Ph.D. Candidate

Tomáš Beran

Graduate Academic Unit

Geodesy & Geomatics Engineering

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May 22, 2008

1:00 p.m.

ADI Studio (Room HC 25)
Head Hall

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Examining Board

Dr. Richard Langley (Geodesy & Geomatics Eng.) Supervisor
Dr. Peter Dare (Geodesy & Geomatics Eng.)
Dr. Marcelo Santos (Geodesy & Geomatics Eng.)
Prof. Mary Kaye (Elect & Comp Eng.)
Dr. Ed Biden (SGS) Chairperson

External Examiner:
Dr. Rock Santerre, QLS, P.Eng.
Director, GPS-Geodesy Laboratory
Dept. of Geomatics Sciences
Laval University

The Oral Examination will be chaired by:
Dr. Ed Biden, Associate Dean of Graduate Studies

BIOGRAPHY

Universities attended:

1999-2008 PhD candidate, University of New Brunswick
1993-1999 MScE in Geodesy and Geomatics Engineering from Czech Technical University (CVUT) in Prague, Czech Republic.

Publications:

Beran, T., S. Bisnath, R.B. Langley and L. Serrano (2007). "High-Accuracy Point Positioning with Low-Cost GPS Receivers." *Navigation: Journal of the Institute of Navigation, Vol. 54, No. 1, Spring 2007; The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 53-63.*

Beran, T., S. Bisnath, R.B. Langley and L. Serrano (2005). "High-Accuracy Point Positioning with Low-Cost GPS Receivers: How Good Can It Get?"*Proceedings of ION GPS/GNSS 2005, 18th International Technical Meeting of the Satellite Division of The Institute of Navigation*, Long Beach, CA, 13-16 September 2005, The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 1524-1534.

Beran, T., S. Bisnath, and R.B. Langley (2004). "Evaluation of High-Precission, Single-Frequency GPS Point Positioning Models." *Proceedings of ION GPS/GNSS 2004, 17th International Technical Meeting of the Satellite Division of The Institute of Navigation*, Long Beach, CA, 21-24 September 2004, The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 1893-1901.

Beran, T., (2003). "Single-Frequency, Single-Receiver Spaceborne GPS Orbit Determination.", Ph.D. Dissertation Proposal, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Fredericton, Canada, 30 pp.

Beran, T., D. Kim, and R.B. Langley (2003). "High-Precision Single-Frequency GPS Point Positioning." *Proceedings of ION GPS/GNSS 2003, 16th International Technical Meeting of the Satellite Division of The Institute of Navigation*, Portland, OR, 9-12 September 2003, The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 1192-1200.

Beran, T., D. Kim, and R.B. Langley (2002). "Multipath Filtering in the Spaceborne Environment: Simulation Study." Poster presented at the GEOIDE 4th Annual Conference, Toronto, Ontario, 22-24 May 2002.

Bisnath, S., **T. Beran**, and R.B. Langley (2002). "Precise Platform Positioning with a Single GPS Receiver." *GPS World*, Vol. 13, No. 4, 2002; pp. 42 – 49.

Beran, T., S.B. Bisnath, and R.B. Langley (2001). "Single Receiver GPS Positioning in Support of Airborne Gravity for Exploration and Mapping." Poster presented at the GEOIDE 3rd Annual Conference, Fredericton, 20-22 June 2001.

Bruton, A. M., M. Kern, K.P. Schwarz, S. Ferguson, A. Simsky, K. Tennant, M.Wei, J. Halpenny, R. Langley, **T. Beran**, K. Keller, P. Mrstik, K. Kusevic and R. Faulkner (2001). "On the accuracy of Kinematic Carrier Phase DGPS for Airborne Mapping.", *Geomatica*, Vol. 55., No. 4, 2001; pp.491 – 507.

Beran, T. (2000). "Improvement of GPS Ambiguity Resolution." Graduate Student Seminar, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Fredericton, Canada, pp. 15.

Beran, T. (1999). Zaměření osy koleje kinematickou metodou GPS (Measurement of the railroad track axis by kinematic GPS method). Masters diploma thesis, K 152 Department of Advanced Geodesy, Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic, 54 pp.

Conference presentations:

Beran, T., S. Bisnath, R.B. Langley and L. Serrano (2005). "High-Accuracy Point Positioning with Low-Cost GPS Receivers: How Good Can It Get?"*Proceedings of ION GPS/GNSS 2005, 18th International Technical Meeting of the Satellite Division of The Institute of Navigation*, Long Beach, CA, 13-16 September 2005, The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 1524-1534.

Beran, T. (2004). "Review and Analysis of Deformation monitoring Techniques.", Course on Deformation Surveys and Related Topics, Canadian Centre for Geodetic Engineering, Fredericton, NB, Canada, December 2, 2004.

Beran, T., S. Bisnath, and R.B. Langley (2004). "Evaluation of High-Precission, Single-Frequency GPS Point Positioning Models." *Proceedings of ION GPS/GNSS 2004, 17th International Technical Meeting of the Satellite Division of The Institute of Navigation*, Long Beach, CA, 21-24 September 2004, The Institute of Navigation, Alexandria, Virginia, U.S.A., pp. 1893-1901.

Several other conference presentations

SINGLE-FREQUENCY, SINGLE-RECEIVER TERRESTRIAL AND SPACEBORNE POINT POSITIONING

Abstract

High-accuracy, point positioning has been an attractive research topic in the GPS community for a number of years. The overall quality of precise point positioning results is also dependent on the quality of the GPS measurements and the user's processing software. Dual-frequency, geodetic-quality GPS receivers are routinely used both in static and kinematic applications for high-accuracy point positioning. However, use of low-cost, single-frequency GPS receivers in similar applications creates a challenge because of difficulty of handling the ionosphere, multipath and other measurement error sources. Potential use of such receivers to provide horizontal positioning accuracies of a few decimetres will be examined in this dissertation. Practical applications of post-processed, high-accuracy, single-frequency point positioning include a myriad of terrestrial and space-borne applications, where the size and cost of the GPS unit is an issue.

The processing technique uses pseudorange and time-differenced carrier-phase measurements in a sequential least-squares filter. In developing the approach, different techniques were investigated. Ionospheric delay grid maps are used to remove the bulk of the ionospheric error, while tropospheric error is handled by a prediction model. Pseudorange multipath errors are mitigated by means of stochastic modelling and carrier-phase cycle slips are detected-and corrupted measurements are removed-in a quality-control algorithm.

The technique was first tested on L1 measurements extracted from datasets from static, high-quality GPS receivers. Accuracies better than two-decimetres in horizontal components (northing and easting r.m.s.), and three-decimetre accuracies in the vertical component (up-component r.m.s.), were obtained. A test dataset from a stationary low-cost GPS receiver has been processed to demonstrate the difference in data quality. Positioning results obtained are worse than those of a high-quality GPS receiver, but they are still within the few decimetre accuracy level (northing and easting r.m.s.). The use of the technique is not restricted to static applications, and the results of kinematic experiments are also presented. These experiments consist of terrestrial data processing and spaceborne data processing. The kinematic terrestrial tests include processing of single-frequency data from geodetic-quality GPS receiver and low-cost GPS receiver from a moving vehicle. The spaceborne kinamatic tests include processing of dual-frequency data from geodetic-quality GPS receiver on board of low Earth orbit (LEO) satellite, and processing of the simulated single-frequency data from a low-cost GPS receiver for a future satellite mission.

The question whether it is possible to use low-cost GPS receivers for high accuracy GPS positioning has been answered. Contributions to the leading edge research in the area of high precision GPS point positioning have been made. The software that was developed is the only software capable of reliable pseudorange and carrier-phase data processing from low-cost GPS receivers. Its reliability is accomplished through data quality control based on residual outlier detection theory.The implemented algorithm is capable to detect 99% of outliers. Despite of the encouraging results the limitations of this technique were found. During the static terrestrial data testing it was found that the presence of multipath has negative impact on the positioning results from low-cost GPS receivers. The kinematic terrestrial data testing is limited to short periods of time when reliable reference solution is available. Majority of the test results are from terrestrial platforms, because the spaceborne single-frequency point positioning requires more sophisticated ionospheric models than the terrestrial single-frequency point positioning. One example of sophisticated ionospheric model is a global 3D ionospheric model was tested in this dissertation.