

Second Annual Progress Report
December 15th 1999 – November 15th 2000
Project GEOIDE ENV#14

Research Team

Dr. Rock Santerre, Scientific Supervisor, CRG (Centre for Research in Geomatics, Laval University)

Dr. Richard B. Langley, Scientific Supervisor, UNB (Department of Geodesy and Geomatics Engineering, University of New Brunswick)

Dr. Brian Morse, Research Partner, U. Laval (Department of Civil Engineering, Laval University), since June 2000

Dr. Jianjun Zhu, Post Doc., CRG, since July 2000

Dr. Donghyun Kim, Post Doc., UNB

Annie Biron, M.Sc. Student, CRG

Stéphanie Michaud, M.Sc. Student, Part-time, CRG, from March to July 2000 (now student at the Department of Physics Engineering at Laval University, since September 2000)

Claude Poulin, M.Sc. Student, CRG, June-September 2000

Sunil Bisnath, Ph.D. Student, UNB, since September 1999

Sophie Hetet, Visiting student from Le Mans, France, UNB, June-September 2000

Dr. Mami Ueno, Research Associate, CRG, until June 2000 (starting a Post Doc. in September 2000 in Nice, France)

Julien Sanscartier, Research Associate, Part-time, CRG, from September 1999 to February 2000 (now at BAE Systems Canada (formerly Marconi Canada) in Montreal)

Partners

Viasat (Viasat Géo-Technologie inc.): Denis Parrot, Claude St-Pierre (Research Associate, part-time).

GSD (Geodetic Survey Division, Geomatics Canada): Pierre Tétreault

CCG (Canadian Coast Guard): Guy Marceau

CHS (Canadian Hydrographic Survey): Daniel Langelier

Publications and Presentations **(reverse chronological order)**

- Kim, D. and R.B. Langley (2001). "Estimation of the Stochastic Model for Long-Baseline Kinematic GPS Applications." Paper to be presented at the U.S. Institute of Navigation National Technical Meeting 2001, Long Beach, California, January.
- Kim, D. and R.B. Langley (2000e). "GPS Ambiguity Resolution and Validation: Methodologies, Trends and Issues." Paper to be presented at the 7th GNSS Workshop and International Symposium on GPS/GNSS, Seoul, Korea, 30 November - 2 December.
- Langley, R., chairman of Session: Atmospheric Effects at the U.S. Institute of Navigation GPS 2000 Conference, Salt Lake City, U.S.A., 19-22 September 2000.
- Ueno, M., co-chairman of Session: Algorithms and Methods at the U.S. Institute of Navigation GPS 2000 Conference, Salt Lake City, U.S.A., 19-22 September 2000.
- Kim, D. and R.B. Langley (2000d). "A reliable approach for ambiguity resolution in real-time long-baseline kinematic GPS applications." *Proceedings of the U.S. Institute of Navigation GPS 2000 Conference*, Salt Lake City, U.S.A., 19-22 September (in press). [Note that acceptance of papers for presentation at this conference is highly competitive. The success rate of authors is only about 50%.]
- Bisnath, S.B. (2000). "Efficient, Automated Cycle-slip Correction of Dual-frequency Kinematic GPS Data." *Proceedings of ION GPS 2000*, the 13th International Technical Meeting of The Institute of Navigation, Salt Lake City, Utah, 19-22 September (in press).
- Hetet, S. (2000). *Signal-to-Noise Ratio Effects on the Quality of GPS Observations*. Internal report, 30 August, 30 pp.
- Langley, R.B., H. Jannasch, B. Peeters, and S. Bisnath (2000). "The GPS Broadcast Orbits: An Accuracy Analysis." Presented in Session B2.1-PSD1, "New Trends in Space Geodesy", 33rd COSPAR Scientific Assembly, Warsaw, 16-23 July 2000.
- Kim, D. and R.B. Langley (2000c). "Kalman-filter-based GPS ambiguity resolution for real-time long-baseline kinematic applications." Paper presented at the Workshop on Satellite Navigation Systems, Olsztyn, Poland, 3-5 July.
- Ueno, M., R. Santerre, D. Langelier and G. Marceau (2000c). "Improvement of GPS ambiguity resolution using height constraint for bathymetric surveys." *Proceedings of the IAIN (International Association of Institutes of Navigation) 2000 World Congress*, San Diego, California, 26-28 June, pp. 842-850.
- Santerre, R. and R.B. Langley (2000). "Improvement of kinematic OTF-GPS positioning over long distances." Poster presented at the 2nd GEOIDE Annual Conference, Calgary, Canada, 25-26 May (CD ROM).

- Kim, D. and R.B. Langley (2000b). "GPS ambiguity resolution for long baseline kinematic applications." Paper presented at the 2nd GEOIDE Annual Conference, Calgary, Canada, 25-26 May (CD ROM).
- Biron, A. and R. Santerre (2000b). "Integration of GPS and Glonass satellite positioning systems." Paper presented at the 2nd GEOIDE Annual Conference, Calgary, Canada, 25-26 May (CD ROM).
- Ueno, M., R. Santerre, D. Langelier and G. Marceau (2000b). "Improvement of GPS ambiguity resolution using height constraint for bathymetric surveys." Poster presented at the 2nd GEOIDE Annual Conference, Calgary, Canada, 25-26 May (CD ROM).
- Santerre, R., R.B. Langley, M. Ueno, A. Biron, D. Kim, D. Parrot, C. St-Pierre, P. Tétreault, G. Marceau et D. Langelier (2000). "Amélioration du positionnement cinématique GPS-OTF sur de longues distances: Applications aux levés bathymétriques." Article présenté à la Conférence Hydrographique du Canada 2000, Montréal, Québec, 15-19 mai (Compte-rendu sur CD-ROM).
- Biron, A. and R. Santerre (2000a). "Integration of GPS and Glonass satellite positioning systems." Poster présenté à la Conférence Hydrographique du Canada 2000, Montréal, Québec, 15-19 mai.
- Kim, D. and R.B. Langley (2000a). "The multipath divergence problem in GPS phase smoothed pseudorange." *Proceedings of the 47th CASI (Canadian Aeronautics and Space Institute) Conference*, Ottawa, Canada, 30 April – 3 May, pp. 161-163.
- Bisnath, S.B. and R.B. Langley (2000). "Automated Cycle-slip Correction of Dual-frequency Kinematic GPS Data." *Proceedings of the 47th Annual Conference of the Canadian Aeronautics and Space Institute*, Ottawa, 30 April - 3 May 2000; pp. 121-125.
- St-Pierre, C., D. Parrot et R. Santerre (2000). "Reference station network : A solution for precise GPS positioning over long distances." Présentation orale à la Conférence Géomatique 2000, Montréal, Québec, 8-10 mars.
- Ueno, M., R. Santerre, D. Langelier and G. Marceau (2000a). "Improvement of GPS ambiguity resolution using height constraint for bathymetric surveys." Paper presented at the Geomatics 2000 Conference GEOIDE Session: Data Acquisition, Montreal, Quebec, 8-10 March.
- Kim, D. and R.B. Langley (1999). "A Search Space Optimization Technique for Improving Ambiguity Resolution and Computational Efficiency." Paper presented at GPS99, International Symposium on GPS: Application to Earth Sciences and Interaction with Other Space Geodetic Techniques, Tsukuba, Japan, 18-22 October 1999; Reviewed and published in *Earth, Planets and Space*, Vol. 52, No. 5, pp. 807-812.

Executive summary

Research highlights:

Improvement of phase ambiguity resolution: In collaboration with the Canadian Hydrographic Service, a priori information on water level from tide gauges has been integrated with the GPS measurements to improve the resolution of phase ambiguities. Research has also focused on the development of an optimized least-squares ambiguity search algorithm and the improvement of robust solutions.

GLONASS positioning: Methods for combining GPS and GLONASS (the Russian counterpart of GPS) data have been developed. Software development for GLONASS is under way.

Ionospheric modelling: Investigations of algorithms for correcting for ionospheric errors have been undertaken in collaboration with Viasat.

Addition of a new research axis: The study of the squat and under-keel clearance of merchant ships using positioning provided by GPS-OTF solutions.

This new research axis of Project ENV#14 will be conducted under Dr. Morse's supervision. Dr. Morse is a professor in the Civil Engineering Department at Laval University and he is a specialist in hydrodynamics. Dr. Morse had also worked more than 6 years at the Canadian Coast Guard. He has many contacts within the maritime navigation sector (Canadian Coast Guard, Transportation Development Centre, St. Lawrence Seaway Corporation, maritime shipping,...).

This research will focus on the determination of ship under-keel clearance which also includes the study of ship squat. This will lead to an optimal ship loading procedure in a secure manner. Keep in mind the important economic impacts and the competitiveness of Canadian harbours in the North American maritime transportation market. For example, an additional 10 cm of under-keel clearance means an additional benefit of \$100,000 for the maritime carrier, for every voyage.

Under-keel clearance depends on the channel depth, the water level, the ship's draught and the ship's squat. The squat is mainly a function of the ship's surface speed squared and the width of the channel. The squat value can reach many decimetres.

Field tests are going to be performed this fall on the St. Lawrence Seaway. The field operations are financed (outside the GEOIDE Project) by the St. Lawrence Seaway Corporation, the owners of shipping lines, the pilot associations and managed by the Transportation Development Centre. Dr. Morse is also acting as a consultant in this field test.

The measurements of under-keel clearance will be conducted on 8 types of ship travelling on the St. Lawrence Seaway. The measurements to be collected are: GPS-OTF positioning (each ship will be quipped with 3 or 4 GPS antennas), water level, river topography, water current, ship's speed and the details on other ship traffic. These parameters will be useful to study the effect of squat and to determine ship's under-keel clearance. The theoretical study of under-keel clearance and the squat of ship will be performed by Dr. Morse and his team within Project ENV#14.

Project structure

Our Project ENV#14 is composed of many research axes, namely:

The improvement of phase ambiguity resolution; the integration of GLONASS and GPS phase observations; ionospheric modeling, the use of multiple GPS reference stations; and the study of squat and under-keel clearance of merchant ships.

The Project ENV#14 team is composed of specialists in GPS, geodesy, hydrography, navigation, physics and hydrodynamics.

The research team and our partners come from the private sector (Viasat Géo-Technologies), the governmental sector (Canadian Coast Guard, Canadian Hydrographic Service and Geodetic Survey Division) and the academic sector (UNB and Laval University: 3 Departments).

Sub-projects

Research activities (15th December 1999 – 15 November 2000)

OTF phase ambiguity resolution:

Dr. Ueno has compared COWLIS (Coastal and Oceanic Water Level Information System) and SINEM (interpolated COWLIS values) water level (information provided by the CHS and CCG) to water level obtained from GPS (with appropriate height reduction) for several days of data (survey seasons 1998 and 1999) with different types of ships and different lengths of baselines. Viasat also supplied to CRG intermediate results from the Bathykin software to facilitate the analysis of the data. The use of a priori water level information to constrain height helps to correctly fix the GPS carrier phase ambiguities. The assessment of the precision of the a priori height from COWLIS tide gauges (reduced to the ellipsoid) has also been carried out. Results have been reported in a paper presentation at the Geomatics 2000 Conference (Ueno et al., 2000a) as well as at the IAIN (International Association of Institutes of Navigation) Conference (Ueno et al., 2000c). A poster presentation on this topic has also been displayed during the Second Annual GEOIDE Conference (Ueno et al., 2000b).

Dr. Zhu (new Post Doc. at the CRG, since July 2000) took over this research axis since Dr. Ueno started a Post Doctorate in France in September 2000.

Dr. Zhu's works are related to the uses of a priori height, obtained from the tide gauges, as pseudo observations in GPS data processing, rather than as a comparison for the solution (height from GPS-OTF).

Hydrographic field tests are being made this fall by CHS and CCG with DSNP (formerly Sercel) equipment. The raw data will be available to the Project ENV#14's Team for data analysis and software performance comparison.

Dr. Kim has continued his work on an optimised least-squares ambiguity search technique and on the improvement of reliable and robust OTF solutions. Data sets from the CHS have been used for testing the algorithms. Cycle-slip algorithms have been developed using triple, quadruple and quintuple differences. Initial work has been done to evaluate the multipath effect at the rover site, and the development of the ambiguity algorithms using a Kalman filter approach. A paper on multipath divergence in carrier-smoothed pseudorange was presented during the CASI Conference (Kim and Langley, 2000a). An oral presentation on Dr. Kim's work was given during the Second Annual GEOIDE Conference (Kim and Langley, 2000b) as well as at a satellite navigation workshop in Poland (Kim and Langley, 2000c). Dr. Kim presented a paper describing his ambiguity resolution technique at ION GPS 2000 in Salt Lake City in September (Kim and Langley, 2000d) and has prepared a review paper on GPS ambiguity resolution and validation for presentation at a meeting in Seoul, Korea, later this fall (Kim and Langley, 2000e). Lastly, a paper by Kim and Langley on stochastic modeling for the ambiguity resolution problem has been accepted for presentation at the U.S. Institute of Navigation National Technical Meeting 2001, in Long Beach, California in January (Kim and Langley, 2001).

Initial work at UNB has been started on software enhancement of DIPOP (by Sunil Bisnath) to be able to process kinematic data which will include Dr. Kim's software modules. Applications are also planned for the determination of low-earth-orbit satellite trajectories, as part of an IGS (International GPS Service) project, recently authorised by IGS.

Practical tests on assessing the effect of signal-to-noise (S/N) on observation precision have been carried out by Sophie Hetet (Hetet, 2000). This initial effort on studying S/N effects will be useful in developing reliable observation variance-covariance matrices.

Dr. Kim visited Viasat in July (see the section: Exchange of Personnel) to exchange information about his research to our private sector Partner (Viasat).

Annie Biron and Dr. Mami Ueno visited UNB during the summer (see the section: Exchange of Personnel)

Ionospheric modelling:

C. St-Pierre (Viasat) has continued to work on the interpolation of ionospheric delays. An oral presentation has been made during the Geomatics 2000 Conference (St-Pierre et al., 2000).

Precise GPS orbit:

S. Michaud worked on the interpolation of precise GPS ephemerides and satellite clock corrections. She compared different interpolation approaches and coded the algorithms ready to be implemented in GPS-OTF software. GSD provided us with the precise GPS ephemerides that they compute on a regular basis. GSD is an IGS (International GPS Service) Analysis Centre.

The UNB Web site (<http://gauss.gge.unb.ca/grads/orbit/>) now includes a section on the assessment of the accuracy of the GPS satellite broadcast ephemerides. They are compared daily with the IGS orbit products (predicted, rapid, and precise orbits). A visiting researcher from Germany, Holger Jannasch, contributed to this project and his visit to UNB was funded by Project ENV#14. A paper on the comparisons was presented at the COSPAR 2000 meeting in Warsaw (Langley et al., 2000).

GLONASS positioning:

A. Biron has completed the development of her software for the code data processing and also for the carrier phase data processing in static and rapid static modes for GPS, GLONASS, and GPS+GLONASS solutions. Data set has been tested and analysis has been done. Kinematic algorithm development and coding have started this summer; this will be completed early this Fall. A poster presentation on this topic has been displayed during the Canadian Hydrographic Conference 2000 (Biron and Santerre, 2000a). An oral presentation has also been given during the Second Annual GEOIDE Conference (Biron and Santerre, 2000b).

A. Biron went to work with Dr. Kim and Langley at UNB for 2 weeks at the beginning of August (see the Section: Exchange of Personnel).

A. Biron's M.Sc. thesis is scheduled to be completed by December 2000.

Squat and under-keel clearance of large ships:

A new research axis has been added to the Project ENV#14. This is related to the determination of the squat and under-keel clearance of merchant ships using positioning and attitude information provided by GPS-OTF solutions. Dr. Brian Morse, specialist in hydrodynamics, from the Department of Civil Engineering at Laval University (and formerly with the Canadian Coast Guard) has joined the Project ENV#14 Research Team. He will be in charge of the theoretical study of the squat and under-keel ship clearance.

New GEOIDE funding has been authorised September 29th from DFO to integrate Dr. Morse into our Team. Dr. Morse has been co-operating with the Transport Development Centre, the St. Lawrence Seaway and its clients on a major field research project to improve the safety and efficiency of the St. Lawrence Seaway System. The field work was performed during October and November 2000. It consisted of observing ship positions and elevations throughout the lower part of the Seaway System using 4 GPS receivers aboard at least 6 different kinds of ships on at least two upstream and two downstream trips. In all, over 20 trips were monitored. With the help of a land-surveyor and a Université Laval student, on four of the trips, Dr. Morse used a 2-D laser (RIEGL LMS-Q140) to validate GPS observations and to assess the technology for determining the impact of the ships passage on water level fluctuations. Students under the supervision of Dr. Morse will be analysing the squat study results with the specific objectives of validating the systemic accuracy of GPS data, determining quantifying squat and underkeel clearance with respect to the effect of channel confinement, rapid changes in channel bathymetry and homogeneity of the Seaway System. The ship's dynamic behaviour (bending and twisting) will also be quantified.

Dr. Morse is presently recruiting a graduate student and undergraduate student at Laval University.

GEOIDE ENV#14 Internet site:

An Internet site, containing a section on Project ENV#14, has been completed by J. Sanscartier at the CRG. The site is upgraded on a regular basis by the CRG. This site includes all the

activities performed within the Project GEOIDE ENV#14 (www.scg.ulaval.ca/gps-rs/ Under Section: Research). The following information can be found on this site: The summary of the project ENV#14 meetings, the summary of the GEOIDE GPS Round Table Meeting held during the second annual GEOIDE meeting in Calgary, the publication list of project ENV#14 (with access to the abstracts or the complete papers), the viewgraphs of presentation of the project ENV#14, etc.

Milestones

Here are the milestones of Project ENV#14 until December 2001.

Milestones for Squat study:

1. Field program: Validation of systemic GPS vertical positioning and ship squat / hydrodynamic interaction using a 2-D laser. November 1 to November 13, 2000. (Complete)
2. Assessment of laser data and technology for georeferencing ships and water surfaces. November 14 to December 31, 2000.
3. Assessment of dynamic ship behaviour (twisting and bending): January 1 to March 31 2001.
4. Validation of GPS determination of ship squat using laser data: 1 April 2001 to 1 July 2001.
5. Evaluation of GPS derived squat homogeneity and effect of channel bathymetry on ship squat: 1 July 2001 to 31 December 2001

Evaluation of channel confinement on ship squat: 1 January 2001 to 31 March 2001.

Milestones for UNB's researches:

1. Multipath modeling for pseudorange and phase observations; tropospheric delay prediction; stochastic modeling; and cycle slip detection and correction (until December 2000).
2. Satellite orbit error; antenna phase center; quality assurance; and system evaluation and demonstration (for the year 2001).

Milestones for CRG's researches:

1. Glonass phase observation processing; the use of a priori height information as quasi observation (until December 2000).

2. GPS attitude determination in relation to the study of squat and underkeel clearance determination; comparison of fixed and float ambiguity solutions; Bayesian estimation (for the year 2001).

Deliverables

The software module for the interpolation of the ionospheric delay from GPS reference stations is completed. Another software module for the interpolation of precise orbits and satellite clock correction has been tested and coded ready to be implemented into the existing main GPS programme. An automated WWW site to assess the accuracy of the GPS satellite broadcast ephemerides is now operational (see gauss.gge.unb.ca/grads/orbit/).

Training of HQP

Right now, eleven graduate students (M.Sc. and Ph.D.), post-doctoral fellows and research assistants (our former graduate students) are working or have worked within the Project ENV#14.

Most of the project research is carried out by our students and research assistants, under close supervision by the Project Leaders. Indeed, our project budget is almost entirely dedicated to pay their salaries.

Almost all publications of our Project ENV#14 have at least one student as a co-author or first author.

The complete list of our graduate students, post-doctoral fellows and research assistants is given in the menu: Participants.

We anticipate that new graduate students and visitors will join the project at both Laval and UNB in 2001.

Networking and Partnerships

In addition to the Networking within the Project ENV#14 and within GEOIDE, as reported below, let also mention the following:

One paper (Ueno et al., 2000a) has been presented during the Geomatics 2000 Conference in the GEOIDE Session: Data Acquisition held in Montreal, 8-10 March. Five members of the Project ENV#14 attended this conference.

Two oral presentations and 2 posters have been presented at the 2nd GEOIDE Annual Conference, held in Calgary, 25-26 May 2000. During this GEOIDE Annual Conference a meeting of the project ENV#14 has been held as well as the first GEOIDE GPS "Round Table" Meeting organised by Dr. Langley (co-Project Leader ENV#14).

Networking within the project

A project meeting was held during the Second Annual GEOIDE Conference in Calgary, May 2000. Another one was held, November 2nd 2000 at Viasat in Montreal. The next two Project Meetings are scheduled in March 2001 at the Geodetic Survey Division, in Ottawa and at UNB, (Fredericton) in June 2001 during the Third Annual GEOIDE Conference.

All the meeting summaries are available on the Project ENV#14 Internet site.

Visit of Dr. Kim (UNB) to Viasat (18-21 July 2000):

Here are the works which have been accomplished during this visit: Presentation of Dr. Kim's OTF algorithms. Data processing (of problematic GPS data sets) with Dr. Kim's software for comparison of the results including the analysis and identification of solutions (improvements). Presentation of potential OTF algorithm improvements.

Visit of A. Biron (CRG) to UNB (July 31st - August 11th 2000):

The following paragraph summarise the activities performed during this visit: Introduction to the research of Dr. Kim for possible integration of GLONASS observations into his algorithms.

Familiarisation with the data processing GPS-GLONASS software and with the receivers of the company Javad (now Topcon). GPS-GLONASS observations collected with Javad receivers have been processed with A. Biron's software.

Visit of Dr. Mami Ueno (CRG) to UNB (17-23 August 2000):

Dr. Ueno visited UNB to learn first-hand about Dr. Kim's recent work and to investigate the possibilities for a joint-research partnership between UNB and ACRI Mécanique Appliquée et Sciences de l'Environnement in France where Dr. Ueno is now a post-doctoral fellow.

Project ENV#14 WWW site:

The summary of the meetings as well as the papers written within the Project ENV#14 are included on this site.

During the remaining period of the project, exchanges and visits involving Viasat (our industry partner) will be intensified to make sure that the results of research at the universities will be used concretely.

Networking across projects within GEOIDE

GEOIDE NCE GPS "Round Table" Meeting:

In order to begin the process of improving networking on GPS-related issues within the GEOIDE NCE, a GPS "Round Table" meeting was held during the 2nd GEOIDE NCE annual meeting. Representatives from each of the five GEOIDE projects (ENV#14, ENV#17, RES#47, TCO#51 and TCO#53) with a significant GPS component were invited to participate. The meeting was well attended with 16 representative from academia, the government, and the private sector (see the Project ENV#14 WWW site for the complete summary).

Representative from each of the projects were asked to introduce their project, concentrating on the GPS aspects, and briefly summarising the project accomplishments to date and to suggest possible topics and avenues for collaboration between projects.

It was felt that cross-project meetings such as this one should be a regular feature of GEOIDE NCE annual meetings.

Following this meeting, Dr. El-Rabbany (TCO#51) and Dr. Gao (TCO#53) showed their interests in closely collaborating with our Project ENV#14. Let's also recall that Dr. Langley is a participant in GEOIDE Projects ENV#17 and RES#47.

The Second Annual GPS Round Table Meeting will be held in Fredericton, June 2001 (during the Third Annual GEOIDE Conference).

During the U.S. Institute of Navigation GPS Conference held in Salt Lake City, 20-22 September, a meeting gathering several GPS Canadian researchers (from the 4 Canadian Universities involved in GPS) has been held to discuss a future common project to be proposed to the GEOIDE Network. This meeting was initiated by the Project ENV#14. The participants at this Meeting were:

- Dr. Ahmed El-Rabbany, Department of Civil Engineering, Ryerson Polytechnic University, (Project TCO#51);
- Dr Naser El-Sheimy, Departement of Geomatics Engineering, University of Calgary;
- Dr Yang Gao, Departement of Geomatics Engineering, University of Calgary (Project TCO#53);
- Dr Richard B. Langley, Department of Geodesy and Geomatics Engineering (Projects ENV#14, ENV#17, RES#47);
- Dr Rock Santerre, Département des sciences géomatiques, Université Laval (Project ENV#14).

We arrived at a consensus on a research project which has rallied everybody. The project to be proposed to the GEOIDE Network for the years 2002-2005 will be related to the Galileo

Positioning System. Government agencies as well as industry partners have been approached to participate in the project. A letter of intent is in preparation for the December 1st 2000 deadline.

Networking outside GEOIDE

Three researchers of project ENV#14 (R.B. Langley, R. Santerre and D. Kim) are members of GPS special study groups of the International Association of Geodesy (IAG) which gathers GPS specialists all around the world.

The title of those IAG Committees are: Wide Area Modelling for Precise Satellite Positioning and Refractive Indices of Light, Infrared, and Radio Waves in the Atmosphere, both directly related to the research activities of the project ENV#14.

Through our collaboration with former GEOIDE investigator, Dr. Ueno, we are developing a possible joint project with researchers at one or two French institutes involved in GPS research.

Eventually, the St. Lawrence Seaway wants to implement a real-time vessel management system to optimise vessel squat, vessel safety, vessel fuel consumption and just-on-time delivery. Our research demonstrates the potential of GPS and GIS technology to meet these management objectives. Due to the collaborative nature of the project and its international scope, findings of the study will be available to vast number of marine users (agents, navigators, controllers, managers, owners, etc.).

Partnerships and leverage

Any algorithms, software and processes developed within project ENV#14 with commercial potential will be first offered to our private sector partner (Viasat). Note that Viasat is a very dynamic geomatics company with a development division. Among their services and expertise, Viasat is developing and marketing GPS software for GIS and surveying applications. The algorithms and software developed within project ENV#14 could be integrated in Viasat's GPS software suite. All of the research activities carried out within project ENV#14 can be applied

not only to the marine navigation sector but can also be adapted to any other applications requiring precise geo-positioning (GIS, surveying, geodesy, etc.) - markets which Viasat has been developing for many years.

For the development of commercial products, our private sector partner (Viasat) will probably prepare a proposal for the GEOIDE Market Development Fund.

Our new academic research partner, Dr. Morse had also worked more than 6 years at the Canadian Coast Guard. He has many contacts within the maritime navigation sector (Canadian Coast Guard, Transportation Development Centre, St. Lawrence Seaway Corporation, maritime shipping,...).

New research funding (\$25,000) has been provided from DFO to integrate Dr. Morse into our Team.

Note about CHS and CCG's in-kind contributions:

All the field tests of our research project have been done in collaboration with CHS and CCG during their regular survey operations or during their own GPS field tests. Consequently, this has decreased their in-kind contributions.

Project Management

Comments on the RMC Evaluation Letter (October 2000):

Equipment budget: This is used mainly for the rental of GPS receivers (owned by Laval University and UNB) to support field tests, and for the maintenance costs and the purchase of auxiliary equipment, including data processing computers.

HQP budget: For the financial supports of post-doctoral fellows and M.Sc. and Ph.D. students

Among the 11 graduate students, some students are working on the project part-time, other ones are no longer participating in the project, mainly because they have completed their graduate studies and found a job.

The personnel identification, their engagement status (part-time or full-time), the dates of their engagement, the percentage of their salary paid by GEOIDE and their actual status, all this information can be found under the personnel menu on the GEOIDE Internet site.

Dr. Morse's student(s) will be hired soon. This was not possible to actively recruit personnel since the additional funding to support Dr. Morse's new research was not available until 1 October 2000. Already an undergraduate Geomatics student was involved in the field study. During a mini-project (3 week study), Dr. Morse has already evaluated (and rejected) one post-graduate student. He is currently negotiating with a potential Ph.D. Student (A. Shandyba) and is trying to encourage an undergraduate student (B. Ringo) to do a work term on the subject.

Milestones for the new research direction is included the section: Milestones, above.

Serious efforts will be made to increase our publication rate in reviewed journals. Right now there are two refereed papers (published or accepted), two others will be submitted in the next few months.

Management strategy: The Project ENV#14 management is under the control of the two co-project leaders, namely Dr. Santerre (CRG-U. Laval) and Dr. Langley (UNB). The budget is divided into two equal parts and coordinated research is being carried out at the two universities. Additional funding from DFO to support Dr. Morse's new research activities is managed by Dr. Morse via the CRG at Laval University. Project meetings are scheduled on a regular basis to report to all the team members the status of the on-going research activities and to plan and to coordinate the future research. This is done in close collaboration with our government agency partners (DFO, Geomatics Canada) and our private industry partner (Viasat).

Other comments

Note on the technologies menu:

Right now there is no entry in the technologies menu of the GEOIDE database. For the moment there is no patent or disclosure, but let's note that some software modules (with a commercial potential) have been completed or will be completed soon.