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Geospatial Intelligence comes to the oil and gas industry, as **James H. Anspach, P.G. of Cardno, Inc. and ASCE's Energy Division (USA)** presents.

Pieces of the PUZZLE

A not-so-quiet revolution is taking place in our world. We see it every day in our private lives. The connections between cloud servers and our mobile phones and tablets are managing immense amounts of data. That data is pushed on demand in order to help us stay connected, remain up to date on important events, and to improve the management of our daily activities in today's modern world. Google, Twitter, Facebook, Snapchat and now Uber are all changing the way we communicate, search, purchase, socialise, commute, and locate the products and services we desire. Now this same revolution is coming to the oil and gas industry.

Big data systems, mobile, cloud and geospatial technologies

There are now some early oil and gas industry adopters that are using these emerging technologies to integrate departmental silos and create seamless information flow across various divisions and departments. They are capturing, recording, qualifying and analysing large amounts of data very quickly and displaying that information on familiar-looking dashboards and smart mobile computing devices. This in turn enables operations to be more effective and efficient throughout the planning, design, installation and maintenance lifecycle. It also better protects the asset and reduces downtime and incidents often caused by a lack of accurate and timely information.

Figure 1. ecom/Samsung Rugged Tablet.

Figure 2. BlueStarGPS Unit.

Oil and gas operators have legitimate concerns over new technologies. One concern that looms large is data security. After all, we do not want others to have access to our data for nefarious purposes, intentional or accidental. As such, we tend to want to keep our data in-house, locked into file cabinets and stored in on-premise servers over which we have complete control. Sometimes we even keep it from the people who could do their job functions better if they had access to it when and where it was most needed.

However, we do not think twice about doing our banking and investing from our mobile phones or our home computers: these industries have invested heavily into very robust and proven security protocols. We can now do the same with oil and gas data. We are at a point where we are able to confidently use the same military grade three-part security sign-on and business privilege sign-in steps to access the data we need to do our jobs, with a company administrator controlling and assigning various user privileges for that data, including a specific time and date, a defined region or read/write or read only access.

Another concern for businesses is 'the Cloud'. What does it really mean to be in the Cloud? The Cloud is nothing more than data storage and software on someone else's premises. Cloud servers have several advantages to enterprise on-premise data and programme storage. Cloud computing allows a company to utilise subscription-based methods of computing, rather than license-based ones. Traditional software license deployment requires IT departments to be responsible for items such as databases, servers, server hardware, networking, etc. With the software as a service (SaaS) subscription model, an IT department can shift responsibility and direct costs to the SaaS provider. The benefits of the SaaS deployment model are time to market, scalability, product ever-greening, and superior functionality and flexibility to the business. This is the same model provided by 'SaaS' business solution providers SAP and Salesforce.com, whose applications are widely accepted and proven to be efficient and scalable. Running in the Cloud gives you freedom to adapt. Hardware resources are already setup and ready to be deployed. Scaling is simplified because servers can be allocated as the demand for services requires. Costs related to maintenance, patches, upgrades, downtime, customisations, integration and vendor-dependent software and application changes/upgrades are also reduced. Cloud initiatives have accelerated lightweight client access to powerful processing services hosted at remote locations.

Innovative companies are developing new Cloud, mobile, and geospatial technologies that enable lots of data to be captured, stored, organised, and geo-referenced with unprecedented confidence. Geographic information systems (GIS) have of course been around for a long time. For many years, we have been stuck with proprietary platforms that cannot adapt quickly enough to our changing needs and data

models. That has also changed. A host of extensible mark-up languages (XML) have opened up data exchange to facilitate interoperability between platforms. These include Industry Foundation Classes XML (ifcXML), Building Information Model XML (BIMXML), LandXML, PipelineML, agcXML and TransXML. Each has its advantages and disadvantages. One aspect they all have in common is that they each use XML as their base format which allows automated programs to exchange this data. Utilising Open Geospatial Consortium (OGC®) standards, including web feature services and web mapping services removes proprietary restrictions on how data are consumed or presented. We can now go easily between differing CAD and GIS platforms and enjoy the advantages of both.

Connecting the field to the office securely

Another element now in place is the connection of real-time communication between the field worker, the field portable device (smartphone or tablet), the Cloud and the office. Instant visualisations of where assets (such as pipelines) are located – and changes, corrections and additions to data – provide great efficiencies and quality assurance benefits. Rugged portable field tablets are tackling legacy issues of field suitability and security and are able to comply with SSAE 16 and/or the SOC framework (Figure 1).

Samsung and ecom instruments has solved both the mobile security and device safety concerns. For example, Samsung has developed Knox, which leverages hardware security capabilities to offer multiple levels of protection for the operating system and applications. Both the US Department of Defense and the FBI have approved and recently deployed the KNOX Android platform introduced by Samsung. In addition, the KNOX platform features a new enterprise enrolment process that vastly improves the experience of both the employees and IT administrators when enrolling devices into the company's mobile device management (MDM) system. ecom instruments, through an exclusive partnership with Samsung, ruggedises and modifies the tablet device to make it more secure and safer for use in harsh and hazardous environments where temperatures can reach -30°F or +120°F and potentially explosive gas, liquids, or dust could be present.

Location, location, location

Traditional survey techniques that used to be costly, relegated to specialised personnel and required extensive processing, are now being augmented with sub-metre (and imminently centimetre) accuracy in the x,y plane with no post-processing of the data. New equipment and technology is constantly evolving.

One such product now on the market is the BlueStarGPS™ (Figure 2). BlueStarGPS is designed specifically for use with Android mobile devices, including smartphones, tablets and notebook computers. BlueStarGPS is a standalone receiver with Bluetooth™ technology that provides interoperability between the BlueStarGPS and other devices such as cable and pipe 'locating' tools with a connectivity range of up to 1 km. This technology was adopted from forestry industry applications where conditions are harsh, mostly remote and often with severe canopy cover.

BlueStarGPS offers both GPS and GNSS options in a rugged, light weight and low cost package. BlueStarGPS was designed specifically with sub-metre mapping and data collection performance specifications. It squeezes accuracy utilising SBAS corrections including 3-channel, parallel tracking SBAS' operated by the Federal Aviation Administration, the European Geostationary Navigation Overlay Service, the Multi-functional Satellite Augmentation System (Japan) and the GPS aided Geo-Augmented Navigation System (India). The strength of BlueStarGPS is in not only providing sub-metre precision without post-processing, but its ability to maintain accurate positioning when the SBAS signal is obstructed. In fact, this receiver is able to maintain sub-meter accuracy for up to 40 mins after the loss of a differential correction source signal. This means that you can use BlueStarGPS under trees, around buildings and in rugged terrain where other receivers can fail to deliver.

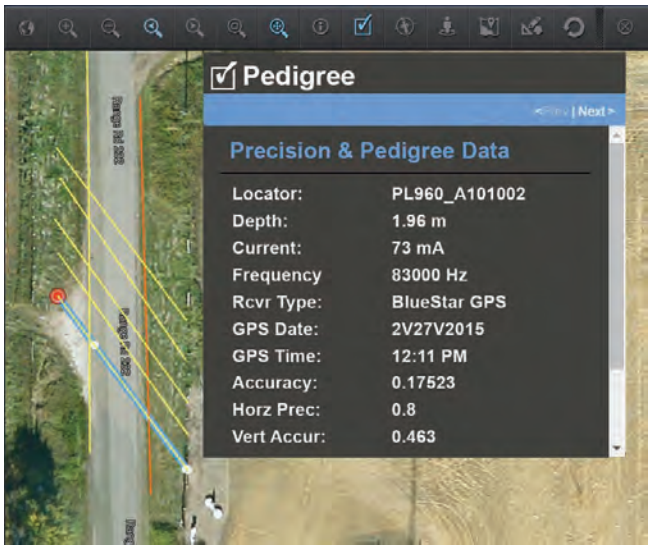

Figure 3. Several of the many metadata fields with attributing of Pedigree and Precision.

Figure 4. How ProStar integrates processes and technologies.

This accuracy is changing the way we do business in ways that are still being imagined. Objects, easements, structure location, vehicles, people, camera pictures, utility locations and equipment can all be accurately measured, captured, visualised and displayed in real-time to anyone having the proper log-in credentials, whether that person is sitting in the office, in their vehicle or standing over a buried asset.

It's all about the data: delivery, security, and quality

But how do we know that we can trust the data? Pipeline operators and their supporting functional partners such as project designers, constructors, right-of-way agents, equipment suppliers, surveyors and others need good data in order to make good lifecycle decisions. Data may have started out good, but good in the past may not be good enough now. Positional references may have changed. Data may have been lost, corrupted, inaccessible, incompatible or inaccurate when it was first developed or recorded. Garbage in-garbage out (GIGO) was first termed by the IRS in 1963, popularised by IBM in the 1970s, and it still applies today. Turning bad data into good is now possible more quickly and efficiently than ever. The ability of survey equipment and blue-toothed accessories to capture specific data on its measurements – the 'who, what, where, when and how' – allows a subsequent reviewer or user of that data to get a sense of its reliability. Knowing if that data is original or has been changed in some manner is also valuable in determining reliability. These processes are termed the 3Ps of data – precision, pedigree and provenance (precision and pedigree are trademarked terms of ProStar's data applications). The 3Ps can supplement professional engineers' or surveyors' 'seal' of data for end-users (Figure 3). The 3Ps can supplement utility data engineering reliability standards such as first published in 2002 as ASCE 38 (USA), and subsequently published as PAS 128 (UK), CSA S250 (Canada), 5488-2013 (Australia), SGUUM (Malaysia) and NTE INEN 2873 (Ecuador).

'V' value

The use of all these new technologies results in a large amount of possible data. The data, when collated and analysed, is something we commonly refer to today as 'Big Data'. Big Data as a concept probably originated with John Mashey of Silicon Graphics in the mid 1990s. Although its origins are fuzzy, its concepts are not. In order to make large amounts of data work, they must contain elements of the 'Vs': volume, variety, velocity, veracity, variability, visualisation and value. Combining mobile data collection with a) real-time data back to the Cloud, b) GIS analytics with streamed public and private databases, and c) the 3Ps, these new technologies now being implemented in the oil and gas industry can produce tremendous 'geospatial intelligence' with data analytics, predictive modelling and optimisation of resources.

The right data

Now that necessary background has been established, let's see how technologies are being used in the asset lifecycle process from planning through designing and building and operating.

A specific example may help illustrate how the technologies integrate over the lifecycle of an asset. Imagine the following scenario.

Planning

A pipeline operator/owner needs to develop a new pipeline. Preliminary routes are developed. Google Earth, Bing, or even private photogrammetry from company data or UAV surveys are utilised. Parcel information is pulled into the Cloud from public and private data sources. Values of crops, tenant income, historical land prices, ownership, wetlands issues, other easements crossings and other relevant data are instantly available and visualised in the office.

Various alternative routes are easily investigated as to their impacts and constructability. A primary route is selected based upon jurisdictional and company criteria.

Boots hit the ground. Google Directions and other programmes are launched on a mobile pad or phone to route the land agent in the most efficient way given current traffic conditions to a selected starting point. Arriving onsite, the tablet queries its exact location and knowing the land agent's typical functions, pulls up a list of forms that might be applicable. Many fields within the forms are auto-populated by Cloud data: owner name, parcel information, tenants, contact information, and so on. The land agent fills in the other fields with drop-down menus and may alter auto-populated fields based upon conversation and observation. With hands full, voice activated field entry can be used. Deviations in pipeline routing can be instantly made and agreed upon by the landowner, with crop values and property values instantly available and sourced. Deals can be negotiated on the spot, with real-time submittal of documents for review to the applicable departments, and signatures obtained that same visit (if one is really lucky that is). Notes to future constructors can be annotated, with pictures for clarification, on where temporary construction can be staged, which gates are off-limits, and so on. Real-time visualisation of all this to the property owner hopefully puts a smile on their face, something spontaneously rare in the easement business.

Design

More details about the selected route are developed. Mapping of the existing public and private utilities that may be encountered is performed by engineering and survey crews. Easements are recorded. For major projects, this may be performed by crews working under the direct responsible charge of licensed professionals who will push their sealed data into the Cloud. Other projects may utilise the services of in-house locators with field tablets displaying utility record information and instant recording of their pipe and cable locating device's data into the Cloud with 3P attribution and metadata for later quality assurance checks. When discrepancies between existing company utility records and field verifications are discovered, immediate requests for corrections or for future follow-up can be emailed, texted, or otherwise communicated back to the relevant departments. Observance of issues such as missing valve covers, leak odour, vegetation damage, broken fencing and so on can be instantly

captured, documented, and sent to the relevant departments for corrective action. The tablet's GPS is capturing precise location data about where this is happening, and specific forms are auto-populated and conveyed.

Construction

Pipe is ordered and RFID tagged. Construction crews plan and implement their project taking into account the data on the Cloud from the planning and design stages and landowner requirements. Construction crews' locations and all equipment on site are monitored in real-time GIS if desired. All One-Call tickets are developed from the Cloud data, transmitted to the applicable One-Call Centre, and downloaded back into the Cloud. Documentation of trench construction, pipelaying, welding, and all the other elements of a necessary pipeline integrity management programme are captured by exact location, pedigree, and precision data, along with auto-populated and manually voice activated forms and pictures and transmitted instantly to the Cloud. Progress from a cost and production standpoint are tracked in real time for the contractor. The project progress is also exposed to the owner/operator so that they are kept abreast of the most relevant information regarding their facilities. Field changes to the design are noted and passed along to the owner through automated as-built drawing documents.

Operations and maintenance

Rugged field tablets with blue-toothed accurate and inherent GPS are issued to applicable operating and maintenance personnel. All data available on the facility and its environment, in other words all photos, drawings, reports, forms, maintenance operation and safety manuals, are instantly available to be displayed in the field. Forms or reports on maintenance activities can be produced and instantly sent back to the Cloud and reviewed by authorised users. Traffic and weather conditions can be monitored. Vehicle and personal and equipment locations can be monitored and utilised for emergency and routine awareness. All data is streamed directly from the source as needed and is therefore as up to date as possible.

Imagine a transparent Earth

One such provider of Cloud, Mobile, and Geospatially Intelligent Technologies is ProStar Geocorp™. ProStar has developed Transparent Earth™ (TE), an Open GIS that is a 'look and feel-alike' of Google Earth but with functionality geared specifically to the precise location of assets, which could be located under, on, or above the surface of the Earth. Integrating the look, feel, and familiar operations of technologies provided by the likes of Google, Facebook, Dropbox and Uber, ProStar has successfully developed and

deployed a simple, easy to use toolbox that accomplishes all the tasks outlined throughout this article (Figure 4).

In April, ProStar received FIATECH's coveted Celebration of Technology Innovation (CETI) award for Life Cycle Data Management & Information Integration. The CETI press release included the following:

In October 2014, ProStar successfully deployed Transparent Earth (TE) and its companion mobile solution (PointMan™) to improve damage prevention and asset management practices. This provided the real-time ability to aggregate vast amounts of information from multiple sources and seamlessly and securely made this information readily available to field and office workers where and when it was most needed. Workers captured and recorded new data as well as viewed historical records, assessed this information in real-time and immediately made informed business decisions and provided feedback when updates or revisions were required. Interoperability between internal and external data sources included functionality for engineering, One-Call, construction, land services, projects, and maintenance divisions. The implementation of TE, leveraging industry standards, accelerated interoperability throughout the enterprise and meant asset information was captured in accordance with regulatory requirements, including the ISO 15926 standard for data integration, sharing, exchange, and hand-over between computer systems. Other benefits resulting from implementing the ProStar technology suite include more efficient business processes, reduction of paper forms, improved location accuracy and the timely delivery, collection, and sharing of information.

Innovative companies servicing the oil and gas operator industry are committed to integrating TE and PointMan into their daily routine functions. One example is Loenbro. Loenbro, a leading construction and energy services company servicing the Rocky Mountain region, intends to implement TE for planning, building and monitoring pipeline construction projects. "It is our company's mission to bring positive change to our industry. One of the best ways to do that is to be on the leading edge of technology, Prostar is that leading edge in our industry." said Paul Leach, President and Co-Founder of Loenbro. "In today's world, there are constant advances in modern technology, with very little of it utilised in oil and gas. Prostar's geospatial intelligent capabilities will forever change the way Loenbro's projects are designed, managed, and maintained."

Loenbro sees commercial, quality, efficiency and safety advantages in employing the Prostar Solution across its family of pipeline construction, industrial construction, fabrication, inspection, and oilfield services companies. In particular, Loenbro sees ProStar's suite of Mobile and Cloud Solutions as the place to view and manage all construction related activities. These activities include identifying bid opportunities, producing preliminary project estimates and quotes, time management, One Call verification, safety, equipment and personnel dispatch, managing process workflow, and monitoring project progress in real time. Loenbro is developing a 'War Room' with extensive video and telecommunication capabilities where project planning and tracking can occur with the use of the latest technologies in real time, all possible with the ProStar solution. Also available are queries, reports, and key metrics that can be run from the dashboard associated with each project so that management can view individual project details. One specific use being investigated is the RFID tagging of materials and subsequent documentation required for Pipeline Integrity Management purposes. This RFID tagging would be achieved by combining the PipeTalker™ ECHORFID system with ProStar's Transparent Earth and PointMan so that this information can be tracked and reported, from initial component delivery to final installation.

Pipeline planning and design firms are also taking a look into integrating their service offerings and deliverables data into ProStar's Transparent Earth platform. T2Utility Engineers operating in Canada, and Cardno, Inc. a global civil and environmental engineering firm headquartered in Australia, are investigating pushing their ASCE 38-compliant utility mapping data directly into Transparent Earth, coupled with jpegs, forms, and reports that are all referenced positionally to specific points, lines, and polygons, for those clients utilising Transparent Earth.

The next generation of geospatial sciences and analytics

Universities are realising the need to integrate these open geospatial solutions and technologies into their existing educational offerings. At North Carolina State University, The Center for Geospatial Analytics announced the launch of the CGA Industry Experience Programme (IEP). This new programme gives graduate students the opportunity to immerse themselves in real-world geospatial projects through industry partnerships over multiple semesters while simultaneously working towards a degree. NCSU recently announced that their first industry partner is ProStar Geocorp™.

Summary

Geographic Information Systems (GIS) did not always live up to the promise in its name. The 'geographic' portion implied accuracy but accuracies in location were difficult to verify, if they existed at all. 'Information' had no means to verify good versus bad. 'Systems' were propriety in nature and often required significant training and certification in order to fully utilise and operate them. GIS made for a good planning tool, but was not a reliable design or operations tool. In these traditional systems, data resided back in the office and was siloed, unable to be sorted and assembled or used, especially in the field where it was often the most needed. Today, we are seeing a change in guard within an industry where workers and executives are asking questions surrounding antiquated business practices that have been in place for decades, and why technologies used every day to improve our own personal lives are not being integrated and adopted to enhance our business operations.

Cloud-based data repositories, integrated into mobile and open geospatial technologies with real-time communication between the office and the field, can turn isolated, disparate, and often questionable data into big, standardised, and qualified data. When combined with a precise, accurate, pedigreed location, geospatial intelligence can be realised. This technology and process is now in the oil and gas industry pipeline.