

**Geodesy and Geomatics Engineering  
Graduate Seminar and Student Technical Conference**

*Dineen Auditorium – C13  
Monday March 10<sup>th</sup>, 2008*

- 01:30      Opening Remarks  
            Chair: Ian Church
- 01:40      On the Assessment of Geoid Models  
            *David Avalos*
- 02:00      Geodetic Monitoring and Physical Interpretation of Deformation in PCS Potash  
            Mine in Sussex, NB, Canada  
            *Maciej A. Bazanowski*
- 02:20      A Generic Method for RPC Refinement Using Ground Control Information  
            *Zhen Xiong*
- 02:40      Geographic Information Services For Public Health  
            *Sheng Gao*
- 03:00      Assessment of NAD83 (CSRS) Weekly Solutions as part of a Stable North  
            American Reference Frame (SNARF)  
            *James Mtamakaya*
- 03:20      Closing Remarks
- 03:30      **Light Refreshments in Lobby**

**Geodesy and Geomatics Engineering  
Graduate Seminar and Student Technical Conference**

*Dineen Auditorium – C13  
Tuesday March 11<sup>th</sup>, 2008*

- 09:00            Opening Remarks
- Session 1        Geographic Engineering and Ocean Mapping**  
**Chair: Kealeboga Moreri**
- 09:10            Managing Oceanographic Profile Data to Support Hydrographic Data  
Management  
*Suresh Jeyaverasingam*
- 09:25            Examination of the Behavior of Sub-Sea Sand Dunes off the Coast of Grand  
Manan Island  
*Clark Langridge*
- 09:40            Boundary Dispute Resolutions in the Provinces of Alberta, Quebec, Ontario and  
New Brunswick  
*Natalie Waye*
- 09:55            3D Image Processing and Online Mapping  
*Burns Foster*
- 10:10            An Analysis of Municipal Offshore Boundaries in Rio de Janeiro, Brazil  
*Jennifer Hennessy*
- 10:25            **Coffee Break**
- Session 2        Surveying**  
**Chair: Vincent Le Roy**
- 10:45            High Precision Measurements in HA17 to Position Pillars in Target X,Y,Z  
System  
*Rory C. O'Connell*
- 11:00            Can RTK GPS attain the accuracy required to coordinate a Legal Survey?  
*Timothy Moore*
- 11:15            Governing the use of GPS in Cadastral Surveying in Western Canada  
*Marc Steeves*
- 11:30            Testing Electronic Tacheometers for Urban Cadastral Surveying  
*James Dorland*
- 11:45            Analysis of the Performance of four High-Precision Geodetic Theodolites in a  
Metrology environment.  
*Adam Patterson*

- 12:00-1:15      Lunch
- Session 3      GPS and Geodesy**  
**Chair: Ben Wuest**
- 01:15            A Comparison between GPS C/A Code and L2C Code Under Limiting Acquisition Conditions  
*Kyle Bower*
- 01:30            Analysis of the Empirical Stochastic Model  
*Jeremy Inman*
- 01:45            A Simulation and Analysis of a Hull-Mounted LBL System  
*Brett Richardson*
- 02:00            An Assessment of the New Global Earth Gravitational Model EGM08  
*Genevieve Baker*
- 02:15            **Coffee Break**
- Session 4      CIG Paper Competition**  
**Chair: Tristan Goulden**
- 02:30            A Comparative Analysis of RTK GPS and Conventional Methods for Delayed Posting  
*Christopher Fox*
- 02:45            Examining Gridding Methods of Lidar Data of an Urban Area  
*Sarah Moore*
- 03:00            An evaluation of Leica Spidernet for RTK reference data at various baselines  
*Nick Bardsley*
- 03:15            An Analysis of Contouring Algorithms within CARIS Software  
*Alix d'Entremont*
- 03:30            Analysis of Multi-frequency Carrier Phase Linear Combinations for GNSS  
*Landon Urquhart*
- 03:45            Graduate Awards Presentation**
- 04:00            CIG Paper Competition Award Presentation**
- 04:15            Reception in C-122**

# On the Assessment of Geoid Models

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## Abstract

Geoid modelling is now theoretically robust considering the powerful theoretical basis developed by the Geodesy Research Laboratory, but it continues improving. Its practical implementation involves software which was chosen to compute official national geoid models for both Canada and Mexico. However, determining the quality of a geoid model is a difficult task, for many factors like the accuracy and geographic distribution of input data may affect unpredictably the accuracy of the final product. A practical and common way to assess the accuracy of geoid models is comparison versus geoidal heights from GPS observations on benchmarks. It is shown that the knowledge of vertical crustal movements play an important role for this technique to be valid. Vertical displacements over Mexican territory have been unknown and this work intends to produce estimations useful to assess the corresponding geoid model.

Point estimations of vertical crustal movements have been made using GPS time series from two Mexican networks of reference stations. Using precise point positioning technique to compute sampled daily positions of each station, it has been obtained an estimate of the time change in geodetic height. The results show significant land motion ranging from -59 to 0 mm/year, which should be considered when deriving height values from old reference marks and when combining height values from different epochs. A parallel set of vertical velocities was derived from tidegauge records of mean sea level. Analyzing the impact of these velocities in the geoid assessment technique, it has been found that metre level errors can be expected from geoidal heights derived from GPS on benchmarks when the vertical displacements are neglected in the Mexican scenario.

# **Geodetic Monitoring and Physical Interpretation of Deformation in PCS Potash Mine in Sussex, NB, Canada.**

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## **Abstract**

Potash Corporation of Saskatchewan (PCS) potash mine is located 8 km east of Sussex, N.B., Canada. Mining of high grade sylvinitic deposit started in mid 1980's. Since 1989 PCS started systematic monitoring programs in cooperation with UNB. Initially, monitoring included only geodetic levelling. In 1993 GPS was added. In the same year Total Station was used for the first time to monitor horizontal movements. Currently all three methods are used simultaneously to measure the annual movements of the surface. In 1995, based on monitoring results, geological data and mechanical properties of the rock masses the first prediction model of subsidence was created, using Finite Elements Method (FEM). The main goal was to determine future annual and final deformations. In 1997 the water inflow to lower parts of the mine took place, which resulted in occurrence of secondary subsidence basin on the surface. Another prediction models using FEM was performed to determine what was the cause of water inflow. It was established that the mining activity changed the initial stress field in the rock masses in such a way that it allowed for water flow from previously unknown underground water reservoir. The FEM models helped to determine the approximate size and location of aforementioned reservoir using the monitoring results. Comparison of monitoring results with prediction model allows for better understanding of the behaviour of rock masses and optimal design of future mining activity.

# **A Generic Method for RPC Refinement Using Ground Control**

## **Information**

Zhen Xiong

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## **Abstract**

RPC is a kind of generic sensor model which can be used in different remote sensing systems, such as the high resolution satellite and air borne remote sensing system. Up to date, numerous researchers have published a lot of papers about RPC refinement. The bias-compensation method is so far the best one which is accepted and widely used. But bias-compensation method has rigorous conditions. It can only be used to improve the RPC of the narrow field of view camera with small enough attitude error, such as the IKONOS, QuickBird. In many cases, these rigorous conditions may not be satisfied, e.g. the wide field of view camera and some satellites with large ephemeris error and attitude error. Therefore, a robust method which can be used to refine RPC under different conditions is always attractive. In this paper, a generic method for RPC refinement is proposed. The method restores the sensor's pseudo position and attitude first. Then the sensor's position and attitude are adjusted using ground control points. Finally a new RPC is generated based on the adjusted sensor's position and attitude. At the beginning of the paper, we review the latest ten years research on RPC refinement, and compare the characteristics of different methods. Later we present the methodology of the proposed generic method for RPC refinement. In the experiment section, we designed two sets of experiments to compare the proposed generic method and the bias-compensation method. The experiment results show that the bias-compensation method works well only when the rigorous conditions are met. With the increasing of the sensor's position error and attitude error, the accuracy of the refined RPC by the bias-compensation method reduces fast. But the proposed generic method works well and can always improve the RPC to a sufficient high degree of accuracy under different conditions.

# **Geographic Information Services for Public Health**

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## **Abstract**

With the growing concern of people on public health security, sharing of health information has become very important. Due to the natural relation of health information with spatial location, Geographical Information System (GIS) provides an efficient and dynamic way to generate health maps. The emergence of Web based GIS provides flexible data sharing and possibility for human collaboration via the Internet. However, four major problems still exist in these geographic health applications. They are related to health mapping methods, mapping variables, reusability of health applications, and interoperability issues.

To handle these problems, we designed a Health Representation XML (HRXML) schema and SOA based framework to support health data sharing and representation. The HRXML schema makes it possible to exchange the statistical results of health data as well as their representation based on XML and GML. The HRXML schema includes three parts: health, mapping data, and representation. To achieve interoperability in geographic health applications, the geospatial standards, proposed by Open Geospatial Consortium (OGC), such as Web Map Service (WMS), Web Feature Service (WFS), and Web Processing Service (WPS) are implemented to enable the statistical exploration and representation of health information. A web portal is developed for community health Programs of the New Brunswick Lung Association to support the integration of different services for visualization of health maps, hypothesis generation, and decision making. This architecture provides quick access to spatial and health data for understanding the trends in diseases, and promotes the growth and enrichment of the Spatial Data Infrastructure (SDI) in the public health sector.

# **Assessment of NAD83 (CSRS) Weekly Solutions as part of a Stable North American Reference Frame (SNARF)**

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## **Abstract**

The International Earth Rotation and Reference Frames Service (IERS) and International Global Navigation Satellite System (IGNSS) are the IAG services that provides accurate and consistent reference frame, including velocity models, procedures and transformations, tied to the International Terrestrial Reference Frame (ITRF). They accomplish through regional working groups 1.3a through 1.3f of IAG Sub commission 1.3-Regional Reference Frames. Group 1.3c is the North American Reference Frame.

For long, the Geodetic Survey Division of Natural Resources Canada (NRCan) has been playing a leading role in the maintenance and densification of the International Terrestrial Reference Frame (ITRF) in North America. The NAREF network has continuously operating GPS reference stations (about 1000) that are operated and maintained by six (6) different groups in Canada and the U.S. Each group provides weekly coordinate solutions which are combined together in an official NAREF solution that is aligned with the ITRF reference frame of date. Currently, the solutions are also used to estimate annual velocity solutions that are used to evaluate crustal deformations in various parts of the continent and to more accurately determine the motion of stable North America as basis of definition of a plate-fixed Stable North American Reference Frame (SNARF). This new, high accuracy reference frame may eventually supersede NAD83.

This Graduate Seminar reviews and assesses the weekly NAD83 (CSRS) solution as computed by the Geodetic Survey Division of NRCan for the month of March, 2006. A free adjustment approach has been adopted with the Bernese software V5.0 available at the GGE department, using the most recent error models available.



# **Managing Oceanographic Profile Data to Support Hydrographic Data Management**

Suresh Jeyaverasingam

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## **Abstract**

This technical report addresses the needs of oceanographic and hydrographic data management issues, and specifically aims to fulfill two objectives. The first objective is with regard to presenting a case for manufacturers of Moving Vessel Profilers (MVP) and other oceanographic sampling devices in general, to use XML as a data storage format. The manufacturer that is cited in this TR is ODIM Brooke Ocean, based out of Dartmouth, Nova Scotia. The second objective is to demonstrate to the Ocean Mapping Group (OMG) of the University of New Brunswick the benefits of using a database backend as a central data repository for their oceanographic and hydrographic data holdings. The first objective entailed the review of existing XML format for storing oceanographic profile data before suggesting a replacement format. The replacement format recommended in this TR is the NcML-GML mediation markup language. The second objective entailed the development of a fully functional web application prototype that allowed the interactive query, display and extraction of oceanographic profile data for OMG survey programs of the Nova Scotia coast. The web application could be reached at <http://jsuresh.net/googleMaps2/mapIndex.php>. The objectives for this TR were fully achieved.

# **Examination of the Behaviour of Sub-Sea Sand Dunes off the Coast of Grand Manan Island**

Clark Langridge

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## **Abstract**

With the continually increasing concerns about the impact of human activities, more and more emphasis is being placed upon alternative energy sources. One of these proposed sources is tidal power generation: a more stable and reliable source of energy than wind or solar power. In order to place these structures on the sea floor, however, the stability of the sea floor must be determined. Even after installation, some method is needed to determine whether there are any changes occurring in the seabed near the generators.

In this presentation, we explore the use of a spatial cross correlation algorithm as a method for determining how the surface of the sea floor is changing with time. To do this, we use data collected by the Ocean Mapping Group of the University of New Brunswick during the summer of 2007 survey season. This data consists of a set of six sandwave fields off the southern coast of Grand Manan Island. As well, recommendations are made as to how the spatial cross correlation algorithm, as well as the survey techniques, may be improved for the future.

# **Boundary Dispute Resolutions in the Provinces of Alberta, Quebec, Ontario and New Brunswick**

Natalie Waye

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## **Abstract**

A thorough review of the current non-judicial boundary confirmation mechanisms is needed for the provinces of Canada. The number of boundary uncertainties lying dormant in provinces is increasing; therefore an assessment of the mechanisms to resolve them is required. Provinces have individually developed legislation and procedures for the management of boundary confirmation within each of its jurisdictions. Alternative Dispute Resolution (ADR) is a term used for a wide range of processes which can be used to resolve disputes other than the usual steps in court cases, such as litigation. Some provinces have developed such ADR methods for solving disputes over the confirmation of boundaries through arbitration, mediation, and negotiation. These alternative dispute resolution methods are also designed to reduce the number of cases in the congested provincial court system and to increase the level of expertise in difficult boundary cases. Knowledge of ADR within the land surveying community is increasingly important.

This report reviews the current non-judicial boundary confirmation mechanisms in 4 Canadian provinces: Alberta, Quebec, Ontario and New Brunswick. The major focus is on Alberta's *New Boundary Resolution Process* and the centuries old process in Quebec, *bornage*. These two processes will be thoroughly examined, followed with recommendations for their improvement. Alternative approaches, i.e., the *Boundaries Act* and the *Boundaries Confirmation Act*, in Ontario and New Brunswick respectively, will also be overviewed and assessed. The overall goal of the report is to show how

specific provinces approach boundary disputes and if these processes could be helped with a larger understanding of alternative dispute resolutions.

# **3D Image Processing and Online Mapping**

Burns Foster

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## **Abstract**

This project revolves around adapting existing software for conventional 2D displays (monitors) to work with new technology, namely an autostereoscopic display, which is capable of displaying stereo images in 3D without the need for additional visual aids (e.g. colored or polarized glasses). The software package was developed by previous graduate students and research assistants under the supervision of Dr. Yun Zhang, which processes overlapping pairs of high-resolution satellite imagery into a single anaglyph (red/cyan) image. The resulting image can be viewed in colour 3D on conventional 2D displays using red/cyan glasses, transmitted to the user via web page documents accessed over the Internet.

The processing aspect of the system involves the use of automatic matching and re-sampling overlapping satellite images into epipolar images, which are then merged into a single anaglyph format image. For display on an autostereoscopic (3D) monitor, a new image format was chosen from four available options, namely a line interlaced format, where alternating pixel rows from each image are merged into a single image in full colour. The processing software was modified such that the generated epipolar images can now be merged in either the anaglyph or interlaced format.

The display aspect of the system involves a Java Applet imbedded into a web page document, transmitted to a client machine and executed locally. The Java Applet then retrieves the image to be displayed from the server and presents them in a typical imagery viewer, which features standard pan and zoom functionality. Some modification had to

be made to accommodate the new line interlaced format. In particular, a 3D Refining function, which reduces the parallaxic separation of objects in anaglyph images for more comfortable viewing, had to be disabled when viewing the new format, while still remaining enabled for anaglyph images.

The adaptation of the software succeeded in satisfying all requirements, and interested viewers with autostereoscopic displays can now access these images over the Internet. Further research might include adapting the Java Applet for a different autostereoscopic display method, one which preserves more image resolution than the current line interlace.

# **An Analysis of Municipal Offshore Boundaries in Rio de Janeiro, Brazil**

Jennifer Hennessy

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## **Abstract**

The potential of offshore petroleum resources along the coast of Brazil results in a need to delimit offshore boundaries between municipalities. There are numerous municipalities in Brazil who are unable to reach an agreement on the locations of such boundaries. The purpose of this report is to investigate two of the significant delimitation issues which may be preventing these municipalities from reaching an agreement. The first issues deals with how the boundaries are currently being delimited and the second issue deals with how much a change in reference frame is shifting the map projection.

The first issue has been examined in this report by generating municipal offshore boundaries using CARIS LOTS<sup>®</sup> software according to the Brazilian legislation. Some additional boundaries have also been generated as possible alternate solutions. The second boundary delimitation issue of this report has been examined by using ArcGIS<sup>®</sup>. software to transform the boundaries generated in one reference frame to another.

The method of generating boundaries according to the Brazilian legislation yielded two very different boundary solutions which results in an inequitable boundary solutions for certain municipalities. One of the proposed alternate boundary solutions yielded a much more equitable boundary between the municipalities than the boundaries which were generated based on the Brazilian legislation. It is recommended that Brazil modifies their legislation so that municipalities can delimit consistent boundaries that are more equitable, such as the alternate boundary solution.

The results of the coordinate transformations on the delimited boundaries yielded large offsets which indicate that Brazil needs to be consistent with the reference frame used.



# **High Precision Measurements in HA17 to Position Pillars in Target X,Y,Z System**

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## **Abstract**

Three dimensional [3D] coordinating is not a new technique in positioning point targets. However, its use has not been very common in the past 15 years despite the particularly impressive accuracies attained by a proper coordination effort. The overall goal of the research performed here was to determine precise coordinates for the pillars in HA17 by utilizing a precision electronic theodolite.

Although simulations suggested that the confidence regions and vertical intervals should be well within the sub-millimetre range, due to a large variance factor, the results do not concur with the predictions. In the past, similar methods have been employed in other projects claiming that the sub-millimetre range is achievable as well. Unfortunately the discrepancy between the results and these claims may be due to use of software designed specifically for geocentric coordinate use rather than Cartesian coordinate adjustments. However, results from this research still show impressive precision with 95% confidence intervals near the millimetre mark, indicating that this technology is still competitive as a tool for high precision applications.

# **Can RTK GPS Attain the Accuracy Required to Coordinate a Legal Survey?**

Timothy Moore

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## **Abstract**

Real time kinematic (RTK) GPS is a fast and efficient way to survey, compared to traditional methods. This report tests whether RTK GPS can achieve the accuracy required to set up control points for a legal survey.

To begin, this report provides a brief overview on how GPS works then continues into a more in depth look at its RTK aspects. This report also provides information about the standards set in place by various associations across Canada on the use of GPS as a control survey tool. Some fieldwork work was done comparing the positions of known coordinated monuments to determinations by the RTK receiver. This data was analyzed to make a statement about the accuracy of an RTK unit and this was compared to the New Brunswick standards to make a decision.

In the end, the result veered towards being negative, but recommendations were also made for better standards to be created for dealing with GPS.

# **Governing the use of GPS in Cadastral Surveying in Western Canada**

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## **Abstract**

The objective behind this report is to review publications from the land surveyor's associations with regard to the use of GPS technology within the profession. As a professional association, the land surveyors are responsible for governing the use of any equipment within their jurisdictions. It is this reason that guidelines and standards publications are a necessary means to ensure this transpires. This report will cover the publications put forth by the respective Saskatchewan, Alberta, British Columbia, and Canadian land surveyors associations or government agencies. Examining these four jurisdictions will provide insight into how the land surveyors have accommodated the integration of GPS into their profession. This insight is to give more detail into what areas the guidelines address, also what are the difficulties in compiling and maintaining such a work. The review of each jurisdiction is to be supplemented with an interview from the respective association's executive director or other recommended personnel for the purpose of providing an inside perspective on the matter.

# **Testing Electronic Tacheometers for Urban Cadastral Surveying**

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## **Abstract**

Cadastral surveyors are forced to place a lot of trust in the manufactures of electronic tacheometers since; they are unwilling to release the results of their own internal testing; the purchase price of proper calibration equipment is prohibitive; and no independent testing laboratories are commonly available to have these instruments checked. A hierarchy of testing and calibration and its applicability from initial product release to everyday use is described. A comprehensive overview of error sources encountered during the use of electronic tacheometers is examined. Taking into consideration these error sources and equipment commonly available and used by cadastral surveyors, performance tests are described and results from an actual field example are given.

# **Analysis of the Performance of four High-Precision Geodetic Theodolites in a Metrology Environment**

Adam Patterson

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## **Abstract**

Metrology surveys often require the highest degree of accuracy achievable. The level of accuracy attainable with a theodolite is highly dependent on the effects systematic and random errors. The current standard used to estimate a theodolite's precision has serious shortcomings with respect to metrology observations.

A modified ISO test was developed and carried out to estimate the performance of four high-precision theodolites in a metrology environment. Several tests were developed and carried out for several theodolite accessories with specific metrology applications. Results show that two instruments failed to meet their manufacturer's claimed performance and that the Kern E2 is best suited for metrology applications due to its higher degree of precision and stability.

# **A Comparison between GPS C/A Code and L2C Code Under Limiting Acquisition Conditions**

Kyle Bower

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## **Abstract**

With the modernization of the GPS signal, there are numerous possibilities for new GPS applications. The Block IIR-M satellites are in the midst of being launched into a full constellation. These satellites are the introduction of the M-code and, more importantly to civilian use, the L2 civil signal. L2C is projected to be similar to the C/A code, yet more advanced with possibilities of new applications. The new L2C signal can be beneficial to both dual-frequency users in professional engineering and surveying as well as consumer and commercial use found in single-frequency GPS units.

L2C was created to offer the L2 frequency a similar, but more advanced signal than the C/A code readily available on the L1 frequency. To test the new L2C signal, a comparative analysis was devised to demonstrate how well L2C performs with respect to C/A code. The GPS survey was designed to see how the signals performed under different limiting acquisition conditions ranging from open sky coverage to tree coverage to indoor applications. The analysis of the data targets the signal availability and the signal-to-noise ratio in attempt to determine if L2C provides an equally or more robust signal than the C/A code.

# **Analysis of the Empirical Stochastic Model**

Jeremy Inman

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## **Abstract**

Stochastic modeling has an influence on coordinate determination using GPS and plays a fundamental role in GPS data processing. This work provides an analysis of an empirical stochastic method for creating the covariance matrix for GPS observations. The intentions are to further validate the developed model through data processing and residual assessment. Understanding the stochastic behavior of GPS observations allows realistic estimates to be generated and consecutively improves GPS data processing.

The Empirical Stochastic model (ESto model) attempts to fully populate the covariance matrix of the observations through stochastic analysis of raw data. The parameters of the stochastic model are determined empirically. They are used to create the observation covariance matrix utilized in the ESto model. The model was designed to handle short GPS baselines therefore a short baseline was processed. As a comparison, two additional stochastic methods (Formal DD and Elevation-based) are introduced and used to process the same baseline.

In the present study, findings were compared with past results which were determined during the development of the ESto model. The obtained results do not provide further validation for the model as uncertainty exists regarding the current findings. The

similarities which were present give some reassurance that further research of the model will provide improvements in GPS data processing.

## **A Simulation and Analysis of a Hull-Mounted LBL System**

Brett Richardson

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### **Abstract**

Because of extreme current conditions in the San Francisco Bay, traditional sub-sea survey techniques are not providing the positioning precision that is required in the area. With this in mind, this report is focused on the modeling of an alternative positioning method that may be used to overcome the significant changes in the water's sound speed over short periods of time.

By developing a Monte Carlo simulation of the model, scenario based data can be created by varying the simulation inputs. This allows for result precisions (data repeatability) to be studied. The report presents with figurative explanations the results of the processed data along with descriptions of the technical aspects of the model development and the testing procedures performed. Results are provided for two different barge geometries. In the scenario 1 model, the drill string is lowered through the moon-pool (center of the barge) down to the seafloor. The scenario 2 model has the drill string lowered off the side of the barge.

In the report, sensitivity of the barge's horizontal position is analyzed when sound speed changes are applied. These sound speed changes are represented by scaling the acoustic



ranges in the simulation. Results presented are based on acoustic range scalings of 0%, -5%, and 10% of water depth. These are unrealistic scalings and for that reason it shows the strengths and weaknesses of the two models. It will be seen that when these range scalings are implemented, the scenario 1 barge model can maintain its horizontal position to within 20 cm at a 95% confidence level. The scenario 2 barge results are not as good, as its horizontal position varied by approximately 4 m between the -5% and 10% acoustic range scaling tests.

# **An Assessment of the New Global Earth Gravitational Model EGM08**

Genevieve Baker

*Supervisor: Dr. Marcelo Santos*

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## **Abstract**

The Earth Gravitational Model 2008 (EGM08) will be the newest model to provide a global fit to the geoid, the surface that approximates mean sea level. The model was designed through a collaboration of the National Aeronautics and Space Administration Goddard Space Flight Center (NASA GSFC), the National Imagery Mapping Agency (NIMA) and Ohio State University. Before the release of the official EGM08, the test model, PGM2007A, will be assessed by a Joint Working Group (JWG).

The aim of the EGM08 is to provide the best global fit for the geoid over the surface of the Earth. As GPS and other technology become more advanced, it has become increasingly more important that the most accurate model of the geoid be established, and only with the input of many tests and assessments can this truly be done.

This report provides an analysis of the test model in Mexico. Different input methods were available for the computation of the geoidal undulations at scattered points. Two data sets comprised of GPS observations on levelling benchmarks were input into the PGM2007A and compared with the original data. Differences ranged from 1.838 m to -1.134 m. The best results were found using the first input option,  $isw = 80$ , and an

average difference of 0.50-0.60 m was obtained depending on which input file was used. The Mexican geoid, GGM05, was also examined to see how the global model compared to a localized model. The average difference was 0.672 m. Maps were created to ease the visualization of the differences and to help with the analysis.

## **A Comparative Analysis of RTK GPS and Conventional Methods for Delayed Posting**

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### **Abstract**

In order to implement the use of RTK GPS in delayed posting applications, precisions of less than two centimetres must be achievable in the horizontal components. These results must be attainable at a reasonable frequency so as to make the implementation of these systems beneficial to the user. The implementation of these systems at a high level, coupled with the current conventional method could potentially lead to a far more efficient process for delayed posting projects.

This research determines under what conditions RTK GPS and conventional Total Stations are able to attain the required precisions for a typical delayed posting site. Both conventional and RTK data have been collected and analyzed in a case study, completed in the field on a delayed posting project.

It is shown that RTK GPS cannot achieve the required precision one hundred percent of the time, but that given an ideal GPS environment the required precisions can be met.

Furthermore, it shows that the most efficient method for these types of projects involves a combination of the two methods which utilizes the strengths of each individual method.

## **Examining Gridding Methods of Lidar Data of an Urban Area**

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### **Abstract**

When processing LiDAR data, it is difficult to determine what gridding method should be used. There has been very little research done on the selection of a proper gridding method for the processing of LiDAR data from an urban area. Those processing the data often choose Triangulation without any reason other than its quick gridding time and its ability to honour the actual data points. This report examines the different gridding methods that can be used to process the LiDAR data and makes recommendations on what gridding methods and parameters should be used when processing LiDAR data of an urban area.

LiDAR data collected over the University of New Brunswick campus was gridded in Surfer© using the different methods and parameters that could be chosen. This data was then compared with points determined using traditional surveying techniques of two buildings from the same area.

After taking into account file size, gridding time and method performance, it was determined that Triangulation and Natural Neighbour methods at grid node spacings of

0.75m, 1.0m or 1.5m are most suitable for gridding LiDAR data of an urban area with a point spacing of approximately 0.5m.

## **An Evaluation of Leica Spidernet for RTK Reference Data at various Baselines**

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### **Abstract**

Leica's Global Positioning System (GPS) Spider reference station software (SpiderNET) allows a GPS receiver to continuously operate as a real-time kinematic (RTK) reference station and broadcast its corrections over the internet. Using SpiderNET, multiple users can wirelessly connect with the continuously operating reference station (CORS) and obtain its carrier phase observations.

This report gives a description of the background, design, implementation and results of a project aimed to evaluate the use of SpiderNET at various baseline distances. The test used 6 control points at baseline distances ranging from 1-24.5 km. The test yielded RTK position precisions (at 95% confidence) of 1.8 cm horizontal and 2.3 cm vertically with a 10 km baseline and a RTK position precision (at 95% confidence) of 2.8 cm horizontal and 3.3 cm vertically with a 24.5 km baseline.

In the near future, CORS networks will serve a more important role in mapping, engineering and navigation applications by providing continuous RTK reference station

data to large areas. It has been shown in this report that a rover using SpiderNET for RTK reference data at baseline lengths up to 24.5 km can obtain precisions which can meet the requirements of many RTK applications.

## **An Analysis of Contouring Algorithms within CARIS Software**

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### **Abstract**

This report presents concepts and a prototype implementation of an efficient grid contouring algorithm to be considered as a future addition to CARIS' contouring libraries. Many hydrographic and oceanographic agencies have moved or are moving towards gridded bathymetric products. An algorithm designed to efficiently generate contours from gridded bathymetry is an essential tool for any application creating hydrographic products. Various contouring techniques are presented and reasoning is given to support the implemented methods. Results from the prototype algorithm are analyzed and compared to that of several commercial applications. It has been concluded that a commercial implementation of the concepts presented in this report could prove to efficiently create accurate contours.

# **Analysis of Multi-frequency Carrier Phase Linear Combinations for GNSS**

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## **Abstract**

With the modernization of GPS and the eagerly anticipated deployment of Galileo, there will be an increase in the number of carrier phase signals arriving from space which are at our disposal for positioning and navigation. To take advantage of these signals it is possible to form carrier phase linear combinations to: 1) reduce ionospheric delay; 2) reduce receiver noise; and 3) increase the wavelength of the observable. This means improved position capability and more reliability for these space based systems. This report focuses its investigation on those combinations which mitigate ionospheric delay, reduce receiver noise and perform best under “typical” survey conditions. To perform the analysis of the optimal linear combinations, simulated data provided by the University of Calgary is used. An analysis was performed in the measurement domain to determine the improvement in accuracy of the optimal linear combinations versus the standalone L1 observable. A number of conclusions are reached. The use of triple frequency combinations for eliminating the effect of the ionosphere versus that of current dual frequency combinations is more effective at eliminating the ionospheric delay and will improve the precision of the measurement. Concerning receiver noise, it was shown

that although the triple frequency narrow-lane combination does improve the precision of the measurement, it is more effective to use the three frequencies independently to improve the precision in the position domain. It is also shown that by using an optimal combination for “typical” field conditions with a single receiver, an improvement of 57% was seen in the overall measurement accuracy. Finally, it is demonstrated that there are “optimal” combinations which can be used to significantly improve the accuracy and precision of the GNSS measurements.