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Coordinates

Volume VI, Issue 12, December 2010

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

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GPS/DR CAR NAVIGATION SYSTEM

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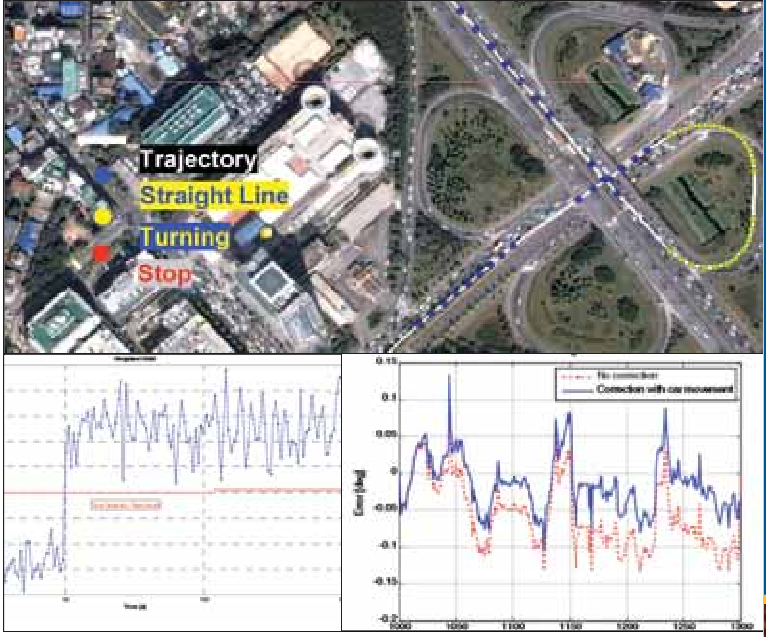

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WickedLeaks...

Diplomacy, democracy, autocracy, hypocrisy.

Mess, Press, suppress.

Expose and impose.

Dare, share and scare.

Fear and smear.

Right and rights.

Preach and practice.

Action and overreaction.

Force and coerce.

Sneak and sleaze.

Damage and rampage.

Credibility and vulnerability.

Cover and cover up.

Control, control and control.

Bal Krishna, Editor
bal@mycoordinates.org

A study on GPS/DR car navigation system using vehicle movement information

The integrated GPS/DR navigation system provides an appropriate performance under GPS blockage condition

Jong-Hwa Song
Electronics Engineering
Konkuk University, Korea

Gyu-In Jee
Electronics Engineering
Konkuk University, Korea

This paper describes the performance improvement of GPS/DR (Global Positioning System/Dead Reckoning) Integration system utilizing the area decision algorithm and vehicle movement information. In GPS/DR Integration system, generally DR sensor errors are estimated and corrected using GPS information when GPS is available. In GPS signal blockage area, i.e., tunnel and underground parking area, DR sensor errors are accumulated and navigation solution is diverged eventually. We utilize the car movement information and area decision algorithm to reduce accumulated DR sensor error. The vehicle movement information is obtained by analyzing the DR sensor data. The car movement is divided into stop, straight line, turn and movement changing region. The car experiment is performed to verify the proposed method. The results show that proposed method provides smaller position and heading error than previous method. When GPS is blocked in 300 sec, the position error is smaller than 9 times in straight line area and 3 times in turn area.

Introduction

Recently the car navigation systems have been widely installed in many vehicles. Generally the car navigation system uses navigation information obtained from GPS (Global Positioning System) satellite signal because GPS provides good navigation information to user when GPS signal is available. However GPS does not work well in an underground parking area, tunnel and urban areas due to signal blockage or attenuation. The GPS and DR (Dead Reckoning) sensor integration can be one of the solutions. GPS shows a long-term error performance, on the other hand, DR sensor shows a good performance in short-term. So the integrated GPS-DR navigation system is widely used for car navigation [1~3].

The DR sensor which is generally used in car navigation is low-cost and has large noise. Thus the DR sensor navigation solution dramatically diverges without GPS even in short term blockage. In GPS/INS (Inertial Navigation System) Integration system, car aiding measurements are used to solve this problem. The car aiding measurements are restricted car movement, i.e., non-holonomic constraints. The non-holonomic constraints mean that the velocities in vertical and lateral directions are zero if the vehicle does not jump off and slide on the ground. Also, if vehicle moves on the flat road surface, then we assume that roll and pitch angle are zero. Then accelerometer and gyro scope errors can be corrected using vertical/lateral accelerometer and roll/pitch gyro output with zero reference [4-9].

It is impossible to apply the INS non-holonomic constraints to the DR navigation system. Since the DR navigation system consists of only one velocity sensor and rotation sensor. In this paper, we use other car movement information to apply the non-holonomic constraint for DR navigation system. In general, a land vehicle drives on the road and its movement is restricted as stop, straight line and turn. This is an important difference

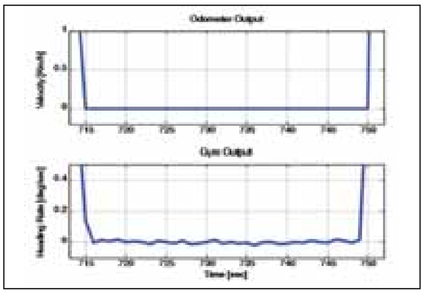

Fig.1 Velocity and angular rate when car is stopped

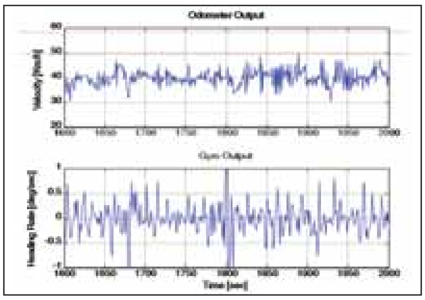

Fig. 2 Velocity and angular rate when car is moving in straight line

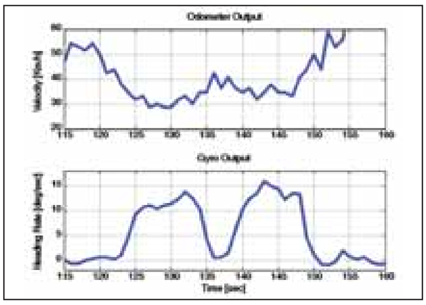

Fig. 3 Velocity and angular rate when car is moving in turn

between land vehicle and other vehicles such as airplane and ship. Ideally, if a ground vehicle is driving in a straight line, gyroscope output is zero when gyroscope bias is zero. So the gyroscope bias error can be estimated using this constraint.

The heading error of DR navigation system consists of two components: bias error and scale factor error. Gyro bias affects the measurements from the gyro at all times. This error becomes directly observable in the system when the vehicle is stationary or travelling in a straight line. Gyro Scale factor affects the measurements only when the vehicle takes a turn. This error becomes directly observable in a system when the vehicle takes a turn [4].

In this paper, we propose the GPS/DR integration algorithm for car navigation using vehicle movement information. The odometer and gyroscope are used as DR sensors and a distributed filter approach is employed for the GPS/DR integration. To improve the performance of the integrated GPS-DR navigation system, Car movement is additionally used. Gyro and odometer data was analyzed to determine the current car movement. The heading filter measurement model is appropriately used according to car movement information.

Section 2 introduces the car movement decision algorithm. Section 3 explains the total structure of the proposed integrated GPS/DR navigation system and each filter structure. Finally Section 4 shows the experimental results. The experimental results show that the integrated GPS/DR navigation system provides an appropriate performance under GPS blockage condition.

Car movement decision

In this section, car movement is defined as stop, straight line, turning and changing region. The car movement decision rule is represented using odometer velocity and gyroscope angular rate. The car movement decision results for real car driving data are plotted in Google map.

Stop

Ideally, odometer and gyroscope output is zero when the car is stopped. The stop area can be determined using this property. The raw odometer measurement is a pulse signal according to the rotation of wheel. For example, our odometer output is 4 pulses per one rotation of wheel. There are differences in true distance and odometer output and generally true distance is equal to or larger than distance from odometer. For this reason, we don't know exactly when the car is stopped. Thus gyroscope angular rate is used to determine the more precise moment. When car was stopped, gyroscope outputs the zero-mean white Gaussian noise with very small variance. Figure 1 shows the odometer velocity and gyroscope angular (heading) rate when car was stopped. The stopped time is 715 sec from velocity and 716 sec from angular rate. From this figure, car stop moment can be decided more accurately through angular rate. We decide that the car stopped when odometer velocity was equal to zero and gyroscope angular rate was smaller than 0.1 deg/sec.

Straight line

When car is moving in straight line, gyroscope outputs zero mean white noise with small variance. This variance is larger than stop area. When car is moving in straight line, the odometer and gyroscope outputs are represented in figure 2, respectively. The bottom figure shows that magnitude of angular rate is about 0.5 deg/sec. When odometer velocity is larger than zero and gyro angular rate is smaller than 0.5 deg/sec, we decided that the car is moving in a straight line.

Turning

When car was in a turning area, gyroscope angular output has large value than other movement. We decide car is tuning if gyroscope angular rate is larger than 2 deg/sec. The threshold is determined through data analysis and figure 3 shows odometer

Car Movement	Decision Condition
Stop	Velocity=0 km/h, Angular Rate < 0.1 deg/s
Straight Line	Velocity>0 km/h, Angular Rate < 0.5 deg/s
Turning	Velocity>20 km/h, HDOP<3, Angular Rate > 2 deg/s
Changing	0.5≤Angular Rate≤2 deg/s, HDOP<3

Table 1. Car Movement Decision Condition

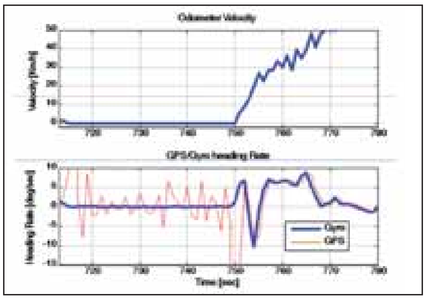

Fig.4 Angular rate of GPS and gyroscope with velocity

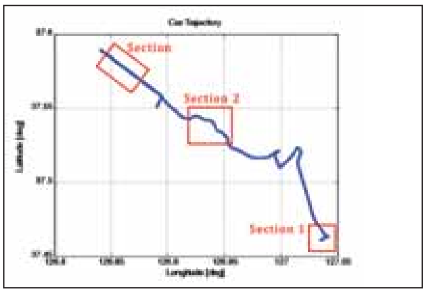

Fig.5 Car driving trajectory

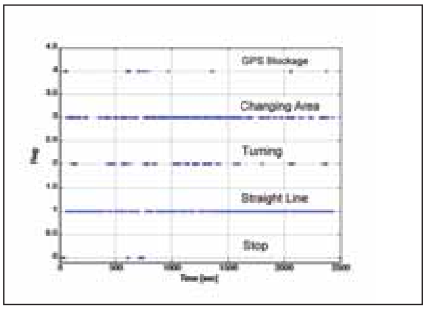

Fig.6 Car Movement Decision Results

Fig.7 Car Moving Decision Results in Section 1

Fig.8 Car Moving Decision Results in Section 2

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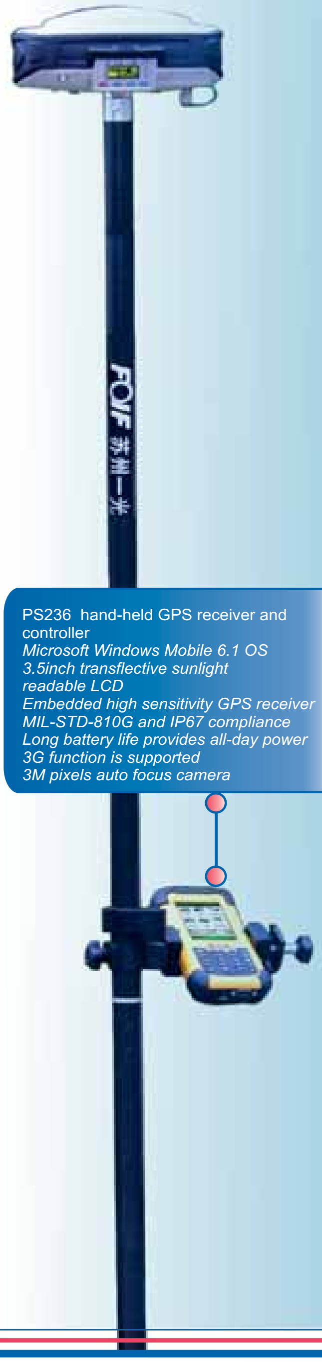

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and gyroscope output in turning area. To correct the gyroscope scale factor error in turning area, we use the GPS heading output as reference. When car is moving with low velocity, we cannot trust GPS heading output. Since GPS heading and velocity outputs are incorrect when vehicle is moving slowly. We determine the velocity threshold by comparing the GPS and gyroscope angular rate with velocity. Figure 4 represents the angular rate and velocity output. GPS heading output is similar with gyroscope when velocity is larger than 10 km/h. From this result, we determine the velocity threshold as 20 km/h. To confirm the availability we use GPS angular rate when HDOP (horizontal dilution of position) is larger than 3.

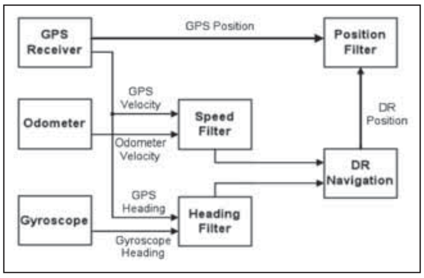

Fig.9 Basic GPS/DR Integration System

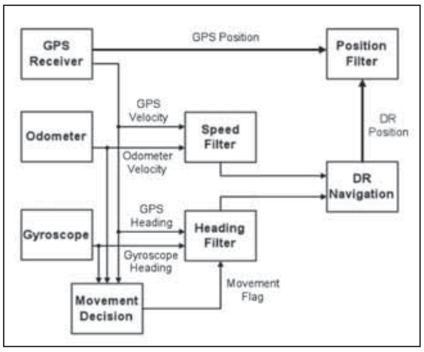

Fig.10 Proposed GPS/DR Integration System

Fig.11 Estimated position in straight line

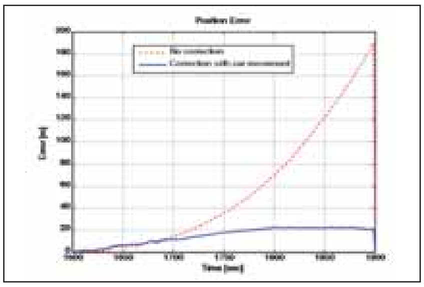

Fig.12 Position error in straight line

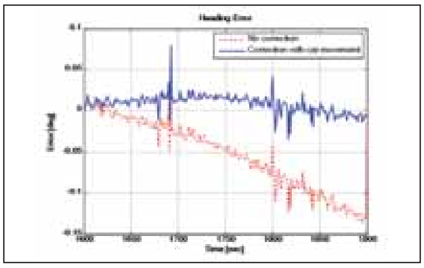

Fig.13 Heading error in straight line

The car movement decision condition is represented in table 1. The changing area covers those cases other than the ones listed and when GPS data is available. In the changing area, we estimate the heading error than bias or scale factor error.

To verify the car movement decision condition, we apply to the real data and analyze the result. Figure 5 shows the overall car driving trajectory and test results are represented in figure 6~8. Figure 6 shows the overall decision results. Flag 0~4 mean the stop, straight line, turning, changing area and GPS blockage, respectably. Decision results in section 1 and section 2 in figure 5 are represented in figure 7~8 using Google map. In these figures, white line represents the cars moving trajectory and blue, yellow and red dot mean straight line, turning and stop. As shown in figure 7~8, decision condition can detect the car movement well.

GPS/DR integration algorithm

The basic and proposed GPS/DR integration system structure is represented in this section. The integration system designed is based on distributed kalman filter. Each filter model is explained with car movement decision condition.

One rotation /pulse number	tyre circumference (m)	scale-factor (m/s/pulse)
1/4	1.681156	0.4203

Table 2. Specification of odometer

bias voltage (mV)	scale-factor (mV/deg/s)	bias (deg/s)
1650	16.5	100

Table 3. Specification of gyroscope

GPS/DR integration system structure

The integrated GPS/DR navigation system is composed of GPS receiver, odometer and gyroscope to obtain position, velocity and attitude of the vehicle, respectively. Figure 9 shows the block diagram of the basic car navigation system. As figure 9 shows, this system consists of three filters such as the velocity filter, the heading filter, and the position filter. The velocity filter and heading filter estimate the odometer and gyroscope error to correct the raw sensor data. These filter measurements are difference of GPS and DR sensor velocity and heading. The DR navigation algorithm generates the position of the vehicle by using estimates of the speed filter and the heading filter. From this information and GPS position information, the position filter gives an estimated position to the driver [10]. When GPS signal is blocked, DR sensor error cannot be estimated and corrected with this structure. Then position of integration system is diverged as time passes. To solve this problem, additional measurement is needed. In this paper, car movement information is used to correct the DR sensor data. The car movement information has smaller error than GPS heading or velocity in low velocity and straight line area. Figure 10 shows the proposed GPS/DR integration system block diagram. First, the current car movement information is decided using velocity and heading of GPS, odometer and gyroscope. Then heading filter measurement model is changed according to car movement. We can estimate the gyroscope error using this method when GPS signal is blocked or GPS measurement has large error. Each filter structure is explained in the following sections.

Heading filter

The objective of the heading filter is to estimate a heading angle error, bias error, and scale factor error of gyroscope by using GPS and car movement information. When the car is stopped or moving in a straight line, gyroscope bias error is estimated using car movement information, i.e., zero reference. The gyro scale factor error is estimated using GPS heading measurement in turning.

In changing area, heading angle error is estimated. As above, the heading filter measurement model is changed according to car movement. The gyroscope error model equation is represented by

$$\delta\dot{\theta} = \delta SF_{gyro}\left(\frac{1}{N}\sum_{n=1}^{N} V_g^n - V_{bias}\right) - \left(SF_{gyro}\right)\delta V_{bias} + w_{\dot{\theta}} \quad (1)$$

where, $\delta\dot{\theta}$, δSF_{gyro} and δV_{bias} are each heading, scale factor and bias error. V_g and V_{bias} are output voltage and bias voltage. SF_{gyro} is scale factor and N is sample number of 1sec. $w_{\dot{\theta}}$ is white noise. When car is stopped or moving in a straight line, sample mean of output voltage and bias voltage is same. Then first term of equation (1) can be eliminated. In this case, heading error can be a function of bias error. When car is driving with turn, first term of equation (1) increases as heading angle is large. On the other hand, second term is maintained as a constant value. In this paper, three types of measurement models for heading filter are used with relationship between heading error equation and car movement. When car is stopped or driving in straight line, we use the bias error model. We use the scale factor error model if car is turning. Last, when car is driving in changing area, heading error model is used. The following are the heading filter equations

$$\begin{bmatrix} \delta\dot{\theta} \\ \delta\dot{SF}_{gyro} \\ \delta\dot{V}_{bias} \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{N}\sum_{n=1}^{N} V_g^n - V_{bias} & -SF_{gyro} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \delta\theta \\ \delta SF_{gyro} \\ \delta V_{bias} \end{bmatrix} + \begin{bmatrix} w_{\delta\theta} \\ w_{SF_{gyro}} \\ w_{V_{bias}} \end{bmatrix} \quad (2)$$

where, $w_{\delta\theta}$, $w_{SF_{gyro}}$ and $w_{V_{bias}}$ are process noise of bias error, scale factor error and heading error.

The measurement equation is represented by different three types as below:

Stop/straight line

$$z_\theta = \theta_{gyro} = \begin{bmatrix} 0 & 0 & -\Delta t \cdot SF_{gyro} \end{bmatrix} \begin{bmatrix} \delta\theta \\ \delta SF_{gyro} \\ \delta V_{bias} \end{bmatrix} + v_\theta \quad (3)$$

Turning

$$z_\theta = \theta_{gyro} - \theta_{GPS} = \begin{bmatrix} 0 & \Delta t \cdot \left(\frac{1}{N}\sum_{n=1}^{N} V_g^n - V_{bias}\right) & 0 \end{bmatrix} \begin{bmatrix} \delta\theta \\ \delta SF_{gyro} \\ \delta V_{bias} \end{bmatrix} + v_\theta \quad (4)$$

Changing

$$z_\theta = \theta_{gyro} - \theta_{GPS} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \delta\theta \\ \delta SF_{gyro} \\ \delta V_{bias} \end{bmatrix} + v_\theta \quad (5)$$

In stop and straight line area, measurement equation is same but we apply the different measurement noise.

Speed filter

The objective of the odometer filter is to estimate a scale factor error of odometer. From the compensated scale factor error, a velocity of vehicle is obtained. The scale factor error is modeled as random walk because a scale factor error of odometer does not change rapidly with time.

$$\delta SF_{odo} = w_{odo} \quad (6)$$

$$z_{odo} = V_{GPS} - V_{Odometer} = n \cdot \delta SF_{odo} + v_{odo} \quad (7)$$

where δSF_{odo} is a scale-factor error, n is a pulse number obtained from the odometer, and Z_{odo} is a measurement vector obtained from GPS velocity and odometer velocity information. Also w_{odo} and v_{odo} are a process noise and a measurement noise of the odometer filter, respectively.

Position filter

The DR navigation algorithm calculates the vehicle position by using a velocity obtained from odometer and a heading angle obtained from gyroscope. The objective of the position filter is to estimate the vehicle position by using GPS and DR information. The followins are the position filter equations.

$$\begin{bmatrix} \delta\dot{x} \\ \delta\dot{y} \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \delta x \\ \delta y \end{bmatrix} + w_{pos} \quad (8)$$

$$z_{pos} = P_{GPS} - P_{DR} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \delta x \\ \delta y \end{bmatrix} + v_{pos} \quad (9)$$

where δx and δy are position error of east and north axis. Z_{pos} is difference of GPS and DR position, w_{pos} and v_{pos} are process noise and measurement noise of heading filter. The position filter updates by considering GPS status.

Performance Analysis

Test environment

The integrated GPS-DR navigation consists of GPS receiver, odometer and gyroscope. The GPS receiver SiRFstarIII GSC3e/LP, which has ARM7TDMI processor of 50MHz and can track 20 GPS channels, is used. As table 2 shows,

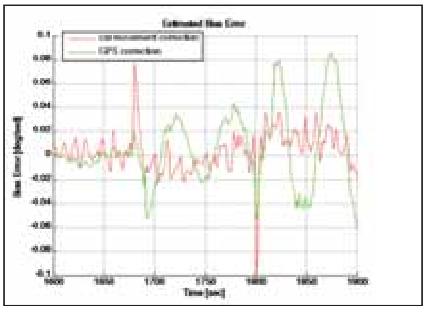

Fig.14 Estimated bias error in straight line

Fig.15 Position error in turning

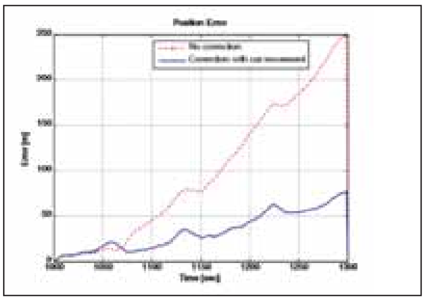

Fig.16 Position error in turning

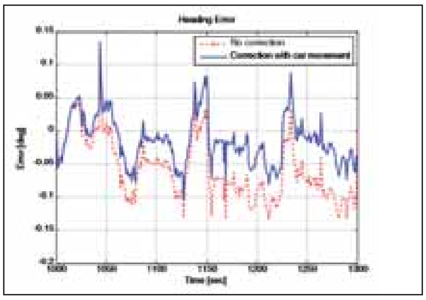

Fig.17 Position error in turning

Fig.18 Estimated position in underground parking

when the tyre circumference of vehicle is 1.681156m the odometer generates four pulses for one rotation of aetyre. So the scale-factor of odometer is 0.4203. The gyroscope XV-8000CB of EPSON TOYOCOM is also used. The specification of this is shown in Table 3.

To test the integrated GPS/DR navigation system, we consider the path where GPS signal is available. The figure 1 represents the overall driving trajectory of experiment. The results are analyzed in section 2 and section 3 in Figure 1. The section 2 is turn area and section 3 is straight line area, respectively. In these areas, we assume that GPS signal is blocked and analyze the results to compare with GPS solution. Last, the underground parking test results are shown.

Test results

First, we analyze the straight line test results and these are represented in figure 11~14. Figure 11 shows the position result in Google map. In these figures, blue line represents the proposed system result and red line represents the basic system result. The white line means the cars true trajectory is obtained from GPS solution. The estimated position with car movement is more similar with true car trajectory. The position error is shown in figure 12.

The proposed system has 9 times smaller error than the basic system. Figure 13 shows estimated heading error. The basic system estimated heading error increases as time passes. In proposed system, gyroscope bias error is estimated using car movement information and heading error doesn't increase. Figure 14 shows estimated gyroscope bias error. The green line means heading error is calculated using GPS and red line means heading error is calculated using car movement. Since the car is moving in a straight line, car movement correction result is more accurate than GPS correction results.

Next is turn area results and these are represented in figure 15~17. The proposed system result error is smaller than the basic system. In this case, proposed system error is also increased as time passes. Since bias, scale factor and heading error cannot be estimated in this section.

Finally, proposed system is tested in underground parking. Figure 17 shows estimated position of both systems. The car had been turned several times with same trajectory in underground parking. The proposed system estimated position has more regular trajectory than the basic system. For this reason, we cannot calculate the position and heading error since there are no reference solution.

Conclusions

This paper represents the GPS/DR car navigation system using vehicle moving information. GPS and DR sensor measurements are analyzed to decide the car movement. We implement the multi-measurement model for heading filter using this additional information. When GPS signal is blocked, gyroscope bias error is estimated using car movement information. A car experiment was performed to verify the proposed algorithm. The results show that the supposed method provides smaller position and heading error than previous method. When GPS is blocked in 300 sec, the position error is smaller than 9 times in straight line area and 3 times in turning area.

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References

- Jinwon Kim, Gyu-In Jee, and Jang Gyu Lee: Design of a Navigation System Using GPS and Dead-Reckoning, Vol. 2, No. 3, pp.188-193, 1996.
- Jae-Kuen Lee: GPS and DR Integration Technique for Car Navigation System, Master's Dissertation, Konkuk University, 1997
- Dae Seon Park: Development of a GPS/DR Integrated Unmanned Ground Vehicle Navigation System Using Real Time OS, Master's Dissertation, Konkuk University, 2000.
- Madhukar, B.R., Nayak, R.A., Ray, J.K., Shenoy, M.R., "GPS-DR Integration Using Low Cost Sensors," ION GPS 99, pp537-544, 1999.
- G. Dissanayake, S. Sukkarieh, E. Nebot, and H. Durrant-Whyte, "The aiding of a low-cost strapdown inertial measurement unit using vehicle model constraints for land vehicle applications," IEEE Trans. Robot. Autom., vol. 17, no. 5, pp. 731–747, Oct. 2001.
- Shin. E. H..: Estimation Techniques for Low-Cost Inertial Navigation, Ph.D. Thesis, University of Calgary, 2005.
- S. Godha and E. Cannon: GPS/MEMS INS integrated system for navigation in urban areas, GPS Solution., vol. 11, no. 3, pp. 193–203, Jul. 2007.
- N. El-Sheimy and X. Niu: The promise of MEMS to the navigation community, InsideGNSS, vol. 2, no. 2, pp. 46–56, Mar./Apr. 2007.
- [9] Itzik Klein, Sagi Filin, Tomer Toledo: Pseudo-Measurements as Aiding to INS during GPS Outages, ENC-GNSS 2009, May, 2009.
- [10] Kwang-Hoon Kim, Jong-Hwa Song, Gyu-In Jee: GPS-DR Integration Navigation System for Car Navigation, 2009 International Symposium on GPS/GNSS, Oct., 2009.

NRSC Data Centre

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Information from space for Improved agriculture management

Food ~~In~~security

"We have a unique business model with a large international network"

says Matthew M O'Connell, CEO, President and Director, GeoEye

From 2006 to 2010, it has been quite a journey for GeoEye. What were the highlights of this incredible journey?

It's hard to believe how far we've come. Just 7 ½ years ago, GeoEye had 60 employees generating $9 million per year, and our equity was worth zero. Now, we're 560 employees generating over $300 million per year, and our equity is worth almost a billion dollars. In a very short time, we went from bankruptcy to Fortune Magazine's list of the 100 fastest growing companies in America.

Early 2006 marked a year of change and incredible growth for GeoEye. We acquired Space Imaging from Lockheed and Raytheon in late 2005. The acquisition of Space Imaging gave us a great satellite – IKONOS, key channel distribution in the form of 10 international partners and the critical mass we needed to compete.

We merged with Space Imaging and re-branded ourselves as GeoEye. Incidentally, we paid off the $58 million we paid for Space Imaging in one year out of operating cash flow. That's amazing, when you consider that just three years earlier we couldn't raise $7 million to get out of bankruptcy.

I think our greatest success through that period was beating a combination of three huge companies—Lockheed, Raytheon and L3—for that $500 million NextView contract. We worked hard. We listened to the customer. We gave the customer what they wanted.

Of course, we launched GeoEye-1, the world's highest resolution commercial Earth-imaging satellite, in 2008, and it became operational in 2009. Winning the National Geospatial-Intelligence Agency's $3.8 billion EnhancedView award in August 2010 was another huge milestone for GeoEye.

The contract for the development and construction of the GeoEye-2 satellite and associated command and control systems has now been finalised. Once the satellite is operational in 2013, what will be the added benefits for the customers?

When GeoEye-2 begins operations in 2013, it will be the world's most accurate and highest resolution commercial satellite, with resolution at 33 centimeters. In addition, the satellite will have significant improvements in performance capabilities, such as enhanced tasking and the ability to collect more imagery at a faster rate. The improved resolution, along with greater agility and maneuverability, will allow GeoEye-2 to collect more point targets. This will help us keep up with increased global demand for imagery collection in the commercial and government markets.

Also in 2013, we'll begin work on GeoEye-3 to replace GeoEye-1 in the 2017 timeframe. GeoEye-2 and GeoEye-3 will expand our constellation, and they'll provide continuity for our imagery collection business.

From satellite imagery to aerial imagery to solutions, what would be the next step in the ever-expanding GeoEye portfolio?

As GeoEye evolves, we are seeing increased demand for information services. We're developing new online tools, like our Web-based information dissemination platform, EyeQ™, to make imagery more accessible to our customers.

In addition, we recently announced that we are acquiring the industry's leading geospatial predictive analytics company, SPADAC, Inc. SPADAC provides solutions that enable customers to analyze where activities or events may occur that will

affect, or are critical to, their day-to-day operations. They do this by combining location-based information, geographic data and historic events with a wide range of other information sources. By combining our industry-leading imagery collection capabilities with location-based analytics, we can help our customers gain unprecedented insight about the areas in which they operate.

We have a wealth of collective knowledge through our own work, and, more importantly, through the work of our partners. Our goal is to leverage that knowledge and apply it to new products, services and relationships. Increasingly, one company cannot get its arms around all the innovation and all the applications for location-based information. This is definitely the time and place for collective innovation. One of GeoEye's key goals is to create value for our stockholders by achieving sustained growth across our business, both organically and through acquisitions.

We have seen many picture perfect imageries from GeoEye. On an average, what percentage of imagery is unusable due to cloud cover?

We generally consider imagery with more than 20 percent cloud cover to be unusable, and that includes approximately 35 percent of the imagery we collect. This means that about 65 percent of the imagery we collect is usable, with less than 20 percent cloud cover.

Some customers accept higher cloud cover, if they can view their primary area of interest in a highly cloud-covered image. Some customers may find that multiple cloud-covered images stacked on top of each other will meet their demands.

Which regions have seen higher demands for satellite imagery in the last one year?

Russia, Ukraine and Belarus have seen the highest change in demand for new collection in the last year.

For example, in May we announced that we signed a multi-year, multi-million dollar contract with our Russian reseller, ScanEx Research and Development Center, for more than two million square kilometers of high-resolution satellite imagery. The world's first commercial high-resolution satellite, IKONOS, is capturing imagery of infrastructure facilities, major population centers and tourist locations over Russia and neighboring areas.

The areas of highest demand are always the Middle East and Far East, since we have regional affiliates in addition to other business in those areas. Generally, areas of conflict, borders, bounty and major disasters generate the highest demands for satellite imagery.

What do you think are the reasons for the immense success of the commercial satellite service providers like GeoEye, given that many countries have their own Resource Satellite Systems?

One reason for our success is we have a unique business model with a large international network of major partners, which includes commercial, government and non-government entities. They purchase our imagery and data, which saves them the high cost of developing their own space-based imagery systems. They also receive reliable service without overhead of development and maintenance costs. Several of these partners and affiliates are part of our heritage – they have been with us for 10 years or longer. Today, we have more than 96 international resellers and distributors, and that number continues to increase. We opened GeoEye Asia in Singapore to be closer to our customers and provide support to our partners in North and South Asia and India.

We also own one of the largest commercial color archives in the world, which contains more than 483 million square kilometers of color imagery of the Earth. The combination of our highly accurate satellite and aerial imaging assets, our high-resolution image processing and production facilities—especially our multi-source production capability—and our color digital imagery library differentiate us from other providers. This combination also enables us to deliver a comprehensive range of imaging products and services to our diverse customer base.

Could you please elaborate on the role of the GeoEye Foundation?

In 2007, we established the GeoEye Foundation, a 501(c)(3) non-profit organization, on the belief that we have an obligation and social responsibility to share GeoEye's technology and resources.

The mission of the Foundation is to foster the growth of the next generation of geospatial technology professionals. The Foundation provides satellite imagery to students and faculty at educational institutions to advance research in geographic information systems and environmental studies. It also offers imagery to non-government institutions to support their missions of humanitarian support and environmental research.

Since the Foundation's creation, professors and students have used GeoEye's imagery awards to study archaeology, coastal zone management, land cover assessment, climate change, forestry, geospatial intelligence and many other areas of interest. Non-governmental organizations have used our imagery for humanitarian relief and disaster response. These entities are doing important, interesting work, and we've published a number of their case studies on our Web site. It's satisfying to know that we've contributed to their successful research.

GeoEye has shown strong revenue growth and operating margins in the recent months. Would it be correct to say that GeoEye has crossed over the economic slowdown of the last couple of years?

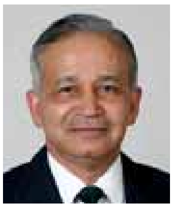
We believe that the worldwide imagery demand for surveillance and change monitoring will continue to resist recessions. Our satellite imagery helps many countries and companies around the world monitor their infrastructure and region-of-influence. By purchasing our imagery and data, they save money on the high cost of developing their own space-based imagery systems.

Even in these uncertain times, GeoEye is hiring. We expect to add at least 100 new jobs in our new headquarters location just outside Washington, D.C., over the next three years. It's finding the right people with the right skill sets that could prove to be a bigger challenge than the economy.

It's crucial for the geospatial industry that more students focus on the STEM disciplines – Science, Technology, Engineering, and Math. We're going to need all the bright young minds we can find to help us keep up with our current growth rate, and to deliver the imagery that our customers need to develop, monitor and protect their interests.

Modernizing the Indian airspace

This is an introductory article focussing on communication navigation and surveillance systems in india



Suresh V Kibe
Brahmprakash Professor
ISRO HQ, Bangalore
India.

The Ministry of Civil Aviation, Government of India has the sovereign authority to modernize the Indian Airspace. Rapid strides have been made by the Ministry of Civil Aviation in implementing many elements of the Global Air Navigation Plan recommended by the International Civil Aviation Organisation (ICAO) for Communications, Navigation, Surveillance (CNS)/Air Traffic Management (ATM) systems. India is a founding member of ICAO and is a regional member of the ICAO Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) based in Bangkok.

ICAO and Global air navigation infrastructure

There are 199 Member States in the ICAO. The future Air Navigation System (FANS) Committee of ICAO has recommended the use of Global Navigation Satellite System (GNSS) in modernizing CNS/ATM systems. Any State that provides global air navigation infrastructure benefits by reduction in the overall cost of operation and maintenance of facilities as the traditional ground systems become obsolete and satellite technology is increasingly employed. They will also benefit from the enhanced safety. Modern CNS/ATM systems provide a timely opportunity for developing States to enhance their infrastructure to handle additional traffic with minimal investment.

The Asia-Pacific Region

Most Economies in the Asia Pacific Region weathered the recent economic downturn well and are growing rapidly again with India and China leading the growth. Half of the world's civil aviation traffic added during the next 20 years is expected to be from or within the Asia Pacific Region. The total traffic for the region is expected to grow roughly at 7% per year during this period. Driven by economic development and the increasing accessibility of air transport services, traffic within the region will also grow faster than traffic to and from other regions. Discounting the slump in the growth of airline industry in the last two years, this industry is poised for rapid growth in the next two decades. The dramatic increase of air transportation industry in the Asia Pacific Region and a large economy like India requires a modern CNS/ATM systems.

Modern CNS/ATM

Modern CNS/ATM system is to employ digital technologies including satellite systems together with various levels of automation for CNS and as a strategic vision work towards a seamless global air traffic management systems that will enable aircraft operators to meet their planned times of departures and arrival and adhere to their preferred flight profiles with minimum constraints and without compromising agreed levels of safety. The ICAO global plan implementation would improve upon the present levels of safety, regularity, efficiency, capacity of airspace and airports, minimize fuel consumption and aircraft engine emissions, increase the availability of user preferred flight schedules and profiles and minimize differing equipment carriage requirement between regions. India is well on its way to implementing many elements of the ICAO plan.

- A modern CNS/ATM system improves **Communications** and hence the handling and transfer of information; improves **Navigational** accuracy leading to among other things reductions in separation between aircrafts and allowing for an increase in airspace capacity and extends **Surveillance** using the latest surveillance systems such as Automatic Dependence Surveillance (ADS). Advanced CNS systems will also see the implementation of ground based computerized systems to support increases in traffic. These ground based systems will exchange data directly with flight management System (FMS) onboard aircraft through a data link. This will benefit the ATM provider and airspace user by enabling improved conflict detection and resolution through intelligent processing, providing for automatic generation and transmission of conflict free clearances as well as offering the means to adapt quickly to changing traffic requirements. As a result, the ATM system will be better able to accommodate an aircraft's preferred flight profile and help aircraft operators to achieve reduced flight operating costs and delays.

- ATM includes Air Traffic Service (ATS), Air Traffic Flow Management (ATFM), Air Space Management (ASM) and the ATM related aspects of flight operations. An effective ATM is essential to ensuring safety, regularity and efficiency of International Civil Aviation. The challenge for the planner and designer is to develop an adequate understanding of the cost, benefits and operational suitability of these alternatives while considering the legal, organizational, environmental and financial aspects.

Communication Navigation and Surveillance systems in India

Communication

In CNS/ATM systems, the transmission of voice will continue to take place over existing very high frequency (VHF) channels. However, the same VHF channels will be increasingly used to transmit *digital data.* Satellite Data and voice communications capable of global coverage are also being introduced along with data transmission over high frequency HF channels. The International Air Traffic Association (IATA) Member Airlines support VHF Data Link (VDL) Mode 2 as the communications infrastructure for Controller-Pilot-DataLink-Communication (CPDLC) at present.

Navigation

The terrestrial navigational aids currently used in India and elsewhere are Non-Directional Beacon (NDB), Distance Measuring Equipment (DME) and Instrument Landing System (ILS). Improvements in navigation include progressive introduction of area NAVigation (R-NAV) capabilities along with Global Navigation Satellite Systems (GNSS).

These systems provide world-wide navigation coverage and are already being used for world-wide enroute navigation and non-precision approaches. With appropriate augmentation systems and related procedure it is expected that these systems will also support most precision approaches. The GNSS systems provide a high integrity, high accuracy, all weather world-wide navigation service with enhanced continuity and availability. The Indian Space-based Augmentation System (SBAS) is called GAGAN and when implemented in 2013 shall provide uniform navigational accuracies over the entire Indian Airspace. The ability for an aircraft to navigate in all types of airspaces in any part of the world are added advantages of the modern navigation systems. This does not mean that the conventional radio navigation aids are ready to be removed.

Surveillance

Traditional Secondary Surveillance Radar (SSR) modes will continue to be used. Gradually, SSR with mode S in both terminal areas and high density continental airspace will be introduced. The major breakthrough in surveillance technology is the implementation of Automatic Dependence Surveillance (ADS). ADS allows an aircraft automatically transmit its position, heading, speed and other useful information contained in the flight Management System (FMS) via a satellite or other communication link to an Air Traffic Control Unit (ATU). The position of the aircraft is displayed in a manner like that on a radar display. ADS is a true merging of communications and navigation technologies to provide surveillance. ADS along with ground system automation enhancements will allow for the introduction of significant improvement for ATM especially over oceanic airspace which lacks radar coverage. ADS-B (ADS-Broadcast) is a further improvement on the ADS technology wherein the aircraft disseminates its position not only to the ATC but to other aircrafts in its vicinity in its airspace. ADS-A/C is the latest advancement in the ADS technology and stands for ADS-Addressed or Automatic for ADS-A and ADS-Contract for ADS-C. ADS-A/C contains the software algorithms to transmit the position of the aircraft (either via SATCOM or VHF) every one to five minutes to an ATC listening station within the Fight Information Region (FIR). India has ADS-C facility over the Indian FIR including oceanic routes.

Indian Airports

India has 124 civil airports – 83 operational and 41 non-operational airports. 5 more airports are likely to be made operational by 2011. All airports have VHF Omni-directional Range (VOR) and Distance Measuring Equipment (DME). There are 99 domestic and 79 international ATS routes in and out of the country which operate through more than 80 civil airports in India. There are 14 Monopulse Secondary Surveillance Radars (MSSRs), 8 Primary Surveillance Radars (PSRs) in S-band and 2 primary radars in L-band. Out of these, 6 airports (Delhi, Mumbai, Bangalore, Hyderabad, Chennai and Kolkata) carry more than 90% of the revenue earning traffic and command more than 90% of the passenger traffic. 38 stations are being upgraded to be provided with ATC automation systems with the capability of integrating data (Radar and Flight plan data with the main systems at Chennai, Kolkata, Mumbai and Delhi systems). All of these airports are equipped with Instrument Landing System (ILS). There are over 400 passenger aircrafts in the country today and according to one estimate the additional no. of aircrafts needed over the next 2 decades is about 900.

[The Indian Flight Information Region (FIR) is supported by ADS-C. Delhi has category-IIIB Landing facility, Kolkata and Lucknow have Category-II and the Airports Authority of India plans to install 7 Cat.I ILS equipment, 3 Cat.III ILS and 2 Cat.III ILS at Amritsar, Jaipur, Jammu, Delhi, Mumbai etc. The number of tourists visiting India has increased from 10 Million in 2005 to 17 Million in 2010 and is slated to increased to 25 Million in 2013. Large airports in India such as, Delhi and Mumbai are being planned to handle a capacity of 100 Million passengers per year].

Performance Based Navigation (PBN)

In conventional navigation, the aircraft uses the ground based terrestrial navigation aids for position determination and flies from its departure point to destination point with reference to the air traffic control points. The flight path is, therefore, fixed . In Performance Based Navigation (PBN) the aircraft determines its position from Global Navigation Satellite Systems (GNSS) which is integrated into the on-board navigation and flight management system. This allows the pilot to fly an efficient and flexible path to its destination. Area Navigation (ARNAV) and Required Navigation Performance (RMP) are two constituents of PBN. Airports Authority of India (AAI) has adopted an integrated approach towards implementation of PBN procedures. Efficient implementation of PBN will result into enhanced airspace capacity, enhanced safety, repeatability of flight path, reduction in controller pilot communication, reduced fuel burn and reduced reliance on ground based navigation infrastructure.

Benefits of modern CNS/ ATM systems to Airlines, States and environment

A modern CNS system will enable airlines to fly the aircrafts with reduced separation standards over all oceanic airspace with reduced vertical separation for more dynamic and direct routing with an overall enhancement of safety. For States which introduced the modern CNS/ATM systems, the overall cost of operation and maintenance of ground infrastructure is expected to reduce, timely introduction of these modern systems will help enhance the States infrastructure to handle additional traffic with minimal investment. It will also permit better upper Airspace management and bring in to the basket of greater access to unusable airspace. As the Aviation industry grows more and more the impact of air traffic operations on the global atmosphere becomes increasingly important in addition to the local affects of noise and air quality. Improved ATM could help reduce aviation fuel burn and thereby reduce the levels of aircraft engine emissions.

The indirect benefits are lower fares and passenger time savings, transfer of high technology skills, productivity improvements and industry restructuring, stimulation of related industries, enhanced trade opportunities and increased employment.

Green fields airports

The Ministry of Civil Aviation has formulated a policy for Green-field airports development. By definition, a green-field airport is an infrastructure created in a place where no CNS/ATM facility existed earlier. Introduction of GNSS based CNS/ATM assists in providing advanced CNS/ATM services to green-field airports at a relatively low cost and the aircraft carries a certified CNS system.

We track QZSS Satellite and its New L1C signal

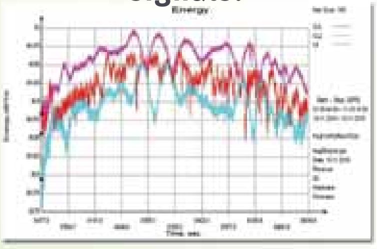
Another first: On the afternoon of Friday October 29, 2010, JAVAD GNSS engineers in Moscow tracked Japan's first QZSS satellite and its new L1C signal, as we reported earlier.

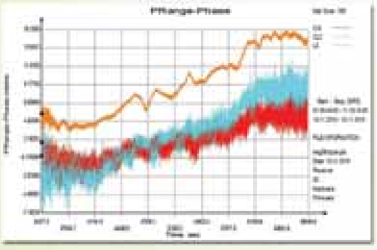
We update our report by presenting C/A, L2C, L5, SAIF and the new L1C signals that were collected on Nov 10, 2010 from 02.00 till 12.00 UTC, when QZSS-1 satellite was visible in Moscow. QZSS is the first satellite which transmits new L1C signal.

All of the current JAVAD GNSS receivers, including OEM boards, ALPHA, DELTA, SIGMA, TRIUMPH-1 and TRIUMPH-VS can track QZSS signals with a software update. The software upgrade may be released as early as next week.

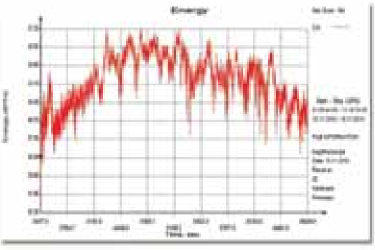
Figures below show "SNR" and "code-minus-phase" plots for all the above signals

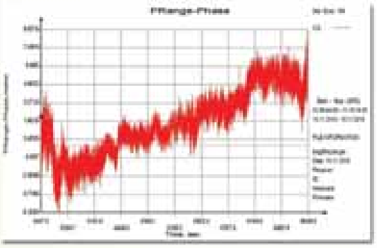
QZSS C/A, L2C, L5 signals:



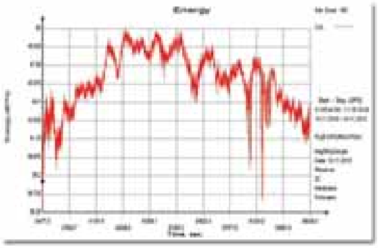


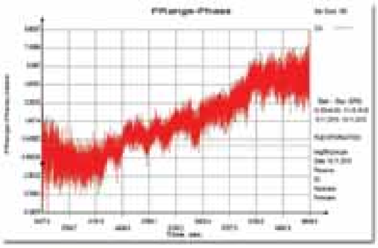
QZSS SAIF signal:

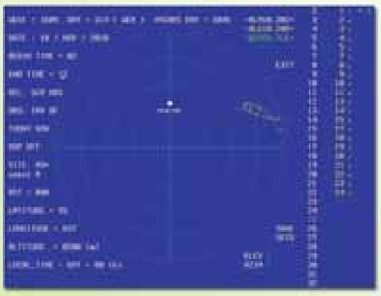




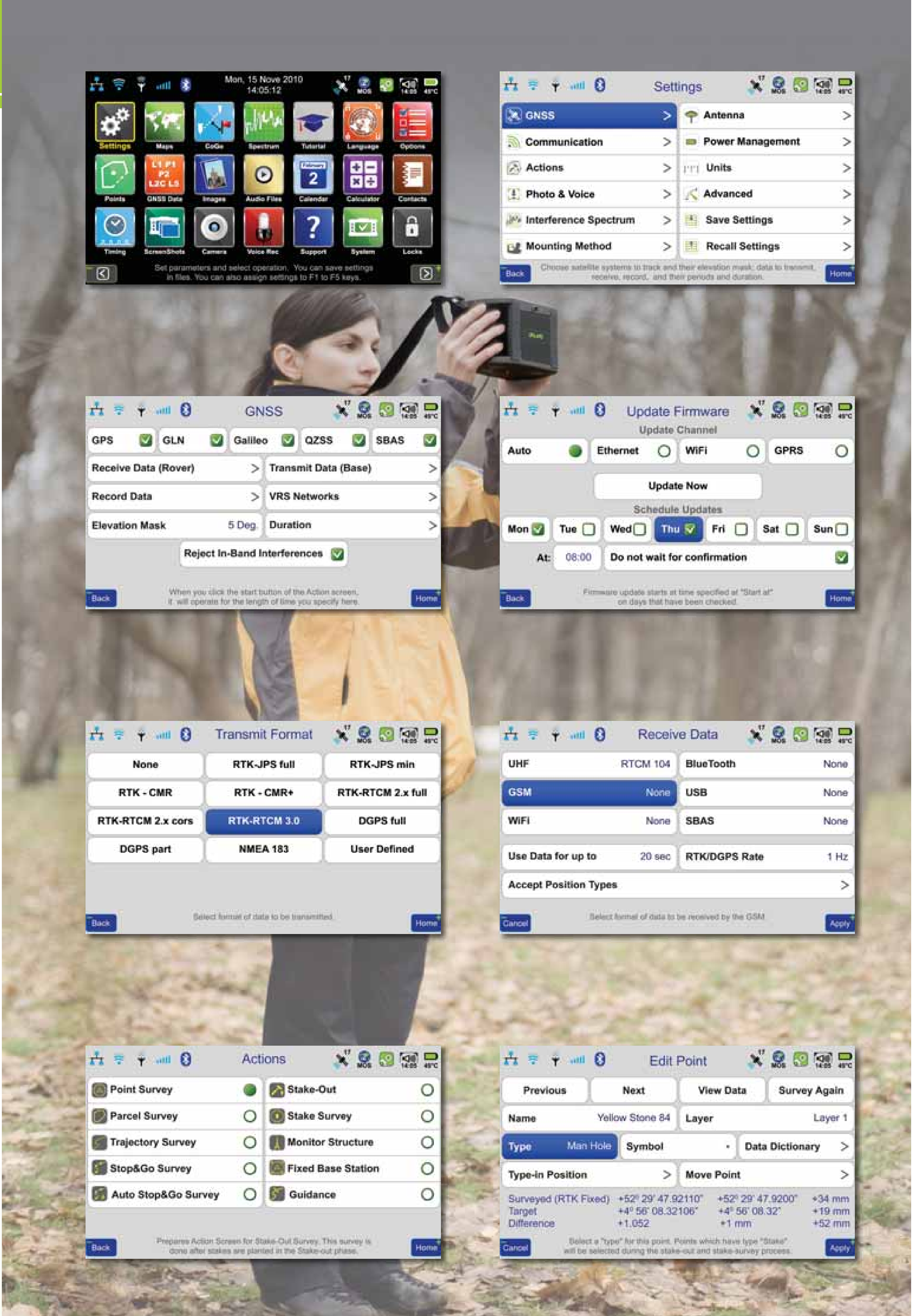
QZSS L1C signal:







Michibiki satellite has a periodic Highly Elliptical Orbit (HEO). In Moscow it's day track is shown on the next figure.



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Tutorial
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Points
GNSS Data
Images
Audio Files
Calendar
Calculator
Contacts
Timing
ScreenShots
Camera
Voice Rec
Support
System
Locks
Set parameters and select operation. You can save settings in files. You can also assign settings to F1 to F5 keys.
Settings
GNSS
Antenna
Communication
Power Management
Actions
Units
Photo & Voice
Advanced
Interference Spectrum
Save Settings
Mounting Method
Recall Settings
Back
Choose satellite systems to track and their elevation mask; data to transmit, receive, record, and their periods and duration.
Home
GNSS
GPS
GLN
Galileo
QZSS
SBAS
Receive Data (Rover)
Transmit Data (Base)
Record Data
VRS Networks
Elevation Mask
5 Deg.
Duration
Reject In-Band Interferences
Back
When you click the start button of the Action screen, it will operate for the length of time you specify here.
Home
Update Firmware
Update Channel
Auto
Ethernet
WiFi
GPRS
Update Now
Schedule Updates
Mon
Tue
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Thu
Fri
Sat
Sun
At:
08:00
Do not wait for confirmation
Back
Firmware update starts at time specified at "Start at" on days that have been checked.
Home
Transmit Format
None
RTK-JPS full
RTK-JPS min
RTK - CMR
RTK - CMR+
RTK-RTCM 2.x full
RTK-RTCM 2.x cors
RTK-RTCM 3.0
DGPS full
DGPS part
NMEA 183
User Defined
Back
Select format of data to be transmitted
Home
Receive Data
UHF
RTCM 104
BlueTooth
None
GSM
None
USB
None
WiFi
None
SBAS
None
Use Data for up to
20 sec
RTK/DGPS Rate
1 Hz
Accept Position Types
Cancel
Select format of data to be received by the GSM
Apply
Actions
Point Survey
Stake-Out
Parcel Survey
Stake Survey
Trajectory Survey
Monitor Structure
Stop&Go Survey
Fixed Base Station
Auto Stop&Go Survey
Guidance
Back
Prepares Action Screen for Stake-Out Survey. This survey is done after stakes are planted in the Stake-out phase.
Home
Edit Point
Previous
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View Data
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Layer 1
Type
Man Hole
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Data Dictionary
Type-in Position
Move Point
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+52° 29' 47.92110"
+52° 29' 47.9200"
+34 mm
Target
+4° 56' 08.32106"
+4° 56' 08.32"
+19 mm
Difference
+1.052
+1 mm
+52 mm
Cancel
Select a "type" for this point. Points which have type "Stake" will be selected during the stake-out and stake-survey process.
Apply

Three New Revolutionary Products

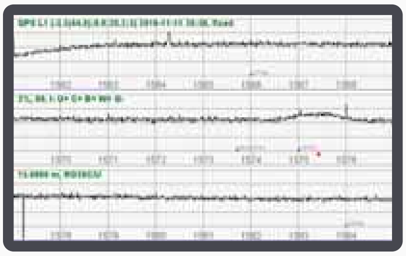
Packaged in One!

TRIUMPH-VS shows interferences in all GNSS bands

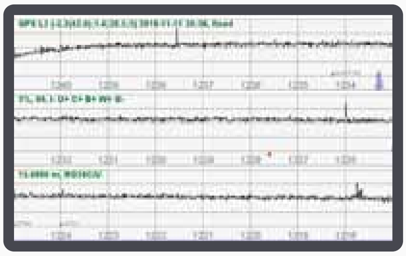
Your GNSS receiver sometimes does not track satellites? Sometimes RTK solutions get stuck in “Float”, or take longer to converge to “Fixed”? You may have interferences in one or more of your GNSS bands. In addition to harmonics of signals like local TV and radio stations, now there are $10 GNSS jammers on the market that interfere with GNSS signals as well!

The GNSS spectrum analyzer feature of TRIUMPH-VS does much more than a generic $30,000 spectrum analyzer. TRIUMPH-VS shows interferences by analyzing signals before RF and after digital sections and quantifies how much interference is in your neighborhood. See the reverse side for more detail.

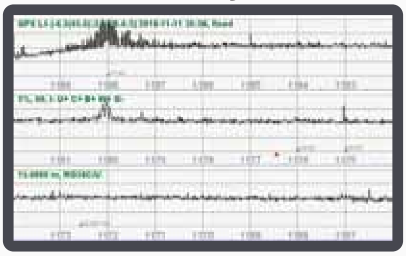
GPS L1



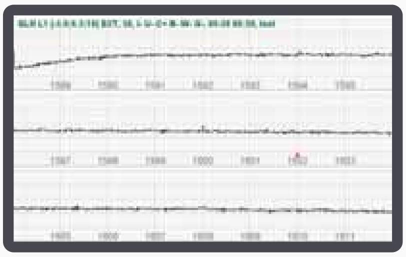
GPS L2



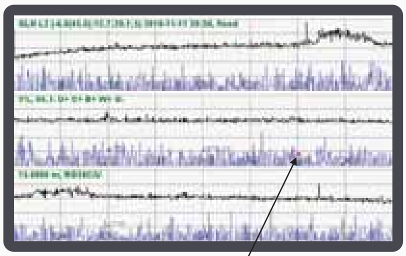
GPS L5



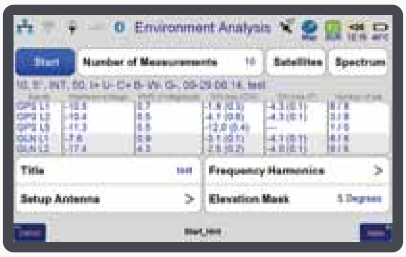
GLONASS L1



GLONASS L2



Center of the Band



TRIUMPH-VS not only scans the GNSS bands and shows the shape and frequencies of the interferences, but it also quantifies the magnitude of the interferences in two distinct and complementary ways: a) by analyzing the analog signal and determining the “Interference Magnitude”, and b) by analyzing the S/N (Signal-to-Noise ratio) of all satellites’ signals after they are digitized and processed (after code and carrier correlations) and determining the “Satellites S/N loss” due to interferences.

“Interference Magnitude” is determined by analyzing the amount of gain that we can apply to the GNSS signal before digitizing it. The more interference there is, the less we can amplify the signal to avoid saturation. We can determine the “Interference Magnitude” by comparing the actual amplification magnitude with our nominal amplification magnitude (when no interference exists).

“Satellites S/N loss” is determined by comparing the actual measured S/N of each satellite (for each of its signals) with its nominal S/N at that elevation angle and then averaging all such deviations for all satellite signals.

TRIUMPH-VS not only analyzes and shows interferences, it also has In-Band Interference Rejection option that removes in-band interferences.

German Aerospace Center (DLR) Reports

Multipath Error on Different Receivers

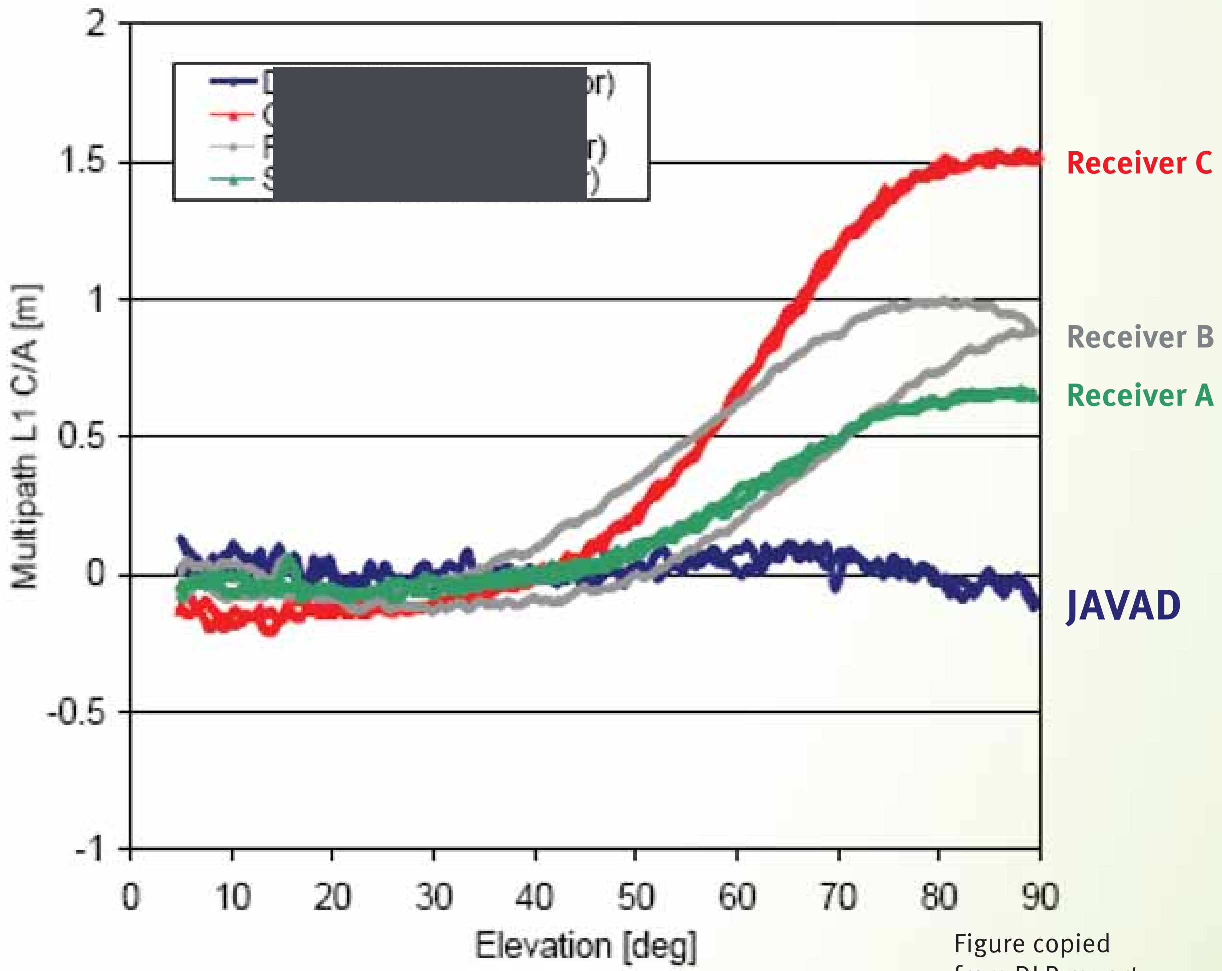


Figure copied from DLR report

JAVAD GNSS receivers virtually remove multipath errors in all elevation angles. Other receivers get affected by up to 1.5 meters!

The study was sponsored and performed by German Aerospace Center (DLR) using their 30-m dish antenna in cooperation with U.S. GPS Air Force authorities.

The complete report along with identity of other receivers will be published soon by DLR and Springer Publishing.

"GRAV-D has the potential to provide very significant benefits to the public"

Says, Dr Dru Smith, Chief Geodesist of NOAA's National Geodetic Survey while explaining the GRAV-D project

What is the GRAV-D project?

GRAV-D stands for "Gravity for the Redefinition of the American Vertical Datum". It is a multi-year project designed and led by the National Geodetic Survey (NGS). GRAV-D was initiated to measure and monitor the Earth's gravity field with the goal of accurately defining a geopotential reference frame for the United States, to replace the current vertical datum NAVD 88 (the North American Vertical Datum of 1988).

What are the components of the GRAV-D project?

GRAV-D consists of three major data collection campaigns. The first is an airborne gravity survey over the United States and its surrounding territories. This is the largest campaign in both time and money, expected to be complete around 2022. It should yield a highly accurate "snapshot" of the gravity field over the USA. The second campaign is about monitoring the continental changes to the gravity field, through a combination of repeated terrestrial gravity measurements, satellite gravity missions and geophysical modelling. This is necessary for the long-term maintenance of the geopotential reference frame. The third campaign is mostly just an idea for now, consisting of partnership surveys in localized areas of significant geophysical change (such as southern Alaska, southern California or Hawaii). In that campaign, NGS would expect to cooperate with local groups with an interest in highly detailed change detection.

In addition to these data collection campaigns, the ultimate goal of GRAV-D is to use this gravity information to define an accurate geopotential reference frame (which includes a zero-height surface, known as "the geoid"). While data collection is ongoing, research is also being conducted to ensure that the equations used to model the geoid and other aspects of the gravity field are accurate enough to provide a geoid model to 1 centimeter where possible.

What are the current problems with 'height' that the GRAV-D project looks to address?

Firstly, there are many different definitions of "height". It is likely that the most common use of "height" is the orthometric height, which is colloquially (but inaccurately) called a "height above sea level". The orthometric height is the one most frequently plotted on topographic maps and is extremely good at telling the direction of water flow. Another different height is the ellipsoid height, which is a sort of mathematical abstraction which comes as an artefact of GPS positioning. Ellipsoid heights are determinable very accurately using GPS, but they are not good at determining the direction of water flow.

The improvements which GRAV-D will provide to "height" are twofold. The first improvement is solely in the determination of the "zero height surface" (or "geoid") itself. The current official vertical datum of all civilian federal mapping authorities in the USA is NAVD 88. That datum was established using traditional levelling techniques over decades preceding the final release of NAVD 88 in 1991. Recent studies have shown that NAVD 88 has a zero height surface that is biased from the geoid by about 50 centimeters and tilted across the country by about 1 meter. Furthermore, NAVD 88 is accessed through the publication of heights on hundreds of thousands of passive geodetic marks (called "bench marks") whose heights are rarely checked, and are therefore vulnerable to subsidence and bulldozing.

The second improvement which GRAV-D will empower is to no longer rely on unchecked passive control to provide access to heights. Rather, a GPS receiver, with a geoid model from GRAV-D, will provide immediate and accurate access to orthometric heights directly.

Who all are collaborating on the GRAV-D project with National Geodetic Survey (NGS)?

NGS has appreciated the collaborative efforts of a variety of other agencies in the few years since GRAV-D's inception. Foremost amongst these are the Naval Research Laboratory (NRL), the U.S. Army Corps of Engineers (USACE), the National Geospatial-Intelligence Agency (NGA) and the Bureau of Land Management (BLM). However, the long-term operational funding for GRAV-D remains solely that of NGS at this time.

Besides helping NGS to fulfil its mandate to provide accurate positioning, there are several other benefits that will accrue from the completion of the GRAV-D project. Could you please elaborate on these benefits?

GRAV-D has the potential to provide very significant benefits to the public, beyond the NGS mission objectives. First, all of the data collected will be in the public domain, hopefully spurring academic research for years to come. Furthermore, the access to this data should improve all other models of the gravity field, not just those over the USA, due to the spatial correlation properties of gravity. This means that groups modelling the gravity field over Canada, or over the entire world, may see benefit from GRAV-D.

Other improvements may come from some collaborations, such as the flying of a magnetometer by USGS on GRAV-D flights (which has been done experimentally, but NGS hopes can become standard operating procedure).

Indirect benefits come from the performance of NGS's mission, as the provider of geodetic control information to the rest of the federal government. That is, NGS expects that FEMA floodplain mapping, USGS topographic mapping and USACE levee monitoring surveys may all benefit from an accuracy improvement as GRAV-D finishes and the new geopotential reference frame is put in place.

Do you think a world-wide effort along the lines of GRAV-D will become essential in the years to come?

I do not feel that a world-wide effort would be essential, but I think some specific country-wide efforts will be so. Mapping the gravity field from space has rapidly improved our ability to use this information to improve heights, but even the best missions (GRACE and GOCE) cannot see the finest details of the gravity field which airborne (or terrestrial) gravity mapping can show. In many cases, budgets will prevent the accomplishment of GRAV-D style projects over many countries. Furthermore, mapping the ocean areas (aside from where they are nearest to occupied land) is not necessary. Ocean gravity mapping, in deep waters, is already a well-established science using altimetry data. With this in mind, I see large scale airborne mapping of the gravity field being mostly performed by large countries or groups of countries with the resources to do so, and the need for the highest accuracy heights.

CONFERENCE

ION GNSS 2010

21-24 September, Portland, USA

The ION Satellite Division's 23rd annual international meeting was held from the 21st to the 24th of September 2010 at the Oregon Convention Center, Portland, Oregon, USA.

At the opening plenary session issues related to 'sustainment, robustness and interchangeability' of global positioning and timing were taken up by the speakers. The session was moderated by Dr. Bradford Parkinson, the founding commander of the GPS Joint Program Office and a Stanford University professor emeritus. Other panellists included David Turner, deputy director, Office of Space & Advanced Technology, U.S. Department of State; Phil Ward, of Navward GPS Consulting; Dr. Mike Miller, Air Force Research Laboratory (AFRL); and Dr. Paul Massatt, senior engineering specialist, in The Aerospace Corporation's Navigation and Geopositioning Systems Department.

Over the three days 260 papers were presented in 36 parallel sessions. More than 60 companies and organizations participated in the accompanying exhibition and there was a four percent increase in attendance from last year.

The Johannes Kepler Award was awarded to Dr. Todd Walter for his contributions to space based augmentation systems and the education of the next generation of navigation professionals.

While Ali Broumandan of the University of Calgary was awarded the Bradford W. Parkinson Award for graduate student excellence in Global Navigation Satellite Systems in his thesis "Enhanced Narrowband Signal Detection and Estimation with a Synthetic Antenna Array for Location Application."

The GNSS Program Updates panel discussion was moderated by Dr. John Betz of the MITRE Corporation. This panel also had a presentation by GPS Wing's new commander, Col. Bernard Gruber and an update on GLONASS by Dr. Sergey Revnivykh, Deputy Director General of Roscosmos's Central Research Institute of Machine Building.

The first Civil GPS Service Interface Committee (CGSIC) meeting was also hosted by ION.

The ION GNSS 2011 will be held from the 23rd to the 25th of September 2011 at the Oregon Convention Centre, Portland, Oregon, USA. For more details contact lbeaty@ion.org.

From Galileo to Multisystem: Evolution of Integrity concept

The use of Galileo and EGNOS system as a single and augmented constellation allows us to develop the positioning algorithm and to improve the position accuracy

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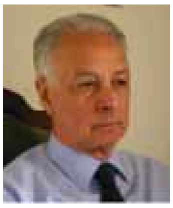

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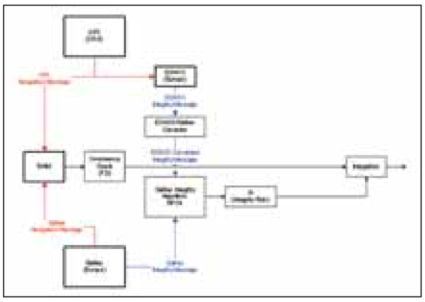


Fig. 1 – Galileo-Based Integrity Algorithm

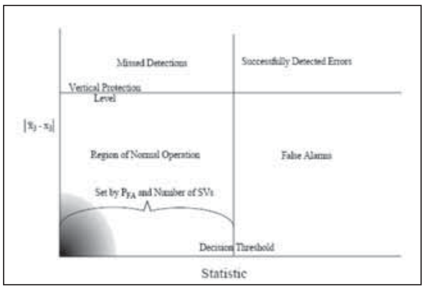


Fig. 2 – Distribution of vertical error and RAIM statistic for normal operations.

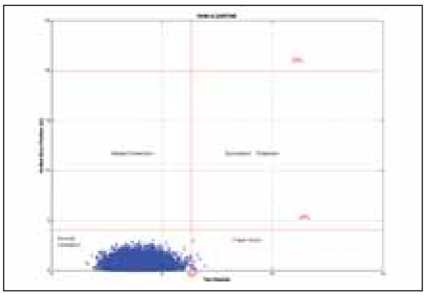


Fig. 3 – WRAIM in Faulty Free condition.

The integrity concept, intended as a continuous control of the information broadcast by the satellites, has been introduced by the Galileo system. Though the RAIM technique represents the first example of integrity monitoring, it has the characteristic to detect only local errors, at receiver level. The integrity monitoring applied by EGNOS, instead, could be seen as the forerunner of the Galileo one. Though there are many differences in the definition of integrity of the two system, the main aim is the same for both, that is to protect the user against failure of the system, warning him in the shortest time and with the greater precision. The integrity includes the system's ability to supply, at the right time, reliable warnings to the user (alarm). The main problem in supplying this service is to determine which one could be considered safe, in fact it depends on the required operation in every fields of application. Traditionally the following parameters are used to define the safety of the service for a specific application:

- *Alarm Limit* (AL): maximum error allowed in the position domain before the alarm generation.
- *Time To Alarm* (TTA): time elapsed between error's overcoming of the AL and reception of the alarm by the user receiver.
- *Integrity Risk* (IR): probability that the alarm is not delivered within the TTA.

Galileo integrity

The integrity concept developed in Galileo has the aim to ensure the correct position's computation, achieved by the receiver, and provide a valid alarm to the user if the error in the position solution exceeded a fixed threshold, the Alert Limit, relative to the specific application.

The Galileo system provides three elements to preserve the user integrity:

- Signal-in-Space Accuracy (SISA): is the expectation of the errors relative to the SW's clock and ephemerides, founded on long term observations.
- Integrity Flags (IF): is a warning relative to a satellite that is transmitting a signal with an excessive error. IF is founded on the short term observation of the clock's variations, the ephemerides and the RF signals.
- Signal-in-Space Monitoring Accuracy (SISMA): is an estimation of the accuracy of the Signal-in-Space Error (SISE).

The user receiver judges the accuracy of the computed position solution, typically in term of Horizontal Protection Level (HPL) and Vertical Protection Level (VPL), through an estimate of the errors of the system, an estimate of the local errors and the knowledge of the number and geometry of the SWs used for the positioning algorithm. The computed Protection Level is then compared with specific Alert Limit, in order to determine the availability of the navigation service. The error detected by the ground segment can be modeled with a zero-mean Gaussian distribution with variance $\sigma^2 = \sigma^2_{SISA} + \sigma^2_{u,L}$.

Galileo integrity risk

The evolution of the Galileo integrity concept concerns the verification of the system's integrity. The separation between the vertical and the horizontal computation of the protection level has been united in an unique concept, or rather the user will be able to compute a probability, named *Hazardous Misleading Information Probability* (P_{HMI}), which will be compared with a threshold (TH).

Integrity Risk Algorithm

From the quantities listed above mentioned (SISE, SISA, SISMA, IF and TH), the user receiver can derive the integrity risk for the user position solution. This integrity risk is always computed for a given alert limit. Whenever the derived IR at the AL is larger than the allowed IR, the user equipment shall raise an alert.

The assumptions made for the derivation of the user integrity equation are summarized as follow:

- In a *Faulty Free* mode, the true SISE for a satellite is zero mean Gaussian distributed with standard deviation SISA.
- In general faulty satellite will be flagged *Don't Use*.
- For each instance in time, one satellite of those flagged *OK* is considered to be faulty but not detected (*Faulty Mode*). The distribution for the SISE of a faulty satellite is Gaussian with expectation value TH and standard deviation SISMA.

Once the distribution of the error in the reference frame is known (Gaussian overbounding distribution with SISA and SISMA respectively), deriving the associate integrity risk is straightforward. Therefore the error distribution for the vertical (one dimensional Gaussian distribution) and horizontal (Chi Squared distribution with two degree of freedom) cases need to be derived and the corresponding integrity risk can be easily computed by analyzing the integral for both distribution with respect to the given alert limit. Finally, the integrity risk at the alert limits HAL (Horizontal) and VAL (Vertical) are computed by adding the vertical and horizontal contribution (eq. 1).

$$P_{HMI}(VAL,HAL) = P_{IntRisk,V} + P_{IntRisk,H} = 1 - erf\left(\frac{VAL}{\sqrt{2}\sigma_{u,V,FF}}\right) + e^{-\frac{HAL^2}{2\xi^2_{FF}}} +$$
$$+\frac{1}{2}\sum_{j=1}^{Nsat\_Galileo} P_{fail,sat_j}\left(\left(1-erf\left(\frac{VAL+\mu_{u,V}}{\sqrt{2}\sigma_{u,V,FM}}\right)\right)+\left(1-erf\left(\frac{VAL-\mu_{u,V}}{\sqrt{2}\sigma_{u,V,FM}}\right)\right)\right)+$$
$$+\sum_{j=1}^{Nsat\_Galileo} P_{fail,sat}\left(1-\chi^2_{2,\delta_u,H}cdf\left(\frac{HAL^2}{\xi^2_{FM}}\right)\right) \quad (1)$$

where N is the number of satellite used for the positioning algorithm.

Multisystem integrity

With the advent of Galileo users will be provided with multiple signals coming from different satellite systems. This will improve position accuracy, because the number of satellites in view per user will be almost doubled. Moreover, the higher measurements redundancy will help to guarantee a safer position and the detection of errors. This will result also in an improved availability and in this way the requirements for more demanding flight categories can be satisfied. Therefore, it is necessary to introduce a base-line for a combined system, defining new parameters, new integrity algorithm and possible ways to combine the two independent systems.

With the term "Multisystem", we mean the improvement of the accuracy and availability of the navigation solution using the combined Galileo and GPS signals. In this context, it is essential for the user to take advantage of the integrity information coming from both Galileo and GPS satellite constellations in order to prevent users from errors that might represent an excessive risk. The multisystem integrity algorithm has to establish a link between the two generations of GNSS, defining the relation for integrating different integrity monitoring schemes.

Galileo-Based Integrity Algorithm

In order to define a new Integrity algorithm, for this study we have chosen an approach known as GBIA (Galileo-Based Integrity Algorithm), through which the integrity data coming from the two systems considered, Galileo and EGNOS, are implemented inside the Integrity Risk equation of Galileo. Figure 1 shows the block diagram of a GBIA system. The fundamental block of this diagram is the EGNOS/Galileo converter, that has the aim of converting the EGNOS Integrity message into a message useable by the Galileo Integrity Algorithm.

EGNOS is a SBAS (Satellite Based Augmentation System) that has the aim to improve the GPS system through a constellation composed by three GEO satellite and a ground segment. In EGNOS, the quality of the information is provided in the form of standard deviations related to two type of corrections, namely:

The UDRE, that is the variance of residual clock ephemeris errors;

The UIRE (User Ionosphere Range Error), that is the variance of residual ionospheric errors, obtained through a model based on GIVE and UIVE (User Ionospheric Vertical Error). Hence, like in Galileo case, the error detected by the ground segment can be modeled with a zero-mean Gaussian distribution with variance:

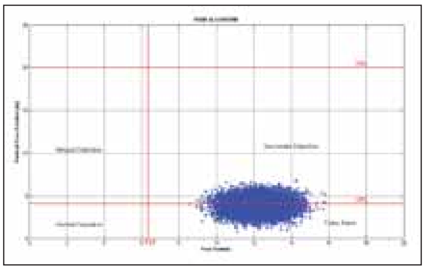


Fig. 4 – IR algorithm in Faulty Free condition.

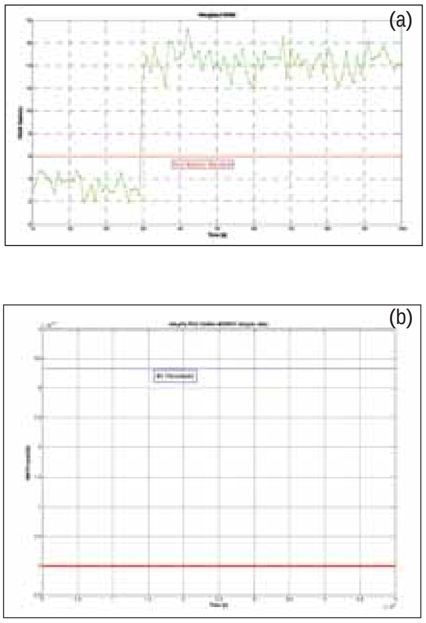


Fig. 5 – RAIM and bias on pseudorange – satellite Galileo PRN 4. (a) – RAIM Algorithm (b) – Multisystem Integrity Algorithm.

$$\sigma^2 = \sigma^2_{UDRE} + \sigma^2_{UIRE} + \sigma^2_{air} + \sigma^2_{tropo} \quad (2)$$

where:

$$\sigma^2_{UIRE} = \frac{\sigma^2_{UIVE}}{1 - \frac{R_E \cos El}{R_E + h_I}},$$

where σ^2_{UIVE} is the variance of the vertical ionospheric error contribution, R_E is the mean radius of the earth, E_l is the elevation angle of the satellite and h_I is the height of the maximum electron density;

σ^2_{air} results from the receiver noise and multipath;

σ^2_{tropo} is the variance of the tropospheric error contribution.

The main functions implemented by the EGNOS-Galileo converter are the following:

$$\sigma_{SISA,GPS} = f_{SISA,GPS}\sigma_{UDRE}$$
$$\sigma_{SISMA,GPS} = f_{SISMA,GPS}\sigma_{UDRE} \quad (3)$$

Taking into account the different integrity allocation between the Galileo concept, that foresees the use of four failure mechanism, and the EGNOS

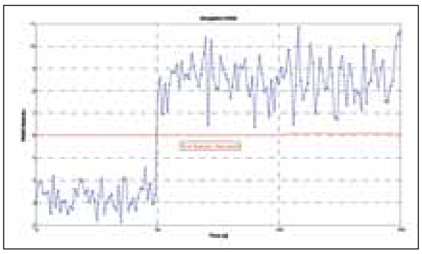


Fig. 6 – RAIM and bias on pseudorange – satellite GPS PRN 8.

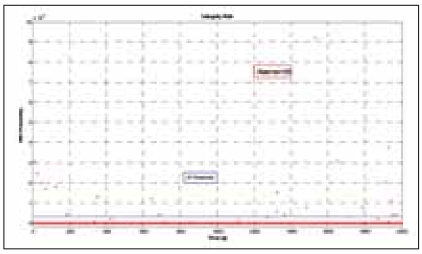


Fig. 7 – IR algorithm combined constellation and bias on SISA and SISMA, satellites Galileo PRN15 and PRN22.

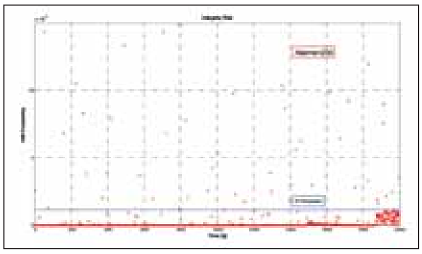


Fig. 8 – Galileo IR algorithm and bias on SISA and SISMA, satellites Galileo PRN15 and PRN22.

concept, based on a failure assumption, the contribution of GPS satellite to IR computation is reduced only to the faulty free mode. Then it is possible to assume $f_{SISMA,GPS} = 0$ and $f_{SISA,GPS} = 1$, that is:

$$\sigma_{SISA,GPS} = \sigma_{UDRE} \quad (4)$$

Moreover, in order to estimate the standard deviation of the error, can be used the following equation:

$$\sigma^2_{u,L,GPS} = \sigma^2_{UIRE} + (\sigma^2_{Air} + \sigma^2_{Tropo}) \quad (5)$$

Multisystem integrity algorithm implementation

The proposed algorithm merges integrity data originated by Galileo and EGNOS systems and employs a Receiver Autonomous Integrity (RAIM) technique (Weighted RAIM). The potentiality of this algorithm is represented by the combination of the IR algorithm with the RAIM technique. RAIM is able to detect failures not detected by the IR algorithm; in case of multiple failures, when the WRAIM technique fails, the IR algorithm triggers alarm. The aim of this research is to enable the user to take advantage of the data transmitted by the Galileo and EGNOS systems: the user receiver must consider a single and large constellation in order to strengthen the positioning algorithm and improve the accuracy. This idea just need the definition of a new integrity concept, able to put together the techniques mentioned above.

IR equation

In EGNOS domain, IR is the probability that the horizontal (vertical) PL exceeds the horizontal (vertical) AL, without the user got any alarm. This definition asks for making a clear distinction between the horizontal and vertical case. So it is necessary to split IR in two a priori fixed quantities. On the contrary, with Galileo system, the users do not have to evaluate the horizontal and vertical protection levels, but directly the global IR without making strict allocations. The first step on the definition of a new integrity algorithm concerning a combined constellation (Galileo+GPS), is the characterization of equivalent elements belonging to the two navigation system. In order to achieve the test on the position solution, we opted for the relationship between σ^2_{SISA} of Galileo and σ^2_{UDRE} of EGNOS (Section - Galileo-Based Integrity Algorithm). First of all, these are quantities defined in the same domain SIS, moreover are related to the same typology of error (clock and ephemeris).

The local contribution to the variance of the error in the SIS depends from the elevation angles of the satellite belonging to the two constellation considered. As mentioned before, in order to consider a single constellation composed by booth GPS and Galileo SW, we have considered the variance of the error in the SIS as follow:

$$\sigma^2_i = \sigma^2_{SISA/UDRE,i} + \sigma^2_{u,L,i} \quad (6)$$

where the second term represents the local error contribution.

Through a Matlab® routine we can implement the IR equation. *FF* and *FM*, in Eq. 1, suggest the *faulty* and *faulty free* mode. In fact, the Galileo system assumes two separate scenarios: one in which the satellites are all set as *use*, and the other in which one of the satellites set as *use* is supposed not functioning. When you are in *faulty* mode, in case of Galileo satellites, the SISMA element comes out; instead, in EGNOS case, only the faulty free mode is expected and, because we could not find an equivalent for the Galileo SISMA in its navigation message, we are going to consider the following situation:

- *Faulty free:* for the Integrity Risk computation we consider all satellite in view, GPS and Galileo set as *OK*.
- *Faulty mode:* the involved satellite are only those belonging to the Galileo constellation, hence the index of the sum is related only to those satellites.

Inputs of the implemented algorithm

Pseudoranges are obtained by the true satellite-user distance adding a zero-mean Gaussian noise with variance depending on SISA and elevation angles of satellites.

Regarding SISA and SISMA evaluation, actual values have been considered, adding a Gaussian noise:

$$SISA = 0.87 + N\left(0, \sigma_{SISA}\right)$$
$$SISMA = 0.7 + N\left(0, \sigma_{SISMA}\right) \qquad (7)$$

In this case, $\sigma_{SISA,GPS} = \sigma_{SISMA} = 0.01$, in order to simulate a sort of degradation on the signal received. We must also describe the behaviour of the positioning algorithm in the combined constellation case. Generally, if we define X^k, Y^k and Z^k as the coordinates of the K-th satellite and X, Y and Z as the coordinates of the user position, we are able to compute the distance between the satellite and the user (d^k) and the pseudoranges (ρ^k) as follow:

$$d^k = \sqrt{(X^k - X)^2 + (Y^k - Y)^2 + (Z^k - Z)^2} \qquad (8)$$

and

$$\rho_c^{(k)} = d^{(k)} + c\delta t_u + \tilde{\varepsilon}_\rho^{(k)} \qquad (9)$$

where:

ε^k_p: residual error on k-th satellite.

b: clock's offset.

Applying a linearization to the (5.4), we get the expression of the pseudo range model:

$$\Delta\underline{\rho} = G\Delta\underline{X} + \underline{\varepsilon}_\rho \qquad (10)$$

The matrix G is named *Design Matrix* and consists of the linear coefficients obtained by the partial derivatives of the observation's equations with respect to the estimated coordinates. This matrix characterizes the user-satellite geometry. The number of the columns of G agree with the number of unknowns to be determined (X,Y,Z and b), while the rows equals the number of the available observations (number of satellites in view for both navigation systems).The union of the Galileo and the GPS constellation causes a change into the G matrix, in fact the number of unknowns became five, in order to compute the clock's offset for both the systems. For the user position's estimation ($\Delta\tilde{X}$) we have to apply the weighted least mean square method to the pseudo range model, organizing the weight matrix (W) by the information contained into the navigation message sent by EGNOS or Galileo satellites (in this count are considered those SWs with an elevation angle greater then 10°):

$$\Delta\tilde{X} = \left(G^T \cdot W \cdot G\right)^{-1} \cdot G^T \cdot W \cdot \Delta\rho \qquad (11)$$

where G and W are two matrices of dimension Nx5 and NxN respectively, with N representing the number of the satellite used in the positioning algorithm.

Receiver autonomous integrity monitoring

Before going into deep in the description of the tests effected on the implemented algorithm, it is right to make an overview of the other integrity technique used in the algorithm, in parallel to the IR equation. This technique is the Weighted RAIM, that is one of the variant of the well-known RAIM.

RAIM algorithms implementation deals with multipath errors, interferences, jamming and ionospheric effects. This integrity monitoring technique strengthens the user's protection against such local errors. The key element for the statistical test computation, inside the RAIM algorithm, is the residual error in the range domain:

$$\varepsilon = \Delta\rho - \Delta\rho_p \qquad (12)$$

where $\Delta\rho$-$G\Delta X$+ε_p is the *pseudorange* model and $\Delta\rho_p$ is the predicted one estimated through the least square algorithm.

Once illustrated the error, we can define the following scalar element:

$$WSSE = \Delta\rho^T W(I - P)\Delta\rho \qquad (13)$$

WSSE: Weighted Sum of Squared Errors

$\sqrt{WSSE}$ is the statistical test allowing the user to judge the goodness of the least square estimation.

Figure 2 shows the typical representation of the distribution of operation points in the statistic vertical error plane, in a no failure conditions. The plane is divided into four regions consisting of: the normal operation points, the false alarm, the missed detection and the successful detection. The statistic is depicted by an ellipse of point that, in the case of absence of failure, is placed near the origin, instead in presence of failure the ellipse moves along a straight line, named as Vslope, towards the detection region.

Outputs of the implemented algorithm

In this Section we show the results of some simulation test organized by different typology (with or without failure) and different duration, in order to test the validity of the proposed algorithm and confirm the foreseen results.

The proposed algorithm elaborates the position computation, the RAIM statistics and the IR equation every second, therefore it is useful to refer the probability mentioned above to one second. In order to perform this conversion, we use the binomial distribution, obtaining, through a Matlab® routine, the value of P_{HMI} and P_{FA}, both initially set (Equal split between the two integrity requirements from the initial value of $1X10^{-7}$/150s defined by the ICAO for the avionic integrity requirements.) at $\frac{1\times10^{-7}}{2}$, referred at one epoch (second).

The failure have been reproduced in two different ways:

- Introduction of a step function, at given test epoch, on the pseudo range of a satellite in view.
- Bias on SISA and SISMA.
- The step function has been chosen because it is able to characterize a lasting failure on a satellite. SISA results from predictions on satellite clock and ephemeris errors and this error's estimations are based on long term observations: SISA increases mark out long term failures. SISA derives from a large data batch, so the anomalous behaviour of a sample is not relevant. On the other hand, pseudorange variations point out instantaneous failures.

No failure mode

In a no failure condition we are able to judge the behaviour of the new algorithm with respect to the single constellation case, and also we can evaluate the performances offered by this code in term of probability of false alarm and missed detection.

The Figure (3) illustrates the RAIM statistic in normal operation (Vertical case), without failure, showing the correct functioning of this part of the algorithm.

As the same we tested the IR algorithm, for the two constellation, in absence of failures (Fig. 4).

Figures 3 and 4 show that the RAIM statistic presents some samples exceeding the threshold, in particular these samples do not exceed the VPL (Vertical Protection Level). By this, we gather that the RAIM statistics presents a low probability to trigger an alarm, when it is not necessary (the main reason for this behaviour of the WRAIM could be seen in the largest sensibility to the *outliers* of this integrity algorithm). Instead, the IR algorithm has a lower false alarm probability than the previous case, consequence of the fact that the threshold is never exceeded and the system do not trigger any alarm when the SIS is not affected by any bias.

Error on Pseudoranges

The local error was simulated adding a bias (fixed value) to the pseudoranges. The aim of the introduction of this bias, was to emulate the contribution of some kind of errors (i.e. multipath), that are not present in the SIS transmitted (local errors), and consequently not detectable by the ground segment of EGNOS or Galileo, but only by a RAIM technique. Besides the noise, in order to simulate the malfunctioning in the biased case, by a certain epoch a fixed value has been added to the range measurement. Since the IR algorithm isn't able to detect these kind of error, we show the results of the WRAIM part of the proposed algorithm for this first model of failure.

Figures 5 (b) and 6 show the istantaneous behaviour of the RAIM statistic in the presence of a bias of 20 meters inserted from the 30-th epoch in a satellite belonging to the Galileo constellation, and a bias of 10 meters, from the 50-th epoch, in a GPS satellite. In both the cases the RAIM statistic (green and blue curves) exceeds the Test Statistic Threshold with a probability of 100%. This way of representing the RAIM process is not the typical one, in fact in the example depicted in Figure 2 different sample of one epoch (the satellite configuration remains the same during the simulation, instead the noise added to the pseudoranges is varying) are considered in order to obtain an estimate of the proper functioning of the algorithm. Figure 5 (a) shows this kind of analysis made for the biased case (Galileo satellite, Vertical case); as can be seen the RAIM technique detects the error in the pseudorange, in fact the ellipse of point leaves the normal operation region exceeding the TST. The same result can be achieved also in the GPS biased case

Error on SISA/SISMA value

The error on the signal in space has been simulated by adding a bias on the standard deviation of the noise considered in the SISA and SISMA computation of two random satellite belonging to one of the two constellation considered. In this failure mode, SISA and SISMA value have been implemented as in Eq. 7, assuming the following value for the respective standard deviation:

$$\begin{aligned} \sigma_{SISA} &= 10 \\ \sigma_{SISMA} &= 7 \end{aligned} \qquad (14)$$

The following Figure (7) shows the behaviour of the implemented algorithm, in particular the IR equation, when the bias on SISA and SISMA is considered in two Galileo satellites. In this case the algorithm triggers alarms with a probability of 2%.

Making a comparison with a single constellation case (only Galileo satellite), Figure 8 shows the behaviour of the Integrity Risk algorithm in Galileo case, considering the same size of bias, for the same satellite. What is clear from this comparison, is the decrease of alarms (~10%, in the second case) triggered by the system achieved by the use of the combined constellation, this means that in a dual constellation the combined system provides a safe position to the user.

Conclusions

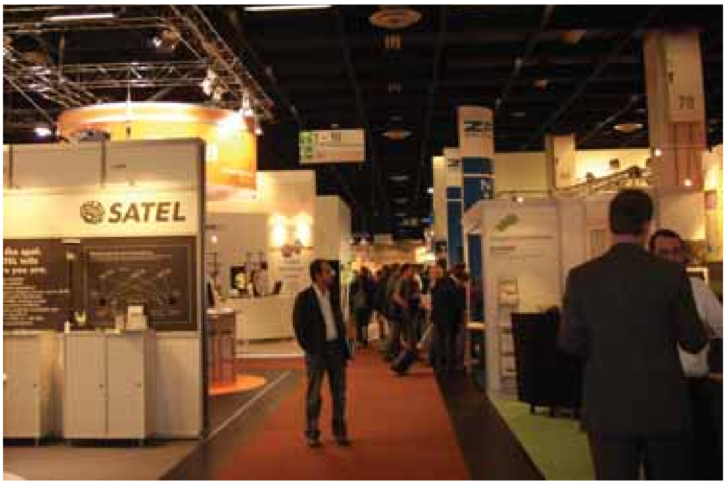
The totality of the tests made on the implemented code has been planned with the aim of characterizing the performances of the algorithm respectively in faulty free and in faulty mode. The use of Galileo and EGNOS system as a single and augmented constellation allows us to develop the positioning algorithm and to improve the position accuracy. Moreover the combination of the two SVs systems leads to obtain some benefit from the RAIM point of view.The proposed solution starts from the integrity equation defined for the Galileo system and adapts it to the combined system Galileo+EGNOS with the aim of computing the Hazardous Misleading Information Probability. We focused our attention on the IR equation: the implemented code reproduces the IR equation as is presented in literature, that is with the SISA values relative to Galileo and GPS satellites and SISMA relative only to the Galileo ones, in faulty free and faulty mode respectively. The results obtained testing the algorithm in presence of failure, have provided positive indications on the IR equation implemented: in these cases, the HMI probability increase with the value of the bias.

Though the IR protects the user against extended failure, whose effects revert on the SISE estimation, the RAIM technique, instead, could highlight instantaneous errors on the distances measured by a Galileo or a GPS satellite. RAIM and IR compensate each other, or rather the RAIM indicates failure unperceived by the IR and vice versa. This technique is based on a very different concept than protection levels and leads to different results. However, the Galileo integrity concept is more complete than GPS/SBAS and RAIM integrity concepts and offers more protection to failures. On the other hand, this concept still needs further investigations, in particular regarding the assumptions to be used for the error distributions and the parameters to be considered in the integrity equation. Indeed, although more complete, the new integrity concept introduced by Galileo is more complex and less intuitive than SBAS and RAIM protection level concept.

The paper with references can be seen at www.mycoordinates.org

Clear growth signals from the Intergeo 2010

Dr. Hartmut Rosengarten gave a concise summary of the three days of INTERGEO in Cologne: Whereas the focus in 2009 was on "Geo is in", the talk among industry representatives this year was of "Geo is interconnecting". The Chairman of the INTERGEO Exhibitor Advisory Board also emphasised that geodata is a key element in today's IT infrastructures, making INTERGEO the central hub for recording, gathering, processing, distributing and supplying geoinformation. "We were able to make excellent use of the three INTERGEO days to provide information on career paths and training opportunities in our sector and target potential employees directly," said Prof. Karl-Friedrich Thöne, President of the event's patron, DVW (German Society for Geodesy, Geoinformation and Land Management). He added: "Together we are stronger and better able to achieve our goals. INTERGEO sent out a clear signal for international industry networking within the framework of a geo community. This was highlighted in particular by the key conference topic "The environment and geo information". With their first-class presentation at the joint stand, the organisations in the geo sector successfully promoted the idea of joining forces rather than everyone going their separate ways."



With over 17,500 visitors, almost 1,500 conference participants and an increase in exhibitor numbers and exhibition space, INTERGEO continued its growth trajectory, thus confirming its position as a leading international conference and trade fair for geodesy, geoinformation and land management in Cologne. More than 500 exhibitors from 32 countries - with more than 30 percent coming from outside Germany - presented themselves and their innovations to a fascinated audience. The fair, that was held during 5-7 October, 2010, set a new record for international participation, with 25 percent of visitors coming from abroad. "No other non-company conference in our industry records such a high percentage," explains Dr. Rosengarten, adding: "Business is better than was predicted a year ago. We expect clear project growth in services and technology in 2011."

The exhibitor survey reflected the upbeat mood of the three-day event at the Exhibition Centre in Cologne. Almost 90 percent of exhibitors said that they met their goals for INTERGEO participation. These included "establishing new contacts" (approx. 93 percent), "fostering existing contacts" (approx. 85 percent), "showcasing innovations" (approx. 70 percent) and "image cultivation" (approx. 70 percent). Over three-quarters of the exhibitors expect to do good post-trade fair business on the basis of serious enquiries made at the event. While the results of this year's survey tended to be cautiously optimistic compared to the statistics from last year's event in Karlsruhe, opinion on the industry's current economic situation was clearer across the board. In Cologne, almost 50 percent described the situation as "very favourable" or "favourable", while around 40 percent still described the outlook as "average". Results for this question the year before were the other way round.

This is also confirmed by the information gleaned from exhibiting companies. Prof. Gerd Buziek, Head of Marketing at ESRI Deutschland, was delighted with the results, saying: "Once again, INTERGEO this year met our expectations. For example, the visitors' positive response to our new product ArcGIS for INSPIRE clearly showed that we are on the right track with our software and services. Overall, we were able to see clearly how things stand today in terms of performance with GIS and the potential that can be unlocked, for example, for GIS applications in cloud computing or simple and user-friendly web clients. The discussions we had with visitors from the business and scientific communities and public administration bodies as part of our conference activities were also very valuable".

Petra Wagner, Head of Marketing at Leica Geosystems GmbH Vertrieb, said: "As expected, visitor turnout was once again high at our stand on all three days of the fair and the response to our innovations was very good." Monika Semmler, Marketing Manager at Pitney Bowes Business Insight, said: "We value INTERGEO first and foremost as a platform for reaching decision-makers from the different specialist areas in the geoinformation industry. In this way, it perfectly complements the other specialist conferences that we attend and our internal events. I would like to thank all the visitors who stopped at our stand - we enjoyed many high-calibre discussions. It is discussions such as these that enable us to develop intelligent and practical solutions." Dr. Johannes Riegl, CEO of RIEGL Laser Measurement Systems GmbH, said: "INTERGEO is a key event in the business calendar. The opportunity to meet here with our customers and business partners and share information with them has become an established tradition. And naturally we welcome the chance to present our innovations to a wide audience. This year, for example, we showcased the RIEGL VZ-1000 terrestrial 3D laser scanner and the NP680i 'turnkey' airborne scanner platform. One of the highlights was our INTERGEO partner dinner to which we invited business partners and friends from over 20 countries."

The conference in Cologne saw the successful launch of two new features - daily keynote speeches and the INTERGEO Academy. The keynote speeches featured high-profile figures such as Constitutional Court judge Udo Di Fabio, ESRI president Jack Dangermond and FIG president Stig Enemark, while the INTERGEO Academy got off to a flying start with a total of 170 participants. "Geo is interconnecting - and as a facilitator of the industry, INTERGEO will continue to drive forward international dialogue and the networking of disciplines, looking ahead to Nuremberg in 2011," explained Olaf Freier, Managing Director of HINTE GmbH and INTERGEO organiser.

All JAVAD GNSS receivers track QZSS Satellite

JAVAD GNSS engineers in Moscow tracked Japan's first QZSS satellite and its new L1C signal. The C/A, L2C, L5, SAIF and the new L1C signals were collected when QZSS-1 satellite was visible in Moscow. QZSS is the first satellite which transmits new L1C signal. All of the current JAVAD GNSS receivers, including OEM boards, ALPHA, DELTA, SIGMA, TRIUMPH-1 and TRIUMPH-VS can track QZSS signals with a software update. *http://javad.com*

European Satellite Navigation Competition awards

This year's ESA Innovation Prize for the European Satellite Navigation Competition has been awarded to an application that uses satellites to detect river pollution. A separate prize supported by ESA was awarded to a startup company for a pioneering system that uses satellite data to boost investment in farming. Altogether 357 ideas from 44 countries were submitted to the 2010 European Satellite Navigation Competition (ESNC). In addition to the grand prize, 21 regional winners and six special topic prizes were awarded at ESNC 2010 by partners from industry and research institutions for the best applications that make use of GNSS. *www.esa.int*

Lockheed Martin delivers key GPS III test hardware

The Lockheed Martin-led team developing the next-generation GPS III has completed the program's first contract deliverable ahead of schedule, by shipping the GPS III Bus Real Time Simulator (BRTS). It is a specialized piece of test equipment designed to reduce risk and ensure total mission success. *www.lockheedmartin.com*

China launches sixth Compass satellite

China has successfully launched its sixth orbiter which will form part of its indigenous satellite-navigation and positioning network. The network eventually will consist of 35 satellites. *Xinhua News Agency*

Broadcom announces QZSS position fix

Broadcom's BCM4751 chipset is single-chip GPS receiver with low power consumption, higher sensitivity, small footprint (3cm^2) and support for GPS, SBAS and QZSS. Broadcom have confirmed their first position fix using the data transmitted by Michibiki. *www.broadcom.com*

GNSS-based carpool scheme in Delhi, India

Delhi State's transport department in association with Mega Car Pool Private Ltd, launched 'carpooling initiative.' Delhiites can enrol for the scheme by registering with the service provider. Each member will be given a mini computer like device, to be installed in the vehicle and a smartcard bearing his/her photograph. When the member needs a ride, he/she needs to call the centralised helpline number of the service provider to requisition a ride. The request will flash on tablets installed in the cars of all members driving in that area, who will be tracked through a GPS fitted in the device. *http://timesofindia.indiatimes.com*

GLONASS goes to India

The federal network operator NIS GLONASS signed an agreement to establish a consortium with DIMTS (Delhi Integrated Multimodal Transit System), India, for participating in tenders to create Intelligent Transport Systems (ITS). Under the New Delhi transport monitoring and management pilot zone based on GLONASS/GPS technology, the software and hardware supply contract was signed with GLONIS Solutions. Additionally, a MoU was signed with Kerala State Electronic Development Corporation Limited (KELTRON) for a pilot project in the state of Kerala and joint participation in state government tenders. *http://indrus.in*

Glonass-K2 satellite in 2013

Russia's next generation Glonass-K2 navigation satellite will be launched in 2013. "We have decided to modernize the Glonass signal system. We will introduce new signals with a code separation," said Sergei Revnivykh, Deputy Director of Roscosmos's Central Research Institute of Machine Building. Besides signals on the L3 frequency in the 1205 MHz band, signals will also be transmitted on L1 and L2 frequencies. The new design will have a 10-year service life.*http://en.rian.ru*

US and Australia cooperation on GPS

Officials from the Governments of the USA and Australia met to review progress under and build future activities on the Joint Delegation Statement on Cooperation in the Civil Use of GPS and Space-Based PNT Systems and Applications. The framework will encompass collaboration on important space applications such as satellite-based land and sea remote sensing, climate change research and meteorology, and space-based PNT, as well as opportunities for early discussions on new systems and future civil space-related missions under development.*www.pnt.gov*

All hands on deck for European space

High level representatives have weighed in on European space activities, including EGNOS and Galileo, at a recent conference hosted by the European Parliament. European Commission Vice President Antonio Tajani said that Galileo and GMES are "tackling societal and environmental challenges". With a revision of the Commission's budget for space activities expected by the end of 2010, his comments were pertinent. Galileo, he said, in combination with GMES, will be a key tool for agriculture in the future, particularly important in helping to insure food stocks in the developing world. EGNOS, the European satellite navigation augmentation system, is already making great strides in the precision agriculture market. *www.gsa.europa.eu*

ESRI supports NetHope

ESRI supports NetHope by providing GIS software and support via the ESRI Nonprofit Organization Program. NetHope is a consortium of the international community's leading NGOs that helps members better leverage their technology investments. *www.ESRI.com/nonprofit*

ADC WorldMap releases Digital Atlas V6.0

ADC WorldMap Digital Atlas version 6.0 features the addition of level two administrative boundaries for many countries along with up to date country and level one political boundaries for the entire world. The new product also includes worldwide demographic data and statistical information for economy, communications and military. *www.adcworldmap.com*

New U.S. - India "Monsoon Agreement"

Under the new Monsoon agreement, the U.S. will create a monsoon forecast desk at the National Centres for Environmental Prediction, part of NOAA's National Weather Service. Atmospheric scientists from India's Ministry of Earth Sciences will collaborate with NOAA scientists to share knowledge and skills to improve the Climate Forecast System (CFS) for long-range forecasts of the monsoon. *www.ncep.noaa.gov*

Solution for Geophysical Information Management

Geosoft has introduced the geophysical Exploration Information Management Solution (EIMS). It bundles Geosoft professional services and its DAP Server technology, which is designed to organize and distribute large geophysical and exploration datasets, into one packaged solution that can be scaled to government agencies and exploration companies of all sizes. *www.geosoft.com*

UN launches tool to map emergency stockpiles

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the Logistics Cluster, led by WFP, has launched an interactive web-based tool, "Global Mapping of Emergency Stockpiles". The tool displays information on emergency relief warehouses managed by international humanitarian organizations. The aim of this tool is to assist affected countries and humanitarian relief agencies identify and send emergency relief items in response to crises. *www.humanitarianinfo.org*

China to expand digital mapping coverage in five years

According to State Bureau of Surveying and Mapping, China, 120 cities and districts at the prefecture level would be covered by the digital mapping network by the end of this year, and the network would be extended to most prefecture-level cities by the end of 2015. Digital mapping would feature the cities' geographical characteristics, roads, river systems, properties and addresses of street locations, among others, both for public information and for government agencies. *http://news.xinhuanet.com*

Vietnam protests Chinese map of disputed islands

Vietnam is protesting a Chinese map of disputed islands in the South China Sea. China's state bureau of surveying and mapping recently launched online maps that claim sovereignty over the Paracels and Spratlys. *www.taiwannews.com.tw*

Australia catalogs biodiversity in an Atlas

The Atlas of Living Australia is a newly launched website that aims to catalog Australia's biodiversity, providing a site for researchers and others to access, combine and visualize data on the country's animals, fungi, microorganisms and plants. The site offers many mapping options, including a mapping tool that lets search, analyze and combine biodiversity and environmental data. *www.ala.org.au*

NGA's new vision

National Geospatial-Intelligence Agency, USA, director Letitia A. Long presented a new vision for the agency. Long presented her vision-"Putting the Power of GEOINT in the Hands of the Users"- and established two main goals. First, fundamentally change the user experience by providing online, on-demand access to our GEOINT knowledge. Second, create new value by broadening and deepening analytic expertise by providing contextual analysis of places informed not only by the Earth's physical features and imagery intelligence, but also by "human geography." *www.nga.mil*

StreetMapper GIS

StreetMapper GIS, a new version of the mobile laser mapping system with an integrated panoramic camera, has been launched by 3D Laser Mapping and IGI mbH. It is easy to mount on any type of vehicle and offers a cost effective solution for collection of street level asset information for use in GIS or other desktop software solutions. *www.3dlasermapping.com*

TatukGIS fGIS

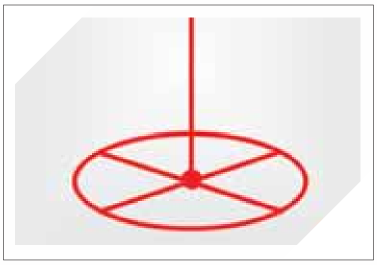
TatukGIS Consulting new fGIS is a customisation built upon the TatukGIS Editor product. It is a multi-purpose, full-featured, GIS application providing supported upgrade path for current users of fGIS. *www.tatukgis.com*

LIS commissioned in Nigeria

Sivan Design has announced the successful commissioning of PLAGIS - GIS with ERP capabilities for land and cadastre management in Nigeria. PLAGIS is a unit of the Ministry of Land, Survey and Town Planning of the country. *http://finance.yahoo.com*

USB cable transfer

SD card Function and USB interface



Larser Plummet

SUPERTECH SALES AND SERVICES
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Phone: 0120 2425491 Mob: 9810788846, 9810703308 Email: supertechsns@rediffmail.com

SPOTMaps is a resounding success

SPOTMaps are mosaics made from SPOT 5 satellite images where features as small as 2.5 metres can be resolved, equivalent to a mapscale of 1:10 000. Coverages are seamless and uniform over the territory of a country or even several countries. SPOTMaps are used as georeferenced basemaps to view an entire territory, simulate new infrastructure planning, perform impact studies, produce or update zoning plans and map. *http://spotmaps.spotimage.com*

3D Laser Mapping system to predict avalanches in India

Laser mapping technology is being employed to predict avalanches in the Himalayas. The Snow and Avalanche Study Establishment (SASE) is now using SiteMonitor technology to monitor the snow cover build up, as well as access its displacement with passage of time, and provide valuable inputs for improving the accuracy of avalanche prediction in the Himalayas.*www.3dlasermapping.com*

India's RISAT-1 launch next year

India to launch RISAT-1 early next year. The satellite's all weather capability to take images of the earth could also be used to keep an eye on the country's borders round-the-clock and to help in anti-terrorist and anti-infiltration operations. The Synthetic Aperture Radar (SAR), being developed indigenously by ISRO, has the capability to take pictures of the earth 24 hours-a-day, through rain and cloud, thus boosting the country's disaster response capabilities. *http://ibnlive.in.com*

LizardTech unveils GeoExpress 8

LizardTech® version 8 of GeoExpress® image compression software enables geospatial professionals to compress and manipulate satellite and aerial imagery. It introduces the MrSID® Generation 4 (MG4™) format for compression of raster data, adding support for multispectral data, alpha channels and improved mosaicking. *www.lizardtech.com*

GeoEye finalizes contract for GeoEye-2

GeoEye Imagery Collection Systems, a wholly-owned subsidiary of GeoEye has signed a procurement contract with Lockheed Martin Space Systems Company to complete the development and construction of the GeoEye-2 satellite and the associated command and control. *www.geoeye.com*

Milan Cathedral restoration goes hi-tech

A highly accurate, 3D model is to support restoration work at the Milan Cathedral in Italy. Millions of laser-scanned measurements were combined with other survey data and photogrammetric images allowing researchers from the Politecnico di Milano to generate both 2D and 3D visualisations, classical plans and elevations, as well as computer-generated animations. The main aim of the project was to obtain an understanding of the state of the spire in order to support restoration operations. *www.pointools.com*

ESA helps Indonesia

Java's Mt Merapi in Indonesia has been spewing volcanic ash clouds into the air to deal with this situation, European Space Agency (ESA) is sending email alerts about sulphur dioxide in near-real time. A map around the location of the sulphur dioxide peak is put on a dedicated web page. This Support to Aviation Control Service is based on data from ESA's Envisat, Eumetsat's MetOp and NASA's Aura satellites. ESA started the 'Support to Aviation for Volcanic Ash Avoidance' project as a demonstration that uses satellite data and wind measurements to compute the injection heights of volcanic emissions. *www.esa.int*

Telogis delivers new ADAS capabilities

Telogis has integrated Advanced Driver Assistance Systems (ADAS) data from NAVTEQ® into its GeoBase geospatial platform. The platform uses NAVTEQ map data and integrates its Enhanced Geometry, Slope and Height, and Curvature products allowing application developers to build advanced enterprise software solutions. *www.telogis.com*

HARMAN launches in India

HARMAN is delivering the first integrated navigation and infotainment systems with detailed Indian road maps by MapmyIndia. The first vehicles from BMW with the system will be delivered sometime soon. *www.harman.com*

Garmin hanging up on smartphones

Garmin is abandoning the smart phone business after failing to find its way in the highly competitive sector with a handset released a year ago. "We thoroughly analyzed the rapidly changing dynamics of the smart phone market and concluded that we cannot reach the scale necessary to effectively compete in the industry," said CEO of Garmin Mr. MinKao. *www.garmin.com*

Air Force warns against location-based app

Air Force communications officials are warning Facebook users of a new location-based application that may pose a security risk because it publicises users' locations without their specific consent. The features called "Places I check in to," and "People Here Now" use IP addresses and smartphone GPS capabilities to locate a user when logging onto Facebook. The app then publishes that information on the user's profile page, and the information could become public depending on the user's profile security settings. The feature is automatically active and must be turned off by the user. *www.military.com*

At a Glance

- MicroSurvey announced the purchase of STAR*NET software.
- MetaCarta announced that it has been acquired by Qbase, LLC.
- Garmin announced the acquisition of Belanor AS.
- NAVTEQ has acquired PixelActive.
- SeaSpace Corporation announced the acquisition of the Remote Sensing Solutions products and services division of Vexcel Corporation.
- TomTom is increasing its stake in its Indian joint venture from 60% to 90%. The company will be renamed TomTom India Ltd.
- Hemisphere GPS expanded its OEM agreement with ComNav for Vector G1 GPS Satellite Compass.
- Imagemaps announced that Vexcel Imaging GmbH has extended Imagemap's distribution coverage to include India.
- SuperGeo Technologies announced Spatial Perspective as exclusive reseller to distribute SuperGIS software in South Africa, Lesotho, Swaziland, Zimbabwe, and Botswana.
- ERDAS announced that Edge-Pro for Information Systems is now the official distributor for the ERDAS APOLLO suite of products in Egypt.
- CHC Navigation announced the signature of supplier agreement for Carlson's SurvCE data collection software for its RTK GNSS receivers.
- TomTom announced that Tele Atlas has extended its contract with MiTAC to include Magellan branded products.

Galileo update

Contract signing gives Galileo system its operators

ESA signed a contract with Spaceopal, the company providing ground-based services needed to operate the Galileo constellation once it has been fully deployed. The agreement was signed by René Oosterlinck, ESA's Director of the Galileo Programme and Navigation-related activities, and by Francesco D'Amore and Hubertus Wanke, both Managing Directors of Spaceopal in the presence of Diego Canga Fano, Deputy Head of Cabinet to European Commission Vice President Antonio Tajani.

The agreement is the fourth of six Galileo Work Packages (WPs) identified by the European Commission and ESA as necessary to reach Galileo's Full Operational Capability (FOC) to be signed. This WP6 Framework Contract is dedicated to preparation activities as well as all the operations services the fully-deployed Galileo system requires. WP1 for system support, WP4 covering spacecraft and WP5 dedicated to launch services have already been signed. Now only WP2, for ground mission, and WP3 covering ground control still to be finalised.

WP6 Work Order 1 covers all activities related to the completion of the Galileo In Orbit Validation (IOV) activities – the first four Galileo satellites due to launch next year. WP6 Work Order 2 is dedicated to the implementation and activities of an integrated engineering team supporting ESA for system operations. WP6 Work Order 3 deals with the completion of deployment of operations for Galileo's FOC, scheduled for 2013. WP6 Work Order 4 covers the full deployment of the two Galileo Ground Control Centres, in Germany at Oberpfaffenhofen and Italy at Fucino. *www.esa.int*

SES to contribute to Galileo operations

SES S.A. has become a key partner in the future operations of Galileo satellite navigation system. ASTRA TechCom Services, an SES company, has signed a contract with Spaceopal, the company providing ground-based services required to operate the Galileo constellation until it has been fully deployed. The agreement was signed in Munich by Gerhard Bethscheider, Managing Director of ASTRA TechCom Services and by Francesco D'Amore and Hubertus Wanke, both Managing Directors of Spaceopal. ASTRA TechCom Services' contribution to WP6 covers engineering support to Spaceopal and a leading role in the In Orbit Testing (IOT) of the Galileo FOC Satellites. To this end, ASTRA TechCom Services will work through its subsidiary, Redu Space Services, to utilise the Galileo IOT infrastructure in Redu to deliver this critical service. *www.ses-astra.com*

T-Systems takes over logistics systems for Galileo

Deutsche Teleom's T-Systems corporate customer division has won a contract to manage all global logistics processes for Galileo. In addition, T-Systems is helping the ESA to build a global network. T-Systems has developed and is operating the maintenance and logistics system based on the Integrated Logistic Support (ILS) process. It is also helping the ESA connect 30 Earth stations worldwide with the two Galileo control centres in Munich, Germany, and Fucino, Italy. *www.telecompaper.com*

3rd Generation RTK S760 by SOUTH

SOUTH has released the 3rd generation RTK product, S760. A single rugged unit, independent to any external device, has integrated antenna, mainboard and PDA all together, which is an ideal high precision handheld GIS data collector in urban and rural areas. *www.southinstrument.com*

Palm-sized receivers from Geneq

Geneq announced the SXBlue III GPS, one of the smallest dual frequency RTK GPS receivers, weighing slightly more than one pound (517g) and fitting comfortably in the palm of ones hand. Equally small is its patch antenna. At only 5.5cm wide and weighing a mere 80 grams. *www.sxbluegps.com*

SBAS test signal in the Caribbean, Central and South America

GMV and Inmarsat announced the successful integration of their technologies resulting in the broadcast of a satellite-based navigation test signal covering the Caribbean, Central and South America for the first time. GMV contributed its new SBAS processing centre, magicSBAS, which accepts real-time data from any place in the world; while Inmarsat provided its SBAS signal generator and the space capacity – the navigation transponder on the Inmarsat-3F4 positioned over the Americas region. For years, ICAO has supported and fostered the provision of a specific SBAS in these regions, and this initiative is a huge step towards this objective. *www.gmv.com*

Leica Geosystems and Swepos agreement

Swepos is the national GNSS network provider in Sweden and its network covers the whole country, offering GNSS-correction data from approximately 200 reference stations to more then 1500 professional users since 1998. With the new GNSS data exchange agreement, Leica Geosystems will be able to build up a fully covering Network-RTK solution for Sweden in combination with the Swepos reference sites, in a very short time. The new network called SmartNet will be part of the European-wide Leica SmartNet System. *www.leica-geosystems.se*

GSA releases GNSS Market Monitoring Report

The European GNSS Agency (GSA) has recently published the 2010 GNSS Market Monitoring report. According to the smae, the market for GNSS will grow significantly over the next decade, at a CAGR of 11%, reaching some €165 billion for the core GNSS market in 2020. Delivery of GNSS devices will exceed one billion per year by 2020. www.gsa.europa.eu/go/download_the_gsa_gnss_market-report

Trimble's 5th International User Conference - Trimble Dimensions 2010 - was held with the theme 'Converge, Connect and Collaborate'. From November 8 to 10 over 2900 attendees from 67 countries gathered at the Mirage, Las Vegas, USA for the conference.

Keynote speakers included Steve Berglund, Trimble President and CEO; Keith Ferrazzi Founder and CEO of the consulting, training, and research firm Ferrazzi Greenlight; and Dr. Steve Squyres Principal Investigator, Mars Exploration Rover Project.

"We are extremely pleased with the continued and strong interest demonstrated in Trimble Dimensions," said Bryn Fosburgh, Trimble vice president. "It is truly a unique conference focused on how advanced technology solutions are transforming the way work is done."

With more than 400 sessions the conference explored the use of technology in a wide range of applications including surveying, engineering, construction, mapping, GIS, geospatial, utilities and mobile resource management.

SOKKIA SRX robotic TS

SOKKIA has released four new SRX total stations -- SRX1X, SRX2X, SRX3X and SRX5X. The new series is developed to maximize all performances, primarily focusing on auto-tracking and distance measurement capabilities. A completely new auto-tracking system has been developed and includes new motors and driving mechanism, new optics and laser system. In addition, newly refined tracking algorithm enhances the ability to predict the future prism positions, enabling more stable tracking and faster prism reacquisition. *www.sokkia.com.sg*

Geospatial intelligence to insurers

Teradata Corporation has joined CoreLogic to provide insurance companies with intelligent geospatial solutions that bring together the key business components necessary for underwriting processing, risk management, marketing and distribution management for optimal decision making. *www.teradata.com*

Topcon QS Robotic TS series

Topcon Positioning Systems introduced its new generation of robotic total stations, the QS Series (Quick Station). The QS Series – featuring the X-TRAC 8 prism tracking technology – is designed to provide unprecedented power and speed to dramatically enhance productivity and save time and money on every job. *www.topcon.com*

Pictometry in legal dispute with Blom

Blom ASA is in legal dispute with its technology partner Pictometry International Corp who has invented the oblique imagery technology in 1996 and supplied it to Blom under a Technology License Agreement (TLA). Recently Pictometry has notified Blom that they consider Blom to be in breach of the TLA and has terminated the agreement with immediate effect. Blom believes "[it] has not violated the TLA, thus the notice of breach and termination is null and void and of no effect. Blom has through legal advisors taken all required actions to protect its interests.” *www.blomasa.com*

Trimble Nomad series computers

The Nomad 900 series adds a 5MP auto-focus camera with flash, enhanced GPS performance, and new Wi-Fi® capabilities. These new features, along with the its rugged construction and computing power, make it ideal for mobile workers in forestry, public safety, surveying, construction, mapping, field service, utilities, and other outdoor or service-related fields. *www.trimble.com*

Trimble Tunnel Construction Solution

Trimble introduced a new field solution designed to streamline the precision construction of road and railway tunnels. Now, contractors can improve the efficiency and safety of production blasting while providing near real-time progress monitoring and reporting accurate as-built information for project sign-off. It leverages the Trimble SCS900 Site Controller Software Tunneling Module, Trimble Tablet controller and the SPS930 Universal Total Station. *www.trimble.com*

HD Traffic now in 16 countries

TomTom has launched HD Traffic technology in eight additional countries: Denmark, Finland, Ireland, Italy, New Zealand, Norway, Spain and Sweden. It said that “HD Traffic is now available to more than 200 million cars worldwide – 76 million of which are in the eight new countries.” *www.tomtom.com*

New LOSTnFOUND mobile trackers

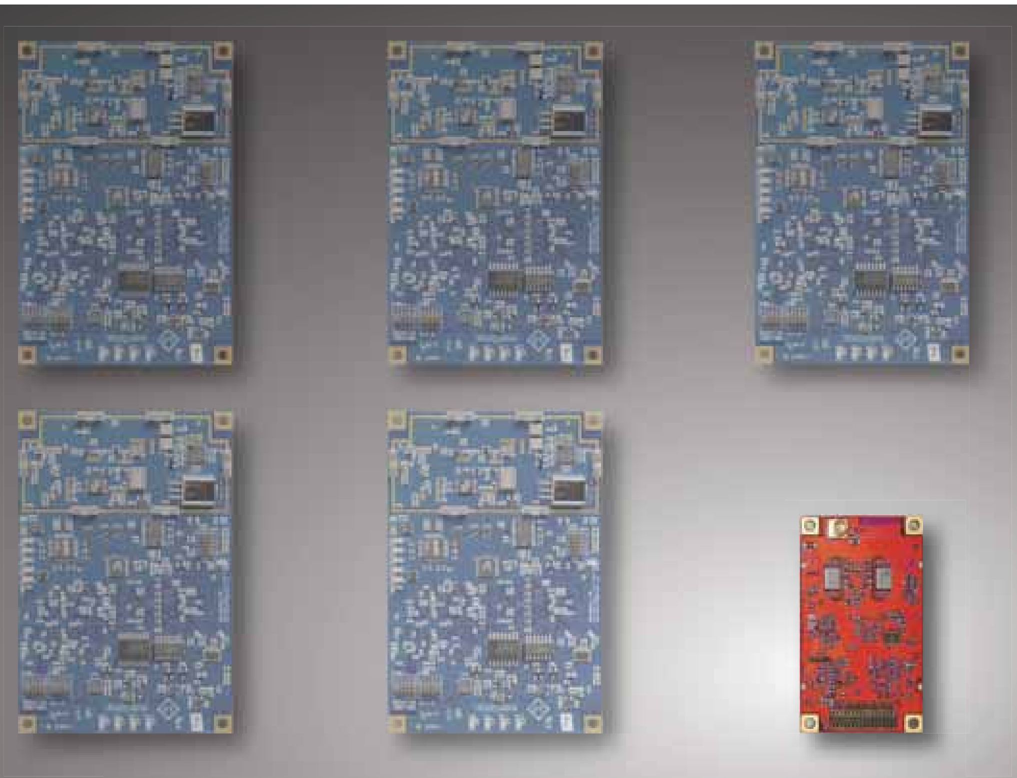
Mountain Group relies on u-blox’ GPS and GSM/GPRS module technologies for its new “LOSTnFOUND®” suite of tracking devices. The suite consists of the “ALTUS”, “CALVUS”, and “CIRRUS” trackers which report the location of cars, trucks, people, belongings and pets on 5 continents. *www.u-blox.com*

Frost & Sullivan forecast

Frost & Sullivan forecasts a PND growth from 315,000 units in 2009 to 1.7 million units in ASEAN region by 2015. Penetration among total vehicles in operation is expected to grow from 1.8 percent to 11.8 percent over the period. *www.frost.com*

TeleNav launches Social Networking App

TeleNav MyTies is a mobile-only, private social networking application for the iPhone. It allows iPhone users to leverage their personal address book and contacts to create multiple private networks by inviting contacts to join and form groups.*www.telenav.com*



MARK YOUR CALENDAR

February 2011

ILMF 2011
7 - 9 February
New Orleans LO, USA
www.lidarmap.org/ILMF.aspx

16 International Geodatic Week
13 - 19 February 2011
Obergurgl, Austria
http://geodaesie.uibk.ac.at/obergurgl.html

March 2011

The Munich Satellite Navigation Summit 2011
1-3 March
Munich, Germany
www.munich-satellite-navigation-summit.org

GEOFORM+2011
15-18 March
Moscow, EcoCenter Sokolniki
www.geoexpo.ru/defaulteng.stm

April 2011

6th National GIS Symposium in Saudi Arabia
24 – 26 April
Khobar, Saudi Arabia
www.saudigis.org

Geo-Siberia 2011
27-29 April
Novosibirsk, Russia
www.geosiberia.sibfair.ru/eng/

May 2011

ASPRS 2011
1-5 May
Milwaukee, Wisconsin, USA
www.asprs.org/milwaukee2011/

Gi4DM 2011
3-8 May
Istanbul, Turkey
www.gi4dm.org

June 2011

Trans Nav 2011
15-17 June
Gydnia, Poland
www.transnav.am.gdynia.pl

South East Asian Survey Congress
22 - 24 June 2011
Kuala Lumpur, Malaysia
www.seasc2011.org

2011 Cambridge Conference
26 June - 1 July
Winchester, England UK
www.cambridgeconference.com

July 2011

Survey Summit
7 - 11 July 2011
San Diego, California
www.thesurveysummit.com/

ESRI International User Conference
11 - 15 July 2011
San Diego, USA
www.esri.com

August 2011

XXV Brazilian Cartographic Congress
21-24 August 2011
Curitiba - State of Paraná, Brazilia
sbc.tatiana@gmail.com

XXII ISPRS Congress
25 August - 1 September 2011
Melbourne, Australia
http://www.isprs2012.org

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Looking for income opportunities?

We are in the process of searching for worldwide distribution partners for our products and services.

Surveyors all over the world use MicroSurvey Software to complete their infrastructure and design projects. MicroSurvey has been building software for the surveying industry for over 20 years. With this experience, we are able to offer some of the best software and hardware systems for surveyors today.

Featured Product:

Nautiz X7 by Handheld

A rugged device with numerous features.

- Bluetooth, WiFi, GSM SIM card slot (data & phone)
- IP67, 806 MHz , Windows Mobile, 640x480 display
- GPS, 3 MP camera, altimeter, electronic compass
- Free OfficeSync® included with each Nautiz

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= **A powerful data collection and remote synchronisation combination.**

Collect data with **FieldGenius**.

Compatible with many GPS and Total Stations.

3 megapixel digital camera.

Send data back to the office using **OfficeSync**.

Browse the web or use as a mobile phone.

Our software is designed so it can be localised without making changes to the source code. Distributors can create local language versions and maintain the version to ensure quality. MicroSurvey has the most tightly integrated Field to Finish system available. It is currently available in English, Spanish, Chinese and Russian. Distributors that help with translation will have the first opportunity to sell in their region. Please visit www.microsurvey.com/translate for more information.

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