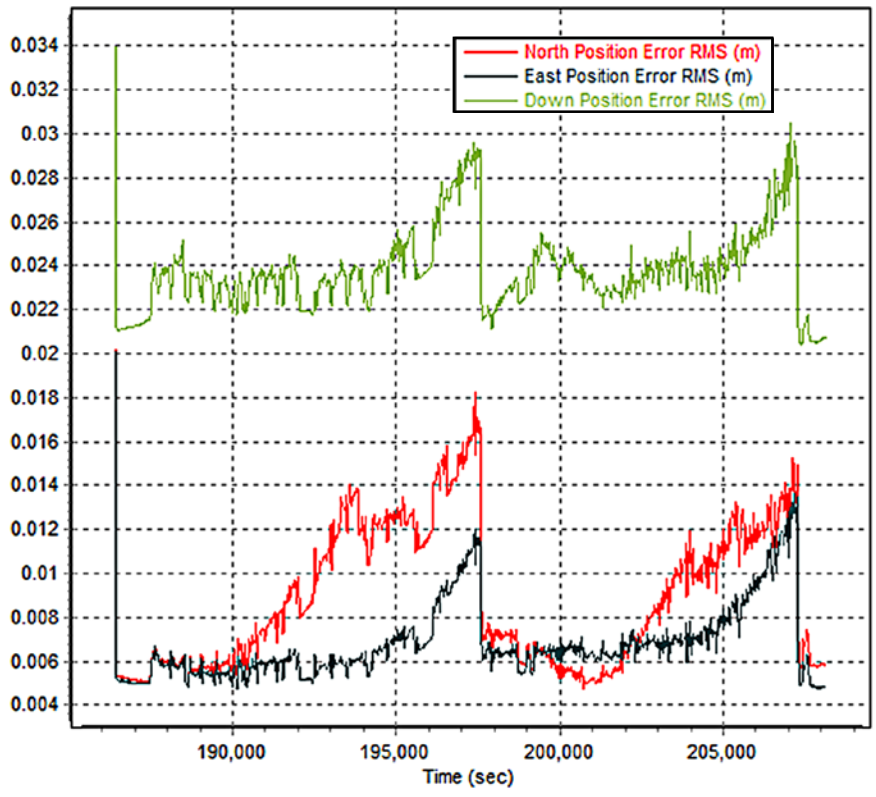
Mobile LiDAR Collection Team

Since acquiring our system several years ago, we have assembled a complete instruction manual outlining procedures for successful execution of Mobile LiDAR collections. Originally intended as a one-stop resource and training tool for new operators, the manual documents collection best practices, boresight calibration, data extraction, trajectory processing and field quality control measures that are followed by our collection staff. Similar to a Project Management Plan, the manual is a living-document, and is updated as necessary—such as when equipment advisories or other feedback are provided by the equipment manufacturer. In developing, modifying and maintaining these documents over the years as an internal best-practice, we unknowingly laid the foundation for ISO certification.

Aside from the collection and processing, we capitalized on the ISO certification process to document all other Standard Operating Procedures (SOP) employed during all other phases of the work including, project/mission planning, reporting and data transmittal among others.

It goes without saying that the successful execution of a project begins with the creation of a well-designed project plan. As such, ISO devotes a section to product realization with the intent that the client's needs and requirements (including, statutory and regulatory) are achieved. The development of the project plan, and if required, a ground control plan, utilizes the scope of work to identify the specific requirements and communicate them to the team. As many agencies develop standards and checklists for Mobile



The root mean square (RMS) error for a Mobile LiDAR collection. During field QC, the plots are used for inspection that the real-time metrics observed during collection are realized.

LiDAR, it is vital to have a defined process in place to distinguish unique requirements up front, and effectively manage those needs to generate desired outcomes. Equipping the collection team with all available information affords them the ability to augment field activities should unforeseen conditions be encountered—weather and traffic conditions being the most prevalent.

Execution (or more appropriately in the surveying world), repeatable and defensible results, are paramount, and our collection team relies on the Quality Manager (QM)—the final approver before data is transmitted to our processing unit (i.e.—where the buck stops)—is responsible for validating that the project plan was executed effectively; the data to be transmitted for processing is complete, including boresight calibrations; and that field Quality Assurance/Quality Control (QA/QC) procedures were performed as prescribed. Of course if you're a believer in Murphy, or prescribe to Burns' phrase "The best laid schemes o' mice an' men…" you're well aware that there will be times when the plan cannot be followed as originally designed due to various local or environmental factors. An effective QMS must contain the flexibility to account for contingencies, mandatorily document any such deviations, and empower the QM to communicate the divergence.

The primary objective of our QMS is "customer" satisfaction. It is rare that our true end-client actually utilizes the rawest form of data collected from our Mobile LiDAR system. The LiDAR deliverables are typically post processed into a variety of products outlined in the scope of work, for which it is primarily the LiDAR Processing Team's responsibility to generate. So from the Mobile LiDAR Collection Team perspective, we have to reconsider who the immediate client is. In our workflow, it is more applicable to treat our LiDAR Processing team as the customer—after all, they are the ones responsible for generating products from the collection(s). The LiDAR processing staff is directly responsible for providing direct feedback regarding the delivered data following careful review. While some feedback is immediate and can be applied on the next project, more complete information is obtained only upon completion of the project.

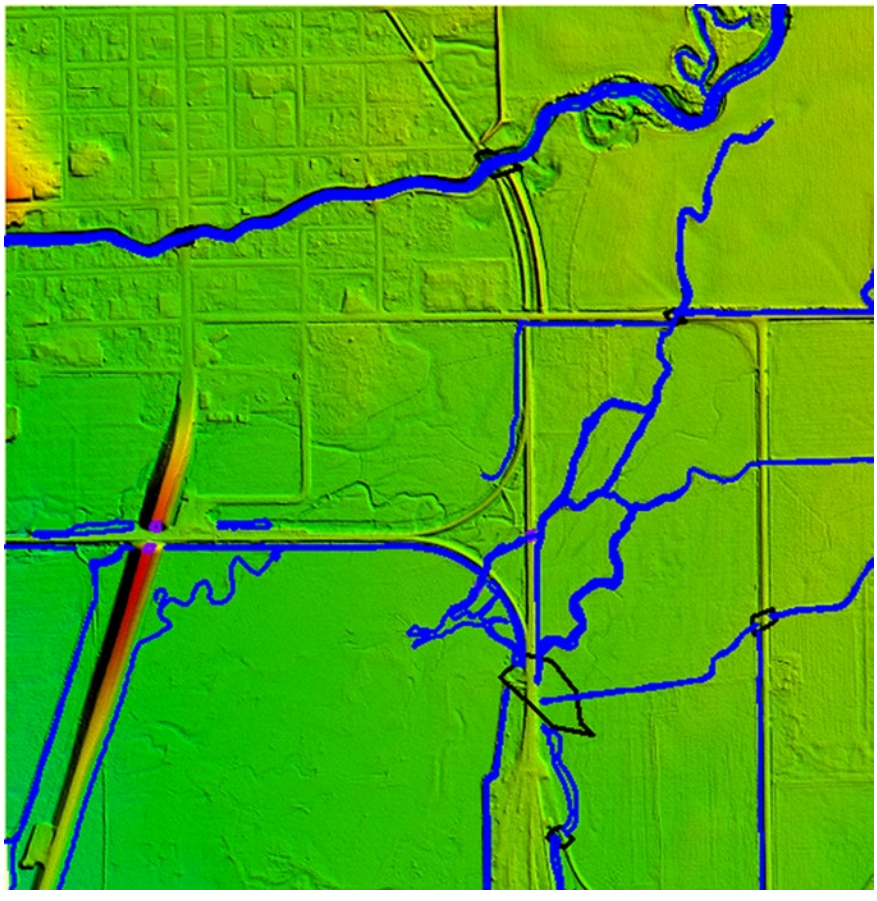
Feedback is gathered through the completion of a short questionnaire and consolidated within a tracking spreadsheet. The results, as well as any free-form comments, are provided to our collection team. As mentioned earlier, an objective of ISO certification is continuous improvement. If our client identifies any non-conforming product (which thankfully has not occurred in a long time), corrective actions are taken to remedy the situation. As a condition of certification, annual surveillance audits are performed by a third party registrar. The auditor reviews completed questionnaires and corrective actions to determine that continuous improvement has been institutionalized.

LiDAR Processing Operations

A core component of the QMS is the determination of requirements related to the product. Therefore, the first steps performed by our LiDAR Processing team involve data receipt and validation. Another key component as to why we pursued separate ISO certification for our LiDAR Processing operation is because this group is not solely tied to Mobile LiDAR processing. LiDAR data arrives at our facility from an array of sources—the Mobile LiDAR team, Baker's Aerial LiDAR unit, Baker's Static LiDAR team, or a myriad of subconsultants.

Regardless of where the data originates, there are documented procedures for data check-in and performance of initial validations to determine if the most basic requirements are present—such as the contracted LiDAR point density or nominal point spacing. The data receipt SOP outlines file and server naming conventions, back-up of data, and preliminary QA/QC checks, as well as corrective and preventative action plans that would be implemented should submitted data be incomplete or flawed. Different SOPs are applied based on the source (mobile, aerial, or static).

During the receipt and validation of incoming LiDAR data, the processing team reviews the Project Management Plan and scope of work thoroughly to identify project requirements and other conditions. Similar to the collection, it is important to know and understand the task at hand to effectively manage and complete the services required. Aside from the primary work products, some of the details vital to success include project coordinate system, reporting requirements (various plots or statistics that are increasingly being required),



Example of non-conforming items identified during the aerial LiDAR QC process: classification not including ground points, breaklines should meet monotonicity, and breaklines at bridge are missing.

schedule and client specific standards (seed files, cell libraries, and templates). All too often, the scope of work is silent on some details. Using processes and documentation developed in support of certification, we are able to remove any ambiguity by determining those requirements not stated and receive confirmation from the client.

There are a number of work products that can be developed from Mobile and Aerial LiDAR—classified point clouds, intensity images, digital terrain models (DTMs), and topographic maps to name a few. Each of these products or processes has a representative SOP document. Some of these documents are incredibly detailed and specific to software packages (and their graphical user interfaces) utilized to perform the processing—for example: GeoCue for project setup or TerraMatch for LiDAR adjustment. In some cases, SOPs provide guidance rather than detail specific directions.

The most important SOP documents are those pertaining to employed quality control measures and reporting. Since there are a broad array of services, clients and requirements, we have to perform

multiple types of QC routines. For mobile projects, we typically perform control reports evaluating the positional accuracy of the point cloud to established ground control or check profiles prior to and following constraint, while QC for aerial projects, may involve validation of point density or nominal point spacing in addition to positional accuracy within various land cover classifications.

As with any geospatial activity, there is always potential that an error is not identified or caught by the QC process. The successful application of a QMS is much like atomic half-life. With each improvement in the process, the likelihood of an event gets smaller and smaller. The SOPs therefore will continue to improve over time as the staff responsible for implementation and maintenance remains committed.

As with our Mobile LiDAR team, customer satisfaction surveys for LiDAR processing are issued in conjunction with each deliverable, which are more to further address topics such as budget, schedule and end products. Unlike our Mobile LiDAR team, our LiDAR processing clients can either be external (public or private organization) or internal (another Baker practice area or office). Similar to the Mobile LiDAR operations, any non-conforming product triggers a corrective action—the non-conformity could include budget, schedule or communication and not necessarily a derived LiDAR product. The corrective action plan requires a summary of the problem, probable causes, immediate action, schedule and responsible parties.

Upon project completion, Baker follows established document management guidelines for storing and maintaining project files. LiDAR data in LAS or other format is a document that must be preserved as a record of the project—much like a surveyor's field notes. In addition to the potential use of the data in the future for further needs, there are regulatory and statutory requirements for preservation of the documents associated with a project. Therefore, document retention and destruction requirements are clearly outlined.

Results

Early in the pursuit of certification, it seemed like a daunting task to complete. The review of the ISO 9001:2008—Quality Management Systems requirements and the thought of internal and external audits, at first glance, appeared inevitable to generate additional headaches and late nights at the office. However, Baker was already employing very similar steps in our daily operations through a regimented project management approach. The primary difference was the additional documentation, review and maintenance that ISO requires.

A contributing factor to our successful implementation was that several of our other Geospatial Information Technology operation centers had already achieved certification for their activities. Instead of reinventing the wheel, we were able to adapt some of their documentation for our purposes and rely on them for guidance—maintaining regular conference calls between the various management representatives to review processes, lessons learned and results of audits. After all, once certified, the work does not stop. We strive to for continuous improvement and customer satisfaction.

Stephen J. Clancy, PSM is Assistant Vice President and Technical Manager responsible for Baker's Mobile LiDAR operations. He holds active Professional Surveyor licenses in multiple states and is a Certified GIS Professional.