Geodesy and Geomatics Engineering
Semi-Annual Student Technical Conference

Dineen Auditorium – C13
Wednesday, March 24, and Thursday, March 25, 2004

Wednesday, March 24

1330	Opening Remarks
Session 1	**Hydrography and Ocean Mapping**
	Chair: Garret Duffy
1340	Comparison of Single Beam Vertical Incidence Sediment Classification and Oblique Incidence Backscatter: Caraquet Shoal Case Study *Beth-Anne Martin*
1355	A Proposed Mine Warfare Pilot *Andrew Muir*
1415	A Proposal to Evaluate the CARIS HPD in the Production of Paper Charts, ENCs and AMLs *Leonel Pereira Manteigas*
1435	**Coffee Break**
Session 2	**Land Administration**
	Chair: Meredith Hutchison
1450	An Evaluation of the Current State of Aquaculture Surveys in Prince Edward Island *Jill Cheverie*
1505	Designing a Statute Retrieval Framework for Spatial Queries: A Case Study of New Brunswick Marine Space *Brian Burridge*
1520	The Design of a Data Requirements Model to Support the Coastal Areas Protection Policy in New Brunswick *Bronwyn Cox*
1535	Investigating the Tools of ArcGIS Survey Analyst Within the Industry of Spatial Information *Matt Berrigan*
1550	**Coffee Break**
Session 3	**Geographic Information Systems and Remote Sensing**
	Chair: Gang Hong
1605	Modelling the Retreat of the Scarborough Bluffs with GIS *Melissa Condie*
1620	Mapping Storm-Surge Flood Risk Using Airborne LIDAR *Steven Dickie*
1640	Design of an Unmanned Aerial Vehicle for Watershed Analysis *Rosalind Bobbitt*

Thursday, March 25

Session 4 **Global Positioning Systems**
Chair: Mustafa Berber

1030 Analysis of Automated Online GPS Processing Services
Jamie Leslie

1045 Dealing with Multipath in the Context of the Princess of Acadia Project
Mohammed Al-Shahri

1105 A GPS Velocity and Accelerometer Sensor: How Accurate Can It Be? - A First Look
Luis Serrano

1125 GPS Data Processing with DIPOP-FACE V1.1
Mazhar Rafiq

1145 Lunch Break

Session 5 **Global Positioning Systems and Geodesy**
Chair: Luis Serrano

1245 Determination and Mapping of Usable GPS Satellite Signals in the UNB Woodlot
Keith Jamieson

1300 A Systematic Analysis on the Accuracies of IGS Satellite Orbits
Rob Molaski

1315 An Introduction to Stokes-Helmert Method for Precise Geoid Determination
Huaining Yang

1335 Spatial Analysis and Treatment of Tide Gauge Records Using GIS
Azadeh Koohzare

1355 Coffee Break

Session 6 **Engineering and Mining Surveys**
Chair: Jason Bond

1410 Development of Graphical Display Software for Finite Element Analysis
Chris Gairns

1425 Determination of Surface Subsidence Due to Fluid Withdrawal by Combining the Influence Function and the Nucleus of Strain Approaches
Eulalio Ortiz

1445 Integrated Analysis of Ground Subsidence at PCS Potash Mine
Matthew Chandler

1500 Cylindrical Surface Modeling with Reflectorless EDM Total Station for Deformation Surveys
Ron MacMaster

1515 Coffee Break

Session 7 **CIG Undergraduate Student Paper Competition**

Chair: Jonathan Beaudoin

1530 The Study of Total Propagated Error in Hydrographic Surveys
Corey M. Collins

1545 Comparison of GPS and RTS Performance Within an Open Pit Environment
John Broderick

1600 Comparison of PCI Geomatica's Pixel-Based Image Classification Techniques and eCognition's Object-Oriented Image Classification
Marc Cormier

1615 Assessing the Feasibility of Ultra-Short Baseline Acoustic Positioning Techniques for Spoolpiece Metrology
Michelle Weirathmueller

1630 Geoid Modeling Using a Combination of Geometrically Determined and WGS84 EGM96 Geoidal Undulation Values
Paul Andrew Burbidge

1645 **Presentation of Awards and Closing Remarks**

1700 **Reception**

COMPARISON OF SINGLE BEAM VERTICAL INCIDENCE SEDIMENT CLASSIFICATION AND OBLIQUE INCIDENCE BACKSCATTER: CARAQUET SHOAL CASE STUDY

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Sediment Classification is an important tool for fisheries and aquaculture. It aids in associating sea bottom types with species of marine life, in order to gain a greater understanding of their habitat. With this information, it is possible to optimize harvesting procedures as well as monitor the habitat for conservation. Two systems that perform sediment classification are examined in this report. One method of collection and processing is the QTC View single beam vertical incidence sediment classification. The other method is oblique incidence backscatter using Knudsen sidescans. Caraquet Shoal served as a test area for both systems.

The objective of this report is to examine the theory behind each classification method, discuss the data collection and processing methods, and make comparisons from the results. This was achieved through collaboration with the Ocean Mapping Group, and the Department of Fisheries and Oceans, who were the groups responsible for the collection and processing of the data. An examination of the numerical values produced by each system was performed to find possible correlations that may exist between the two methods. Qualitative plots were also produced to allow for a visual interpretation and comparison. It was found that the two methods produce different results that do not always correlate with each other. Although neither method can be deemed to be the absolute truth, the oblique incidence backscatter is the easiest to interpret, and shows visible patterns on the seafloor.

A PROPOSED MINE WARFARE PILOT

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Mines are relatively cheap, easy to produce, simple to lay and constitute a threat to maritime forces out of all proportion to the effort and skill needed to deploy them. The mere threat of mines is often enough to cause a significant disruption to commercial shipping or naval operations. The best way to reduce the risk is to avoid the mine or minefields or to minimise their effectiveness. Route Survey (RS), a passive form of Mine Counter Measures (MCM), uses side scan sonar to survey potential shipping routes in peacetime and then through re-survey in times of conflict can detect mines or mine-like objects effectively by analyzing the differences in the surveys.

The main operational requirements stated in the Canadian Navy's Mine Warfare Blueprint 2010 is the maintenance of a RS database for Canadian waters and to establish and maintain an up to date Mine Warfare Pilot (MWP). The MWP contains important environmental data in advance of the mining, provides tactically relevant information and provides for the best route selection for reduction of mine risk.

This report will use a Case Study of the GGE 5083 Hydrographic Operations Survey of Grand Bay/Westfield Channel during May 2003 outlining parallels between the course and Canadian RS in equipment, procedures, processing and archiving. It will review applicable national policy and plans, international and CANUS agreements and formats and result in the production of a fully functioning MWP.

A PROPOSAL TO EVALUATE THE CARIS HPD IN THE PRODUCTION OF PAPER CHARTS, ENCS AND AMLS

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CARIS Hydrographic Production Database (HPD) is one of the most representatives, from a new generation of software systems to the production of nautical cartographic products. Its concept is based on a system of applications implemented above a Spatial Database and Management System (SDBMS). The SDBMS is used to manage the data, and the products creation is done by the applications from the selection of the related data. With this solution each feature just need to be stored once in the SDBMS, and one system using the same data set can produce all the range of cartographic products that are in the incumbencies of a common Hydrographic Office (HO), which simplifies significantly the production and the updating processes.

The objective of this paper is to introduce some of these cartographic products and describe the proposed studies to evaluate the HPD in meeting the general requirements of an HO like the Portuguese one, in the data management and in the production of Paper Charts, ENCs and Additional Military Layers (AMLs). The general requirements will be identified, and the HPD will be populated with simulated data to the AMLs products and data from three Portuguese ENC cells containing a common area in different scales. With these data will be produced an ENC, a paper chart and some AML products. All the processes implicated will be analyzed and a comparison between the products produced by the Portuguese HO and the HPD generated ones will be performed.

AN EVALUATION OF THE CURRENT STATE OF AQUACULTURE SURVEYS IN PRINCE EDWARD ISLAND

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In the past, the aquaculture industry in Prince Edward Island has grown from a small developmental industry to one that is a significant contributor to the provincial economy. Today, landings exceed forty-five million pounds and have a value of thirty million dollars.

Prince Edward Island is unique in its management of aquaculture. Prince Edward Island is the only maritime province where Fisheries and Oceans Canada maintains jurisdiction over shellfish leasing. A “One Stop Process” is used to reduce the amount of time and work required by an aquaculture proponent to acquire a lease in PEI waters.

This research paper examines the current procedure in administering the aquaculture surveys, evaluates these procedures over a spectrum of criteria, and proposes specific recommendations on survey guidelines and procedures for PEI aquaculture leases.

DESIGNING A STATUTE RETRIEVAL FRAMEWORK FOR SPATIAL QUERIES: A CASE STUDY OF NEW BRUNSWICK MARINE SPACE

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To make valuable use of laws that affect an area, knowledge of what these laws mean, and where these laws apply is crucial. The lawmakers will possess expert knowledge, however, the users of these laws must possess a basic knowledge as well. In recent years, the development of a marine cadastre has been a significant topic of research in many parts of the world. A theme in this research has been the noted absence of an effective system for retrieving different laws, which apply to different uses. Currently, many users of marine space find themselves confused when determining what laws govern their activity, and their space. A user-based framework is needed in order to accurately answer any spatial queries that these day-to-day users may have with regard to what laws apply.

The objective of this paper is to provide this framework for case studies of two marine spaces in New Brunswick. These are the proposed Musquash Marine Protected Area (M.P.A), and the St. Andrews Harbour. Because these are New Brunswick marine spaces, a framework for New Brunswick legislation will be conceived. These areas were chosen because they are two very different spaces, not only in terms of location, but also in terms what the main uses are. The proposed M.P.A. is a space for which uses are mainly oriented to the preservation of the environment, where St. Andrews Harbour may see more uses of the economic nature. This paper sees a noticeable desire by the marine space user, for information about their space. As the matter of the marine cadastre grows, so will these users' desires. This paper understands a high possibility of expansion, past simply the province of New Brunswick, to other provinces, and eventually to a Federal level.

THE DESIGN OF A DATA REQUIREMENTS MODEL TO SUPPORT THE COASTAL AREAS PROTECTION POLICY IN NEW BRUNSWICK

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As the fragility of the Earth's environment continues to be revealed, the need for responsible management of natural areas has required that protective frameworks be put in place to govern the use of sensitive coastal zones and prevent further exploitation. Recently, the New Brunswick government has released a policy document entitled "A Coastal Areas Protection Policy for New Brunswick" in order to communicate the government's intentions with respect to coastal zone management. The New Brunswick policy was created to deal with two primary issues—the protection of coastal features such as beaches and sand dunes, and to restrict development in the coastal region in order to minimize the government's liability with respect to homes damaged by storm surges.

A tremendous amount of data is required to support the implementation of this policy. In order to enforce this policy and restrict development in each of the defined zones, property information must be known and information such as tidal levels, erosion patterns and areas susceptible to storm damage are useful. This technical report outlines the data required to ensure that the Coastal Areas Protection Policy is complete. This is accomplished by developing a data requirements model based on a review of other jurisdictions currently enforcing similar policies: Queensland, Australia, North Carolina and Oregon, U.S.A. Along with the identification of necessary information, the report describes methods employed by other countries to effectively manage and share the data between users.

INVESTIGATING THE TOOLS OF ARCGIS SURVEY ANALYST WITHIN THE INDUSTRY OF SPATIAL INFORMATION

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As computing power has substantially evolved over the decades, it has allowed old ideas to be put into practical use. The theory of measurement-based multipurpose cadastral systems has been around as late as the 1980's and, with the growth of technology, is now re-emerging as a possible tool to be employed by industry.

The fundamental concept of a measurement-based system is that the measurements are first class objects and the primary support for spatial information. Environmental Systems Research Institute (ESRI) uses this idea of a measurement-based cadastre and incorporated within the ArcGIS program through the Survey Analyst extension.

Survey Analyst combines surveying tools with a GIS environment to unite into one system for the improvement of spatial accuracy. Investigations were completed to examine how the program responded to accepting raw survey files, and conducting simple measurement-based functions within the database. Interviews with GIS users in the Fredericton area reviled their views on where a program such as Survey Analyst stands, and how it conforms to the surveying industry.

MODELLING THE RETREAT OF THE SCARBOROUGH BLUFFS WITH GIS

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The Scarborough Bluffs is a glacial landform that spans approximately 14 km of the Lake Ontario shoreline east of downtown Toronto, Ontario. In some areas, the cliffs rise about 80 m above lake levels and erode at an accelerated rate. The erosion of the bluffs poses a continuing problem for landowners and land managers. Although, the bluffs are being monitored periodically, there is little analysis being done to predict the spatial time frame and the extent of their retreat.

The goal of the project was to spatially predict the long-term erosion trend of the Scarborough Bluffs with the use of a GIS. This was achieved through the creation of a model that incorporated data, derived from aerial photography, for each of the main factors contributing to the erosion. The use of a GIS-based model proved to be an effective tool for modelling the erosion; thus, providing decision-makers with a better picture of this continually changing landscape.

MAPPING STORM SURGE FLOOD RISK USING AIRBORNE LIDAR

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Precision mapping plays an important role in determining the impacts of sea-level rise and storm surge events for coastal regions. This paper examines some of the steps used to map water levels in Charlottetown, Prince Edward Island as part of a Climate Change Action Fund (CCAF) project investigating climate change and sea-level rise in the southern Gulf of St. Lawrence.

To achieve desired results from storm surge flood risk mapping, the CCAF project decided to use airborne light detection and ranging (LIDAR) to acquire a high-resolution digital elevation model (DEM) of the urban waterfront in August, 2000. Several problems with the LIDAR dataset included both sparse coverage on asphalt surfaces and improper classification between "ground" and "non-ground" laser returns. CCAF project partners and contractor validation also showed calibration problems as a result of a power loss to the LIDAR system, requiring a vertical offset adjustment to the DEM. Subsequent examination of the DEM resulted in improvements to the surface representation of waterfront structures by combining selective "ground" and "non-ground" elevation points.

Prior to flood mapping, the DEM was adjusted to hydrographic chart datum using values supplied by the Canadian Hydrographic Service. Three storm surge water levels were provided by CCAF project partners and used to map flood limits: the actual high water level observed by the Charlottetown tidal gauge during a 21 January 2000 storm surge, and two higher levels representing storm surge scenarios under rising sea levels. Flood mapping was performed on the DEM using a geographic information system and remote sensing software. The resulting binary grids were vectorized and flood extents were modified to exclude low-lying isolated areas not having free exchange with harbour waters. Vector datasets depicting flood limits were provided by CCAF project partners to municipal planners and socio-economic impact analysts.

Results demonstrated that it was possible to map small changes in water levels from storm surge events using a high-resolution LIDAR-derived DEM. A key recommendation arising from this project showed the need for extensive ground validation using geodetic-quality GPS, which was completed in 2001. Future research indicates an evaluation of the spatial uncertainty for datasets being used for a similar project in southeastern New Brunswick will be necessary.

DESIGN OF AN UNMANNED AERIAL VEHICLE FOR WATERSHED ANALYSIS

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One very important use for an unmanned aerial vehicle is the preservation and management of watersheds. The protection of these areas is crucial to the well-being of society. By employing unmanned aerial vehicles adapted to perform specific tasks, protection of these areas can be done more quickly, thoroughly and cheaply than by traditional methods.

This technical report will support a project proposed by the Fredericton Area Watersheds Association to design a specialized unmanned aerial vehicle with sensors adapted for watershed analysis. The report will include an examination of the types and costs of a device with sensors which can meet accuracy requirements, with a view to finding the best and most economical combination of components needed for watershed analysis.

ANALYSIS OF AUTOMATED ONLINE GPS PROCESSING SERVICES

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Positioning survey monuments historically has been a rigorous process involving a great deal of time and effort. With the integration of the Global Positioning System (GPS) into the Geomatics industry, this process has been revolutionized. Users are now able to accurately position points in a manner remarkably easier than in the past. However with increasing demands for a certain technology, industry must come up with more efficient ways of marketing it. This has been done with the emergence of a number of online GPS processing services in recent years.

These services provide highly accurate positions to the user free of charge and with unlimited access. The processed results are received through electronic communication from various organizations located all over the globe. The user sends a Receiver Independent Exchange Format (RINEX) file to the service and within a short period of time, the corrected position is sent back to the user via their email address.

The goal of this research project is to diminish any concerns associated with the inaccuracies that users may have regarding these online GPS processing services. An analysis of the results provided from five online services was performed using four different data sets collected in the Fredericton area. Each data set consisted of a two-hour time block, the minimum amount required for processing. The results from the five services were compared to their corresponding published values obtained from the Service New Brunswick website. Additionally the data was processed using Trimble Total Control, a commercially available software package to provide a further comparison. The results from both comparisons proved that highly accurate position fixes could be obtained from each of these services.

DEALING WITH MULTIPATH IN THE CONTEXT OF THE PRINCESS OF ACADIA PROJECT

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Global Positing System (GPS) has been a powerful technique for navigation purposes. There are some limiting errors that affect the final results. One of these limiting factors is multipath. Multipath is defined as the phenomenon whereby a signal arrives at a receiving antenna via two or more different paths. In our project, which located in Bay of Fundy, GPS receivers will collect data from stations located on both sides of the Bay of Fundy, Coast Guard Saint Johan (CGSJ), New Brunswick, and the other side in Digby Regional High School (DRHS), Nova Scotia. Also, a rover station located on board the ferry The Princess of Acadia. As the project is intended to investigate the performance high accuracy (cm-level) positioning and navigation using GPS carrier phase, multipath will be the dominant error as it could generate maximum error of 0.25_ (≈4.5 cm) on carrier phase measurements. The primary focus will be on static multipath on CGSJ, DRHS, and rover on the ferry when it is docked. DIPOP software at the department of Geodesy and Geomatics is used to process the data and generate double difference solutions. Also, Teqc software is used to check the quality of the static and kinematic data. In static environment multipath signature repeats itself every sidereal day (around 23hr 56 min) if the structure around antenna remains unchanged. In the project, the correlation day to day of the residuals of double difference between successive days will be used to detect multipath error. Then, multipath parameters would be estimated. Multipath would be analyzed for different combination of satellites at different azimuth and elevation angles.

A GPS VELOCITY AND ACCELEROMETER SENSOR: HOW ACCURATE CAN IT BE? - A FIRST LOOK

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To obtain accurate velocity information, traditional optical velocity sensors and RTKGPS positioning are common but expensive solutions. However, velocity information can be obtained from the time-differential method using a stand-alone single-frequency receiver without resolving carrier phase ambiguities. In dynamic vehicle testing, such a GPS sensor is attractive because it enables a single person to conduct performance tests quickly and easily.

We have investigated the feasibility of a low-cost GPS velocity sensor for applications such as vehicle testing. We developed post-processing software which uses the first order central difference approximation of the carrier-phase rate. The advantage of this approximation is simplicity, which facilitates implementation of algorithms into the receiver. In this paper, we mainly focus on the scientific aspects of the GPS velocity determination. We investigated the potential accuracy which can be achieved with low-cost receivers, and evaluated the error budget present in the estimation. The algorithms consider specifically data smoothing, multipath, and modeling of ionospheric effects as well as efficient handling of cycle slips and other data anomalies. Acceleration determination algorithms, which are still being developed as a complement part for the velocity estimation, for the analysis of the kinematic tests and to improve the accuracy in the velocity estimation under different and higher dynamics, can later be integrated in a more general kinematic acceleration application, such as airborne gravimetry.

This paper describes an algorithm developed at UNB, for velocity and acceleration estimation, results and analysis of the field tests and future work to be done.

GPS DATA PROCESSING WITH DIPOP-FACE V1.1

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DIPOP is a differential point positioning software, which is being successfully used, in the Geodetic Research Laboratory for the processing of Global Positioning System (GPS) carrier phase data. The pre-processing of both single and dual frequency data is performed using DIPOP's two subprograms PREGO and PREDD. The main and post processing is done using the subprogram MPROC. The software was written in FORTRAN using ANSI (American National Standards Institute) FORTRAN 77 standards, and has been implemented on IBM PC compatibles, Macintosh, and UNIX, but later versions only run on UNIX. PREGO reads observation files from a single receiver to eliminate errors and phase discontinuities from data. PREDD reads output files from PREGO, pertaining to two simultaneously observing stations, and the corresponding ephemerides files and combines them to form cleaned carrier phase double differences. The double differences and satellite coordinates are written to an output file to be used in a sequential least-squares parametric adjustment in MPROC. The MPROC's output consists of receiver coordinates and nuisance parameters. It also provides an estimation of refraction zenith delays. FACE ver.1.1, a user-friendly software written in a Java-based open source development environment, is designed to work in a client/server network computing setup with DIPOP. FACE's objective is to considerably improve the efficiency of daily GPS data processing. The utilization of open source environment has made it economically viable to be used on both LANs and WANs. In the present study the GPS data was processed on DIPOP both with and without FACE. The detail processing of GPS data using FACE has led to the conclusions, that there needs to be further improvement in the current status of the software with emphasis on incorporating additional tools for data collection and integration and removing some of the redundant and undesirable resources from the application.

DETERMINATION AND MAPPING OF USABLE GPS SATELLITE SIGNALS IN THE UNB WOODLOT

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The use of GPS for forestry applications is becoming increasingly common for such purposes as delimitation of forestry treatment areas, vehicle monitoring, and road profiling. The use of GPS allows for fast and accurate collection of spatial data to provide the information necessary to make informed decisions. Forest environments, however, provide challenges to the effective use of GPS due to the high probability of signal obstruction by tree canopy.

The objective of this paper is to determine the usable GPS satellite elevation angle for various types of tree cover in the UNB woodlot. A static survey was performed for several points in front of hardwood and softwood tree lines using Trimble 5700 dual frequency receivers. The tree line was measured from these points using the Trimble 5600 reflectorless total station. The GPS data was analyzed with Trimble Geomatics Office software to determine the elevation and azimuth of the satellites when the signals became unusable. The elevation and azimuth of the GPS satellites was then mapped with respect to the tree line using AutoCAD 2000. The maps show that a usable GPS signal can be found to dip below the tree line in certain instances.

A SYSTEMATIC ANALYSIS ON THE ACCURACIES OF IGS SATELLITE ORBITS

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Three dimensional earth positioning is always plagued by errors in its position. The important thing in this task is to understand the accuracies of the components which determine a position on earth and how accurate it is. One type of error that plays a key role in positional error, is orbital error. The International GPS Service (IGS) is an organization which provides coordinates for three different types of orbits; these three orbits include: Final orbit, Rapid orbit, and Ultra-Rapid orbit. They have determined that the accuracy of the predicted Ultra-Rapid orbit is approximately 10cm, the observed half of the Ultra-Rapid is less than 5cm, the Rapid orbit is less than 5cm, and the Final orbits is less than 5 cm. These accuracies are based on the average of the analysis centre's determinations of these orbits.

This research project is an analysis of the accuracy of the three different orbits provided by the International GPS Service (IGS). This will be done by comparing the Ultra-Rapid and Rapid orbits to the "fixed" Final orbit in a Satellite Centered Coordinate System. This in turn will provide a better understanding of how accurate the published orbits really are.

AN INTRODUCTION TO STOKES-HELMERT METHOD FOR PRECISE GEOID DETERMINATION

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The geoid plays a very important role in geodesy. It cannot only be seen as the most natural shape of the earth, but it also serves as the reference surface for most of the height system. The geoid is chosen in a way that it equals approximately the mean sea level. The approach taken at the University of New Brunswick to compute the geoid is called the Stokes-Helmert method. The principle of this approach is to condense all masses above the geoid in an infinitesimally thin layer on the geoid, so the disturbing potential can be considered harmonic outside the geoid and the boundary value problem can be solved.

This paper gives an overview on the theory of precise geoid determination as developed and implemented at the University of New Brunswick according to the Stokes-Helmert scheme. It shows the main steps of this method and explains the related theory in detail. Several graphical plots would show you the being finished computation results clearly.

SPATIAL ANALYSIS AND TREATMENT OF TIDE GAUGE RECORDS USING GIS

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For modelling linear vertical crustal movement over Canada, we employ tide gauge records, which reflect the glacial isostatic submergence of the coasts. Two questions arise:

1) How can we distinguish between Glacial Isostatic Adjustment (GIA) and other global, regional and local effects in the records, such as Tectonic contribution, river discharge and sediment subsidence?
2) How can we spatially find the optimum network of tide gauges to reduce these effects?

In this study, we use Arc GIS to visualize the theoretical approaches in answering these questions, and to integrate and analyze different spatially distributed data such as tide gauge records, geological and climate related data. To use the most reliable dataset of tide gauges, which reflect the postglacial rebound signal, we just select the tide gauges with long time records. Then, we reject those tide gauges, which are affected by river discharge and other impacts. We show that GIS presents a highly efficient instrument for such impact study.

Monthly mean sea level records in adjacent tide gauges are then differenced to reduce the regional noises. In order to select the optimal pairing of sites for differencing method, regional correlation matrices and correlation coefficient confidence intervals for each pairs of records are constructed using Pearson's linear correlation. Having constructed the matrices, searching is done based on the highest correlation coefficient, using spatial relationships in GIS. The results are presented in the form of the optimum tree diagram of the tide gauges in eastern coast of Canada. This work provides the framework for multidisciplinary studies of postglacial rebound in the region and allows the incorporation of more data in future investigations.

In this paper, we also show that GIS provides us with useful tools for the *treatment* of tide gauge data in modelling vertical crustal movement.

DEVELOPMENT OF GRAPHICAL DISPLAY SOFTWARE FOR FINITE ELEMENT ANALYSIS

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The need for graphical display of a mesh design is a very important tool in the finite element method for numerical modelling of deforming bodies. Deforming structures must be monitored for possible safety, economic, and environmental issues. Numerical methods are a useful tool in this process, of which, the finite element method, is the most powerful.

The Canadian Centre for Geodetic Engineering has developed a software package which can perform the finite element method. A portion of this software package creates finite element mesh designs with assigned material types given to each element. The digital display of this data located in the exported text file, however, is difficult to interpret and hard to locate any possible errors in the data.

This report will deal with the development of a software program that will use the data in this output file and produce a graphical representation of the finite element mesh with associated element material types. It will be demonstrated that this software is a useful tool in verifying the mesh geometry and decreasing the time involved in the overall numerical modelling process.

DETERMINATION OF SURFACE SUBSIDENCE DUE TO FLUID WITHDRAWAL BY COMBINING THE INFLUENCE FUNCTION AND THE NUCLEUS OF STRAIN APPROACHES

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Subsidence is the lowering of the earth surface due to extraction of underground materials. As materials are removed from underground, the resulting change of stresses is transferred to the surface creating bowl-shaped depressions, which are mainly produced due to underground mining and exploitation of underground fluid reservoirs. Several techniques have been developed for the prediction of surface subsidence. In underground mining, for instance, a so-called "influence function" technique determines the contribution of elementary extraction elements to the maximum subsidence expected at surface points of known position. By integrating the contribution from all the elementary extraction elements, surface subsidence is calculated. In subsidence due to fluid withdrawal, an approach called "nucleus of strain" considers the volumetric strain at a point in a reservoir, caused by a local reduction in pore pressure, as a center of compression in an elastic half-space that produces a displacement field at the surface. By integrating the contribution of all the compression points over the reservoir, the resulting surface subsidence is calculated.

In this paper, the "influence function" and the "nucleus of strain" approaches are combined to create a technique for the determination of subsidence due to fluid withdrawal when the shape, location, compaction coefficient and pressure decline field of the reservoir are known. If numerical integration is used, the proposed technique will allow for the determination of surface subsidence for reservoirs of any shape and dimensions.

INTEGRATED ANALYSIS OF GROUND SUBSIDENCE AT PCS POTASH MINE

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This project uses a unique interdisciplinary approach in order to interpret ground movement patterns which are occurring at the Potash Corporation of Saskatchewan (PCS) mine near Sussex, New Brunswick. Since 1989, the Canadian Centre for Geodetic Engineering at UNB has been involved in geodetic monitoring and physical interpretation of ground subsidence in the area of PCS potash mining near Sussex, N.B. Till 1997, the ground subsidence followed a regular pattern, as predicted by a deterministic model based on the finite element method. In 1997, the PCS mine encountered an increased water inflow followed by a creation of a secondary subsidence basin on the surface. In 2003, a new finite element analysis was performed to explain the extent of the water aquifer. The agreement between measured and calculated horizontal displacements was not satisfactory. Therefore, the purpose of this report was to improve the agreement by using a redesigned finite element mesh.

This interdisciplinary approach uses a combination of geodetic monitoring results and deterministic modeling such as the finite element method to model the horizontal and vertical displacements that occur due to the mining process. The basis of the finite element method is to divide the investigated mining cross-section into a number of finite elements which creates a mesh. Knowing the material type of each element, its material characteristics, and creating equilibrium equations the displacements are calculated. The geodetic monitoring techniques used in the project include global positioning system observations, first-order levelling, and a high precision traverse. The calculated displacements are compared to the measured values which were obtained from the surveying observations.

The results obtained from the finite element model using an enlarged mesh are encouraging. The vertical displacements show very good agreement between the measured displacements and the calculated displacements. The horizontal displacements did improve from the previous model but they are still not compatible with the measured displacements. In order to obtain better agreement between the measured and calculated displacements further investigation is required. The mesh designed for this project will be used in further investigations.

CYLINDRICAL SURFACE MODELING WITH REFLECTORLESS EDM TOTAL STATION FOR DEFORMATION SURVEYS

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Reflectorless EDM is a technology that has developed in total stations within the last decade. There are numerous survey applications that may benefit considerably by utilizing this new method of distance measurement. This report will examine one particular application, by testing the performance of a precision reflectorless total station for determining and modeling the size, shape and orientation of a cylindrical surface.

This experiment will model a concrete cylindrical surface with the use of a Leica TCRA1101 precision grade, reflectorless EDM total station. A best-fit surface will be created through a least squares adjustment, where the residuals from the adjustment will be used to gauge the accuracy of the model. This research will aid UNB's Canadian Centre for Geodetic Engineering in determining if reflectorless EDM total stations may be used for deformation modeling of oil tanks in Venezuela.

THE STUDY OF TOTAL PROPAGATED ERROR IN HYDROGRAPHIC SURVEYS

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In order to assess the accuracy of hydrographic data properly, it is crucial to obtain a complete knowledge of the uncertainties involved in each phase of data collection and analysis. Although multibeam sonars are highly efficient, the accuracy of their depth measurements is also dependent on the performance of the additional sensors within the system as a whole. Error sources affecting these sensors need to be isolated, and in turn, these errors propagated through into errors in depth measurements, depth reduction, and the position of each sounding. Therefore, there is a need to make realistic depth and position error estimates for each and every depth acquired by multibeam systems.

The object of this paper is to study the behavior of the total propagated error (TPE) associated with multibeam swath systems within CARIS HIPS v5.4. The studied uncertainties will be the total depth uncertainty (Dp-TPE) and the total horizontal uncertainty (Hz-TPE). The swath sonar will be studied as a stand-alone sensor, and then coupled with pertinent sensors (GPS, motion sensor, gyro, etc.) along with the uncertainties associated with each. Furthermore, a study of the contribution of pitch, roll, and heave on the total propagated error was completed as well. Understanding how these errors contribute to the total reduced depth and positional accuracy of each individual sounding will help us to verify that the final reduced depth values meet accuracy requirements, or more importantly, warn us when they do not.

COMPARISON OF GPS AND RTS PERFORMANCE WITHIN AN OPEN PIT ENVIRONMENT

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The stability of steep embankments is a serious safety issue for a variety of industries today. If an embankment was to collapse, this could lead to the loss of equipment and the lives of the people using them. The Canadian Centre of Geodetic Engineering (CCGE) have been working on a structural and slope stability monitoring system which they have named ALERT. It is designed to warn of any movements in the investigated object that could lead to its failure. The main component of this system is a Robotic Total Station (RTS), which can continually shoot to object mounted prisms without the need for an operator. This system has been used at the Highland Valley Copper open pit mine in British Columbia. Due to a number of different reasons, RTS alone cannot achieve the desired accuracy required at the mine site. It is here where the augmentation of the monitoring system by GPS can be vital.

The objective of this paper is to perform a detailed comparison of GPS and RTS observables derived from measurements of two baselines at the mine site. There have been several different session lengths analyzed to indicate how the accuracy of GPS and RTS will change as observation time increases. The results obtained from the testing lead to interesting conclusions. The testing also indicates that removal of observation outliers is a major priority if GPS and RTS are to be combined into one monitoring system.

COMPARISON OF PCI GEOMATICA'S PIXEL BASED IMAGE CLASSIFICATION TECHNIQUES AND ECOGNITION'S OBJECT ORIENTED IMAGE CLASSIFICATION

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Satellite imagery has become a popular tool for gathering information on the earth. One of the many image-processing techniques used to gather this information is image classification. Traditional software such as PCI Geomatica use pixel based methods that evaluate individual pixels. Another software package called eCognition uses an object-oriented classification technique that first breaks the image into smaller portions or objects and then performs classification on the objects.

The objective of this paper is to evaluate the classification results and procedures of both software packages. Classification was done using PCI Geomatica and then using an online trial version of eCognition Professional. The results were compared to the original image as a reference for ground truthing to determine accuracy. The ability to see objects such as buildings in the resulting thematic image was also looked at. Procedures were assessed on difficulties encountered, the number steps required and the level of expertise needed. The results suggest that similar accuracies can be achieved by both packages.

ASSESSING THE FEASIBILITY OF ULTRA-SHORT BASELINE ACOUSTIC POSITIONING TECHNIQUES FOR SPOOLPIECE METROLOGY

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Spoolpiece metrology is one of the most demanding tasks in offshore positioning. A spoolpiece is the section of pipe connecting a pipeline to a structure. For the fabrication of the spoolpiece, the positions and orientations of the connections must be known to a very high relative precision. The method currently used is Long Baseline (LBL) acoustic positioning. LBL meets the accuracy requirements of the task, but is very expensive and time consuming. It requires the installation and calibration of a seabed array consisting of at least three transponders, and then using these to determine the position of the transponders on the pipelines. The measurements are done with respect to a local coordinate system, which is independent of the position of the vessel.

This technical report examines the feasibility of using another acoustic positioning technique, Ultra Short Baseline (USBL). This technique is much cheaper, very easy to use, and many of the vessels that would usually do LBL work would already have USBL capabilities. USBL is commonly used for tasks that require less accurate positioning. The errors that make a contribution to the final position are examined individually in the context of how they could be minimized for a better solution. These errors can be divided into two main sections: The determination of the transducer position, and the relative position of the transducer with respect to the subsea transponders. The potential of using USBL is assessed, and some suggestions are made as to how USBL could be applied to spoolpiece metrology.

GEOID MODELING USING A COMBINATION OF GEOMETRICALLY DETERMINED AND WGS84 EGM96 GEOIDAL UNDULATION VALUES

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Precisely determining the position of the geoid has long been a focus in the field of geodesy. The precision of this determination has become increasingly important due to the use of the Global Positioning System (GPS) which references heights to a mathematically defined ellipsoid. These heights must be converted to traditional vertical datums which use the geoid as their vertical reference. For this reason a precise determination of the separation of these two surfaces is necessary. During this project two methods of geoid modeling were used to create a third, combined model.

The two methods of geoid modeling used in this project were the global geoid model WGS84 EGM96 and geometrically determined points of geoidal undulation. Geometrically determined geoidal undulation values are available for points which have been heighted using GPS and levelling techniques. The primary objective of this project was to incorporate the best features of each of the combined geoid modeling methods in the combined model. Interpolation based on geometric data can be very accurate near measured points but deteriorates quickly as interpolative distance increases. The WGS84 EGM96 represents the geoid's shape very well but features poor absolute accuracy. The geoid model created during this project used the geometrically known points of geoidal undulation to constrain the WGS84 EGM96 geoid. The results of this combination are encouraging. The combined model is able to more precisely model the geoidal undulation of a point than either of the original methods.