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GEOMATICS ENGINEERING

SCHULICH School of Engineering — UNIVERSITY OF CALGARY

DEPARTMENT OF GEOMATICS ENGINEERING

Geomatics News

Message from the Head

Dear Valued Reader

Once again we finished another academic year. Throughout the year, the faculty members together with the administrative and technical staff have been doing an excellent job in ensuring the best service to our undergraduate and graduate students. Therefore, I would like to thank them all for their services, contributions, and continued commitment to the Department. Also, I would like to thank our undergraduate and graduate students for their achievements. In June, the department celebrated the graduation of 58 students (36 BSc, 14 MSc, and 8 PhD). On behalf of the department, I would like to congratulate our graduates and wish them all the best in whatever endeavor they undertake and hope that they will promote the department wherever they are.

The Department is pleased to share with you that our faculty members and students received several prestigious national and international awards. In this regard, I would like to highlight the achievements of our graduating BSc students. In this years' Capstone Design Fair, which took place on April 11th, Geomatics students won the first, second, and third place for the best three projects among almost 100 projects (Internet of Things & Quadcopter; Subdivision Design: Nosehill; and Terrestrial Photogrammertry) as voted by the student body.

Dr. Ayman Habib
Professor and Head

Faculty and Staff, 2012 Strategy Meeting

From L to R: Quazi Hassan, Susan Skone, J.W. Kim, Steve Liang, Monica Barbaro, Mark Petovello, Yang Gao, Naser El-Sheimy, Gerard Lachapelle, Ayman Habib, Bill Teskey, Jodie Stevens, Michael Sideris, Courtenay Canivet, Marcia Rempel, Kyle O'Keefe, Michael Barry, Garth Wana-maker, Andrew Hunter, Kirk Collins, and Derek Lichti.

Inside this issue:

Congratulations

- Congratulations to students who completed their graduate studies: Jing Wang, MSc; Charlene Radons Beckie, MEng; Baijie Wang, MSc; Feng Tang, PhD.

- Professor Cannon received the Centennial Leadership Award from the Association of Professional Engineers and Geoscientists of Alberta.

- Saeed Daneshmand and Ali Jafarnia-Jahromi placed third out of nearly forty competing teams in the 2012 National Security Innovation Competition organized by the (U.S.) National Homeland Defense Foundation (www.nhdf.org). Their entry on *GPS Anti -Interference: A Practical Array Processing Approach* describes a sophisticated technique to thwart interference attacks on GPS signals that can lead to incorrect navigational data and misdirect users, and was the only one submitted from outside the United States.

- Three graduate students in the department of Geomatics engineering received scholarships from Alberta Innovates – Technology Futures. Mr. Ali Jafarnia Jahromi and Mr. Rakesh Kumar each received the Doctoral Scholarship. Mr. Mohammed Shariful Islam received the Master's Scholarship.

"*The Alberta Innovates Graduate Student Scholarship program (GSS) is designed to enable these promising students to succeed in areas of scientific research which are strategically important to Alberta.*" – AITF Website

- Congratulations to Jacky Chow who has been awarded an Honorary Izaak Walton Killam Memorial Scholarship. This prestigious scholarship is awarded to doctoral students of outstanding caliber.

Jacky graduated with a BSc from the department in 2010 and is currently pursuing his PhD under the supervision of Dr. Teskey and Dr. Lichti. His research focuses on portable 3D imaging using laser scanners, low-cost inertial sensors and gaming sensors (Microsoft Kinect).

- Dr Quazi Hassan was awarded the 2012 Canadian Remote Sensing Society Bronze Medal. The CRSS Bronze Medal Award was established in 2009 as an early-career achievement award to recognize emerging excellence in remote sensing in Canada.

- Dr. Mark Petovello received a 2011-2012 Students' Union Teaching Excellence Award for his efforts teaching ENGO 465 (Satellite Positioning) in Winter 2012. The SU Teaching Excellence Award is the only campus-wide recognition program for those instructors who make a long-lasting impact on students. Most importantly, students determine the nominees and winners adding to the significance and importance of the recognition.

Alumni Voice

Coming out of grade 12, I wasn't sure what I wanted to be when I grew up. In grade school I had a passion for art and liked high school chemistry. I went into engineering partly as a means of dodging the endless choices offered in general studies and thought, perhaps, that I would become a Chemical Engineer. Once enrolled in Engineering at the U of C, I was fascinated by the maps and images that I saw on the walls of the Geomatics Engineering Department. These maps and remotely sensed images looked like works of art, which piqued my interest, and I wasn't liking my current 1st year university chemistry class. I was also intrigued by the variety of disciplines available in Geomatics Engineering and the breadth of courses that were offered. After a deeper look into the department, my focus changed and during 2nd year I enrolled in Geomatics Engineering instead of Chemical.

I graduated from the U of C Geomatics Engineering department seven years ago with a Bachelor's and a Master's degree. I started work in the survey industry and have settled into the disciplines of photogrammetry, LiDAR and GIS at ORTHOSHOP Geomatics Ltd. My role in the company as Director of Development consists of engaging with clients to engineer and implement solutions using the tools of photogrammetry, LiDAR, satellite imagery, land survey and/or GIS solutions. ORTHOSHOP currently operates one of the most advanced LiDAR and photogrammetry technologies available in the marketplace today and is one of the few companies in our industry to address the elements of engineering, execution and analysis in house. This includes flight operations and aircraft maintenance, which offer thrills that are rare in many other disciplines. This profession has given me access to numerous industries including oil and gas, energy, utilities, transportation, mining, government, military, forestry and environmental monitoring and protection. The variety of disciplines and technology that I experienced throughout my education in Geomatics Engineering at U of C are still what attract me to this profession today. My degrees in Geomatics Engineering have offered me the luxury of a profession that is always fascinating, always changing and that keeps me on my toes. That, and the fact that I still appreciate when aerial images and remotely sensed data look like works of art.

Landra Trevis, MSc 2005

Research Spotlight

CanX-2 GPS Receiver Payload

Article by Kyle O'Keefe, Erin Kahr, Susan Skone and Michael Swab (Positioning, Navigation and Wireless Location)

On April 28th, 2008 our department's first space experiment was launched on board the CanX-2 nano-satellite mission. A nano-satellite is a very, very small satellite, in this case only 10 x 10 x 35 cm. The satellite was designed, built and operated by the Space Flight Laboratory at the University of Toronto Institute for Aerospace Studies is carrying, among other payloads, a Novatel OEM4 commercial off-the-shelf GPS receiver and antenna for the University of Calgary. The purpose of this payload is to collect radio occultation data and demonstrate for the first time that it is possible to collect the same useful atmospheric data from a nanosatellite carrying COTS components as from a dedicated mission carrying a space qualified receiver.

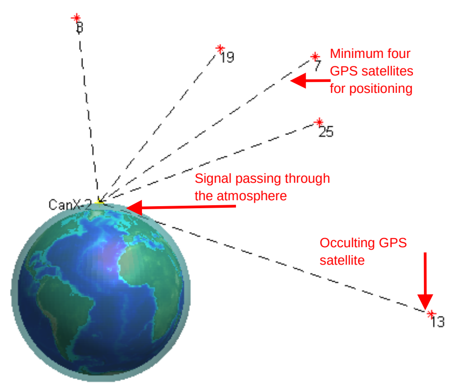

Figure 1 GPS radio occultation for atmospheric profiling

The basic concept of a radio occultation experiment is that a GPS receiver on a low earth orbiting satellite can track setting GPS satellites, in order to observe the atmospheric delay as their signal paths pass through the various layers of the atmosphere tangentially. The path delay can be used to derive information about the electron density in the upper atmosphere, or temperature, pressure and water vapor in the lower atmosphere. The minimum requirement for the radio occultation experiment is that five GPS satellites are simultaneously tracked, and that one of these GPS satellites is setting, or occulting. The remaining four (or more) tracked GPS satellites are required to accurately position the low earth orbiting satellite. Commercial radio occultation missions typically make use of multiple antennas, with a dedicated antenna pointing towards the horizon to track occulting GPS satellites, and several antennas pointing at various parts of the sky to track a maximum constellation for positioning On CanX-2, during occultation data collection the single antenna is pointed to 60 degrees off-zenith in the negative velocity direction in order to maintain the best compromise between signal strength on the occulting satellite and positioning geometry of the visible constellation.

In addition to the primary goal of radio occultation experiments, CanX-2's receiver has also been used for an assortment of other experiments including testing the ability of the receiver to acquire in space, testing difference data collection strategies for orbit determination, and being simultaneously GPS and radar tracked to test the ability of ground based radar to track very small targets.

There are many challenges arising from the use of a small satellite as a platform for a GPS receiver. First, a single receiver and antenna was all that could fit on the satellite, so there will be a trade-off between positioning accuracy and the ability to observe low elevation GPS satellites to perform radio occultation. The receiver was not designed for space. The only modifications made by Novatel were to disable the COCOM limits that prevent tracking above a velocity of 515 m/s and altitude of 18000 m. The satellite has very small solar panels and only limited battery power, memory, and telemetry capabilities meaning that the GPS receiver can only be turned on when in use, and then only for tens of minutes each day. The various payloads are operated on a rotating schedule, which generally allows for four weeks of intermittent GPS data collection followed by a couple of months during which CanX-2's resources are dedicated to the other payloads. This combined with the limited operation each day leads to an additional problem: The receiver, which expects to operate on ground vehicles and aircraft, has difficulty in quickly acquiring a position fix since using a warm start approach. Using the last known position to search for visible satellites and their associated Doppler shifts doesn't really make sense if the receiver is travelling 7 km per second and may have completed dozens to hundreds of orbits since its last position fix.

We have developed a method to warm start the receiver by predicting the satellite's position and attitude and the GPS constellation visibility offline and then uploading command scripts to force the receiver to search for specific GPS signals on specific Doppler frequencies. To do this, we first needed to compute the antenna's field of view given that the attitude of the satellite can be controlled. Upon startup, each receiver channel is assigned with a particular GPS satellite to track, along with its expected Doppler shift.

Figure 2 displays the relative motion induced Doppler shifts seen in various parts of the satellite's field of view. The top of the plot is the forward motion direction of the satellite, the center is zenith and the satellite's horizon is the bold line at 0 degree elevation. The observed Dopplers are plotted extending to the earth's surface at approximately -25 degree elevation. Signals from GPS satellites normal to the nanosatellite's velocity experience the smallest Doppler shift (Doppler goes to zero when the satellite trajectories are briefly parallel), but the highest rate of change in the Doppler shift (as the LEO passes beneath the GPS satellite the Doppler changes from positive to negative).

Using our method, it takes on average 40 seconds for the first signal to be acquired, and an additional 40 seconds for acquisition of four L1 signals. In theory a position could be calculated at this point, although an additional 84 seconds are required for the receiver to acquire L2 signals and process the position solution. The time from receiver start up to a position fix is 3 minutes 20 seconds on average, and from the first channel assignment to a position fix is 2 minutes 44 seconds, which includes 11 seconds of pauses between each channel assignment command in the script.

Cold starting a commercial receiver in space typically takes 7-15 minutes, but can occur in as little as 2 minutes if the right geometry exists. Space qualified receivers, which are very expensive and have additional channels to speed the search have been found to take an average of 2.5 minutes for the U.S. Space Shuttle's LPT receiver, 3 minutes 46 seconds for the Disaster Monitoring Constellation (DMC) satellites' SGR-10 receivers, and typically less than 15 minutes

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![Geomatics Engineering]

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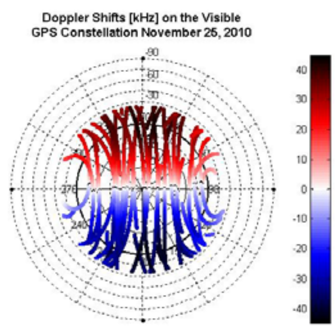
for the Blackjack receiver onboard the CHAMP satellite. Warm starting receivers in space using onboard orbital propagators has typically taken 90 seconds.

For CanX-2's receiver, the cold start time is typically on the order of 20 minutes with the antenna pointing to zenith, and although it has never been attempted, it is unlikely that the receiver would acquire a position fix at all if it were cold started with the antenna pointed in the negative velocity direction for radio occultation data takes. The 3.5 minute TTFF achieved with CanX-2's receiver using channel assignment is an undeniable improvement over its 20 minute cold start, and allows the commercial receiver to achieve a level of performance comparable to specialized space receivers in cold start. It has also allowed for the successful collection of radio occultation data in spite of the intermittent receiver operation, which otherwise would not have been possible.

In next month's newsletter, watch for a research spotlight describing the ionospheric profiles we have obtained with data collected by the CanX-2 mission.



Acknowledgements: The UofC CanX-2 team would like to thank the University of Toronto Institute of Aerospace Studies for operating the CanX-2 mission and Novatel for donating the receiver.

***Figure* 2 – GPS Doppler frequencies observed by a receiver in low earth orbit**

Department Activities

- The Building Block Party was a celebration of the completion of the school's Phase 1 renovations. The Schulich School of Engineering welcomed nearly 600 guests to the engineering complex May 24 for the biggest party in its history. During the party, Gendron unveiled the school's expansion designs. A new 16,000-square metre, four-storey building will provide a central hub for the engineering school. For more information about the Engineering Leaders campaign and to see renderings of the proposed new building, visit schulich.ucalgary.ca/schulichgiving.

- U-blox, a high-sensitivity GNSS receiver manufacturer, has donated five of their EVK-6T evaluation kits to the department of Geomatics Engineering. The approximate value of the donation is nearly USD 1,750.00.

Coming Events

- Survey Camp 2012, ENGO 501 Field Surveys —August 20-29
- ENGO 638—GNSS Receiver Design, August 13 - 24, Instructor, Dr. Daniele Borio

Sites to Visit:

- *http://www.csrs-sct2012.ca*
- *http://http://www.albertatechfutures.ca/*
- *http://www.orthoshop.com/*
- *schulich.ucalgary.ca/schulichgiving*.
- *http://www.ucalgary.ca/kpgokeef/*