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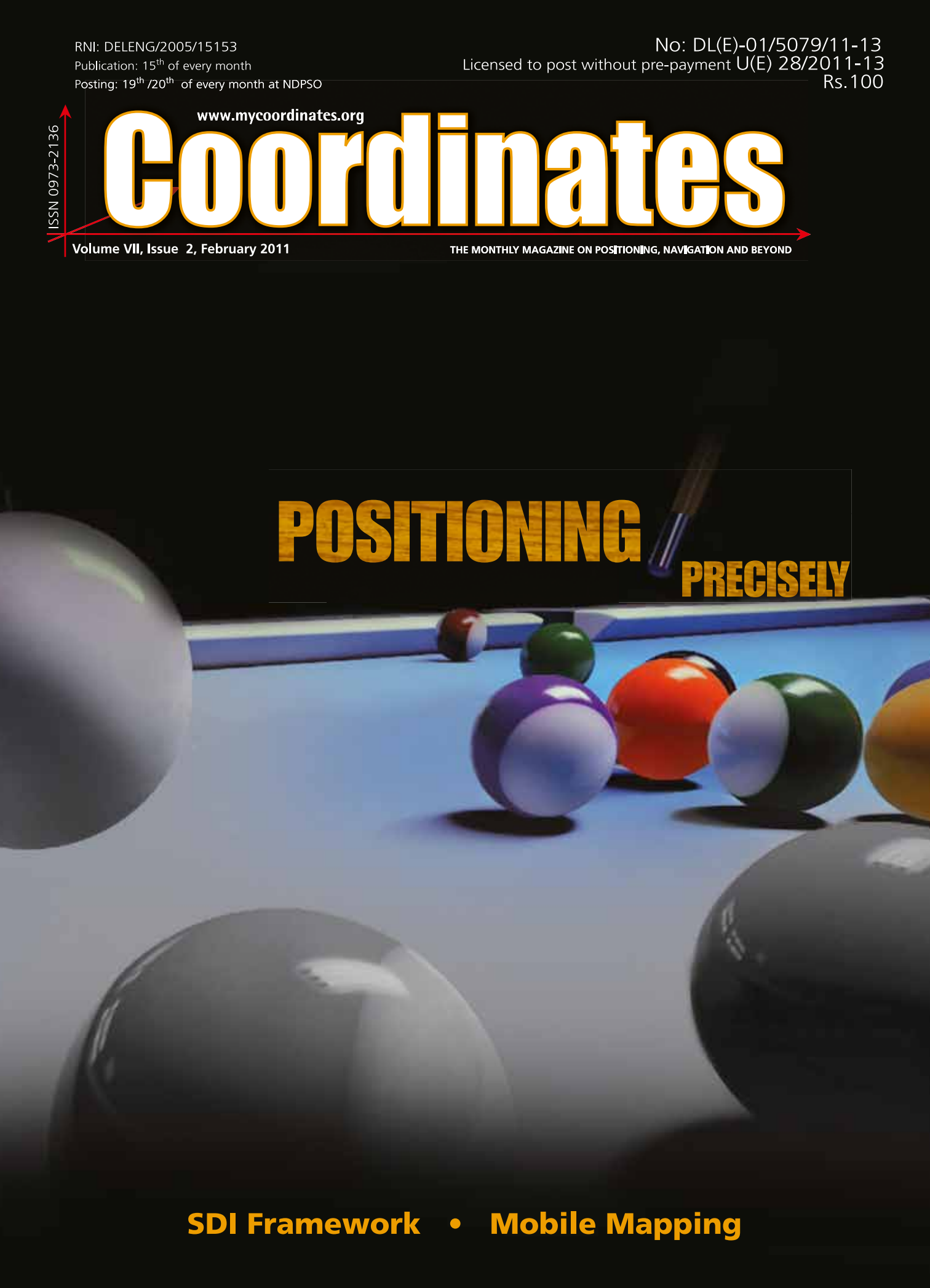

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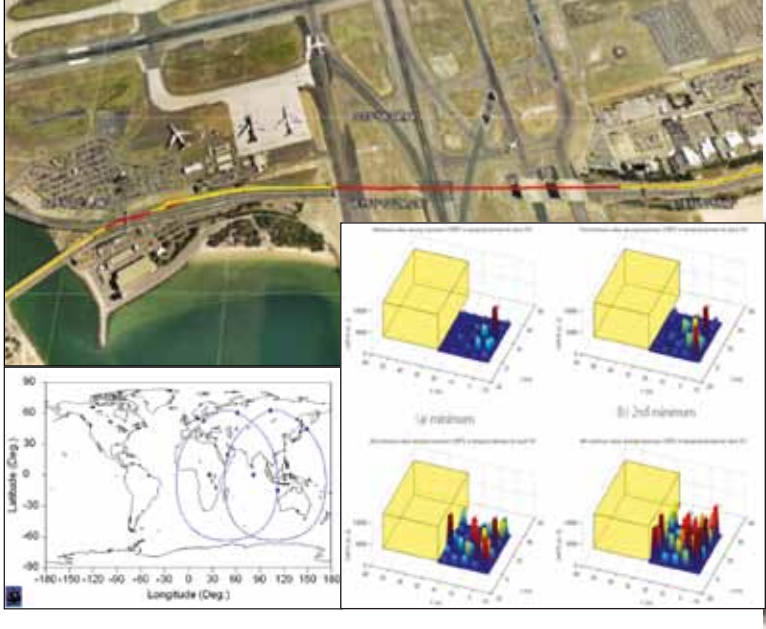

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Columns

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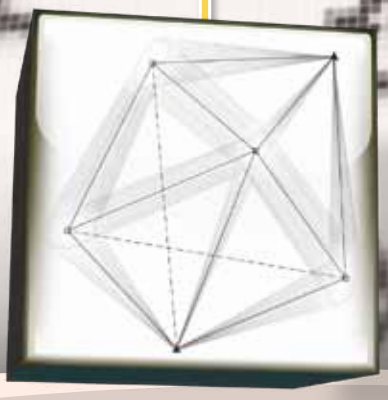

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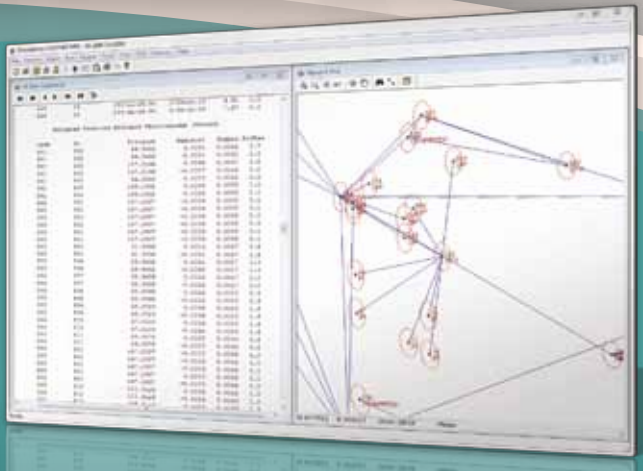

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A 'low' end application of GPS,

Set to emerge.

Bal Krishna, Editor
bal@mycoordinates.org

Continuous high precision navigation

Using MEMS inertial sensors aided RTK GPS for mobile mapping applications

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In a modern mobile mapping system, the navigation component usually consists of a GPS receiver and an inertial navigation system (INS), which can provide accurate geo-referencing to the imaging sensors [1][2]. To achieve centimetre-level positioning accuracy, RTK-GPS is a natural choice. However, RTK-GPS in urban areas suffers from frequent outages due to blockages of either the GPS signals or the reference station radio links. In addition, multipath from buildings, trees and heavy vehicles could degrade the accuracy of the GPS when the vehicle is near them. Integration of an INS and GPS can bridge the GPS outages and maintain accuracy over short time periods, but a high–precision INS is too expensive for many land vehicle applications.

Keeping in mind that many mobile mapping practioners already have the RTK GPS devices, the ideal system configuration would be that such users simply plug their RTK-GPS receivers into an integration device, which has built-in MEMS inertial sensors and can integrate the two data streams when they are available. The integration device should be something like a "universal" box that has sufficient flexibility to be compatible with many different RTK-GPS receivers.

This paper describes the "NavExplorer", a low-cost GPS/INS integrated system which uses inexpensive MEMS inertial sensors and RTK-GPS to balance affordability and accuracy, providing a continuous, high accuracy navigation solution. To achieve maximum flexibility, field programmable gate array (FPGA) technology is used to implement the integration device. The FPGA approach allows us to easily configure the logic and software of the system without any changes to the hardware components of the integration device when it is connected to a different GPS receiver.

By integrating the NavExplorer with the PGR Ladybug panoramic camera and Multiple SICK laser scanners, a mobile mapping system has been developed for the Taipei 3D Urban Reconstruction. NavExplorer generates position data for precise 3D object geo-referencing. The NavExplorer consists of a MicroStrain inertial sensor, unit and a Trimble RTK-GPS receiver. The Trimble receiver outputs the position solution in either RTK- or standalone GPS when the RTK corrections are unavailable. With the Trimble operating in the RTK-GPS mode, the integration solution achieves centimetre-level accuracy. This accuracy can be maintained for a short period of time when the RTK corrections are blocked. With the integration Kalman filter, the NavExplorer can provide accuracy to a reasonable level when the host vehicle is driven in a tunnel or operated in an environment of frequent GPS outages. The performance of a GPS/INS integrated system during GPS outages is an excellent indicator of the successful design of the system [3].

Many road tests have been conducted in Sydney and Taipei to evaluate the performance of the NavExplorer. The results indicate that the NavExplorer can maintain good GPS accuracy in multipath environments, and provided smooth and continuous solutions in tunnels when the GPS signals have been completely lost.

Configuration of the system

Hardware components

The hardware components of the NavExplorer consist of a Trimble BD950 GPS receiver, a MicroStrain 3DM-GX2 MEMS inertial sensor unit, and an FPGA-based time-sync data logger, as shown in Fig 1. The time-sync data logger collects the GPS and INS data and stores them on a SD card. In addition to accepting a PPS input for precise time synchronisation, the NavExplorer also provides PPS output for time synchronisation of other components of the mobile mapping system.

The hardware connections are detailed in Fig. 2. The PPS output of the BD950 is at 7.2v/50ohm, which is converted to a TTL level, which is fed into the time-sync data logger for time synchronisation of its internal clock with GPS time. The PPS signal is also split for output for other devices. It is fed into the 3DM-GX2 in the current configuration to trigger its sampling. The 3DM-GX2 and BD950 are connected to the time-sync data logger via the ports COM1 and COM2. The radio modem is connected with the BD950 via the port COM3.

Operation of NavExplorer

The BD950 and 3DM-GX2 are configured to output the data at 10Hz and 20Hz respectively. The operation status of the NavExplorer will be displayed on the LCD screen of the data logger. Three flags indicate all the data of INS, GPS, and PPS are being received by the data logger. The button on the data logger controls start/stop of logging data on the SD card. The logging status is displayed on the LCD screen.

The Files: Three files are written to the SD card for each logging session. These files are named as "GPS_x.BIN", "INS_x.BIN" and "PPS_x.BIN", where "x" corresponds to an index number of the logging sessions from 0 to 9. The data are recorded in the binary format.

The Button: The button controls SD card mounting and data logging. When the device is powered on data inputs from the two serial ports and the PPS will be displayed on the LCD. When the button is pressed the SD card will be mounted and new files will be created if the SD card is mounted successfully. The data is then logged to the SD card. When the button is pressed again, the current logging session will be terminated, and the card is unmounted and can be removed from the device.

The LCD screen: The LCD displays operation status of the device, and the data input from the GPS, INS and PPS. The indicators of data input flip once when new data arrives. The total bytes of the incoming data is displayed and updated from time to time.

The software package

NavExplorer's software package "LCIKF" (loosely-coupled integration Kalman filter) can post-process the recorded data to achieve the highest possible accuracy from an integration of GPS/GNSS and INS. With its loosely-coupled integration design, the NavExplorer can support a wide range of GPS/GNSS receivers and inertial sensors. A screen shot of LCIKF is shown in Fig. 3.

LCIKF provides a graphical user interface for data file selection and the integration Kalman filter tuning, as in Fig. 4, where the initial position is set from the average of static GPS position during the pre-set period of time, and the tilt angles are obtained from the static accelerometer readings, and the initial heading is obtained from the magnetometer readings. The lever-arm vector refers to the vector from the INS mass center to the GPS antenna's phase center. The user interface allows the user to input the lever-arm with respect to the Body frame (B-frame).

Design of the system

Tsync accuracy

The techniques for multisensor time synchronisation can be categorised into two types – the analogue domain and the digital domain. For analogue domain time synchronisation, the analogue signals from the inertial sensors are sampled under the control of its internal clock, which may be aligned with a standard time through the input pulse-per-second (PPS) signal output by a GPS receiver. Time synchronisation is implemented at the stage when the signal is converted from analogue to the digital form. The signal transmission lag can be reduced to a minimum with the analogue domain implementation. However, many applications require an off-the-shelf INS product which has implemented the A/D conversion internally based on its own free-running system clock and, in most cases, it operates in the absence of an external PPS signal. Such an INS packages the digital messages and sends them out through an interface to the outside world. Compared to the

Fig. 1 The hardware components of NavExplorer

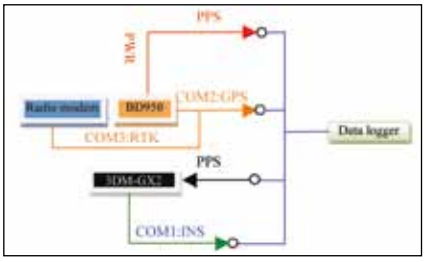

Fig. 2 Illustration of hardware connections

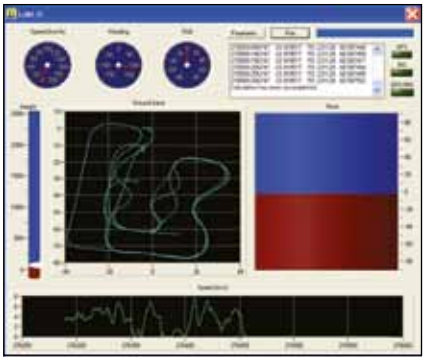
Fig.3 Screen shot of LCIKF

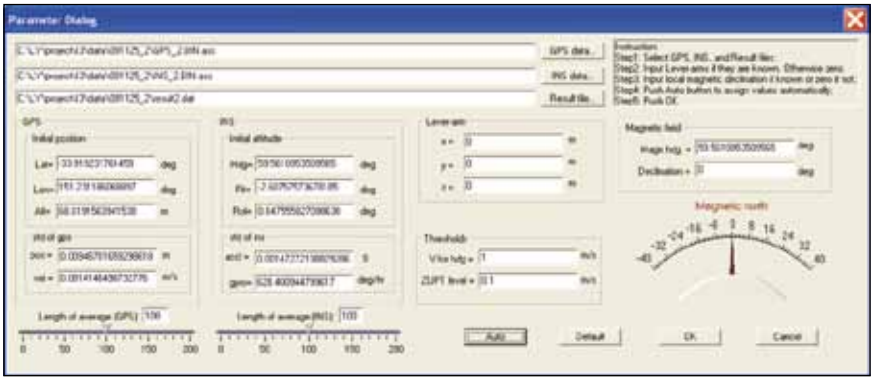
Fig.4 Parameter setting dialog box

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analogue domain implementation the main advantage of the digital domain implementation is its flexibility to support a wider range of INS and GPS devices using the same integrating platform.

NavExplorer uses an FPGA to implement time synchronisation in the digital domain. Assuming the PPS transmission delay is small enough that it can be neglected, the sampling tags time-marked by the 3DM-GX2's internal clock represents the fraction of the time when the data is sampled. Because the moment of PPS time issued at the GPS receiver is known, the accurate INS sampling time in the GPS time-frame can be derived by a combination of the PPS time and the INS time [4]. The result can be expected to have a high accuracy because the PPS time is accurate to the one tenth of nanosecond level, and the INS internal clock is also stable during two PPS pulses.

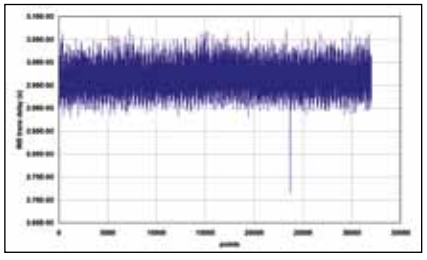
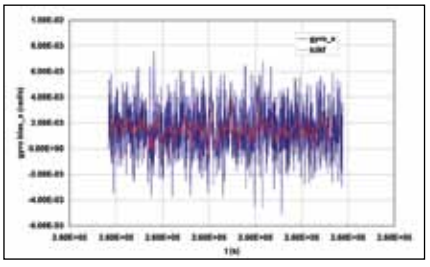
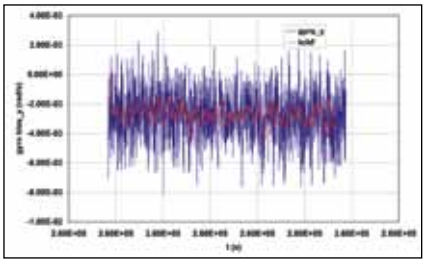


Fig. 5 Transmission delay of the 3DM-GX2





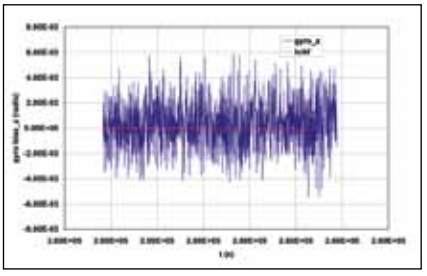


Fig. 6 Gyro outputs and estimate of gyro biases

The INS data has a transmission delay when it arrives at the FPGA data logger. This delay can be estimated using the method described above. A typical delay of the 3DM-GX2 is shown in the Fig. 5, from which an average delay of 2.97ms can be computed.

Gyro biases

For MEMS gyros, removing the average of the static gyro outputs can improve the accuracy of the attitude solution. Results from testing show that the LCIKF can capture the gyro biases adequately, as indicated in Fig. 6. The raw gyro output is shown as blue lines and the LCIKF's estimate of the gyro biases is shown as red lines. From Fig. 6 it can be seen that the LCIKF can track the average of the gyro outputs for all 3 axes.

Lever-arms

The hardware components of a mobile mapping system will typically be mounted at different physical locations on the host vehicle. The offset between the phase centre of the GPS antenna needs to be compensated for so that the integrated position is INS mass-centred. The LCIKF allows the input of the lever-arm between the INS and GPS, which is then applied to the integration Kalman filter:

$$\mathbf{z}_p = \mathbf{r}_{ins} - \mathbf{r}_{gps} + \mathbf{C}_b^n \mathbf{l}^b + \boldsymbol{\epsilon}_p \quad (1)$$

$$\mathbf{z}_v = \mathbf{v}_{ins} - \mathbf{v}_{gps} + \mathbf{C}_b^n \boldsymbol{\omega}_{nb}^{b\times} \mathbf{l}^b + \boldsymbol{\epsilon}_v \quad (2)$$

where r_{ins} and v_{ins} are the position and velocity of the INS in the Navigation-frame (N-frame), r_{gps} and v_{gps} are the position and velocity of the GPS in the N-frame, is the lever-arm from the INS mass centre to the GPS antenna phase centre, and w^b_{ib} is the body rotation angular velocity related to the N-frame expressed in the B-frame, and ϵ_p and ϵ_v are the position and velocity noises.

Similarly, a device such as the camera has an offset l^b from the INS. The position of that device can be calculated from the GPS/INS integrated solution:

$$\mathbf{r}_{dev} = \mathbf{r}_{ins} + \mathbf{C}_b^n \mathbf{l}^b \quad (3)$$

where r_{dev} is the position of the device.

Quality control

Although the velocity flag indicates the velocity of the BD950 is calculated from the Doppler measurements, it has been found that the velocity could contain large jumps during the integer ambiguity procedure when the RTK-GPS radio link is connected.

Therefore the LCIKF must have a mechanism to check the quality of velocity measurement. One method is to start feeding the GPS solution into the integration Kalman filter after the integer ambiguities are fixed. However this arrangement is not practical, especially when the system is operating in an area where no RTK-GPS signals are available. An additional Kalman filter is then applied in the LCIKF to monitor the quality of the GPS solution.

In addition to the abnormal jumps in velocity, the position accuracy levels are used to set up the R matrices of the Kalman filters. The noise level of the GPS position and velocity can be manually input or automatically calculated in the LCIKF.

Institute for Information Industry mobile mapping system

By integrating the NavExplorer with the PGR Ladybug panoramic camera and Multiple SICK laser scanners, a mobile mapping system has been developed at the Institute for Information Industry for the Taipei 3D Urban Reconstruction. NavExplorer generates position data for precise 3D object geo-referencing even when the host vehicle is driven in a tunnel or operates in an environment of frequent GPS outages. Fig. 7 shows the I3 mobile mapping system mounted on a car, where the NavExplorer (the small white box) is installed behind the GPS antenna. Both are connected with yellow cables.

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Fig. 7 Mobile mapping system developed at the Institute for Information Industry

Fig.8 Effect of GPS multipath, GPS/INS(red) vs GPS-only (yellow)

Fig. 9 Bridging the GPS outage through the Sydney airport tunnel, GPS/INS (red) vs GPS-only (yellow)

Fig. 10 Test on UNSW campus of combination of multipath and GPS outages, GPS/INS (red) vs GPS-only (yellow).

Fig. 11 Test in Taipei with GPS outages, GPS/INS (red) vs GPS-only (yellow)

Road tests

Tests in Sydney

The RTK-GPS correction signals will cover most of suburban Sydney after the state-wide CORS network is fully operational. However, there could be no RTK-GPS corrections available unless a local reference station is temporarily setup in the test area. Therefore, the system operated in non-RTK mode for road tests in Sydney. The tests aimed to study the performance of the NavExplorer when there was serious multipath, or during GPS outages, or combination of both.

Fig. 8 shows the GPS/INS integrated solution even when the GPS 'jumps' off the road because of the effect of multipath in a test that was conducted in the suburb of Rockdale on 26 November 2009. The smooth red line is the GPS/INS integrated solution, and the yellow line is the GPS-only solution distorted by the multipath.

Fig. 9 shows that the GPS/INS integrated solution can bridge the 35s GPS outage through the Sydney airport tunnel in a test on 26 November 2009. It can be seen that the GPS/INS integrated solution (red line) has output in the tunnel whereas the GPS solution (yellow line) is lost. The integrated solution seamlessly matches the GPS solution when the GPS solution becomes available again once outside of the tunnel. Before entering the tunnel, the vehicle was driven under a bridge caused a GPS outage of 6s. It can be seen that this GPS outage has also been smoothly bridged by the integrated solution.

Fig. 10 shows the GPS/INS integrated solution in a test conducted on 25 November 2009 on the UNSW campus, where the GPS suffers from both frequent outages and the effects of multipath caused by trees and buildings. It can be seen that the GPS/INS integrated solution (red line) is quite smooth during the whole test. It can not only smooth out the multipath from the GPS-only solution (yellow line) but also smoothly bridges the GPS outages.

Tests in Taipei

The test was conducted in Taipei on 1 June 2010. In the test the vehicle with the mobile mapping system was driven through a tunnel of length 600m. The NavExplorer's position is plotted in red on Google Earth in Fig. 11. The GPS-only solution is in yellow.

Fig. 11 shows the track of a test with four GPS outages with lengths 5s, 9s, 36s, and 55s. It can be seen that the integrated solution seamlessly bridges all of these GPS outages.

Concluding remarks

An inexpensive integrated positioning device has been built for the I3 mobile mapping system. Tests conducted in both Sydney and Taipei demonstrate that the integration of RTK-GPS and MEMS inertial sensors can provide continuous position data in difficult environments with sufficient accuracy. Further tests will compare the NavExplorer solution with a solution of a higher accuracy.

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Real time precise-point-positioning

PPP is becoming an alternative for precise positioning even in real time applications

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Nowadays, a growing number of GNSS users demand highly-accurate positioning with minimal latency. PPP is a new positioning technique providing centimeter-level error. Precise Point Positioning (PPP) processes measurements from a single user receiver, using detailed physical models and corrections, and precise GNSS orbit and clock products computed beforehand. PPP differs from other precise-positioning approaches like Real Time Kinematic (RTK) in that no reference stations are needed in the vicinity of the user. Another advantage is that since the GNSS orbit and clock products are by nature global, the PPP solutions are also global. However, it should be noted that it is possible to set up a regional PPP service using a regional network of stations.

A PPP solution requires some time to converge due to the need for properly estimating phase ambiguities, but the use of combined GLONASS and GPS measurements leads to significantly better results when the observation time is short. For the GNSS user, this means that up to 18 GPS+GLONASS satellites can be simultaneously visible in open-sky areas, which represents an increase of around 60% in satellite availability compared to the GPS-only scenario. This will lead to higher accuracy and faster convergence in precise positioning applications.

A further improvement will be obtained in the near future thanks to the deployment of new regional systems in geosynchronous orbits. With these systems, the convergence time or the accuracy on a short observation time would remain unaffected, but the accuracy on applications that can afford a long observation time will be significantly improved. To achieve this, it is important to be able to compute accurate geosynchronous orbits; this is currently a challenge, but appears to be feasible in the near future.

MAGICPPP description

The PPP algorithm uses as input code and phase observations from a dual-frequency receiver, and precise satellite orbits and clocks, in order to calculate precise receiver coordinates and clock. The observations coming from all the satellites are processed together in a filter that solves for the different unknowns, namely the receiver coordinates, the receiver clock, the zenith tropospheric delay and the phase ambiguities.

The accuracy of the satellite clocks and orbits is one of the most important factors affecting the quality of the PPP. Another relevant factor that affects the PPP performances is the amount and quality of the observations. For instance, more satellites in view improve the observability of the zenith tropospheric delay. Therefore, a possible way to increase the reliability of this technique is to process GPS and GLONASS observations together.

Given that PPP is not a differential technique, it cannot resolve carrier phase ambiguities and they need to be estimated with the aid of the code measurements. This fact makes the convergence period longer than in other techniques (RTK, for instance). The generation of precise satellite orbits and clocks in real time becomes a major challenge for enabling a real time positioning service. GMV has developed an infrastructure for

Fig. 1: magicGNSS product suite

the generation of highly precise GPS, GLONASS and Galileo orbits and clocks in real time. magicGNSS is a web-based suite of GNSS algorithms and products developed by GMV are available at magicgnss.gmv.com. It includes a state of the art PPP module, able to compute precise positioning for static and dynamic users in real time. In addition to the web application, an e-mail based PPP service is also provided. The accuracy of the PPP solution (vs. IGS) is around 1 cm, both for GPS and GPS+GLONASS, for 1-day-long observation times.

PPP with 1-hour-long observation time performances, are usually below 10 cm, and quite often below 6 cm. An observation time of 24 hours is adequate for a high accuracy post-processing solution, but is not very suited to field measurement, where shorter measurement intervals would be more practical. Fig. 2 shows the performances of Static PPP of one IGS station selected as test user (GLSV), for different observation times ranging from 1 to 24 hours. The results for GPS-only and GPS+GLONASS are shown together for comparison. It can be clearly seen that there is a benefit from longer observation times with a significant improvement after 3 hours. For 1-hour observation time, there is also a significant improvement coming from the multisystem configuration.

These performances present multi-system PPP as an interesting option for precise positioning, since sub-dm accuracy can be reached with one hour observation time. The latency with which the solution can be obtained depends only on the latency of the reference products. Real-time generation of products implies that the solution is available immediately after the collection of the measurements.

The main application of real-time PPP, however, is kinematic positioning. In order to evaluate the performances, a receiver was installed on the roof of a van, and data were recorded during a 30-min drive in the countryside near GMV premises, illustrated in Fig. 3.

GPS data were then processed off-line with the new kinematic PPP and compared with a reference trajectory. This reference path was calculated with RTK, using a reference station installed a few km away. The difference between the solutions versus time is shown in Fig. 4. The results match up to a few cm. Additional tests in more challenging visibility conditions and with other type of users (e.g. flight trajectories) are currently on-going, with very promising results as well. It is expected that the addition of GLONASS will improve the performances in more challenging visibility conditions.

Regional PPP

A PPP service is normally a global service, considering that the orbit and clock products are themselves global. This is true as long as the tracking stations used for the computation of the products are distributed worldwide. In this case, there is good visibility of the satellites along all their orbits, and the accuracy of the orbit and clock estimations does not depend on the location. This may pose some limitations as there are mainly two options:

- To deploy a global network of stations, this may be complex and expensive to operate for a regional service provider
- To relay on an external orbit and clock provider, this may limit accuracy, real time capabilities and multisystem approaches

GMV has overcome this problem as magicGNSS is able to compute their own orbit and clock products using a regional network of stations. In this case, the accuracy of the orbits and clocks is slightly degraded but this degradation occurs mainly outside the area where the stations are deployed. Inside this region, the combination of orbit and clock products is such that the positioning performances are good. Indeed, it is possible to achieve positioning performances at the same level as with a global network. This opens very interesting possibilities to regions already operating networks of GNSS receivers (e.g. for RTK), as they can deploy a PPP service using their own resources. Such service could complement RTK for areas far away from any of the base stations requiring much less stations than a classical RTK approach for the same level of precision.

In order to demonstrate this concept some tests have been performed over different regions. The following example illustrates the PPP performances that can be achieved using a regional network of only seven stations over a relatively small country like Japan. It can be observed that PPP solutions based on regional networks,

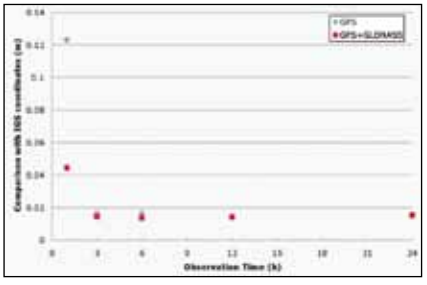


Fig. 2: Static PPP Performances at GLSV


Fig. 3: Test route for kinematic PPP

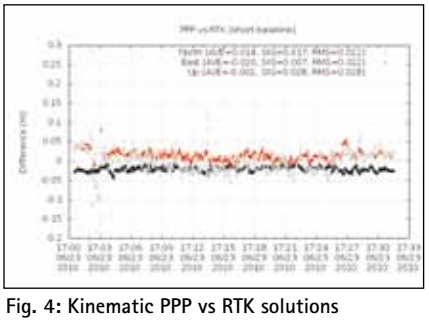


Fig. 4: Kinematic PPP vs RTK solutions

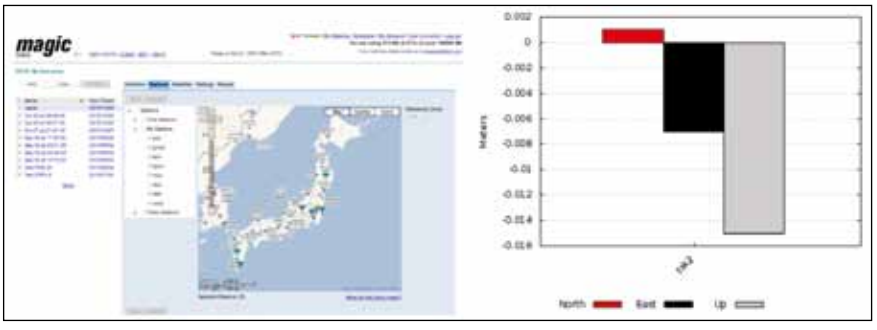
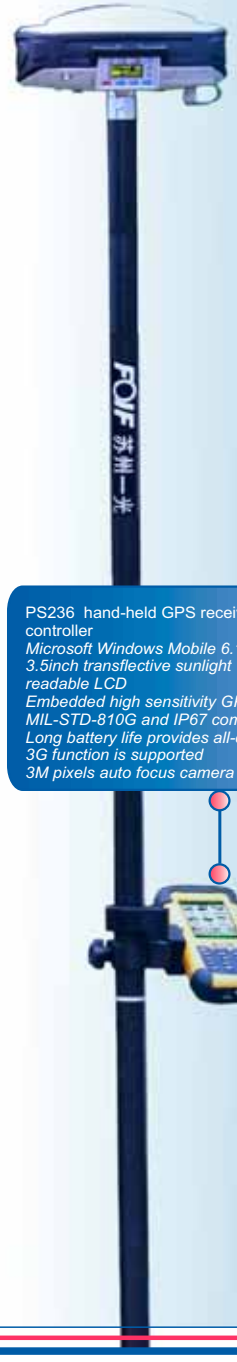


Fig. 5: Network of stations in Japan and differences between the coordinates estimated using products computed with the regional network and global IGS orbits

FOIF GNSS Receiver A20

More flexible system with following features:

- Fully rugged design with simple "One Button" base setup
- Equipped with industry standard GNSS engine(Trimble, NovAtel, Javad...), and proven PCC or Satel radios
- Compatible with existing popular brand GNSS systems
- It is available for wireless data link by FOIFNet transceiver
- GPRS data link reconnecting automatically as base station
- Switch from internal radio to GPRS, or both can work together
- RTK Network rover:VRS, FKP, MAC
- Modular design - simple to extend or replace the Bluetooth, radio or GPRS and SD/SIM card module
- Field software: FOIF Survey_GPS or FOIF FieldGenius



PS236 hand-held GPS receiver and controller
Microsoft Windows Mobile 6.1 OS
3.5inch transflective sunlight readable LCD
Embedded high sensitivity GPS receiver
MIL-STD-810G and IP67 compliance
Long battery life provides all-day power
3G function is supported
3M pixels auto focus camera

GNSS antenna

Voice messages

Super bright OLED display & LED

Li-ion battery, 8hrs continuous working time(RTK)

Multi interface: RS232X2, Bluetooth PPS, Ext Event USB&Ethernet supported

Supports internal /external radio, GPRS

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even for small regions, are as accurate as PPP solutions using global networks. This opens new ways for providing precise positioning services at regional basis.

PPP performances with regional navigation satellite systems

In order to evaluate the PPP performances that can be achieved with regional navigation satellite systems, a simulation tool has been developed based on the analysis of the covariance of the PPP associated processes. It is an evolution of the covariance tool developed for analyzing OD&TS processes, described in Reference [1]. The PPP simulation tool has been validated and calibrated by comparing the simulated results with PPP results in real GPS and GLONASS scenarios obtained with the magicGNSS PPP service, see Reference [2].

The regional navigation constellation that has been used as an example for analyzing the PPP achievable performances is a LCNSS (Low Cost Navigation Satellite System, see Reference [3]) constellation with 9 satellites, 3 geostationary satellites in longitudes 24.5º E, 82.1º E and 128.8º E, and 6 satellites in geosynchronous eccentric inclined orbits, in 3 different orbital planes, optimized for maximizing the navigation performances over India. The inclination has been set to 63.4º, and the eccentricity to 0.6. The ground tracks of the constellation satellites have been plotted in Fig. 6.

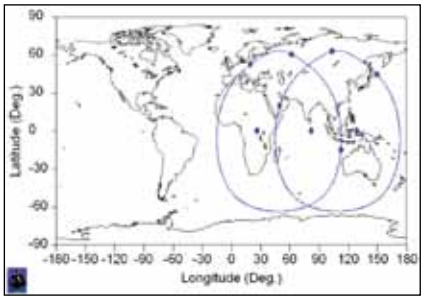
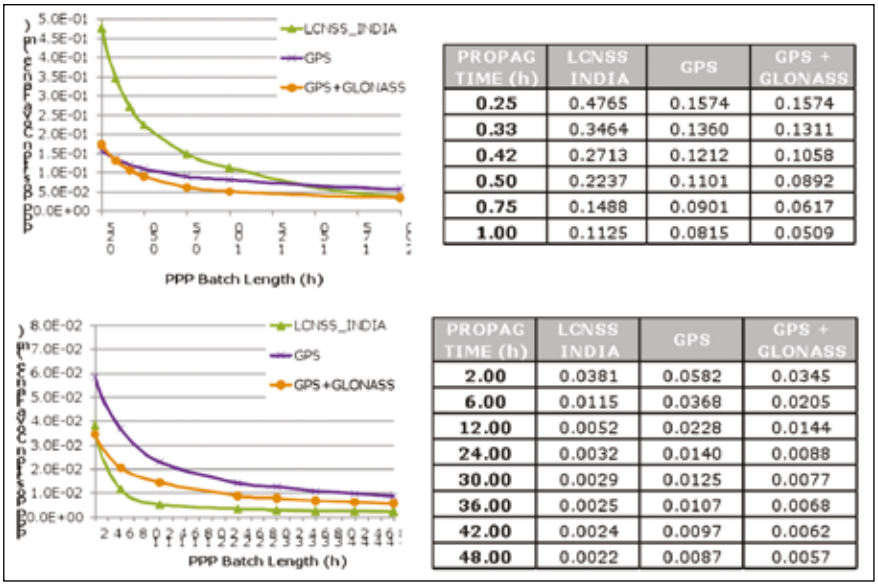


Fig. 6: Regional Navigation Constellation Ground Tracks

The simulated PPP performances that can be achieved over India have been plotted in Fig. 7 below. For comparison purposes, analog GPS and GPS+GLONASS PPP performances are also shown. It can be observed that the PPP performances for the regional constellation are not excellent, particularly if the PPP batch length is short, but they significantly improve as the PPP batch length increases. For 2-hour-long batch length scenarios, the regional constellation PPP performances have reached those provided by the GPS+GLONASS combined constellations. For longer batches, the regional constellation PPP performances keep on improving, reaching a very good performance level, about four times better than GPS for batches between 12 and 48 hours long.

This apparently surprising result, can be justified considering the following two facts: first, with the regional navigation constellation alone, it is difficult to estimate the tropospheric zenith delay for time periods shorter than 2-4 hours, and second, due to good visibility conditions of the considered regional navigation constellation, the station-satellite passes are relatively long, and thus, the ambiguity resolution is more accurate than for the GNSS satellites, especially for long batches. This means that regional navigation constellations can be used for some PPP purposes, such as scientific applications, which demand high precision, but in which the convergence time is not the most stringent requirement.



PROPAG TIME (h)	LCNSS INDIA	GPS	GPS + GLONASS
0.25	0.4765	0.1574	0.1574
0.33	0.3464	0.1360	0.1311
0.42	0.2713	0.1212	0.1058
0.50	0.2237	0.1101	0.0892
0.75	0.1488	0.0901	0.0617
1.00	0.1125	0.0815	0.0509

PROPAG TIME (h)	LCNSS INDIA	GPS	GPS + GLONASS
2.00	0.0381	0.0582	0.0345
6.00	0.0115	0.0368	0.0205
12.00	0.0052	0.0228	0.0144
24.00	0.0032	0.0140	0.0088
30.00	0.0029	0.0125	0.0077
36.00	0.0025	0.0107	0.0068
42.00	0.0024	0.0097	0.0062
48.00	0.0022	0.0087	0.0057

Fig. 7: PPP Simulated Performances in meters

Precise orbit determination

Regional navigation systems are providing excellent performances for applications requiring extreme accuracy. This would only be possible if very precise orbits could be computed. Regional navigation systems are based on geosynchronous orbits, either inclined or equatorial. The computation of precise orbits for satellites in geosynchronous inclined orbits can be done by using classical methods, based on the use of the navigation signal and ground stations. It is more complex to compute precise orbits for geostationary satellites. The relative geometry between the geostationary satellites and the ground stations does not change, which makes it very difficult to discriminate any bias that may be present in the measurements leading to high correlations between orbital parameters and measurement biases or clock parameters.

A simulation tool validated with real data has been used to assess the orbit determination accuracy that can be achieved for each of the satellites in the constellation, see Reference [1]. The same 9 satellites regional constellation optimised over India introduced in the previous section and the 4 stations tracking network depicted in Fig. 8 below have been used for this orbit determination accuracy analysis. The achieved orbit determination accuracy is represented in Fig. 9 below. Satellites 1, 2 and 3 are geostationary satellites, and the rest are all in geosynchronous, eccentric, inclined orbits (GEIO). It can be observed that the orbits of the geostationary satellites cannot be computed with the same accuracy as the GPS or GLONASS

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National Remote Sensing Centre
Indian Space Research Organisation
Balanagar, Hyderabad - 500 625
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Fax: +91 40 2387 8158, 8664
Email: sales@nrsc.gov.in
Website: http://www.nrsc.gov.in

orbits or even with the same accuracy as the orbits of the geosynchronous satellites in inclined orbits.

The only way to improve the OD&TS process for the geostationary and geosynchronous satellites is by improving the tracking geometry. This may be done by taking benefit of the eccentricity of the satellites in inclined orbits, and consequently by using measurements between the satellites. To do that it will be assumed that the satellites are emitting a navigation signal with a transmitter located in the side facing to the Earth, and that the satellites are also equipped with a navigation receiver placed on the side facing opposite to the Earth. A tracking visibility of 180 degrees has been assumed for both, transmitter and receiver. It shall be noted that for this analysis only geometrical considerations have been taken into account. A more detailed analysis is needed to analyse the impact on the satellite, receiver and payload design.

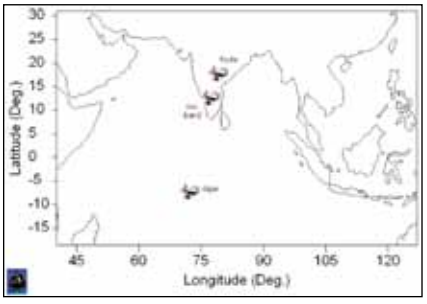

Fig. 8: Tracking Network (4 stations)

Fig. 10 bellow illustrates the OD&TS accuracy that could be achieved by using only four ground tracking stations (as depicted in map in Fig. 8) together with inter satellite ranging measurements: It can be concluded that it is feasible to compute very accurate orbits (a few centimetres) and clocks for all the satellites in the constellation. This is possible thanks to the use of inter satellite ranging using the navigation signal and consequently minimising the complexity of the overall system. One of the main advantages of the proposed approach is the reduced number of ground stations required; in this analysis only four of them have been used. It is important to notice that due to the regional character of the constellation there are some locations from where it may be possible to have all satellites in view during certain time periods. This opens new possibilities for computing real time navigation message parameters.

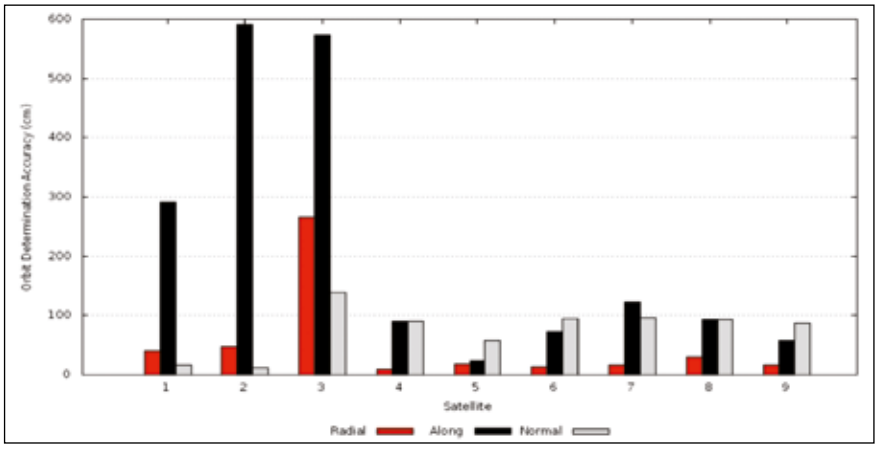

Fig. 9: Orbit determination accuracy for the nine satellites in the constellation. Satellites 1, 2 and 3 are geostationary satellites

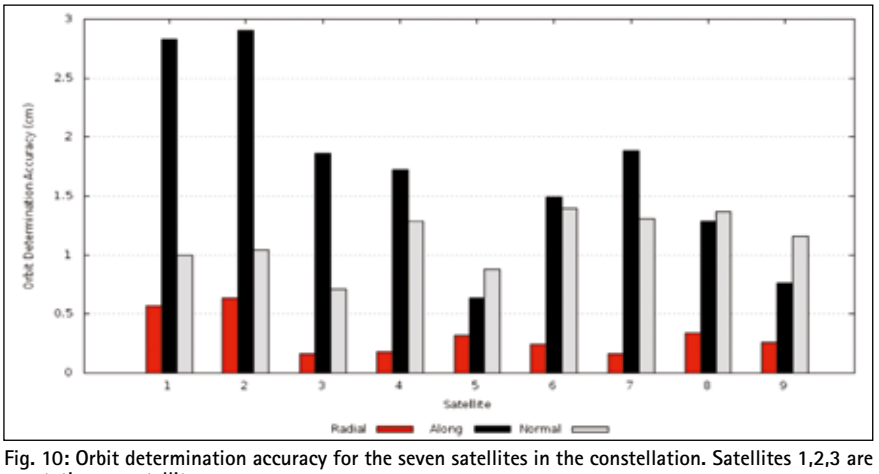

Fig. 10: Orbit determination accuracy for the seven satellites in the constellation. Satellites 1,2,3 are geostationary satellites

Conclusions

PPP is becoming an alternative for precise positioning even in real time applications.

GMV has developed magicPPP, an infrastructure ready to be used as COTS to be installed in any region of the world, which provides about the same accuracy as current RTK systems, both for static and dynamic users, requiring significantly less number of stations, reducing consequently the deployment and maintenance costs

magicPPP works with a regional network of stations, and is highly flexible for selecting the location of the stations facilitating the possibility of doing precise positioning in remote areas.

Regional navigation constellations can be used for some PPP purposes, such as scientific applications, demanding high precision but in which the convergence time is not the most stringent requirement

The use of inter satellite ranging is fundamental for the operation of regional navigation systems, in particular for the precise orbit determination of the satellites in geostationary orbits

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2. Píriz, R., Calle, D., Mozo, A., Navarro, P., Rodríguez, D., Tobías, G., Orbits and Clocks for GLONASS Precise-Point-Positioning, ION GNSS 2009

3. Laínez, María D. Romay, Miguel M.: Low Cost Navigation Satellite Systems, Coordinates magazine, 2008.

You've come a long way, Survey!

Don't Look!
Don't Touch!

"Lift & Tilt" Survey with TRIUMPH-VS

JAVAD

WWW.JAVAD.COM

Listen

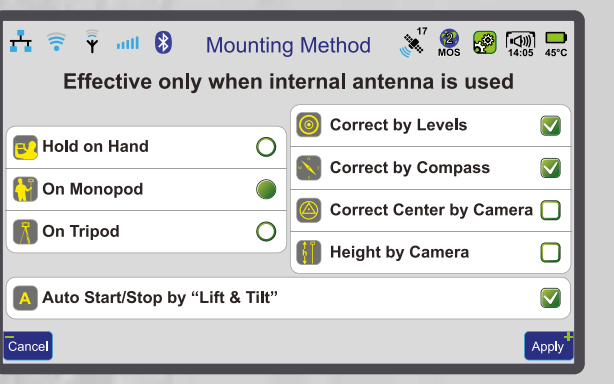
&

Talk

(Sometimes)

Lift

First, put TRIUMPH-VS in “Lift & Tilt” mode.

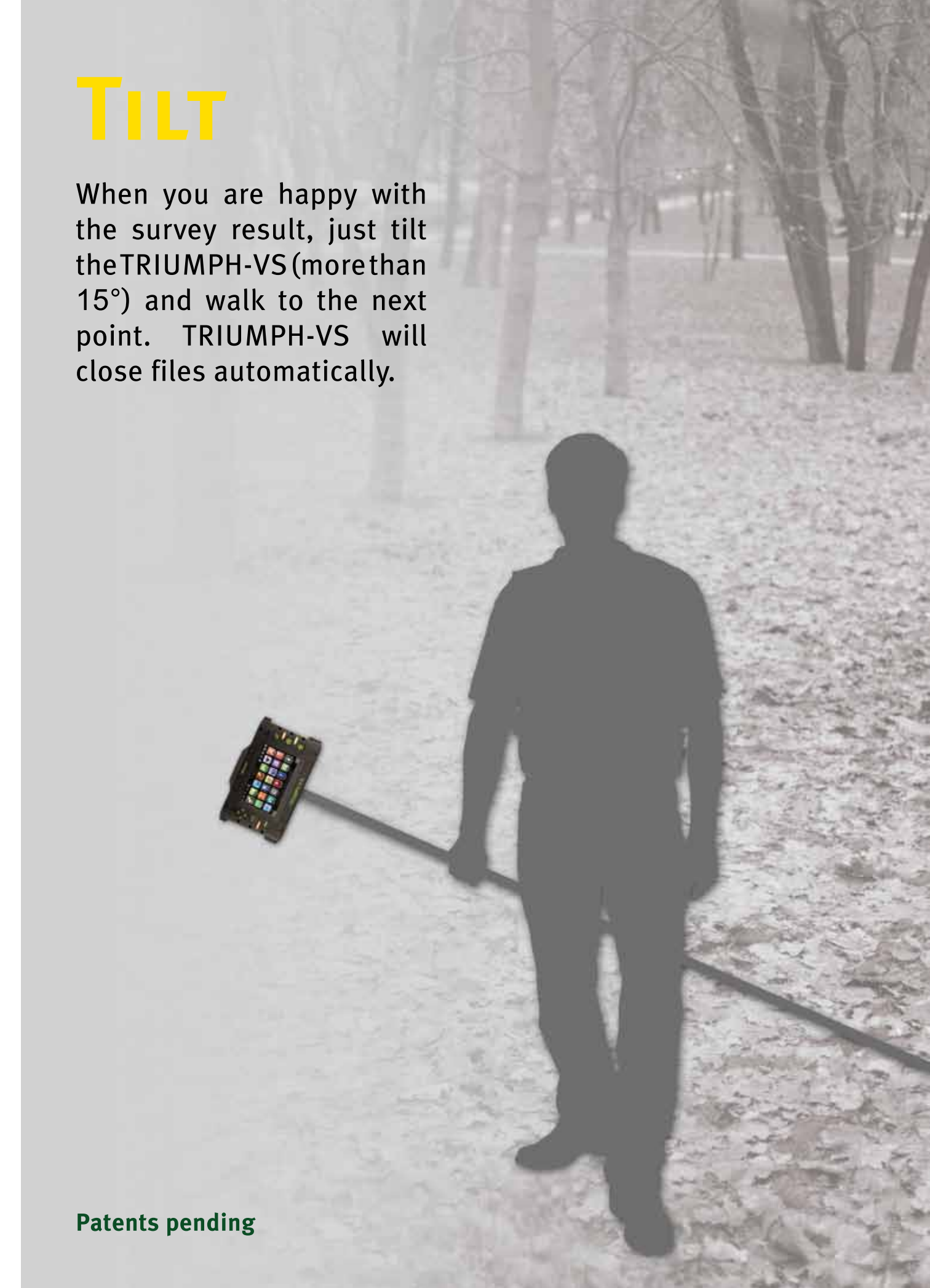


Then, go to the survey mark, lift TRIUMPH-VS to near vertical (better than 5 degrees). Survey will start automatically and sensors continuously compensate for leveling offsets. Audio tones keep you informed of the survey progress. You can use a headset if you are in noisy area. You can also take notes by talking to TRIUMPH-VS.

Patents pending

Tilt

When you are happy with the survey result, just tilt the TRIUMPH-VS (more than 15°) and walk to the next point. TRIUMPH-VS will close files automatically.



Patents pending

Lift

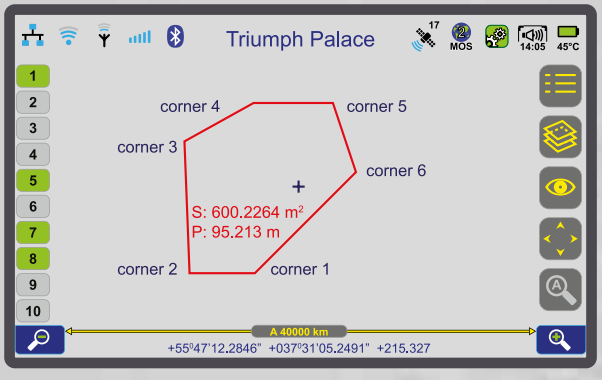
Then go to your next point. Lift it up and do again as you did in the previous survey point: Do Nothing! Just lift it up to near vertical.

Patents pending

Tilt

When you are happy again, tilt it again, and walk to the next point. Points and file names will auto-increment. You can over-write names if you like.

If you are doing a parcel survey (for example) after the last parcel point, push “Parcel End” and see the parcel map, parcel area and parcel perimeter instantly.



Patents pending

Introducing "Lift & Tilt" Survey

It seems TRIUMPH-VS reads your mind!

Many sensors, intelligence, and innovations inside TRIUMPH-VS bring this new revolution to surveyors.

You don't need to look.
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Our history

TRIUMPH-VS

GNSS Spectrum Analyzer in **TRIUMPH-VS**

Also first with GLONASS, Galileo, QZSS

And we keep working harder!

Seamless WLAN/GPS hybrid localization

An experimental feasibility study to investigate measurements trends

Young Jun Lee
School of Electronics, Telecomm. & Computer Eng., Korea Aerospace University, South Korea

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School of Electronics, Telecomm. & Computer Eng., Korea Aerospace University, South Korea

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School of Electronics, Telecomm. & Computer Eng., Korea Aerospace University, South Korea

Around the transit area between the indoor and outdoor environments of buildings, it is anticipated that the number of available measurements may not be sufficient for localization and the undesirable non-line-of-sight (NLOS) and multipath errors would severely deteriorate the localization accuracy. To estimate user location reliably where measurements from global positioning system (GPS) receivers are corrupted or not available, network-based methods have been actively investigated. Among the many network-based methods, localization method based on wireless local area networks (WLAN) has been considered as one of most attractive approaches since sufficient number of WLAN signals for localization can be easily found in most places [1-3].

To design an efficient localization algorithm that combines the measurements from WLAN and GPS, it is necessary to investigate if there are sufficient number of measurements and if it is possible to identify good and bad measurements. To check the possibility of seamless WLAN/GPS localization, an experiment was performed to investigate measurement trends. The trends of both the WLAN and GPS measurements were visualized and analyzed. It was confirmed that more than two GPS measurements were available in the transit area due to the utilization of the high-sensitivity GPS receiver. However, it was found that, due to the high-sensitivity of the GPS receiver, discrimination of the multipath-affected GPS measurements is very important for reliable positioning. In addition, it was also found that and the NLOS-affected WLAN measurements need to be calibrated.

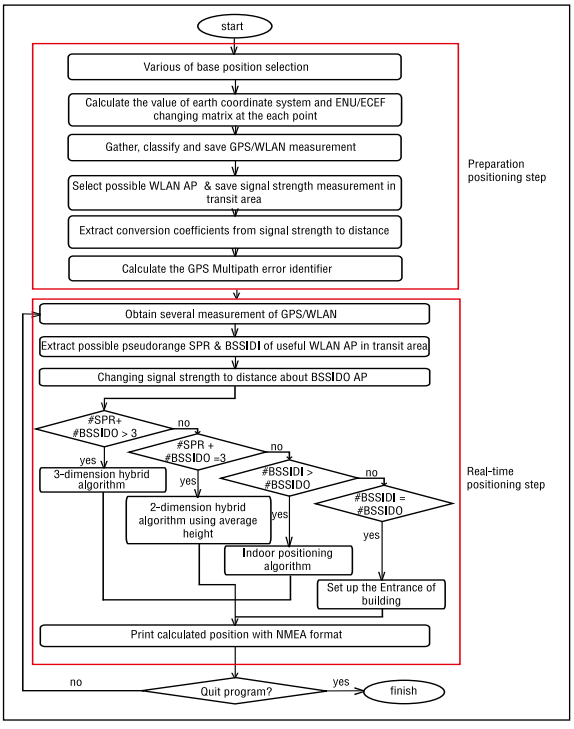


Fig. 1 Flow chart of WLAN/GPS hybrid localization method

If visible GPS satellites are more than four, it is possible to estimate user locations without relying on WLAN measurements. Indoor/outdoor transit areas, however, are most problematic areas where GPS signals are frequently corrupted by multipath errors or obstructed by surrounding structures. In the cases when visible GPS satellites are less than four, it is helpful to utilize WLAN signal strength measurement to avoid shortage of measurement in estimating user locations. The problem of WLAN measurements appearing in transit areas is that they are usually affected by NLOS errors like those appearing in indoor area. Thus, it is necessary to provide any form of NLOS error calibration strategy. Based on the investigated measurement characteristics, a simple WLAN/GPS hybrid localization method is proposed for accuracy improvement. The proposed localization method is capable of combining GPS/WLAN measurements in the presence of both multipath errors and NLOS errors.

WLAN/GPS hybrid localization

The proposed method is divided into two stages as shown in Figure 1. In the first stage for the preparations, WLAN signal strength measurements are surveyed around the transit area. By the measurement surveying, NLOS calibration parameters are extracted and saved. In the second stage for real-time positioning, GPS measurements less affected by multipath errors are selected based on multipath test statistics. Parts of WLAN measurements are converted to distance values based on the pre-computed NLOS calibration parameters. By combining range measurements from GPS and WLAN, improved position estimates are calculated.

The preparation stage of the proposed method is purposed to collect WLAN measurements at surveyed locations to extract NLOS calibration parameters.

For the purpose, the measurements of predetermined types are collected around the transit area of interest and saved into a database. During the WLAN measurement collection, coordinates of surveying locations are either calculated by using a separate device like a GPS receiver or marked on the map. The collected WLAN measurements are registered into the database according to the format summarized in Table 1. In addition, ephemeris parameters, pseudorange measurements, and carrier phase measurements are collected and registered into a database according to the format summarized in Table 2.

Format	Content	Unit
hhmmss.ss	UTC time	sec
hh-hh-hh-hh-hh	BSSID	
%d	Signal strength	dBm
%s<CR>	AP name	

Table 1 Specification of collected WLAN measurements

Item	Content	Measure
hhmmss.ss	UTC time	sec
%d	Num. SV	
%d %d ...%d	PRN list	
%f %f %f<CR> ... %f %f %f<CR>	PR CP DPPL (1) ... PR CP DPPL (J)	m m m/sec ... m m m/sec

Table 2 Specification of collected GPS measurements

By applying a variation of the algorithm explained in [4] to the surveyed WLAN measurement, the NLOS correction parameters are obtained for the conversion from signal strength measurements to range values. By applying the multipath test statistic algorithm explained in [5] to the surveyed GPS measurements, distribution of the multipath test statistic values are obtained. Based on the distribution, the threshold value for multipath detection is prepared.

After the NLOS calibration parameters and the threshold value for multipath test statistic are extracted, the preparation stage is finished and the real-time positioning stage begins. With respect to a set of WLAN/GPS measurements flowing into the mobile device in real-time, the first step of the real-time positioning stage is applied. During this step, the multipath-affected GPS measurements are identified and rejected. The second step identifies the WLAN measurements transmitted by the access points (APs) that are registered in the surveyed WLAN measurement database. The identified signal strength measurements are converted to range values for the compatibility with the GPS measurements.

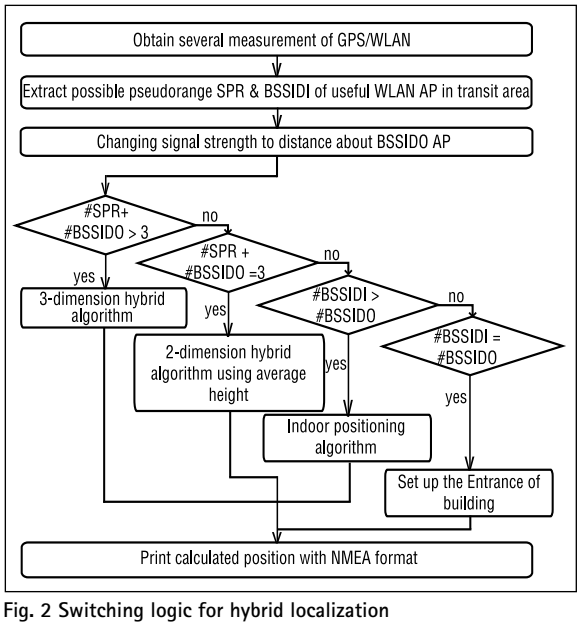


Fig. 2 Switching logic for hybrid localization

Fig. 3 Equipments and experiment area

For the computation of user location, the coordinates of signal sources need to be prepared. In the case of GPS, broadcast ephemeris is utilized to compute the coordinates of satellites with respect to earth-centered earth-fixed (ECEF) frame. In the case of WLAN, the AP coordinates referencing a local coordinate system are converted to those referencing the same ECEF frame as GPS.

Once all the necessary information is pre-processed, the WLAN/GPS hybrid localization algorithm can be applied. The switching logic utilized in the proposed localization algorithm is illustrated in Fig. 2. In Fig. 2, SPR, BSSIDO, and BSSIDI indicate the pseudorange, the AP installed outside the building, and the AP installed inside the building, respectively. According to the switching logic shown in Fig. 2, the WLAN/GPS hybrid algorithm is applied when the total number of visible GPS satellites and available WLAN AP is more than four. In this case, three-dimensional coordinates can be estimated. When the available measurements are three, two-dimensional coordinates are estimated utilizing the average height of the area.

Experiment

To verify the performance of the proposed WLAN/GPS hybrid localization algorithm, an experiment was performed. Figure 3 shows the equipments and the experiment area. Before applying the localization algorithm, the reduced GPS visibility affected by the nearby building was investigated. For the purpose, GPS measurements were collected at known locations utilizing a U-blox LEA-4T receiver. Since the receiver is of high-sensitivity type, it was found that more than four satellites are always visible at all the surveyed locations. However, it was found that parts of GPS measurements are affected by multipath errors.

To investigate how many measurements were affected by non-negligible multipath errors, test statistic values were computed and plotted as shown in Fig. 4. In Fig. 4, the parallelepiped in each plot illustrates the location of the building. The height of the parallelepiped corresponds to the threshold value of multipath test statistic. If a sequence of measurements from a channel produces the test statistic value that is larger than the threshold, it may be affected by non-negligible multipath errors. According to the test statistic values, it was found that more than two GPS satellites are

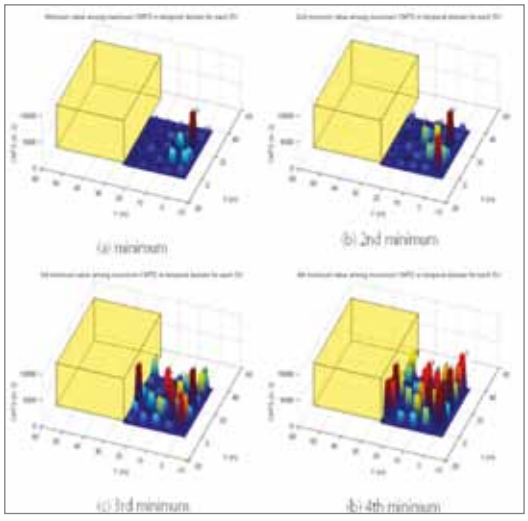
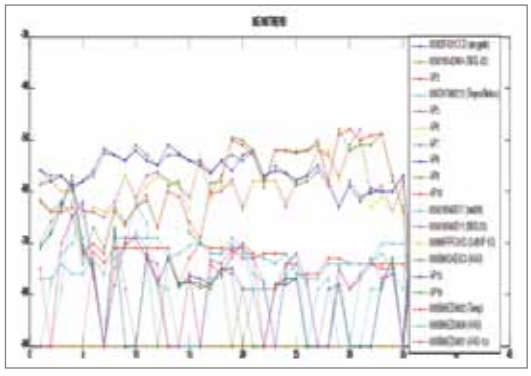


Fig. 4 Distribution GPS multipath test statistics



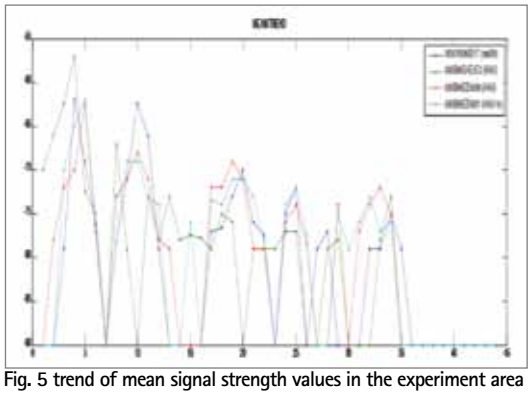


Fig. 5 trend of mean signal strength values in the experiment area

Mean error of standalone GPS & hybrid WLAN/GPS						
point	GPS x	GPS y	GPS z	G/W x	G/W y	G/W z
1	15.6378	-39.5468	53.2049	12.559	-36.0879	-1.5445
2	27.3981	-43.9196	68.0891	16.9825	-14.2565	4.866
3	-3.7046	-7.2105	-1.5987	-5.1643	-1.3192	-9.5349
4	-2.8228	-9.9228	11.7143	-3.6282	-4.8664	4.145
5	-11.8604	3.573	-18.6296	-8.3118	2.0393	-12.0302
6	32.2336	-47.1407	91.0569	33.0683	-23.6566	-12.2482
7	27.9447	-39.6379	65.1213	26.8041	-22.7412	-15.719
8	-6.8569	-6.6152	16.2325	-9.5942	-2.5536	6.8361
9	-1.534	-5.357	17.5122	-3.9485	-2.1259	9.7581
10	-11.7766	1.979	18.8831	-11.8959	3.5976	15.7175
11	-4.7391	0.0886	-14.2315	-8.7586	4.6048	-19.0611
12	-4.2687	-3.6836	15.1014	-5.9174	-1.6476	10.5515
13	24.439	-24.3963	45.5111	10.8701	-11.7571	8.9093
14	28.0314	-28.3565	54.3435	13.5788	-15.4522	12.5698

Table. 3 Comparison of mean errors

not largely affected by multipath errors at all the surveyed locations.

In the case of WLAN signal strength measurements, total 19 APs were found in the experiment area as shown in the upper plot of Fig. 5. Among them 19 APs, 4 APs were considered to be feasible for hybrid localization. The trend of signal strength values at each surveyed location is depicted in the lower plot of Fig. 5. Thus, it can be seen that more than four measurements are always available in the experiment area and three-dimensional coordinates can be produced in the experiment area.

Finally, to evaluate the accuracy improvement by the proposed hybrid algorithm as compared with the simple GPS-only algorithm, the surveyed measurements were processed. The result is summarized in Table 3 for the mean error of each direction at 14 locations. As shown in Table 3, mean errors are reduced, in general, by the proposed hybrid localization method. For more detailed information, circular error probable (CEP) values were computed. By the computation, it was verified that the proposed algorithm produced the accuracy of CEP 8.9 meters as compared with the GPS-only algorithm producing the CEP of 13.7 meters. Thus, it can be seen that approximately 35 % of accuracy improvement could be obtained by the proposed WLAN/GPS hybrid localization algorithm.

Conclusion

To design a seamless and accurate localization method applicable to indoor/outdoor transit area of buildings, it is necessary to investigate measurement. By measurement collection and analysis, it was found that high-sensitivity GPS receivers provide sufficient number of measurements but with considerable multipath errors. It was also found that sufficient number of WLAN signals can be obtained nearby buildings but should be treated by considering NLOS errors.

Based on the investigation on measurement characteristics, a simple but efficient WLAN/GPS hybrid localization was designed. To evaluate the accuracy of the proposed hybrid localization method, an experiment was performed by field-collected measurements. By the experiment, it was shown that approximately 35 % of accuracy improvement was obtained by the proposed localization algorithm as compared with the conventional GPS-only algorithm.

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SDI framework

The work of building Spatial Data Infrastructure is in progress all over the world. There are many challenges: governance, organisational, technical, data sharing, transitional and more. We present here the first part of the paper.

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"The first man who, having fenced in a piece of land, said, 'This is mine,' and found people naïve enough to believe him, that man was the true founder of civil society." (from Discours sur l'Origine et le Fondement de l'Inégalité Parmi les Hommes, 1754, - Jean-Jacques Rousseau)

The building of 'Spatial Data Infrastructure' (SDI) is being undertaken all over the world. This work involves coordinating the development of the infrastructure needed to support: the maintenance of spatial information, the utilisation of spatial information in decision making and collaboration between various parties based on spatial information. These endeavours include a wide range of challenges: regulatory, governance, policy, institutional arrangements and agreements, organisation structure and roles, skills and capabilities, technologies and technical standards, transitional and project phasing.

The opportunity to use world best practice in establishing SDI should be available to everyone. Best practice needs to encapsulate the insights, lessons and experience from other nations and organisations involved in creating effective, self-sustaining modern land administration.

A national SDI (NSDI) can be considered to consist of a set of SDI's traditionally oriented at different constituencies and purposes. So a national SDI is a meta-system that sits across these and ensures their coherence and usefulness. AN NSDI needs to ensure that in line with the strategies and cultures of those countries and their agencies, organisations, enterprises, people and society benefit

State and private sector organisations share the mandate to establish an NSDI. The State necessarily plays a foundational role in the establishment of key building blocks of NSDI suited to land administration, as the SDI needs to tie intimately to management of land tenure. A key requirement in NSDI design is sustaining the capacity of the public and private sector entities. As an NSDI extends a framework is necessary that allows the roles of all the parties involved to be understood as a whole, for the entities to evolve themselves and for sum to be melded.

In implementing an NSDI one needs to ensure it can evolve. This allows it to be extended to address all the users' needs, though initially may only be focused on a narrow set of users. This evolution will be encompass renovation and innovation and involve improvements in design and implementation of operational support systems. The evolution of systems requires that the underlying purpose for the design of the systems and organisations are understood i.e. their experience is institutionalised and retrograde enhancements can be avoided.

The paper seeks to outline a framework for: expressing the natural boundaries of responsibility within an SDI; undertaking work in SDI that allows recognised best practice and standardised reference models to be used; managing the knowledge of why the SDI exists as it is as a basis for future extensions.

This framework ensures semantic precision (a series of increasingly precise definitions for data elements in knowledge representations) and allows easy case by case instantiation (e.g. by country, by culture). It relates patterns, principles, standards, building blocks, reference models and maturity levels and allows the adoption, emphasis or abnegation of the elements in the framework in each specific implementation.

This allows the framework to be common while each implementation

is different with a mapping between the common framework and the specific implementation.

Analysis of the NSDI meta problem

NSDIs are complicated systems that relate to complex organisational structures. They are typically networks of systems, distributed and loosely coupled, in federated or discrete organisations, serving a multitude of purposes and audiences, support transactional and archival functions. They have all the complexities of traditional IT systems with additional concepts, data types and technologies that are not traditionally dealt in commercial solutions. So the NSDIs systems and the approaches for the implementation have the challenge of traditional large IT projects and additional challenges.

Many specialists in the area look at the specific or unique, technical, social and regulatory challenges of SDI systems. They fail often to realise that not all best practice needs to be reinvented and by focusing on the details there is a risk of not seeing the forest for the trees.

To address the problems effectively we need to learn from other complex disciplines better and recognise that many of the best practice that applies to these other information infrastructures applies to NSDI.

Specifically we could start by looking at the generic problems associated with the implementation of complex IT systems (especially in government).

The Royal Academy of Engineering and The British Computer Society observed that

"A significant percentage of IT project failures, perhaps most, could have been avoided using techniques we already know how to apply. For shame, we can do better than this."

They go on to say:

"It is alarming that significant numbers of complex software and IT projects still fail to deliver key benefits on time and to target cost and specification. Whilst complex IT project success rates may be improving, the challenges associated with such projects are also increasing rapidly. These are fuelled in large part by the growth ... in the capability of hardware and communications technology, and the corresponding inflation in people's expectations and ambition."

They examine how complex IT projects differ from other engineering projects, with a view to identifying ways to augment the successful delivery of IT projects. Amongst their findings and recommendations are:

- *"A striking proportion of project difficulties stem from people in both customer and supplier organisations failing to implement known best practice. This can be ascribed to the general absence of collective*

professionalism in the IT industry, as well as inadequacies in the education and training of customer and supplier staff at all levels"

- *The significance of systems architecture is not appreciated.*

- *Further developments in methods and tools to support the design and delivery of such projects could also help to raise success rates. In particular, basic research into complexity is required to facilitate more effective management of the increasingly complex IT projects being undertaken.*

- *There is an urgent need to promote the adoption of best practice amongst IT practitioners and their customers.*

They also identify some things that we think most people have known for some time e.g. the need for good project management and risk analysis. However both of these tasks are significantly impeded if the underlying knowledge required for analysis is not available.

What issues does an NSDI framework address?

The NSDI is a means to assemble geographic data nationwide to serve a variety of users. The framework is a collaborative community based effort in which these commonly needed data themes are developed, maintained, and integrated by public and private organizations within a geographic area.

The NSDI will provide a base or structure of relationships among data producers and users that will facilitate data sharing. The increased ability to share data through common standards and networks will, in turn, serve as a stimulus for growth. Building an effective NSDI will require a well coordinated effort among government authorities and academic institutions, as well as a broad array of private sector geographic, statistical, demographic, and other business information providers and users. Only through this cooperation will the NSDI become a reality.

In our view then an NSDI framework must help address these issues:

- *improving collective professionalism - by providing all parties a way of undertaking analysis, design and planning in an effective and professional manner.*

- *education and training - by providing an explicit relationships between the outcomes, the procedures and systems, the organisations and roles, and the skills required.*

- *architecture - by provide a template for defining: sector or industry (NSDI) architect, the enterprise architectures and systems architectures*

- *strategies for dealing with complexity - by providing methods and tools that support the analysis, design and delivery of NSDIs*

- *promote the adoption of best practice - it is too easy to speak of adopting best practice, everyone does, but in order to do this we really need to define what the elements of best practice are, how* this knowledge is manner and provide a strategy for its adoption. That is what our SDI frameworks seek to do.

What capabilities does an NSDI framework need to provide?

It needs to allow federated group (of public and private sector) participants to do a number of things. In all cases the greater the transparency the better the result. Transparency helps people understand what and why they agree or disagree on things in an objective and unemotional manner. Reaching consensus is therefore easier. The capabilities include the ability to:

- Capture drivers and requirements - these are the things that determine what an NSDI should do. Each and every elements of an NSDI solution (roles, skills, technologies etc.) must derive from these;

- Undertake analysis - a simple structured way to analysis is required. Analysis can be organised around simple set of canonical model (Goals, Facts, Beliefs and Recommendations). Where: goals are things you are trying to achieve, sometimes expressed as principles, issues (goals stated the reverse), visions, measures, objectives or KPIs; facts are not disputable and include laws, regulations, social factors and technical constraints; beliefs are based on facts and relate to goals and include causes, findings, implications; and recommendations are based on beliefs and achieve goals and strategies, plans etc. In addition we would want some grouping concepts (classification systems) for: terms, patterns, principles, technologies, standards etc. By support business or analysis with this paradigm we move for persuasive narrative to structured reasoning;

- Design and decide - Designs are assemblages of elements. So we need to be able to record these things (and relate to externalities e.g. technologies). Design and decision making is made based on analysis of alternatives. So we have the information on drivers and requirements and are able to undertake analysis we can make explain the basis of decisions and designs;

- Plan, Programme & Phase - these require us to understand sequencing, prerequisites and co-requisites. Intrinsic is the relationship between the requirements and the designs;

- Promulgate, educate, communicate and socialise - we need to be able to very selectively extract information for the framework that is suited to a particular audience, purpose or interest. We don't then need to manually reconstruct communication artefacts for each different purpose;

- Estimate the effort, costs, risk and timeframes associated with people, technology, procedures - in practice costs can only be effectively estimated by examining the proposed implementation i.e. the designs. But decisions need to be made related to the requirements and outcomes therefore we need to understand how the elements of the implementation relate to the requirements (and the marginal economic impact of each requirement);

- Support the validation, assessment, quality assurance and review - by making the above relationships explicit and transparent we provide a mechanism for doing this.

What is the best practice (what can we learn from)?

We can learn from a number of standards and approaches that are applied elsewhere by examining some existing methods e.g. ValIT (Val IT - is framework addressing the governance of IT-enabled business investments), COBIT (Control Objectives for Information and related Technology), OSIMM (Open group SOA Integration Maturity Model), CMMI (Capability Maturity Model Integration), FEAF (Federal Enterprise Architecture Framework), DODAF (Department of Defense Architecture Framework), TOGAF (The Open Group Architectural Framework), Zachman Framework , ITIL (Information Technology Infrastructure Library), IFW (Information FrameWork), DSM (Design Structure Matrix), Pattern Language (i.e. Alexander's seminal work). These are from many disciplines e.g. engineering, architecture, portfolio analysis, defense, IT, etc.

Our approach to an SDI framework is informed by these sources and others. We can also see that a number originated in Government (and have subsequently been adopted in the private sector). The effectiveness of these approaches has in the past significantly impacted in most cases by their means of implementation (usually many documents and consultants). We need an approach that minimises the need for both.

Space does not permit a full review of all of these but we believe that there is general consensus that following seem to make good sense:

- Business case and investment models - FEAF, ValIT
- Reference Models - FEAF, OSIMM
- Patterns - DODAF, Pattern Language, TOGAF
- Principles - Pattern Language, TOGAF,
- Standards - TOGAF, FEAF, ITIL, OSIMM
- Taxonomies - DODAF, Zachman
- Maturity models - CMMI, OSIMM, TOGAF (implied)
- Compliance mechanism - Cobit, FEAF, OSIMM. CMMI
- Different levels (of detail, of technicality)-Zachman, Pattern Language
- Instantiation - almost all of these frameworks allow instantiated instances

Additional organisational and process challenges

Government is usually implemented via a set of federated agencies - global, regional, federal, state and local. A Model for data sharing through Government agreement is the one negotiated between the Victorian Government and local government (LG). [Gruen]

With an NSDI we are also able to deal with evolving roles of both public and private sector organisations, and both national and international players e.g. range from Google to United Nations.

In addition to the normal challenges we are usually dealing with federated and distributed organisations. That is to say that

we have a network of organisations with different responsibilities goals and agenda and we need to under the basis on trade-offs are made. The Netherlands Gideon project offers excellent direction.[Gideon]

Further there is increasingly there is a demand for open government: citizen-centric services (giving people access to their data about their land); open and transparent government (being able to say what is known about land); innovation facilitation (facilitating innovation by all parties on knowledge about the NSDI) Reference the 'The three pillars of open government stated by the Australian Federal Government' [Senator Lundy]

- Citizen-centric services
- Open and transparent government
- Innovation facilitation

We also need to deal with archival and reference requirements; and transaction and functional requirements. This has a number of implications including that we need to use information engineering oriented techniques and process oriented techniques for understanding things.

In the ideal world the vast majority of data in an NSDI system is accretes as a natural by product of transactional activities i.e. few additional costs (non-transaction related costs) need to be incurred. In a similar fashion that data that populates an NSDI frameworks need to accrete as a by product of the work on NSDIs that is undertaken. In both cases frameworks and taxonomies are required to make this possible and small adjustments to day to day processes are required to enable to occur.

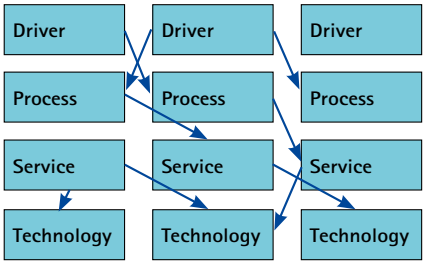
SDI framework based on multidiscipline best practice

What analysis is enabled by semantic precision of the framework?

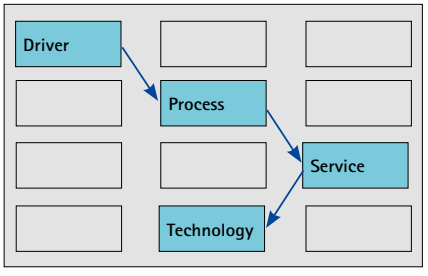
There are two types of analysis that we want to be able to do. We call them referential and inferential.

Referential analysis allows us to confirm that the relationships between element are correct this allows us to follow a path of relationships i.e. if this skill is unavailable what is affected, if this goal is to be achieved what is required, what elements are affected by this projects.

When we look at this:



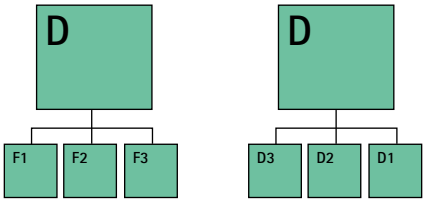
It allows us to quickly see:



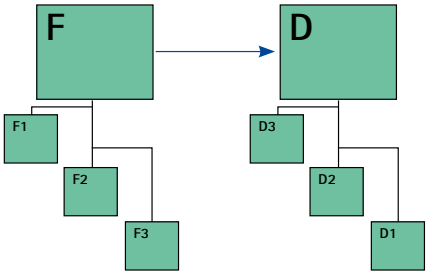
Inferential analysis is useful when we have compositions or when we have reference models - where we can relate our implementation to the reference models. It allows us to infer what relationships should exist i.e. are implied to exist but do not. It allows us a check on correctness.

Reference models would usually be instantiated e.g. for example a functional (F) reference models indicates a function is performed, our instantiation would indicate how we perform it. A data (D) reference model indicates the data we need and our instantiation would indicate how we manage it exactly.

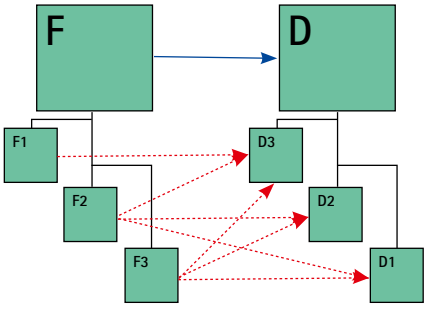
Let us say F >> F1, F2, F3 (i.e. F decomposes into F1, F2, F3) and D >> D1, D2 (i.e. D decomposes into D1, D2).



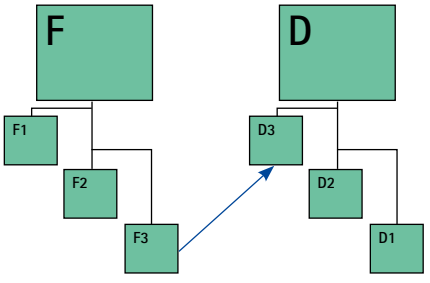
If D relates to F



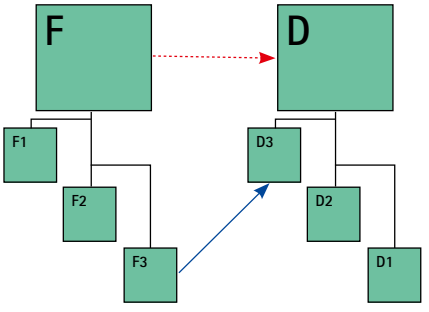
We can tell that one or more of F1, F2, F3 must relate to one or more of D1, D2 i.e. in the follow diagram one of the red relationships must exist.



We can also tell that if F3 relates to D3



We should expect to see F relating to D.



While this seems obvious in this example when the relationships above are all described textually e.g. in a document inconsistencies are not so easy to see. Even when they are dealt with graphically when there are large amounts of information (or multiple level of decomposition) these inconsistencies are hard to see. In both cases best practice would be to have systems do these checks (rather than checking for them manually).

To be concluded in March 2011 issue.

Japan to own navigation system

Japan is considering launching new satellites to establish its own global navigation satellite system (GNSS) in a bid to reduce its reliance on GPS network. The country aims to make it 10 times more accurate than GPS. The satellites would be of the same type as the so-called quasi-zenith satellite, Michibiki, or of a geostationary type. The project is being drafted by the Strategic Headquarters for Space Development headed by Naoto Kan, Prime Minister, Japan. The government is likely to finalise the plan in August, 2011. The project is expected to cost as much as 200 billion yen and it will be public-private venture. *www.yomiuri.co.jp*

Michibiki satellite signal to be free

Japan Aerospace Exploration Agency (JAXA) and Science and Technology Ministry, Japan, is considering to make signals from its Michibiki navigation satellite available free of charge to Australia and South Korea. JAXA will sign agreements with the Korea Aerospace Research Institute and the government and universities in Australia and provide receivers from this spring. In Japan, the technology, which can be used for agricultural production and information devices, is estimated to create a market with annual sales of up to 1 trillion yen (USD 12.02 billion) for receivers, data processing software and other related hardware and software, the daily reported. *Reuters*

Michibiki improves GPS accuracy

A new technology developed by Mitsubishi and the JAXA improves accuracy of GPS (which is approximately 10cm) to 3cm. This record for a non-military system was achieved during a recent public test in Japan, with a car driving at 20km/h. JAXA and Mitsubishi claim former tests have shown their system maintains its accuracy with cars even driving up to 80km/h. Michibiki satellite can cover Japan for just eight hours a day, two more satellites are needed to provide high-quality GPS for 24 hours. *www.crunchgear.com*

US Air Force upgrades GPS software

The US Air Force officials from the 2nd Space Operations Squadron at Schriever AFB, Colorado, completed the Architecture Evolution Plan 5.6 software upload. "This AEP 5.6 is a small software update, bringing specific changes to support the upcoming IIF-2 launch," said Col. Harold Martin, the acting Positioning, Navigation and Timing Command lead of the Air Force Space Command Directorate of Air, Space and Cyberspace Operations. *www.military.com*

Russia to begin full- scale operations of GLONASS by July

Russian Federal Space Agency expects to start the full- scale operations of Global Navigation Satellite System (GLONASS) by July 2011. "At present, GLONASS has 21 operational satellites among a total 26 satellites of the GLONASS-M type orbiting the Earth," Itar Tass quoted Director Anatoly Perminov. *www.brahmand.com*

Russian officials feeling heat of failed satellite launch

Russian President Dmitry Medvedev has formally reprimanded the chief of his country's national space agency (Roscosmos) and fired two other high-ranking space officials over the loss of three state-of-the-art navigation satellites, according to a Kremlin (Russia Federal Government) statement. A follow-up investigation traced the failure to an embarrassing mistake: "Technicians apparently loaded the Proton rocket's Block DM-3 upper stage with one to two tons more fuel than planned, which sent the booster off course." A new series of Glonass satellite, the Glonass-K series, is currently in development, Russian space officials have said. *www.msnbc.msn.com*

United Arab Emirates GNSS Workshop

The United Nations International Committee on GNSS (ICG) and the U.S. State Department organized a workshop on GNSS applications recently. This was one in a series of workshops organized internationally by the UNOOSA and its various divisions to promote the use of satellite navigation applications. It was the first to be held in the Middle East.

GPS to curb government vehicle misuse

Government vehicles in China's Guangzhou city will have GPS to curb misuse and reduce unnecessary expenditure. A satellite positioning terminal will be installed on each official vehicle and through GPS a government car's position can be checked at any time and would show on the map. *www.hindustantimes.com*

GPS to check diesel adulteration

Oil minister S Jaipal Reddy has said his ministry will re-introduce chemical marker within six months to check diversion of subsidised kerosene for adulteration of diesel and ask states to fit satellite tracking systems on tankers used by civil supplies departments to ferry the poor man's fuel. *www.timesofindia.com*

50th Space Wing completes Phase 1 of E24

The 50th Space Wing has announced the completion of phase one of a two phase GPS constellation expansion known as "Expandable 24." When fully complete, this expansion will increase global GPS coverage and provide civil, military and commercial GPS users with more robust satellite availability and a higher probability of signal acquisition in terrain challenged environments. Expandable 24 is a U.S. Strategic Command commander directed initiative, executed by the wing, specifically the 2nd Space Operations Squadron, to reposition six satellites in the current GPS constellation. Phase one of Expandable-24 began Jan. 13, 2010 when 2 SOPS performed maneuvers to reposition three GPS satellites, one of which took 351 days to maneuver. The last of the satellites completed repositioning on Jan. 18, 2011.

Law to ensure use of geospatial in Delhi

A year after the Delhi government, India, launched its much-publicised INR 120-crore geo-spatial project to map the land and utility service records of the city, it has been observed that its officials prefer sticking to the old ways. Hence the Delhi State Government is now planning to enact a law to ensure that its officials use the technology in everyday applications. Rakesh Mehta, Chief Secretary of the Delhi government, said, "Getting departments on board has been an uphill task. "We have asked all 33 departments to submit three applications listing where the technology will be used but since the technology is new, comfort level is low in the departments,". *www.timesofindia.com*

Sri Lanka prepares environ database

The Central Environmental Authority (CEA), Sri Lanka, is conducting a survey on industrial processes across the island. After the survey a database will be developed by the Research and Special Project Unit of the CEA, based on GIS including all social and environmental information from these areas. It will include information about environment systems such as water bodies and forest cover, about culturally important places such as schools, temples, archaeological sites and information about the administrative setting of the area. The survey will see industries divided into three categories as large, medium and small-scale. *Sunday Observer*

Geospatial sales registered growth

According to a study by Daratech, sales of GIS/Geospatial software, services and data grew a robust 10.3% in 2010 to USD 4.4 billion. Overall, the geospatial industry depends very much on its base markets in North America and in Europe; however, strong growth in Asia/Pacific, particularly in China, India and other emerging economies of the world should help ensure that the industry's growth continues strong into the foreseeable future. For 2012 through 2015, Daratech is forecasting double-digit geospatial industry revenue gains as the factors fuelling growth gain more traction.

MAPPS urges FTC to redefine "precise geolocation data"

MAPPS - the national association of private sector geospatial firms in the US, has submitted comments to the Federal Trade Commission (FTC) opposing regulatory language that would limit the collection, sharing or use of "precise geolocation data". The association said a draft regulation, proposed in a FTC staff report, threatens data collection, applications and growth in the private geospatial profession. It urged the FTC staff to more clearly define the term "precise geolocation data." The draft regulation, "Privacy in an Era of Rapid Change," is intended to protect consumers' privacy by requiring that "companies must provide prominent disclosures and obtain affirmative express consent before using consumer data in a materially different manner than claimed when the data was collected." MAPPS called compliance with requirement "impractical to the point of impossible" for geospatial firms. *www.mapps.org*

Intergraph, Bentley settle lawsuit

An eight-year lawsuit between the former Intergraph Corp. and Bentley Systems has been settled for nearly USD 200 million, according to court documents. Now, Cobalt BSI Holding, which bought Intergraph in 2006, will sell back to Bentley its 15.6 million shares of Bentley stock, at a purchase price of just over USD 12 per share, totalling about USD 198 million. In July 2010, Sweden-based Hexagon AB bought Intergraph from Cobalt for USD 2.1 billion.

Dubai Map 2010 now available

Dubai Municipality released third edition of emirate map - Dubai Map 2010, 10 years after the last edition. The municipality claims that it is the most up-to-date map of the emirate. The map provides the latest geographical information about the nook and corner of the emirate, including the major projects that have been planned, completed and those under construction. *www.khaleejtimes.com*

Google violate laws in S. Korea

Google has been accused of collecting emails and other personal information from unsecured wireless networks while it took photos of neighborhoods in South Korea for its "Street View" mapping service between October 2009 and May 2010. In May, the search engine announced it had inadvertently collected fragments of people's online activities from unsecured Wi-Fi networks in more than 30 countries, prompting investigations around the globe. *http://www.google.com*

Vietnam university for geospatial tech

Natural Resources and Environment University will be set up in Hanoi, Vietnam. Nguyen Manh Hien, Deputy Minister for Natural Resources and Environment, Vietnam, made this announcement. The university will focus on remote sensing, meteorology, maritime and island management, geology and minerals, and cartography. In addition, on priority basis, it will train managers and fundamental surveying specialists. *www. vovnews.vn*

New President of The Institution of Surveyors, India

On 21st December, 2010 the AGM of the Institution of Surveyors was held in New Delhi. Mr T K Bandyopadhyay, Retd Addl Surveyor General from Survey of India has taken over as President of the Institution of Surveyors.

China's Map World fully operational

China's State Bureau of Surveying and Mapping (SBSM) brought China's official online mapping service - Map World, out of beta. The trial version was operating since late October 2010. Meanwhile, more than 100 domestic and overseas companies that provide online mapping services have received licenses to continue doing business in China, while another 100 were still applying for a license. *www.english.peopledaily.com.cn*

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From ISRO's desk

ISRO, DRDO now no more in US export control list

The US has removed nine Indian space and defence-related companies from the so-called Entity List. The companies removed from the list for sensitive items include subsidiaries of Defence Research and Development Organisation (DRDO) and Indian Space Research Organisation (ISRO).

NRSC inducts Airborne Large Format Digital Camera into service

National Remote Sensing Centre, Hyderabad, India has inducted state of the art Airborne Large Format Digital Camera (LFDC) into the country and successfully carried out the first operational task during December, 2010 over 10 towns in Chhattisgarh state for the Department of Land Records, Government of Chhattisgarh. NRSC utilized it Super King Air B -200 aircraft fitted with Computer Controlled Navigation System (CCNS), Gyro stabilized mount and Kinematic GPS system (KGPS) for the survey. Aerial photography survey was carried from Raipur airport as the operations base at a flying height of 3300 ft above ground level. The LFDC camera provided digital stereo colour imagery with 10 cms GSD (resolution). A GPS base station was operated at each of the towns during aerial photography to obtain better positional accuracy. The collection of about 90 Ground Control Points (GCPs) has been completed in post pointing mode within a few days after the aerial surveys. The final deliverables are colour orthos photos in 1:1000 scale to facilitate measurement accuracy of 20 cms.

ISRO to assist defence forces

Indian Space Research Organisation (ISRO) has joined hands with Scanpoint Geomatics Limited (SGL) to assist defence forces in strategic planning and analysing data. SGL will develop imaging software for the defence forces. The project will start next month and will be completed by October this year. SGL has already developed an imaging software. *www.timesofindia.com*

ISRO to launch three satellite

Indian Space Research Organisation (ISRO) is planning three major satellite launches in the first quarter of this year. 'Resourcesat-2', an advanced remote sensing satellite, 'Youthsat', a participatory scientific mission with payloads from both Russia and India, and X-sat, Singapore's first indigenous satellite, will be the launched on board of home made PSLV C-16 in. *IANS*

RS tech aids in measurement of carbon monoxide

Boundary-layer concentrations of carbon monoxide (CO), a vital pollutant, can now be measured from space by exploiting the multispectral capabilities of MOPITT (Measurements of Pollution in the Troposphere), according to an article published in SPIE. The article, Space-based measurements of boundary-layer carbon monoxide, is authored by Merritt Deeter, Helen Worden, David Edwards and John Gille. *www.sple.org*

Maldives selects GeoEye for vessel monitoring

GeoEye won a contract from the Republic of the Maldives for a vessel monitoring system that is being developed for fisheries management and safety.

As part of this contract, GeoEye will build the secure infrastructure for a countrywide vessel monitoring system and supply ten Osprey Personal Tracker terminals for a trial deployment. *www.GeoEye.com*

Consumers share uneasy relationship with LBS

Location-based advertisements prompt nearly half of customers to take action, says a new study from Microsoft. The Microsoft-commissioned research in the UK, Germany, Japan, the U.S. and Canada, and found that 18% of consumers (22% in the U.S.) have seen an advertisement based on their location. Of those, 46% have taken action, including redeeming the coupon offered or visiting the store. Nine in 10 users think location-based ads are useful. *www.Inc.com*

ChinaMobile to enter LBS market

China Mobile's online application store, Mobile Market, has revealed that the company's LBS module will be launched in February 2011. The development module is mainly designed for non-technical developers, who can directly create simple applications with the online editing tools, without worrying about the development languages and the coverage of mobile phone modes. *www.chinatechnews.com*

Nike, TomTom to produce GPS sports watch

Nike and TomTom are to release a sports watch with a touchscreen display and integrated GPS, available from April 2011 onwards. The display is intended to make it easy for runners to check their progress en-route, while GPS can track and map each run. *www.independent.co.uk*

GlobalTop embeds geofencing inside GPS modules for tracking solutions

GlobalTop Technology new firmware customization suite designed specifically for asset management applications is now available for their lineup of GPS modules based on the latest MediaTek chipset. These customizations include "Last Position Retention", "Distance Calculation" and most interestingly "Geofencing", which marks the first time such function ever featured inside a

GPS module. Through Geofencing, asset tracking hardware designers can easily implement a virtual circular perimeter by giving the module a set of coordinate that marks the center of perimeter, along with the length of radius which defines the size of area which the geofencing zone covers. *www.gtop-tech.com*

Garmin launches StreetPilot Navigation app for IPhone

Garmin has announced StreetPilot, for the iPhone. It offers voice-prompted directions-with text-to-speech capability for reading aloud street names-along with a variety of more advanced GPS features. *www.pcworld.com*

Huawei selects TCS for Location-Based Services

TeleCommunication Systems (TCS) has announced that it will be supplying its LBS platforms to Huawei. TCS will provide its end-to-end Xypoint LBS solutions to harmonize Huawei's products and solutions. It will also deploy a dedicated team to support Huawei with business, marketing, and technical resources. *http://wirelessfederation.com*

Broadcom, CSR Settle Patent Fight Over GPS Devices

Broadcom Corp has settled a patent dispute with CSR Plc over technology used in GPS. The settlement includes a pledge by both chipmakers not to sue each other for five years, Broadcom said in a statement. The agreement covers civil lawsuits and a case pending before the U.S. International Trade Commission in Washington. The dispute dates to Global Locate Inc., now owned by Broadcom, and SiRF Technology, now part of Cambridge, England-based chipmaker CSR, when they were standalone companies. Each accused the other of infringing patents as part of a battle over who would supply chips for GPS devices including for those made by TomTom NV. *www.bloomberg.com*

Galileo update

Wikileaks syndrome affects Galileo project

Berry Smutny, CEO of OHB-System, has lost his job because of Wikileaks. He was reported in a Wikileaks' cable to have told US diplomats that Europe's Galileo satellite-navigation project was a "stupid idea". Although Smutny has denied the cable's contents, OHB's board has decided to remove him from his post.

The cable, which was published by the Norwegian daily Aftenposten, quoted the OHB-System chief as saying, "I think Galileo is a stupid idea that primarily serves French interests", and, in particular, French military interests. Smutny was further reported to say that Galileo was "doomed for failure" or would "have to undergo drastic scalebacks for survival". OHB-System and UK-based company Surrey Satellite Technology Limited (SSTL) were awarded a contract valued at 566m euros (GBP 465m) in January 2010 to start the production of the Galileo constellation. *OHB-System & BBC*

Carlo des Dorides of Italy to head Galileo agency in Prague

Carlo des Dorides of Italy will head the Galileo Supervisory Authority (GSA) that will be based in Prague, the European Commission and the Czech Transport Ministry. *http://praguemonitor.com*

GIOVE-A still working well

The first prototype satellite of Galileo 's GIOVE-A-is still working well after five years in space. Soyuz rocket from Baikonur in Kazakhstan launched the first 'Galileo In-Orbit Validation Element', GIOVE-A, on 28th December 2005, carrying a prototype rubidium atomic clock designed for the Galileo constellation. It was joined on 27 April 2008 by GIOVE-B, equipped with an ultra-precise passive hydrogen maser design as well as a second rubidium clock. *http://www.sify.com*

European satellite navigation programs Galileo and EGNOS

Last week, the European Commission presented its midterm review on the development of Galileo and EGNOS. Recent progress in the development of Galileo, including the signature of four major contracts and the testing of the first four operational satellites, means the satellite navigation system will deliver initial services in 2014. There has also been considerable progress with the EGNOS program which increases the accuracy of signals from satellite navigation systems.

Airborne wins contracts

Airborne has been awarded contracts to manufacture the solar array panels for the first 14 satellites of the GALILEO programme, and for two flight models of AstroTerra which is based on the AS250 platform, a recurring commercial satellite from Astrium. Combined with the running contracts for the earth observation satellites Sentinel 1 and Sentinel 2, this adds up to more than 100 solar array panels that Airborne will produce the coming years. The first two flight sets for Sentinel are in the final steps of panel assembly at Airborne and the first satellites are planned to be launched by the Ariane 5 launcher at the end of 2012. *www.airborneinternational.com*

JAXA selects Spirent

To further the development of the Quazi-Zenith Satellite System (QZSS) program, the Japanese Aerospace Exploration Agency (JAXA) has selected Spirent Communications' testing solutions to verify performance of its satellite receivers. JAXA is using Spirent's GSS8000 Multi-GNSS Constellation Simulator. *http://telecommunicationnews.net*

Another first from Javad: JAVAD GNSS receivers can track Compass

JAVAD GNSS was the first for GLONASS, GALILEO, and QZSS. And now it is Compass (Beidou-2), which JAVAD commercial receivers can track with optional software. With modified firmware, all JAVAD GNSS receivers can track Chinese Compass B1 signal now. This is 6th GNSS system supported by JAVAD GNSS. Other five are GPS, GLONASS, GALILEO (GIOVE), SBAS (EGNOS), QZSS. Compass system currently consists of 6 alive satellites, of which 4 are visible in Moscow. JAVAD GNSS will add Compass tracking to almost all receivers in near future (firmware upgrade). *www.javad.com*

LTL Holdings chooses Bentley Substation V8i

Bentley Systems has announced that LTL Holdings, a fast-growing engineering enterprise focused on power generation, transmission, and distribution infrastructure in Sri Lanka, Bangladesh, Kenya, and other developing countries, has deployed Bentley Substation V8i.

HORIZON launches its GNSS products

The HORIZON Kronos product range was officially launched in India on 8th January 2011. These products have been tested rigorously for about a year prior to its release. The core technology of the product is based on the proven Trimble Maxwell 6 system, and the hardware carefully designed and manufactured in Holland for durability and aesthetical considerations.

CARIS launches S-57 Composer 2.2

CARIS, with S-57 Composer 2.2, now offers a DNC Plug-in available through an optional license. The DNC Plug-in has a unique capability of automatically converting, with a first-pass success rate of 80%, DNC to ENC and vice versa. The DNC Plug-in allows for further refinements to the conversion with user customized mapping support and built-in editing and quality assurance tools. *www.caris.com*

Public health assessment teams benefit from Handheld MobileMapper 6

Interview teams assisted by Team Epi-Aid, an award-winning volunteer group at the University of North Carolina Gillings School of Global Public Health, are conducting cluster sampling studies using Ashtech® handheld MobileMapper® 6 smart GPS/GIS devices to navigate to designated survey sites and collect point specific field data. These studies, usually conducted by 10, two-person teams, are carried out under the auspices of the University of North Carolina Center for Public Health Preparedness Spatial Health Assessment and Research Program (SHARP). *www.ashtech.com*

u-blox unveils smallest GPS singlechip

Designed for small, low-power, low cost applications, u-blox' latest GPS single-chip UBX-G6010-NT delivers the industry-leading positioning performance of u-blox 6 technology in a micro-miniature package: only 5 x 6 x 1.1 mm. *www.u-blox.com*

Trimble TSC3 handheld controller

The Trimble® TSC3 controller is the new controller that allows surveyors and geospatial professionals to collect, share and deliver data for improved accuracy, efficiency and productivity between the field and office. Optimized for use with Trimble Access™ field software, the It delivers more capable data collection, computing and connectivity. *www.trimble.com.*

Trimble launches Mobile GIS Developer Community

Trimble has launched the Trimble® Mobile GIS Developer Community. The new site provides a rich and growing selection of developer tools and services, hosted within the Trimble Connected Community (TCC) portal. *www.trimble.com*

Survey Data Collector Solutions

Spectra Precision has introduced additions to its line of outdoor rugged data collectors—the next generation Ranger™ 3 data collector series and the Nomad® 900 series. These new advanced solutions are designed to operate with Spectra Precision Survey Pro™ field software to optimize mainstream surveying operations. *www.trimble.com*

Leica MobileMatriX 4.1 supports the new Leica Viva Total Stations

Leica MobileMatriX 4.1 fully integrates the new Leica Viva Total Stations and has many other improvements. It is one of the most advanced solution for mobile GIS applications in combination with GNSS, Total Stations, Level, Digital Cameras, and Laser Range Finders. *www.leica-geosystems.com*

Terrestrial GPS Augmentation Network

Leica Geosystems have launched their GPS Augmentation Network, incorporating exclusive technology developed by Locata Corporation. The network ensures 24/7 positioning coverage in adverse GPS situations. Open cut mines can present challenges for satellite based positioning as the pit becomes deeper, and on sites where the walls are steep. The positioning signals transmitted from satellites can become obstructed by the pit walls, reducing GPS availability and accuracy. The angle of 'sky view' is further reduced where machinery is in close proximity to the pit walls. Leica's GPS augmentation network fills holes in coverage and ensures consistent and accurate positioning is always available.

AAM helps in Brisbane flood crisis

AAM's 3D flood simulation of Brisbane was used extensively by Australian and global media during the recent flood crisis in Brisbane. This was a very effective way of communicating the impact of the flood on buildings and infrastructure and it provided a valuable tool in assessing the potential risk for the city in the days leading up to and during the flood peak. *www.aamgroup.com*

RADARSAT-2 to the Geospatial Community

ERDAS announced its collaboration with MDA Geospatial Services Inc. recently to develop pilot projects demonstrating real-world applications of RADARSAT-2 data using the IMAGINE Radar Mapping Suite. It is now possible to map inter-scene changes at the wavelength or even sub-wavelength scale. Thus C-band radar, with a 6 cm wavelength, can potentially quantify changes at the cm level. Because radar imagery penetrates cloud cover, perennially cloud covered areas may be mapped using orthocorrected radar images. *www.erdas.com*

Blue Marble to add GeoCalc Java to Software Development Kits

Blue Marble Geographics GeoCalc is now in beta testing for Java users. It will be adding Java interface support to the existing GeoCalc libraries. GIS software developers will be able to incorporate the libraries into their software in a Java development environment. *www.bluemarblegeo.com*

Spirent New Record & Playback System A "Real-World" Navigation and Positioning Testing

A critical challenge to achieving the performance and quality of experience expectations of today's navigation and positioning systems is accurately testing user devices in complex and dynamic real-world scenarios. To address this issue Spirent Communications has introduced the GSS6400 Record and Playback System, a solution designed to improve device performance while reducing the need for and cost of field testing. The GSS6400 is designed to capture complex environments efficiently and with the fidelity to ensure playback that is truly representative of challenging real world conditions. The unit is appropriate for a wide range of test applications, from optimization of GNSS chipset performance in difficult environments through to testing mapping applications and location enabled services. *www.spirent.com*

Raytheon to set up GPS center at El Segundo

Raytheon Co. will open a new center in El Segundo to advance cooperation

with the Air Force on GPS technology. It plans to open the 17,900-sqft center near its El Segundo campus as well as the Los Angeles Air Force Base's Space and Missile Systems Center, which is the military's purchasing arm for satellites and launch vehicles. *www.dailybreeze.com*

Ezy2c buy OmniTRACK

Ezy2c Australia recently acquired OmniTRACK business from OmniSTAR, a leading provider in positioning data and a market leader in the design and development of Differential GNSS positioning technology and asset monitoring solutions. Ezy2C have over 4000 vehicles being tracked in every state and territory of Australia with a further 800 in Africa. *http://www.newsmaker.com.au/news/7060*

$37,000 worth of damage after following GPS directions

An elderly British couple is recovering after a faulty GPS system led them to crash into a 19th-century German church, causing $37,000 worth of damage. The couple were traveling from Austria to France guided by their GPS system. The 76-year-old husband, who was driving, followed instructions to "turn right" but ended up hitting the chapel near Freundpolz, Bavaria. The man and his 78-year-old wife were taken to the hospital suffering from shock and bruises, before returning by train to Britain. *http://www.heraldsun.com.*

Mesa Geo 3G Rugged Notepad from Juniper Systems

Juniper Systems has announced the availability of Mesa Geo 3G Rugged Notepad. In addition to all of the features available on the Mesa Geo model (Bluetooth® wireless technology, Wi-Fi®, GPS, and digital camera), the Mesa Geo 3G offers a 3G GSM cellular data modem which provides real-time wireless connectivity while working in the field. *www.junipersys.com*

MARK YOUR CALENDAR

March 2011

International Hydrographic Seminar
3 - 4 March
Delhi, India
www.hydrobharat.nic.in/HYDROIND_2011.htm

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

Global Space & Satellite Forum
9-11 May
ANEC, Abu Dhabi
www.gssforum.com

Geospatial Intelligence Middle East
15-18 May
Abu Dhabi
www.geospatialdefence.com

FIG Working Week 2011
18-22 May
Marrakech, Morocco
www.fig.net

June 2011

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

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

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

July 2011

Summer School "Advanced Spatial Data Infrastructures
4 – 8 July (Advanced SDI-Management)
7-15 July (Advanced SDI-Professional)
Leuven, Belgium
www.spatialist.be

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

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

August 2011

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

7th International Symposium on Digital Earth
23-25, August
Perth, Australia
www.isde7.net

September 2011

ION GNSS 2011
20-23 September
Portland, USA
www.ion.org

INTERGEO
27 - 29 September
Nuremberg, Germany
www.intergeo.de

October 2011

ACRS 2011
3-7 October
Taipei, Taiwan
www.acrs2011.org.tw

AfricaGIS 2011
10-14 October
Cairo, Egypt
www.eis-africa.org/EIS-Africa

November 2011

Regional Geographic Conference – UGI 2011
14-18 November
Santiago, Chile
www.ugi2011.cl

ENC 2011
29 Nov-1 Dec
London, UK
www.enc2011.org


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