GPS Research Group

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In Simple Terms, How Does GPS Work?

The Navstar Global Positioning System, or GPS for short, consists of three segments or components:

- A constellation of about 30 satellites orbiting about 20,000 km above the earth's surface;

http://www.nasm.si.edu/gps/

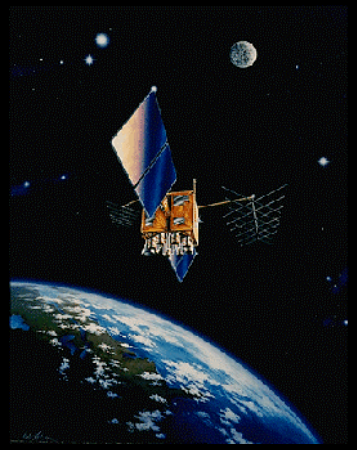
- A control segment which maintains GPS through a system of ground monitor stations and satellite upload facilities;

- The user receivers – both civil and military.

http://www.geocaching-waypoint.com/

In Simple Terms, How Does GPS Work?

Each satellite transmits a digital code which is picked up by a GPS receiver's antenna. The receiver determines how long it takes the signals to travel from the satellite to the receiver. These timing measurements are converted to distances using the speed of light.



http://tycho.usno.navy.mil/gpscurr.html

http://trimble.com

http://garmin.com

Measuring distances to four or more satellites simultaneously and knowing the exact locations of the satellites, the receiver can determine its latitude, longitude, and height while at the same time synchronizing its clock with the GPS time standard which also makes the receiver a precise time piece.

What's Our Research All About?

Research topics of the group aim to a better understanding of the transmitted signals as well as all effects which should be considered in GNSS (Global Navigation Satellite Systems) measurements. The general ultimate goal of our research is the development of tools and methods to improve positioning and navigation with GPS as well the Russian GLONASS system and the future European Galileo system. We work with topics such as:

Development of algorithms for GPS positioning and navigation applications

Development of models to reduce the effect of the atmosphere on GPS signals

Using GPS as a sensor of the atmosphere

Testing GNSS performance in challenging environments

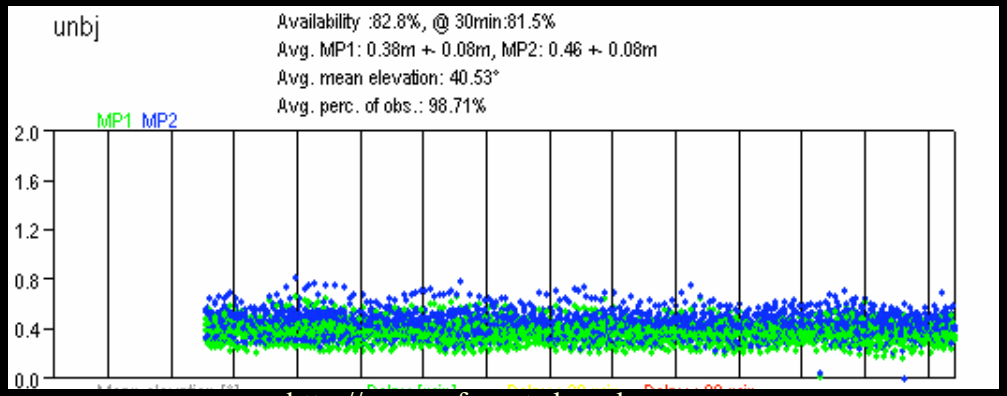
Quality control and analysis of current and new GNSS signals and their augmentations

UNBJ – UNB's IGS station

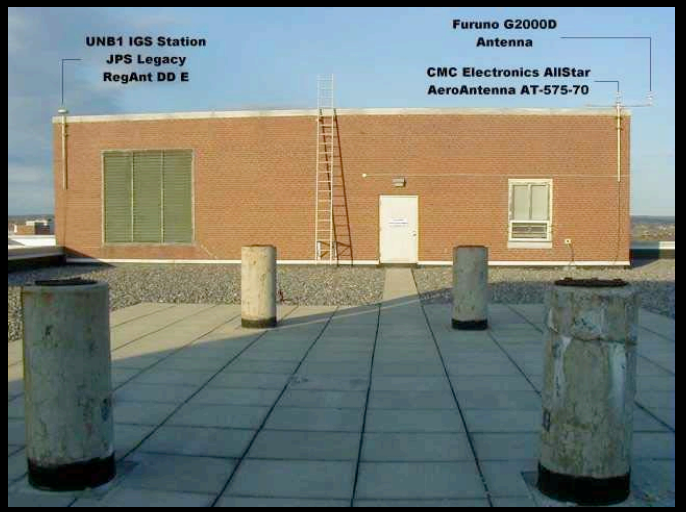
http://igscb.jpl.nasa.gov

The International GNSS Service (IGS) is a voluntary federation of more than 200 worldwide agencies that pool resources and permanent GPS & GLONASS station data to generate precise GPS & GLONASS products, such as precise satellite positions.

The University of New Brunswick runs a continuously operating GPS/GLONASS receiver situated on the roof of the Head Hall building, on the UNB Fredericton campus. Data have been continuously archived since 15 July 2001.

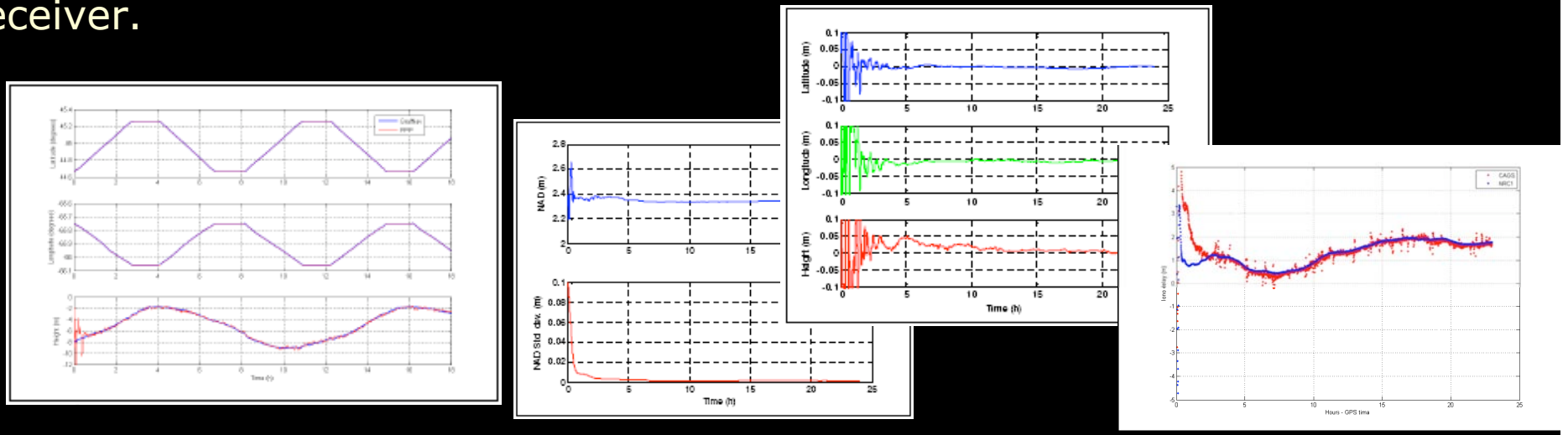


http://www.gfz-potsdam.de



Precise GPS Point Positioning

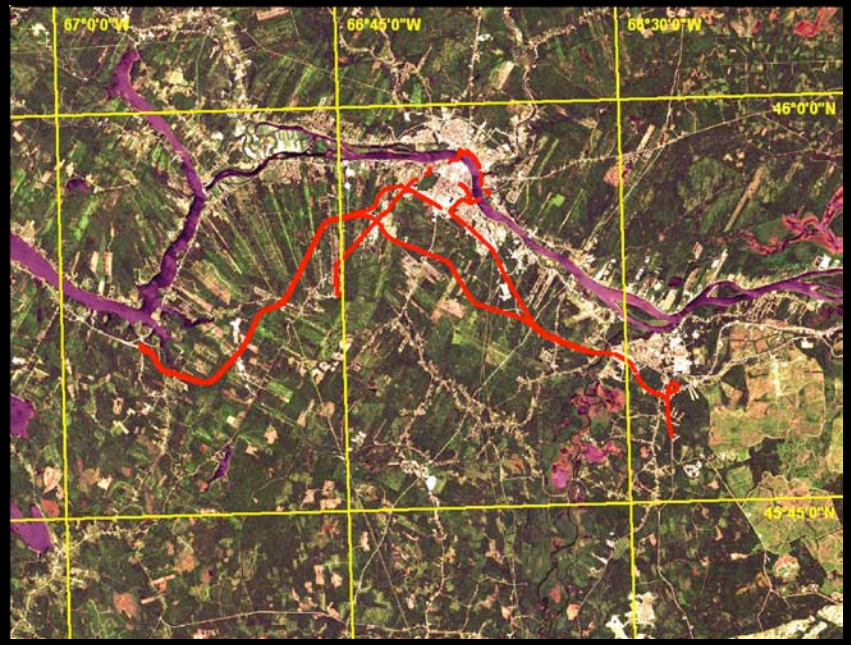
Precise point positioning (PPP) is a positioning technique in which a single receiver is used to determine its coordinates. It is said to be "precise" because precise products such as the satellite orbits are used in the data processing. More than that, PPP techniques use a very complete mathematical model to account for the several effects present in GPS signals, to achieve the best accuracy that can be possibly met with one single receiver.

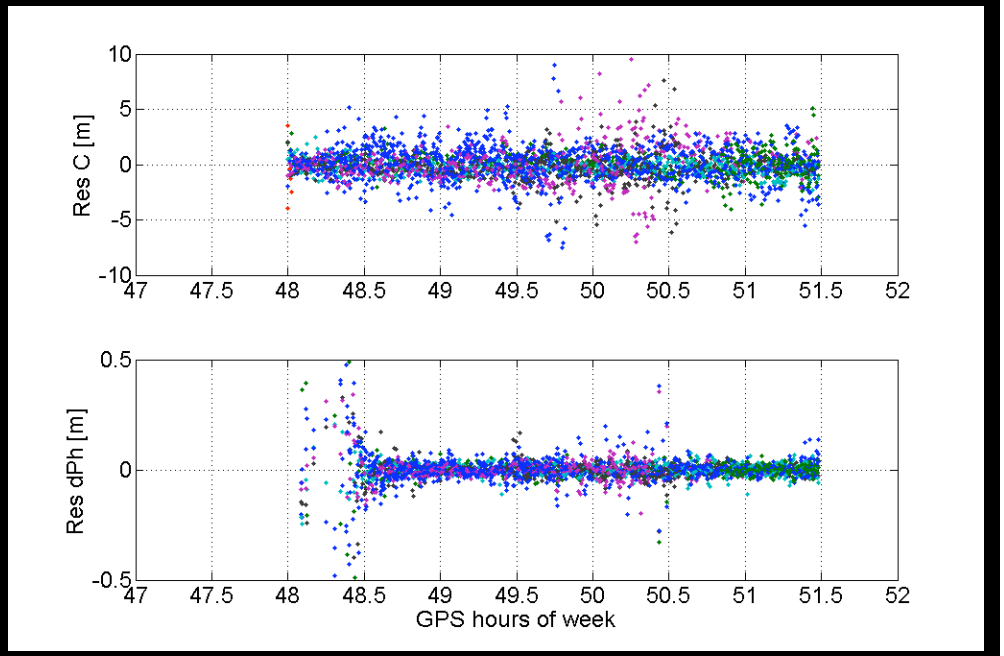


GAPS (GPS Analysis and Positioning Software) is a PPP software package which has been developed at UNB. Besides its use for coordinates determination, UNB researchers designed GAPS to be also used as a tool for GPS data analysis and quality control.

Low-cost, High-accuracy Positioning

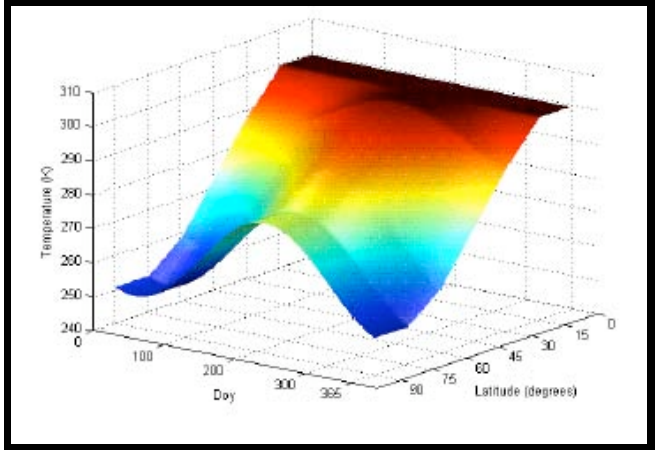
The use of low-cost, single-frequency GPS receivers for high accuracy positioning in static and kinematic applications creates a challenge because of how the ionosphere, multipath, and other measurement errors are handled. A processing technique using pseudorange and time-differenced carrier-phase measurements in a sequential least-squares filter was developed to provide horizontal positioning accuracies of a few decimetres.

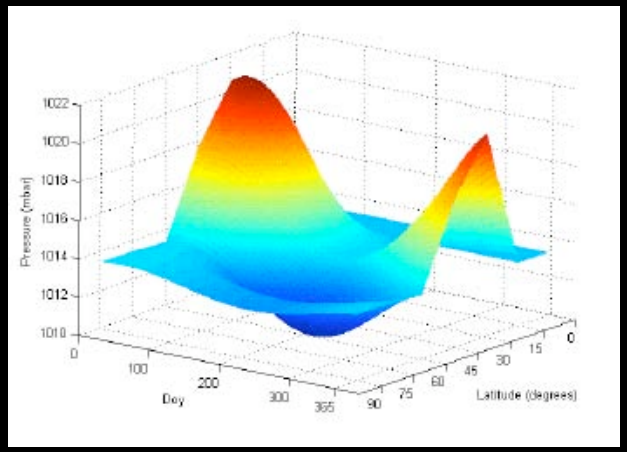


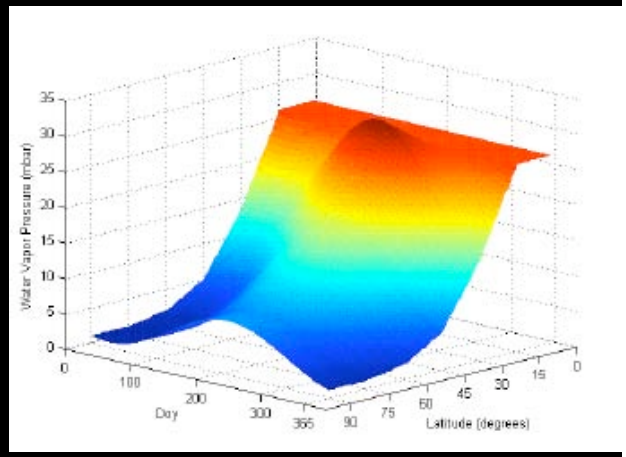


Atmospheric Correction Models

Before GPS receivers can pick up the satellite signals, the signals pass through the atmosphere and suffer changes in their speed, resulting in erroneous measurements. UNB researchers have developed models over the past decade or so to reduce the impact of the atmosphere in GPS positioning and navigation.







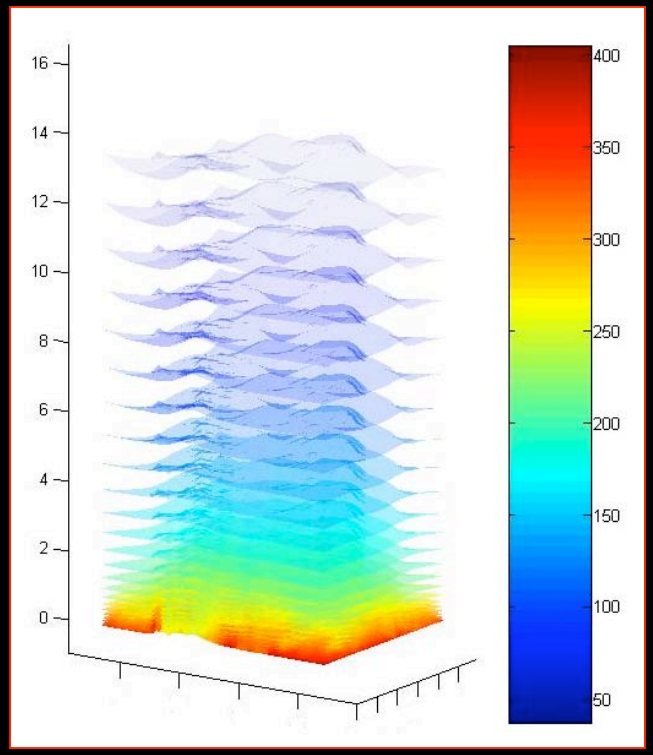
Algorithms and software developed at UNB are widely used in GPS applications. The microprocessor in virtually every GPS receiver sold today includes a UNB-developed atmospheric model.

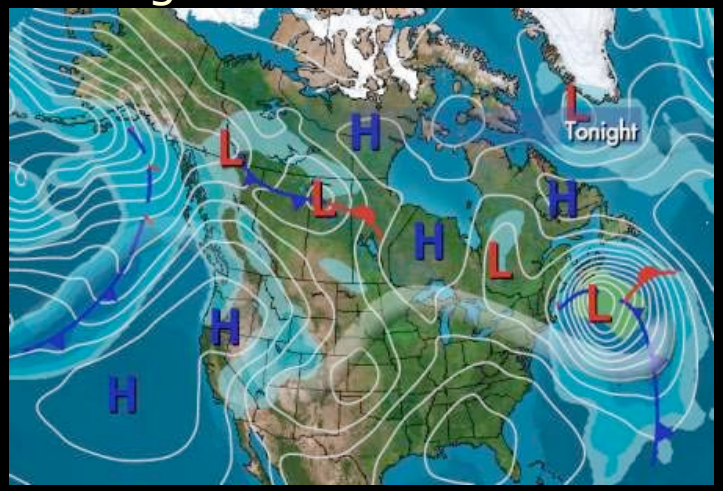
UNB2 - UNB's GPS-based Weather Station

UNB runs a continuously operating GPS receiver dedicated to meteorology. The receiver is part of SuomiNet which is a network of GPS receivers at universities and other locations providing real-time atmospheric precipitable water vapour measurements and other geodetic and meteorological information. The data is being used operationally by meteorologists to improve short term weather forecasts.
The GPS receiver is supplemented by accurate electronic weather sensors and a water vapour radiometer.

Weather Models for GPS

Before GPS receivers can pick-up the satellite signals, the signals pass through the atmosphere and suffer changes in their speed, resulting in erroneous measurements. UNB researchers have investigated the applicability of weather forecast models to reduce the impact of the atmosphere in high precision GPS positioning.

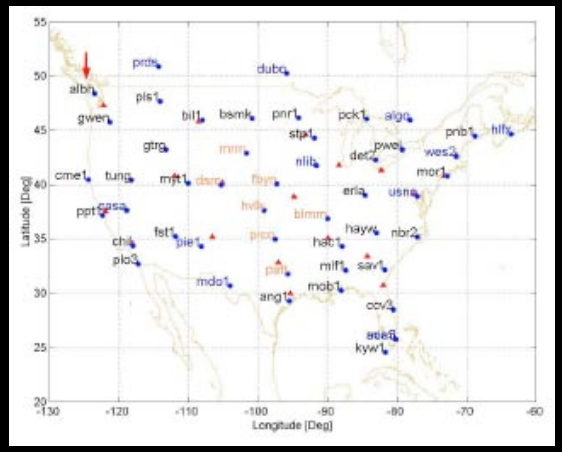


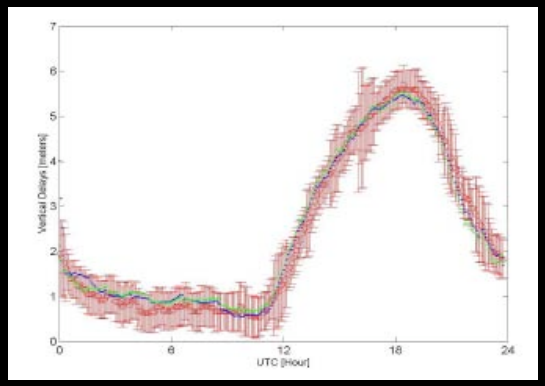


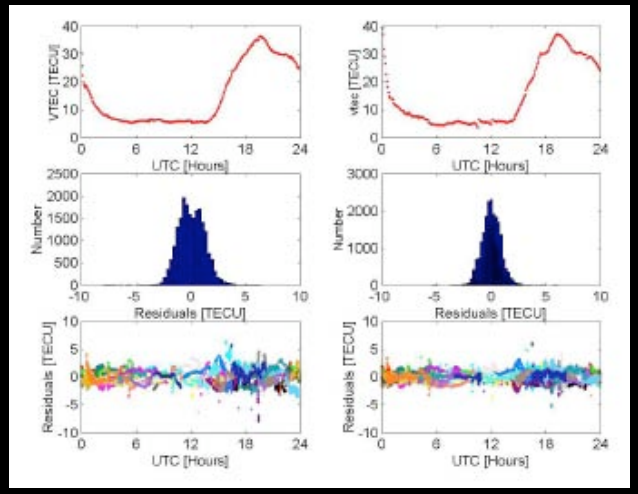
These models are useful because the effect of the atmosphere on GPS depends on weather parameters. The models are made available by the weather forecasting agencies as three-dimensional grids with values of pressure, temperature, and relative humidity.

GPS and the Ionosphere

One of the several effects suffered by GPS signals is caused by a particular region of Earth's atmosphere, the ionosphere. In this layer the particles are ionized, due mainly to the effect of solar radiation, and are affected by geomagnetic activity. Because the behaviour of the effect of this region on GPS is very unstable at times, its modeling can be very difficult.







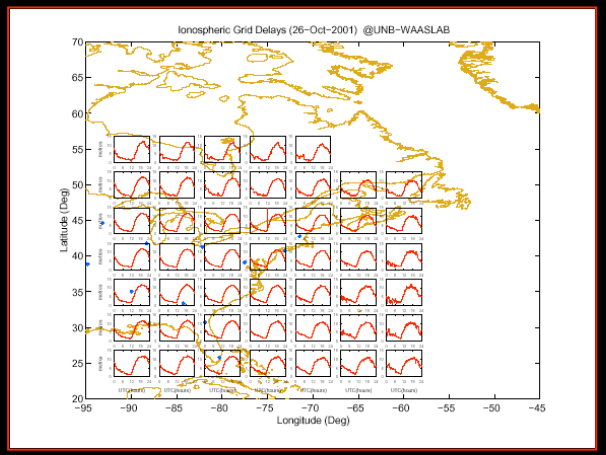
For several years UNB researchers have developed approaches which are suitable for modeling the ionosphere over very large or wide areas. These models are useful for satellite-based augmentation systems, such as WAAS and the Canada-wide Differential GPS Service.

UNB WAAS Monitoring Station

http://gps.faa.gov

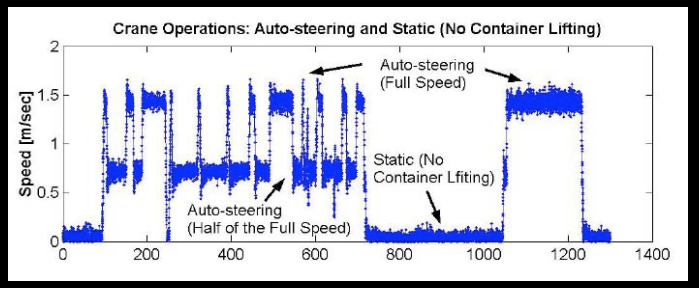
WAAS (Wide Area Augmentation System) is a system developed to allow the use of GPS as a primary means of navigation in the U.S. National Airspace System. It is designed to provide accurate, continuous, and all-weather coverage to satisfy today's aviation needs. In this system, geostationary satellites send messages with information used to improve navigation accuracy and reliability.

The University of New Brunswick runs a continuously operating GPS receiver with WAAS capability. The goal of this work is to access and test the WAAS messages.

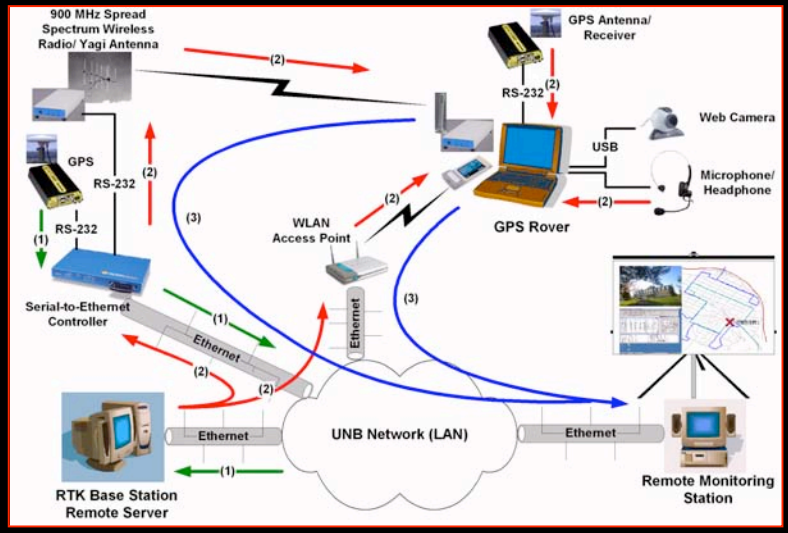


Machine Control with GPS

Machine control applications such as a gantry crane auto-steering system require positioning accuracies better than a few centimetres with extremely high reliability in real time.



To enable control in automatic mode, UNB has developed an ultrahigh-performance GPS RTK software for gantry crane auto-steering. The UNB RTK system determines the position and orientation of the crane every one tenth of a second with accuracy better than 2 centimetres with extremely high reliability.



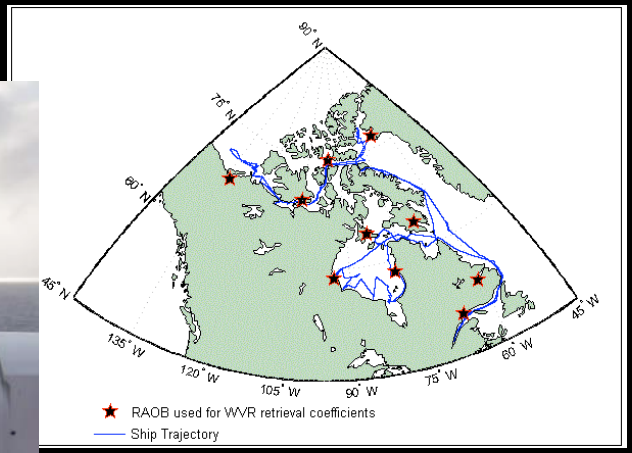
Princess of Acadia Project

In this project a GPS receiver was placed on board a ferry boat travelling between the cities of Saint John and Digby, across the Bay of Fundy. Data was recorded over one year, resulting in a rich dataset for GPS research.

The objective of the project is to investigate the performance of high-accuracy (cm-level) positioning and navigation using GPS, in terms of area coverage and variability of weather conditions.

GPS in Arctic Regions

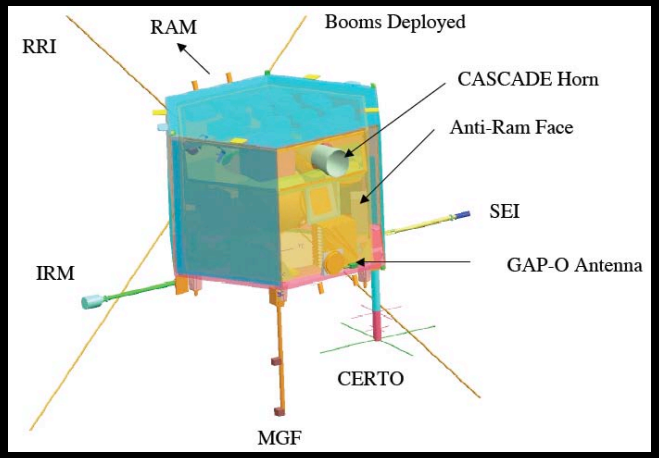
The use of GPS in the arctic can be a challenging activity, because the satellite orbits design results in the satellites not being well distributed over the sky as in other regions. Besides that, relatively little is known about the arctic atmosphere's impact on GPS, and sometimes atmosphere models used regularly in other regions might be not effective enough at northern latitudes.

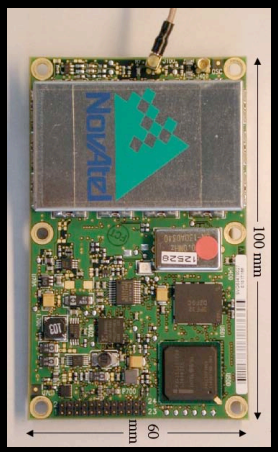


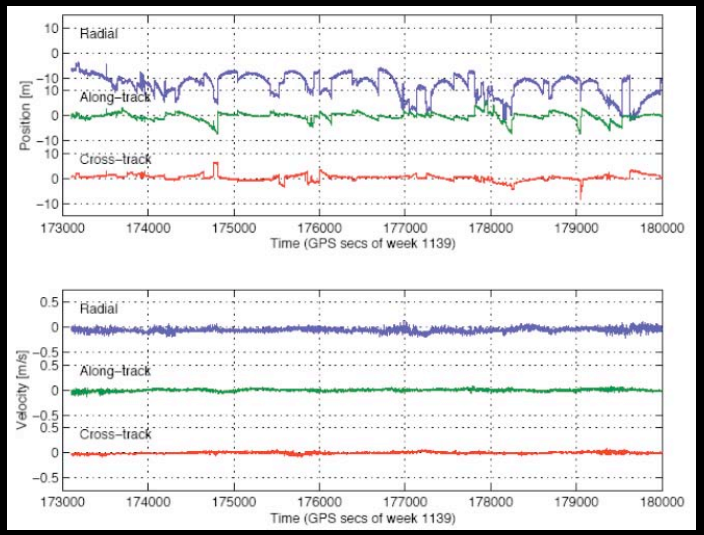
UNB researchers have participated in GPS campaigns in the arctic region, collecting various types of data to investigate the impact of different approaches for handling the atmosphere in high accuracy GPS positioning.

Qualification of GPS Receivers for Spacecraft

CASSIOPE is a Canadian satellite scheduled for launch in 2007 and its mission is designed for a wide range of tasks. Once in orbit the satellite position and velocity will be determined by means of onboard GPS receivers. This satellite will carry a device called GAP which consists of 5 NovAtel OEM4-G2L GPS receivers. UNB is responsible for GAP design and testing.



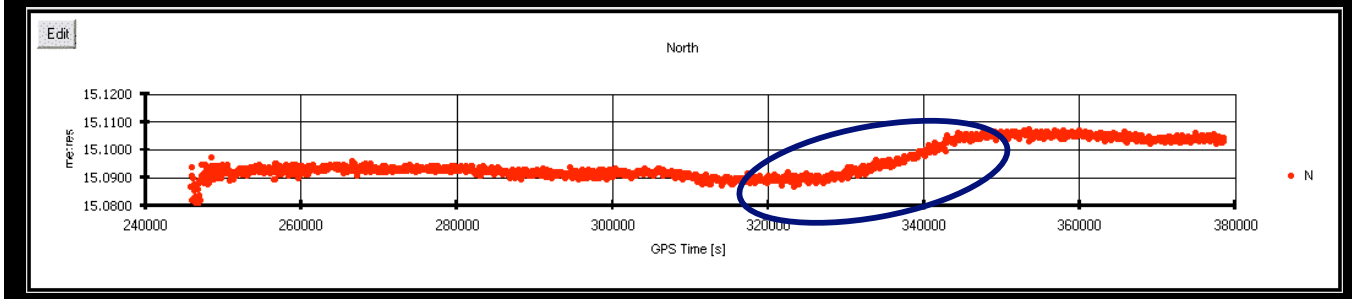


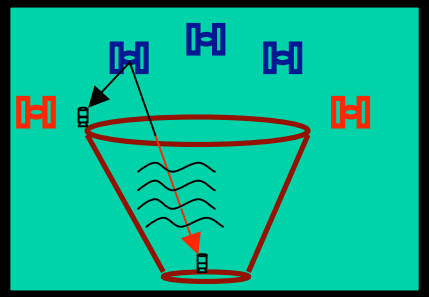


An extensive series of tests has been conducted to assess the suitability of the use of this GPS receiver in this application. These include GPS signal simulator tests to validate the signal acquisition and tracking performance, as well as environmental tests to demonstrate the survivability of the receiver hardware under space conditions.

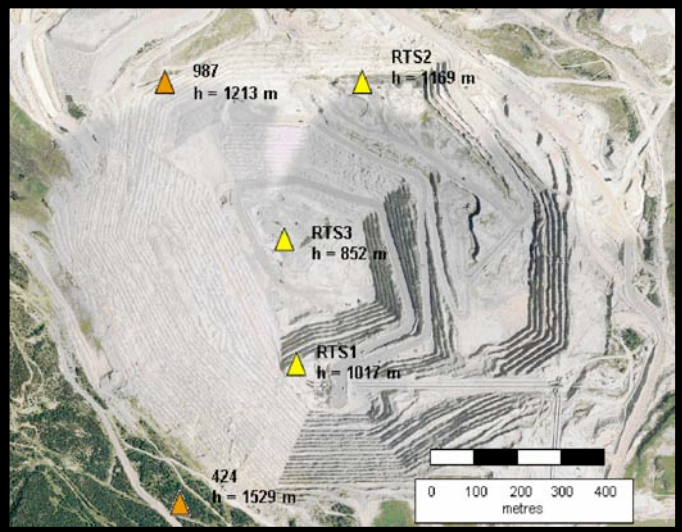
GPS for Deformation Monitoring

Real-time deformation monitoring is a key activity in hazardous areas, such as open pit mines. This activity is fundamental because a collapse of the involved structures can be anticipated by means of detecting small precursor movements of strategic points.

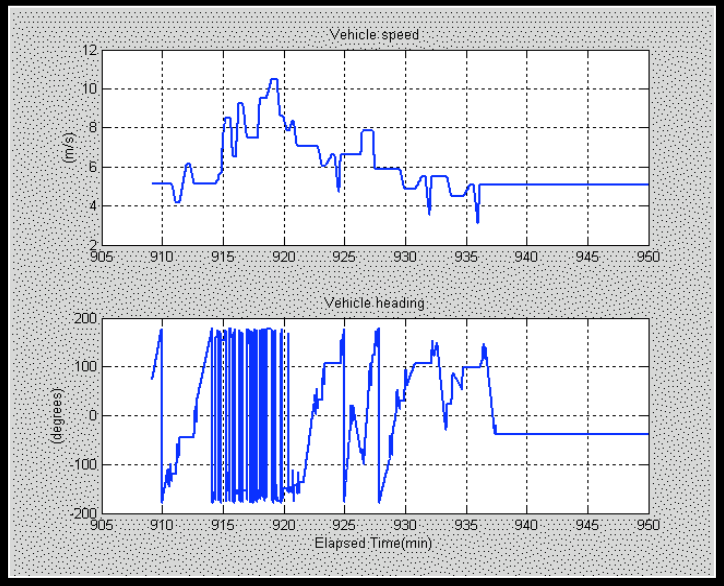




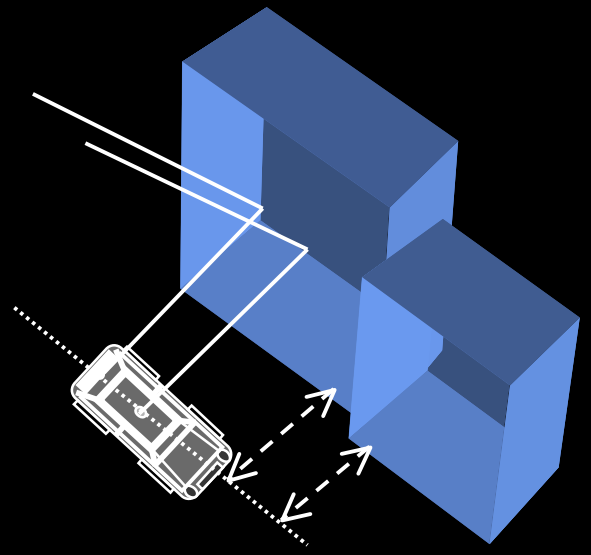
The major goal of monitoring activities is to save lives and prevent structural damage by providing quicker emergency response times. UNB researchers have developed approaches aiming at a robust, high precision GPS deformation monitoring system to be used in real time.



Multipath Mitigation

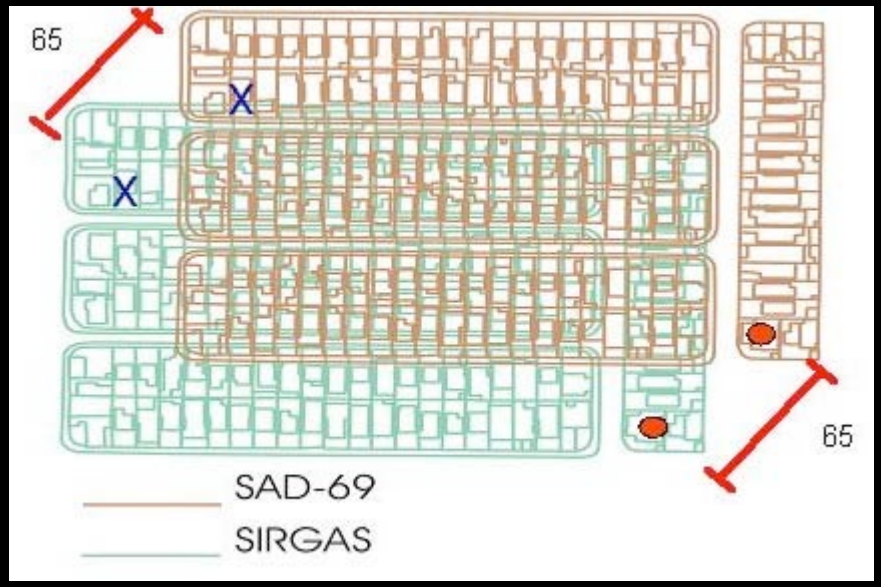


Phase multipath is probably the most difficult error to model in real-time, cm-level GNSS applications. At UNB, we have been designing strategies to tackle this effect using multipath-physical models, and precise platform dynamics/attitude. They are suitable for applications such as RTK vehicle navigation, machine guidance, attitude systems, etc.



National Geospatial Framework Project

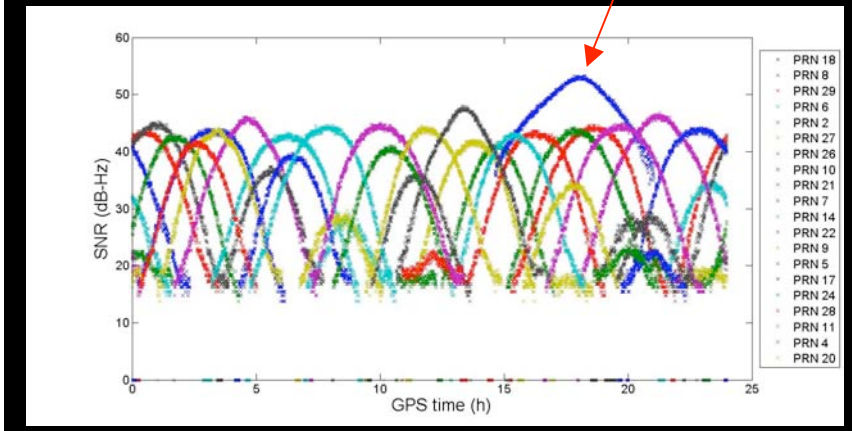
The University of New Brunswick, with support from the Canadian International Development Agency, is one of the institutions assisting Brazil in its long-term needs for land reform, environmental management and sustainable development of its natural resources. The objective of the National Geospatial Framework Project is to collaborate and assist Brazilian efforts to realize the national adoption of a coordinate system based on modern satellite technologies.

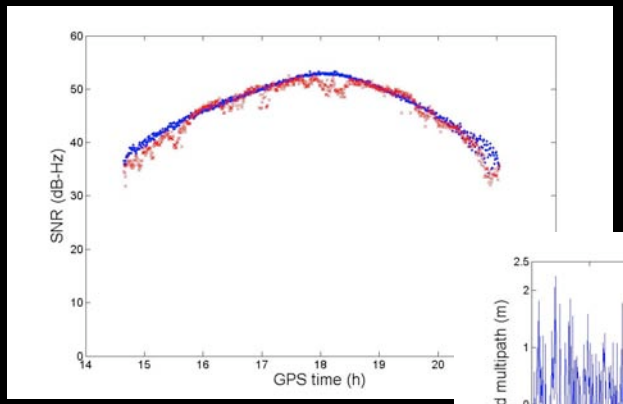


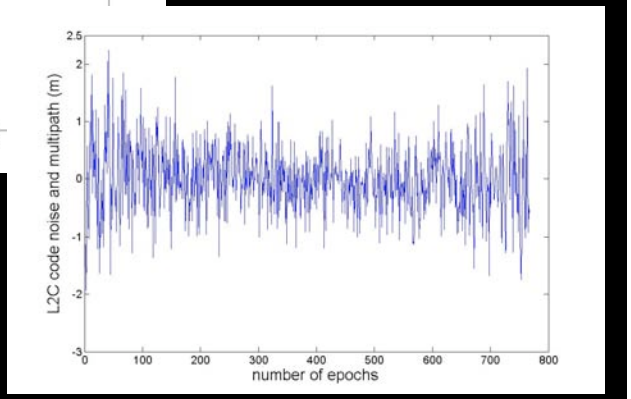
Impact of the coordinate system change

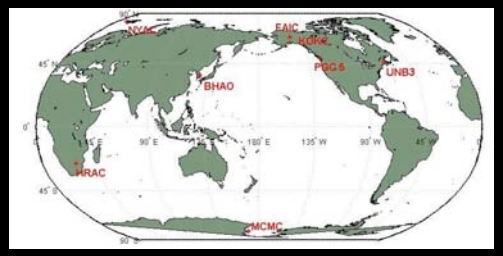
UNB3 Station – New GPS Signal

The United States started an extensive modernization program to provide better service to Global Positioning System (GPS) users. This modernization program includes launching of modernized GPS satellites, transmitting a new open civil signal, called L2C.





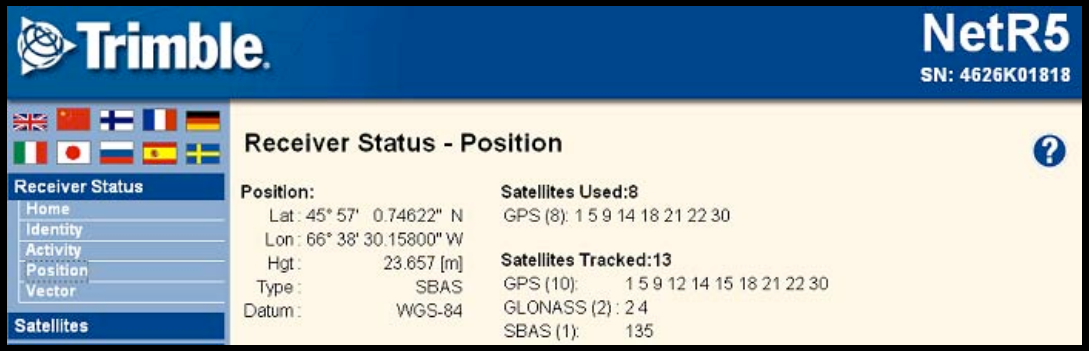


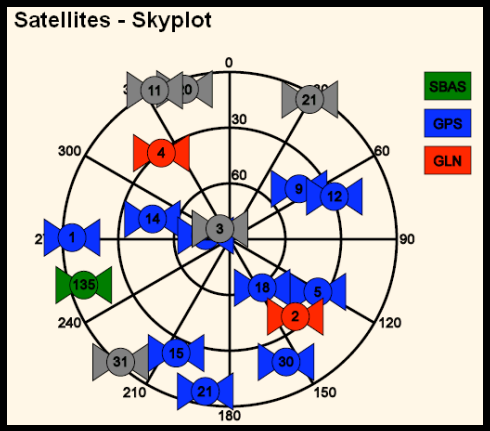


IGS has organized a network of L2C capable GPS receivers which have been established in different places. One of these stations is UNB3, operated by UNB. The role of this project is to analyze the quality of the new signal, as well as the impact of its use for positioning and navigation.

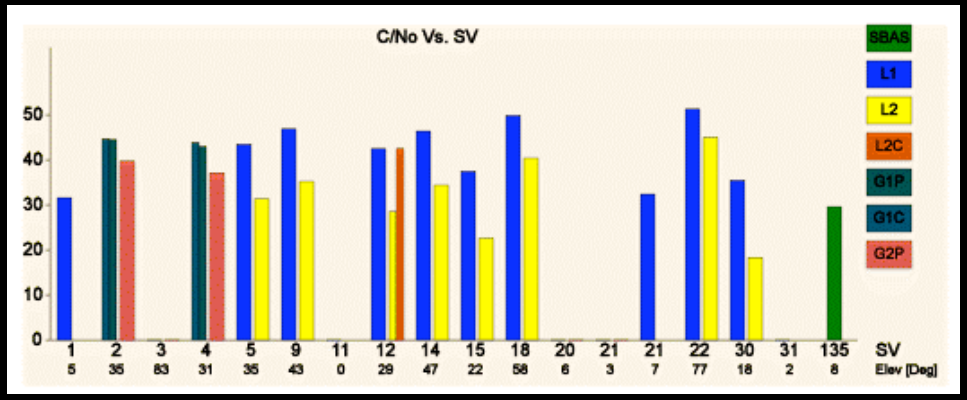
UNB3 Station – Trimble NetR5 Receiver

GPS station UNB3 is operated with a Trimble NetR5 receiver. This receiver is owned by Trimble and it is on loan to UNB. In compensation for this loan, the members of the GPS Group provide feedback to Trimble with respect to performance of the receiver and its related utilities.





http://trimble.com



Contacts

Department Web page:

http://gge.unb.ca

Research group page and resources pages:

http://gge.unb.ca/Research/Research.html
http://gge.unb.ca/Resources/Resources.html

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