

Ph.D. Candidate

Hyun Ho Rho

Graduate Academic Unit

Geodesy & Geomatics Engineering

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**May 28, 2019**

**2:00 p.m.**

**Forestry/Geology Bldg.  
Room 202**

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Examining Board:

Dr. Peter Dare (Geodesy & Geomatics Eng.)

Dr. Bruce Colpitts (Electrical & Computer Eng.)

Dr. Attila Komjathy, Adjunct Prof. (Geodesy & Geomatics Eng.)

Dr. Richard B. Langley (Geodesy & Geomatics Eng.)

Supervisor

External Examiner:

Dr. Kyle O'Keefe, PEng.

Professor and Associate Head – Undergraduate

Dept. of Geomatics Engineering

University of Calgary

The Oral Examination will be chaired by:

Dr. Heather Sears, Assistant Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2000 – present

PhD candidate, University of New Brunswick

1997 – 1999

MScE, Dept. of Geographic Information Engineering, Inha University,
South Korea

1989 – 1995

BScE in Engineering, Dept. of Urban Engineering, University of
Suwon, South Korea

Selected Publications and Conference Presentations:

Rho, H., R.B. Langley, B. Ober, R.O. Pérez and R. Prieto-Cerdeira (2017). "Analysis of the Interoperability of the GPS and Galileo Ionosphere Models.", Proceeding of ION GNSS 2017, 30th International Technical Meeting of the Satellite Division of the Institute of Navigation, Portland, OR, 25-29 September, pp. 4139–4160.

Zhang, W., A. Komjathy, S. Banville, H. Rho, and R.B. Langley (2015). "An Improved Ionospheric Modelling Technique Using GPS and Empirical-Orthogonal-Function Fits.", Proceeding of ION 2015 Pacific PNT Meeting, Honolulu, Hawaii, 20-23 April, pp. 63-70.

Rho, H. and R.B. Langley (2013). "Evaluation of Precise Wide Area Differential GPS Positioning.", Viewgraphs presented at GNSS Precise Point Positioning Workshop: Reaching Full Potential, Ottawa, ON, Canada, 12-14 June 2013.

Rho, H. and R.B. Langley (2012). "Precise Point Positioning with GPS Dual-Frequency Carrier-Phase Measurements using WADGPS Correction." Proceeding of ION GNSS 2012, 25th International Technical Meeting of the Satellite Division of The Institute of Navigation, Nashville, TN, 17-21 September, pp. 3683-3695.

Rho, H. and R.B. Langley (2009). "The WAAS L5 Signal: An Assessment of Its Behavior and Potential End Use." GPS World, Innovation, May 2009, pp. 42-50.

Rho, H. and R.B. Langley (2008). "Evaluation of the New WAAS L5 Signal." Proceeding of ION GNSS 2008, 21st International Technical Meeting of The Institute of Navigation, Savannah, GA, 16-19 September, pp.1667-1678.

Rho, H. and R.B. Langley (2007). "The Usefulness of WADGPS Satellite Orbit and Clock Corrections for Dual-Frequency Precise Point Positioning." Proceedings of ION GNSS 2007, 20th International Technical Meeting of The Institute of Navigation, Fort Worth, TX, 25-28 September 2007, pp. 939-949.

Rho, H. and R.B. Langley (2007). "Dual-frequency GPS Precise Point Positioning with WADGPS Corrections." Navigation: Journal of The Institute of Navigation, Vol. 54, No. 2, Summer 2007, pp. 139-152.

Several other Publications and Conference Presentations

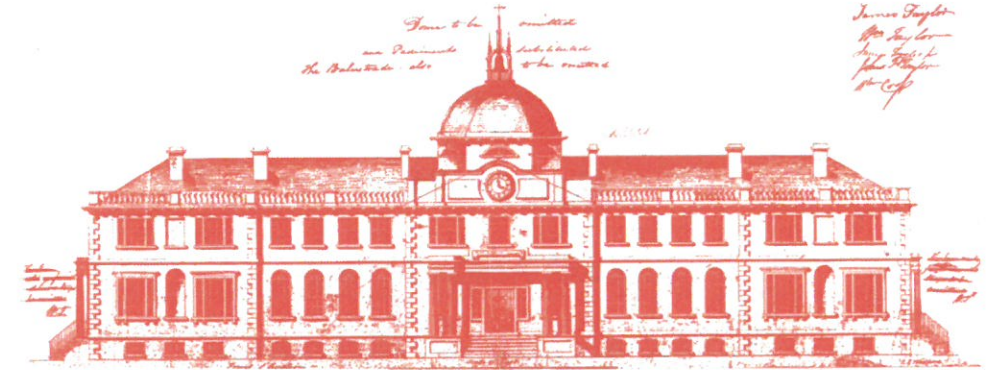
Precise Point Positioning with Wide Area Differential GPS Corrections

Abstract

Wide area differential GPS (WADGPS) satellite-based augmentation system (SBAS) services, such as the Wide Area Augmentation System (WAAS) in U.S.A., provide satellite orbit and clock corrections and ionospheric delay corrections. Although their corrections are optimized for use with GPS single-frequency pseudorange measurements, the satellite orbit and clock corrections can be used to improve GPS positioning accuracy for dual-frequency users. The main objective in the research described in this dissertation is the design of a GPS dual-frequency data processing technique capable of producing high-accuracy point positioning results with WADGPS corrections.

In this research, by considering the ways to handle the identified major issues, i.e., the satellite clock referencing issue, the resolution of the fast clock correction issue and the residual orbit and clock issue, in a precise point positioning (PPP) process are different for different position estimators and different basis observables, a SBAS PPP with a weighted least-squares approach using a carefully designed sequential forward carrier-phase smoother and a SBAS PPP with sequential least-squares approach using un-differenced dual-frequency code and carrier-phase measurements have been developed. To account for the satellite clock referencing issue, the effects of the satellite instrumental biases have been precisely investigated and the observation equations for the different observables assuming the source of corrections is WADGPS have been developed. To account for the low resolutions of WAAS (or/and any SBAS corrections which follows the RTCA standard [2001]) fast clock corrections, a weighted moving average filter was adopted and a proper smoothing factor has been carefully determined. Finally, to take into account the residual orbit and clock errors, a varying carrier-phase ambiguity concept has been applied rather than assuming the ambiguity is constant over time. This method is only applicable for the SBAS PPP with a sequential least-squares method which has an ambiguity parameter for each satellite in the observation model.

Results determined via developed software indicate a few decimeter-level of positioning accuracy for both developed PPP algorithms with (real-time) WADGPS orbit and clock corrections in kinematic mode could be attainable. Although a few decimeter-level of positioning accuracy are slightly less accurate than that of using precise orbit and clock products, it will give more flexibility and chances to choose a proper positioning technique, which can meet the majority of user expectations and their application needs. Furthermore, the algorithms developed in this research can be used for seamless PPP solutions with future SBAS corrections when all the planned SBASs are in operation.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

The University of New Brunswick recognizes that the university sits on traditional Wolastoqey territory. The river that runs right by our university – the St. John River – is also known as Wolastoq, along which live the Wolastoqiyik -- the people of the beautiful and bountiful river.

UNIVERSITY OF NEW BRUNSWICK SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Hyun Ho Rho

**IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF**

DOCTOR OF PHILOSOPHY