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Coordinates

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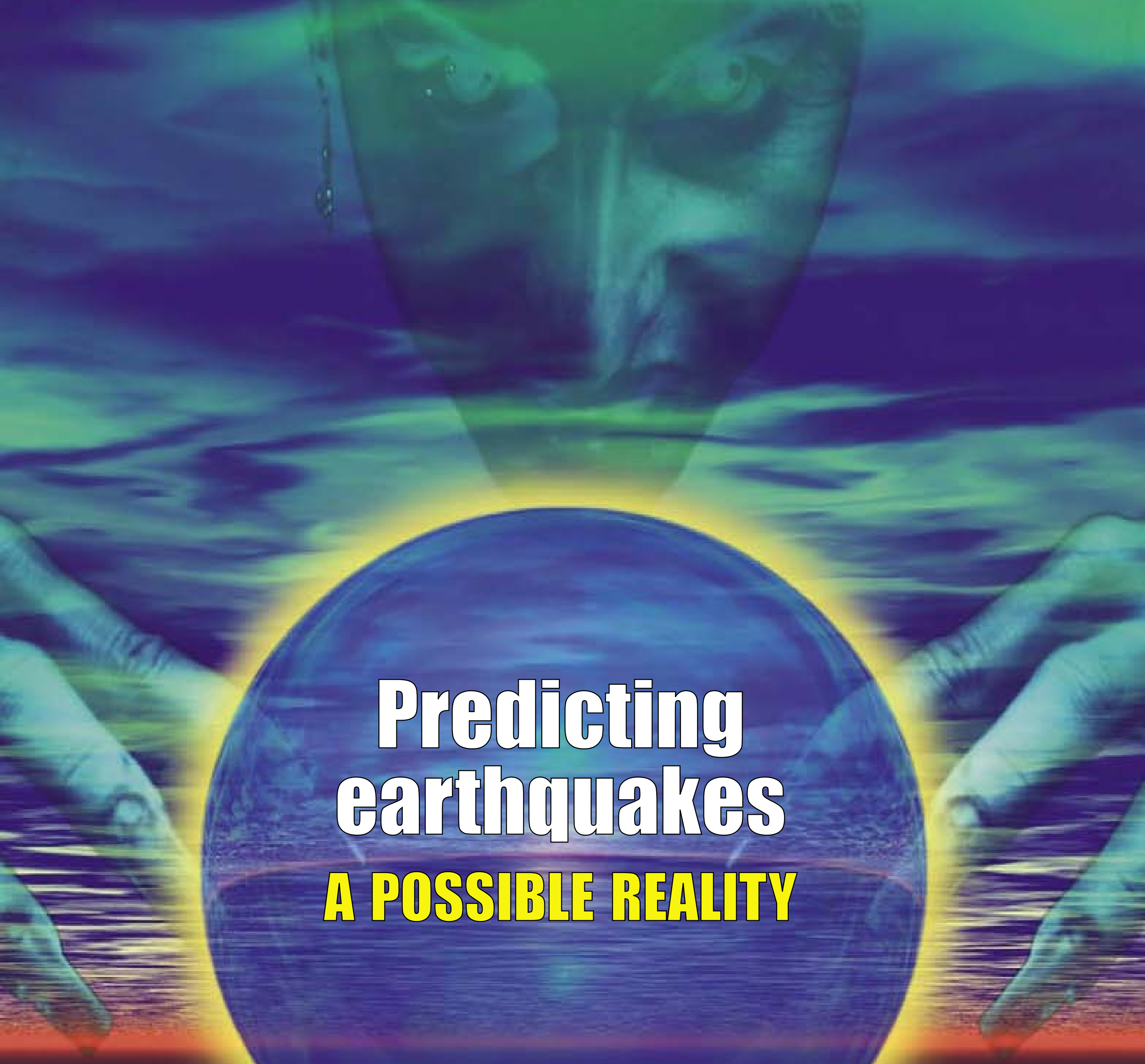
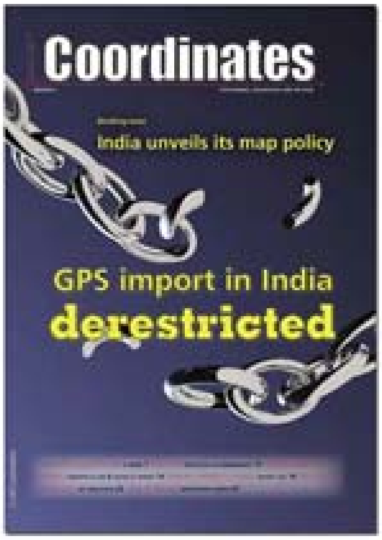
POSITIONING, NAVIGATION AND BEYOND



Predicting earthquakes

A POSSIBLE REALITY

A cGIT publication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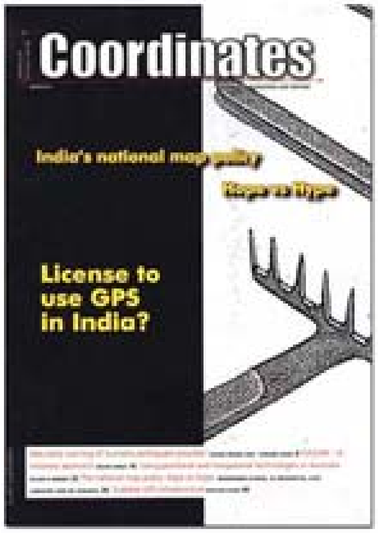
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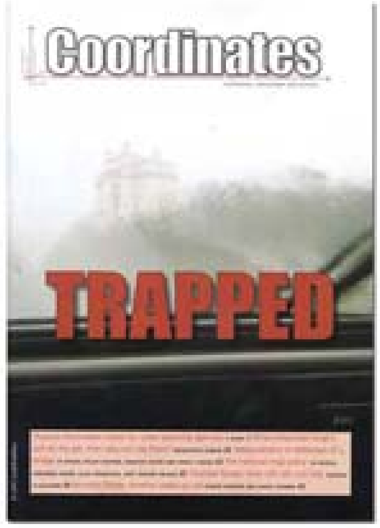
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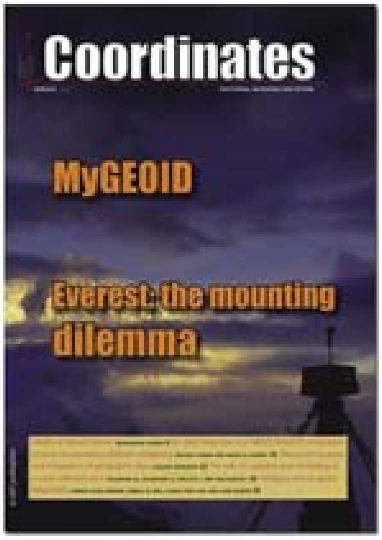
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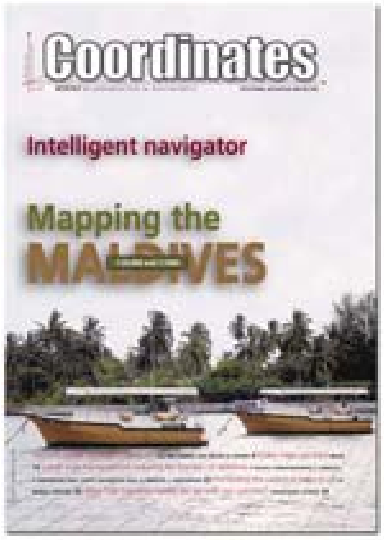
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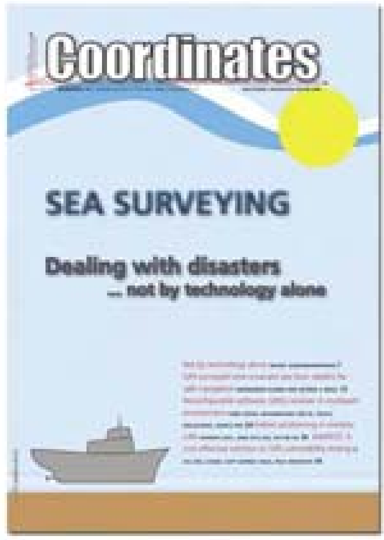
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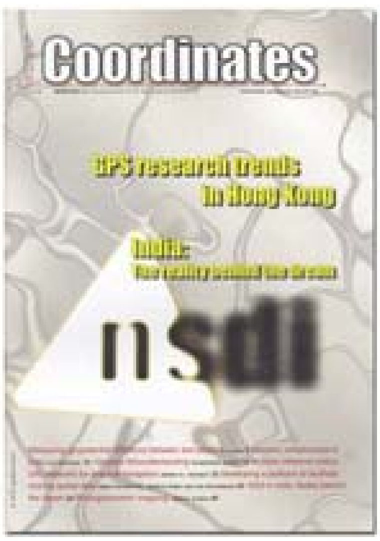
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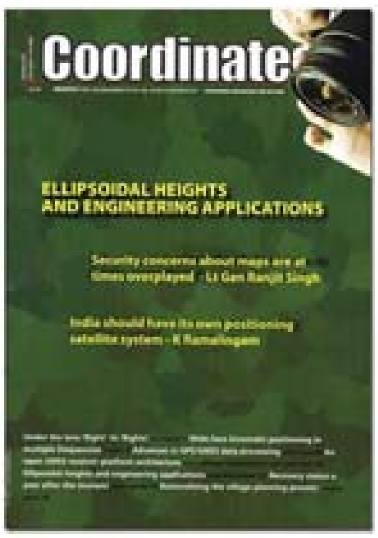
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India should have its own positioning
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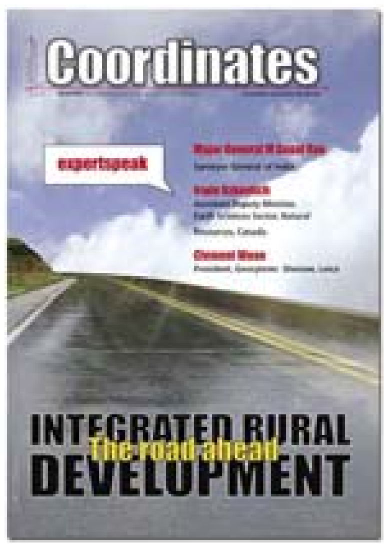
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DEVELOPMENT

Articles

Columns

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This issue of Coordinates is of 44 pages, including cover.

A capital chaos

Delhi faces confusion and chaos.

With a pressure to host Commonwealth games in 2010.

Unauthorized construction, encroachments, illegal uses of residential properties, etc.

Court orders against ‘unauthorized’ and ‘illegal’.

And that provokes many to make efforts to counter it.

Debate starts on rules and applicability, practice and practicalities, law and legalities.

Livelihood is pit against planning.

And planning becomes a casualty to politics. Politics of elections and votes.

Or, might be a case of callousness in planning itself.

There are rules and regulations.

And, its violations too.

That too in connivance with authorities.

We are in a mess.

Basically, a consequence of corruption in concerned public offices and public life.

And, corruption is not an issue in this country.

That’s a way of life.

Isn’t it?

Bal Krishna, Editor
bal@mycoordinates.org

Was there any pre-signal of Pakistan earthquake?

The authors have already reported the case of the Sumatra offshore earthquake in this magazine in July 2005. In this issue the results of Pakistan earthquake has been reported

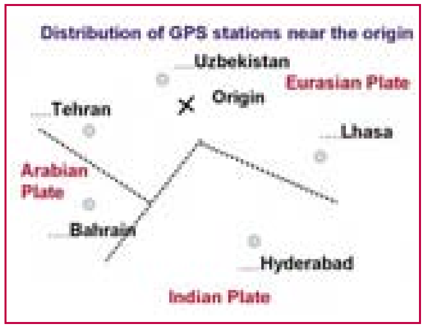
Shunji Murai and Harumi Araki

The authors have continued a research on the prediction of earthquake using GPS data in Japan, one of the disaster prone countries since 2000. The authors have discovered pre-signals of those past big earthquakes with more than M6, such as Miyagi Offshore and Hokubu Earthquakes (2003.5.26; M7.1 and 7.26; M6.4), Tokachi Offshore Earthquake (2003.9.26; M8.0), Niigata Chu-etsu Earthquake (2004.10.23; M 6.8) and Fukuoka West Offshore Earthquake (2005.3.20; M7.0) with use of "Electronic Control Points" or GPS stations constructed by the Geographic Survey Institute (GSI) as well as Sumatra Offshore Earthquake (2004.12.26; M9.0) and Pakistan Earthquake (2005.10.8; M7.7).

The authors have already reported the case of the Sumatra Offshore Earthquake in this magazine in July 2005. This time we would like to report the results of Pakistan Earthquake. Though the number of GPS stations of International GPS Service (IGS) near the origin of the earthquake was very few, the distance change ratio between Uzbekistan and Bahrain and the area change ratio of the triangle of Uzbekistan, Tehran and Lhasa showed pre-signals two or three days before the earthquake occurred.

Distribution of IGS GPS stations

Figure 1 shows the location of the origin of Pakistan Earthquake. Figure 2 shows an example of large scale landslide occurred due to Pakistan Earthquake, which was taken by ASTER satellite. GPS stations near the origin were very few as shown in Figure 3. In this figure, the nearest GPS station is Uzbekistan (kit3) located in Eurasian Plate. Tehran (tehr) and Lhasa (lhas) are also located in the same plate. Bahrain (bhar) is located in Arabian Plate and Hyderabad (hyde) is in Indian Plate. The origin is located near the border of those three plates.



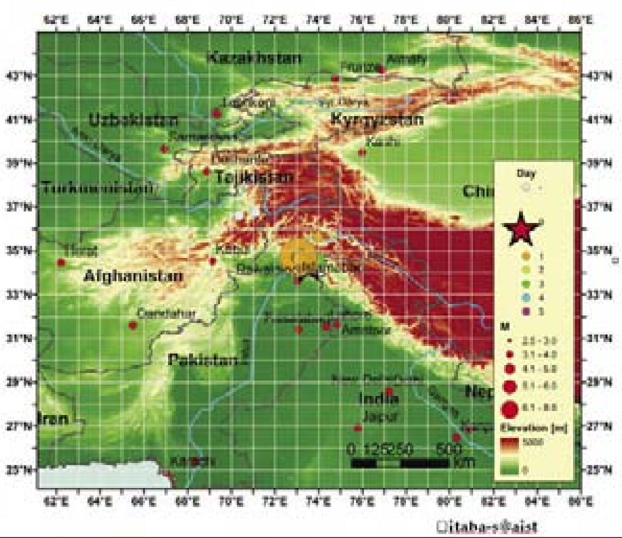
Checking pre-signals before the earthquake

The authors checked GPS data in the geocentric coordinate system from 10 days before to the day of the earthquake.

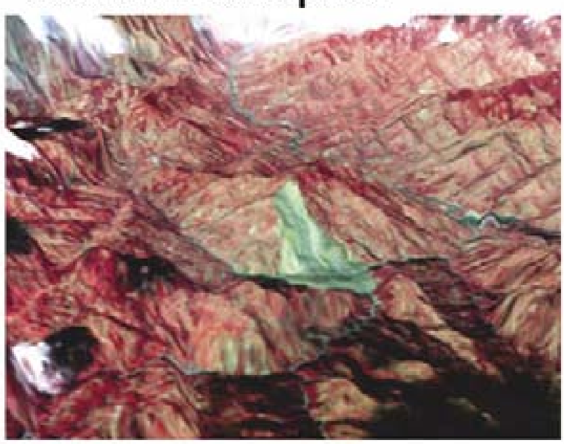
The following two indicators were checked.

1) Daily distance change ratio in ppm; all combinations of distance between the five GPS stations in X, Y and Z axis. As shown in Figure 4, the daily distance change ratio in Y axis between Uzbekistan and

Vicinity of Pakistan Earthquake



Large scale of landslide due to Pakistan Earthquake



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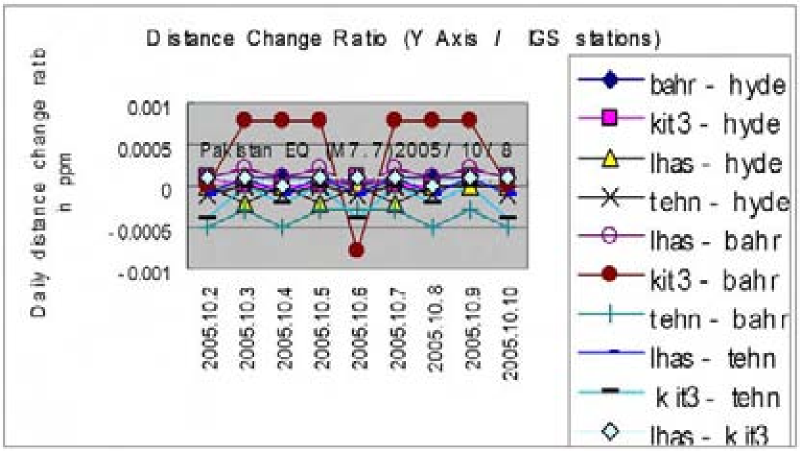

Bahrain showed remarkable pre-signal on the 6th October 2005, two days before the earthquake.

2) Daily triangle area change ratio in ppm; all combinations of triangle consisting of three GPS stations out of the five GPS stations were checked. As shown in Figure 5, the triangle of Uzbekistan, Lhasa and Tehran showed the maximum change ratio in XY projection plane on the 5th October 2005.

Conclusion

It is obvious that there were pre-signals of Pakistan Earthquake in the indicator of daily distance change ratio as well as daily triangle area change ratio in GPS data as described in this report. The authors are honored to inform the readers that the Japanese Patent Bureau has approved our patent on "Prediction of Earthquake and Volcanic Eruption" (Patent No. 3763130) using GPS data as of the 27th January 2006. We will expect some businesses on the prediction of earthquake in Japan. Though we can discover pre-signals, we cannot foretell exactly when earthquake will occur. From our experience, two days at earliest to three months at slowest were critical days with red signal before earthquake.

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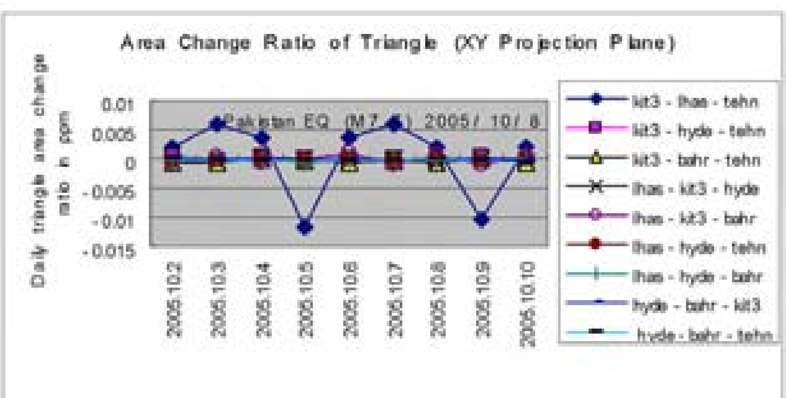

Innovation

GLOBAL Reckoning of Latitude and Longitude

(N↑→E)

Presently, the GPS is globally accepted as the best and most accurate positioning system and survey technique. Let us start reckoning the latitude and longitude in a global way.

In the new global reckoning way

a. Latitude (φ) is 0° at the South Pole, 90° at the Equator, and 180° at the North Pole.
b. Longitude (λ) is eastward from 0° to 360°East.

This global reckoning eliminates the need for " N or S", "E or W", and/or "Negative/Minus (-) or Positive/Plus (+) in all our applications all over the world.

Example: Coordinates "065°/ 240°" and "145° / 240°" identify two positions in two hemispheres with no ambiguity and in a new unique way.

If we adopt this "simple" system, both for civil and military, it will be a truly global approach to use with the GPS surveying technique.

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Optimizing gravimetric geoid solution

Various modification approaches are examined in this study which might be implemented in generalised Stokes scheme

SK Singh, Brig (Dr) B Nagarajan, PKGarg

Transformation of GPS derived ellipsoidal height to orthometric height is one of the most important applications of gravimetric geoid. Its applicability remains questionable if the above transformation cannot be done to a reasonable order of accuracy. Use of GPS observations at levelling benchmarks and subsequently determined geoidal seperation using the geometrical relationship between geoid and ellipsoid (see fig. 1) serve as standard for accuracy assessment of gravimetric geoid. Stokes's (1849) solution of geodetic boundry – value problem requires a global integration of gravity anomalies to compute the separation (N) between the geoid and geocentric reference ellipsoid.

In any gravimetric geoid computation at regional or local level the gravity data only to the extent of region of interest is inevitably used. The Stokes integral formula which is generally used to provide the gravimetric geoid solution, requires a global integration of surface gravity anomaly data over the entire Earth. However, this requirement is practically difficult to meet due to the reasons of security and political sensitivity, the integrations is performed over a limited spherical cap, which is bounded by the spherical distance Ψ_0, where $0 < \Psi_0 < \pi$.

This practical approach usually result in errors what has been called as truncation error (Molodensky et.al., 1962). In any gravimetric geoid computations at a regional or local level the gravity data only to a limited extent is used, therefore Stokes formula in its original form may not provide the desired solution. This truncation error

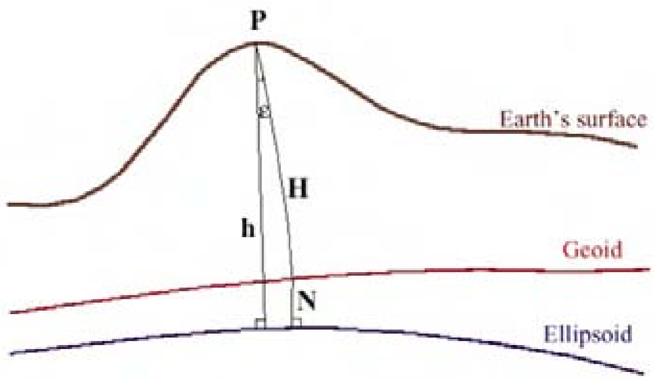

Fig 1: Relationship between Ellipsoidal height, Orthometric height, Geoidal height

can be treated as a remote – zone contribution and computed using the spherical harmonic expansion of the coefficients that comprises a global geopotential model (Evans & Featherstone, 2000). Since such models are available only to an expansion of 360 degrees the truncation error remains due to omission of the higher degree terms. In order to reduce the effect of these errors and influence of other potential resources and also to attain the geoid solution which is best fit to the geometric geoid computed from GPS – Levelling observations at discrete points, an appropriate modification to Stokes kernel and an optimum value of spherical cap radius over which the integral will actually performed are the most desired quantities. This will allow for the best estimate of geoid height to be made from an approximated (i.e. truncated at (Ψ_0) integration of Stokes formula. The present study is focussed on the determination of optimum values for these quantities by making use of GPS – levelling observations at few selected points in the region of interest.

Basic theory of Gravimetric Geoid Computation

Remove - compute – Restore (RCR) type of estimator using appropriate modification of Stokes integral kernel is the most popular technique of regional or local gravimetric geoid computation in preset scenario. The RCR technique invariably utilized the global geopotential model's potential coefficients viz. EGM96 to remove the long wavelength effect from the local terrestrial gravity data at the remove stage which is added back to the geoid height computed from residual gravity data using Stokes Integral at the restore stage. The reference global geopotential model (GGM) usually provides long-wavelength information of Earth's gravity field whereas the local/regional terrestrial data such as gravity anomalies supplement this information with the short wave-length geoid information to get the reasonably accurate gravimetric geoid for the region of interest. The combination of these kind of data sources for determination of geoid height N has been termed as generalized Stokes scheme for geoid computation (Vaniček and Sjöberg, 1991). According to the scheme the long wave length contribution of a GGM viz. EGM96 (N_M) are corrected to a certain extent by a global integration of residual gravity anomalies to get the geoid height (N_1) at the computation point by the expression

$$N_1 = N_M + R/4\pi\gamma \int_{\alpha=0}^{2\pi}\int_{\psi=0}^{\pi} S(\psi)\, \Delta g_M \sin\psi \, d\psi d\alpha \quad \text{----(1)}$$

Where, γ = normal gravity at the surface of reference ellipsoid

$S(\Psi)$ = Stokes kernel

Δg_M = residual gravity anomalies after removing the contribution of GGM to a degree M from the local terrestrial data

Ψ = spherical distance from the computation point

α = azimuth of line joining the computation point and a surface element

The spherical Stokes Kernel in its closed from is represented in the form of trigonometrical function (Heiskanen and Moritz, 1967)

$$S(\psi) = \frac{1}{\sin(\psi/2)} - 6\sin(\psi/2) + 1 - \cos\psi$$

$$(5+3\ln[\sin(\psi/2) + \sin^2(\psi/2)]) \text{ ---------(2)}$$

For $0 \le \psi \le \pi$

The low frequency geoid undulation (N_M) are computed from spherical harmonic coefficients of global geopotential model:

$$N_M = c\sum_{n=2}^{M} \frac{\Delta g_n}{n-1}$$

Where $c=R/2\gamma$, Δg_n the estimated gravity anomaly from nth degree spherical harmonic coefficients and M is the maximum degree of geopotential model. Δg_M is evaluated by the expression:

$$\Delta g_M = \Delta g - \sum_{n=2}^{M} \Delta g_n$$

where Δg is the observed gravity anomaly at computation point.

As already explained it is impractical to evaluate the integral of equation over the entire earth due to the various constraints associated with data availability it is preferred to perform the evaluation in a domain of predefined spherical cap of radius ψ_0 $(0 < \psi_0 < \pi)$ about each geoid computation point. This convenience from computational point of view result in leakage of low frequency gravity errors into the geoid solution a direct consequence of the approximation of the generalized Stokes integral (Vanicek and Featherstone, 1998). The orthogonality property of surface spherical harmonics breaks down under the approximation made in generalized Stokes scheme (eqn 1) and non-zero truncation coefficients of significant magnitude may appear in the region $(2 \le n \le M)$.

To circumvent effect of leakage of errors in geoid model solution the ideas of using an appropriate modification of the original Stokes kernel along with optimum value of spherical cap radius (Ψ_0) has gained significance in geodetic literature.

Optimisation process of gravimetric geoid solution

The Stokes kernel to a great extent forms a weighted integral function for gravity data in geoid model solution given by numerical solution of Stokes integral. This strong dependence of the geoid computation and associated errors on the kernel is the basis for any kernel modifications, the objective being to reduce the error. Since the basic purpose of determination of geoid is to transform the GPS derived ellipsoidal heights (h) to orthometric heights (H) using the relationship; h=N+H, the most appropriate form of kernal modification and optimum size of the cap radius is determined empirically on trial and error basis.

Choice of kernel modifications

The approaches of kernel modifications are broadly classified into two categories, deterministic and stochastic, The stochastic approach essentially requires the error characteristics of local gravity data and global geopotential model which is not known to a satisfactory level in most of the cases and hence are of limited practical applications. The deterministic approaches presented by Wong and Gore (1969), Heck and Grüninger (1987) and Vaniček Kleusberg (1987) are more frequently used in geoid computation and hence considered to be potential alternatives. All these approaches are related to each other in general as by making certain changes one's expression degenarates to the other the origin being the simple approach presented by Wong and Gore (1969) which involves removing the low – degree terms from the original kernel, according to:

$$S^{WG}(\Psi) = S(\Psi) - \Sigma^{P}_{k=2}\, 2k+1/k-1\ P_k(\Psi) \text{ ---------(3)]}$$

For $(0 < \Psi \le \Psi_0)$ and P<M (the maximum degree of geopotential model used).

This equation is also known as spheroidal Stokes kernel (Vaniček and Sjöberg, 1991, Featherstone, 2003) when P=M and is denoted as $S^P(\Psi)$). Heck and Grüninger approach is implemented by substracting spheroidal Stokes kernel $S^P(\Psi)$ at the truncation radius from the kernel itself inside the cap; This is

$$S^{HG}(\psi) = \{_{0}^{Sp(\psi)-Sp(\psi 0)\quad 0\le\psi\le\psi 0} \ \psi 0 < \psi < \pi$$

Another approach that addressed a better modification of the kernel though a little complex to implement is called Vaniček and Kleusberg approach and revised by Vaniček and Featherstone (1998).

The expression is

$$S^{VK}(\psi) = S^P(\psi) - \Sigma^{P}_{k=2}\ 2k+1/2\ t_k(\psi_0)\ P_k(\psi)$$

Which is dependent on the $t_k(\psi_0)$ co-efficient and $S^P(\psi)$. These coefficients are computed using the tools available in literature (for explanation see Featherstone, 2003).

Accuracy of computed geoid undulations depend largely on the extent of the terrestrial gravity anomaly data used around the computation point. Nagarajan (1994) has shown that due to propagation of error with increase in the cap radius beyond certain value ,does not improve rather degrades the geoid undulation results.The choices of size of the cap radius and approach of kernel modifications are strictly region dependent and till today no approach is claimed to be an ideal one which can straightway be used irrespective of the size and location of the area of interest. Therefore it is rather difficult to make the choice of most suitable kernel modification approach or size of the cap radius unless the geoid results are compared with the GPS – levelling observations results thus making it an essential component of gravimetric geoid computation process.

Case study

GPS-levelling and gravimetric geoid

In order to illustrate the procedure to achieve an optimized solution for gravimetric geoid the free air gravity anomaly data from Bangalore and adjoining region in a block of 2° X 1° was taken for computation. The RCR technique implemented in generalized Stokes scheme was adopted and contribution of EGM96 (Lemoine. et.al.) global geopotential model to degree and order of 360 was removed from the observed gravity data. A local DEM was also developed based upon the available height data in the region and terrain effect was removed from the reduced gravity anomaly data. The complete procedure is not explained here as the study is focussed on selection of most appropriate size of cap radius and approach of kernel modification to derive the gravimetric geoid solutions which is best fitted in least square sense to the geometric geoid derived from GPS observations at levelling bench marks.

GPS observations at about 84 leveling bench marks were carried out by Geodetic & Research Branch, Survey of India, as a part of project undertaken to provide Ground Control Points (GCPs) to develop a comprehensive development Plan for Bangalore City (See Nagarajan and Singh, 2005). Out of these 84 points 68 points were selected for performing a realistic assessment of geoid model and subsequently optimized the integral parameters of Stokes Formula.

In order to avoid the complexity in comparison of different geoid solutions correspond to different modification approaches with geometrically derived geoid heights from GPS-leveling observations, we have chosen the most widely used Wong and Gore (1969) approach and geoid solutions were obtained by varying size of cap radius (Ψ_0) and degree of modification P. For each typical combination of cap radius and degree of modification the fitting of gravimetric geoid heights to observed GPS – Leveling height differences at discrete points has been analysed and statistics of differences were computed. Fig. 2 to Fig. 5 represents the fit of gravimetric geoid heights to geometric geoid heights for different combinations.

Analysis of results

A visual inspection of above figures give an idea about the extent of deviation of gravimetric geoid heights from GPS – levelling geoid heights. It could be well ascertained that optimum size of cap radius should be larger than 1° and degrees of modification should be around 60 – 70 for this particular region in order to achieve an optimum solution for gravimetric geoid. It is further argued that due to varying error characteristics of gravity data sources, different results can be expected in different regions. It has also been seen from the Fig. 6 that any value below 1° of cap radius result in comparatively worse fit due to numerical instability in the solution.

However, as size of cap radius approach close to 1.5 degree the solutions attain the stability as evident from the Fig. 6 wherein it is clearly shown that increase in size of cap radius beyond 1.5 does not improve the root mean square (RMS) error of differences between gravimetric (computed) and observed geoid heights. Thus the most appropriate size of cap radius is 1.5° for the given data and now only task remains to determine the optimum value for degree of kernel modification P. This is again done by plotting the RMS error against each corresponding degree of modification for fixed cap radius of size 1.5° (see fig. 7). Featherstone (2003) demonstrated that due to removal of the low – frequency Legendre polynomials the spheroidal (Wong and Gore) Kernel oscillates between positive and negative values and the oscillation increases with increase in degree of modification. The increased oscillation of the kernel induced numerical instability in solutions of Stokes Integral. However, it is not always necessary that the lowest of the

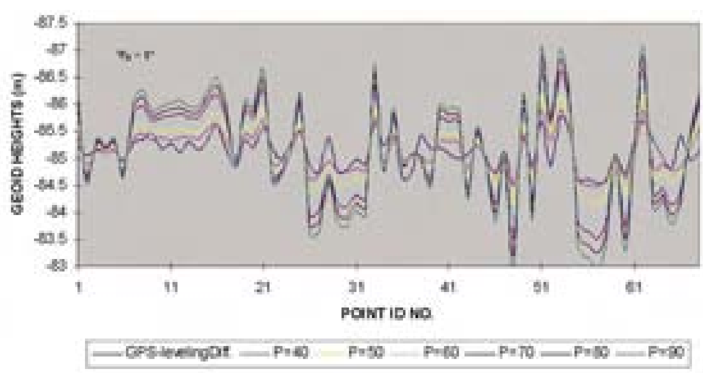

Fig.2 Comparison of observed (GPS-leveling diff.) and computed (gravimetric) geoid heights for $\Psi_0 = 1^0$ for different degrees of modification (P)

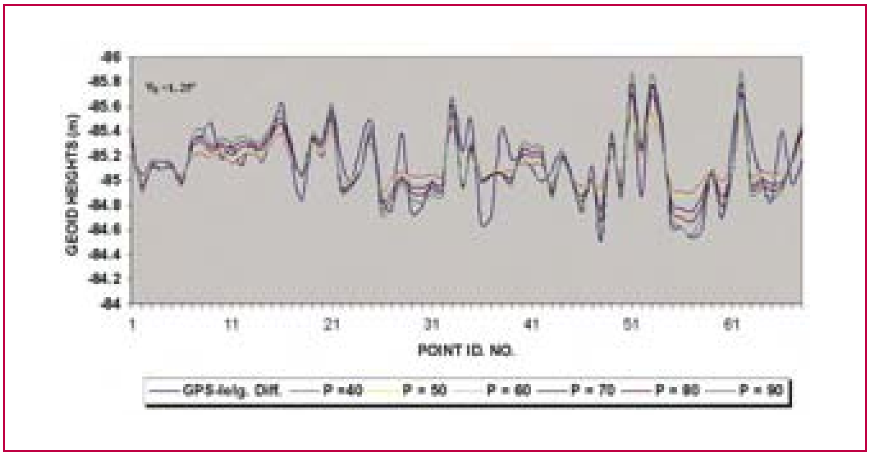

Fig.3 Comparison of observed (GPS-leveling diff.) and computed (gravimetric) geoid heights for Ψ_0= 1.25⁰ for different degrees of modification (P)

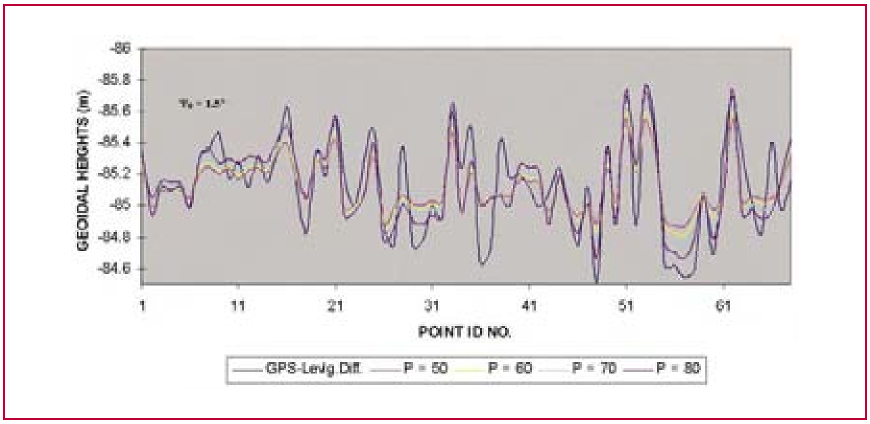

Fig.4 Comparison of observed (GPS-leveling diff.) and computed (gravimetric) geoid heights for Ψ_0 = 1.5⁰ for different degrees of modification (P)

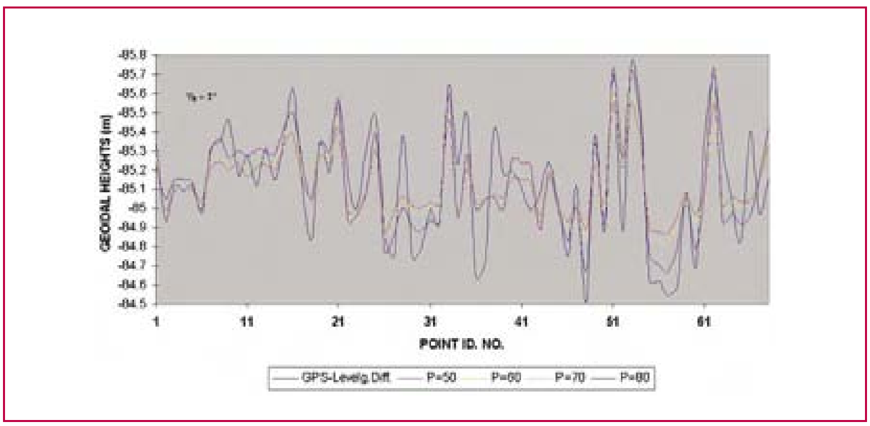

Fig.5 Comparison of observed (GPS-leveling diff.) and computed (gravimetric) geoid heights for Ψ_0 = 2⁰ for different degrees of modification (P)

low degree range gives better solutions. Considering these facts we testified the results starting with P=40 and allowed to vary in the step of 10 to evaluate the change in performance. The RMS error was taken as the standard parameter in order to select the optimum degree of modification. Fig. 7 clearly indicates that RMS error of the Least square fit is lowest for the solution derived using P=70 as degree of kernel modification.

The above illustrations gives an overview of the procedure to be adopted while deriving the optimum solution for gravimetric geoid. The GPS–leveling observations are of great help in this process and without it the quality assessment of gravimetric geoid solution can not be made with authenticity.

Conclusion

Rather than presenting simply the requirements of GPS – levelling data only for comparison purpose this study has focussed its importance in deriving an optimized solution of gravimetric geoid. Wonge and Gore modification approach was examined and its performance was evaluated by changing size of cap radius and degree of modifications which is an arguably more informative exercise rather than making the geoid determination as routine computation. The problems that may be encountered when practically applying the modified kernels have been described. The case study has practically proved the optimisation procedure to be followed and importance of GPS–leveling data in this process. However, because of the pecularities of local gravity data error characteristics the modifications approach and its parameter might vary from region to region in practical gravimetric geoid computation

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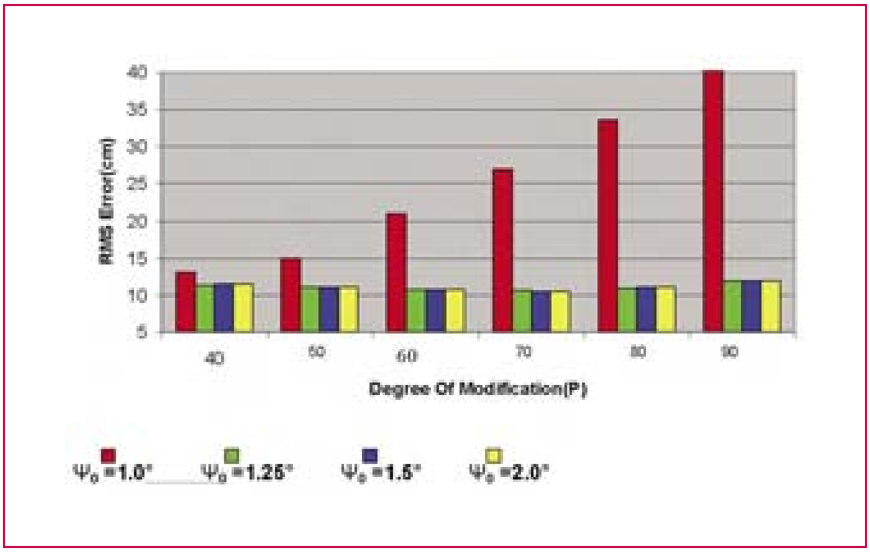

Fig.6 Performance evaluation of different cap radii (Ψ_0) for different degrees of modification (P)

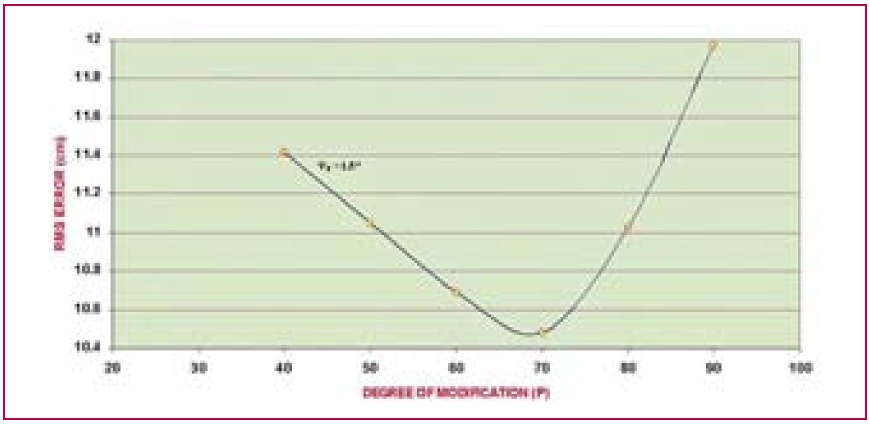

Fig.7 RMS Error variations for selected cap radius of size (Ψ_0 = 1.50) with degrees of modification (P)

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Products

New Tiny Surface Mount GPS Receiver

Trimble has introduced its new Copernicus GPS receiver – a thumbnail-sized, surface-mount, low power module ideal for adding GPS capabilities to Bluetooth appliances, sport accessories, personal navigators or cameras, computer and communication peripherals as well as vehicle tracking, navigation, and security products.

It enables system integrators to easily add GPS capability to a mobile device with minimal impact on its size or battery life at a very economical price. *www.trimble.com*

GNSS technology for surveying applications

The Leica Geosystems launches Leica GX1230 GG and Leica ATX1230 GG sensors for surveying applications as well as the GRX1200 GG Pro sensor for reference station networks. The new ultra precise GNSS measurement engine now supports both GPS L2C signals and GLONASS satellites. Users of these solutions will benefit by having up to 100 % more satellites available than GPS alone. These systems are designed to track future GNSS signals, such as GPS L5 and Galileo.

It also announces availability of Leica CloudWorx™ 1.0 for PDMS, that enable professionals to use rich, as-built point cloud data directly in their native desktop design and visualization platform. PDMS is part of AVEVA's VANTAGE Plant Design family. *www.leicageosystems.com*

Topcon opens G3 door to the future

Topcon Positioning Systems (TPS) introduces the Paradigm G3 chip, a new technology that sets the standard for the future of satellite positioning. The new Topcon G3 technology takes it a step further by adding the soon-to-be-available GALILEO . The G3 chip with its patented Universal Signal Tracking capabilities has 72 universal channels that can receive signals from up to 36 satellites simultaneously. G3 can track all signals from all available satellite positioning systems. It is designed to dynamically adjust to satellites with best signal strength. The streamlined chip profile is 75 percent smaller than current chips, enabling small, lighter receiver design. Users of Topcon Positioning Systems GPS+ technology and equipment can access three additional navigational satellites in the GLONASS system also. When faced with environmental challenges such as narrow streets with tall buildings, dense forests and mountainous terrain, Topcon's G3 system can provide better satellite coverage than before.

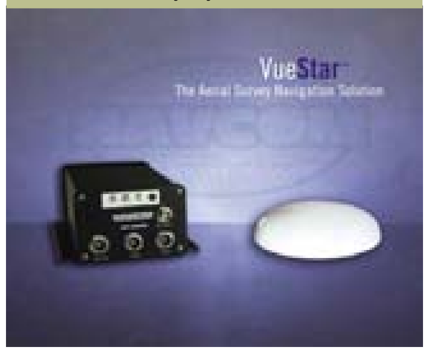
GfK MACON re-digitalizes topographical maps of India

The India Edition, which contains the world's only six-digit postcode map of that country, is being supplemented to include a lot of topographical information, including more than 3,000 new city points. It comprises detailed postal and administrative units as well as a large selection of topographical map layers, such as roads, railway lines, cities, rivers and elevations. The digital maps are supplied as vector data records in the standard GIS formats. *www.gfk-macon.com*

PCI Geomatics develops SAR Polarimetry Workstation

PCI Geomatics announces the development and release of the SAR Polarimetry Workstation (SPW) as part of the Canadian Space Agency (CSA) Earth Observation Application Development Program (EOADP). The SPW is available as an add-on module to Geomatica 10. It can directly read data products from the AIRSAR, ENVISAR ASAR, CV-580, and SIR-C systems. It is also able to read synthetic RADARSAT-2 data products and will be able to read the real data products once they become available. PCI Geomatics also released Geomatica 10 for Linux™ and Solaris™ users. The latest version emphasizes automation, productivity, and support for more than 100 geospatial data formats. *www.pcigeomatics.com*

Enhanced VueStar (TM) Aerial Survey System



NavCom Technology, Inc., announces the introduction of the newly enhanced VueStar(TM) aerial survey solution combining its new StarPac(TM) utility software that facilitates better integration into pre-existing workflows.

VueStar's complete global navigation system utilizes the global satellite-based StarFire(TM) Network to provide precise positioning worldwide without the need for RTK base stations or GPS post processing. This new system introduces three significant enhancements: Improved GPS signal processing, StarPac Mission software, and the optional Event Latch Interface. The 12-channel, dual-frequency GPS receiver computes real-time positions at up to 25 times a second, re-acquires GPS signals faster, and includes improved troposphere modeling which better compensates for changes in altitude. *www.NavComTech.com*

Garmin introduces portable GPS navigators

Garmin International, Inchas announced the GPSMAP378 and

GPSMAP 478 – two versatile and portable GPS navigators that come pre-loaded with a comprehensive set of maps and charts. The 2 navigators are waterproof to IEC 60529, IPX-7 standards (submersible to one meter for up to 30 minutes) and have a high-resolution 256-color sunlight readable TFT display. *www.garmin.com*

StreetPro Singapore version 3 by MapInfo

MapInfo Corporation announced the release of StreetPro for Singapore. It is a digital database comprising an extensive array of layers including a high quality street network, and a variety of contextual layers to enhance analysis and map presentation; integrated postcode boundaries and 6 digit postcode points supporting location intelligence, landmark and feature categories providing comprehensive local content and detailed coverage of the entire country. *www.mapinfo.com*

Next Generation Geospatial and Civil Engineering Solution

Autodesk, Inc. launches the Autodesk Civil 3D 2007, Autodesk Map 3D 2007, and Autodesk Raster Design 2007 software products. These new solutions enable the integration of computer-aided design (CAD) and geospatial information system (GIS) data allowing customers to create, manage and share valuable spatial information for better decision-making and improved operational efficiency helping municipalities, engineering and construction, public works, transportation and utility customers be more productive and provide better.

Earlier, it also introduced the new version of MapGuide Open Source, its next generation web mapping software originally called MapServer Enterprise, hosted by the Open Source Geospatial Foundation (http://mapguide.osgeo.org).

It is a free software which enables users to quickly develop and distribute spatial and design data over the web, as well as reduces their total cost of ownership for a web mapping solution. The company plans to offer a commercial version called Autodesk MapGuide Enterprise 2007 later this year.

Standard Galileo-ready Receiver & Antenna

NovAtel Inc. announces the release of its first production standard Galileo-ready receiver and antenna. Its L1L5E5a receiver offers superior 16 channel tracking of GPS L1/L5, Galileo L1/E5a and SBAS signals in a Euro form-factor card, packaged in a EuroPak enclosure. The complementary 704X passive antenna offers access to multiple GNSS including GPS, Galileo and GLONASS frequencies.

Innerspace Introduces Portable Hydrographic Survey System

The Innerspace Technology Model 620 Portable Hydrographic Survey System (PHSS) is designed to collect X-Y-Z data from a small boat. It is both easy to set up and easy to use and operation is self taught, no factory training is necessary. It consists of survey depth sounder, DGPS and Windows XP based hydrographic (X-Y-Z) data collection software. *www. innerspacetechnology.com*

Thales GPSDifferential Module

Thales has introduced GPSDifferential Module, a software extension for Mobile Mapper CE that seamlessly adds the power of post processing to virtually any mobile GIS/mapping software application. With this, sub-meter and up to sub-foot mapping is easy to achieve, even where real-time corrections are not available, or when used in difficult signal environments *www.thalesgroup.com/navigation*

Bentley Connects MicroStation to Google Earth Service

Bentley Systems announces that it has connected MicroStation to the Google Earth™ service. As a result, for the first time, users can view and navigate 2D/3D models of infrastructure projects in the context of the Google Earth environment.

Hemisphere introduces GPS for agriculture

Hemisphere GPS announces the introduction of Outback® BaseLine – high-definition GPS for agricultural applications that is much more accurate than standard GPS, and much more affordable than RTK GPS.

It is aimed at the large high-definition market – including row crop and controlled traffic applications – that welcomes enhanced GPS accuracy but rejects the high cost of RTK GPS. It's ideal for many agricultural tasks including planting, seeding, cultivating and harvesting. Farmers who haven't yet invested in GPS guidance can use one Outback BaseLine. *www.hemispheregps.com*

Business

GeoEye receives additional awards from NGA

GeoEye announces its Clear View contracts for map-accurate imagery and services with the National Geospatial-Intelligence Agency (NGA) have increased in value by an additional $13 million taking the total value upto $49 million in 2006.

These most recent increases represent additional imagery to be collected by the company's IKONOS and OrbView-3 high-resolution earth-imaging satellites. The contracts require GeoEye to complete a variety of specific imagery collections supporting many NGA requirements. *www.geoeye.com*

Infotech Enterprises gets multi million dollar contract

The Los Angeles Region Imagery Acquisition Consortium (LAR-IAC) -a consortium of 26 state and local government agencies within the county of Los Angeles (LA) USA has selected VARGIS LLC - a fully owned subsidiary of Infotech Enterprises Limited in U.S, to provide digital aerial imagery data with GIS, web mapping system with computer aided design and engineering design applications. It will be providing digital imagery data and related photogrammetric services for the entire LA country area. *www.infotechsw.com*

Bangladesh National Mapping from East View Cartographic

East View Cartographic (EVC) announces an agreement to become an official reseller of topographic and thematic maps from the Survey of Bangladesh. These nationally produced maps offer large-scale coverage available for Bangladesh and are ideal for uses such as project planning, natural resources development, trade and investment, humanitarian/disaster response, academic research, and even travel and tourism. The Survey of Bangladesh has also produced a number of specialized series including 1:10,000 coastal mapping, a Dhaka city plan at 1:5000 scale, and a variety of political-administrative and thematic maps. *www.eastview.com*

Intermap partners with Tele Atlas for navigation

Intermap has recently partnered with Teleatlas to develop vehicle navigation applications. The new collaboration combines Tele Atlas' 2D road data with Intermap's 3D NEXTMap data. The companies will first work to produce an operational scale pilot incorporating Intermap's 3D elevation map of California, the most accurate map of the state ever produced, and Tele Atlas road vectors. The resulting application will allow visualization systems to operate at higher levels of detail and accuracy than any other statewide dataset *www.tribuneindia.com*

POSTrack for remote sensing solution

Applanix introduces POSTrack, the first fully integrated, real-time direct georeferencing and flight management system designed to support aerial remote sensing solution. POSTrack streamlines mission planning and dramatically reduces in-flight operation workload stress *www.applanix.com*

Geokosmos announced its acquisition of UltraCAM-D

Geokosmos has announced its acquisition of the UltraCAM-D digital aerial topographic camera, a Vexcel Imaging (Austria) product. The Ultra-CAM-D is a full-scale digital aerial camera with the high-resolution rate (86,25 mega pixel), which will be used within the territory of the former Soviet Union states. It plans a joint use of the camera and aircraft-installed ALTM LIDARs, which will allow to create detailed texturing 3-D DTM and DSM

Boeing Awarded $240 Million JDAM Contract

Boeing received a $240 million contract from the U.S. Air Force to produce 10,000 Joint Direct Attack Munition (JDAM) tail kits for existing 500-, 1,000- and 2,000-pound bombs purchased by the U.S. Air Force and Navy. Known as the world's most accurate bomb, JDAM is a Global Positioning System-aided, near-precision weapon that has been used extensively in global operations by the U.S. Air Force and Navy. *http://webwire.com*

Chunghwa Telecom and SiRF to offer A-GPS services

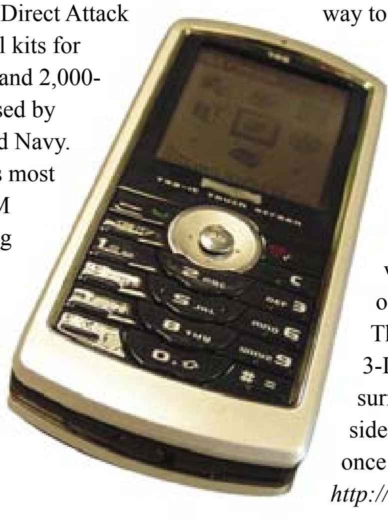
Chunghwa Telecom in Taiwan announced the formation of an alliance with SiRF International to establish an A-GPS platform for operation of mobile location services in the Taiwan market. CHT has finished R&D and testing of the A-GPS platform that integrates GPS technology with CHT's mobile communication infrastructure, It initially offered A-GPS services to Taiwan SECOM, one of the largest provider of security services in Taiwan, at the end of last year and plans to offer personal A-GPS value-added services to mobile communication users later this year. *www.digitimes.com*

World's Smallest Real-Time GPS Tracker

The WorldTracker SMS unit measures just 2.56 by 1.7 by 1.1 inches (45 by 66 by 25 millimeters) and weighs a mere 3.1 ounces (87 grams). The device is completely self-contained and features built-in GPS and GSM antennas, as well as a rechargeable lithium ion battery. It features a WAAS-enabled GPS receiver. The Federal Aviation Administration (FAA) and the Department of Transportation (DOT) developed the WAAS program for use in precision flight approaches.

Japan's KDDI offers 3-D navigation on cellphones

Japanese mobile operator KDDI unveiled plans to let users find their way to shops and restaurants by looking at 3-D satellite images on their cellphones. The service is an updated version of its already popular "EZ Navi-Walk" programming which uses the GPS and offers vocal guidance. The new version offers 3-D images that show surrounding buildings and side streets or directions once one is inside a building. *http://mybroadband.co.za*



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GLONASS for civilian use in 2006

The restrictions on precise satellite definition of on-land coordinates will be lifted by yearend, a senior military official said. Lieutenant-General Valery Filatov said the location of geographical objects at accuracy of up to 30 meters would be available for civilian use from the Russian GLONASS satellite system and the US GPS. *www.spacedaily.com*

Oregon testing new GPS-based road tax system

US state Oregon is investigating a new method of assessing taxes used to bankroll state highways. Instead of collecting money via gasoline taxes, Oregon is testing a GPS-based system, which levels taxes based upon miles driven.

By switching to such a system, the state would not lose revenue with every resident that purchases a more fuel-efficient vehicle. The 'black box' system keeps tabs on how many miles are racked up both in and out of Oregon's borders, as well as during rush hour, and levies taxes on the totals accrued. As things stand, Oregon derives some 80-percent of its highway funding from its 24-cent-per-gallon tax, thus the move towards more fuel-efficient vehicles stands to negatively impact the state's coffers by millions of dollars. *http://sports.autoblog.com*

US 3.3 billion GPS products from China - Taiwan

Mainland China and Taiwan are expected to manufacture a combined US$3.3 billion worth of GPS products in 2006—an increase of 20 percent. 80 percent of production is expected to be exported. China Sourcing Report provides production; technology, price and component supply forecasts for the GPS industry in both the countries. It features detailed profiles of 32 leading manufacturers compiled through factory visits, plus specifications for 112 popular export products. *www.pr.com*

China steps towards securing the country's cultural safety

Archeologists in China are launching a new round of investigations to determine the number of sites of historical interest and to protect them better. They will be using technologies such as GPS, aerial photography, remote sensing, digital cameras and computers to survey sites of historical interest across the country. The investigation is an important step towards securing the country's cultural safety. *www.shanghaidaily.com*

Tracking buses in Indore, India

Indore City Transport Service (ICTSL) will soon introduce the GPS for an online bus tracking system (OBTS) to offer better facilities to commuters in this Indian city. ICTSL held a pre-bid conference for the project. It is planning a control room for OBTS, and every bus would have a GPS-based tracking device installed with online data transfer facility. Initially it will flash the estimated time of arrival at 50 bus stops. *www.business-standard.com*

GPS collars for Kashmiri red deer

The Jammu and Kashmir Wildlife Department, India, has opted for GPS to monitor the endangered red deer or the Kashmir stag. In collaboration with the Dehradun based Wildlife institute, the department has procured 8 GPS collars from Germany. *www.indianexpress.com*

Indian schools to be mapped with GPS

As many as 56,000 schools in Tamil Nadu, India will be mapped with the help of GPS to facilitate future decisions on upgrading the schools or giving funds. The data will contain details on the number of schools, students in each school, number of teachers and the student-teacher ratio in each hamlet. The project has been launched by the state's Madurai Kamaraj University and the Bharatidasan University in collaboration with the government programme 'Sarva Shiksha Abhiyan' (SSA), education for all. *www.newkerala.com*

Vehicle tracking device in Ludhiana, India

Micro Technologies in India launches a special software package in Ludhiana for truck and bus-fleet owners, called Micro VBB Marshal. The software identifies the location of vehicles and ensures the safety of passengers. Ludhiana has one of the largest fleet-owning communities in the country. As of now, the company has stocked the product with leading petrol pumps and prominent dealers in the city. This mobile phone and GIS-based vehicle location and tracking application security product with messaging system is available at an array of dealers in the city. *www.business-standard.com*

Border inspection mapping operation

China and Nepal will jointly launch a border inspection mapping operation. Both countries will apply GPS to survey the border marks. The major mapping work will be done by Chinese workers and then workers from Nepal will check the mapping data and results. The Surveying and Mapping Bureau of Shaanxi, from northwest China, has been appointed to take the task and will form the main body of the China team. The first batch of mapping workers are scheduled to arrive in the China-Nepal border area next month and all the outdoor surveying is planned to finish by the end of September. It is expected that the final mapping outcome will be unveiled by the end of 2007. *www.vnagency.com.vn*

New land-use map for Kathmandu valley

Town Development Committee (TDC) of Nepal, under the Ministry of Works and Physical Planning, is set to come up with a new land use map of the Kathmandu Valley soon aiming at finding out the changed land use pattern over the two decades. The existing land use map was prepared 22 years ago. Preparation of the detailed land use map would finish within the current fiscal year. *www.gorkhapatra.org.np*

Indonesia enters into agreement for spatial data interoperability

Indonesia's National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL), and Credent Technology Asia signed a Memorandum of Understanding (MOU) to foster the application of interoperability standards and support the implementing of National Spatial Data Infrastructure policy in Indonesia. This MOU also includes an Intergraph's Open Interoperability Grant through Intergraph's Open Interoperability Grant Program, with a commercial value of more than US$12.4 million *http://www.credent-asia.com/*

Pakistan gets satellite data equipment

China has provided meteorological satellite data reception equipment to Pakistan to help reduce natural disaster and gather data for a variety of purposes. This technology would provide real time data collected by China's Fengyun meteorological satellite series. *www.hindu.com*

Singapore completes first phase of Tsunami Warning System

Singapore announced the completion of the first phase of its Tsunami Early Warning System while celebrating this year's World Meteorological Day. Phase one of the system provides Singapore with the capability to exchange real-time earthquake data with seismic networks operated by countries in the region. Developed by the Meteorological Services Division of the NEA, the system worth 3 million Singapore dollars is expected to be completed by the end of 2007. *www.hinduonnet.com*

nowCOAST Web Mapping Portal goes live

NOAA has launched an updated version of the nowCOAST web portal. It is a web mapping portal providing coastal communities with real-time observations and NOAA forecasts. It allows users to view real-time surface observations 'on-the-map' along with the latest GOES satellite cloud imagery and NOAA National Weather Service weather radar images. *www.noaanews.noaa.gov*

Satellite imageries enhance map of Kolkata

Kolkata Municipal Corporation (KMC), India would shortly develop a map enhanced by satellite imageries of the entire city of Kolkata. It will provide the entire satellite mapping of the city. Kolkata will be one of the first Indian cities to have its own unique satellite map. The map, developed through picture taken either through satellite or from the air, has been developed by Riddhi Communications and Netguru India has been assigned the task of maintaining the site. A GIS model has been utilised in preparing the satellite map of the city. *http://dnaindia.com*

Geomorphology study for Indian district

Tiruchy district in India has been selected for a national geo-morphological study. The five districts are: Tiruchy (granitic terrain), Jalore (desert), Himachal Pradesh (Himalayan terrain), Mahanadhi delta (coastal terrain) and Madhya Pradesh (Deccan trap). The imageries would be utilised for the development of the economy. The study will be conducted by the National Resources Repository in association with the Geological Survey of India. *www.newindpress.com*

GRASS GIS 6.0.2 released under General Public License

The Geographic Resources Analysis Support System, commonly referred to as GRASS GIS, is a GIS used for data management, image processing, graphics production, spatial modeling, and visualization of raster, vector and sites data. It is open source Free Software released under the GNU General Public License (GPL). The new features of GRASS 6 cover a new topological 2D/3D vector engine and support for vector network analysis. Attributes are managed in an SQL-based DBMS. A new display manager has been implemented. The NVIZ visualization tool was enhanced to display 3D vector data and voxel volumes. Messages are partially translated (i18N) with support for FreeType fonts, including multibyte Asian characters. GRASS is integrated with GDAL/OGR libraries to support an extensive range of raster and vector formats, including OGC-conformal Simple Features.

Forest cover in Philippines on the rise

The Department of Environment and Natural Resources (DENR) revealed recently that satellite imagery and remote sensors indicate that the forest cover in Central Luzon has increased to 7.2 million hectares from 6.5 million hectares in 1988. *www.manilastandardtoday.com*

NOAA sponsors Remote Sensing Market Survey

The U.S. National Oceanic and Atmospheric Administration (NOAA) Satellite and Information Service has awarded the 'NOAA Remote Sensing Survey and Analysis of the Asia Aerial and Spaceborne Remote Sensing Market' to Global Marketing Insights, Inc. This is a follow-up to the global survey conducted in 2005. The new project will study aerial and space-borne remote sensing trends and activities in more than 20 Asian countries. Global Marketing Insights shall cover eight sectors : aerial film, aerial digital, aerial sensors, satellites, commercial end users, value added hardware and software, academic and government.

Space accords signed during Russia PM visit

India and Russia signed two agreements on jointly launching and developing satellites for the space-based global navigation system during Russian Prime Minister Mikhail Fradkov's New Delhi visit . These agreements would put into the practical plane Indo-Russian accord on India's participation in operationalising and commercialising the ex-Soviet GLONASS, signed during Russian President Vladimir Putin's India visit in December 2004. *http://sify.com*

India, Myanmar sign Remote Sensing agreement

An agreement for mutual cooperation in the field of remote sensing between India and Myanmar was signed as per which India will provide Myanmar access to data from Indian remote sensing satellites at subsidized rates. India announced a grant of USD 1.3 million for upgrading Remote Sensing Ground Receiving Station in Yangon and another grant of USD 3 million for assistance with delineation of Myanmar's continental shelf in addition to technical assistance for the project.

Google Mars explores the Red Planet

Google Mars allows users to view the surface of the Red Planet either by a colour coded altitude map, black and white photographs, or an infrared map.. Another service, Google Moon, lets users to view the sites of moon landings. The maps used on Google Mars were made from images captured by NASA probes Mars Odyssey and Mars Global Surveyor, both currently orbiting the planet. *http://news.bbc.co.uk*

China to launch 18 land observation satellites

The China Center for Resources Satellite Data & Application (CRESDA) announced that China will launch 18 land observation satellites in the next ten years. The Sino-Brazil earth resource satellite 02B will be launched in 2007 and its data will be released for free. The 18 satellites made up of land resource and environmental series, together with the marine and meteorological ones, will help China build up an earth observation system for long- term stable operation *http://english.people.com.cn/*

Flood-mapping service in eastern France

A satellite-based rapid mapping service developed in eastern France is now ready and on call 24x7. This service has been designed to manage floods. Apart from being applied to risk assessment and prevention efforts, the ESA-backed Flood Plain Monitoring Service aims to deliver map products to end users within six hours during times of crisis. *www.innovations-report.de*

Satellite based natural resource census in Orissa

A satellite-based natural resources census is to be launched by Orissa Remote Sensing Application Centre (ORSAC) in the Indian state of Orissa soon. This remote-sensing and GIS-based census would be carried out over a period of two years in all the 314 blocks of Orissa. The ORSAC has signed an MoU with the Department of Space for the purpose. ORSAC has also tied up with Indian Space Research Organisation to secure two-phase satellite imagery from IRS I-D and ResourceSat. Apart from land use, it would also carry out a forest survey. The census, which would take at least two years, will also conduct a two-phase survey of the crop during rabi and kharif seasons. *www.newindpress.com*

First Images from Goodrich Optical System

The Japan Aerospace Exploration Agency (JAXA) has released the first images from the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) payload on their Advanced Land Observing Satellite (ALOS). The imagery was released less than one month after the ALOS launch, much quicker than is typical for sophisticated imaging systems. The images clearly show objects as small as cars and the stereo imaging, a unique capability for an Earth observation satellite, allows generation of three-dimensional "fly-by" movies *www.jaxa.jp/press/2006/02/20060215*

New iceberg spotted near Antarctica

The National Ice Center, US, using satellite imagery from the Defense Meteorological Satellite Program, spotted an iceberg now named D-16. The iceberg is about 8 miles wide and 15 miles long. The city-sized iceberg broke free of the Fimbul Ice Shelf, a large glacial ice sheet along the northwestern section of Queen Maud Land, in the eastern Weddell Sea near Antarctica. *www.livescience.com*

"The wireless market can transform the way people do business"

says Dr Vanessa Lawrence, Director General and Chief Executive while discussing the latest trends and activities at Ordnance Survey

What's the latest in Ordnance Survey?

We are taking several important steps towards an enhanced data capture, management and supply process focused on the needs of our customers and partners. Pressing ahead with plans for an integrated IT architecture and data model will enable seamless data collection, storage and management to address the growing demand for location information. The new system will manage a greater volume of data while enabling more efficient collection, boosting the potential for new products while ensuring currency and consistency between all existing datasets. We are completing a comprehensive six-year programme of positional accuracy improvement (PAI) affecting around 155,000 square kilometres of Great Britain. The programme was prompted by advances in surveying technology that made it difficult to align higher-accuracy work to rural mapping previously surveyed at 1:2 500 scale. PAI, which has involved extensive customer contact, is a vital underlying element in ensuring our product portfolio remains interoperable.

The last year has seen a large increase in the numbers of customers and partners moving from dependency on older large-scale products to OS MasterMap, our latest generation of data surveyed at 1:1250. In so doing, customer and partners gain the scope to use structured, intelligent and well maintained geographic data as a fully integrated business database.

Enhancements soon to be incorporated into our most highly detailed address data – OS MasterMap Address Layer - will add 1.3 million buildings to the spatial dataset. Address Layer 2 will include a geographic alternative such as the locality or district name and alias details, such as the name of the property as well as its number and street. Previously "non-addressable" properties - those without letterboxes such as utilities plant, community halls, churches and public conveniences - will prove vital references for emergency response, civil contingency planning, risk assessment, asset insurance, planning, customer services and asset maintenance. Each building will be classified as "residential" or "commercial", and a cross-reference table will link our data with that of other key address providers.

"Freedom of Information" what do you mean by this?

The Freedom of Information Act (FOIA) 2000 came into law in Great Britain in January 2005. It gives the right to any person making a request of a public authority (including Ordnance Survey) to be told whether it has the information they are interested in and to have that information given to them. The aim is to ensure there is openness and public accountability in government activity, balanced with the need to protect legitimate confidential information. Since the Act came into operation, Ordnance Survey has responded to almost 200 requests from individuals and organisations. Government analysis has consistently found our response rate to meet or approach 100% within the standard statutory deadline of 20 days.

However, I want to make it clear that prior to the FOIA, we already had an established customer contact centre handling in excess of 2,500 enquiries per month, demonstrating our commitment to operating within the spirit of the legislation even before it came into force.

Tell us about the National GPS Network

The National GPS Network is an infrastructure of active and passive Global Positioning System (GPS) reference stations enabling surveyors to determine precise coordinates in GPS and British National Grid spatial reference systems. Over recent years, considerable progress has been made in enabling the use of GPS technology within the National Grid by defining published coordinate transformations, most recently OSTN02.

In December 2005 we launched OS Net, a publicly available GPS correction network, enabling up to centimetre-accuracy data collection and a range of positioning services both in real time and for post-process applications. This 90-strong base station network is the country's most comprehensive high-accuracy positioning framework and has already delivered significant efficiency improvements for our 285 field surveyors.

The network has been trialled by major utility companies, and partners can add their technical and commercial expertise to develop positioning applications tailored to their customers' requirements. This means utilities, construction companies and other users of high-level positioning services no longer have to set out their own base station network to use centimetre- or decimetre-level GPS. Potential benefits include cost savings in hardware, set-up and maintenance for industries including construction, land survey and agriculture.

It is said that with the services offered by the website, you can achieve high absolute positioning accuracy throughout Great Britain. Please elaborate.

The GPS website (www.gps.gov.uk) provides a coordinate converter to transform horizontal and vertical coordinates to ETRS89 (GPS) coordinates and vice-versa. The precise transformations can be downloaded free of charge and incorporated into third-party software packages. The website also gives access to a database of passive stations with precisely measured GPS coordinates and there is a facility to download data from active GPS stations for post-processing user data to improve the level of precision.

The GPS correction network has boosted the amount of free raw data available on the website by 90% for GPS users including civil engineers and surveyors, asset managers, engineers and academics.

Data from individual OS Net stations is fed to the website directly from one central server held at our head office rather than from each one individually. This has speeded and streamlined the delivery of real-time data to customers, safeguarding accuracy through direct data flow.

How active is private sector in the activities of Ordnance Survey?

As Great Britain's national mapping agency, Ordnance Survey operates as a public sector trading fund which means we are financed through data licensing rather than direct funding from the tax-payer. The aim is to provide a sharper focus on achieving value for money and providing key services and supplies more effectively. Last year we returned a trading revenue of £100.4 million. We receive more than half of our trading revenue from the private sector and work alongside partners and customers to develop and deliver our products and services.

Our geographic information underpins an array of tasks such as performance analysis, asset management, consumer profiling, routing and supply chain management. The accessibility and flexibility of our digital data presents new and exciting possibilities for customers and partners and can help inform policy and planning, deliver improved services, join up disparate datasets and boost process efficiencies.

Awareness and use of location information is growing rapidly across the private sector, with GI underpinning a growing number of services and processes across many markets. We collaborate with a wide range of partners and developers who evolve products and services based on our GI. System suppliers develop data-enabling tools, software and services to enable the management and integration of our data.

Given the terrorist attack last year in London, do you think that there is a need to restrict spatial data access to genuine users only?

You have to understand that Ordnance Survey information underpins £100 billion of economic activity in Great Britain every year. That is about 8% of GDP. It is used in a vast range of applications from educational provision to emergency services. To restrict this information would have a great impact on our economy. The issue is to make sure that all our data is licensed to end users. We will continue to highlight the benefits of GI as location data moves further into the mainstream. As this information is being handled by an increasing number of people with less specialist GIS knowledge, systems will become easier to use. Like any other data business, we are well aware of the balance to be struck between providing data for the legitimate user of information and protecting society from perceived threats. Our view is that the potential for misuse is overwhelmingly outweighed by the tremendous benefits that our data brings to society.

Our Mapping for Emergencies scheme supplies paper map products and GI to national organisations and emergency services to support their response to major civil crises. In the immediate aftermath of the London bombings, we worked alongside other government agencies to produce a range of wall maps, flyers and handouts incorporating

London Transport data. In the weeks that followed, we supplied a number of organisations with full national coverage of requested data products to inform their contingency planning.

Galileo will be able to break the existing US monopoly. Comment.

Ordnance Survey strongly supports the evolving Galileo satellite navigation system. Galileo is still some years away but it has the potential to deliver major advances to the location industry and beyond. The ideal scenario will be if the European and US systems can be made as interoperable as possible. Combining the two will benefit mobile internet services, positioning and navigation systems, road charging schemes and many other applications, physically providing greater signal availability, redundancy, acquisition speed and accuracy over and above GPS on its own.

While assurances have been made regarding GPS availability, there are no guarantees. Galileo has been developed by the European Union to specifically benefit the European citizen. It will have guaranteed levels of service and the legally binding operational assurances that are needed for public safety as well as commercial services. Galileo will therefore provide a stable satellite navigation system, delivering the consumer confidence necessary to stimulate investment in the development of end user applications. Increased redundancy and integrity will create the potential to derive a wider breadth of services.

Galileo will facilitate efficiencies in our field data capture process, while all professional users of satellite navigation will enjoy greater signal availability, acquisition speed and accuracy to enable or support initiatives including improving personal safety, reducing traffic congestion and the location and relocation of utility assets.

How do you see the emerging market of LBS?

The wireless market can transform the way people do business, with mobile and fixed broadband connections enabling customers to transfer and receive a mass of information. GI can greatly boost this market, adding valuable context to information disseminated via high-bandwidth wireless connections helping companies to make services relevant and personal to a customer's physical location.

Beyond information delivery, geographic data can greatly assist in the planning and implementation of wireless infrastructure, aiding the rollout of masts by assessing their physical locations. Projects can be managed remotely, saving time and costs by identifying potential issues at the planning stage.

The LBS market is estimated to reach 200 million EUR by 2007 and wireless carriers around the world are location-enabling their networks to facilitate worldwide demand for LBS services such as social networking, gaming, personal navigation and directions.

GIS provides the tools to deliver and

Vanessa Lawrence is Director General and Chief Executive of Ordnance Survey, Britain's national mapping agency. A world renowned geographer, she is responsible for creating and maintaining the master map of the entire country, from which Ordnance Survey produces its intelligent geographic information, digital map data and paper maps. As the head of Ordnance Survey, Vanessa is adviser to the UK Government on mapping, surveying and geographic information. On her appointment to head Ordnance Survey in 2000, she was described by the Government Minister responsible for the mapping agency as "a world-class professional known in both the private and public sectors for her vision, dynamism and wealth of knowledge."

Since then, she has helped reshape and restructure Ordnance Survey to make it much more customer focused and led a comprehensive strategy to transform it into an e-business technologically, commercially and culturally. The strategy has won distinguished praise from Ministers, and as a result Vanessa has been personally appointed one of the government's official e-champions. In addition, she was made a non-executive director of the Board of the Office of the Deputy Prime Minister (ODPM). Another key highlight of the past five years has been the complete restructuring of the topographic database that underpins mapping in Great Britain; this involved a large IT project delivered on time and to budget. The launch of OS MasterMap, the new definitive map database backed by an online service, means information from both the public and private sector can be successfully 'joined-up' offering potential benefits to the whole nation.

Following a degree in Geography at the University of Sheffield, Vanessa gained an MSc in remote sensing, image processing and the application of geographic information systems at the University of Dundee. In 1996 she joined Autodesk; firstly as Regional Business Development Manager and then Global Manager - Strategic Marketing and Communications for the GIS Solutions Division. She has been awarded an Honorary Doctorate at Oxford Brookes University and an Honorary Degree of Doctor of Laws at the University of Dundee. In addition, she has been awarded Honorary Degrees of Doctor of Science from the University of Sheffield, Kingston University, the University of Glasgow and The Nottingham Trent University. She is a Visiting Professor at Kingston University and the University of Southampton. She was appointed a member of the Council of the University of Southampton in 2002. She is a companion of the Chartered Management Institute, a Fellow of the Royal Institute of Chartered Surveyors, and a member of the Council of the Royal Geographical Society.

administer base map data such as man-made structures (streets, buildings) and terrain (mountains, rivers). It is also used to manage points-of-interest data such as the location of petrol stations, restaurants and nightclubs.

The rollout of 3G mobile phone systems has been somewhat slower than anticipated due to the cost and complexity of the new access network the technology requires. This has reciprocally affected the growth of location-based technologies. However, Galileo will offer a good platform for them, especially if more handheld devices are fitted with GPS.

What are your future plans in Ordnance Survey?

A central part of our future vision is a new corporate headquarters suitable for a forward-looking information and technology organisation. In December 2005 we announced plans to move from our current building in Southampton to a development site on the edge of the city. This is a sound investment which means we can continue to offer efficient, attractive working conditions in the area for staff. Such is the scale and complexity of the project that we are not likely to move until 2008.

Our products and services will continue to be driven and shaped by customer demand and it is a priority to continue to respond to their evolving needs. As a government trading fund, our activities are financed through data licensing rather than direct funding from the taxpayer. This gives us the scope to deliver products and services that reflect market demand while completing essential activities vital to the national interest but which cannot be justified on purely commercial grounds.

The Digital National Framework (DNF) is becoming the de facto enabling standard facilitating the sharing and integration of GI from multiple sources. The collection and use of mapping data to DNF standards will facilitate the linking up of disparate datasets belonging to a range of organisations. Promoting the potential of cooperation across the GI community will facilitate, I believe, greater use of geographic data for decision-making within both the public and private sectors.

Medium-term research into future applications to evolve data capture techniques, boost data interoperability and add spatial intelligence to navigation, gaming, asset management and tourist information products has a considerable focus at Ordnance Survey.

A number of pioneering ideas are under development within our Research and Innovation department and with external commercial and academic partners.

Remembering Everest

Beginning with this issue, JR Smith traces the life and work of Sir George Everest

Coordinates pays tributes to legends of mapping sciences. One way to do this is to revisit their contributions to the science. In this effort, we are pleased to introduce a series by Jim Smith, author of *Everest, The Man and the Mountain*, on Sir George Everest.

My interest in Everest came about in two ways. Firstly in the early 1980s I had the idea of compiling a history of land surveying. It was soon obvious that it was a far too wide a topic to do justice to so I refined it to a history of geodesy – still in itself a large subject but hopefully manageable. Then around late 1989 it was pointed out to me that 1990 would be the 200th anniversary of the death of Sir George Everest.

At that period I was much involved in the Royal Institution of Chartered Surveyors and its technical meetings and considered that something should be done to commemorate the Everest event. This was to lead to two notable events, one in London and the other in India at Dehra Dun.

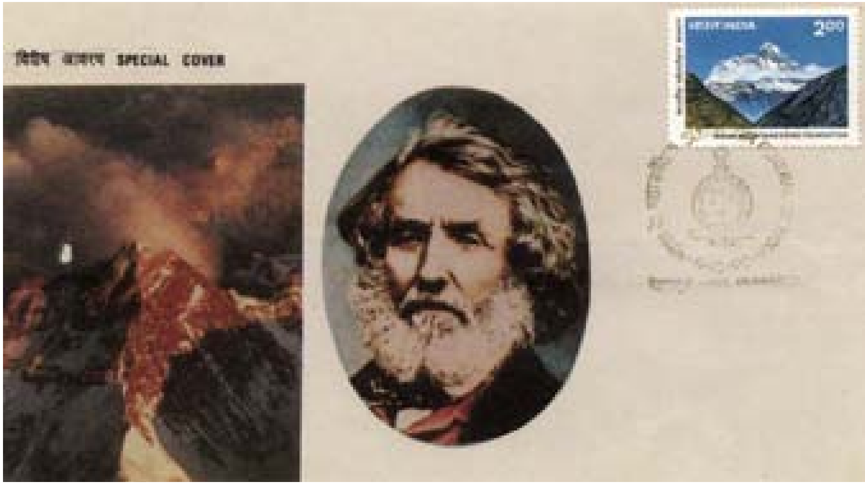
I began by looking for a biography of him but it soon became apparent that no such volume existed. That seemed strange for a person of his status and the fact that a major world feature was named after him. However it became obvious that such was the case so I took it upon myself to compile what I could.

The Survey of India marked this occasion with a gathering in Dehra Dun on 4 October 1990. Many dignitaries and numerous surveyors from around India attended. This was the occasion to launch several special Everest maps and a First Day postal cover. In addition delegates were presented with a memento in the form of a model of the Great Theodolite. The delegates from the U.K. presented the Survey of India through its Surveyor General Lt.Gen.S.M. Chadha with a framed painting of the Everest Coat of Arms as used by Sir George after he retired to England. This painting was specially commissioned by the Royal Institution of Chartered Surveyors and Royal Geographical Society and was executed by the heraldic artist Henry Gray. Various talks were given by a range of notable speakers from India, the U.K. and the United States.

That evening special busts were unveiled in the grounds of the Survey of India to commemorate Sir George Everest, Nain Singh and Kishen Singh. At the same time the National Survey Museum was inaugurated by Mrs Suda Gowariker.

The following day delegates had the opportunity to visit the Everest Estate in the hills above Mussoorie. Here we could not fail to be captivated by the superb scenery and general location of the Estate. The tragedy was that the building was in ruins and it was hoped by all there that it could be restored and put to some useful surveying purpose such as a survey school. Whether that ever happened is not known.

In London, as in India, a special First Day postal cover was launched for 4th July. A Committee was formed and arrangements made for a conference to be held at the Royal Geographical Society in London on 8 November 1990. Some 75 delegates, speakers and guests attended and 8 technical papers presented. Among the guests were the then Surveyor General of India, Lt.Gen.S.M. Chadha and his later successor as Surveyor General, Sri V.K.Nagar; also in attendance were H.E. Maj.Gen. Bharat Kesher Simha from the Royal Nepalese Embassy and Col. Gupta of the Survey of India. The technical papers covered a wide range of aspects including the general Mapping of British India from 1757 to 1830; The Instruments of the Time; Everest's time at the Cape of Good Hope; His achievements in Geodesy; The New map of Mount Everest; The Present time at the



Survey of India and a Short Biography of the Man. During the events a presentation was made by General Chadha to The Royal Institution of Chartered Surveyors of a painting of Everest's Estate near Mussoorie.

It became obvious as I compiled my contribution to that conference of the short biography of him that sources of information about his personal life were almost non-existent. Hence the reason why no-one had previously tried to compile any story of his life. The reason for this became clear upon perusing some of the published writings of his niece Mary Everest Boole. In one of her articles she said " .. That circumstances into which I cannot now enter, led to the destruction of nearly all written memorials of his life…."

No other references have so far brought to light what those circumstances were although there have been various un-substantiated suggestions. Unlike most other important scientists and notable persons of his time he appears not to have deposited any of his papers in a national archive for posterity so subsequent researchers had but scattered crumbs to draw upon. This should not be confused with his professional life which as far as the Survey of India is concerned is well documented and archived in Delhi as will be seen as this series progresses.

Sparked by the knowledge that this great person had not been written about in any detail and coupled with the interest shown at the events in India

and London I set to and gathered as much as I could about him. It is this that will be related in a series of short articles over the coming months.

If any readers can add to the information given in any of these instalments or wish to comment on it in any way then I would be very pleased to hear from them. Much of the content will also be found in :- Smith, J.R. 1999. Everest. The Man and the Mountain. Whittles, Scotland.

JR Smith
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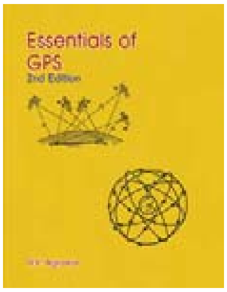
BOOK REVIEW



Essentials of GPS

2nd Edition
NK Agrawal
Price: Rs. 260/,
Pages: 145

Reviewed by Dr I V Murali Krishna
Professor and Head, Jawaharlal Nehru,
Technological University, Hyderabad

The 2nd edition of the book contains questions included after each chapter, which makes it more useful for students and teachers of colleges and universities, where GPS is being taught. It qualifies now to be introduced as textbook. Some new articles on GPS by the author, which have been published in various journals, have been included in the book. The book contains fundamental and essential information required for students, teachers and practicing, surveyors, scientists and all those who are using GPS in anyway.

It has chapters on Geodesy, Indian Geodetic Datum, WGS 84, DGPS, GPS Observable, Errors, Applications and Definitions. It also contains useful and interesting articles on various aspects of GPS by the author.

The book covers entire syllabus of the subject GPS of courses M. Tech. (SIT) and M. Tech. (RS and GIS) of JNTU Hyderabad. The book will be extremely useful to the students and teachers of Geodesy, GPS, Geology, Geography, Geo-Physics, Science, Engineering, Geophysics, Oceanography, space sciences etc., and all those who are interested in GPS. This is the first Indian book on GPS and priced moderately. Shri Agrawal deserves congratulations for bringing out 2nd edition. I recommend it as a valuable book for students, teachers and professionals.

The author, Mr. NK Agrawal can be contacted at ***nande@rediffmail.com***

Galileo update

Galileo – the European Programme for Global Navigation Services for civil purposes is an initiative led by European Union. We provide regular updates to our readers on the Galileo programme.

Europe and Russia to restart talks on Galileo and Glonass operations

Negotiations on interoperability between the European Galileo and Russian Glonass satellite navigation systems are expected to restart soon, after a yearlong hiatus. The hope of talks follows an agreement on dialogue structures between the European Commission and Russia's Federal Space Agency (FSA).

A trilateral steering board has been created for discussions between the EC, European Space Agency and the FSA. ESA already has working groups covering areas of co-operation under its framework agreement with the FSA, including satellite communications, global navigation and technology. These will include EC representatives and will report to the new steering board. A new working group on Earth observation will also be created. *www.flightglobal.com*

Emergency service based on Galileo precursor EGNOS

Alcatel Alenia Space has announced that it will demonstrate the first emergency service based on EGNOS, a precursor of Galileo, in Lisbon, Portugal. The integrated end-to-end Location-Based Solution (LBS), designed under the coordination of Alcatel Alenia Space, enables the Civil Security forces and Fire Brigades to locate emergency calls from mobile phones and efficiently guide the intervention team. Using EGNOS-enhanced accurate positioning integrated with the telecom network and the emergency control centre application, the service improves the speed and efficiency of the rescue, increases the team safety and optimizes the resources needed for overall incident management.

This emergency management solution has been developed in the scope of the European Research and Development project SCORE (Service of Coordinated Operational Emergency & Rescue using EGNOS). As prime contractor of SCORE, Alcatel Alenia Space is leading a consortium of 8 European companies dedicated to establish solutions for emergency call positioning (E112) and rescue force guidance during accidents or natural disasters.

Launched in February 2004, SCORE is managed by the GJU (Galileo Joint Undertaking) and publicly funded under the 6th Framework Program of the European Commission, with partners coming from Austria, the Czech Republic, France, Italy, the Netherlands, Portugal and Spain. *www.spacedaily.com*

Launch of second Galileo test satellite postponed

The second experimental satellite, Giove-B, for the European satellite navigation system Galileo will probably be postponed several months. Instead of being launched in April, the satellite called Giove-B will probably take off between September and November, a spokesperson from the European Space Agency ESA told. *www.heise.de*

Water vapour estimation at few GPS sites in Indian subcontinent

Precipitable Water Vapor (PWV) in the atmosphere can be estimated from GPS data by determining the travel time delay of GPS radio signals through the troposphere

Sridevi Jade and MSM Vijayan

Atmospheric water vapour estimation from the GPS data, surface total pressure and the mean tropospheric temperature is the most cost effective method which gives all weather good spatio-temporal coverage. Precipitable Water Vapor (PWV) in the atmosphere can be estimated from GPS data by determining the travel time delay of GPS radio signals through the troposphere. Water vapour is already identified as an important scientific input needed at various sites for atmospheric and space related studies: improving short term cloud and precipitation forecasts, sharpening images of mesospheric and stratospheric phenomena, to name a few. Its systematic estimation at and around GPS sites would, in turn, considerably enhance the vertical precision of site coordinates, thereby making it a valuable tool in monitoring and modelling of the vertical deformation of environmentally stressed sites.

Radio signals transmitted by GPS satellites are refracted by the earth's atmosphere and the ionosphere, thereby resulting in their delayed arrival at a receiving station, relative to their vacuum path. The delay caused by the ionosphere depends on the total electron content along the path and the signal frequency. Signals monitored at two frequencies using dual frequency GPS receivers, therefore, provide a tractable means of estimating the time delay contributed by the ionosphere, and this quantity can be subsequently used to estimate the distribution of TEC (Total Electronic Content) in the regional ionosphere. The troposphere, on the other hand, is non-dispersive.

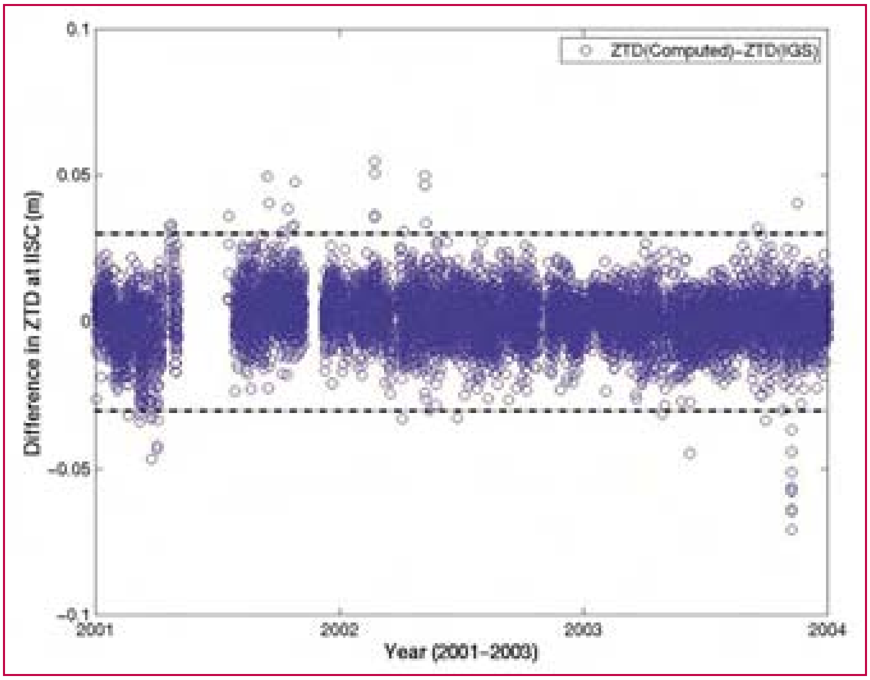


Figure 1: Comparison of ZTD computed for IISC GPS site and the ZTD values hosted on the SOPAC website

The path delay caused by it is not dependent on frequency but on the constituents of the atmosphere that are a mixture of dry gases and water vapour. The signal delays introduced by these components, when vertically scaled, represent the Zenith Total Delay (ZTD). The Signal delay (Bevis et al., 1992) is measured by a GPS receiver from all satellites in view, when mapped to the vertical using the cosec function (elevation angle of the satellite) and added, yield the zenith total delay (ZTD). Saastamoinen (1972) showed that the ZTD can be expressed as the sum of Zenith Hydrostatic Delay (ZHD) and Zenith Wet Delay (ZWD). At sea level, ZTD has a magnitude of ~230 cm, of which, the hydrostatic and wet components contribute about ~90% and ~10% respectively, corresponding approximately to the ratio of the total mass of dry air to water vapor in the atmosphere (Cucurull et al., 2002).

PWV from GPS data

ZTD at a GPS site is estimated from analysis of the GPS data generated at the site along with those at a network of widely spaced IGS (International GPS service) monitoring sites. After accounting for all the errors due to ionospheric refraction, orbital accuracy, antenna phase center modeling, signal mutli-path and scattering by the neighbourhood environment of the receiver, the residual quantity is modelled as being the contribution of the neutral atmosphere. The ZHD is modelled from the surface pressure data at the site, applying a mapping function. ZWD is then obtained by

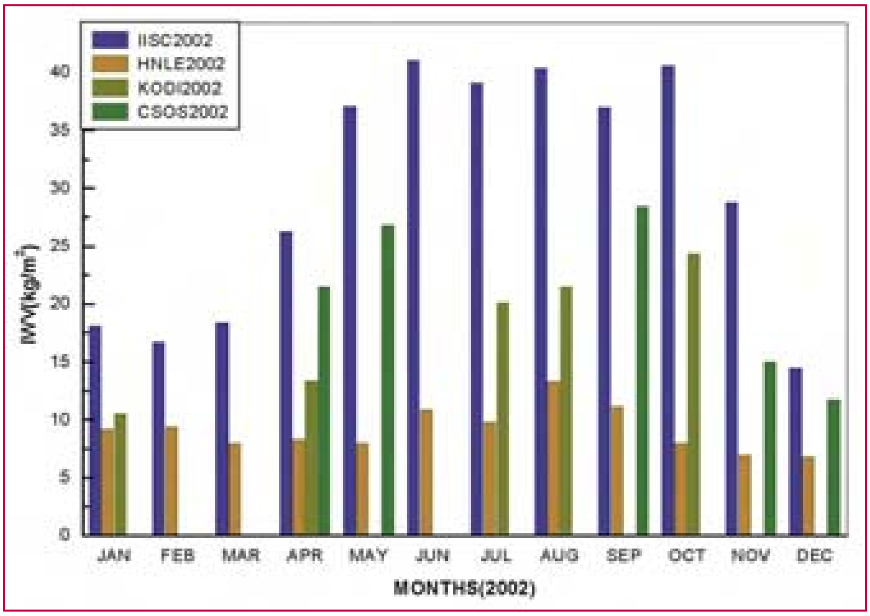


Figure 2: PWV estimated from the GPS data for Bangalore (IISC), Shillong (CSOS), and KodaiKanal (KODI) and Hanle (HNLE) GPS sites

subtracting ZHD from ZTD. The Zenith wet delay thus obtained, is related to the PWV directly above the GPS antenna through a factor proportional to the mean temperature of the atmosphere (Sridevi Jade et al., 2005).

C-MMACS scientists, in collaboration with scientists of the various academic host Institutions have established 14 permanent GPS stations in different parts of the country: Bangalore, Kodaikanal, Bhopal, Almora (UP), Leh and Hanle in Ladakh, and eight others in northeastern India. These stations form part of the national network of GPS stations sponsored by the Department of Science and Technology for earthquake hazard assessment studies. All these stations are slated to be equipped with meteorological packages within the next one year so that water vapour estimations at these sites can be routinely made for research and development of potentially operational frameworks for real-time assimilation in meteorological data for numerical weather prediction.

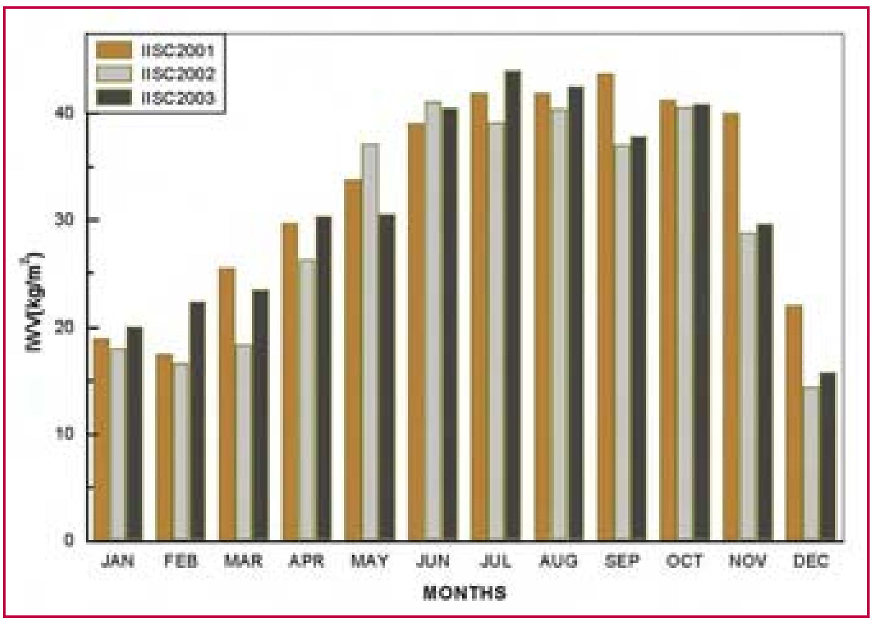


Figure 3: PWV estimates for Bangalore site from 2001 to 2003

At present, contemporaneous meteorological data for such estimations are available only at four sites: Bangalore (13.02° N, 77.57º E), Kodaikanal (10.23° N, 77.47º E), Hanle (32.78° N, 78.97º E), and Shillong (25.57° N, 91.86º E). Accordingly, available daily mean data at these sites for the years 2001, 2002 and 2003, have been used to study the variability of water vapour across a wide region from the temperate Bangalore (MSL ht 929.32m) to the high altitude desert site at Hanle (MSL ht 4324.41m) .

Data analysis

Zenith Total atmospheric delay at the above sites was obtained from the analysis of GPS data using GAMIT/GLOBK 10.05 data processing software along with the IGS (International GPS Service) sites. These have been compared (Figure 1) with the Zenith total delay at the IGS sites hosted on the SOPAC/CSRC archive (http://garner.ucsd.edu/pub/troposphere/) and the difference between the expected and observed values fall within the band of ± 0.03m. The Zenith Total atmospheric delay obtained from these analyses for the four GPS sites were used to derive the Zenith wet delay and Precipitable Water vapour (PW) in mm and IWV in kg/m2 using the surface temperature and pressure values to constrain the atmospheric model. The ratio of derived values of PW/ZWD is found to be 0.165 at Bangalore, 0.163 at Shillong, 0.140 at Hanle and 0.157 for Kodaikanal which compare well with the value of 0.15 ± 20% given by Bevis et al. (1994).

GPS derived IWV values presented here, are the first such determination over the Indian subcontinent. GPS derived integrated water vapour estimation at four GPS sites geographically spread across the Indian subcontinent (Figures 2 to 4) show the variability of water vapour across the sites with Bangalore having the highest value, Hanle the lowest, Shillong and Kodaikanal having intermediate values, each corresponding well with its geographical location. The Inter-

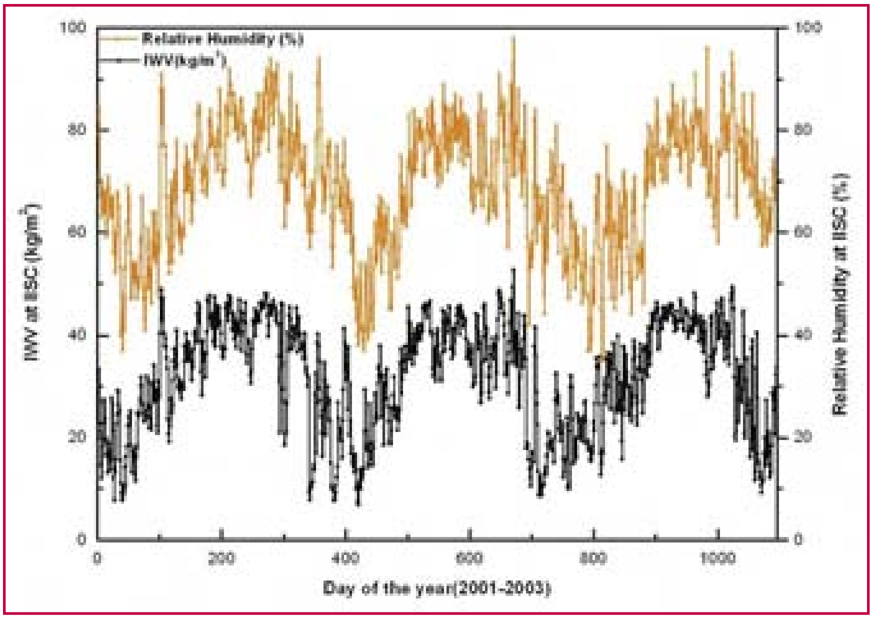


Figure 4: PWV and Relative Humidity for Bangalore site for 3 years

annual variability of IWV (Figure 3 and 4) over the 3 years roughly corresponds to the Indian monsoon intensity with 2002 being the lean one. Water vapour variations (Figure 4) over the year for all the 3 years roughly correspond to the Indian monsoon period with December to March being the dry season and June to October the peak monsoon period, and the intervening months marking a transitional period. IWV estimated from GPS data (Figure 4) is virtually in-phase with the ground humidity values.

Future

Whilst these results are still far from providing the vertical profile of water vapour in the atmosphere, that needs further developments and modelling to make water vapour tomography possible, currently available approaches as demonstrated above can yield accurate and reliable estimates of vertically integrated IWV above a GPS antenna site using, all weather, inexpensive GPS receivers capable of being deployed widely. 4-dimensional assimilation of IWV estimates when available from widely spread GPS stations, into a meso-scale model, have the potential of greatly offsetting the uncertainties of meteorological forecasts by creating continually updated initial state models. This, however, necessitates real time or near real-time availability of IWV estimates which, in turn, require installation of meteorological sensors at all the GPS sites to measure the surface pressure and temperature to desirable accuracy. With consistent data analysis in terms of methods and models, ground-based GPS will, as the length of the time series grows, become an independent data source in climate monitoring. Meanwhile, simulation experiments designed to assess the quality improvement of forecasts when GPS derived IWV data are incorporated, may generate insightful ideas as to how best may one fruitfully exploit the potential possibilities.

Acknowledgements

We acknowledge the scientific support from Drs S K Srivastav, S K Subramanian and SC Sahu of IMD. We would also like to acknowledge the help rendered by Dr Tushar Prabhu, BC Bhatt and Dr SS Gupta of Indian Institute of Astrophysics.

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Design methods for RF part of GNSS software receivers

The paper focuses on the construction of RF front end for experimental and software GNSS receivers

PAVEL KOVÁŘ, PAVEL PURIČER, JOSEF ŠPAČEK

Many researchers and R&D laboratories in the world deal with the design of the software-based or experimental GNSS receivers using digital signal processing for work and experiments with received navigational signals. These concepts have one in common: the necessity of use of some analogue RF part before conversion of the signal to the digital domain. The problem of the RF front end design of the experimental or special purpose navigation receivers has to be solved. It is not an easy task as can be seen from many papers and conference contributions. The aim of this paper is analysis of the possibility of such GNSS RF front end design. We will discuss the following three main approaches:

- Possibility of the use of the lot manufacture receiver RF front end,
- Application of RF front end GPS/GNSS ASICs,
- RF front end design from universal RF integrated circuits and components.

Technical requirements and characteristics of the experimental receiver RF front end come from the research aims. In this design phase the designer has to define the parameters like

- Number of RF channels,
- Processing frequencies,
- Bandwidth of each channel,
- Channel selectivity,
- Local oscillator frequency stability,
- Output signal specification,
- Dynamic range

Experimental versus lot manufacture receivers

The requirements on RF front end of the experimental GNSS receiver are rather different than requirements on RF front end of the commonly manufactured GNSS receivers. The lot manufacture receiver processes navigation frequencies in which the navigation service is routinely provided. Most simple receivers process only GPS L1 frequency. Some present high performance receivers process also GLONASS L1 and GPS L2 signals. On the other hand the experimental GNSS receivers should process all known navigation signals in extreme case.

The bandwidth of the common production receiver depends on its type. Low cost low power consumption GPS receivers use low sampling frequencies and bandwidth of about 2 MHz. These receivers usually have not implemented any multipath mitigation algorithms. The bandwidth of the high performance lot manufacture GPS receivers is much wider, i.e. 8 – 16 MHz. The bandwidth of the experimental receivers depends on the receiver mission. Typically, the bandwidth of such receiver should be adjustable in wide range to support broad spectrum of experiments.

The frequency plan of the lot manufacture receivers is optimized from many aspects. The all required frequencies used for frequency conversion, signal sampling, and processing should be derived from one low cost high stability frequency standard. The power consumption of this frequency source should be kept low. Therefore most RF ASICs use only one synthesizer, which directly generates signals of the first local oscillator. The remaining frequencies are derived from this signal by dividers. This approach leads for utilization of the non standard intermediated frequencies. It is not problem for mass market products, where the special IF filters and frequency standard of required frequency are developed and produced for particular chip sets. The filters are usually manufactured by lot manufacture low cost SAW technology.

In the case of experimental GNSS receivers, the development and production of the specialized components in the same manner as in the case of lot manufacture is very expensive. Therefore the standard RF components and integrated circuits should be used. The power consumption of the experimental receiver, cost and count of the components are not critical measures. It is appropriate to use common frequency standard and standard intermediated frequency. Nevertheless, the design of the synthesizers for experimental receivers is more complicated.

Lot manufacture receiver front end

The easiest and cheapest way how to develop RF front end for GPS/GNSS signal experimentation is an utilization of the RF front end of the lot manufacture GPS receiver. The most modern GPS receivers consist of at least two chips or blocks, RF ASIC and IF DSP ASIC. The signal on the RF ASIC output can be easily split and utilized for the experiments. For example in fig. 1 is shown archaic GPS receiver Magellan Meridian XL artificially equipped

Fig. 1 Magellan Meridian LX receiver front end utilization for experiments

with connector, which carries out RF front end output after the limiter, ground, and sample clock signal. In such receiver adjustment the receiver signal have not to be overload and special care must be taken not to inject noise and interference inside.

The most GPS/GNSS receivers and OEM modules can be adjusted by similar way. Most popular is utilization of the GPS OEM module with the Zarlink/Plessey chipsets [Kelley (2002)].

Some drawback of this method lies in the fact that the bandwidth, intermediated frequency, ADC resolution, and other parameter of the front end cannot be optimized for specific experiments. The experimental receiver clocks are usually derived from the clock standard of the adjusted receiver, which is not sufficient for some kind of experiments.

On the other hand only a little experience with RF circuit design is needed and special RF measurement equipment is not required.

GPS/GNSS front end ASIC

The next possibility how to design RF front end of the experimental GPS/GNSS receiver is utilization of the RF ASIC of the existing GPS/GNSS chipsets. These chipsets are produced by many semiconductors manufactures and widely used in GPS receivers and OEM modules. The chips usually require only small number of external components and low cost RF and IF filters, which are designed especially for these chipsets.

The drawbacks of such RF front end design are mainly caused by high optimization of these chips. The designer in general cannot modify frequency plan of such front end, resolution of the ADC, sampling frequency etc. The bandwidth of the front end can be rather hardly adjusted only in confident range depending on availability of the IF filters on proprietary frequencies. The RF front end characteristics are thus mainly defined by the chip manufacturer.

The designer of discussed front end should be familiar with RF design. The design itself is however eased thanks to availability of the reference design and application notes usually provided by the chip manufacturer. The RF front end design approach is complicated by availability and applicability of particular RF ASICs and some critical passive components like filters and frequency standard oscillators. The popular RF ASIC for experimentation with GPS is for example GP2015 produced by Zarling.

RF front end design based on discrete components

The above mentioned RF front end design approaches have many limitations. Only the mass market receiver's features are supported and the RF ASIC and receivers for new GPS and Galileo frequencies are not available. Special requirements on receiver bandwidth, frequency stability, resolution of the analog to digital converter etc. cannot be met, or can be met with extreme difficulty. In this case the special RF front end with "discrete" universal integrated circuits and discrete RF components has to be designed.

The first step of the design of the discrete RF front end is a definition of the frequency and level plan of the receiver. In this step the following features must be taken in to account:

1. Output signal analog to digital conversion method. Two basic methods are available:
   - Direct analog to digital conversion of the IF signal. In this method the care must be taken to use proper selection of the sampling frequency to avoid the degradation of the signal to noise ratio on the output of the high resolution A/D converter by jitter of the sampling signal.
   - Analog conversion to the base band (I&Q) and then analog to digital conversion. In this method the quadrature demodulator amplitude unbalance can cause a problem during high resolution analog to digital conversion.
2. Availability of the IF filters. The broad offer of IF filters with various bandwidths are available only on several frequencies for example 70 MHz and 140 MHz. The selectivity of the receiver can be also formed by the digital filter implemented to the receiver ASIC, FPGA, DSP or to the software. In this case the high resolution of A/D converter is needed.
3. Availability and performance of the RF filters. The high performance RF filters of various bandwidths, insert

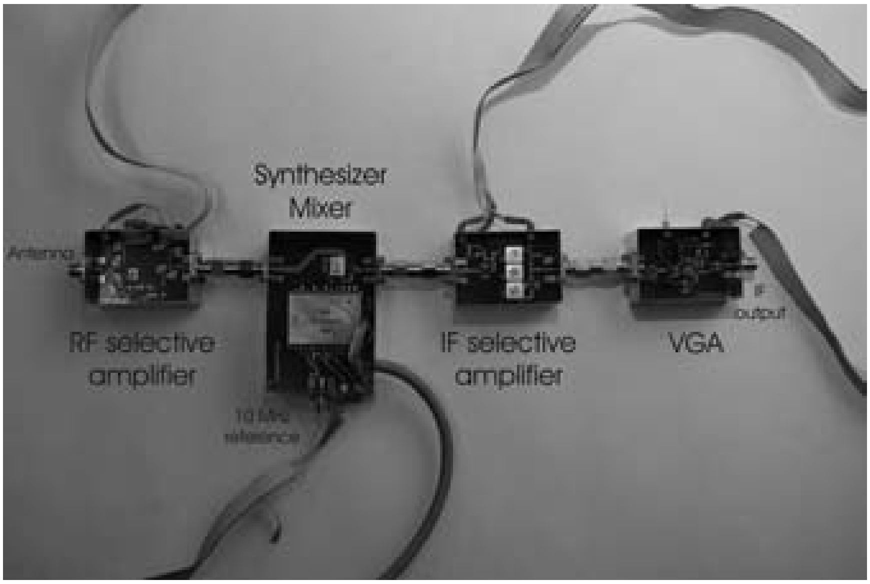

Fig. 2 Experimental GNSS receiver RF channel

loss, and selectivity are basically available for GPS L1 frequency. Some manufactures offer a few filters for GPS L2 frequency too. The RF filters for other GNSS signals like GPS L5, GLONASS and Galileo E5, E5a, E5b, E6 are basically not available at present. The development and manufacture of custom-made RF filters are generally out of feasibility of the researcher. The solution of this problem is an implementation of helical filters, which are suitable for prototyping. Helical filters are customer tunable and available in sufficient range from various manufacturers. However, the parameters of these filters are worse than the SAW filters. These parameters can be compensated by proper design of the frequency plan, use of relatively high intermediated frequency and implementation of the active components with higher dynamic range.

This third approach is the most suitable for the design of the special purposes or experimental receivers. The following discrete RF front ends that have been designed at the Czech Technical University [Kacmarik (2005)] for the purposes of use in experimental GNSS software receivers can describe the design genesis and concrete solutions.

RF front end kit

The RF front end for the first version of experimental GNSS receiver uses modular architecture. Up to two RF front end channels are housed in 19“ box (Fig. 3), equipped with power supply and high stability 10 MHz frequency standard. Each channel (Fig. 2) consists of four replaceable blocks:

- RF selective amplifier,
- Synthesizer & Mixer,
- IF selective amplifier,
- VGA amplifier.

The RF front end is a single conversion receiver with intermediated frequency 70 MHz. The RF selective amplifier consists of low noise RF amplifier, helical filter, and antenna supply bridge. Synthesizer & Mixer block converting RF signal to the IF frequency uses external 10 MHz frequency standard. The IF selective amplifier consists of cascade of monolithic amplifiers and helical filters. The last block of the cascade is variable gain amplifier (VGA). The gain of this block can be controlled either by the AGC loop or via the external signal. Gain control range is approximately 50 dB.

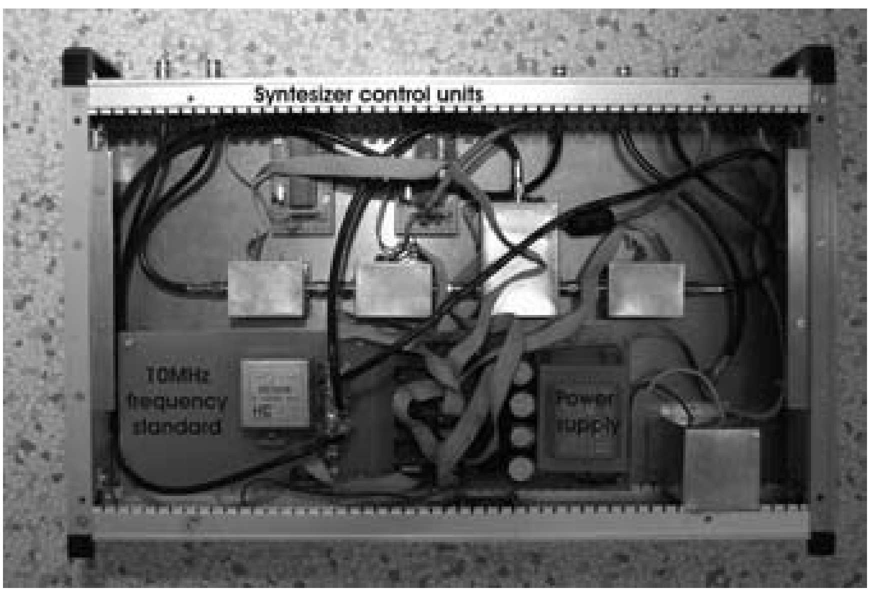

Fig. 3 Experimental GNSS receiver RF front end housed in 19” rack

Compact design

A natural process of design optimization led to the more compact RF front end (Fig. 4) for the second generation of experimental GNSS receiver. The intermediated frequency of this front end was increased to 140 MHz to improve suppression of the mirror reception. The helical IF filter was replaced by the SAW filter with much better form factor. The bandwidth of the filter is 16 MHz. The bandwidth of the signal can be further reduced by digital filter in receiver DSP if needed. The complete RF chain with microcontroller for synthesizer control was integrated into one box (50×70 mm) [Spacek (2005)].

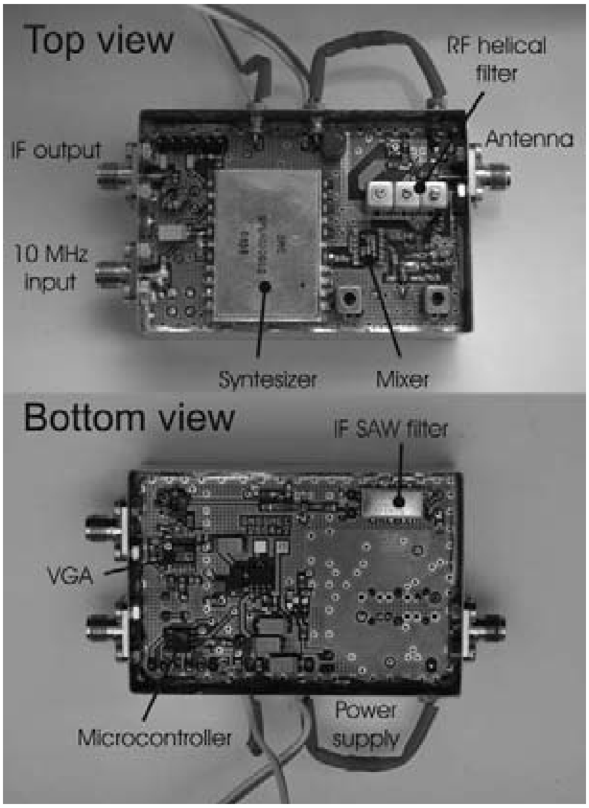

Fig. 4 Compact RF front end for second generation of experimental GNSS receiver

The final step was development of the RF front end version for compact version of the receiver for GPS L1 and L2 frequency in euro card (100 x 160 mm) format. The designed compact RF front end has been again revised and 3V technology was used for all parts. The helical RF filters were replaced by the SAW filters. The hybrid synthesizers were replaced by the integrated ADF4360 by Analog Devices controlled by the external inductors. The more compactness of the design and use of unified 3V technology were paid by limited tuning possibility of the synthesizer and lesser flexibility of the design due to necessity of matching RF and IF amplifiers to 50 W. In the case of the use for the different navigation frequency the RF front end must be completely redesigned. The block diagram of such RF front end is in Fig. 5.

Summary

The concrete selection of the design method for RF front end depends on many factors like research aims, available technology and experiences. The simplest way how to design RF front end for experimentation with the GPS/GNSS signals is utilization of the RF front end of lot product receiver. This approach does not require many experiences with RF design. The features of the RF front end are done by manufacture and can be hardly fit to researcher requirements.

More flexible approach is a design of the custom made RF front end. The design using GPS/GNSS RF ASIC is easier, but less flexible than the design based on universal RF components and integrated circuits. The most flexible solution is RF front end assembly from replaceable blocks. This approach enables easily modified RF front end characteristic in accordance with the application requirements.

The modular design with validated parameters can be then optimized to the compact non-modifiable version.

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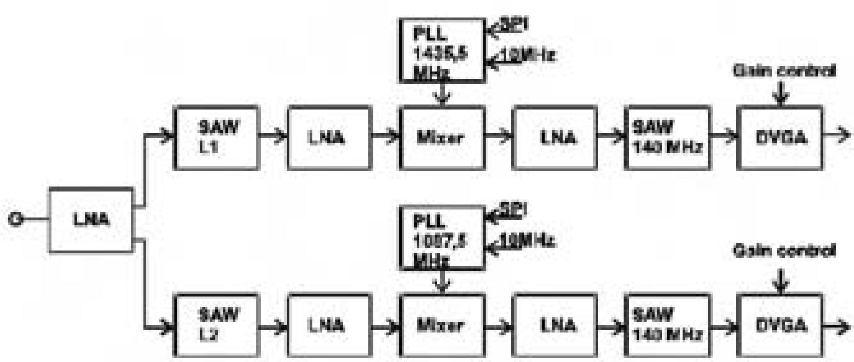

Fig. 5 Block diagram of the 3V GPS L1/L2 RF front end

Advent of modern cartography in nautical charting

The paper highlights the role of modern cartography as emerging tool for integration of multimedia data at various scales during compilation of nautical charts and its production

RB Singh

A nautical chart is a medium of information and tool for safe maritime navigation. It is the chief nautical instrument for ocean route planning and safe navigation. With the time not only the user's requirements have increased, but also the advancement in the expertise in the field of nautical cartography has resulted in better product in the most useful way. With the advent of modern cartography, chart contents are stored in digital form as database offering flexibility of producing nautical charts at any chosen scale and projection without going through the process of redrawing. Computer aided cartography since the nautical cartographers realized computer as their tool, has matured to an interdisciplinary field of research by now.

Cartography is undergoing a period of rapid change as a result of the process and product of information revolution. GIS, GPS, Geosciences, Oceanographic studies and thematic mapping through remote sensing has taken their berth in place of traditional mapping. The 1980's saw an accelerating pace of technological change as the computer found its way into all aspects of cartographic production.

Modern cartography is capable of generating data in static and dynamic modes for different environment also. As automated cartographic technique, it is highly useful to capture, store, retrieve and presentation of hydrographic and topographic data into both raster and vector mode for compilation of nautical charts at different scale using various software.

The specific characteristic of modern cartography is to integrate various thematic data with aid of GIS, and remote sensing into required format for decision makers and planners during production of nautical charts.

Cartographic revolution

Cartography evolved through three stages, the pre historic stage (from evolution of man to 4th century BC), the medieval stage (4th to 5th century) and the modern stage. In the primitive stage, cartography meant lines and sketches on the rock, leaves, and animal skins with the help of fibers of coconut tree and seashells. The first map were made by people of Marshal Island (pacific) and were used a " Portland charts"

Greeks were pioneer in modern cartography, Anaximander (611 BC – 547 BC) draw first map of Greece with geographical information. Periplus Maric Erythroci is the manual of Erythracean Sea prepared by an unknown Roman merchant is a significant contribution of cartography. During the middle age, Arabian and British geographer contributed a lot of work in the field of cartography and Portolon maps were prepared with the help of compass.

The modern stage of cartography starts from 1500 AD with the works of Nicholous, Crab, Martin, Pedru, Renial etc. The modern technique in cartography includes models, aerial photographs, Photogrammetry Remote sensing data and GIS, which make the subject methodical and rational. It has also reduced the time involved in the production of a map and nautical charts.

Development in nautical charting

Indian nautical cartographer has a good knowledge of astronomy and it is probable that they had prepared route and navigational chart though no ancient maps exist in India. The Indian Naval Hydrographic Department (INHD) is one of the oldest hydrographic departments in the world deriving its origins from the earliest voyages of the Europeans into the Indian water.

The earliest compilation of nautical charts of the Indian Ocean and Indian coasts was date back to 1703. The Naval Hydrographic Department was established in 1954 and assumed the national responsibility for hydrographic surveys of Indian water and production of the navigational charts. The early chart was published in 1959 using the cartographic standardization contained in chart branch order. The earlier charts (pre-1966) were totally hand drawn. The introduction of photo type- setting machine for lettering (1967) and scribe for line work (1969), made dynamic change in appearance of the nautical chart.

The chart provides a complete coverage of the area to cater for mariners need. Since the navigational chart is used by International shipping, it is essential that the symbol and abbreviation used on chart are in standard format so that these can be understood the world over. The face of Indian charts is totally modernized after switching over to new fonts and styles on acquisition of new model of photo type setting machine (1973). The line work which was hand drawn was gradually replaced by scribing which resulted in mass scale modernization of Indian nautical charts Today, the nautical chart must respond to the fast changing requirement of navigators and other specialist users.

Modern cartography

Following the impact of computer technology on cartography, the working group of International Cartographic Association defines modern cartography as " A holistic representation and intellectual abstraction of geographical reality, intended to be communicated for a purpose or purposes, transferring relevant geographical data into an end product which is visual, digital or tactile''. Now a day's computer has influenced every aspect of manual and analytical cartography in both static and dynamic environment.

Ease in updating of existing chart and map is the key advantage of modern cartography. Updating of topographic and hydrographic details for nautical chart interacting by using high resolution satellite images and digital ortho photos, supplemented by field data collected using GPS and processed through coordinate geometry is now well established.

Cartographer is now beginning to exploit the tools and methods of the new interactive media, multimedia and animation to show spatial distribution over time and space for various charting purposes.

Computers have influenced every aspect of manual and analytical cartography. The first aspect is cost effectiveness. After initial investment in digitization and creation of database for base map/ chart, the updating and multipurpose chart production by adding value added layer to the base map is both time and cost effective. Various thematic maps and charts can be produced using digital cartography.

Element of modern cartography

Hardware

The most important development for modern cartography was incorporation of microprocessors directly into the display device. Over time, more and more functions and capabilities have moved from the main computer and have been directly incorporated into the graphic terminal. The next logical development was the disconnection of graphic terminal from mainframe as standalone system, called workstation. Some of the known workstation are SUN, SPACE, DEC, ALPHA, HP, IBM, INTRGRAPH and Silicon graphic. The additional components are monitor, digitizer and scanner and output devices like pen plotter, raster plotter and image setter equipment.

Software

Modern cartography now overlaps with GIS more than over before. This is a result of building more and more cartographic capabilities into GIS and even into remote sensing system. Some of the well known software package which are used in cartographic work, are listed below.

Remote sensing

EASI/PACE, Image Analyst, ERDAS imagine, Er Mapper, TNTMips

Geographic Information System

Geomedia Professional, SPAN, ARC/INFO, MGE, MapInfo, ILWIS, IDRIS, CARIS GIS

Computer aided drafting system

Auto Cad, Micro station, Arc Cad

Mapping System

ACE (from PCI Geomatic) Map composer (from ERDAS) Map publisher (from INTERGRAPH) Arc plot (from ESRI)

Relation between cartography, remote sensing and GIS

Cartography, Remote sensing and Geographic Information System together with Geodesy, Photogrammetry and Surveying are grouped under the mapping science. From review of definition of cartography, RS and GIS, it can be demonstrated that there is a considerable overlap. Depending on the definition selected either cartography or GIS can be interpreted as totally subsuming the activities that might be claimed by others. There are various models, which outline possible conceptual relationship among this field, out of which three models are discussed here.

(i) **linear model** This model implies the sequence of activities as data acquisition (RS), followed by data management (GIS) and data presentation (Cartography)

(ii) **cartography dominant model** This model places cartography in an unrivalled position. The case for this model is made when data is collected and manipulated for display as a map, the usual outcome of acquisition and manipulation of geo - reference data.

(iii) **GIS dominant model** Similar to cartographic dominant model, where in RS and GIS are visualized as subset of cartography, in GIS dominant model, GIS is placed at the helm of affairs and RS and cartography are treated as part of GIS.

Modern cartography as integrating tool

Today with arrival of satellite data, microprocessors and computer aided system i.e. GIS, We have modern cartography with various software (ARC/INFO, ERDAS, INTERGRAF, CARIS) which have been proved to integrate multimedia data layers into a required format and scale for better and faster charting practice. The recent development in modern cartography has proved their capabilities to produce nautical charts in analogue form and electronic navigational chart in the form of electronic navigational chart database (ENCDB) for requirement of safety and automated navigation. Preparation of chart involves the integration of various topographic and hydrographic source materials into a balanced and harmonic composition on a specified scale.

National Hydrographic Office, Dehradun, India, under ministry of defense (Navy), is the pioneer office to produce nautical charts for marine safety navigation. To achieve the faster production of chart, NHO has been provided with modern cartographic division to integrate different types of ocean and topographic data into a required scale and projection with the help of INTERGRAPH workstation.

Preparation of fresh compilation for nautical chart using original hydrographic and topographic data involves the digitization of various analogue data which is available in the form of survey fair sheet, toposheet, satellite imageries, tidal data, current data, sailing direction etc. on different scale and projection. The scope and purpose of modern cartographic section at NHO are as follow.

(i) To create a fair drawing material (film positive and negative) from chart compilation.

(ii) For auto compilation of various source data to create database for paper chart and ENC generation.

(iii) To prepare electronic chart from existing chart database.

The work procedure for production of nautical chart, involves inputting of data (hard copy and digital), preprocessing, compilation/auto compilation of various charts, ENC generation and chart preparation. The whole workflow is classified into five main activities as follow.

(a) Data input: (Type and Source)

(b) Data processing: Auto compilation, digitization and creation of master file.

(c) Data output: Fair drawing and ENC generation.

(d) Quality control: It is an issue, which can be controlled by verification and inspection at each step from data capture to presentation.

(e) Records and reference.

Application in support of nautical charting

Nautical chart is a specialized map, which is a legal tool for marine navigational safety and research. It is specifically designed to meet the requirement of marine navigation showing depth of water, nature of bottom, elevation and configuration of coast, danger and aids to navigation. Modern cartographic tools are being increasingly used world over for ocean and land management application. Digital Photogrammetry and image processing of remote sensing data jointly meet the mapping requirement of coastal and hydrographic management application. In addition to this technology, tools for integrating various thematic data and generation of hydrographic database for paper and ENC chart production are now available with modern cartography.

Based on experience of other International hydrographic offices, National Hydrographic Office, Dehradun also expects to utilize modern cartographic tools for nautical charting in the following ways.

(a) Modern cartographic tools are useful for the generation of paper chart database and electronic navigational chart database (ENCDB) to produce paper chart and ENC.

(b) To meet the greater demand of chart for safety of navigation, it provides the faster production of nautical charts.

(c) It is highly utilized in generation of grids, graticules, ticks, labels, projection scales and map legend during auto compilation of charts.

(d) It can be effectively depict low tide line, high tide line, nature of coastline, danger line and isolated shoal patch on chart for safety navigation.

(e) Modern cartography plays a vital role to collect and represent accurately the valuable topographical information including conspicuous objects along coast, which are aids to navigation.

(f) It is widely applicable to integrate multi thematic data and RS data into digital format for terrain measurement and management to study coastal resource development. The modern cartography in conjunction with GIS, RS, Photogrammetry, GPS and modeling tools is enable to shoreline mapping, coastal highway and gas pipeline mapping, coastal habitats and low water features representation in support of coastal zone management chart production.

(g) It is capable to analyze and integrate spatial data in requisite projection and all scale ranging from 1: 1000 to 1: million as required to produce large scale to small scale nautical chart.

Further improvement in modern cartography with aid of information technology will provide valuable information to represent marine features such as pinnacle rock, wreck, navigational buoys, beacon etc. that are important in nautical charting for safety navigation.

Conclusion

Modern cartographic techniques are being increasingly used world over

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27-30 Aug
www.digitalearth06.org.nz
james@eventdynamics.co.nz

September 2006

WALIS Forum
14 - 15 September Perth Convention Centre, Australia
davidls@walis.wa.gov.au
www.walis.wa.gov.au

17th UNRCC for Asia and the Pacific/ 12th Meeting of the PCGIAP
18-22 September, Bangkok
http://www.gsi.go.jp/PCGIAP/

ION GNSS 2006
26 - 29 September, Fort Worth TX, USA
www.ion.org/meetings#gnss

October 2006

Intergeo 2006
10 -12October, Munich, Germany
ofreier@hinte-messe.de
http://www.intergeo.de

XXIII International FIG Congress Back
15-20, Germany, Munich
http://www.fig2006.de/index2.html
Office@fig2006.de

The 12th IAIN World Congress 2006
18-20 October, Jeju, Korea
http:// 203.230.240.83/

Geoinformatics 2006
20-21 October, Wuhan, China
lilyshi@lmars.whu.edu.cn

The 12th IAIN World Congress 2006
18-20 November, Korea
jkinpr@mail.hhu.ac.kr

November 2006

GSDI-9 - Geospatial Information: tool for reducing poverty
03-11 November, Santiago de Chile, Chile
gsdi9@igm.cl
http://www.igm.cl/gsdi9

Trimble Dimensions
05 - 08 November, Las Vegas NV
http://www.trimble.com

AFITA-2006
9-11 November, 2006
The Indian Institute of Science, Bangalore
http://www.afita2006.org


Leica SmartRover
Travel light
SMART TRACK
BLUETOOTH
WINDOWS CE
WORKING TOGETHER
FUNCTION
integrated
LEICA SYSTEM 1200