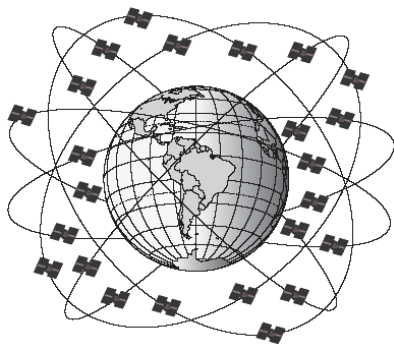


Introduction

Satellite navigation is a leading-edge technology which allows anyone with a receiver to determine their position very accurately at any time by picking up signals from a constellation of several satellites. Currently, the United States Global Positioning System (GPS) and the Russian GLONASS system are the only operational Satellite navigation systems. Europe has begun the development of a third independent global system, known as 'Galileo'.

Satellite navigation Overview

The following system overview uses examples based on GPS, however the principles apply to all satellite navigation system. GPS is a satellite navigation system capable of providing a highly accurate, continuous, global navigation service independent of other positioning aids. GPS provides 24 hour, all-weather, worldwide coverage with position, velocity and timing information.



The system uses 24 operational satellites to provide a receiver with at least six satellites in view at all times. A minimum of four satellites in view are needed to allow the receiver to compute its current latitude, longitude, altitude and time. With this information the user's receiver can also calculate other parameters such as its velocity and acceleration.

GPS Satellite Orbit Arrangement

Any satellite navigation system has three parts:

- The Space segment
- The Control segment
- The User segment

All these parts operate together to provide accurate three-dimensional positioning, timing and velocity data to users worldwide.

The Space Segment

The GPS system constellation has 24 satellites in six 55° orbital planes, with four satellites in each plane, with room for spares. The orbit period of each satellite is approximately 12 hours at an altitude of 20,183 kilometers. With this constellation, a user receiver has at least six satellites in view from any point on earth. Other systems use satellites in different orbits and orbital periods.

The satellite broadcast signal contains data which identifies the satellite and provides the

positioning, timing, ranging data, satellite status and corrected orbit parameters of the satellite.

GPS satellites transmit on two frequencies; one centered at 1575.42 MHz, known as L1 and the other at 1227.60 MHz, known as L2. The L1 carrier is modulated by the C/A code (Coarse/Acquisition) and the P code (Precision). P code is encrypted for military and other authorized users. The L2 carrier is modulated only with the P code. Similar signals exist for Galileo and GLONASS, although both systems differ in the way signals are delivered. New L2C and L5 signals are being added to the system as new satellites are launched.

The Control Segment

The GPS control segment consists of a master control station, five base stations and three data up-loading stations in locations round the globe. Other configurations are possible for other satellite navigation systems.

The base stations track and monitor the satellites via their broadcast signals. These signals are passed to the master control station where orbital parameters and timing corrections are computed. The resulting corrections are transmitted back to the satellites via the data up-loading stations.

The User Segment

User receivers, can be referred to as the User Segment, and consist of equipment which track and receive the satellite signals. User receivers must be capable of simultaneously processing the signals from a minimum of four satellites to obtain accurate position, velocity and timing measurements. However accuracy and reliability is enhanced as the number of visible satellites increases.

How does a receiver calculate position?

A user receiver calculates its location on the earth's surface using the known positions of the satellites being tracked - in effect measuring the distance to each satellite and then triangulating a position. With as few as four satellites in view, the position of the receiver, in three-dimensions, can be determined. Only one receiver is needed to achieve position accuracies in the order of 20 metres. Basic positioning may be improved to within less than 1 metre or even to within a few centimeters using more complex processes, which include augmentation by ground based networks and re-transmitted corrections by both radio and satellite, and by using the phase portion of the signal.

Satellite navigation and NovAtel

NovAtel in Calgary, Alberta, Canada is a company which has been able to extract the very last bit of precision from GPS. NovAtel developed its first single frequency receivers in 1992, and by 1995 had mastered the complexity of dual frequency positioning. Dual frequency receivers not only use the open L1 signal, but are also able to receive and process the encrypted military signals on L2. By combining these two measurements, NovAtel receivers are able to measure position extremely accurately.



NovAtel is currently fielding its fourth generation dual frequency GPS receiver. These receivers are used by NovAtel's customers in applications which are widely varied and different. Indeed, applications are only limited by the imagination and inventiveness of the people who wish to apply satellite navigation positioning to all forms of commercial, military and recreational uses.

Satellite navigation applications are almost limitless, but some typical ones include:

- air traffic navigation and control and their related accuracy and integrity; enhancement infrastructure;
- management and tracking of ship and land vehicle fleets;
- rental and personal car navigation systems;
- automation of container location and tracking to increase the efficiency of ports;
- navigation systems for remotely piloted air, land and water vehicles;
- road and rail traffic monitoring;
- dispatch and monitoring of emergency services;
- automated car and truck guidance systems;
- automated guidance of agricultural equipment for efficiency improvements in crop spraying and harvesting
- recreational guidance for hikers, boaters, cyclists and explorers;
- aerial, seismic, and land surveying;
- large structure monitoring (such as dams, bridges, buildings, etc);
- accurate timing systems for communications and commerce; and
- earthquake and tsunami detection and warning systems.



Agriculture



***NovAtel WAAS
Receivers in China***



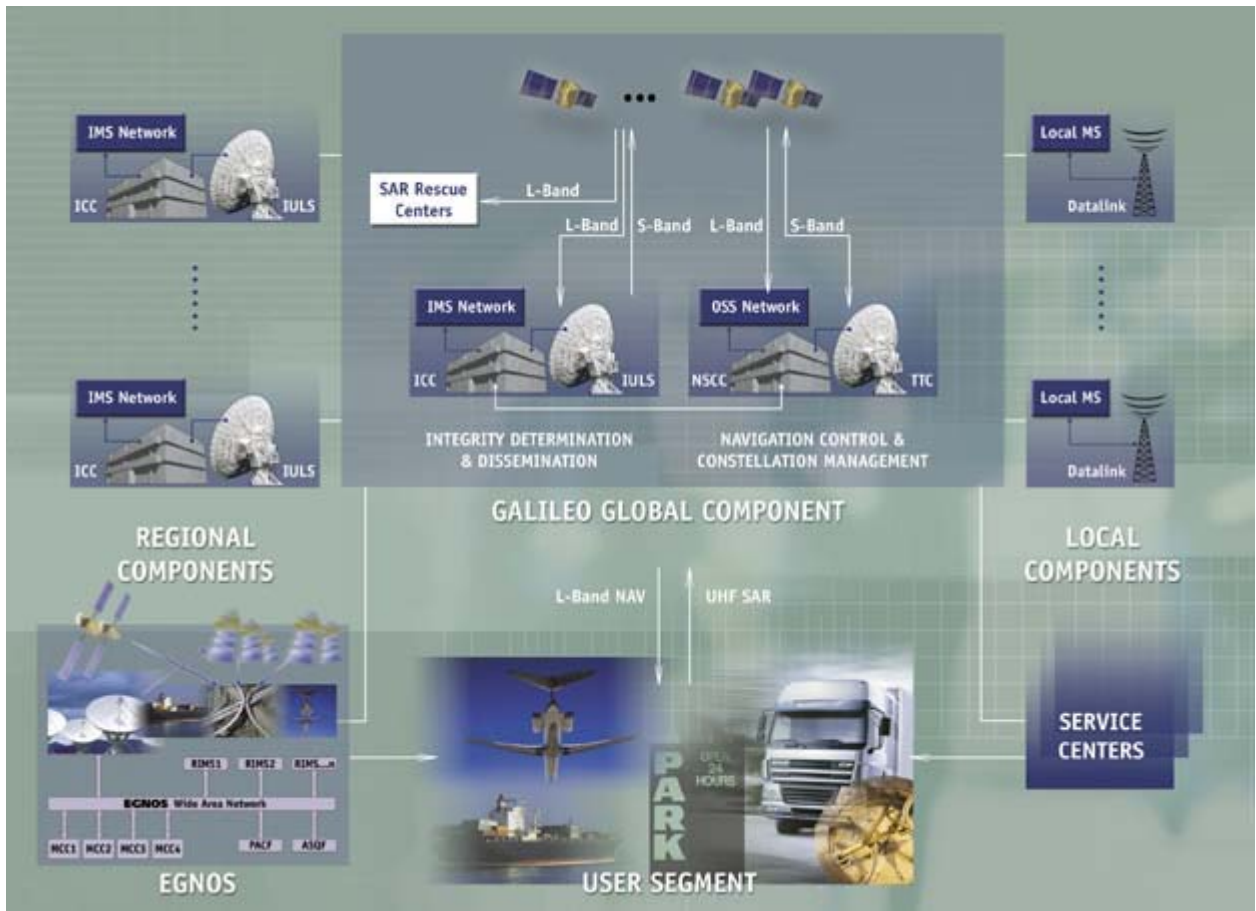
Race Car – camera tracking



Unmanned Aerial Vehicles

Galileo Background

The European Commission (EC) first presented plans for a European Galileo satellite navigation system in 1999. A four-phase development is planned with funding from both public and private sectors. Galileo is designed for both civilian and government purposes, the system will be controlled and operated by civil management. Galileo will be composed of: a constellation of 30 satellites; a number of globally located ground stations; and a ground control and monitoring system – very similar to the structure, format and layout of GPS. Development of the system has been underway since 2001.



Galileo System overview

To ensure a single management and financial structure for the development program, the Galileo Joint Undertaking (GJU) was established in March 2002, with EC and the European Space Agency (ESA) as founding members. In May 2003, ESA and the EU reached an agreement on financing for the Galileo satellite navigation system, and released initial development funding.

The development and deployment of Galileo over the longer term is expected to have significant involvement by the private sector. The intent is to begin initial development through ESA/EC public funding and to then hand over deployment and operation to a private Concession holder. A number of private organizations have grouped together to bid for the Galileo Concession rights. Galileo operating costs are expected to be recovered by charging for some services.

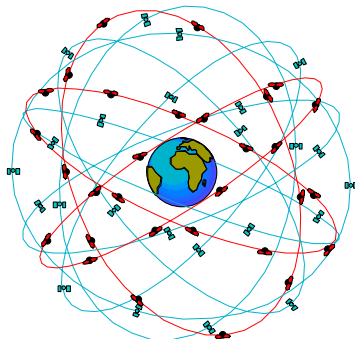
Galileo and its spin-offs are expected to create a huge private sector market for equipment and services. Galileo will offer a commercial service which will promote the development of professional applications by providing enhanced accuracy and integrity performance. This service is intended to generate user fees for the Concession.

Galileo will offer several worldwide service levels, including open access and restricted access for various segments of users. These services include:

- A basic Open Service (OS), supplied free of charge to the general public. This service is equivalent to that provided by L1 C/AGPS, however the intent is to provide improved quality and reliability.
- A Commercial Service (CS) facilitating the development of professional applications where high precision is required and premium cost can be supported.
- A Safety of Life Service (SoL) providing enhanced accuracy and integrity information for safety-critical applications, such as aviation, shipping and other vehicle control applications.
- A Search and Rescue (SAR) service that will greatly improve existing recovery services using the COSPAS-SARSAT system.
- A Public Regulated Service (PRS), which will be encrypted and resistant to jamming and interference. Access will be reserved principally for public authorities responsible for civil protection, national security and law enforcement where a high level of secure and reliable service is required.

These services are largely compatible with existing GPS services, and the expectation is that users will demand the added signal reliability, integrity, and functionality that a combined GPS and Galileo capability will provide when used together. Typical advantages to a user of a receiver utilizing both systems, include:

- Twice as many satellites means twice the probability of receiving good signals from good parts of the sky when visibility is reduced such as in a valley or in an urban centre.
- Cars in cities will have more signals, more often and will suffer less from signal blockage.
- Surveyors will be able to make higher accuracy measurements more consistently.
- Automated guidance for agricultural sprayers, combines and harvesters will be more accurate and signal reception will be improved, reducing signal outages.
- Difficult inshore navigation on rivers and canals will be safer and more reliable.
- Aircraft enroute navigation, final approach and landing will have far greater signal redundancy, which could well result in improved safety margins and decision heights for landing.



Together, GPS and Galileo will provide around 60 satellites, and more than double the number of available signals for all user segments.

Canada and NovAtel's involvement in Galileo

Canada, acting through the Canadian Space Agency (CSA), is a participating member of the European Space Agency, which celebrated its 30th anniversary this year. Canada contributes to the annual budget of ESA and to specific programs where a special agreement is in place. Galileo is one of those special programs where Canada has decided that a level of focused investment is appropriate. The relationship with ESA has existed for a number of years and has led to the participation of many Canadian companies in ESA and ESA sponsored programs.

Following a UK initiative in 2000, the CSA decided to support NovAtel's participation in the European Geostationary Navigation Overlay System (EGNOS), a program that was to later become the first phase of Galileo. EGNOS is Europe's initial satellite navigation program, designed to primarily provide the aviation community in Europe with the required enhanced accuracy and integrity to allow use of GPS and GLONASS for aircraft navigation. ESA lead the development of EGNOS on behalf of the various European navigation service providers, through its prime contractor Alcatel, in Toulouse, France. NovAtel became one of three companies selected to develop ground reference receivers for the EGNOS system.

At that time, NovAtel had already been selected to supply ground reference receivers for the US Federal Aviation Administration (FAA) Wide Area Augmentation System (WAAS), and the WAAS system was in the advanced stages of fielding and initial operation.



EGNOS ground network

NovAtel was therefore able to modify its WAAS reference receiver design to provide the additional functions required for EGNOS and was the first of three manufacturers to deliver qualified EGNOS Remote Integrity Monitoring System (RIMS) receivers into the European system. Through the EGNOS program NovAtel was able to establish an excellent reputation with ESA and a number of European primes and receiver suppliers.

NovAtel's Involvement in Galileo

Galileo has now been underway for many years. The initial phases involved feasibility analyses and requirements studies, which lead into initial concepts and designs.

NovAtel's first Galileo project began in Spring 2001 for ESA, and involved analysis of receiver impacts using a draft signal specification. The study indicated that there would be significantly more receiver complexity and cost as a consequence of this particular signal configuration. Subsequently, the Galileo program adopted a signal format which actually 'overlaid' that of the majority of the existing GPS signals, and this has led to considerable simplification of receiver designs.

During the 'B2 phase' of Galileo from December 2001 through to June 2002, NovAtel undertook two studies for Thales Avionics in Valance, France. The first examined the

requirements for a Galileo control segment reference receiver and the second looked at the configuration of user receivers.

Galileo is a joint program of ESA and the EC, and each has allocated funding for different aspects of system development. ESA is focusing on the development of the Galileo infrastructure – such as the ground control system, the uplinks to the satellites and the satellites themselves. The EC has a broader role and is supporting development of the applications and social infrastructures which will benefit from Galileo. Canada is , not only as a participating member in ESA, but also signed special agreements for participation in the Galileo program. However, no such agreement is in place with the EC. Therefore when a Canadian company wishes to participate in an EC program, alternate funding sources need to be accessed.

In July 2002, CSA funded a project which allowed NovAtel to undertake part of an EC program, which included an investigation into 'Interoperability' aspects of receiver design – in essence a study of how a receiver could be best designed to take advantage of both Galileo and GPS at the same time. Thales ATM in Langen, Germany was the European sponsor for this work, and a report was delivered in October 2002.

NovAtel returned to working directly for ESA during that same month in 2002, and undertook a new project to not only identify the requirements for a ground reference receiver, and scope the associated project effort required, but also to develop a fully functional software model of a Galileo receiver. The model can be configured to use any of the planned Galileo signals and predict the performance of a user receiver. This model was used to confirm the initial specifications for the Galileo ground control segment reference receiver.

All NovAtel's Galileo work up to this point had been focused on requirements and design concepts – from December 2003 through to June 2004, however, NovAtel began to implement receiver hardware under a contract from the CSA. The huge reservoir of GPS receiver technology that NovAtel had accumulated since 1992 now began to be used to bring life to not only a prototype Galileo receiver, but also helped create one of the first actual transmitted Galileo signals.

An existing configurable GPS receiver was re-programmed to receive and decode the Galileo signal. Since Galileo satellites had yet been put in orbit, NovAtel had to create the signals needed to verify the receiver. A signal transmitter, originally developed to verify a new GPS signal, was modified to generate and decode a subset of the Galileo signal, referred to as 'BOC(1,1)'. The program demonstrated that the receiver matched the theoretical forecast of performance for this signal/receiver combination.



Galileo BOC(1,1) prototype receiver and signal transmitter

Both NovAtel and the CSA gained significant confidence from this initial prototype development, and in September 2004 a follow-on development was launched. This time the objective was to develop a fully functional dual frequency Galileo receiver and signal generator.

North America's First Dual Mode GPS/Galileo Receiver

While these Galileo programs were underway, significant parallel efforts had also been underway in NovAtel's on-going US WAAS programs. A new WAAS reference receiver, ground uplink receiver and signal generator had been developed and were in production. These new products provided the enclosure, receiver and signal generator base technology to be merged with the new Galileo receiver development.

The objective of the next phase of Galileo receiver development was to develop an L1/E5a dual frequency Galileo receiver to be embedded in the WAAS enclosure. The reconfigurable GPS receiver from the WAAS uplink receiver provided the digital baseline for the new Galileo receiver, and a modified signal generator provided the two Galileo L1 and E5a signals.

Through early 2005, Galileo test signals were being piped round the local distribution network within the NovAtel Aviation Group to allow developers to test the new Galileo receiver. As part of the test program, the receiver was configured to track GPS signals. Without Galileo satellites, using GPS signals is the only way a receiver can derive time and establish a position. So the dual mode Galileo/GPS receiver gradually came to life tracking signals from both systems.

In May 2005, a formal progress review with the CSA included a demonstration of the first North American dual-mode GPS/Galileo dual frequency receiver and signal generator at NovAtel's facilities in Calgary.



NovAtel's L1/E5a Galileo/GPS receiver



CSA & NovAtel team celebrate successful Galileo receiver demonstration



Demonstration test set-up

This is a most significant achievement and marks the beginning of a new phase in the evolution of global satellite navigation with Canada playing a significant role in the development of the European system.

Completion of the debugging and testing of the receiver will be followed by integration into a customized enclosure and delivery to the CSA by early 2006. This will be in time for the launch and orbital checkout of the first two Galileo test satellites. The CSA is therefore expected to be one of the first organizations with the capability to receive and output data from the first Galileo satellites.

Overcoming Obstacles

This involvement in Galileo has come as a result of a sustained campaign by NovAtel over a number of years to participate in all aspects of the program. With strong support from the CSA and the Canadian Government, and by building on the successes of winning national reference network receiver contracts in the US, Japan, Europe, China and India, NovAtel had a strong calling card to present in Europe. Nevertheless, winning an important place in a European program which has an objective of establishing the prominence of European industry, has not been an easy undertaking. When earlier program doors began to close, Canadian programs were won which maintained

momentum. Many agreements with key European partners were needed to gain access, and deflect the political hurdles a Canadian company should expect to encounter in Europe.

The process involves many early morning telephone conferences to support an eight-hour time difference, many rapid turn-round responses to difficult technical, program and contractual action items, many transatlantic flights and connections to hard-to-reach European locations such as Noordwijk-Holland, Valance, Toulouse & Paris-France, Milan & Rome-Italy, Ulm-Germany, video conferences before dawn – significant investments over many years.

Understanding and managing a very different approach to development, business and above all to contracting, required patience, persistence and the growth of competencies which did not exist at the beginning of the campaign. The creation and strengthening of links to agencies in Ottawa and Montreal was essential to the success of the NovAtel Galileo strategy.

One of the most difficult concepts for NovAtel to cope with was the management of Intellectual Property developed through the various Galileo programs and the protection of NovAtel's existing technology, know-how and trade secrets. Huge amounts of internal management attention and external legal support have been necessary to arrive at the levels of protection which have now been established. Additions to the 'reservoir' of technology have indeed created a pool of extremely valuable know-how, skills and experience for the future.

Where will this all lead?

NovAtel has now incorporated these Galileo receiver development efforts into a new program to develop, qualify and supply the actual ground reference receivers for the Galileo ground control system. Selected in July 2005 by ESA, Galileo Industries and Alcatel through competitive procurement, along with its partner Alenia-Spazio Laben Directorate in Milan, Italy, NovAtel will undertake this critical Galileo system development activity over the next three years. The fully funded program is worth over seven million Euros (\$11 million Cnd), and will deliver a number of engineering development models and 24 production systems to the Galileo program.

NovAtel has also been selected, along with its partner CMC Electronics in Montreal, to undertake another critical Galileo receiver development. Under partial CSA funding, NovAtel and CMC will develop a Galileo Safety of Life receiver demonstration system. This receiver will be based on the receiver delivered to CSA under the previous program, with the addition of an E5b receiver by NovAtel and external integrity algorithms developed by CMC. This program is an essential step along the road to an airborne GPS/Galileo receiver for civil passenger aircraft.

And in the long run, the receiver technology NovAtel has developed through these programs, for all Galileo civil frequencies and services, will be migrated into NovAtel's core OEM receiver business. Because in the future, when Galileo becomes operational, GPS and Galileo will be used together to significantly improve the quality and reliability of satellite navigation. This means that the market for commercial receivers will be

refreshed by a demand for dual function GPS/Galileo high performance receivers. As the technology leader in North America, NovAtel is uniquely positioned to meet this demand.

In addition, national GPS augmentation networks around the world, which are already equipped with NovAtel ground reference receivers, are also expected to require Galileo capability upgrades to enhance their capabilities.

Sustained growth over the long term – Galileo is a key facet of NovAtel's business plan.