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on the cover ...

Bergeron Centre for Engineering Excellence, York University

also in this issue ...

Geodetic Control Networks for Transit Projects

Getting to the Bottom of our Atlantic Ocean's Mysteries

Experiences in the use of a Terrestrial Laser Scanner at UNB

plus our regular features:

Educational Foundation

News from 1043

Book Reviews

Sites to See

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ONTARIO
PROFESSIONAL SURVEYOR

VOLUME 58, No. 4 Fall 2015

CONTENTS

REGULAR FEATURES

ADVERTISERS

ON THE COVER ...

The *Bergeron Centre for Engineering Excellence,* the new home of the Lassonde School of Engineering at York University, will be opening soon. Photo credit: Maureen Mountjoy. See the article about the centre in The Last Word on page 36.

Professional Surveying in Ontario

encompasses the Disciplines of

Cadastral, Geodetic, Hydrographic, Photogrammetric Surveying & Geographic Information Management

President's Page

By Travis Hartwick, O.L.S.

Before I begin my President's Report, I want to welcome our new Lieutenant Governor Appointees to Council; Miranda Paquette and Peter Meerveld. We look forward to working with you to protect the public interest and uphold our professional status in society.

Having read through numerous President's Pages in past issues of OPS, there are a couple of resounding themes that are common at this time of year, namely, time goes by too quickly and there is not enough time to get everything done. I regret to admit this myself, but it is true! We are just past the half way point in the 2015 Council year and it feels like things are just nicely coming together. There are so many things that deserve attention that it is difficult to sort out the "needs" vs. the "wants". At any given Council meeting we have about 30 to 40 items that could be included in the agenda. It is a challenging task to sort these items, focus on the most pressing issues and assign them the time they deserve. In an effort to stay focused on our Strategic Planning items, Council reviews the key priority activities tracking spreadsheet at each Council meeting. At our last meeting Executive Director Blain Martin provided a summary of our accomplishments to date with regard to the Key Objectives for 2015.

Activity	% Complete
Proposed future changes in regulations identified	0%
New marketing strategy for the profession approved, and resources in place for implementation in 2016	20%
5% increase in articling students over 2014 (actual 27% increase)	500%
Consequences of CPD non-compliance clearly defined and communicated to the membership	80%
100% of membership report compliance with CPD	60%
Revised standards and manuals completed and communicated to membership	80%
PSRI system approved and ready for regulation	50%
Future composition of membership agreed on	10%
Strengthening our relationship with university and college programs	25%

Most of the items are over 50% complete which seems to indicate that we are on target. Others have much of the "heavy lifting" at the front end and I am sure we will see exponential progress as we move ahead. Even though the proposed regulation changes activity is at 0%, they have been discussed at the Council table; we just need to assign a Committee/Task Force to move this forward once a couple of big items are dealt with, i.e., Constitutional Challenge, ODCC, and PSRI, etc. When we decide to move ahead with regulation changes, we want to make sure that it is a complete review and covers as many changes as possible.

In addition to the Strategic Planning items, the following important issues have been discussed:

Motions From the 2015 AGM

a) Preservation of Ontario's EDM Baselines - you should see a SurveyMonkey and some direction on this before year end,

b) Collaboration with PSC - this item has been discussed at length at the Council table and at the Presidents' Forums. A draft letter has been prepared. We are waiting to be notified of PSC's direction after its Board meeting in early October,

c) Constitutional Challenge Funding Mechanism - Council sought advice on the expected costs of this action, we now expect that most of this action will be dealt with in 2016, and we are preparing a fees by-law to address this issue,

d) Granting free membership to Retired Members over 90 years of age. This change will require a fees by-law. The by-law is being developed for circulation to the membership.

Fees Mediation Manual

Council is working on approving a Fees Mediation Manual for the Fees Mediation Committee. The project is in its final stages and we hope to have this completed this term.

Provincial Survey Records Index (PSRI)

Council receives an update from the task force each meeting. The task force is moving forward and working through the different indexing methods in the province.

Ontario Digital Cadastre Corporation (ODCC)

ODCC remains as an active agenda item and the members are now seeing returns for their investments. Some strategically important meetings are taking place in the early fall that will set its agenda moving forward. Council continues to challenge ODCC to finalize the structure of the corporation and move forward as an autonomous entity.

Digital Plans Task Force

The Digital Plans Task Force continues to work with Service Ontario to develop a digital plan submission procedure. Several productive meetings have taken place and we continue to be an important stakeholder in the process.

Salary Survey

Our second salary survey for members was distributed this year. We are in the process of analyzing the results and intend to report back to the membership before the end of the year. We had fewer responses this year but we hope that the results will move us closer to a true base line.

In addition to the ongoing projects, we need to consider and approve the 2016 budget, to approve and announce the candidates for Council next year, to strategize an AOLS staff succession plan, to enforce the Professional Development sections of our legislation and to finalize our AGM. The 2016 London AGM is shaping up to be another great event. The theme centers around collaboration: as Ontario Land Surveyors and as partners in the greater surveying community. I hope that many of you will plan to attend and I look forward to seeing you there.


Carlson for Surveyors
From field... to finish
NEW BRx5
GNSS Receiver
Combined with SurvCE4.0, get highest positional accuracy, plus:
• 270-channel receiver
• Dual Bluetooth ports
• Dual hot-swap batteries
• OmniSTAR capable
• Each receiver can be configured as Base, Rover or Network Rover
Power Your Field Data Collection With –
Carlson SurvCE
Produce Your Deliverables With –
Carlson Survey
And the world's most reliable data collector just got better…
NEW Carlson Surveyor2
• Faster Processor
• Long-range Bluetooth
• Extended Battery Life
• Larger, Brighter Display Screen
• Easier To Use
• More Options
– Integrated camera
– 3G modem
– GNSS receiver
Carlson Surveyor2
Advanced Technology to Improve Efficiency
Carlson CR2/CR5 Robotic Total Station
• Perform measurements automatically
• Track target continually
• Speed staking out
• Get maximum accuracy
• Center accurately & easily
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Experiences in the use of a Terrestrial Laser Scanner at UNB

By Peter Dare, Yong-Won Ahn and Alice Cunningham

Introduction

The Department of Geodesy and Geomatics Engineering (GGE) at the University of New Brunswick (UNB) purchased a Trimble TX5 terrestrial laser scanner in the fall of 2013. This type of equipment has been used extensively worldwide for three-dimensional recording of cultural features and industrial plants partly due to its millimetre precision and accuracy, the millions of data points it can quickly collect, and the fact that each point has a 3D coordinate attached to it.

GGE created an extensive 3D model of part of the living history museum Kings Landing Historical Settlement during the summer and fall of 2014. Subsequently GGE worked with the Fredericton Police Force on the development of laser scanning as a tool to assist in collision investigation and reconstruction. GGE is now working with the NB Department of Transportation and Infrastructure (NB DTI) on a project to monitor the stability of a retaining wall adjacent to one of its major roads. This latest project will be a development of GGE's current portfolio of scanning research whereby the data collected regarding the retaining wall will be used to assess change in the retaining wall since its construction in 1999, and act as a set of "baseline" measurements for future scanning of the site. In the future, we hope to collaborate with UNB's Department of Classics and Ancient History to carry out new investigations on historical sites they have been studying for a number of years, taking advantage of the high resolution and accuracy of GGE's laser scanner.

This article will summarise the two completed projects and discuss lessons learned.

Imaging of Kings Landing Historical Settlement

During the summer and fall of 2014 a team of researchers (students Yong-Won Ahn and Renée Tardif) led by the first named author carried out the first three-dimensional survey of part of Kings Landing Historical Settlement, a living history museum just a few kilometres from Fredericton, New Brunswick. Using both laser scanning equipment and GNSS receivers, the team has produced highly detailed three-dimensional images of part of the settlement, together with fly-throughs of selected areas.

The researchers used the laser scanner to capture the information required to create the 3D images. The scanner sends out millions of laser pulses while it rotates 360 degrees horizontally, and from the zenith to minus 60 degrees vertically, enabling the positions of all the features surrounding the scanner (for example, building walls, historical objects within the buildings) to be determined. Scanning parameters such as resolution and precision were entered wirelessly into the laser scanner (see figure 1). Fifty-five setups of the scanner were required to cover the selected area of Kings Landing, after which, the individual scans were stitched together to create one complete image (the "point cloud"). The stitching together made use of checkerboard targets (visible on the walls in figure 2) that were scanned in adjacent images. The stitching together required a great deal of manual intervention since the software did not automatically recognize many of the checkerboard targets. An alternative to checkerboard targets is spherical targets and an additional issue we ran into with this dataset is that some apples on the trees were flagged by the software as spherical targets! Around four billion data points were collected altogether. Subsequently, by applying coordinates of reference locations determined by students Gozde Akay and Ryan White using GPS, the positions of the features scanned were made to coincide with the legal coordinate system used in New Brunswick.

Figure 1. Peter and Renée controlling wirelessly the laser scanner at Kings Landing.

This type of work creates a detailed digital inventory which will enable museums like Kings Landing to:

- Show what can be loaned to others.
- Have an accurate record of their holdings in case of an insurance claim (theft, flooding, etc.).
- Document and archive the collection in their original state and – for those items on display – in their original location.
- Have a complete record of their holdings.
- Increase the financial stability of the museum by being

able to advertise holdings that could be used by TV and film companies.

- Show to the public more clearly what they can expect from a visit to the living history museum by improving the museum's online content.
- Provide an online educational resource for local schools regarding the history of New Brunswick.
- Show to historians around the world more about historical life in New Brunswick.
- Produce models of buildings and individual items with a 3D printer.
- Items owned but not on display can be shown online.

Other living history museums and historical buildings in New Brunswick and elsewhere would benefit from similar imaging of their properties.

Fly-through movies were created using the point cloud, and two can be viewed here:
http://www2.unb.ca/gge/News/2015/2015.html#3D

One fly-through shows the exterior and interior of St. Mark's Church, one of the two churches at Kings Landing. The other movie shows the various buildings surveyed. Screenshots of the fly-throughs are in figures 2 and 3. It should be emphasized that these fly-throughs, although showing images above ground level, were computer-generated from ground-level data. Coordinates of points creating the point cloud were obtained by monochromatic laser light. The colour comes from colour digital photos, which the scanner took after capturing a scene with the laser. The photos were made to overlay the point cloud from the laser measurements so that every point in the point cloud had a three-dimensional coordinate set along with red, green, and blue colour values.

Figure 2. Screenshot from the movie of St. Mark's Church.

Figure 3. Screenshot from the aerial view movie of Kings Landing.

Vehicle collision reconstruction

Undergraduate students studying in GGE have to complete a major project lasting a full two terms in their final year. The third named author chose to work with the Fredericton Police Force to assess the role laser scanning may have in vehicle collision reconstruction. The intent of the research project was to establish the benefit of laser scanning in collision scene investigation and reconstruction by determining if it is more efficient than traditional methods, if the accuracy is comparable to traditional methods, and to explore whether new information can be deduced from laser scanning datasets that is not possible using traditional methods. To assist with this, the Fredericton Police Force created a mock collision involving two cars. The collision scene was captured by the laser scanner in seven set ups: four set ups around the periphery of the collision scene to capture the majority of the data and three close-up set ups to capture the detailed damage on both of the cars using data windowing techniques while increasing resolution and quality. Four checkerboard targets were strategically placed on tripods around the outside of the collision so that all checkerboards would be included in each scan (see figure 4). As with the Kings Landing data, not all of the checkerboard targets were automatically recognised by the software and so manual intervention was required again.

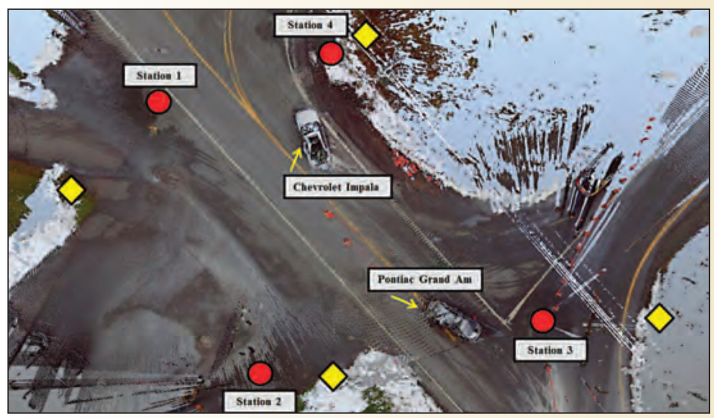

Figure 4. Collision scene diagram (scanner set ups shown as circles, checkerboards are shown as squares).

Upon completion of a thorough scan of the mock collision scene, it was concluded that laser scanning is indeed more efficient than traditional methods while achieving comparable accuracy. The comparison of skid mark measurements obtained using the laser scanning dataset with those made by the police determined a difference as low as zero cm compared with total station measurements and 7 cm when compared with the police baseline measurements, which is acceptable for collision reconstruction purposes. This allows us to conclude the measurements resulting from the laser scanning dataset provide a comparable accuracy to existing methods and the opportunity to make measurements to mm level precision as opposed to cm level.

cont'd on page 6

The research also found that new information can be obtained using laser scanning to model a collision. Perhaps the most beneficial product of the laser scan dataset is a 3D model that provides the ability to view the collision scene from above and from any other viewpoint, a perspective that is not possible using existing methods. This allows a more thorough visualization of both the collision and what may have occurred pre-impact. Figures 4 and 5 show images of the collision created from the scanner data. As with the Kings Landing project, it should be emphasized that these views, although showing images above ground level, were computer-generated from the ground-level scanner data. This is one of the advantages of creating a point cloud from laser scanners - the subject scanned can be inspected from any viewpoint. The 3D model provides the ability to make measurements of the crush impact on the exterior of the car and in addition, measurements can be made on the interior of the cars which is not possible in cases where it is unsafe to get inside the car or physically impossible due to the impact.

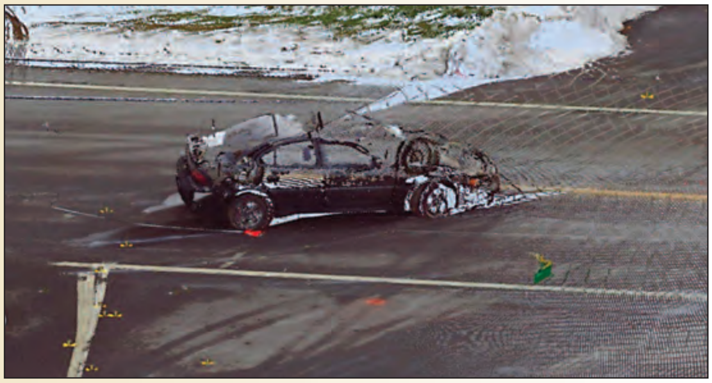

Figure 5. Close-up of one of the damaged vehicles.

In the future, laser scanning offers a decrease in time spent at a collision scene with roads closed and the collision scene blocked off. Police forces can now capture a detailed 3D model of any collision or crime scene that includes imagery of the entire scene. The multitude of measurements and photography previously acquired at the scene following existing approaches can now be captured in several scans in the field and then analyzed in the office. Whereas existing collision reconstruction methods consist of a variety of measurements, diagrams and photography, this can now all be incorporated into one model, and more easily visualized, which can aid in the determination of the cause of the collision. With careful education and project planning, laser scanning holds the potential to make a remarkable impact in the field of reconstruction and investigation capabilities for police forces around the world.

Figure 6. Alice and Yong-Won entering data collection parameters into the laser scanner.

Fieldwork practicalities

We found that the Trimble TX5 laser scanner being battery powered, small and light was easily carried around the site. A fully charged battery lasted about five hours which was extremely helpful given that all the scanning for both of the described projects was outside. Figure 6 shows the scanner set up on a tripod.

Our experience with checkerboard targets was that they required manual intervention as many were not automatically recognised by the software during the image stitching process. In addition, this type of target required them to be rotated in the field to face the laser scanner. Further investigations into this at UNB, and during the new project with NB DTI, has resulted in us changing to spherical targets in place of the checkerboard targets. Depending on the scanning conditions, e.g. distance to the target and lighting conditions, we have found that these targets are generally automatically recognised by the software, although the software did occasionally recognise non-spheres as spheres. In addition, their use reduces field time as no rotation of the target is required, since the spherical target looks like a sphere from all directions.

Conclusions

The paper has shown two very different applications of laser scanning, suggesting that new areas of work for geomatics experts exist with this new technology. As with many other tools now used by surveyors, the skill is now in planning the survey, and the processing and analysis of the data. Processing, analyzing and handling what may be billions of data points (as with Kings Landing) is an extremely challenging task. In GGE terrestrial laser scanning is now taught in our surveying classes to ensure that our graduates are aware of the technology, its applications, and the challenges often faced in the processing.

Peter Dare is a Professor in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick. He was Chair of the Department from 2002-2012. Peter is a member of the Canadian Institute of Geomatics, a Professional Engineer, and a Fellow of the Royal Institution of Chartered Surveyors. Peter can be reached by email at **dare@unb.ca.**

Yong-Won Ahn is currently a PhD candidate in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick, where he has also been teaching undergraduate courses for a number of years. He holds an MScE from the Department of Geomatics Engineering at the University of Calgary.

Alice Cunningham was awarded a Bachelor of Science in Mathematics (First Division) degree in 2012, and a Bachelor of Science in Geomatics Engineering (First Division) degree in 2015 (with a Cadastral Surveying Option). Alice has just completed a four month trip travelling around the world and is now looking for employment in the geomatics industry.

Geodetic Control Networks for Transit Projects

By Murray Shantz, O.L.S., O.L.I.P. and Simeon Mitrev, O.L.S.

Introduction

Transit projects spanning many linear kilometres require sufficiently accurate horizontal and vertical control networks. This is especially true when designing and building rail corridors and tunnels for Light Rapid Transit (LRT) in densely populated urban areas. This article describes the methodology that was used to overcome the issues that our survey team faced when attempting to create an accurate horizontal control network for an LRT running along Eglinton Avenue in Toronto.

The task:

To establish a 20 km 2nd order horizontal control network (1st Order for Tunnels) along Eglinton Avenue, Toronto

Datum: NAD27, CGVD28 (Pre-1978 adjustment)

Fig. 1 – The Eglinton Crosstown LRT alignment

The Problem with the Horizontal Network

With critical project information already in NAD27, we faced the following challenges:

1. **Condition:** Existence of a monumented network with published coordinate values
2. **Verification:** Local and project-wide accuracy deficiencies necessitated an "accuracy upgrade"
3. **Integration and efficient use:** Stay as close as possible to the published values of ground control while utilizing the "control network in the sky" for future works
4. **Application:** Do it all in one easy step

Traditional Approaches

Traditional approaches include matching (degrading) the newer network to the existing network. This is typically done by selecting a number of published points along the route and then adjusting them (distorting) by some form of adjustment (Translation, Compass, Transit or Least Squares) to make the new fit the old. Different datums add complexity to this approach. Not only do the geodesists need to deal with survey errors, but they need to perform transformations between datums.

Another possible approach is breaking the long linear network into two or more sections, each one with sufficient local accuracy. On a complex project involving many contractor teams that could lead to serious survey issues within the section interface zones.

An alternate approach is to publish a transformation polynomial similar to the NTv2. This polynomial would simultaneously transform the survey data between datums and model the errors.

So why not use a polynomial transformation such as NTv2? Polynomial transformations in practice distort accurate networks to fit inaccurate networks, thereby degrading the accuracy of current surveys. Use polynomial transformations only when significant inaccuracies in the existing network cause the "Best Fit" test as described below to fail.

The "Best Fit" Approach

The "Best Fit" approach is a simple yet effective approach. It requires the derivation and use of a single set of "best fit geocentric transformation parameters" that span the entire project. In our case, these parameters transform coordinates directly from NAD83CSRS to NAD27(Hybrid). We use the term Hybrid as it resembles the published NAD27 but maintains unique project specific parameters.

The advantages of the "best fit" approach are as follows:

1. The transformation between NAD83CSRS and NAD27(Hybrid) is conformal and does not distort the NAD27(Hybrid) network. The LRT rails will run straight. The NAD27(Hybrid) published results maintain the same network accuracy as the high accuracy NAD83CSRS network.

2. The transformation is relatively simple to derive using available software.
3. The transformation parameters are relatively easy to load into the GPS units, allowing surveys to be performed in the NAD27(Hybrid). No GPS localization is required.
4. Surveys in the future can accurately reference the NAD27(Hybrid) datum after the surface monuments have been destroyed.

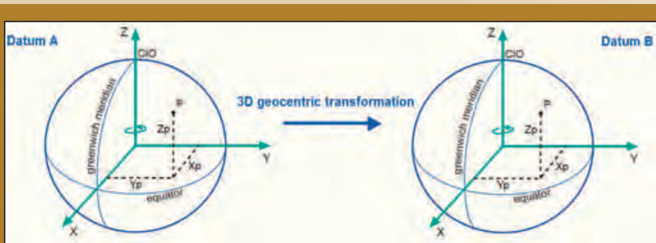

Fig. 2 – Sketch showing 7 parameter geocentric transformation

The Test – Can this "Best Fit" Approach be used?

Will this "best fit" approach of deriving a single set of transformation parameters work for all projects? This approach only works if the existing NAD27 network is an accurate survey containing only systematic errors (i.e. without kinks and stretches). This method of testing is quite easy.

Step #1: Perform a survey to accurately measure key existing monuments along the route. Perform a minimally constrained Least Squares 2D adjustment by fixing a single point in NAD27 (Red Line). **(Do not perform a constrained adjustment as it will distort the results).** Overlay the measured points and compare with the published NAD27 (Blue Lines).

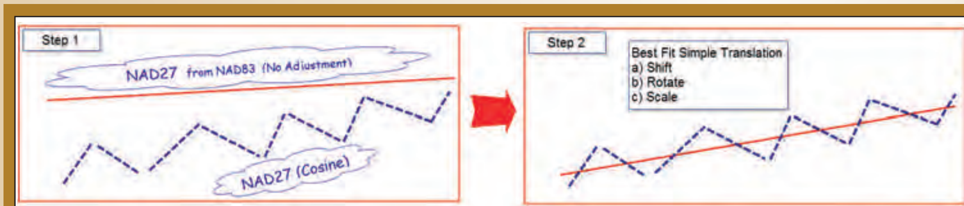

Fig. 3 – Sketch showing simple translation used to analyze conformity of published NAD27 vs. measured NAD27

Step #2: Translate the measured points (Red Line) and perform a best fit to match the published (Blue Lines).

Note: Do not distort the measured points. Apply constant shifts, rotations and scaling to the complete measured (Red) dataset. Compare differences in Northing, Easting. Reiterate until differences have been minimized. This procedure can be performed in CAD or Excel. **Note: Do not use Least Squares as it will distort the measured results rendering this test useless.**

Step #3: If the coordinate differences (after translation) in Step #2 are within an acceptable tolerance then this illustrates that the original survey is homogeneous and the test passes. A single set of transformation parameters can be derived by a classical 3D similarity coordinate transformation.

In our case we determined that the newly measured coordinates (after translation) matched the NAD27 published coordinates within ±6cm along the 20 km traverse. This difference was deemed acceptable for the LRT project. A single set of 3D transformation parameters were then published for the project.

A "bonus" challenge is the orthometric heights that our project uses. That requires the correct application of geoid separations for both local ellipsoids, in order to minimize potential distortions in the calculation of the transformation parameters.

To minimize the potential for errors, we designed our transformation to use the HT2_0 geoid model for converting ellipsoidal elevations from the NAD83CSRS frame, directly into orthometric elevations in our project vertical datum.

The following section illustrates the method to derive a single set of transformation parameters, from NAD83CSRSv6(2010.0) to NAD27(Hybrid) for a NAD27 homogeneous legacy control network using Leica Geo Office software (LGO) and the Classical 3D Bursa-Wolf transformation model.

Fig. 4 – The Eglinton Crosstown LRT alignment and framework points used for the transformation

CALCULATION OF THE TRANSFORMATION PARAMETERS BETWEEN NAD83CSRS AND NAD27(Hybrid):

Definition of input and output coordinate systems:

- Input **(System A):** WGS1984 as defined by default in LGO.
- Output **(System B):** local, defined as follows:
  - Local Ellipsoid: Clarke 1866
  - Projection: MTM10
  - Projection type: TM
  - Geoid model: HT2_0_local

Calculation of parameters:

- Under TOOLS > DATUM/MAP:
  - Select points in **System A:** Geocentric coordinates (X,Y,Z) following a Least Squares adjustment of the framework points in NAD83CSRS. If adjusting with orthometric heights, ensure they are in the CGVD-1928:1978 datum when applying the HT2_0 geoid model, in order for the calculated ellipsoidal heights to be correct

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- Select the same points in **System B,** in N, E, O format, "O" being orthometric heights in the project vertical datum

- Upon selection, the MATCH tab should be available. Complete the match and analyze results:

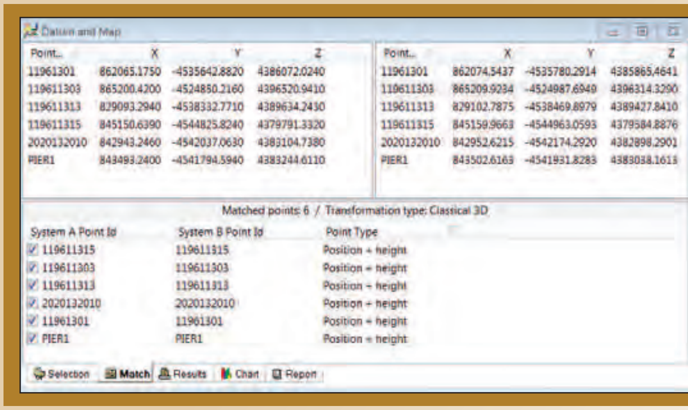

Fig. 5 – LGO Dialogue Box showing common points in NAD83CSRS and NAD27(Hybrid)

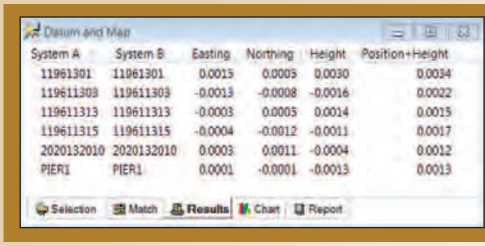

Fig. 6 – LGO Dialogue Box showing statistical output after the match

- Transformation details including the 7 parameters and statistical output are available in the REPORT tab.

LGO TRANSFORMATION PROCEDURE:

1. **Define the coordinate systems that you will be using.**

   1.1. In this instance, the input system is called CSRS2010:

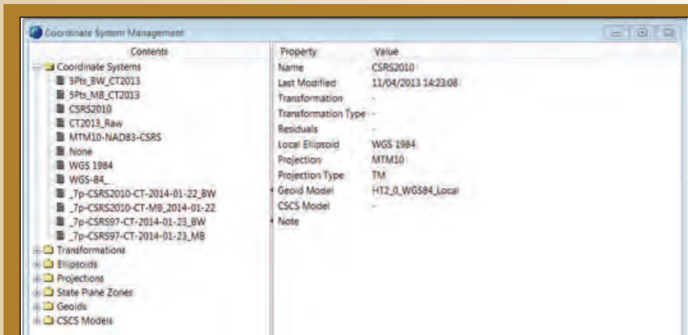

Fig. 7 – LGO Dialogue Box showing Input Coordinate system

Ensure that a local geoid model based on HT2_0 definition is present in the definition.

1.2. The output coordinate system (CT2013) can be created as shown below:

- Follow the same steps; for the "Local Ellipsoid", select "Clarke 1866"
- Ensure that a local geoid model based on HT2_0 definition is present

2. **Transformation parameters**

   Define a new transformation and enter the 7 parameters as follows:

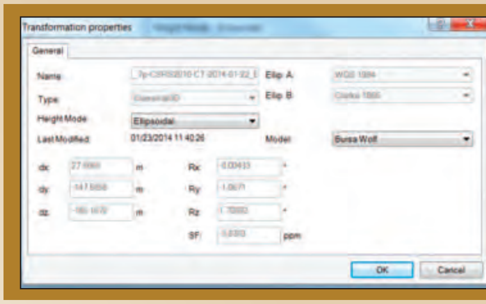

Fig. 8 – LGO Dialogue Box showing transformation properties

Pressing the "OK" button saves the transformation under the "Transformations" category in the Management console in LGO, under the name specified inside the top-left box in Fig.8.

3. **Associate the CT2013 coordinate system with the newly created transformation**

   Right-click the coordinate system in the LGO management console (1) and select "Properties". Under "Transformation", select the name of the transformation above (2). Click "OK".

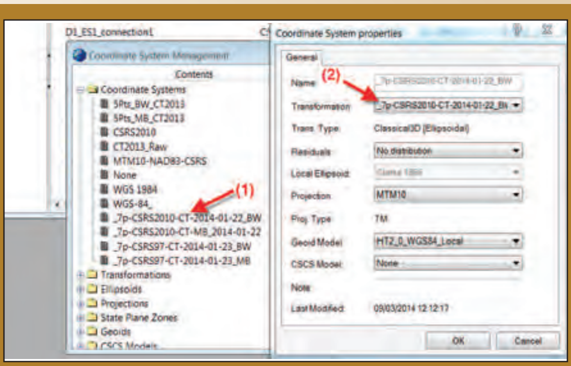

Fig. 9 – LGO Dialogue Box assigning a Transformation to a coordinate system

4. **Create your project file and assign the CSRS coordinate system to it.**

5. **Populate your project point list** correctly by inserting a point list or manually typing point numbers, coordinates and elevations. Ensure you have the correct "Height Mode":

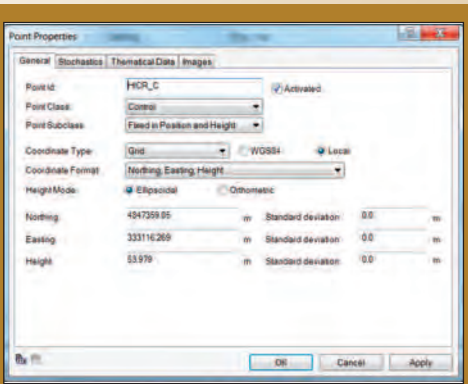

Fig. 10 – LGO Dialogue Box selecting a control point to be transformed

6. **If you have entered orthometric heights,** ellipsoidal heights have to be calculated before continuing. Use the "Tools -> Compute Geoid Separations" menu options.

   This option will only be available if a geoid model file was specified at the time of coordinate system

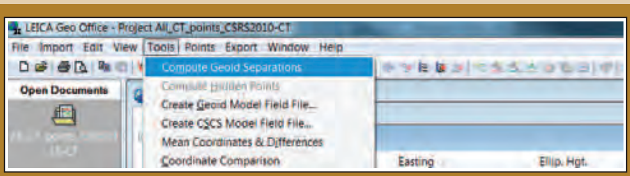

Fig. 11 – LGO Dialogue Box to compute Geoid Separations

definition. After applying the above, ensure that you have the correct resultant elevations.

Note: the transformation parameters were calculated to transform the correct ellipsoidal elevations from WGS1984/GRS80 ellipsoid to orthometric elevations used by CT2013 datum.

7. **Transform!**

   Select all points in your coordinate list, then right-click it. Using the "Exchange Coordinate System" option, convert coordinate values between the input (NAD83CSRS) datum and the Crosstown (CT2013) datum:

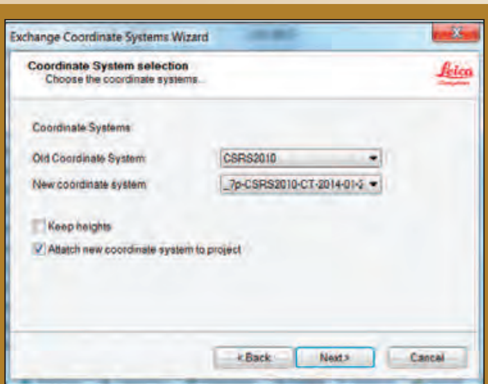

Fig. 12 – LGO Dialogue Box illustrating the Exchange Coordinate System Wizard

8. **Export to field data controller**

   The new coordinate system, along with the working local geoid model file, can be directly exported to a Leica GPS controller by right-clicking on the coordinate system and selecting Send to -> Local Memory Device.

Note: After transformation, points should be field checked to test the accuracy of the established transformation relationship and parameters before formal use. It is highly recommended to always include points with coordinates known in both systems for verification purposes.

CONCLUSION

The successful derivation and use of the "Best Fit" 7 Parameter Geocentric parameters allows surveyors to use a single set of project parameters to accurately transform the "control network in the sky" to a legacy reference system on the ground. These parameters will allow future surveys to be referenced to the LRT project reference system long after the brass caps on the ground are gone, and it can be done in one easy step.

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Calendar of Events

October 18 to 22, 2015

GIS-Pro 2015 and NWGIS 2015
Geography at the Nexus of Collaboration
Spokane, Washington
www.urisa.org/education-events/gis-pro-annual-conference

November 18, 2015

GIS Day
Discovering the World Through GIS
www.gisday.com

December 9 to 11, 2015

9th International Symposium on Mobile Mapping Technology
Sydney, Australia
www.mmt2015.org

February 10 to 12, 2016

GIM International Summit 2016
Amsterdam, The Netherlands
http://www.gimsummit.com

February 24 to 26, 2016

124th AOLS Annual General Meeting
London, Ontario
www.aols.org

July 12 to 16, 2016

ISPRS XXIII Congress
Prague, Czech Republic
www.isprs2016-prague.com

A pocket guide to high-resolution 2D/3D mapping using off-the-shelf drones and photogrammetry software

By Dominique Chabot, Ph.D.

The buzz around drones is getting louder, but beyond casually buzzing around capturing nifty aerial photos and videos, they are increasingly being used to perform serious utilitarian tasks. Among their most prominent applications is mapping, for which they are said to offer unprecedented ground resolution (typically 1–10 cm/pixel) in a distinctly convenient, timely, repeatable and economical fashion. However, it is not quite as simple as tossing a little flying robot into the air under any conditions and letting the magic of technology do the rest, so for those looking to properly harness the mapping potential of drones, here are some basics.

The platform & data collection

At the very least, drone-based mapping requires an autopilot capable of autonomously executing preprogrammed flight plans composed of a sequence of waypoints with XYZ coordinates. This disqualifies the inexpensive "toy" drones available in popular electronics stores that can merely maintain a stable hover. Realistically, one should expect to spend at least $10,000 on a proper mapping system, and several times that for a model with more sophisticated features. One must then decide between a fixed-wing or rotary-wing model. The former invariably boasts longer flight endurance, while the latter has the advantage of being more easily deployed from constrained spaces and able to fly as slowly as needed to allow the camera to keep up when photos must be acquired at very short distance intervals. In the author's experience, a flight endurance of 30–40 minutes at a speed of 50–70 km/h is largely sufficient for most mapping applications, especially given current visual line-of-sight restrictions on drone operation.

Mapping missions consist of flying the drone in a "lawnmower" grid pattern while the camera captures regularly spaced photos that overlap with each other along both axes, which is essential for subsequent post-processing of the photos into a continuous image of the area. Although the amount of overlap required varies depending on several factors, in-track overlap (between successive photos) generally ranges from 60–90% while cross-track overlap (between photos from neighbouring flight lines) ranges from 40–70%. Many autopilot flight control software packages can automatically generate a mapping grid over a specified area based on a combination of the desired flight altitude or ground sampling distance (GSD), aka ground resolution, camera specifications (pixel count, sensor dimensions and focal length), and desired overlap. Lack of such a feature will result in the need for tedious manual calculations and significantly greater time spent creating flight plans.

Most current mapping drones also feature some mechanism enabling the autopilot to trigger the camera's shutter. This allows photo acquisition to be incorporated into flight plans and ensures triggering at specific locations or at fixed distance intervals. The alternative approach of using the camera's time-interval shooting feature results in inconsistent spacing between photos when the aircraft's groundspeed varies as well as numerous unneeded photos captured during the takeoff-departure and approach-landing stages of flights. Ideally, individual photos should also be geotagged by a dedicated GPS connected to the camera or via the autopilot. Most current aerial imagery post-processing packages require this information to initially establish the layout of large photosets. Alternatively, there are methods of extracting the GPS coordinates of photos post hoc from autopilot flight logs, but this adds an extra step to post-processing.

Figure 1 - A sample of an orthomosaic of Marble Mountain, Newfoundland, composed of 142 aerial photos collected by a SenseFly eBee RTK mapping drone operated by UKKO, a division of Ag Business & Crop Inc.

An inherent challenge associated to small lightweight drones is their susceptibility to being muscled by wind gusts and turbulence. The resulting pitch and roll motions of the aircraft can be highly problematic for aerial mapping, which should ideally be carried out with the camera pointing straight-down (aka "nadir") at all times. At best such attitudinal variations lead to geometric distortion of the imagery that impacts the quality of data products, and at worst can result in full-on gaps in area coverage and/or affected photos being unusable. Those looking to perform drone-based mapping should therefore consider platforms that are

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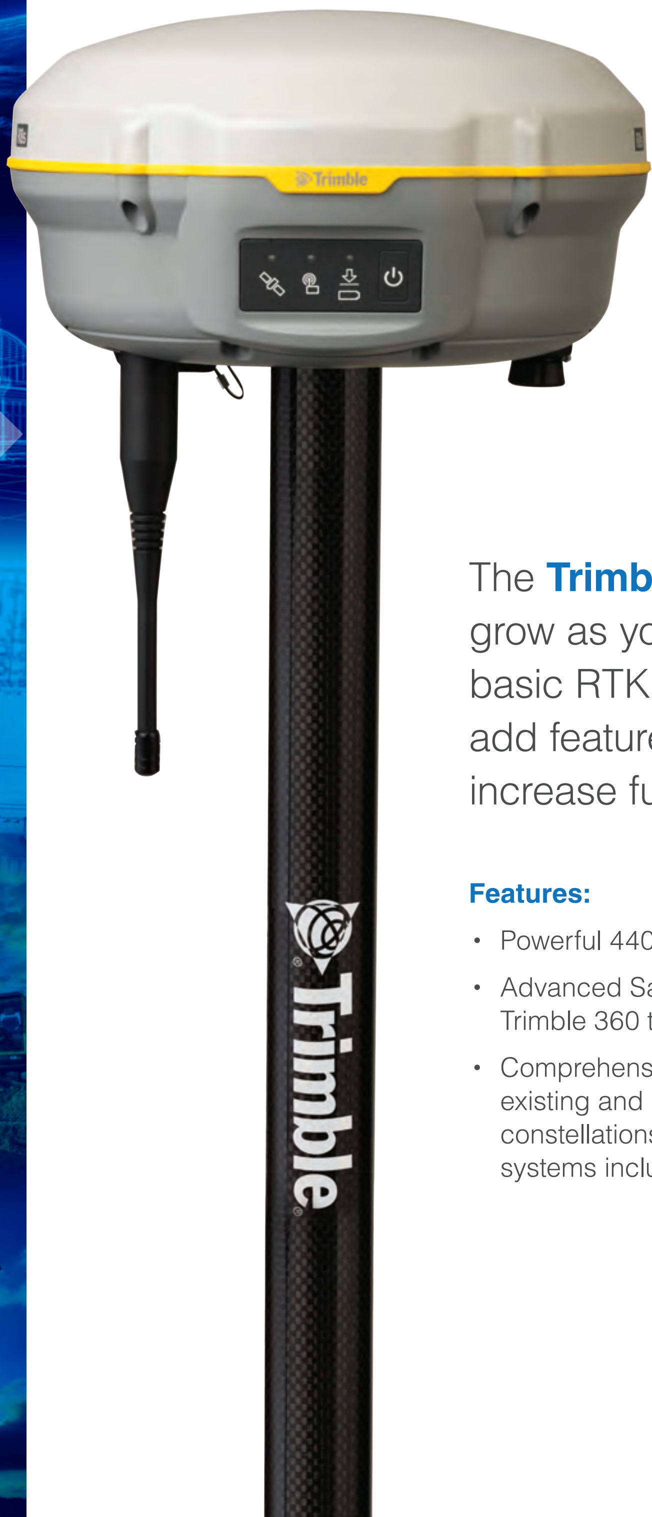

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capable of compensating for, or mitigating, the effects of flight instability. The most straightforward solution is a gimbal, a pivoted support that keeps the camera level throughout aircraft attitudinal variations. Gimbals tend to be more readily integrated onto rotary-wing models however, and an alternative feature more common in fixed-wing models consists of matching individual photos with data from the autopilot's inertial measurement unit (IMU), which records attitudinal variations and subsequently aids the post-processing software in applying geometric corrections to off-nadir photos.

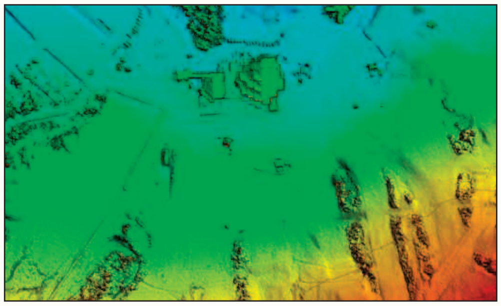

Figure 2 - A sample of the digital surface model (DSM) of Marble Mountain, Newfoundland, derived from the same aerial imagery used to create the orthomosaic shown in Figure 1. The imagery was collected by a SenseFly eBee RTK mapping drone operated by UKKO, a division of Ag Business & Crop Inc.

Another inherent challenge of low-altitude mapping with small drones is posed by areas with significant variation in terrain topography, e.g. slopes, hills/mountains or valleys/depressions. With off-the-shelf systems typically relying on a barometric altimeter that simply maintains a flight altitude in relation to the ground location where the system is first initialized, these models do not perceive variations in the relief of the areas they overfly. Not only can this lead to inconsistent GSD throughout the imagery as well as inconsistent (i.e. insufficient) photo overlap, at worst it can literally result in a drone flying into a cliff or mountainside. Given that manually adjusting flight plans to take relief into account is tedious and approximate, automatic "terrain following" features have recently been introduced into several autopilots, which work by preloading a terrain map onto the autopilot, providing the necessary data for the aircraft to maintain a truly constant above ground level (AGL) altitude.

The post-processing software

The sharply rising popularity of drone-based mapping is arguably as much attributable to progress in platforms as it is to breakthroughs in photogrammetric processing software over the past few years. Formerly confined to scholarly science and software engineering journals, the sophisticated algorithms capable of fully and automatically amalgamating up to thousands of individual aerial photos into seamless 2D and 3D maps are now within the reach of laypeople in the form of user-friendly commercial software packages ranging in price from about $4,000 to $10,000. Leading solutions include Pix4D Mapper, Agisoft Photoscan, Trimble UASMaster, and Canadian-based SimActive Correlator3D. Though each of these products varies somewhat in interface, features and workflow, they generally work as follows.

The user starts by pointing the program towards a folder containing the photoset to be processed, and the XYZ GPS data and camera attributes associated to the photos (as well as IMU data if available) are used to establish the coarse spatial layout and footprints of the photos. In the initial processing step known as aerial triangulation, the program automatically scans each photo for salient features, then matches identified features in overlapping portions of photos, ultimately creating up to numerous dozens of "tie points" per pair of photos. A collective analysis of tie points across the entire photoset then serves to perform a "bundle adjustment" consisting of subtle repositioning, reorientation and stretching/compression of the photos to better align the tie points.

The program then generates a digital surface model (DSM) of the surveyed area using a technique known as Structure from Motion (SfM). Analogous to the way the brain uses the slightly diverging perspectives provided by each eye to create a 3D image of one's surroundings, SfM takes advantage of the fact that the moving drone captures multiple perspectives of ground features in overlapping photos. The GSD of resulting DSMs, which can also be exported as dense 3D point clouds, is typically at best three times coarser than the original photos. Some post-processing packages are further capable of deriving an approximate digital terrain model (DTM) from a DSM using algorithms that automatically detect and remove features that do not belong to the bare terrain, such as trees/vegetation and artificial objects/structures.

cont'd on page 16


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The imagery is then orthorectified by "moulding" the photos onto the DSM or DTM, and finally an "orthomosaic" is created by brightness/colour-balancing the photoset and seamlessly blending the orthorectified photos together into a single continuous image. The entire process can take anywhere from under an hour to a few days depending on the number of photos as well as their pixel resolution, the software used, and computer performance, but it is generally lengthy. Most software packages also include tools to manually edit/refine DSMs/DTMs and orthomosaics, which can be useful to correct DSM anomalies commonly caused by water and highly reflective features such as metallic surfaces, or smooth out conspicuous seamlines in mosaics.

Drone mapping considerations & challenges

Foremost, it is important to recognize that small drones do not constitute an all-encompassing aerial mapping solution. When deciding whether a drone is the appropriate tool to map a given area, it is most practical to first consider spatial scale. Prior to the advent of off-the-shelf drones, a considerable gap existed between ground-based surveying—which achieves the finest resolution but covers the least area per unit of time—and conventional aircraft-based mapping—which can survey far more area in less time and conveniently overfly remote or hard-to-navigate areas, but at a significantly lower resolution. Further along the spectrum are satellite-based imagers, which can cover the most expansive areas but at the coarsest resolution. As it turns out, drones are proving most useful for filling the gap between ground- and conventional aircraft-based mapping, i.e. "intermediate"-size areas that are too large to expeditiously cover on the ground but too small to be worth surveying with conventional aircraft, as well as small areas that are particularly challenging to navigate at ground level, such as wetlands. As the area of interest grows larger, it will become increasingly time-consuming and uneconomical to map using a small drone compared to conventional aircraft or satellites, not to mention that in many cases the subdecimetre GSD provided by drones is simply not necessary or even troublesome.

An often-cited challenge that drone-based mapping poses to lay users is the large volumes of data it generates. One should expect to purchase a few terabyte-class portable hard drives to store photos collected in the field, and *at least* one order of magnitude more internal and backup storage for the post-processing computer if routinely carrying out mapping projects: a typical dataset composed of a thousand or more photos, over the course of post-processing, can easily grow to several hundred gigabytes.

As much as drones are vaunted for the exceptionally high-resolution imagery they yield, the very low-altitude flight required to achieve this poses several challenges from the productivity and photogrammetry perspectives. Not only does the volume of data increase *exponentially* with decreasing altitude as the shrinking photo footprint requires more photos to cover a given area, but this also means more flight lines and therefore time in the field, and more time to post-process the data. Low-altitude imaging also poses problems when overflying particularly homogenous landscapes—notably crop fields—where individual photos may lack sufficient salient features for tie point detection. The only way to mitigate this aside from flying higher—which is often prohibited by airspace regulations—is to increase overlap, which results in even more data. Similarly, it is generally impossible to mosaic photos containing only open water due to lack of salient features—worse, any waves/ripples move between photos—and erratic glare at the surface. Finally, low-altitude imaging of tall objects—notably trees/forests—is problematic due to exacerbation of the "fisheye" effect inherent of all lenses, which can result in the angular perspective on the objects varying so much between overlapping photos that the post-processing software is unable to match them. Again, the solution is to either increase overlap or use a narrower-angle focal length (i.e. more zoom), both resulting in more data.

Because drone datasets tend to be composed of hundreds to thousands of photos that can take several flights over several hours to collect, brightness/spectral variation due to changing sky conditions is another inherent issue. Short of only flying on perfectly clear or fully overcast days, this variation is at best attenuated by the colour-balancing step during post-processing, although results can be less than satisfactory. This is particularly problematic if the imagery must subsequently undergo digital classification, as popular pixel-based spectral classification tools do not cope well with such inconsistency, let alone the fine-scale spectral heterogeneity inherent of drone imagery compared to coarser-resolution conventional aerial/satellite imagery. A first solution to this is to use a multispectral camera, such as the compact models made by MicaSense and Tetracam, which greatly reduce spectral noise by only capturing a handful of discrete narrow bands across the light spectrum, but at lower resolution (typically <1.5 megapixels) and greater cost (>$5,000) than regular consumer cameras. Object-based image analysis (OBIA) tools have also proven to be more effective than pixel-based tools at classifying drone imagery since they can additionally factor in size, shape and texture of features, but again they tend to cost more as well as be more complicated to use.

Finally, although most off-the-shelf mapping drones can directly georeference imagery with an onboard GPS, these do not provide sufficient accuracy for certain applications such as precision agriculture, spatiotemporal change detection, and professional cartography or planimetry. The most common way of improving geo-accuracy is by placing conspicuous ground control points (GCPs), e.g. safety cones, throughout the survey area prior to flying and recording their locations with a survey-grade GPS receiver, or using pre-existing landmarks. Most post-processing packages can incorporate GCP data during the initial setup stage. However, this requires more time in the field, and drone models have now begun to surface that are capable of high-accuracy direct image georeferencing via a combination of real-time kinematic (RTK) GPS enhancement and high-precision camera angle logging by an IMU.

Conclusion

Although the details and nuances go on, the above fundamentals should help one make the right decisions as well as properly understand what they are getting into upon undertaking mapping endeavours using small drones and associated photogrammetry software. Prospective users are further encouraged to keep abreast of the exciting ongoing developments in these rapidly progressing technologies as well as the evolving airspace regulations governing the use of drones.

Dominique Chabot is a graduate of McGill University, where he devoted his M.Sc. and Ph.D. studies to developing and implementing applications for off-the-shelf drones in wildlife research and conservation, notably including habitat mapping and analysis. He has since been working in the commercial drone services industry leading data collection and processing for various sectors including environment, agriculture, forestry and utilities. He can be reached at **dominique.chabot@mail.mcgill.ca** for further information.

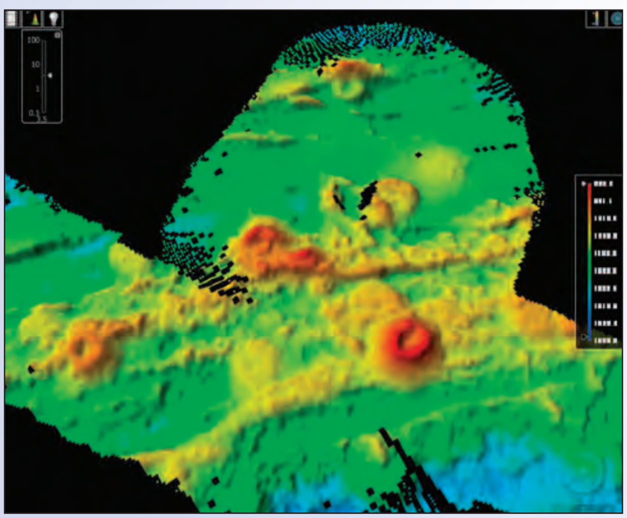
Getting to the Bottom of our Atlantic Ocean's Mysteries

By Denis Hains

Since the arrival of Google Earth, it's hard to imagine that there is anything left to discover. But this summer, an international team of expert hydrographers was excited to be the first to chart several previously unknown volcano-like features during a 12-day mission to survey the Atlantic Ocean seabed.

This was the second expedition under the international partnership between Canada, the United States and the European Union. The six-person team of scientists left Halifax on July 24 on the Canadian Coast Guard ship *Louis S. St-Laurent*, and arrived in Tromsø, Norway with a boatload of fascinating data.

Canada, the U.S. and the European Union all have extensive shorelines along the Atlantic Ocean. In an effort to better understand the waters that connect us, they signed onto an international partnership in 2013 – the Galway Statement - to better share scientific resources and increase knowledge of the ocean.



Multibeam image of volcano-like features mapped by the Galway Statement team on July 29th, 2015 along the North Atlantic Ocean seafloor. The latest measuring of the largest feature shows that it is 1250 m in diameter at the base and 280 m high.

As the experts responsible for hydrographic surveys of Canada's waterways, Fisheries and Oceans Canada's Canadian Hydrographic Service led this summer's expedition.

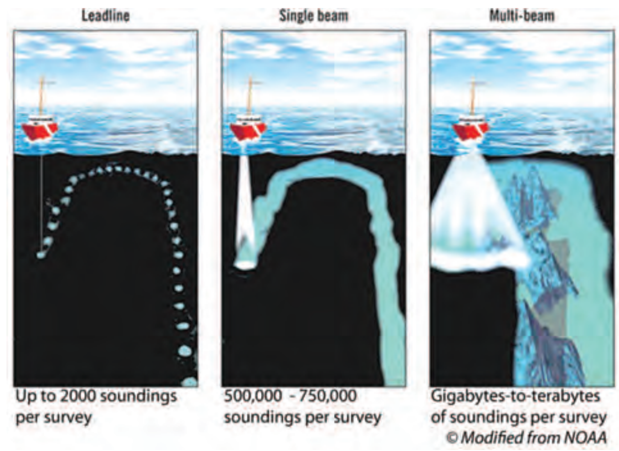
The international alliance and their work is significant because so little of the Atlantic seafloor has been mapped. "While satellites have circumnavigated the globe and given us a bird's eye view of almost every surface on the earth, our resources to see below the surface of the ocean in any detail has been limited," explains Paola Travaglini, Hydrographer with Fisheries and Oceans Canada's Canadian Hydrographic Service.

The largest volcano-like feature the team mapped is 1250 m in diameter at the base and stands at 250 m high. The Mid-Atlantic Ridge, where it was discovered, is part of the fault line that separates the North American and European tectonic plates. These plates are slowly spreading apart by 2 to 5 mm each year and the dramatic formations on the seabed are caused in part by this spreading. The surface is being constantly reformed by molten magma that rises to the surface through this fault line.

The team was led by Hydrographer-in-Charge Paola Travaglini and her colleagues Shauna Neary and David Levy from Fisheries and Oceans Canada's Canadian Hydrographic Service. The crew also included Kirk Regular from the Marine Institute of Memorial University in Newfoundland and Labrador; Edward Owens from the U.S. National Oceanic and Atmospheric Administration; and David O'Sullivan from the Marine Institute and Geological Survey of Ireland. The crew was equipped with a Kongsberg EM-122 deep-water multibeam sounding system built into the hull of the ship.

Hydrographic surveys, charting and other nautical products are the foundation of safe marine navigation. They also contribute to a growing body of knowledge about the Atlantic Ocean and its dynamic ecosystems. The Canadian

Galway Statement project science team - from left to right: David Levy (Fisheries and Oceans Canada), David O'Sullivan (Marine Institute of Ireland), Kirk Regular (Memorial University), Edward Owens (National Oceanic and Atmospheric Administration), Shauna Neary (Fisheries and Oceans Canada), and Paola Travaglini (Fisheries and Oceans Canada) - before their departure from Halifax on July 24th, 2015.



From 2,000 soundings per survey using leadline, to 25 times more data using a single beam sonar, to terabytes of data using multibeam sonar. Today, all CHS survey launches use multibeam sonars.

Hydrographic Service uses cutting-edge multibeam sonar technology that allows scientists to "see" underwater geomorphological features and landscapes and collect water column information.

The technology uses bathymetry, which is the measurement of water depth relative to sea level. It is these measurements that allow us to view the topography of the sea floor, which is as nuanced and dramatic as surface topography revealing canyons, plains, mountain ranges and volcanoes. For centuries, bathymetric mapping was done by sounding line, which was a weighted line lowered into the ocean until it hit the sea floor. The technology became more accurate with the invention of sonar during World War II.

Sonar technology measures depth by sending sound pulses through the water and recording the reception of their echo. The time that elapses between emission and reception indicates depth. Hydrographers have also figured out how to determine the substance of the sea floor by measuring the velocity of the echo on its return. Stronger or faster echoes indicate a harder, denser substance while weaker echoes mean that a softer surface has absorbed some of the sound.

The initial echosounders were limited in how much of the sea floor they could map. Single-beam echosounders are aimed vertically and cannot capture the data on the depth and features in the space between the sounding lines.

The detailed 3D images produced by hydrographic surveys today uses multibeam technology which emits hundreds of beams of high frequency sonar in a fan-shaped pattern. The multibeam uses sidescan sonar as well as vertical sonar beams to get 3D images. The width of the fan-shaped swath depends on the marine conditions but it can be as wide as six times the water depth, allowing

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today's hydrographers to cover significantly more territory than previous technologies allowed.

Projects under the Galway Statement have employed multibeam sonar technology to produce stunning 3D visualisations and detailed maps of the sea floor.

The results of the Galway Statement and its Alliance to date have been two scientific expeditions across the North Atlantic Ocean to map the sea floor and collect valuable oceanographic information. The first expedition was conducted aboard the Irish research vessel, RV *Celtic Explorer* in June earlier this year as it returned to Ireland after completing their annual fisheries survey. The team on board included researchers from Canada's Fisheries and Oceans and the Marine Institute of Memorial University, from the Marine Institute and Geological Survey of Ireland, the United States' National Oceanic and Atmospheric Administration, and the Portuguese Institute for Sea and Atmosphere.

Kian Fadaie (far right), National Director of Fisheries and Oceans Canada's Canadian Hydrographic Service, discusses the upcoming expedition with her team before their departure from Halifax on July 23rd, 2015.

This first expedition uncovered hundreds of square kilometres of ancient glacial features, sediment channels, and continental slopes formed 20,000 years ago. Crossing the Charlie-Gibbs Fracture Zone on the Mid-Atlantic Ridge, the crew created a 3D visualisation of a 3.7 km high previously unknown underwater mountain. Further east, a dramatic ridge was uncovered that is over 140 km long and peaks at 1108 m high. The team also mapped the drop location of the first trans-Atlantic telecommunications cable laid between Ireland and Newfoundland in 1857. And, along the way, oceanographic data such as temperature, salinity, and fluorescence was collected.

The use of the multibeam sonar, along with other oceanographic data collection technologies has contributed to producing high-resolution oceanographic information that benefit all members of the Galway Statement's Research Alliance. By combining resources, they maximize the use of this technology by taking advantage of operational expeditions and turning them into research opportunities.

After leaving Norway, CCGS *Louis S. St-Laurent* continued north to survey parts of the high Arctic. "In recent years, the Arctic has become an extremely active arena for the development of international initiatives falling into a variety of categories," explains Kian Fadaie, National Director of Fisheries and Oceans Canada's Canadian Hydrographic Service. "No matter whether it is sovereignty, environmental science, tourism, legally binding international agreements or international science cooperation initiatives, charting the Arctic is key to ensuring the successful execution and implementation of these initiatives." Because charting is the foundation of navigational safety and many ocean sciences, the Canadian Hydrographic Service will be procuring four new multibeam sonar systems to be installed aboard Canadian Coast Guard icebreakers in order to significantly increase the amount of seafloor surveying conducted in regular operations.

Understanding interconnected ocean environments is vital to the sustainable management of ocean resources, biodiversity and environmental priorities. Resilience in the face of climate change and the responsible consideration of social, environmental, and economic priorities require reliable scientific knowledge. By pooling resources, the various partners within Canada, the United States, and the European Union have been able to collect more data and make greater contributions to the collective, worthwhile goal of maintaining a healthy and productive Atlantic Ocean.

Denis Hains is the Director General, Canadian Hydrographic Service and Oceanographic Services with Fisheries and Oceans Canada. He previously occupied the positions of Director General, Integrated Business Management Services position at the Canadian Coast Guard and Director, Canadian Geodetic Survey with Natural Resources Canada. Mr. Hains holds a Bachelor of Science Degree in Geodesy from Laval University in Québec City, Canada and he is a member of the Québec Land Surveyor Corporation as well as the Canadian Hydrographic Association.

The Top Twelve Ways to Guarantee that You will have a Problem (and Potential Insurance Claim) on Your Next Construction Project

By Joseph Young, O.L.S., on behalf of the Insurance Advisory Committee

Historically, the Insurance Advisory Committee has performed two main functions. The first is to review the annual premium and allocation of the premium formula. The second is to meet quarterly and review all of the claims that have been initiated through our adjusters, Maltman Group International, since the last meeting and comment or potentially advise them on survey-related issues. At the end of each meeting the information shared with the Committee is returned to the adjustors, John Breese or Steve Snider and basically forgotten by the Committee.

I have only been involved with the Committee for a few years now but it is surprising (or perhaps not surprising) that the same types of claims are reviewed at each of our quarterly meetings – and then purposely left behind when we leave the meeting. At a recent meeting we discussed the idea of sharing common claim information with the membership for educational purposes. In future articles when reporting on particular occurrences, all of the names of the surveyors involved in the claims and their clients will be excluded.

In my first article as Chair of the Committee, I thought it would be beneficial to publish the list of the most common and reoccurring actions during a construction project that can lead to insurance claims, which Mark Sampson of The CG&B Group distributes to the articling students during his presentation at the AOLS Professional Lecture Course.

The following list of actions that can lead to claims is in no particular order of cost or frequency of occurrence (all can be equally expensive financially – and damaging to your reputation):

1. Assume that missing dimensions on site plans or architectural plans are not critical to the layout and that it is OK to scale or compute them without further **written** verification from the client. Or, assume that you can decide without further written verification from the client which dimension to hold when the site plan and architectural plan or structural plan do not agree.
2. Assume that digital files from other consultants are always reliable or are the most recent revision, and that you can enquire the drawing to obtain missing design info needed for layout.
3. Believe the site super when he/she says that you don't need a copy of the drawings for your files and Quality Control (QC) review and that the drawings in the trailer are the latest approved drawings and can be used for layout and nothing should change.
4. Succumb to client pressure to get his/her staff or other trades working and allow a field crew to attend the site for preliminary layout work prior to completing the necessary survey research, control establishment, and drawing verification (and/or before the client approves the scope of work and the associated fees).
5. Allow field crews to respond directly to change requests to a design after they arrive on site - the crew is handed the latest revision of the drawings or asked to layout a few unexpected extra points.
6. Allow field crews to use the contractor's control or grid points to verify the contractor's work or to continue with additional layout without independently checking setbacks, horizontal and vertical control, or drawing revisions.
7. Allow field crews to set vertical control on a site from a single bench mark or to run control in a single direction.
8. Allow field crews to set vertical control from the onsite fire hydrant or other temporary structure used in a previous phase of the project.
9. Respond to a client's midday unexpected request for a rush crew to stake some key points for excavation or for footings without completing proper drawing and calculation QC.
10. Continuously alternate crews attending an ongoing construction site and assume they will be aware of any unique conditions and are self sufficient to familiarize themselves when they upload the existing project files.
11. Allow the field crew to prepare field notes and/or to finalize field layout checks including level loop closures or stakeout reports in the office the next day or whenever they are not too busy.
12. Allow the survey project manager to check the crew's layout, level loop closures or stakeout reports at some time other than the next morning or whenever the project manager is not too busy.

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Flying underwater: some results from a swimming hexapod robot

By Michael Jenkin, Ph.D., P.Eng.

Autonomous robots are often proposed as the ideal solution for applications found in complex difficult environments such as disaster investigation and remediation, large-scale infrastructure security, and the like. Such environments pose complex technical tasks in terms of vehicle mobility, sensing, and command and control. Perhaps the most challenging of such environments are found in the sky and underwater. Here the vehicles are presented with a full six degrees of freedom space within which to operate, the space itself is subject to large-scale external forces such as wind and motion of the water column, and errors in vehicle design, implementation or operation can easily result in catastrophic damage or vehicle loss, and certainly imperil mission success.

Although there are many similarities between autonomous flying vehicles and autonomous underwater vehicles there are many differences. Unmanned aerial vehicles (UAV's) can generally assume the existence of a global coordinate frame of reference and reasonably accurate localization within it. Such global localization is not so easily established underwater as the radio signals associated with GPS do not penetrate the water column. To further complicate matters underwater, long distance visibility is a rare occurrence as the water column attenuates light quite quickly. Notwithstanding the technical challenges associated with unmanned underwater vehicles (UUV's) there exist a wide range of real world applications that occur underwater including infrastructure inspection and wildlife monitoring, and a substantive research effort is ongoing worldwide to enhance the capabilities of UUV's to meet the requirements of these applications.

The vast majority of UUV's are based on traditional vehicle designs. They typically use an array of thrusters or thrusters coupled with control surfaces to propel the vehicle through the water column. One downside to this type of approach is that thrusters and propellers, unless properly protected can be a danger to any human operating near the UUV as well as a danger to fish and other aquatic species. Furthermore, this type of locomotive strategy is appropriate only for motion in the water column itself and is not easily adapted to amphibious operation. Given these issues, in the early 2000's, a group of Canadian researchers including Gregory Dudek (McGill University) and I developed AQUA, a six-legged amphibious robot. This robot, shown in Figure 1, was based on the earlier RHex platform and is self-contained for power, sensing and control, and has been operated to depths of over 100 feet. This basic robot design has been used in over a decade of experiments that investigate fundamental and applied questions related to the operation of UUV's in close proximity to humans both underwater and amphibiously.

From a mechanical point of view the AQUA platform is driven by six single degree-of-freedom (DOF) motors each of which actuates an individual fin or flipper. Similar to the fins worn by SCUBA divers underwater, each fin provides directional thrust to the robot. Combining the patterns of motion of each of the fins in an appropriate swimming gait, it is possible to move the robot in a range of directions although not all simple motions are possible. AQUA cannot directly sway, requiring the vehicle to undergo complex maneuvers to execute certain motions including moving side to side. The generation of sophisticated gaits for AQUA has been accomplished through both hand-tuning the pattern of leg motions and also through the automatic generation and tuning of gaits coupled with hydrodynamic modelling and validation on the device itself. Using an appropriate speed gait, the AQUA platform can outpace human divers in the water.

Figure 1. The AQUA being operated at depth by a diver using a tele operational tablet. AQUA is a six-legged swimming robot self-contained for power, sensors and computation.

The photo of AQUA shown in Figure 1 shows the robot equipped with "swimming legs". The vehicle itself was designed to support a range of different leg designs including the swimming legs shown in the photo, as well as purely terrestrial and amphibious leg designs. One reality of the leg designs developed to date is that the best swimming legs and the best walking legs outperform the best amphibious ones, so typically the vehicle is deployed with the legs that are best suited for the task at hand.

Although the AQUA platform has been used as a research platform for a range of different research projects only two will be highlighted here: ego-motion and environment recovery, and human-robot interaction.

Ego-motion estimation and environment recovery. A key problem with performing many tasks with a UUV is the need to develop a model of the environment within which the robot is moving and the robot's pose within it. This task is complicated by the lack of a global position signal, turbidity of the water column, and the motion of fish and debris that may obscure the robot's view of its environment. AQUA is equipped with a forward-facing stereo camera pair and an inertial measurement unit that provides information about the roll, pitch and yaw of the vehicle. Information from these two sensor systems can be integrated to develop a detailed model of the robot's surroundings and the robot's motion within it. For terrestrial vehicles, the process of performing this type of visual odometry is aided by a strong model of the commanded motion of the vehicle. For a free-swimming vehicle this information is not available as the vehicle is not in contact with the ground and wave, tide and current act on the vehicle at all times.

Given the lack of a good motion model, a different approach is followed here. Information from the stereo camera pair is used to build a 3D model of the world at each time instant. 3D point clouds from the previous time instant and the current time instant are coupled with inertial measurements within a robust statistical framework to obtain a 6D egomotion estimate and this information is used to transform 3D points collected over time into a common frame of reference. A key aspect of this approach is the recognition that the environment — although mostly static — does contain a substantive amount of sea life and aquatic snow. The robust statistical framework is used to filter out such "non-stationary" noise from both the environmental model and the egomotion estimation process.

Human-robot interaction. Although the long-term goal of many robotic research projects is the development of fully autonomous robotic systems, practically it is probably more desirable to build autonomous systems that follow the instructions of their human operators. Human-robot communication is a particular problem for UUVs. It can be difficult to ensure that operators of a UUV are appropriately aware of the UUV's state and environmental conditions given their

cont'd on page 26

lack of direct line of sight to the vehicle and the 6 degrees of freedom nature of the robot and underwater tasks. Placing human operators in close proximity to the vehicle helps address some of this operational issue, but introduces a number of problems related to human-robot communication at depth. It is not possible to communicate with the robot using traditional interface devices and even simple wireless communication with the device is not possible.

Within the AQUA project a range of different technologies have been developed to address this issue. Visual tags, either pre-printed or generated using waterproof computer displays, have been used to great effect to communicate from the diver to the robot. For example, a properly enclosed laptop or tablet device with waterproof switches can be used to display machine-readable targets to the robot, which can then interpret the target and respond accordingly. Communication from the robot to the human operator is more complex as the AQUA robot lacks a visible computer display, but very low band-width communication is possible using the robot's external light system.

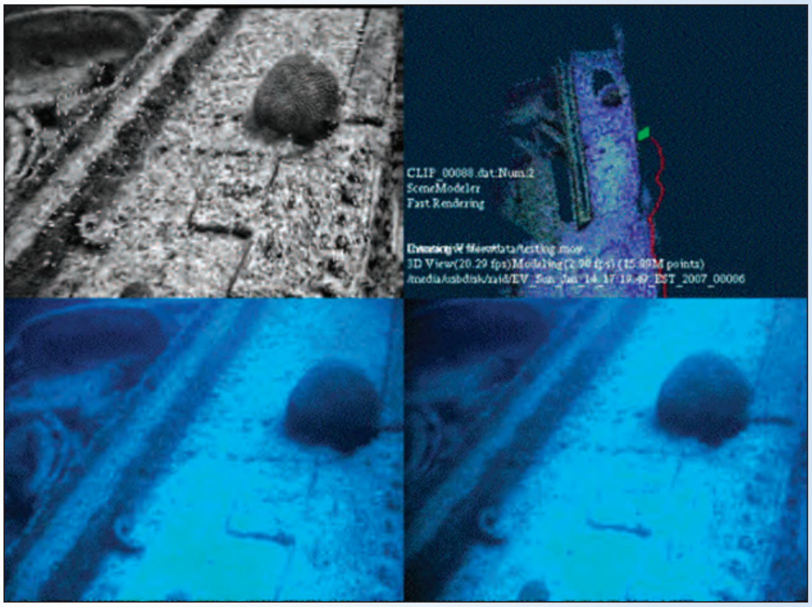


Figure 2. Self-motion estimation and environment recovery. The stereo camera obtains the views shown in the lower half of the image. The upper left shows the motion of features from one time instance to the next. The upper right shows a portion of the recovered 3D model of the wreck along with the estimated motion of the sensor (shown in red) and the position and orientation of the sensor (shown in green).

For more direct operation another approach is to tether the robot to the operator using an appropriate cable as shown in Figure 1. Here the diver is connected to the robot using an optical fibre tether. The operator's control console is based around an Android tablet housed in a waterproof housing augmented with a small number of toggle switches. The tablet itself uses its internal inertial sensors to enable to the diver operator to steer the robot by treating the entire underwater tablet as a joystick, while the switches enable a range of different actions to occur on the robot itself. The tablet display is also used to provide feedback to the diver-operator about the state of the robot and the robot's tasks. Although this approach keeps the diver-operator in relatively close proximity to the robot it still enables the diver-operator to remain at a safe distance from more dangerous environments (e.g., deeper depths, overhead environments and the like) while the robot conducts the more dangerous portion of the task.

The AQUA research project is ongoing with researchers at McGill University and York University continuing to enhance the capabilities of the vehicle. A commercial version of the vehicle is also available through Independent Robotics and the device is beginning to be adopted by researchers worldwide who are interested in conducting research involving unmanned autonomous vehicles.

Michael Jenkin is the director of the York Centre for Field Robotics and Professor of Electrical Engineering and Computer Science at York University. He can be reached by email at **jenkin@cse.yorku.ca**

Acknowledgments. The AQUA robot project is the result of a long-term collaboration between York and McGill universities and would not have been possible without the work of the students, technicians and postdoctoral fellows associated with the project. Financially, the AQUA project acknowledges the generous support of NSERC.

Sites to See

North American River Width Data Set (NARWidth)

http://gaia.geosci.unc.edu/NARWidth/index.html

NARWidth is composed of planform morphometric measurements of North American rivers at approximately mean discharge. It was created using image processing algorithms on Landsat TM and ETM+ imagery. NARWidth is intended to be used in a wide variety of scientific and engineering applications including hydrologic, hydraulic, and biogeochemical models. Additional information can be found on the website in the Data Set Development page.

NEWS FROM 1043

Changes to the Register

Members Deceased

John L. Stewart	CR53	May 25, 2015
G. Douglas Coggan	1414	July 20, 2015
James D. Nisbet	926	Aug. 17, 2015

Retirements/Resignations

Ronald G. McKibbon	1137	June 29, 2015

CofA's Revised

Was: Paul Goodridge, Ontario Land Surveyor
Is: Goodridge Goulet Planning and Surveying Ltd.
North Bay, Ontario, July 25, 2015

CofA's Relinquished

Nisbet, Robertson, Sarnia, Ontario, September 1, 2015

Surveyors in Transit

Rueben Mc Rae is now with **J.D. Barnes Limited** in Whitby, ON.

David Urso is now the managing OLS at **exp Geomatics Inc.** in North Bay.

Adam Domagalski is now the managing OLS at **Sexton McKay Limited (A Division of J.D. Barnes Limited).**

SpatialForge Group is now located at 335 Sutton Rd. RR 2, Gilmour, ON, K0L 1W0. Phone: 613-474-0260.

Harold Hyde is now the managing OLS of **Rasch and Hyde Ltd.** in Dunnville, ON.

Desmond Rasch is now the managing OLS of **Rasch and Hyde Ltd.** in Fort Erie, ON.

Nath Segaran is no longer with **Hunt Surveys Inc.**

Goodridge Goulet Planning and Surveying Ltd. is now located at 490 Main Street East, Unit #1, North Bay, ON, P1B 1B5.

Murray R. Shantz is now with **Ai Geomatics Corporation,** a non-CofA consulting firm, located at 28 Dalecroft Circle, Unionville, ON, L3R 6K2, Phone: 416-399-3447.

Ashenhurst Nouwens & Associates Inc. is now located at 225 King William Street, Suite 112, Hamilton, ON, L8R 1B1.

Zubek, Emo, Patten & Thomsen Ltd. is now located at 200 Mountain Road, Unit 4, Collingwood, ON, L9Y 4V5.

Verhaegen Stubberfield Hartley Brewer Bezaire Inc.is now located at 944 Ottawa Street, Windsor, ON, N8X 2E1.

Alex Marton Ltd. is now located at 160 Applewood Crescent, Unit 8, Concord, ON, L4K 4H2.

Frank Mauro is now the managing OLS at **WSP Geomatics (Ontario) Inc.**

David Kovacs is now with the **Ministry of Transportation Ontario, Geomatics Section** in Thunder Bay, ON. Phone: 807-473-2077.

Martin Nisbet is now the managing OLS at **Monteith & Sutherland Ltd.** which also holds the notes and records of **Nisbet, Robertson.**

Duncan Ashworth is now located at the **Ministry of Transportation Ontario, Geomatics Section** in 1201 Wilson Ave., 3rd Floor Atrium, Bldg "D", Downsview, ON, M3M 1J8. Phone: 416-235-3998.

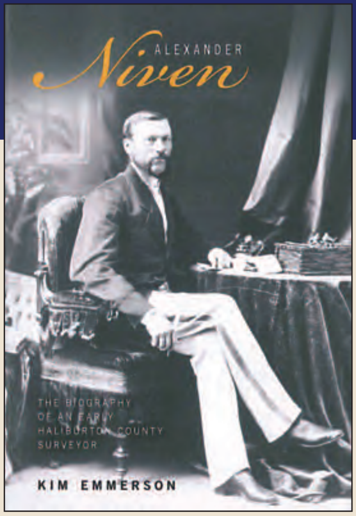
Jason Chun-Ho Mo is now with **Mitsche & Aziz Inc**. in Richmond Hill, ON.

Ganesh Sundar is now with **Ivan B. Wallace Ontario Land Surveyor Ltd.**

cont'd on page 33

A story that needed to be told – *Alexander Niven, the Biography of an Early Haliburton County Surveyor by Kim Emmerson*

By Maureen Mountjoy, O.L.S., Deputy Registrar/Editor
Ontario Professional Surveyor



I first became acquainted with Kim Emmerson when he contacted me in November 2014 to tell me that he was writing a book about Alexander J. Niven, D.L.S., O.L.S. (1836-1911), one of the founding members of the Association of Ontario Land Surveyors (AOLS) and President in 1888 and 1889. Niven who is often referred to as "Ontario's greatest land surveyor" was credited with surveying the interprovincial boundaries of Ontario, Manitoba and Quebec and establishing many base lines in North Eastern Ontario. He was best known for surveying *Niven's Meridian*, a line that he ran in the 1890s straight north from Georgian Bay to James Bay. An Ontario historical plaque located about 3 km west of the Town of Cochrane at a point where the meridian crosses Highway 11 recognizes Niven and his survey.

> ***Niven's Meridian***
>
> ***The surveying of the line which intersects Highway No. 11 here (survey mile-post 162) was the first step taken by the Ontario government in the exploration and development of this region. During the 1890's interest in Ontario's northern mineral, forest and land resources increased rapidly. Accordingly, Alexander Niven (1836-1911) ran an exploration line to James Bay by extending northward what was then the boundary between the Algoma and Nipissing Districts. In 1896 he surveyed the line to mile-post 120 and two years later extended it to a point just north of the Moose River. All later surveys, including the Exploration Survey of 1900 which provided the first detailed report on this region, have been based on this meridian line.***

Kim Emmerson called me because he was sure that many of our members would be interested in the life of Niven during the early days of Ontario and he thought that I might like to feature it in the Book Reviews section of the Ontario Professional Surveyor magazine when it was published. He was right.

In an early email, I asked Kim what made him decide to write a book about Alexander Niven. He replied, "Well, that's a good question. Some of my friends were teasing me that I had lost my mind! Actually, I was born here [in Haliburton] and except for university, have lived here all my life. The business that I have [Emmerson Lumber Limited] is on land that Niven had a big part in. Also, I have an interest in local history. We really don't have a local 'hero' like most towns do, so I thought that it was time that we did. The locals, including the museum, knew of him but information was somewhat of a local mystery. I managed to uncover the mysteries and enjoyed it thoroughly."

In the Preface of the book, Kim writes, "This is the story of one of the true pioneers of Haliburton County. A man who was both interesting and versatile. A man who surveyed across Canada in his later years but chose Haliburton as his home base. A man who was well respected by his peers. A man who was as comfortable in the bush as he was addressing his colleagues at the Parliament Buildings in Toronto. And, a man who expanded his persona with an appreciation of the arts."

Alexander Niven became a Provincial Land Surveyor in 1859. In 1868 he moved to Haliburton not as a surveyor but as a Local Agent for the Canadian Land and Emigration Company Limited. Kim was able to find Niven's diaries from 1869, 1876 and 1884, and a notepad from 1876. He also had access to his survey field notes, AOLS Annual Meeting Reports and a few other sources to "reasonably reconstruct his life". He found that Niven was not only a surveyor, but a politician, a farmer, a real estate speculator and a businessman. He even, according to the book, "…decided to try his hand at teaching." As reported in a paper by Peter Silas Gibson in the 1906 AOLS Annual Report, Niven taught young surveyors about the Surveys Act. He also, as a member of the AOLS Board of Examiners, examined students for their O.L.S. accreditation.

The official launch of Kim's book took place at the Haliburton Highlands Museum on the outskirts of the village of Haliburton in the evening of June 23, 2015. My husband Bob and I just happened to be up at our cottage near Dorset on vacation; it is not too far from Haliburton, so we were able to attend. We had an interesting chat with long-time Haliburton area surveyor Curry Bishop, O.L.S. (Ret). He and his son Greg Bishop, O.L.S. provided Kim with "surveying expertise and local Niven field notes". Bob and I just missed seeing Bruce Pettit, O.L.S. (Ret) and his wife Nancy by a few minutes. As you can see in the photo, the room was set up to celebrate Niven, the land surveyor, with copies of survey plans and notes on display. The community support was very evident; it was very crowded and everyone was excited to get Kim to sign their books. Proceeds from the book sales that evening were donated to the museum.

I think that we are very fortunate that Kim Emmerson's "personal connection with the history of the area and the people" inspired him to research and write the story of Alexander Niven and his life in Haliburton. It reminds us to appreciate those early Ontario Land Surveyors who not only left a legacy by their surveys but were instrumental in founding the association that we are so proud to be members of today.

Bruce Pettit, O.L.S. (Ret) and his wife Nancy chat with Kim Emmerson during his book signing.

On page 365 of his book, Kim references an excerpt from the President's Address at the 1912 Annual General Meeting; AOLS President Thomas Bailey Speight expresses with deep regret the loss of Alexander Niven. "By his death we have lost one of our most honorable and foremost surveyors. The present generation of surveyors need no eulogy of him and for posterity it may be simply stated that they will know him by his good works, which will remain as permanent monuments long after New Ontario has extended its flourishing

cont'd on page 30

Alexander Niven running the Algoma Nippissing Line 1897 *(Credit: AOLS)*

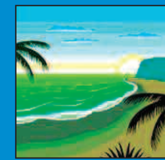
settlements beyond the Transcontinental Railway."

As we discover in the book, Alexander Niven was excessively devoted to his career. Unfortunately all of the time he spent surveying in Northern Ontario kept him away from his wife and family, who left him and moved away. He became a "gypsy of sorts" but always maintained strong emotional ties to Haliburton and called it his home; his wish was to be buried there. Alexander Niven died in his 75th year in Victoria Hospital in Toronto. He rests in the Evergreen Cemetery in Haliburton, which he surveyed in the 1870s.

Alexander J. Niven, D.L.S., O.L.S. *(Credit: AOLS)*

Information about Kim Emmerson's book *Alexander Niven, the Biography of an Early Haliburton County Surveyor* and how it can be purchased can be found on the following website **www.alexanderniven.com** Details about the book are also published in the Book Reviews section on page 35.

Celebrating 20 years of the Geodetic Picnic



The 20th anniversary of the *Geodetic Picnic – Innovations in Geodesy Expo* was celebrated on Friday, September 18, 2015 at the Isaiah Tubbs Resort and Conference Centre in Picton, Ontario.

The idea to hold a one day event to exchange ideas "within the realm of Geodesy" came about during an AOLS Geodetic Committee meeting in May 1995. Ron Berg, O.L.S., O.L.I.P. and James Ferguson, O.L.S., O.L.I.P. have been the primary organizers of the event since the 1st Annual Geodetic Picnic was held on September 30, 1995 at Erindale College, University of Toronto (now UTM). The proceedings of that first meeting were dedicated to the memory of Doctor Attallah Wassef who passed away that October, shortly after the picnic. As many graduates of the Survey Science Program remember, Professor Wassef, a well-respected member of the Geodetic community, taught Geodesy at Erindale College for over 12 years.

"It was a phenomenal pre-fall day at Isaiah Tubbs, and we hope all 105 plus attendees had as fun and educational day as we did" - Ron Berg (left) and James Ferguson.

Over the past 20 years the format has been the same; 3 or 4 speakers, covering a broad range of surveying-related topics, present in the morning; everyone enjoys a bbq lunch and then an outdoor forum is provided for exhibitors in the afternoon. It has always been a very informative event and this year was no exception. Speakers Murray Shantz, Tim Hartley and Dominique Chabot presented their perspectives of a geodetic control network for transit projects; integrating surveys; and mapping with the aid of UAVs and photogrammetric software, respectively, and seven exhibitors took advantage of the good weather to showcase their latest technologies.

Letter to the Editor

Dear Maureen,

If a public airing of a "thank you" is received then, so too, a public "you are welcome" is called for. I refer to the note by Umaru Kargbo in the Summer 2015 Issue of the *Ontario Professional Surveyor*. I was surprised to read the note, but most grateful in the acknowledgment given by Umaru in recognizing the invaluable contribution made by the many guest speakers. Their input and wisdom, based on the collective years of practical experience, represents an indispensable component in the teaching of survey law. We are indeed fortunate to have an undergraduate program in Geomatics Engineering at an Ontario-based university. Nonetheless, this has its own challenges when subjects in survey law are expected to equip the cadastral surveyor of tomorrow with the knowledge and skills to meet the needs of a broad Canadian public in all jurisdictions.

Students of survey law are both challenged and delighted when they realize that law is not a set of rules to be rigidly applied or blindly followed; law sets the context and provides a framework by which cadastral surveyors can approach the challenges of tomorrow. Placing boundaries around parcels of land is less about accurate measurement and more about the qualities which a land information professional has in providing a unique service which supports security of land registration, manages the resource inventory and helps to accommodate a diversity of land tenure types in Canada. Success is not just passing an individual course or two; success is represented by recognizing that professional land surveying involves a commitment to lifelong learning and curiosity.

You are welcome Umaru and your colleagues are to be thanked for being the "All-Star team" that you describe. I look forward to all students being able to embark on the start of fascinating careers in which no two days will ever be alike and the insights learned in survey law inspire creativity in the service of a profession.

Izaak de Rijcke

Sites to See

Flying an Unmanned Aircraft – Update on Permission and Safety Requirements

http://www.tc.gc.ca/eng/civilaviation/standards/standards-4179.html

Transport Canada (TC) regulates unmanned aircraft to keep the public and our airspace safe. As of June 26, 2015, to fly your unmanned aircraft for work or research, you may need to follow strict safety conditions outlined in an exemption or apply for permission from Transport Canada. It depends on the type of aircraft, its weight, as well as how and where you plan to use it. If you qualify for an exemption, you must meet the safety conditions at all times. If you cannot or choose not to meet the safety conditions in the UAV exemptions, you must apply for a Special Flight Operations Certificate (SFOC).

NEWS FROM 1043

cont'd from page 27

THE AOLS IS PLEASED TO ANNOUNCE THAT THE FOLLOWING ONTARIO LAND SURVEYORS WERE SWORN IN:

Gualberto C. Calonia	1982	July 10, 2015	Vaitheki Kumar	1986	July 20, 2015
Matthew de Jager	1983	July 10, 2015	Sophie-Rose Côté	1987	July 20, 2015
Mansour Ghofrani	1984	July 20, 2015	Christopher Fox	1988	August 19, 2015
Simon A. Kasprzak	1985	July 20, 2015			

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BOB MOUNTJOY
JIM NICHOLSON
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FREDERICK J.S. PEARCE
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EDUCATIONAL FOUNDATION NEWS

Two New Awards presented at Richmond Green Secondary School

The very first *Introduction to Surveying* course, created for grade 11 and 12 students in the Construction and Technological Design Department at Richmond Green Secondary School, was successfully delivered in the fall of 2014 and again in the spring of 2015. The feedback from the students was very positive. Since this is such a unique program, the Board of Directors of the Educational Foundation established two new awards, valued at $500 each, for the highest achieving male student and the highest achieving female student from both semesters combined.

Students completing their field assignments at Richmond Green Secondary School.

Joseph Young, President of J. D. Barnes Limited, who was instrumental in helping teacher John Negru launch the course, was invited to attend the Richmond Green graduation ceremony on June 23rd to present awards to **Benedict Ho** and **Vanessa Yiu**. Congratulations to both students.

November 1st - Time to join or renew your membership

As fall approaches we are reminded that it is the time of year that post-secondary students are beginning their fall term as new students or returning students. Some will be looking forward to graduating in the spring of 2016 and hopefully will be turning to our association to begin their professional careers. Currently we have 16 articling students who are Educational Foundation award winners. With rising tuition fees and the expense of living away from home, students feel fortunate to receive an award to supplement their education. Donations can be made online on the AOLS website www.aols.org

BOOK REVIEWS

Published by FriesenPress

ISBN 978-1-4602-6340-2

Alexander Niven

The Biography of an Early Haliburton County Surveyor

By Kim Emmerson

Set in the late 1800s, this well-researched biography takes us into the heart of newly settled Upper Canada, and the rich beginnings of Haliburton County, Ontario. We get a thoughtful and thorough look at the history of the area as we meet Alexander Niven; surveyor, politician, farmer, adventurer, educator, and influential businessman in a blossoming locale. We meet Niven's contemporaries, who alongside this versatile surveyor, formed and shaped the "back woods" settlement into the beautiful area we are familiar with today. This very informative and entertaining biography will immerse you in exciting and sometimes trying times of the period, and paint a picture of early settlement in Haliburton County.

Information taken from the back cover.

Time and Navigation

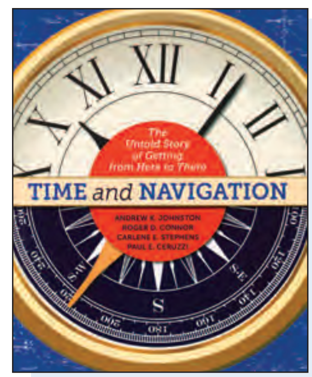
The Untold Story of Getting from Here to There

By Andrew K. Johnston, Roger D. Connor, Carlene E. Stephens, Paul E. Ceruzzi

This beautifully illustrated book covers the breadth of navigation history. It begins with the early history of navigation at sea, including the eighteenth-century development of the marine chronometer and solving the problem of measuring longitude. Explorers then turned their sights to the skies; the need to navigate in the air led to the development of bubble sextants and instruments used by Charles Lindbergh as well as the electronic methods used during World War II. The space race required new technology for navigating in space, including the atomic clock. The next phase in navigation history was the invention of satellite systems for navigating on the Earth. The book also explores the ubiquity of global navigation systems in day-to-day modern life with GPS devices, smartphones, and other personal electronics.

Complete with bios about pioneering navigators as well as missteps in technology that led to later navigation advances, *Time and Navigation* explores the history of navigation technology and its social implications. It helps us understand where we have been, how we got there, and where we are going.

Information taken from inside the front cover.



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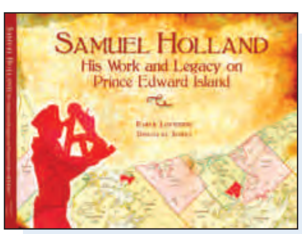

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Samuel Holland

His Work and Legacy on Prince Edward Island

By Earle Lockerby and Douglas Sobey

As surveyor general of the Northern District (eastern North America north of the Potomac River), Captain Samuel Holland surveyed and mapped more than 10,000 miles of coastline from 1764 to 1775. A decade later his survey work along the St. Lawrence River in Upper Canada formed the basis for Loyalist settlement in what is now the Province of Ontario. Governor Simcoe commemorated Holland in his naming of Holland Landing and the Holland River.

Prince Edward Island is where Holland began his General Survey in 1764. The book focuses on the survey of the Island where Holland's mapping produced the first truly accurate map of PEI and where his work has had a more profound and enduring economic, political and social impact than anywhere else. This arose largely on account of the manner in which the British government made land grants that were closely tied to Holland's map, i.e., the land proprietorship system that ensued.

This book, which is well illustrated with maps, addresses Holland's training and the implementation of the survey and provides a critique assessment of the results of his work – including the accuracy of his large (13 feet by 9 feet) map which is on exhibition in Charlottetown after an absence of 250 years. Holland's legacy on the Island is huge and is competently treated in this book, the authors of which are historians with scientific and technical backgrounds.

Information provided by the authors.

The Last Word

Bergeron Centre for Engineering Excellence, York University, Toronto, Ontario

The *Bergeron Centre for Engineering Excellence*, the new home of the Lassonde School of Engineering, will be opening soon. Built in part from a generous, $10 million donation from Doug and Sandra Bergeron, for whom the Centre is named, the new building promises to be a one-of-a-kind addition to what has in recent years been an exciting time for development in engineering at York University.

The vision of the building nicknamed “The Cloud” was “Inspired by nature, the Cloud floats over the rock”. The concept sketch, which incorporates a glass façade in a series of geometric patterns, was created by Architect, Gregory H. Woods, who sadly passed away in 2013. As a consultant for ZAS Architects, he was the design lead for the project.

The Bergeron Centre, which challenges the tradition to define and confine students by engineering discipline, will encompass 167,500 sq. ft. of mixed, open-concept, fluid, highly flexible classroom spaces, alongside study rooms and labs. It brings with it an ambitious goal to realize an engineering school like no other and voice the Lassonde School of Engineering mandate to educate future *Renaissance Engineers:* entrepreneurial engineers with a social conscience and a sense of global citizenship, who will come to campus for active learning sessions with professors, classmates and mentors.

Source of information: http://thebergeroncentre.ca

> “We want Canada’s most promising engineers and entrepreneurs to thrive, to innovate, and to eventually change the world.” *Douglas G. Bergeron, B.A. with Special Honours in Computer Science, York University*

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